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Abschlussbericht

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Abschlussbericht

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Kurzbeschreibung

Die Ergebnisse des Projekts „Zuteilung für Industrieanlagen im EU-ETS nach 2020 - Analyse und Weiterentwicklung der direkten und indirekten Carbon-Leakage-Regelung“ sind in diesem Gesamtbericht zusammengeführt. Ziel des Projekts war die methodisch und empirisch fundierte, zeitnahe und politikrelevante wissenschaftliche Analyse verschiedener Aspekten des Themas Carbon Leakage bei der anstehenden Weiterentwicklung des EU-Emissionshandels für die Zeit nach 2020, und insbesondere der Ausgestaltung der Carbon-Leakage-Regelungen für die vierte Handelsperiode (2020 – 2030) und darüber hinaus. Die Arbeiten wurden vom Ecologic Institut. und dem Zentrum für Europäische Wirtschaftsforschung GmbH (ZEW) Mannheim durchgeführt. Im ersten der insgesamt drei Arbeitspakete wurde der Begriff „Carbon Leakage“ genauer geklärt. Insbesondere wurden die wesentlichen Einflussfaktoren bestimmt, die einen Einfluss auf das Carbon Leakage-Risiko haben. Innerhalb des zweiten Arbeitspakets wurde eine vergleichende Analyse der klimapolitischen Ambitionsniveaus der EU und ihrer größten industriellen Handelspartner-Länder erstellt. Sie liefert ein möglichst aktuelles und möglichst umfassendes Bild des klimabezogenen regulatorischen Rahmens für energieintensive Industrien in den wichtigsten Handelspartnerländern der EU. Im dritten Arbeitspaket wurden die indirekten CO_2-Kosten von Industrieunternehmen näher betrachtet. Unter indirekten CO_2-Kosten werden die zusätzlichen Kosten im Rahmen des EU ETS verstanden, die durch eine Überwälzung der in der Stromerzeugung anfallenden CO_2-Kosten auf den Strompreis entstehen.

Abstract

This report presents the results of the project on " Free allocation for industrial installations in the EU ETS after 2020 - Analysis and further development of the direct and indirect carbon leakage regulations“. The aim of the project was to conduct methodologically and empirically sound, timely and policy-relevant scientific analysis on various aspects of the carbon leakage debate to assist the ongoing development of the EU emissions trading system for the period after 2020, and in particular on the design of carbon leakage regulations for the fourth trading period (2020 - 2030) and beyond.The work was carried out by Ecologic Institut and Centre for European Wirtschaftsforschung GmbH (ZEW). In the first of a total of three work packages, the term "carbon leakage" was clarified more precisely. In particular, the main factors influencing carbon leakage were determined. Within the second work package, a comparative analysis of the climate policy ambition levels of the EU and its largest industrial trading partner countries was carried out. It provides as up-to-date and comprehensive a picture as possible of the climate-related regulatory framework for energy-intensive industries in the EU's most important trading partners. In the third work package, the indirect CO_2 costs of industrial companies were examined. Indirect CO_2 costs are the additional costs within the framework of the EU ETS incurred by passing on the CO_2 costs incurred in electricity generation to the electricity price.

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1 Überblick über das Projekt und Zusammenfassung

Das Projekt „Zuteilung für Industrieanlagen im EU-ETS nach 2020 - Analyse und Weiterentwicklung der direkten und indirekten Carbon-Leakage-Regelung“ besteht aus drei Arbeitspaketen, deren Ergebnisse in diesem Gesamtbericht zusammengeführt werden. Die Arbeiten wurden vom Ecologic Institut und dem ZEW durchgeführt. In diesem Überblicksteil sind die wesentlichen Hintergründe, Methoden und Ergebnisse der Teilberichte zusammengefasst. Die vollständigen Berichte für die Arbeitspakete 1 Teil 2, 2, 3 sind daran angehängt. Die Ergebnisse der Arbeitspakete 1 Teil 1 "Forms and Channels of Carbon Leakage" und Teil 3 "The Innovation Fund: how can it support low-carbon industry in Europe: Design recommendations for the successor instrument to the NER 300 in Phase 4 of the EU ETS" wurden im Bericht 16/2018 bzw. 06/2018 der Serie „Climate Change“ des Umweltbundesamtes veröffentlicht. Sie sind auf der Homepage des Umweltbundesamtes verfügbar.[1]

1.1 Arbeitspaket 1 – Begriffsabgrenzung „Carbon Leakage“

1.1.1 Forms and channels of carbon leakage

Die Diskussion um Carbon Leakage ist keineswegs neu – aber in der jüngeren Vergangenheit hat sich die Welt auf interessante Weise verändert, und damit hat sich auch der Rahmen für diese Diskussion verschoben. Es sind nicht mehr ausschließlich westliche Industrieländer, die ambitionierte Klimapoli-tik verfolgen. Das Pariser Abkommen ist das sichtbarste Zeichen dafür, dass eine wachsende Zahl von Ländern in aller Welt sich dem Klimaschutz verpflichtet fühlt, und entsprechende Maßnahmen ergreift. Zudem wird zunehmend deutlich, dass wirksame Klimapolitik in der einen oder anS.deren Form eine Dekarbonisierung wichtiger Sektoren erfordert – die Verwendung fossiler Brennstoffe muss drastisch verringert, und schließlich ganz beendet werden. Während dieser Prozess in verschiedenen Ländern in unterschiedlicher Geschwindigkeit voranschreiten wird, stellt sich dennoch weltweit die Frage, welche Rolle energie- und ressourcenintensive Industrien in einer dekarbonisierten Weltwirt-schaft spielen werden, und wie ein Strukturwandel zu einer postfossilen Wirtschaft politisch gestaltet werden kann. Dieser Bericht geht der Frage nach, wie diese Änderungen sich auf die Diskussion um Carbon Leakage auswirken. Insbesondere stellt sich die Frage, ob (oder wie lange) zwei zentrale An-nahmen dieser Diskussion noch zutreffen: dass es immer eine Nachfrage nach den Produkten energie-intensiver, fossil-basierter Industrien geben wird, und dass sich immer ein Standort finden wird, an dem diese Güter hergestellt werden.

Dieses Papier dient dazu, einige der Diskussionsstränge rund um das Thema Carbon Leakage zu strukturieren und zusammenzufassen, und die verschiedenen, zum Teil überlappenden und zum Teil verbundenen Diskurse zu entwirren. Das Thema Carbon Leakage hat eine steile Karriere hinter sich – sowohl in der wissenschaftlichen Welt, in der es seit über einem Jahrzehnt ausgiebig beforscht wurde, als auch in der politischen Diskussion. Als Begriff lässt sich Carbon Leakage mit verschiedenen Debat-ten verbinden, die zum Teil schon Jahrzehnte zurückreichen:

[1] Görlach, B. und Zelljadt, E.: Forms and Channels of Carbon Leakage, Climate Change 16/2018, Umweltbundesamt, Dessau-Roßlau. Verfügbar unter: https://www.umweltbundesamt.de/publikationen/forms-channels-of-carbon-leakage, zuletzt abgerufen am 20.11.2018

Duwe, M. und Ostwald, R. The Innovation Fund: how can it support low-carbon industry in Europe?, Climate Change 06/2018, Dessau-Roßlau. Verfügbar unter: https://www.umweltbundesamt.de/publikationen/the-innovation-fund-how-can-it-support-low-carbon, zuletzt abgerufen am 20.11.2018

- Ein Strang der Debatte sieht Carbon Leakage als Problem für die Wirksamkeit unilateraler (oder nicht international harmonisierter) Klimapolitik. In dieser Interpretation ist Carbon Leakage deshalb ein Problem, da Emissionsminderungen in einem Land durch steigende Emissionen andernorts ausgeglichen werden: in der Folge ist die Klimapolitik weniger wirksam als es zunächst den Anschein hat. Dieser Effekt war insbesondere ein Problem im Kyoto-Regime der internationalen Klimapolitik, das auf einer strikten Zweiteilung von Ländern mit bindenden Emissionsgrenzen (Annex-I-Staaten) und solchen ohne Emissionsobergrenzen (Nicht-Annex-I-Staaten) basiert, wes-halb Leakage aus der ersten in die zweite Kategorie in der Summe zu zusätzlichen Emissionen führt. Ob, und in welcher Weise, dieses Argument in der Welt des Pariser Abkommens mit seiner Vielzahl unterschiedlicher nationaler Klimaziele noch greift, bleibt zu diskutieren.
- Ein zweiter Strang betrachtet Carbon Leakage als Problem für die Effizienz einer nicht harmonisierten Klimapolitik: im Optimalfall einer komplett harmonisierten Klimapolitik würden sich die Produktionsanteile zwischen Handelspartnern allein nach deren komparativem Vorteil richten, einschließlich der Fähigkeit, Güter mit geringeren Emissionen herzustellen. Carbon Leakage ver-zerrt diese Verteilung, indem es Produktionsanteile und Investitionen verlagert in Länder mit schwächerer Klimapolitik. Infolge dessen werden Güter mit unnötig hohen Emissionen hergestellt, und werden die Kosten zur Erreichung globaler Klimaziele unnötig in die Höhe getrieben.
- Ein dritter Strang fragt nach den Wirkungen unilateraler, einseitiger Klimapolitik (oder allgemeiner nach den Effekten jeglicher Unterschiede in der Stringenz klimapolitischer Maßnahmen) auf die Wettbewerbsfähigkeit heimischer Industrien, auf die Standortwahl selbiger, und auf die Vor- und Nachteile für klimapolitische Vorreiter. Auf politischer Ebene wird diese Diskussion meist eher defensiv geführt, und dominiert von den Sorgen derjenigen Unternehmen, die ihre internationale Wettbewerbsfähigkeit gefährdet sehen, und die daher entweder auf ein geringeres Ambitionsniveau in der Klimapolitik drängen, oder die Kompensation für die befürchteten Wettbewerbsnachteile erhoffen.
- Und schließlich verbindet ein vierter, bislang eher weniger beleuchteter, Strang die Diskussion um Carbon Leakage mit der Frage nach radikalen Innovationen und industriellem Strukturwandel, die mit der Abkehr von fossilen Brennstoffen verbunden sein werden. Dieselben Industrien, die am stärksten dem Carbon-Leakage-Risiko ausgesetzt sind, stehen auch vor der Herausforderung, ihre Rolle in einer postfossilen Wirtschaft zu finden. Aus diesem Blickwinkel geht es daher eher darum, Innovationen zu fördern und disruptive Veränderungen zu gestalten, als Industrien vor dem Änderungsdruck zu schützen und den Status Quo zu bewahren.

Der zweite Teil dieses Berichts erörtert die verschiedenen Kanäle, durch die Carbon Leakage stattfinden kann, die zu Grunde liegende Logik, ihre Plausibilität und die Schwierigkeiten, sie empirisch zu messen.

- In der kurzen Frist ist das Produktionsleakage der wichtigste Kanal, im Zuge dessen Produktionsvolumina und die damit verbundenen Emissionen von einheimischen zu ausländischen Standorten verlagert werden. Dies findet dabei innerhalb der vorhandenen Produktionskapazitäten statt, und schlägt sich nieder in einem sinkenden Marktanteil der einheimischen Standorte.
- Wenn sich die Produktionskapazitäten ändern (Kapazitätsabbau an einheimischen Standorten und/oder Kapazitätserweiterung an ausländischen Standorten), spricht man von

Investitionsleakage – dabei beeinflussen Unterschiede in der Stringenz der Klimapolitik die Investitionsströme, so dass das Land mit der schwächeren Klimapolitik zusätzliche Investitionen anzieht.

- Ein dritter Kanal verläuft durch den Markt für fossile Brennstoffe. Indem Klimapolitik in einem Teil der Welt die Nachfrage nach fossilen Brennstoffen verringert, führt sie – bei konstant bleiben-dem Angebot – dazu, dass der Preisen für diese Brennstoffe niedriger liegt als im Alternativszena-rio. Dadurch entsteht wiederum für Länder mit schwacher Klimapolitik ein Anreiz, mehr fossile Brennstoffe einzusetzen.
- Ein vierter Kanal wird als indirektes Leakage bezeichnet; treffenderweise handelt es sich um Leakage, das durch einen indirekten Kohlenstoffpreis verursacht wird. Der Kohlenstoffpreis ver-teuert einerseits die Emissionen selbst (direkte Wirkung). Wo die Emittenten aber in der Lage sind, den Kohlenstoffpreis ganz oder teilweise zu überwälzen, erhöht er auch den Preis von Gü-tern, die in der Herstellung kohlenstoffintensiv sind (indirekte Wirkung) – wie etwa Strom. Auch diese indirekte Wirkung könnte zu Leakage führen, etwa indem sie die Wettbewerbs- und Ertrags-fähigkeit großer Stromverbraucher schmälert.
- Nach mehr als einem Jahrzehnt Forschung zu Carbon Leakage durch nicht harmonisierte Klimapolitik, und nach drei Jahrzehnten Forschung zu dem Zusammenhang zwischen umweltpolitischer Regulierung, der Wettbewerbsfähigkeit von Unternehmen und Investitionsentscheidungen, ist der begriffliche Rahmen gut etabliert, und wurden viele der empirischen Zusammenhänge und Kausalitäten unter-sucht. Und dennoch werden viele Fragen weiterhin kontrovers diskutiert: Wie stark ist der Carbon-Leakage-Anreiz durch unterschiedlich ambitionierte Klimapolitik tatsächlich? Und wie stark ist dieser Anreiz im Vergleich zu vielen anderen Trends, die Investitions- und Produktionsentscheidungen beeinflussen – so wie Veränderungen in der weltweiten Nachfrage, Veränderungen der Rohstoffpreise, oder auch Strukturwandel durch technologische Veränderung oder durch politische Weichenstellun-gen? Auf längere Sicht stellt sich die Frage, ob es noch unregulierte Standorte geben wird, an denen potentielle Investoren investieren wollen würden – und wie lange diese Standorte noch frei von klima-politischer Regulierung bleiben werden? Und schließlich stellt sich die Frage, wie eine bessere Balance gelingen kann zwischen der defensiven Diskussion um Carbon Leakage und der proaktiven Frage, wie die nötigen Innovationen und Investitionen für eine kohlenstoffarme Wirtschaftsweise auf den Weg gebracht werden können.

1.1.2 Investitionsverhalten in ausgewählten Industriebranchen im EU-ETS – Empirische Analyse und Fallbeispiele

Führt die Europäische Klimapolitik dazu, dass Unternehmen Investitionen im Inland zurückstellen und Produktionskapazitäten ins Ausland verlagern, um den hohen Folgekosten der Regulierung zu entgehen? Die politische Bedeutung eines solchen Investitionsleakage ist unbestritten, zumal Investitionen mit Arbeitsplätzen, mit zukünftigen Gewinnen und auch mit Steuereinnahmen verbunden sind. Empirisch ist es jedoch umstritten, ob es Investitionsleakage überhaupt gibt.

Dieser Bericht geht der Frage nach, welche Anhaltspunkte es für Investitionsleakage in Deutschland und Europa als Folge des EU-Emissionshandels gibt. Hat Investitionsleakage

stattgefunden, lassen sich konkrete Beispiele finden? Wie groß ist das Risiko des Investitionsleakage tatsächlich einzuschätzen, auch im Vergleich zu anderen Einflussgrößen?

Um sich diesen Fragen empirisch zu nähern, können grundsätzlich verschiedene Ansätze zum Einsatz kommen.

- Eine **statistische Auswertung** der Daten zu Auslandsinvestitionen ist geeignet, um die allgemeinenen Trends und Größenordnungen zu umreißen. Auf Ebene der Branchenstatistiken ist sie jedoch nicht geeignet, um Korrelationen zwischen dem Emissionshandel und dem Investitionsverhalten aufzuzeigen: Zum einen lässt sich die Gesamtheit der emissionshandelspflichtigen Unternehmen in diesen Statistiken nicht sauber abgrenzen; zum anderen liefert die Analyse auf Branchenebene nicht genügend Datenpunkte, um den Effekt des EU ETS von anderen Einflüssen abzugrenzen.
- Eine weitere Möglichkeit sind **Befragungen von Unternehmen** – wie sie etwa durch Verbände, durch Branchendienste oder auch von Wissenschaftlern durchgeführt werden. Hierbei lässt sich zum einen die Gruppe der emissionshandelspflichtigen Unternehmen genau abgrenzen, gegebenenfalls auch im Vergleich zu einer Kontrollgruppe von Unternehmen außerhalb des Emissionshandels. Zum anderen ist es möglich, direkt nach dem Einfluss des EU-Emissionshandels auf Investitionsentscheidungen zu fragen. Der Nachteil ist jedoch, dass die Antworten unter Umständen verzerrt sein können.
- Schließlich lässt sich der Einfluss des CO_2-Preises auch durch **Fallbeispiele spezifischer Investitionsentscheidungen** untersuchen: Welche Rolle hatte der CO_2-Preis für die Investitionsentscheidung? Lassen sich Anhaltspunkte dafür finden, dass der CO_2-Preis ausschlaggebend war für die Standortwahl? Grundsätzlich kann dieser Ansatz belastbarere Einsichten liefern – allerdings sind Investitionsentscheidungen in dieser Größenordnung Einzelfallentscheidungen. Die Erwägungen dafür sind nicht immer transparent dokumentiert, zudem handelt es sich um spezialisiertes Wissen, über das oft nur beteiligte Personen verfügen. Erschwerend kommt hinzu, dass die Entscheidungen zum Teil Jahre oder sogar Jahrzehnte zurückreichen, und die Beteiligten nicht mehr unbedingt im Unternehmen sind.

Dieser Bericht vereint Elemente aller drei Ansätze, zudem gibt er einen kurzen Überblick über den Forschungsstand zum Thema Investitionsleakage.

Um sich der Frage der Investitionsleakage empirisch zu nähern, gibt der Bericht zunächst anhand **statistischer Auswertungen** einen Überblick über die Trends und Größenordnungen bei deutschen Auslandsinvestitionen für die relevanten Sektoren. Hierzu werden Daten zum Investitionsverhalten für ausgesuchte Branchen (bspw. Eisen/Stahl, Chemie, Nichteisenmetalle, mineralverarbeitende Industrie, Papier- und Zellstoffindustrie sowie Raffinerien) dargestellt. Wesentliche Datenquelle hierfür ist die Bestandserhebung über Direktinvestitionen, die die Deutsche Bundesbank jährlich veröffentlicht. Diese Auswertung stellt jedoch keine Analyse möglichen Investitionsleakage dar, da die Gesamtheit der emissionshandelspflichtigen Unternehmen sich in den Investitionsstatistiken nicht sauber abgrenzen lässt, und da das Investitionsleakage durch den EU ETS sich allein anhand der Branchenstatistiken nicht von anderen Einflussfaktoren trennen ließe.[2]

[2] Anders sieht es aus, wenn statt der Investitionsstatistiken auf Branchenebene die Investitionsdaten auf Ebene der Unternehmen herangezogen werden; dies ist jedoch ungleich aufwändiger und war daher im Rahmen dieses Projektes nicht zu leisten. Diesem Ansatz folgen bspw. Koch (2016) für Deutschland und Borghesi et al. (2016) für Italien, siehe 2.3.2).

Im Durchschnitt zeigen die Zeitreihen der Bundesbankdaten einen Anstieg der Auslandsinvestitionen seit 2003, sowohl in der Gesamtwirtschaft als auch in den emissionsintensiven Branchen chemische Industrie sowie Metallerzeugung und –bearbeitung, in denen gerade die Jahre 2005 – 2008 von einer Hochkonjunktur geprägt waren. Dabei wachsen die Investitionen in Ländern außerhalb der EU stärker als solche innerhalb der EU. Zwar war der Anteil von nicht-EU-Investitionen bis 2009 leicht rückläufig, dies hat sich in der Folge aber umgekehrt. Die Trends in den emissionsintensiveren Sektoren Metall und Chemie spiegeln in dieser Zeitspanne den Trend der Gesamtwirtschaft wieder. Bei den Inlandsinvestitionen ausländischer Unternehmen (EU und nicht-EU) hingegen ist dies nicht der Fall: Während die Investitionen aus dem Ausland seit 2003 angestiegen sind, nahm das Volumen ausländischer Investitionen bei Metall und Chemie ab. Sowohl in der Gesamtwirtschaft als auch in den einschlägigen Wirtschaftszweigen nahm die *Anzahl* der investierenden Unternehmen mit ausländischer Beteiligung zu.

Weitere Einblicke liefern **Befragungen** über das Investitionsverhalten emissionshandelspflichtiger Unternehmen, und die Rolle des CO_2-Preises in der Investitionsentscheidungen. Hierzu gibt der Bericht einen Überblick über die Ergebnisse von drei Befragungen: die des Deutsche Industrie- und Handelskammertags (DIHK), von Thomson Reuters und von Business Europe.

- Seit 2004 befragt der **Deutsche Industrie- und Handelskammertag** (DIHK) jährlich seine über sechstausend Mitglieder über ihre Auslandsinvestitionspläne; diese geben einen allgemeinen Überblick über Investitionstrends in der Branche. Allgemein haben weniger als die Hälfte der befragten Firmen überhaupt Auslandsinvestitionspläne – während Firmen in der Metallerzeugung und -bearbeitung diesen Durchschnitt widerspiegeln, sind deutsche Chemieunternehmen überdurchschnittlich auslandsinvestitionsfreudig. Bei der Frage zum Motiv der Auslandsinvestition hingegen geben insbesonder Firmen im Metallsektor überdurchschnittlich häufig die hohen Kosten in Deutschland als Grund an, weshalb sie in anderen Regionen investieren. Interessanterweise hat die Bedeutung Kostenerparnis als Motiv für Investitionen seit 2004 deutlich abgenommen – dies gilt sowohl allgemein, aber auch für die chemische und die Metallindustrie. Der Tiefpunkt lag für alle Branchen im Jahr 2013; in diesem Jahr gab nur jedes fünfte Unternehmen an, dass die Investition primär der Kostenersparnis dienen sollte; für Chemie und Metall lagen die Anteile sogar noch darunter.

- Die jährliche Umfrage von **ThomsonReuters** liefert weitere Daten zur Investitionstätigkeit und den zugrundeliegenden Motiven. Der jüngste Bericht „Carbon 2016“ enthält gezielte Fragen zu getätigten Investitionen und zu Anhaltspunkten für Carbon Leakage. Auffallend ist, dass branchenübergreifend die Mehrzahl der Unternehmen eine Verlagerung der Produktion noch nicht einmal als Option betrachtet. Der Anteil der Unternehmen, die bekennen, Produktionsanteile verlagert zu haben, liegt fast durchgängig bei weniger als 10% der befragten Unternehmen. Am ehesten sind solche Tendenzen noch in der Stahl- und der Zementindustrie auszumachen. Eine weitere Frage, die allerdings nur in der jüngsten Umfrage (2016) gestellt wurde, bezieht sich auf die CO_2-Kosten und deren Einfluss auf Ertragsfähigkeit. Dabei wurde gefragt, ab welchem CO_2-Preis die Produktion in der EU für die jeweilige Firma nicht mehr gewinnbringend ist. Von den 62 diesbezüglich befragten Firmen (alle Emittenten mit Teilnahmepflicht am EU ETS) konnten oder wollten mehr als die Hälfte diese Frage nicht beantworten. 17% der Antworten nannten einen relativ niedrigen (€10) Preis, wohingegen im Schnitt (Median) etwa 20 bis 25 Euro angegeben wurden.

- Die europäische Dachverband nationaler Unternehmensverbände (**Business Europe**) fragte 2016 seine Mitgliedsunternehmen zum Einfluss des CO_2-Preises auf ihr Investitionsverhalten. Im Unterschied zu ThomsonReuters fällt jedoch auf, dass in der Business Europe mehr als doppelt so viele Unternehmen angaben, dass der CO_2-Preis keine Rolle für ihre Investitionsentscheidungen spiele (16% gegenüber 6,7% bei ThomsonReuters). Dies ist aber auch dadurch zu erklären, dass Business Europe sich an alle Unternehmen richtete, die durch die Organisation vertreten werden – und nicht nur an Betreiber emissionshandelspflichtiger Anlagen. Eine genauere Untergliederung nach Wirtschaftszweigen zeigt, dass insbesondere solche auf der Carbon-Leakage-Liste der EU dem CO_2-Preis eine höhere Bedeutung zumessen – insbesondere bei Papierproduzenten ist dies der Fall. Eine Mehrheit der Unternehmen der Papier-, Zement- und der Stahlindustrie betrachtet diesen Faktor als ebenso wichtig wie oder wichtiger als andere Investitionsfaktoren. In der chemischen und der Glasindustrie gab es keine Unternehmen, die dem CO_2-Preis einen besonders großen Einfluss auf Investitionsentscheidungen zuschreiben, der über andere Faktoren hinausgehen würde. Ferner enthielt die Business Europe-Umfrage auch Fragen zu den Zukunftserwartungen der Unternehmen in Bezug auf Investitionsleakage. Die große Mehrheit der Befragten erwartet einen Anstieg der direkten und indirekten CO_2-Preise, und eine Mehrheit erwartet sich davon einen negativen Einfluss auf die Investitionen innerhalb der EU. Allerdings fanden sich in verschiedenen Branchen auch Unternehmen, die erwarten, dass ein höherer CO_2-Preis sich positiv auf Investitionen innerhalb der EU auswirken könnte.

Neben den Umfrageergebnissen gibt der Bericht auch einen Überblick über die – noch überschaubare – **empirische Literatur zu Investitionsleakage**, und zum Einfluss des EU-Emissionshandels auf das Investitionsverhalten insgesamt. Die vorhandenen Quellen kommen aber mehrheitlich zu einem Ergebnis, das auch den Befund der allgemeineren Leakage-Literatur widerspiegelt: demnach hat der EU-Emissionshandel nur eine geringe Wirkung auf das Investitionsverhalten von Unternehmen; sowohl, was Leakage-Investitionen angeht (Aufbau / Erweiterung von Kapazitäten an außereuropäischen Standorten), als auch was Investitionen in Energieeffizienz und Emissionsminderung betrifft. Tatsächlich wird der Effekt des EU-Emissionshandels auf Investitionsentscheidungen in der Regel von anderen Faktoren überlagert; viel bedeutsamer sind etwa Energie- und Rohstoffpreise, vor allem aber Zugang zu Märkten und Rohstoffen. Dementsprechend findet sich auch kein eindeutiger Beleg für Fälle, in denen tatsächlich Investitionsleakage stattgefunden hätte. Deutliche Anzeichen für Investitionsleakage lassen sich demnach nur in modellbasierten Simulationen finden – und hier vor allem in solchen Simulationen, die nicht vom gegenwärtigen CO_2-Preis ausgehen, sondern von dem Preisniveau, das für eine Dekarbonisierung der Europäischen Wirtschaft nötig wäre.

Ergänzend zu der Auswertung statistischer Daten, zu Umfrageergebnissen und der Literaturanalyse betrachtete ein zweiter Teil der Analyse ausgewählte Fallbeispiele großer Investitionsprojekte in den Leakage-gefährdeten Branchen innerhalb und außerhalb der EU. Ziel der Fallstudien war es, herauszufinden, welche Rolle der CO_2-Preis für die Investitionsentscheidung gehabt hat – und ob sich daraus Anhaltspunkte für etwaiges Investitionsleakage finden lassen.

Bei einzelnen Investitionsprojekten anzusetzen ist insofern interessant, als dass Investitionsentscheidungen Einzelfallentscheidungen sind, in die eine Reihe von Erwägungen einfließen, darunter auch der gegenwärtige und der erwartete Kohlenstoffpreis. Welche Erwägungen dies im Einzelnen sind, und welches Gewicht sie jeweils für die Entscheidung hatten, ist jedoch nicht ohne Weiteres ersichtlich. Eine Fallstudie kann diese Erwägungen durch

die Analyse geeigneter Quellen erforschen – in diesem Fall durch die Auswertung anhand von Veröffentlichungen der Unternehmen (wie etwa Geschäftsberichte, Nachhaltigkeits- oder Umweltberichte, Pressemitteilungen), durch Branchendienste, sowie durch Auskünfte von Unternehmensvertretern auf gezielte Anfragen. Es liegt in der Natur der Sache, dass Fallstudien nicht repräsentativ sind, sondern nur Einzelbeispiele liefern können. Gleichzeitig gilt es aber auch zu berücksichtigen, dass es in den betroffenen Branchen EU-weit nur eine überschaubare Anzahl von Investitionsprojekten gibt; komplett neue Anlagen wurden etwa in der Stahl- oder Aluminiumindustrie seit Jahren nicht in Betrieb genommen. Mit Investitionen in der betrachteten Größenordnung legen sich Unternehmen zudem auch auf den Standort fest.

Zur Auswahl möglicher Fallbeispiele diente zunächst eine Übersicht der Neuanlagen und signifikanten Kapazitätserweiterungein im European Transaction Log (EUTL) sowie eine Auswertung von Veröffentlichungen einschlägiger Branchendienste für verschiedene leakage-gefährdete Sektoren. In einem ersten Schritt wurden in Deutschland in 16 Beispiele aus der chemischen Industrie, der Stahlindustrie und der Aluminiumindustrie identifiziert. Ergänzt wurde die Auswahl um 32 Neuanlagen und große Kapazitätserweiterungen in Europa in den genannten Branchen. Hinzu kamen fünf ausgewählte Investitionsprojekte außerhalb der EU von Unternehmen, die in Europa aktiv sind: diese reichten von 60 Millionen bis 5.2 Milliarden Euro in den Branchen Stahl, Chemie, Aluminium in Katar, Brasilien und den USA.

Für eine eingehende Analyse wurden schließlich fünf große Investitionsprojekte in der Stahl-industrie ausgewählt – eines in Deutschland, drei im EU-Ausland und eines außerhalb der EU:

- **Tata Steel** Stahlwerk **Port Talbot**, Rotherham, Großbritannien, 2013: Neuzustellung des Hochofens mit Abwärmenutzungsanlage im Wert von **290 Millionen Euro**;
- **ArcelorMittal** Stahlwerk in **Galati**, Rumänien, 2015: Modernisierung des Hochofen 5 im Wert von **90 Millionen Euro**;
- **Outokumpu Stainless Oy** in **Tornion**, Finnland, 2012: Inbetriebnahme eines neuen Ofens Ende 2012 zur Verdopplung der Produktion, Wert von **410 Millionen Euro**;
- **ThyssenKrupp, Duisburg-Schwelgern**, Deutschland, 2014: Neuzustellung des größten Hochofens Europas im Wert von **200 Millionen Euro**;
- **ThyssenKrupp, Rio de Janeiro**, Brasilien, 2008-2012: Neubau eines Stahlwerks, Produziert fünf Millionen Tonnen Rohstahl/Jahr seit 2010, im Wert von **5.2 Milliarden Euro**.

Für diese Fallstudien wurde insbesondere untersucht, welche Informationen sich zu den Beweggründen für die Investition und zur Standortwahl finden ließen, seien es Verlautbarungen in öffentlichen Quellen oder Aussagen von Unternehmensvertretern, ob es irgendwelche Anhaltspunkte dafür gibt, dass Umwelt-, Energie- oder Klimaauflagen oder damit verbundene Kosten eine Rolle im Entscheidungsprozess gespielt haben, und wie energie- und CO_2-effizient die fraglichen Anlagen nach der Investition waren, auch im internationalen Vergleich. Ebenfalls von Interesse war die globale Investitionstätigkeit der Unternehmen im fraglichen Zeitraum: bei den Unternehmen handelt es sich um multinationale Firmen, die neben EU-Standorten auch an außereuropäischen Standorten produzieren – daher stellt sich die Frage, ob die Unternehmen in der fraglichen Zeit auch außerhalb der EU investiert haben, und ob die Investitionen in der EU in direkter Konkurrenz zu außereuropäischen Standorten standen.

Die Investitionen am **Tata-Stahlwerk in Port Talbot** dienten primär der Produktionssteigerung, in zweiter Linie war auch eine verbesserte Energieeffizienz Ziel der

Investition. Tatsächlich wurde durch die Modernisierung der Anlagen auch eine Energieeinsparung erreicht. Die Investitionen selbst sind state of the art – allerdings auch nicht besser als Neuinvestitionen Tatas an Standorten außerhalb der EU, die ähnliche Effizienzwerte aufweisen. Zur etwaigen Rolle des CO_2-Preises fanden sich leider keine direkten Angaben – allerdings Anhaltspunkte. So hatten Unternehmenssprecher bei früheren Investitionen am gleichen Standort bekundet, dass der CO_2-Preis keine Rolle für die Investitionsentscheidung habe. In der jüngeren Vergangenheit war das Werk erneut Gegenstand von Diskussionen, da zwischenzeitig ein Verkauf des Werks geprüft wurde, da es nicht mehr wirtschaftlich zu betreiben sei; dies wurde unter anderem auch begründet mit höheren Kosten für den Klimaschutz (durch den carbon floor price, den Großbritannien in Ergänzung des EU-Emissionshandels eingeführt hat). Im Zuge dieser Diskussion wurde darauf verwiesen, dass klimaspezifische Kosten nur 2% der Betriebskosten ausmachen; die wirtschaftlichen Probleme des Standorts begründen sich vielmehr mit strukturellen Faktoren (insbesondere der weltweiten Überkapazität bei der Stahlherstellung).

Im Fall des **ArcelorMittal-Stahlwerks im rumänischen Galati** dienten die Investitionen der Erhaltung der Anlage, und im Zuge dessen auch ihrer Modernisierung und Kostensenkung. Maßnahmen zur Energieeinsparung machten dabei einen kleinen Teil des Investitionspakets aus (7 bzw. 8,25 von insgesamt knapp 100 Millionen Euro). Die zusätzlichen Investitionen an Hochofen Nr. 5 (glockenloses Ladungssystem und Profilmessgerät 2013, Blasturbinenmodernisierung 2015) verbesserten die Energieeffizienz der Anlage, und trugen so zur Minderung der CO_2-Emissionsintensität bei: Das glockenlose Ladungssystem ermöglicht eine homogenere Verteilung des Rohmaterials innerhalb des Hochofens. Dies verringert den Brennstoffverbrauch bei erhöhter Produktivität und verlängert die Lebensdauer. Das Profilmessgerät erhöht die Effizienz durch geringere Wärmeschwankungen, sodass der Hochofen mit einer niedrigeren Koksrate und optimaleren Gasverteilung betrieben werden kann. Schließlich konnte durch die Modernisierung von zwei Blasturbinen und deren Kompressoren der Dampfverbrauch des Hochofens halbiert werden. Laut Nachhaltigkeitsbericht 2014 sanken die absoluten CO_2-Emissionen der Gesamtanlage zwischen 2013 und 2014 um 15%, und lagen 2015 bei 4,3 Millionen Tonnen CO_2. Die derzeitige CO_2-Intensität am Standort Galati (knapp unter 2 Tonnen CO_2 pro Tonne erzeugten Stahls) ist etwas besser als das Durchschnittsniveau für ArcelorMittal weltweit (2,14 Tonnen CO_2 pro Tonne Stahl), aber liegt gleichzeitig über dem Durchschnittswert für alle Stahlproduktionsanlagen weltweit (1,8 Tonnen CO_2 pro Tonne Stahl). Als vorrangiges Ziel gab ArcelorMittal an, den Abstand der variablen Kosten zwischen Galati und ArcelorMittals besten Anlagen in Westeuropa zu verringern – und so Galatis Wettbewerbsfähigkeit zu stärken. Es fanden sich keine Hinweise darauf, dass CO_2-Kosten eine Rolle für die Investitionsentscheidung gespielt hätten.

Mit der Investition von 410 Millionen Euro im **finnischen Tornio** verdoppelte der Outukumpu-Konzern die Kapazitäten des Standorts für die Ferrochromproduktion (auf 530 000 Tonnen pro Jahr). Der neue Ferrochromofen ist besonders energieeffizient, da die Nähe zum Erzeugungsort die Nutzung von Ferrochromschmelze und (Nebenprodukt) Kohlenstoffmonoxid als Energierohstoffe ermöglicht. Pelletisierung und Vorzerkleinerung des Ausgangsmaterials reduzieren die Brennzeit im Ofen und dadurch den Stromverbrauch. Da das flüssige Chromeisenerz auf dem kurzen Weg von Erzeugung zu Verarbeitung nicht erhärtet, werden Abwärme- und Prozessgas optimal genutzt. Zudem kommt am Standort Tornio CO_2-freier Strom aus Atom- und Wasserkraft zum Einsatz. Eine Sprecherin von Outukumpu bestätigte, dass standortspezifische Vorteile – Nähe der Chromitmine zur Produktionsstätte – ausschlaggebend waren. Die Minimierung der Erztransportkosten sei der wichtigste Entscheidungsfaktor

gewesen, gefolgt von der am europäischen Standort bestehenden Expertise der Mitarbeiter. Der CO_2-Preis, bzw. die zukünftige Höhe der kostenlosen Zuteilung, wurde nicht genannt.

Bei der Investition des ThyssenKrupp-Konzerns im **integrierten Hüttenwerk Duisburg** handelte es sich um den Umbau eines ganzen Stahlkomplexes, samt Bau eines neuen Ofens (Hochofen 8 in Duisburg-Hamborn), planmäßige Neuzustellung des Hochofen 9, und Außerbetriebnahme des Hochofen 4. Das gesamte Investitionsvolumen betrug 340 Millionen Euro. Leider fanden sich keine Informationen zum spezifischen Effizienzgrad des neuen Hochofens. ThyssenKrupp gibt jedoch an, dass der Umbau des Gesamtkomplexes durch die Logistikoptimierung und Produktivitätsverbesserung zu Energieeinsparungen führte. Im damaligen Geschäftsbericht begründet ThyssenKrupp die Investition als logistische Notwendigkeit - die gesamte Umgestaltung des Komplexes diente hauptsächlich der „Rationalisierung des Produktionsflußes," indem es die Roheisenbasis in Duisburg für die weitere Stahlerzeugung und -weiterverarbeitung in den deutschen Werken stabilisierte. Pressemeldungen legen zumindest nahe, dass CO_2-Emissionen bei der Entscheidungsfindung keine herausgehobene Rolle spielten: Bei der Erläuterung der „Umweltmaßnahmen" des neuen Anlagekomplexes in Duisburg werden Maßnahmen zur Minderung von Staubausstoß und Lärm ausführlich erklärt und als besonders fortschrittlich geschildert. Treibhausgasemissionen dagegen werden nicht erwähnt. Auch in den Jahresberichten aus dieser Zeit wird der Emissionshandel und seine Kosten lediglich als Kostenfaktor für den Energiebezug thematisiert – nicht jedoch in direkter Verbindung mit dem konkreten Investitionsvorhaben.

Bei der CSA Siderúrgica do Atlântico Ltda in brasilianischen Bundesstaat **Rio de Janeiro** handelt es sich um ein komplett neues integriertes Stahlwerk mit einer Jahreskapazität von 5 Millionen Tonnen, das zwischen 2006-2010 auf der „grünen Wiese" gebaut wurde. Die Entscheidung zum Bau wurde 2005 finalisiert – ThyssenKrupp rechnete damals mit einer Investition von 3 Milliarden Euro. Die tatsächlichen Kosten für den Bau dagegen stiegen auf über 8 Milliarden Euro. Im Februar 2017 machte ThyssenKrupp bekannt, dass die Anlage an den argentinischen Stahlkonzern Ternium S.A. verkauft wird. Aus den ThyssenKrupp-Geschäftsberichten der Jahre unmittelbar vor dem Bau der neuen Anlage geht hervor, dass der Effizienzgrad des brasilianischen Standorts mindestens das Niveau vergleichbarer europäischer Anlagen erreichen sollte, und das die firmeneinheitlichen Umweltstandards auch für den Neubau in Brasilien gelten. Dies schlägt sich etwa nieder in dem eingesetzten Kraft-Wärme-Kopplungs-prozess, der wegen seines besonders hohen Wirkungsgrads gewählt wurde. Auch die Nutzung der Hochofengase ging bei dieser Anlage über konventionelle Effizienzmaßstäbe hinaus. Da die brasilianische Anlage nur anlageneigene Prozessgase verwendet, müssen weder externer Brennstoff zugekauft, noch überschüßige Prozessgase abgefackelt werden. Diese Konstellation war laut Firmenangaben zum Zeitpunkt des Baus die erste in Amerika, und ist immer noch die einzige in Brasilien. Was die Entscheidungsfindung angeht, so beruhte der Entschluss zum Bau eines Stahlwerks in Brasilien laut Firmenchronik auf den Annahmen einer weltweit steigenden Stahlnachfrage, explodierenden Rohstoffpreisen und einem zunehmend global agierendem Wettbewerb zwischen den Stahlproduzenten. Als regionaler Kostenvorteil werden nur Nähe zu den Erzvorkommen und Wachstumschancen in der NAFTA-Region explizit erwähnt. Umwelt- oder Energiespezifische Faktoren - wie z.B. etwaige günstigere Energiepreise oder niedrigere Umweltstandards - werden dagegen nicht erwähnt. Insbesondere werden CO_2-Emissionen oder die Regulierung selbiger nicht als Einflussfaktoren genannt.

In ihrer Kommunikation zu den Investitionsentscheidungen gehen die Unternehmen also allenfalls auf Energiepreise ein, bzw. auf Energieeffizienz als Kostenfaktor. Bei den fünf untersuchten Beispielen fand sich trotz intensiver Recherche jedoch keines, bei dem der CO_2-

Preis als ursächlich für die Investitionsentscheidung genannt worden wäre. Dabei gilt natürlich: the absence of evidence is not the evidence of absence – die Tatsache, dass sich kein Beleg finden ließ, kann nicht beweisen, dass der CO_2-Preis für die Entscheidung unerheblich war; dies ließ sich nur in einem Fall belegen anhand der expliziten Aussage, dass der CO_2-Preis keine Rolle für die Investitionsentscheidung gespielt habe. Dass der CO_2-Preis – im Gegensatz zu vielen anderen Erwägungen – aber nicht genannt wird, spricht zumindest dagegen, dass er eine herausgehobene Rolle gehabt hätte.

Ein weiteres, interessantes Ergebnis ist, dass die Investitionen grundsätzlich dem technischen state of the art entsprechen – dass dieser sich aber nicht zwischen Standorten innerhalb und außerhalb der EU unterscheidet, auch deshalb, weil die Unternehmen an diesen Standorten die gleichen Standards für Umweltwirkungen und Effizienz anlegen. Die tatsächliche Effizienz der Anlagen scheint demnach stärker von standortspezifischen Faktoren wie der Anlagenkonfiguration abzuhängen als vom regulatorischen Rahmen vor Ort.

1.1.3 The Innovation Fund: How can it support low-carbon industry in Europe?

Dieser Bericht analysiert eine Reihe von Optionen für die Gestaltung des EU-Innovationsfonds (IF), ein Finanzierungsinstrument, welches im Rahmen des EU-Emissionshandelssystems (ETS) geschaffen wurde, um den technologischen Durchbruch für CO_2-arme Innovationen im Energiesektor und in der Industrie zu unterstützen. Der Bericht kombiniert einen Blick auf die Erfahrungen aus dem IF-Vorgängermechanismus "NER 300" mit Einblicken aus den jeweiligen Optionen der Emissionsminderungstechnologie in drei Schlüsselindustriebranchen (Stahl, Zement, Zellstoff und Papier) auf der Grundlage einer Literaturrecherche und Interviews: Auf dieser Basis schließt das Papier mit Empfehlungen für das Design der IF ab.

Die Erfahrung mit NER 300: Lehren aus der Risikominderung und dem politischen Kommitment

Das Fehlen eines Business Case ist ein grundlegendes Hindernis für Investitionen in ungeprüfte Technologien. Das Ausgeben von Geldern für solche Projekte birgt Risiken ohne erkennbare Belohnungen und kann es schwierig machen, Finanzierungen anzuziehen, weshalb Unternehmen möglicherweise Recht haben, nach öffentlicher Unterstützung für solche Initiativen zu suchen. Das Design des NER 300 (das sich nur an den Energiesektor richtete: CO_2-Abscheidung und -Speicherung (Carbon Capture and Storage - CCS) und innovative Technologien für erneuerbare Energien) wies eine Reihe von Mängeln auf, auch in Bezug auf die Risikoteilung, wodurch Hochrisiko-Technologieprojekte (wie CCS) nicht realisiert wurden. Höhere Kofinanzierungssätze könnten eine Lösung für die Zukunft sein, ebenso wie eine nuanciertere Reihe von Bedingungen für Zahlungen. Ein weiterer Mangel besteht in Bezug auf die politische/öffentliche Unterstützung, deren Fehlen dazu führte, dass einzelne Projekte eingestellt wurden. Es ist offensichtlich, dass mehr Faktoren als nur der Zugang zu Finanzmitteln Hindernisse für Investitionen in kohlenstoffarme Innovationen schaffen.

Industrielle Akteure zeigen eine "Voreingenommenheit des etablierten Unternehmens", brauchen eine unternehmensfreundliche Dekarbonisierungsperspektive

Die Industrieperspektive auf die Chancen und Risiken der Dekarbonisierungsherausforderung ist eher defensiv (insbesondere für Stahl und Zement). Die Interviews und die Dokumente der Industrie-Roadmap zeigten eine Tendenz zu Pessimismus gegenüber neuen Technologien und verschiedenen Produkten, die das Potenzial haben, eine grundlegendere Veränderung der traditionellen Geschäftsmethoden herbeizuführen. Diese traditionelle Perspektive ist verständlich, schränkt aber auch die Möglichkeit ein, zu sehen, was für andere alternative

Zukunftsperspektiven möglich sind und was man als "Elon Musk-Ansatz" für die industrielle Fertigung bezeichnen könnte.

Die Dekarbonisierung der europäischen Wirtschaft und der Erhalt einer starken industriellen Basis in Europa kann jedoch grundlegendere Veränderungen in der Art und Weise erfordern, wie sich die Unternehmen organisieren, welche Produkte sie zur Befriedigung der Kundenbedürfnisse entwickeln sowie eine stärker serviceorientierte Perspektive (weg von einer vereinfachten Fokussierung auf die Verkaufszahlen der Produkte) - zusätzlich zu einer Reduzierung der direkten Emissionen aus der Fertigung. Allwood (2016) und Wyns and Axelson (2016) zeigen exemplarisch, wie solche neuen Visionen eines kohlenstoffarmen Geschäftsmodells aussehen könnten, z.B. für den britischen Stahlsektor, und die langfristigen Aussichten für den Zellstoff- und Papiersektor gehen in diese Richtung und gestalten sich in den Roadmaps von 2050 als "Holzfaserindustrie" (CEPI 2011) neu, die eine Bioökonomie anstreben könnte.

Der IF sollte sich darauf konzentrieren, bahnbrechende Technologien zu erleichtern und nicht bestehende Technologien einzuführen

Die Analyse der Technologieoptionen für die drei Sektoren und die Perspektiven der bestehenden Akteure zeigt, dass die derzeit verfügbaren Technologien in den Industriesektoren für die Emissionsminderung weitgehend auf den vorhandenen Technologiebestand und marginale Verbesserungen ausgerichtet sind und nicht neuere Ansätze und neue Geschäftsoptionen beinhalten. Der zusammenfassende Bericht über den Konsultationsprozess der Europäischen Kommission im Jahr 2017 mit den Interessengruppen der Industrie (Europäische Kommission 2017a) kommt jedoch zu dem Schluss, dass der IF nicht nur die Unterstützung von Projekten mit Technologien, die sich in der Pilotphase befinden (Technology Readiness Levels (TRLs) 6 bis 7), sondern auch von Projekten, die näher am kommerziellen Umfeld liegen (TRLs 8-9), umfassen sollte. Die Ausrichtung der politischen Unterstützung auf solche erprobteren Technologien könnte dazu führen, dass die sich als nicht ausreichend erweisen, um das Ausmaß der geforderten Emissionsreduzierungen zu erreichen. Oder, wenn ein solcher Ansatz das erforderliche Minderungspotenzial erreicht, läuft er Gefahr, dies nur in einer strukturell konservativen Form zu tun, die in einer kohlenstoffarmen Welt möglicherweise nicht kostenwettbewerbsfähig ist (weil es sich um marginale Verbesserungen an bestehenden Anlagen handelt). Es könnte auch eine Reihe neuer Risiken mit sich bringen (z.B. starke Abhängigkeit von der End-of-Pipe-Capture-Technologie). Der Fokus auf erprobte Technologien könnte dadurch das ursprünglich erklärte Ziel des IF gefährden - die Entwicklung bedeutsamer Technologien zu unterstützen, die für weitere erhebliche CO_2-Reduktionen erforderlich sind - ohne ein anderes Instrument, das diese wichtige Funktion erfüllen würde.

Wir sind der Ansicht, dass sowohl bahnbrechende Entwicklungen als auch die Unterstützung des Markteintritts erforderlich sind, dass aber die Hauptfunktion des IF darin bestehen muss, zu Durchbrüchen bei der Dekarbonisierung beizutragen und sich nicht auf marginale Gewinne oder bewährte Technologien zu konzentrieren. Es besteht jedoch das Potenzial, beides im Rahmen der IF zu tun, z.B. durch die Verwendung von Darlehen (anstelle von Zuschüssen) für reifere Technologieprojekte (was bedeuten würde, dass das Geld im Laufe der Zeit zurückgezahlt wird - und somit nicht von bahnbrechenden Finanzierungen abgelenkt wird). Bei der Finanzierung von marktnahen Technologien sollten qualitative und quantitative Beschränkungen angewandt werden, um sicherzustellen, dass der größte Mehrwert in Form von Emissionsminderungen erzielt wird.

‚Mind the policy gap' - zusätzliche Unterstützung ist erforderlich, um die Kluft zwischen dem IF und dem EHS zu schließen.

Die Debatte über den Schwerpunkt der IF-Finanzierung hebt hervor, dass zusätzliche Maßnahmen erforderlich sein können um einigen der Technologien zu helfen aus dem "Tal des Todes" der technologischen Innovation hervorzugehen und sie beim Übergang von der Vorführungsstufe bis zum Markteintritt zu unterstützen. Bestehende Politiken wie das EU-ETS sind am besten geeignet, den Technologieeinsatz zwischen Optionen mit niedrigem Kostenunterschied voranzutreiben, und spielen daher eine Rolle, die hauptsächlich weiter unten in der Technologieeinsatz-Kurve liegt. Im Kontext der Debatte über die Auswirkungen der Klimapolitik auf die Wettbewerbsposition der europäischen Industrie und möglichem Carbon Leakage muss der Fonds selbst in einer integrierten Perspektive für eine kohlenstoffarme Industriepolitik gesehen werden. Die bestehende Regulierungslandschaft muss wegen ihrer gelegentlichen Verzerrung zugunsten kohlenstoffintensiver etablierter Unternehmen und der Konzentration auf bestehende Produkte und Verfahren korrigiert und ergänzt werden, um ein Umfeld zu schaffen, das wirklich Anreize für Investitionen in innovative kohlenstoffarme Technologien sowohl in der Entwicklung als auch in der späteren Nutzung bietet. Ohne eine langfristige Perspektive, wie man einen Business Case für eine kohlenstoffarme industrielle Produktion erstellen kann, kann der IF an sich nicht erfolgreich sein.

Um einen solchen Wandel herbeizuführen, bedarf es sowohl eines Kommitments der politischen Entscheidungsträger als auch eines Perspektivwechsels über die Industriesektoren hinweg und einer engeren Branchenintegration, um zu neuen Geschäftsmöglichkeiten zu gelangen und den Innovatoren die Gewissheit zu geben, dass sie belohnt werden. Die anstehenden Entscheidungen über die Gestaltungsparameter des Innovationsfonds müssen in diesem allgemeinen Sinn gesehen und auf eine neue Perspektive ausgerichtet werden, eine die es ernst meint, eine Zukunft für die Industrie in einer kohlenstoffarmen Welt zu realisieren.

Spezifische Empfehlungen für die zukünftige Ausgestaltung des Innovationsfonds[3]

Auf der Grundlage der vorstehend zusammengefassten Überlegungen hat die Analyse mit den folgenden politischen Empfehlungen abgeschlossen, die sich auf die Finanzierungsbedingungen und die Projektzulässigkeit konzentrieren.

- Sicherung eines Mindestbetrages für die Finanzierung vom IF als Ganzes.
- Höhere Kofinanzierungssätze für Projekte mit hohem Risiko und für kleine Projekte anbieten
- Strenge leistungsbezogene Kriterien als Zahlungsbedingungen vermeiden; Meilensteine verwenden.
- Festlegung der maximalen Förderhöhe pro Projekt als Absolutbetrag fest.
- Fokussierung auf bahnbrechende Technologien für die Förderfähigkeit von Projekten und Finanzierung von Technologien, die bereits näher an der Markteinführung sind, durch Darlehen statt durch Zuschüsse (und mit einem begrenzten Anteil am Volumen des IF).

[3] Diese Empfehlungen sind im folgenden Kontext zu sehen: Die zugrunde liegende Forschung war in Bezug auf den Detaillierungsgrad, den sie berücksichtigen konnte, begrenzt (z.B. eine begrenzte Anzahl von Industriesektoren, eine begrenzte Anzahl von speziellen Experteninterviews), und in einigen Fällen sind die Schlussfolgerungen nicht eindeutig, wenn es z.B. um die statische oder dynamische Wahl der geeigneten Technologien geht.

- Zweckbestimmung von Mindestanteilen der Finanzierung pro Hauptkategorie (CCS, Industrie, erneuerbare Energien), aber Flexibilität bei Nichtgebrauch.
- Ehrgeizige Kriterien für die Auswahl der Projekte festlegen (spezifisch für jede Hauptkategorie), die unter anderem das Potenzial zur Emissionsreduzierung berücksichtigen. Diese könnten mit Kriterien kombiniert werden, die mögliche langfristige Geschäftsmöglichkeiten berücksichtigen, um die Wahrscheinlichkeit zu erhöhen, dass die Technologie nach dem erfolgreichen Demonstrationsprojekt tatsächlich kommerzialisiert wird.
- Aufbauen von Anreizen zur Unterstützung von Produktersetzungsinnovationen.

1.2 Arbeitspaket 2 – Carbon Leakage Risks in a World of Converging Carbon Prices

Die europäische Debatte über die Verlagerung von CO_2-Emissionen (carbon leakage) geht von der Annahme aus, dass die EU eine deutlich ehrgeizigere Klimapolitik verfolgt als ihre wichtigsten Handelspartner. Die dadurch entstehenden Kosten benachteiligten die EU-Industrie im globalen Wettbewerb, insbesondere die energie- und kohlenstoffintensiven Branchen. Diese Prämisse war vor einem Jahrzehnt sicherlich gerechtfertigt, kann aber inzwischen hinterfragt werden.

Zum Zeitpunkt seiner Einführung im Jahr 2005 war das Europäische Emissionshandelssystem (EU ETS) das einzige Instrument weltweit, das ausdrücklich zum Ziel hatte, CO_2-Emissionen aus Industrie und Stromerzeugung mit einem Preis zu versehen. Damals machten die vom EU-Emissionshandel abgedeckten Emissionen etwa 4 % der weltweiten Treibhausgasemissionen aus. Seitdem haben jedoch zahlreiche Länder, Bundesstaaten und Städte weltweit eine Vielzahl von Instrumenten eingeführt, um Kohlenstoffemissionen zu verteuern. Beispiele sind die nordamerikanischen ETS (die Regional Greenhouse Gas Initiative (RGGI) mit zehn nordöstlichen US-Bundesstaaten sowie Kalifornien und Quebec mit eigenen Programmen), das ETS in Neuseeland, der Schweiz, Kasachstan und Südkorea, zwei regionale Programme in Japan (Tokio, Saitama) und die chinesischen Pilot-ETS in sieben Städten und Provinzen. China führt im Moment ein nationales ETS ein; weitere ETS sind in Vorbereitung oder im Gesetzgebungsverfahren, etwa in Mexiko und Kolumbien. Darüber hinaus haben einige Länder und Provinzen eine Kohlenstoffsteuer eingeführt (z.B. Chile, Mexiko, British Columbia) oder sind dabei, dies zu tun (Südafrika). Schließlich haben eine Reihe von Ländern auf der ganzen Welt die verschiedenen Optionen für die Preisgestaltung von Emissionsrechten untersucht oder zumindest ihre Absicht bekundet, solche Instrumente in Zukunft zu nutzen (unter anderem Vietnam, Thailand, die Türkei und die Ukraine). Infolgedessen ist der weltweite Anteil der Emissionen, der von einer Art Kohlenstoffpreis abgedeckt wird, auf 12% gestiegen (Marcu et al., 2013). Dies deutet darauf hin, dass eine grundlegende Prämisse der europäischen Debatte über die Verlagerung von CO_2-Emissionen überprüft werden muss. Aus Wettbewerbssicht ist jedoch weniger relevant, welcher Anteil der globalen Emissionen durch einen Kohlenstoffpreis abgedeckt ist, sondern ob die direkten Wettbewerber europäischer Unternehmen mit einem Preis auf CO_2-Emissionen konfrontiert sind, der mit dem Preis des EU-ETS vergleichbar ist. Dieser Bericht geht dieser Frage nach.

Der Bericht gliedert sich anhand der folgenden Leitfragen: Kapitel 3 diskutiert, welche Länder außerhalb der EU für die Wettbewerbssituation europäischer Unternehmen relevant sind. Dies

geschieht anhand der sektoralen Handelsintensitäten der EU mit Nicht-EU-Ländern für acht Industriesektoren, die gemeinhin als Carbon Leakage-gefährdet angesehen werden. Kapitel 4 erörtert, welche Art von Kohlenstoffpreis oder welche anderen Regulierungen die Emittenten in den fraglichen Sektoren in diesen Ländern betreffen, und wie diese Belastung einzuschätzen ist im Vergleich zu der Belastung, die europäischen Unternehmen durch das EU ETS und andere EU-Klimaregelungen entsteht. Zu diesem Zweck analysiert das Kapitel geltende Regularien – Kohlenstoffpreise und andere klimapolitische Maßnahmen, aber auch Vorgaben zu Energieeffizienz und Luftverschmutzung. Kapitel 5 fasst die Ergebnisse der vorangegangenen Schritte zusammen, um zu beschreiben, wie sich die effektive CO_2-Belastung zwischen der EU und ihren wichtigsten Handelspartnern für die acht betroffenen Sektoren unterscheidet, und um so ein differenzierteres Bild der tatsächlichen Carbon Leakage-Risiken für die EU-Industrien zu vermitteln. Schließlich ergänzt Kapitel 6 die bisherige Analyse um eine vorausschauende und integrierte modellbasierte Bewertung von Carbon Leakage-Risiken. Anstatt die tatsächliche oder geplante Klimapolitik der Länder zu betrachten, geht diese Bewertung von den Klimazielen der jeweiligen Länder aus (wie diese sie in ihren NDCs festgelegt haben). Unter der Annahme, dass alle Länder die notwendigen Schritte unternehmen werden, um ihre NDCs zu erreichen, wird das PACE-Modell – ein multisektorales, multiregionales, berechenbares allgemeines Gleichgewichtsmodell (CGE-Modell) der globalen Produktion, des Verbrauchs, des Handels und der Energienutzung – verwendet, um die Carbon Leakage-Risiken in der Post-Paris-Welt zu bewerten.

Die EU ist eine liberale Marktwirtschaft, die eng mit dem Weltmarkt verflochten ist. Dies gilt auch für die acht Sektoren, die dieser Bericht vorrangig betrachtet. Um die EU und ihre Handelsbeziehungen zu beurteilen, sollte man sich zunächst vergegenwärtigen, dass der mit Abstand größte Handelspartner der EU-Staaten andere EU-Staaten sind – der Handel innerhalb der EU ist deutlich größer als der Handel mit dem EU-Ausland. Da der EU-Emissionshandel und die meisten anderen Klimaregelungen auf EU-Ebene eingeführt wurden und damit harmonisiert sind, kann angenommen werden, dass ein Risiko der Verlagerung von CO_2-Emissionen für diesen Teil des europäischen Handels kaum besteht. Raffinerien und chemischen Erzeugnissen (119 bzw. 101 Mrd. EUR) ist der größte Anteil am Handel mit dem EU-Ausland zuzurechnen; bei Zement und Kalk war das Handelsvolumen mit nur 1,6 Mrd. EUR deutlich geringer. Für jeden dieser Sektoren ist die EU insgesamt sowohl Importeur als auch Exporteur: Bei Nichteisenmetallen sind die Einfuhren höher als die Ausfuhren (65 % des Gesamthandels), während bei Keramik oder Zellstoff und Papier die Ausfuhren höher sind als die Einfuhren (63 % bzw. 64 %). Der Handel mit Zement und Kalk wird vom Export dominiert (85 % des Gesamthandels).

Gemessen am gesamten Handelsvolumen in den jeweiligen Branchen sind die Vereinigten Staaten weiterhin der wichtigste Handelspartner der EU, gefolgt von Russland und China. Für drei der acht betrachteten Branchen sind die Vereinigten Staaten der wichtigste Handelspartner und nehmen in den anderen fünf Industriezweigen den zweiten Platz ein. China ist der Haupthandelspartner in drei Industriezweigen; die anderen sind Algerien (für Zement und Kalk) und Russland (für Raffinerieprodukte).

Um auf die ursprüngliche Frage zurückzukommen – wie stark ist das Carbon Leakage-Risiko der EU-basierten Industrien tatsächlich, wenn man die Klimapolitik der wichtigsten Handelspartner berücksichtigt – ergibt sich folgendes Bild: In allen acht analysierten Sektoren ist die Klimapolitik der beiden wichtigsten Handelspartner schwächer als die der EU. Unter den dritt- oder viertgrößten Handelspartnern dagegen finden sich in den meisten Branchen Handelspartner mit einer der EU vergleichbaren oder sogar noch ambitionierterer Klimapolitik.

- Zwei wichtige Handelspartner der EU befinden sich in unmittelbarer Nachbarschaft: Norwegen und die Schweiz haben eine Klimapolitik, die weitgehend identisch mit der der EU ist. Norwegens Klimapolitik ist sogar etwas ehrgeiziger als die der EU, da das Land zusätzlich zu seiner Teilnahme am EU-ETS ergänzende Maßnahmen (einschließlich Energie- oder Kohlenstoffsteuern für die Industrie) verfolgt. Ein Carbon Leakage-Risiko zwischen der EU und diesen beiden Ländern gibt es somit nicht.

- Für die beiden anderen Haupthandelspartner der EU – die Vereinigten Staaten und China – ist das Bild differenzierter. Während alle Versuche der Vereinigten Staaten, auf Bundesebene einen Kohlenstoffpreis zu verankern, in der Vergangenheit gescheitert sind, gibt es durchaus wirksame Regulierung durch Standards zu Luftqualität und Energieeffizienz, sowie durch klimapolitische Instrumente auf Ebene der Bundesstaaten. Doch unter der Trump-Regierung bleibt ungewiss, wie stark die Industrie durch Klimapolitik belastet wird – abhängig davon, wie widerstandsfähig sich die bestehende Umweltgesetzgebung erweist. Die föderale Ebene ist jedoch nicht unbedingt die einzig maßgebliche: Auf regionaler Ebene setzt das kalifornische Emissionshandelssystem einen Kohlenstoffpreis für die große Mehrheit der Emissionen, darunter auch die Emissionen der energieintensiven Industrie. Das Preisniveau ist dabei vergleichbar mit dem im EU ETS. Zwar gilt dieses System nur in einem Staat (das andere Emissionshandelssystem, RGGI, erfasst keine Industrieemissionen), dafür macht Kalifornien allein aber schon etwa 4% des Handelsvolumens zwischen den Vereinigten Staaten und der EU aus. Ob andere Staaten dem Beispiel Kaliforniens folgen, bleibt abzuwarten – vorerst gibt es ermutigende Signale aus einer Reihe von Staaten; so erwägt der Staat Washington eine Kohlenstoffsteuer einzuführen, der Staat New Jersey beabsichtigt sich wieder der RGGI anzuschließen (nachdem er sich 2011 zurückgezogen hatte), und Oregon diskutiert die Einführung eines Emissionshandelssystems (Temple, 2017).

- In China ist dagegen der derzeit implementierte regulatorische Rahmen für CO_2-Emissionen noch viel schwächer. Seit einigen Jahren jedoch gibt die chinesische Führung klare, starke und wiederholte Signale, dass Emissionen stärker beschränkt werden sollen – nicht nur durch das neue nationale Emissionshandelssystem, sondern auch durch andere Umweltgesetze, einschließlich solcher zur Luftqualität. Das chinesische nationale Emissionshandelssystem wurde offiziell Ende 2017 eingeführt, wird jedoch zunächst nur den Energiesektor abdecken, und es bleibt derzeit unklar, wie verbindlich es sein wird. Die Einbeziehung der Industrieemissionen ist für die kommenden Jahre vorgesehen; es ist daher zu erwarten, dass ein wachsender Anteil der chinesischen Stromproduktion und Industrie in den kommenden Jahren mit immer strengeren CO_2-Beschränkungen konfrontiert sein wird.

- Bei den übrigen Haupthandelspartnern der EU gibt es große Unterschiede. Südkorea verfolgt eine ehrgeizige Strategie, die einen CO_2-Preis mit Politikmaßnahmen zur Verbesserung von Luftqualität und Energieeffizienz verbindet, und die hinsichtlich des Ambitionsniveaus und der Regulierungsintensität mit der der EU vergleichbar ist. Sowohl Russland als auch die Türkei zeigen auf dem Papier ein gewisses Ambitionsniveau, kämpfen aber auch mit Defiziten bei der Umsetzung und dem Vollzug. In beiden Ländern liegt der Schwerpunkt derzeit auf der Messung von Emissionen und der Datenerhebung als Grundlage für eine zukünftige Klimapolitik. Doch die Auswahl konkreter politischer Instrumente und ihre Ausgestaltung bleibt ungewiss; ohne einen starken politischen Impuls ist nicht zu erwarten, dass diese Länder sich in absehbarer Zeit spürbare Beschränkungen ihrer CO_2-Emissionen auferlegen werden. Algerien schließlich ist in der Situation, dass es zwar ein NDC hat, aber das wenige, was es an Instrumenten zur Emissionsminderung gibt, sich nur auf den Ausbau erneuerbarer Energien beschränkt. Maßnahmen, die die CO_2-Emissionen spürbar

beschränken würden, sind in absehbarer Zeit nicht zu erwarten. Für Russland, die Türkei und Algerien ist daher die Annahme gerechtfertigt, dass ein Carbon Leakage-Risiko besteht. Inwieweit dieses Risiko auch eintritt, ist jedoch eine andere Frage und wird auch von zahlreichen anderen Faktoren beeinflusst: so ist der europäische Handel mit Russland in den letzten Jahren in Folge der EU-Sanktionen erheblich zurückgegangen, auch die Investitionen aus der EU in der Türkei oder in Russland stagnierten oder gingen zurück.

Diese Beobachtungen könnten und sollten Auswirkungen auf die europäische Diskussion zu Carbon Leakage haben, sowie über die Gegenmaßnahmen im EU ETS. Zunächst einmal ist es sinnvoll, in der Bewertung des Carbon Leakage-Risikos bei der Handelsintensitätskomponente diejenigen Länder außer Acht zu lassen, die vergleichbar ambitionierte Klimapolitik haben. Für andere sollte die Analyse die unterschiedlichen Ambitionsniveaus in der Klimapolitik berücksichtigen. Insbesondere wäre in Zukunft eine gemeinsame Metrik für nicht-preisbasierte Politiken wünschenswert.

Die Analyse auf Länderebene wurde in einem weiteren Schritt ergänzt durch eine modellbasierte Bewertung des aktuellen und zukünftigen Carbon Leakage-Risikos anhand der Klimaziele, die die Länder sich in ihren NDCs gesteckt haben. Die wichtigsten Ergebnisse dieser Analyse sind im Folgenden zusammengefasst:

- Die EU profitiert eindeutig von multilateralen Maßnahmen in der Klimapolitik. Dies gilt sowohl für makroökonomische Auswirkungen, wie das BIP, als auch für sektorale Auswirkungen auf die Produktion.
- Die Klimapolitik der wichtigsten Handelspartner ist unterschiedlich ambitioniert. Einige Länder, vor allem solche, die sich ein Reduktionsziel in Bezug auf die Kohlenstoffintensität gesetzt haben (wie China) und einige, deren NDC-Ziele nach unseren Modellprognosen tatsächlich nicht bindende sind (wie Brasilien oder die Türkei), können mit deutlichen BIP-Zuwächsen rechnen. Ressourcenreiche Länder wie Russland oder Norwegen werden dagegen Einbußen beim Bruttoinlandsprodukt hinnehmen müssen. Allerdings sind diese Verluste bis 2030 recht moderat (unter 2 % im schwersten Fall).
- Auf dieser Grundlage können einige EU-Handelspartner bis 2030 in makroökonomischer und sektoraler Hinsicht auf Kosten anderer profitieren. In dieser Modellanalyse können solche Effekte für China beobachtet werden (wo sowohl das BIP als auch die sektorale Produktion steigen), während die Vereinigten Staaten gegenüber dem Szenario ohne Klimapolitik verlieren, sowohl was BIP als auch was sektorale Produktion anbelangt. Dieser Effekt ist auf die oben beschriebenen unterschiedlichen Zielsetzungen zurückzuführen, wird aber verstärkt durch die unterschiedlichen Handelsstrukturen in beiden Ländern.
- Die kostenlose Zuteilung einiger Zertifikate – in dem Modell als Subvention für die Produktion dargestellt – kann für die jeweiligen Branchen von Vorteil sein. Dies ist in den energieintensiven Branchen einiger Handelspartner der EU, beispielsweise in den Vereinigten Staaten, zu beobachten. Wenn die EU diesen Branchen kostenlose Zuteilung gewährt, werden sie wettbewerbsfähiger und profitieren dadurch, während die Branchen in den Handelspartnerländern im Vergleich zu der Situation, in der nur sie eine kostenlose Zuteilung erhalten, verlieren (wenn auch in sehr geringem Maße). Andererseits kann die kostenlose Zuteilung auch negative Auswirkungen haben, wenn nur die Handelspartner der EU ihren inländischen Erzeugern eine kostenlose Zuteilung gewähren. Da die in der EU ansässigen Hersteller ihre Produktion verringern, fragen sie weniger Zwischenprodukte aus dem Ausland nach. Wenn die jeweiligen Branchen eng mit den entsprechenden EU-Branchen

verflochten sind, kann es sogar zu Produktionsverlusten kommen. Dies ist in einigen chinesischen Branchen der Fall. Diese Beobachtungen gelten jedoch nur für die Analyse vor 2050. Bis zu diesem Jahr sinkt entsprechend den Szenarioannahmen die kostenlose Zuteilung und 2050 findet keine mehr statt.

Die Auswirkungen der Klimapolitik auf die Wettbewerbsfähigkeit der EU-Industrie hängen daher eindeutig davon ab, welche Klimaschutzmaßnahmen andere Länder ergreifen. Auch wenn ihre Klimaschutzmaßnahmen den Ambitionen ihrer NDCs entsprechen, sind die Auswirkungen auch auf die Volkswirtschaften der EU sehr unterschiedlich. Maßnahmen wie die kostenlose Zuteilung können einige der negativen wirtschaftlichen Auswirkungen mildern. Bei der Interpretation der Ergebnisse ist es jedoch wichtig, die Grenzen des PACE-Modells zu beachten, das beispielsweise weder den endogenen technologischen Wandel abdeckt noch CCS als Option beinhaltet. Beides würde sicherlich einige negative Effekte dämpfen. Schließlich enthält das PACE-Modell, wie die meisten CGE-Modelle, keine Gewinne aus dem vermiedenen Klimawandel.

1.3 Arbeitspaket 3 – Indirektes Carbon Leakage

Neben den unten aufgeführten Arbeiten wurden im Rahmen dieses Arbeitspaketes weitere Beratungsleistungen erbracht, die nicht Eingang in diesen Bericht gefunden haben. Dabei wurde auch die Bedeutung einer Stromerzeugungstechnologie als preissetzende Technologie untersucht. Die Ergebnisse dieser Analyse wurden in einer Fachzeitschrift veröffentlicht, siehe Germeshausen, R.; Wölfing, N. (2020): How marginal is lignite? Two simple approaches to determine price-setting technologies in power markets, In: Energy Policy, 2020, 124, 111482. (https://doi.org/10.1016/j.enpol.2020.111482)

1.3.1 National compensation schemes for indirect CO_2 Costs within the EU Emissions Trading Scheme

Dieser Bericht behandelt die Kompensationsmechanismen verschiedener EU Mitgliedsstaaten für indirekte Kostenbelastungen im Rahmen des EU ETS. So genannte indirekte CO_2 Kosten (oder indirekte EU ETS Kosten) entstehen den Stromverbrauchern, wenn Kosten für Emissionszertifikate aufseiten der Stromerzeugung im Strompreis eingepreist werden. Stromintensive Produktionen wären hiervon besonders betroffen. Aufgrund der Verschiedenartigkeit der Stromerzeugung in verschiedenen Ländern und weiterhin nicht perfekt integrierter Strommärkte unterscheiden sich diese Kosten nicht nur nach Sektor (in Abhängigkeit von der Stromintensität), sondern auch zwischen EU Mitgliedsstaaten. Die EU ETS Direktive (2003/87/EC) und deren Revision von 2009 (2009/29/EC) erlaubte den nationalen Regierungen ab 2013 die Gewährung direkter Beihilfen, um stromintensive Industrien für indirekte Kosten durch den Emissionshandel zu kompensieren. Die Europäische Kommission gab hierzu Richtlinien vor (European Commission, 2012a; EU Guidelines), welche den allgemeinen Rahmen und maximale Höhen für derartige Beihilfen vorgibt. Die Umsetzung in nationales Recht ist hingegen freiwillig und kann in der Ausgestaltung innerhalb des allgemeinen Rahmens variieren. Nationale Kompensationsmechanismen wurden bisher in acht Mitgliedsstaaten und Norwegen beschlossen, nämlich Flandern in Belgien, Deutschland, Finnland, Frankreich, Griechenland, Niederlande, Spanien und im Vereinigten Königreich. Darüber hinaus planen Litauen und die Slowakei eine Einführung von Kompensationsmechanismen. Dieser Bericht untersucht die Unterschiede in den implementierten nationalen Kompensationsmechanismen und diskutiert diese vor dem Hintergrund eines bisher nicht vollständig integrierten Elektrizitätsmarkts.

Die EU Richtlinien für indirekte CO_2-Kostenkompensation geben in erster Linie eine Obergrenze für Beihilfen vor

Die EU Richtlinien stellen den allgemeinen Rahmen für Beihilfen zur Kostenkompensation auf, bestimmen eine Liste mit Sektoren, welche ausschließlich in den Genuss von Beihilfen kommen dürfen, sowie eine Begrenzung von Beihilfen je Anlage. De facto wird damit eine Obergrenze für die Kostenkompensation aufgestellt. Nationale Regierungen können in ihren Beihilfen innerhalb dieses Rahmens unterhalb der maximalen Förderung bleiben, beispielsweise durch den weiteren Ausschluss bestimmter Sektoren, weiteren Einschränkungen in der Höhe der Beihilfen oder Untergrenzen beim Stromverbrauch, für den Beihilfen überhaupt gezahlt werden. Darüber hinaus entscheiden die nationalen Regierungen über das Budget und die Dauer, für welche die Beihilfen gewährt werden, wie diese beantragt werden und welche Institution darüber entscheidet. Die wichtigsten Anpassungen, welche auf nationaler Ebene stattfinden können, sind: der Ausschluss weiterer Sektoren, die Reduktion der Beihilfeintensität, die Anpassung (Reduktion) des anwendbaren Emissionsfaktors, das verfügbare Budget sowie weitere Bedingungen wie beispielsweise zusätzliche Energieeffizienzmaßnahmen. Es zeigt sich jedoch, dass die bereits implementierten Beihilfesysteme den Rahmen aus der EU-Richtlinie weitgehend ausschöpfen, insbesondere im Hinblick auf die Sektoren, die Beihilfeintensität sowie die Emissionsfaktoren.

Unterschiede in bestehenden nationalen Kompensationsmechanismen: Budget, Emissionsfaktor und Höhe des Selbstbehalts

Die von der EU Kommission herausgegebenen allgemeinen Leitlinien für die Kostenkompensation werden von den nationalen Regelungen in Bezug auf die maximale Beihilfeintensität (mit der Ausnahme von Finnland) und die maximale Anzahl von Sektoren weitgehend ausgeschöpft. Die nationalen Regelungen unterscheiden sich hingegen in erster Linie entlang von drei Dimensionen: hinsichtlich der Höhe des Budgets für die Kompensationszahlungen, der Höhe des Selbstbehalts und hinsichtlich des anwendbaren Emissionsfaktors. Während der maximal anwendbare Emissionsfaktor von der EU Kommission festgelegt wird (European Commission, 2012a), können die Länder über ihr Budget und die Höhe des Selbstbehalts selbst entscheiden. Die Höhe des Selbstbehalts ist in den nationalen Regelungen unterschiedlich geregelt. Da die Höhe des Selbstbehalts einen direkten Einfluss auf die Höhe der Kompensationszahlungen für das einzelne förderfähige Unternehmen innerhalb eines Landes hat, könnte dies potenziell dazu führen, dass (vergleichbare) Unternehmen in verschiedenen Ländern unterschiedliche Kompensationszahlungen erhalten. Die existierenden beobachteten Unterschiede in den Budgets, die von den einzelnen Mitgliedsländern für die Kompensation indirekter CO_2 Kosten veranschlagt werden, könnten zum Teil unterschiedliche industrielle Strukturen widerspiegeln. Ein Vergleich der Budgets im Verhältnis zum industriellen Stromverbrauch der jeweiligen Länder verdeutlicht jedoch, dass dies nicht der einzige Grund für die Unterschiede in den Budgets der einzelnen Länder ist. Budgetunterschiede wären für Ländervergleiche jedoch nur dann relevant, wenn die Gesamtmenge an beantragten Kompensationszahlungen das veranschlagte Budget übersteigt. In diesem Fall würden die individuellen Kompensationszahlungen proportional reduziert. Demnach würden dann Unternehmen in diesem Land eine geringere Kompensationszahlung erhalten als ein vergleichbares Unternehmen in einem anderen Land, in dem das Budget nicht vollständig ausgeschöpft ist. Dies würde zu einer Diskriminierung innerhalb der EU aufgrund des verfügbaren Budgets führen. Bisher scheint nur in Spanien das verfügbare Budget die Höhe der gewährten Kompensationszahlungen zu beschränken. Da Daten über die tatsächlichen Kompensationszahlungen nur für eine begrenzte Anzahl von Ländern und Jahren verfügbar sind, gilt dieses Ergebnis jedoch nur vorläufig und sollte mit Vorsicht behandelt werden.

Emissionsfaktoren in EU Richtlinien basieren auf regionalen mittleren Emissionsintensitäten von fossilen Kraftwerken

Die CO_2 Emissionsfaktoren in den nationalen Regelungen zur Kompensation indirekter CO_2 Kosten sind in Anlehnung an die in der EU Richtlinie festgelegten maximalen regionalen Emissionsfaktoren gewählt. In der EU Richtlinie wurden die nur unvollständig integrierten Elektrizitätsmärkte insofern berücksichtigt, dass die maximalen Emissionsfaktoren zwischen bestimmten regionalen Marktgebieten variieren. Diese Marktgebiete sollen die unvollständige Integration von Elektrizitätsmärkten innerhalb der EU widerspiegeln. Folglich dürften Unterschiede in den Emissionsintensitäten in den Marktgebieten wichtig für die Bewertung der Auswirkungen unterschiedlicher nationaler Regelungen sein. Neben den Emissionsintensitäten sollten jedoch auch Unterschiede in der tatsächlichen Kostenüberwälzung in den jeweiligen Ländern bzw. Marktgebieten berücksichtigt werden.

Emissionsintensität der preissetzenden Kraftwerke bestimmen die indirekten CO_2 Kosten

Die empirische Literatur legt nahe, dass die Strommärkte in Belgien, den Niederlande und Deutschland ähnliche Raten bei der Preisweitergabe von CO_2 Preisen aufweisen in einer Spannbreite von 0.5 bis 1 Euro pro Megawattstunde (MWh) je Euro pro Tonne CO_2. Das entspricht in etwa einer vollständigen Kostenweitergabe bei einem Mix von Gas und Kohle als preissetzende Technologien. Ein anzulegender Emissionsfaktor in diesem Rahmen erscheint vertretbar, was somit auch für den in der EU Richtlinie festgelegten Faktor für Zentral-Westeuropa in Höhe von 0.76 zutrifft. Zu beachten ist, dass die gefundene Spanne sehr weit ist. Mokinski und Wölfing (2014) finden beispielsweise für das deutsch-österreichische Marktgebiet einen durchschnittlichen Preiseffekt von 0.64 Euro pro MWh je Euro pro Tonne CO_2, also deutlich unterhalb des Emissionsfaktors aus der Richtlinie. Leider unterliegen derartige Punktschätzungen großer Unsicherheit und regionaler Variation, zumal auch die von der EU Kommission festgelegten Faktoren meist eine andere regionale Abdeckung aufweisen als die Marktgebiete, welche in der Literatur untersucht werden. Der deutlichste Unterschied zwischen einer in der Literatur empirisch geschätzten Preisweitergabe und dem in der Richtlinie festgelegten Faktor findet sich für Spanien und die iberische Halbinsel. Fabra und Reguant (2014) finden für den spanischen Markt eine durchschnittliche Preisweitergabe in Höhe von 0.70 bis 0.75 in Abhängigkeit von der Tageszeit, und somit mehr als die im Kompensationsmechanismus festgelegten 0.57 Tonnen CO_2 je MWh. Einschränkend muss darauf verwiesen werden dass der Emissionsfaktor aus der Richtlinie sich auch auf Portugal bezieht, die empirische Studie jedoch nur den nationalen Strommarkt in Spanien untersucht.

Unternehmensspezifische Faktoren erscheinen für indirekte CO_2 Kostenbelastung nur begrenzt relevant

Eine Variation von indirekten CO_2 Kosten auf Ebene einzelner Unternehmen innerhalb desselben Markt- und Staatsgebiets lässt sich nicht beobachten. Von den verschiedenen Gründen, die zu einer solchen Variation zwischen Unternehmen führen könnte, lässt sich nur ein Aspekt mit dauerhafter Relevanz festhalten: die Möglichkeit, dass verschiedene Firmen zu verschiedenen Tageszeiten unterschiedlich viel Strom verbrauchen und somit unterschiedlich stark den jeweiligen Stundenpreisen ausgesetzt sind. Wenn unterschiedliche Kraftwerke je Tageszeit preissetzend sind, können derartige Unterschiede in den Lastverläufen tatsächlich zu unterschiedlich hohen Belastungen mit indirekten CO_2 Kosten führen. Leider erscheint es nicht möglich die jeweilige Emissionsintensität entlang des Lastverlaufs mit ausreichend hoher Präzision zu erfassen, um eine solide Bestimmung solcher unternehmensspezifischer Unterschiede bei der indirekten CO_2 Kostenbelastung zu gewährleisten.

1.3.2 Compensation for indirect CO_2 Costs within the EU Emissions Trading Scheme after 2020

Mit der Vorbereitung der dritten Phase des EU Emissionshandels (2013-2020) wurde die Auktionierung zum Leitprinzip der Allokation von Zertifikaten. Gleichzeitig wurde anerkannt, dass das Abfließen von Emissionen in unregulierte Regionen oder Sektoren – sogenanntes „Carbon Leakage“ – durch Gegenmaßnahmen zu begrenzen sei. Hierfür wurden zwei zentrale Instrumente entwickelt, um schädliche Effekte sowohl durch direktes als auch indirektes Carbon Leakage zu reduzieren. Um indirektes Carbon Leakage zu verringern, das durch zusätzlichen Kosten im Rahmen des EU-ETS entsteht, die durch die in der Stromerzeugung anfallenden THG-Kosten auf den Strompreis überwälzt werden, erhalten Unternehmen aus entsprechenden Sektoren eine Kompensation auf ihre Stromkosten. Der folgende Bericht fokussiert auf diese Strompreiskompensation (SPK).

Die Analyse stützt sich auf das rechenbare allgemeine Gleichgewichtsmodel PACE, ein multisektorales, multiregionales Modell von Produktion, Handel und Verbrauch auf globaler Ebene. Damit können somit Effekte dieser Politikmaßnahme, die durch ökonomische Wechselwirkungen, wie zum Beispiel internationalem Handel oder der Verwendung von Zwischenprodukten entstehen, untersucht werden. Da ein derartiges globales Modell eher die Makroperspektive einnimmt, kann eine solche Untersuchung die jeweilige Maßnahme nur in ihren Grundzügen abdecken.

Zwei Ausgestaltungsvarianten eine Strompreiskompensation werden in diesem Bericht untersucht. Einerseits beruht die Kompensation auf dem Outputniveau. Die Kompensation wirkt somit wie eine Produktionssubvention. Andererseits wird eine Strompreiskompensation modelliert, bei der davon ausgegangen wird, dass das Kompensationsniveau am realisierten Stromverbrauch ansetzt. In diesem Fall ist die Kompensation in Form einer Stromkostensubvention umgesetzt.

Im Rahmen dieser Modellierung werden diese beiden Optionen in jeweils zwei verschiedenen Politikszenarien untersucht. In beiden Szenarios erhalten Produzenten in energie- bzw. handelsintensiven Sektoren eine Kompensation in Höhe eines bestimmten Anteils der durch den Emissionshandel zusätzlich entstandenen Stromkosten. Dieser Anteil nimmt über die Jahre hinweg ab. Der Unterschied zwischen beiden Szenarien liegt in der Anzahl der Länder, die eine entsprechende Kompensation gewähren. In einem der beiden Szenarien werden nur Produzenten in Deutschland, Frankreich und dem Vereinigten Königreich kompensiert. Im zweiten Szenario ist eine entsprechende Kompensation in allen Mitgliedsstaaten der EU implementiert. Die Ergebnisse dieser beiden Szenarien werden jeweils verglichen mit einem Referenzfall ohne jegliche Strompreiskompensation.

Die Modellrechnungen ergaben folgende Ergebnisse:

- Auf makroökonomischer Ebene finden sich keine beobachtbaren Unterschiede, beispielsweise im Hinblick auf das BIP. Die Summe, die für die Kompensation genutzt wird, führt somit nicht zu nennenswerten Verzerrungen innerhalb der Volkswirtschaften der EU.
- Die Preise für Emissionszertifikate steigen aufgrund der Strompreiskompensation leicht an. Der Grund hierfür liegt in erhöhter Produktion in den kompensierten und somit subventionierten Sektoren.
- Bezüglich des Produktionsniveaus im Vergleich zum Referenzfall profitieren die metallerzeugenden Sektoren sowie die Papier- und Zellstoffindustrie am stärksten von der

SPK. Dies gilt für alle EU-Mitgliedstaaten. Der Grund hierfür liegt im hohen Stromverbrauch dieser Industrien. Ähnliches gilt für die chemische Industrie, jedoch in etwas geringerem Maße.

- Auch wenn die Ergebnisse uneinheitlich sind, lässt sich festhalten, dass die betroffenen Sektoren tendenziell stärker von einer outputbasierten Kompensation profitieren (d.h. in Form einer Produktionssubvention). Dies bezieht sich auf die SPK-Rate für jeden Sektor, welche meist höher ist, wenn das Produktionsvolumen die Grundlage für die Kompensation bildet, aber im Besonderen auf Zuwächse in der Produktion von Sektoren, die von der SPK erfasst werden.
- Nicht überraschend ist, dass eine Ausweitung der SPK auf alle EU-Mitgliedstaaten höhere SPK-Raten in den betroffenen Sektoren nach sich zieht. Sie verursacht insbesondere enorme Produktionszuwächse, die mehr als doppelt so hoch sind wie im Fall, in dem lediglich Deutschland, Frankreich und Großbritannien die SPK anwenden.
- Die SPK löst bezüglich der Emissionen, die vom EU ETS betroffen sind, Verschiebungen in den Vermeidungsanstrengungen der jeweiligen EU-Mitgliedstaaten aus. Das Gesamtniveau der Emissionen in diesen Sektoren bleibt selbstverständlich davon unberührt im Vergleich zu einem Szenario ohne SPK:
- Alle Ergebnisse unterliegen der Annahme, dass die aktuellen Ausgestaltungsoptionen beibehalten werden, insbesondere ein zeitliches Abfallen der Beihilfeintensität. Mögliche Ausgänge der Verhandlungen über die Leitlinien der Europäischen Kommission für staatliche Beihilfen beinhalten entweder ein verlangsamtes Abfallen der Beihilfeintensität, um ein höheres Kompensationsniveau zu erreichen, oder eine Fortsetzung der bisherigen Praxis, wie in diesem Bericht modelliert, oder sogar eine vollständig neue Ausgestaltung der SPK.

Der Bericht beschreibt weiterhin die Optionen für die weitere Entwicklung der SPK, weist auf die wichtigsten wirtschaftlichen und rechtlichen Überlegungen hin, die der SPK in ihrer derzeitigen Form zugrunde liegen, und diskutiert Optionen und Einschränkungen für die weitere Entwicklung der SPK.

Neben den in der Modellierung verwendeten generischen Kompensationsoptionen umfasst die rechtliche Diskussion auch Gestaltungselemente wie eine Anpassung / Aktualisierung von Benchmarks, eine weitere Senkung der Förderintensität und eine differenzierte Anwendung des SPK für Grenzfälle, um die Kompensation so besser auf den tatsächlichen Bedarf auszureichten.

Aus rechtlicher Sicht sind insbesondere die Erwägungen in den Leitlinien der EU-Kommission für staatliche Beihilfen für Maßnahmen im Rahmen des Emissionshandelssystems zu berücksichtigen. Dazu gehört die Anwendung der allgemeinen Grundsätze der Notwendigkeit und Verhältnismäßigkeit, mit den Zielen das Carbon-Leakage-Risiko zu minimieren, die Dekarbonisierung möglichst kosteneffizient zu erreichen und gleichzeitige Wettbewerbsverzerrungen auf dem Markt möglichst gering zu halten.

Die Berichte stützen sich auf diese Aspekte und berücksichtigen dabei absehbare Entwicklungen, einschließlich des künftigen Strombedarfs der Industrie, der sinkenden CO_2-Intensität der Stromerzeugung, der Entwicklung der Ausgangsleistung der Volkswirtschaften und des zukünftigen Leakage-Risikos, der Wettbewerbsfähigkeit und der Überwälzung von Kosten. Jedes dieser Elemente berücksichtigt die Berechnung der SPK und folgt seiner eigenen Dynamik.

In diesem Bericht wird festgestellt, dass diese Elemente zusammengenommen auf ein im Zeitablauf sinkendes Vergütungsniveau hinauslaufen:

- Die Gesamthöhe der Beihilfen sinkt im Laufe der Zeit entsprechend dem vorübergehenden Charakter der Unterstützung und um eine etwaige Abhängigkeit von der Hilfe zu vermeiden.
- Der spezifische Strombedarf in der Industrie sinkt mit zunehmender Effizienz der Produktionsprozesse - obwohl strukturelle Veränderungen des Energieverbrauchs (Elektrifizierung von Industrieprozessen, Sektorkopplung) diesen Trend schließlich umkehren und zu einem stagnierenden Stromverbrauch führen könnten, sofern diese Veränderungen in ausreichendem Maßstab stattfinden.
- Was weniger klar ist, ist die Entwicklung des fossilen Teils des Strommixes. Es ist zwar klar, dass der fossile Anteil an der Stromerzeugung schrumpfen wird und damit die Kohlenstoffintensität des gesamten Strommixes abnimmt. Aber es ist ungewiss, wie sich die verbleibende fossile Stromerzeugung zusammensetzt und wie sich damit die Kohlenstoffkostenkomponente in der Berechnung der SPK entwickeln wird.

Um den sich ändernden Umständen besser Rechnung zu tragen, sollten die wichtigsten Parameter nicht nur auf der Ebene der ETS-Handelsperioden, sondern mindestens alle 4-5 Jahre aktualisiert werden.

Angesichts der Bedeutung von Effizienzsteigerungen für den Gesamtfortschritt besteht eine Überlegung darin, freiwerdende Mittel stattdessen zur Unterstützung und Belohnung von Effizienzsteigerungen in der Industrie einzusetzen, z.B. durch den Innovationsfonds.

Zu den Unsicherheiten, die bei der Neubewertung der Ausgleichsniveaus zu berücksichtigen sind, gehören die künftige Gestaltung der Strommärkte in Europa und die Art und Weise, wie sie die CO_2-Kosten an die Endverbraucher weitergeben werden; dazu gehört auch die zukünftige Nachfrage nach den betreffenden Produkten, wenn Europa zu einer ressourceneffizienteren Kreislaufwirtschaft übergeht. Schließlich müssen die internationalen Entwicklungen im Zusammenhang mit Klimaschutzmaßnahmen und CO_2-Preisen berücksichtigt werden, um zu beurteilen ob und in welchem Maß ein Carbon-Leakage-Risiko überhaupt besteht, und demnach zu kompensieren ist.

2 Overview and summary of the project

The project " Free allocation for industrial installations in the EU ETS after 2020 - Analysis and further development of the direct and indirect carbon leakage regulations" consists of three work packages, the results of which are brought together in this final report. The work was carried out by the Ecologic Institute and ZEW. This overview summarizes the relevant background, methods and results of each sub report. The full reports for work packages 1 part 2, 2 and 3 are attached. The results of work packages 1 part 1 "Forms and Channels of Carbon Leakage" and part 3 “The Innovation Fund: how can it support low-carbon industry in Europe: Design recommendations for the successor instrument to the NER 300 in Phase 4 of the EU ETS" were published in issue 16/2018 and 06/2018 of the "Climate Change" series by the German Federal Environment Agency’s (UBA). They are available on UBA’s website.[4]

2.1 Work package 1 – Definition of “carbon leakage”

2.1.1 Forms and Channels of Carbon Leakage

The discussion on carbon leakage is not new – but recently, the world has been changing in interesting ways: ambitious climate policy is no longer an exclusive pursuit of industrialised countries (if that ever was the case). The Paris Agreement is the most visible sign that an increasing number of countries around the world is committed to take action, or has already done so. In addition, it is becoming in-creasingly clear that effective global climate policies will require some form of decarbonisation, i.e. a drastic reduction in the use of fossil fuels, and eventually their phase-out. While this process will pro-ceed at different speeds in different parts of the world, it does raise the question about the role of en-ergy- (and material-) intensive industries in a decarbonised global economy, and how a structural change away from fossil fuels can be guided politically. As this paper argues, this also changes the terms of the carbon leakage debate. And it means that two central assumptions in the carbon leakage debate – that there will always be a demand for products from energy-intensive, fossil-based indus-tries, and that they will always find a location to continue producing – may need revisiting.

This paper intends to structure and summarise some of the debates around carbon leakage, and to dis-entangle the various, often overlapping and intertwined threads and discourses around this issue. The issue of carbon leakage has seen a steep career, both in the academic realm, where it has been re-searched extensively for more than a decade, and in the political debate. The concept of carbon leakage intersects across different debates, some of which can draw on an intellectual tradition of more than two decades:

- One strand of the discussion sees carbon leakage as a problem that undermines the effectiveness of unilateral (or non-harmonised) climate policy. In this understanding, carbon leakage is a prob-lem because some of the emission reductions achieved in one jurisdiction are offset by emission increases somewhere else – as a result climate policies are less

[4] Görlach, B. und Zelljadt, E.: Forms and Channels of Carbon Leakage, Climate Change 16/2018, Umweltbundesamt, Dessau-Roßlau. Available at: https://www.umweltbundesamt.de/publikationen/forms-channels-of-carbon-leakage, retrieved on 20.11.2018
Duwe, M. und Ostwald, R. The Innovation Fund: how can it support low-carbon industry in Europe?, Climate Change 06/2018, Dessau-Roßlau. Available at: https://www.umweltbundesamt.de/publikationen/the-innovation-fund-how-can-it-support-low-carbon, retrieved on 20.11.2018

effective than they appear to be. This effect was of particular concern in the Kyoto regime with its strict distinction between coun-tries with (Annex I) and without binding emission targets (Non-Annex-I) – where leakage from the former to the latter would result in net additional emissions. To what extent this still applies in the post-Paris world with its broad diversity of different national climate targets is a matter of debate.

- A second strand discusses carbon leakage as a problem for the efficiency of non-harmonised cli-mate policy: In the optimal situation with harmonised climate policy, production would be distrib-uted across countries in accordance with their comparative advantage, including the ability to pro-duce with low emissions. Carbon leakage distorts this process by shifting production and invest-ment to countries with laxer climate regulations. As a result, goods are produced in an unneces-sarily costly and polluting way, driving up the overall costs of production and reaching global cli-mate targets.
- A third strand focuses primarily on the effects that unilateral climate policy (or, more generally, any difference in climate ambition between countries) has on the competitiveness of domestic in-dustries, on location decisions of businesses, and on the first-mover advantages and disadvantages of climate regulation. In the political realm, this tends to be mostly a defensive debate, driven by the concerns of covered companies about impacts on their competitiveness vis-à-vis their interna-tional competitors – conducted either with the aim of lowering the ambition of climate policies al-together, or at least to secure assistance or some form of protection.
- Finally, a fourth (less explored) strand of the debate contrasts carbon leakage with the emerging discussion on radical innovations and industrial restructuring that will become necessary in the process of decarbonisation. The same industries that are most exposed to the risk of carbon leak-age are also challenged to define their role in a future low-carbon economy. From this angle, the policy challenge is to encourage and enable low-carbon innovation rather than shielding industry from pressures to change and preserving the status quo.

2.1.2 Investment behaviour in selected industrial sectors covered by the EU ETS - Empirical analysis and case studies

Does European climate policy lead companies to scale down domestic investments or to relocate production capacities abroad, in order to avoid the high costs induced by climate regulation? The political significance of such an investment leakage is undisputed, especially since investment is linked to jobs, future profits as well as tax revenues. Empirically, however, it remains controversial whether investment leakage actually exists.

This report examines whether there are indications for investment leakage in Germany and Europe as a result of the EU emissions trading system. Has investment leakage taken place, is it possible to identify concrete examples? How great is the risk of investment leakage actually, also in comparison to other factors that influence investment behaviour?

In order to approach these questions empirically, different approaches can be used.

- A statistical analysis of foreign investment data can be helpful to outline the general trends and to get a sense of the orders of magnitude. At the level of industry statistics, however, it is not suitable for showing correlations between emissions trading and investment behaviour: On the one hand, it is not possible to clearly delineate the subset of companies subject to

emissions trading in these statistics; on the other hand, the analysis at industry level does not provide enough data points to distinguish the effect of the EU ETS from other influences.

- Another possibility are surveys of companies - such as those carried out by industry associations, industry information services as well as academics. First, this allows to precisely define the group of companies subject to emissions trading, if necessary also in comparison to a control group of companies outside emissions trading. Secondly, it is possible to ask directly about the influence of EU emissions trading on investment decisions. The disadvantage, however, is that the answers may be biased, and may reflect the perceptions of respondents rather than their actual behaviour.
- Finally, the influence of the CO_2 price can also be investigated by means of case studies of specific investment decisions: What role did the CO_2 price play in a specific investment decision? Is there any evidence that the CO_2 price was decisive for the choice of location? In principle, this approach can provide more reliable insights. And yet,, investment decisions of this magnitude are always individual, singular decisions. The considerations on which the decisions are based are not always transparently documented, and involve specialized knowledge that is often only available to the people involved. Another complicating factor is that some of these decisions go back years or even decades, and the individuals involved may no longer be part of the company.

This report combines elements of all three approaches and gives a brief overview of the state of research on investment leakage.

In order to approach the question of investment leakage empirically, the report first provides an overview of the statistical data on German foreign investments for the relevant sectors (e.g. iron/steel, chemicals, non-ferrous metals, mineral processing industry, paper and pulp industry and refineries). The main data source for this is the inventory of direct investments, which is published annually by the Deutsche Bundesbank. However, this statistical analysis does not represent an analysis of possible investment leakage, since the subset of companies that are subject to emissions trading cannot be clearly delineated in the investment statistics, and since (potential) investment leakage caused by the EU ETS cannot be separated from other influencing factors on the basis of industry statistics alone.

On average, the time series of the Bundesbank data show that foreign investments have increased since 2003, both in the overall economy and in the emissions-intensive sectors of the chemical industry and metal production and processing. Particularly the years 2005 - 2008 were marked by a boom. Throughout the period, investment in countries outside the EU has been growing faster than investment within the EU. Yet, although the share of non-EU investments declined slightly until 2009, this has subsequently reversed. The trends in the more emission-intensive metal and chemical sectors reflect the overall economic trend during this period. This, however, is not the case for domestic investment by foreign enterprises (EU and non-EU): while overall foreign investment has increased since 2003, the volume of foreign investment in metal and chemicals has decreased. Both in the economy as a whole and in the relevant sectors of the economy, the *number* of investing enterprises with foreign participation has increased.

Further insights are provided by surveys on the investment behaviour of companies subject to emissions trading, and the role of the CO_2 price in investment decisions. This report gives an overview of the results of three surveys: those of the German Chamber of Industry and Commerce (DIHK), ThomsonReuters and Business Europe.

- Since 2004, the German Chamber of Industry and Commerce (DIHK) has surveyed its more than six thousand members annually about their foreign investment plans. This survey provides a general overview of investment trends in the German industry. In general, less than half of the companies surveyed have foreign investment plans at all – while companies in metal production and processing reflect this average, German chemical companies have an above-average propensity to invest abroad. When asked about the motives of their foreign investment plans, companies in the metal sector in particular often cite the high costs in Germany as an above-average reason why they invest in other regions. Interestingly, the importance of cost savings as a motive for investment has declined significantly since 2004 – for all respondents, but also specifically for the chemical and metal industries. The low point for all sectors was in 2013; in which year only one in five companies stated that the investment was primarily intended to save costs; for chemicals and metals the shares were even lower.

- ThomsonReuters' annual survey provides further data on investment activity and underlying motives. The most recent report "Carbon 2016" contains specific questions on investments made and on indications of carbon leakage. It is striking that the majority of companies across all industries do not even consider a relocation of production as an option. The proportion of companies that admit to having relocated production shares is almost consistently less than 10% of the companies surveyed. Such trends are still most likely to be seen in the steel and cement industries. Another question, however, which was only asked in the most recent survey (2016), relates to CO_2 costs and their influence on profitability. Respondents were asked at what CO_2 price the production in the EU would no longer be profitable for them. Of the 62 companies surveyed (all of them participants in the EU ETS), more than half were unable or unwilling to answer this question. 17% of the respondents gave a relatively low (€10) price, whereas the average (median) response was about 20 to 25 Euro.

- In 2016, the European umbrella organisation of national business associations (Business Europe) asked its member companies about the influence of the CO_2 price on their investment behaviour. As a notable contrast to the ThomsonReuters survey, more than twice as many companies stated that the CO_2 price did *not* play a role in their investment decisions (16% compared to 6.7% for ThomsonReuters). This can also be explained by the fact that Business Europe surveyed all companies represented by the organisation – and not only at operators of installations subject to the EU ETS, as in the ThomsonReuters survey. A more detailed breakdown by economic sector shows that companies on the EU carbon leakage list in particular attach greater importance to the CO_2 price – this is particularly the case for paper producers. A majority of companies in the paper, cement and steel sectors consider the CO_2 price to be as important as or more important than other investment factors. In the chemical and glass industries, no company considered the CO_2 price as more important for investment decisions than other factors. The Business Europe survey also asked companies about their expectations for the future with regard to investment leakage. The vast majority of respondents expect an increase in direct and indirect CO_2 prices, and a majority expect this to have a negative impact on investment within the EU. However, there were also companies in various industries that expect that a higher CO_2 price could have a positive effect on their investments in the EU.

In addition to the survey results, the report also provides an overview of the – still limited – empirical literature on investment leakage, and on the influence of the EU ETS on overall investment behaviour. The majority of existing studies on investment leakage come to a

conclusion that echoes the findings of the carbon leakage literature in general: according to these studies, the EU emissions trading system has only had a minor impact on the investment behaviour of companies, both in terms of leakage investments (building/extending capacities to outside of the EU) as well as in terms of the development of new technologies.

In fact, the effect of the EU ETS on investment decisions is usually dwarfed by other factors. Prices of energy and raw material are much more important, but above all access to markets and raw materials are dominant considerations. Accordingly, there is no clear evidence of cases of actual investment leakage. Only model-based simulations find clear signs of investment leakage – and here especially simulations that are not based on the current CO_2 price, but on the price level that would be required to decarbonise the European economy.

In addition to the analysis of statistical data, survey results and literature analysis, a second part of the analysis looked at selected case studies of large investment projects in the sectors typically considered to be at risk of carbon leakage, both within and outside the EU. The aim of the case studies was to find out what role (if any) the CO_2 price had played in the investment decision – and whether this could provide an indication of possible investment leakage.

Investigating individual investment projects can provide interesting insights in so far as investment decisions are individual case decisions that take into account a number of considerations, including the current and the expected future carbon price. However, it is not readily apparent what these considerations are in detail and what weight they had in the decision process. A case study can explore these considerations by analysing relevant sources – in this case by evaluating company publications (such as annual reports, sustainability or environmental reports, press releases), through industry information services, and through information obtained from company representatives. As inidivual case studies, they cannot claim to be representative; yet at the same time, there is only a limited number of major investment projects in the sectors concerned throughout the EU. For instance, in the steel and aluminium industry, completely new plants have not been constructed for years. With investments of this magnitude, companies also commit themselves to continue to produce in Europe for the foreseeable future.

To identify possible case studies, a survey of new plants and significant capacity expansions was obtained from the European Transaction Log (EUTL), as well as an analysis of publications of relevant industry information services for the sectors typically considered to be at risk of carbon leakage. In a first step, 16 examples from the chemical industry, the steel industry and the aluminium industry were identified in Germany. The selection was supplemented by 32 new plants and major capacity expansions in Europe in the above-mentioned sectors. In addition, the analysis identied five selected investment projects in non-EU locations that were undertaken by EU-based investors: these ranged from 60 million to 5.2 billion Euro in the steel, chemical and aluminium industries in Qatar, Brazil and the USA.

From this subset, five major investment projects in the steel industry were selected for an in-depth analysis – one in Germany, three in other EU countries and one outside the EU:

- **Tata Steel Steelworks Port Talbot, Rotherham, United Kingdom, 2013:** New lining of blast furnace with waste heat recovery system worth 290 million Euro;
- **ArcelorMittal steel mill in Galati, Romania, 2015:** Modernization of blast furnace 5 worth 90 million Euro;

- **Outokumpu Stainless Oy in Tornion, Finland, 2012:** Commissioning of a new furnace at the end of 2012 to double production, valued at 410 million Euro;
- **ThyssenKrupp, Duisburg-Schwelgern, Germany, 2014:** New lining of Europe's largest blast furnace worth 200 million Euro;
- **ThyssenKrupp, Rio de Janeiro, Brazil, 2008-2012:** Construction of a new steel mill, producing five million tons of crude steel per year since 2010, worth 5.2 billion Euro.

These case studies examined in particular what information could be found about the motives for the investment and the choice of location. This included both statements in publicly available sources or requests to company representatives, to find out whether there was any evidence that environmental, energy or climate regulations or related costs played a role in the decision-making process, and how the investement affected the energy and CO_2-efficiency of the respective plants, also in an international comparison. Also of interest was the global investment activity of the companies during the period in question: all of the companies considered are multinational companies that produce at multiple sites, both within and outside the EU – therefore the question arises whether the companies also invested outside the EU during the same period, and whether the investments in the EU competed with immediate alternatives in non-EU locations.

The investments in the Tata steel mill in Port Talbot were primarily aimed at increasing production, and secondly at improving energy efficiency; and indeed the modernisation of the plants also achieved energy savings. The investments themselves are state of the art – but no better than new investments by Tata in locations outside the EU, which achieve similar efficiency levels. Unfortunately, no direct information was found on the possible role of the CO_2 price – however, there were some indications. In previous investment at the same site, a company spokespersons stated that the CO_2 price had played no role in the investment decision. In the recent past, the plant has again been the subject of much discussion, as a sale of the plant was being considered. One of the reasons why the economic viability was questioned were the alleged higher costs induced by climate regulations (both the EU emissions trading system and the UK carbon floor price). In the course of this discussion, it was pointed out that climate-related costs account for only 2% of operating costs, and that the the economic problems of the site are rather due to structural factors (in particular the worldwide overcapacity in steel production).

In the case of the ArcelorMittal steel mill in Galati, Romania, the investments were made to maintain the plant and, as a result, to modernise it and reduce costs. Energy-saving measures accounted for a small part of the investment package (7 and 8.25 out of a total of almost 100 million Euro). The additional investments in blast furnace No. 5 (bell-less top charging system and profile measuring device in 2013, blast turbine modernization in 2015) improved the energy efficiency of the plant and thus contributed to reducing its CO_2 emission intensity: The bell-less charging system allows a more homogeneous distribution of the raw material within the blast furnace. This reduces fuel consumption while increasing productivity and extending service life. The profile measuring device increases efficiency by reducing heat fluctuations so that the blast furnace can be operated with a lower coke rate and optimum gas distribution. Finally, the modernization of two blast turbines and their compressors halved the blast furnace's steam consumption. According to the 2014 Sustainability Report, the absolute CO_2 emissions of the entire plant fell by 15% between 2013 and 2014 and amounted to 4.3 million tons of CO_2 in 2015. The current CO_2 intensity at the Galati site (just under 2 tons CO_2 per ton of steel produced) is slightly better than the average level for ArcelorMittal worldwide (2.14 tons CO_2

per ton of steel), but is also above the average for all steel production plants worldwide (1.8 tons CO_2 per ton of steel). ArcelorMittal's primary objective was to reduce the gap in variable costs between Galati and ArcelorMittal's best facilities in Western Europe – thus strengthening Galati's competitiveness. There was no evidence that CO_2 costs played a role in the investment decision.

With the investment of 410 million Euro in Tornio, Finland, the Outukumpu Group doubled its ferrochrome production capacity (to 530,000 tonnes per year). The new ferrochromium furnace is particularly energy-efficient, as its proximity to the production site allows the use of ferrochromium melt and the by-product carbon monoxide as energy raw materials. Pelletization and pre-shredding of the inputs reduce the firing time in the furnace and thus the power consumption. Since the liquid chrome iron ore does not harden on the short path from production to processing, waste heat and process gas are optimally used. The Tornio site also uses CO_2-free electricity from nuclear and hydro power. An Outukumpu spokeswoman confirmed that site-specific advantages – such as the proximity of the chromite mine to the production site – were decisive for the location decision. Minimizing ore transport costs was the most important decision factor, followed by the expertise of the employees at the European site. The CO_2 price, or the future amount of the free allocation, were not mentioned.

The ThyssenKrupp Group's investment in the integrated Duisburg steel mill involved the conversion of an entire steel complex, including the construction of a new furnace (blast furnace 8 in Duisburg-Hamborn), scheduled relining of blast furnace 9 and decommissioning of blast furnace 4. The total investment volume was 340 million Euro. Unfortunately, no information was found on the specific efficiency level of the new blast furnace. ThyssenKrupp states, however, that the conversion of the entire complex led to energy savings through logistics optimization and productivity improvements. In its Annual Report, ThyssenKrupp justified the investment as a logistical necessity - the entire redesign of the complex mainly served to "rationalize the production flow" by stabilizing the pig iron base in Duisburg for further steel production and further processing in the German plants. Press releases at least suggest that CO_2 emissions did not play a prominent role in the decision-making process: When explaining the "environmental measures" of the new plant complex in Duisburg, measures to reduce dust emissions and noise are explained in detail and described as particularly progressive. Greenhouse gas emissions, on the other hand, are not mentioned. Also in the annual reports from this period, emissions trading and its costs are only discussed as a cost factor for energy procurement - but not in direct connection with the concrete investment project.

CSA Siderúrgica do Atlântico Ltda in the Brazilian state of Rio de Janeiro is a completely new integrated steel mill with an annual capacity of 5 million tons that was built on a greenfield site between 2006-2010. The decision to build the plant was finalized in 2005, when ThyssenKrupp expected to invest 3 billion Euro. The actual cost of construction, however, rose to over 8 billion Euro. In February 2017 ThyssenKrupp announced that the plant will be sold to the Argentine steel group Ternium S.A.. The ThyssenKrupp annual reports of the years prior to the construction of the new plant show that the efficiency level of the Brazilian site should at least reach the level of comparable European plants, and that the company's uniform environmental standards would also apply to the new plant in Brazil. This is reflected, for example, in the cogeneration process used, which was chosen because of its particularly high efficiency. The use of blast furnace gases in this plant also went beyond conventional standards. Since the Brazilian plant uses only the plant's own process gases, no external fuel has to be purchased or excess process gases flared off. According to the company, this constellation was the first in America at the time of construction and is still the only one in Brazil. As far as decision-making is concerned,

the decision to build a steel mill in Brazil was based, according to the company's chronicle, on assumptions of rising steel demand worldwide, exploding raw material prices and increasing global competition between steel producers. Only proximity to ore deposits and growth opportunities in the NAFTA region are explicitly mentioned as cost advantages of the Brazilian location. Environmental or energy-specific factors – such as lower energy prices or lower environmental standards – are not mentioned. In particular, CO_2 emissions or their regulation are not mentioned as influencing factors.

Thus, in their communication on investment decisions, companies are at best concerned with energy prices or energy efficiency as a cost factor. Despite intensive research, none of the five examples examined found any instance where the CO_2 price, or the cost of climate regulation, was cited as a factor influencing the investment decision. Of course: the absence of evidence is not the evidence of absence – the fact that no evidence could be found cannot prove that the CO_2 price was irrelevant to the decision; this could only be shown in one instance with the explicit statement that the CO_2 price did not play a role in the investment decision. Yet, the fact that – in contrast to many other relevant considerations – the CO_2 price is not even mentioned at least suggests that it could not have had a very prominent role.

Another interesting result is that all of investments represent the technical state of the art – irrespective of whether they are located within or outside the EU, also because companies would often apply the same environmental and efficiency standards at all their production sites. The actual efficiency of the plants therefore seems to depend more on site-specific factors such as the plant configuration than on the regulatory framework in the investment location.

2.1.3 The Innovation Fund: How can it support low-carbon industry in Europe?

This report analyses a range of options for designing the EU Innovation Fund (IF), a financing instru-ment created under the EU Emissions Trading System (ETS) to support technological breakthrough for low-carbon innovations in the power sector and industry. The report combines a look at lessons learned from the IF's predecessor mechanism "NER 300" with insights from the respective emission reduction technology options in three key industry sectors (steel, cement, pulp & paper) based on a literature review and interviews: on this basis, the paper concludes with recommendations for the IF's design.

The NER 300 experience: lessons to be learnt on risk reduction and political commitment

Lack of a business case is a fundamental barrier to investment in untested technology. Spending money on such projects creates risk without obvious rewards and can make it difficult to attract fi-nancing, which is why companies may be right to look for public support for such initiatives. The de-sign of the NER 300 (which addressed only the energy sector: carbon capture and storage (CCS) and innovative renewable energy technologies) had a variety of shortcomings, including regarding risk sharing, as a result of which high risk technology projects (such as CCS) did not materialise. Higher co-financing rates may be one solution going forward, as well as a more nuanced set of conditions for pay-ments. Another shortcoming exists in terms of political/public support, the lack of which led to indi-vidual projects being withdrawn. It is apparent that more factors than merely access to finance are creating barriers to investments in low-carbon innovation.

Industrial players display an "incumbent's bias", need a pro-business decarbonisation perspective

The industry perspective of the opportunities and threats of the decarbonisation challenge is rather defensive (especially for steel and cement). The interviews and the industry roadmap documents ex-hibited a tendency to be pessimistic about novel technologies and various

products which would have the potential to bring about a more fundamental change to the traditional way of doing business. This traditional perspective is understandable, but also limits the possibility to see what other alternative futures may be possible, and what one might call the "Elon Musk approach" to industrial manufactur-ing.

To decarbonise the European economy and maintain a strong industrial base in Europe may, however, require more fundamental changes in the way businesses organise themselves, what products they decide to create to satisfy customer needs as well as a more service-oriented perspective (moving away from a simplified focus on product sales figures) – in addition to a reduction in direct emissions from manufacturing. Allwood (2016) and Wyns and Axelson (2016) point out examples of how such new visions of a low-carbon business model could look like, e.g. for the UK steel sector, and the long-term outlook for the pulp & paper sector goes in that direction, restyling itself in the 2050 roadmaps as the "forest fibre industry" (CEPI 2011) that could strive in a bio-economy.

The IF should focus on facilitating breakthrough technologies, not rolling out existing ones

The analysis of the technology options for the three sectors and the perspectives of the existing play-ers shows that currently available technologies in industrial sectors for emissions reductions are largely focused on the existing technology stock and marginal improvements and do not include more novel approaches and new business options. However, the summary report from the European Com-mission's 2017 consultation process with industry stakeholders (European Commission 2017a) con-cludes that the IF should include support not just for projects featuring technologies that are at pilot demonstration stage (Technology Readiness Levels (TRLs) 6 to 7), but also those closer to the com-mercial environment (TRLs 8-9). Directing policy support to such more proven technologies may turn out not to be sufficient to deliver the magnitude of emissions reductions required. Or, if such an ap-proach does achieve the needed mitigation potential, it runs the risk of doing so only in a structurally conservative form that may not be cost-competitive in a low-carbon world (because it centres around marginal improvements to existing facilities). It could also create a new set of risks (such as strong re-liance on end-of-pipe capture technology). A focus on more proven technologies could thereby jeop-ardise the originally stated objective of the IF – to support the development of breakthrough technolo-gies, needed for further substantial CO_2 reductions - with no other instrument in sight that would fulfil this important function.

We contend that both breakthrough development and support for market entry are needed, but that the primary function of the IF must be to help deliver breakthroughs to enable decarbonisation, and not to focus on marginal gains or more proven technologies. However, there is potential to do both under the IF, for example via the use of loans (rather than grants) to more mature technology projects (which would mean the money is paid back over time – and thus not diverted away from breakthrough financing). Qualitative and quantitative restrictions should be applied to such funding for technologies closer to the market, to ensure that the most value added is created in terms of emis-sions reductions.

Mind the policy gap – additional support is needed to bridge the gap between the IF and the ETS

The debate on the focus of the IF's financing highlights that additional measures may be required to help some of the technologies emerge from the "valley of death" of technological innovation and help them cross from demonstration level to market entry. Existing policies such as the EU ETS are most adept at driving technology deployment between options with a low-cost differential and thus play a role mainly further down the technology deployment curve. In the context of the debate about the im-pacts of climate policy on the competitive position of

European industry and possible carbon leakage, the Fund itself must be seen in an integrated perspective for a low-carbon industrial policy. The existing regulatory landscape must be corrected for its occasional bias in favour of carbon-intensive incumbents and the focus on existing products and processes, and complemented to create an envi-ronment that truly incentivises investment in innovative low-carbon technology, both in development and later deployment. Without a long-term perspective for how to make a business case for low-car-bon industrial production, the IF in itself cannot succeed.

Bringing such a change about requires both a commitment from political decision-makers as well as a change in perspective across industrial sectors and closer sector integration, in order to arrive at new ways of doing business and give assurance to innovators that they will be rewarded. The upcom-ing decisions on the design parameters of the Innovation Fund need to be seen in this general spirit and be shaped to fit with a new perspective, one that is serious about realising a future for industry in a low-carbon world.

Specific recommendations for future design of the Innovation Fund

On the basis of the considerations summarised above, the analysis has concluded with the following policy recommendations, focusing on financing conditions and project eligibility:[5]

- Guarantee a minimum amount of funding for the IF as a whole.
- Provide higher co-financing rates for high-risk projects and for small ones.
- Avoid reliance on strict performance-based criteria as payment conditions; use milestones.
- Establish maximum funding per project as absolute amounts.
- Focus on breakthrough technologies for the eligibility of projects and provide funding for technol-ogies that are already closer to market introduction via loans instead of grants (and with a limited share of the IF's volume).
- Earmark minimum shares of funding per main category (CCS, industry, renewables) but be flexible about them if unused.
- Set ambitious criteria for selection of projects (specific to each main category), addressing inter alia the emission reduction potential. These could be combined with criteria that take into account possible long-term business opportunities, to increase the likelihood that the technology is indeed commercialised after the successful demonstration project.
- Build in incentives to support product substitution innovations.

[5] These recommendations need to be seen in the following context: the underlying research was limited in terms of the level of detail it was able to consider (e.g. a limited set of industrial sectors, limited number of dedicated expert inter-views) and, in some instances, the conclusions are not unequivocal in the case of e.g. static vs. dynamic choice of eligible technologies.

2.2 Work package 2 – Carbon Leakage Risks in a World of Converging Carbon Prices

The current debate on carbon leakage in Europe focuses on the (implicit or explicit) assumption that the EU is pursuing a more ambitious climate policy than its major trading partners, putting its industries – particularly carbon-intensive ones – at a competitive disadvantage. This premise was justifiable a decade ago, but by now has become questionable.

At the time of its introduction in 2005, the European Emissions Trading System (EU ETS) virtually was the only instrument with the explicit goal of introducing a price on CO_2 emissions. At that time, emissions from EU Member States made up about 4% of global greenhouse gas (GHG) emissions. Since then, however, there has been a proliferation of carbon pricing tools around the world. Examples include the North American cap-and-trade systems (the Regional Greenhouse Gas Initiative (RGGI) comprising ten North-Eastern US states, California, Quebec), the ETS in New Zealand, Switzerland, Kazakhstan and South Korea, two regional schemes in Japan (Tokyo, Saitama) and seven Chinese pilot ETS. China is in the process of rolling out its national ETS; further ETS are under preparation or in the legislative process in Mexico and Colombia.

In addition, a number of countries and jurisdictions have introduced a carbon tax (e.g. Chile, Mexico, British Columbia) or are in the process of doing so (South Africa). Finally, a number of jurisdictions around the world have been investigating the different options for carbon pricing, or have at least stated their intentions to use such tools in the future (including, among others, Vietnam, Thailand, Turkey and Ukraine). As a result, the global share of emissions that is covered by some type of carbon price has increased to 12% (Marcu et al., 2013).

This suggests that a fundamental premise of the European carbon leakage debate may need to be revisited. From a competitiveness perspective, however, the question is not so much what proportion of global emissions is covered by some kind of carbon price – but rather whether the direct competitors of European companies face a carbon constraint that is comparable to the EU ETS price. This report sheds some light on these questions.

The report is structured around the following guiding questions: Chapter 3 discusses which countries and jurisdictions outside the EU are relevant for European companies that are most exposed to carbon price risks. This is approximated through the sectoral trade intensities of the EU with non-EU countries for eight industry sectors that are generally considered as having a carbon leakage risk. Chapter 4 discusses what proportion of these foreign competitors faces some kind of carbon constraint and/or carbon price, and how this compares to the constraint imposed by the EU ETS and other climate regulation. To this end, the chapter analyses the applicable regulation – carbon prices and other climate policies, but also regulation relating to energy efficiency and air pollution. Chapter 5 then combines the findings from the previous steps to provide a more nuanced picture of the carbon leakage risks for EU industries, to describe how the carbon constraints differ between the EU and its main trading partners for the eight sectors in question. Finally, chapter 6 complements the previous analysis with a forward-looking and integrated model-based assessment of carbon leakage risks. Rather than focusing on countries' actual or planned climate policies, this assessment takes the respective countries' climate targets (as laid out in their NDCs) as a starting point. Assuming that all countries will take the necessary steps to reach their NDCs, the PACE model – a multi-sector, multi-region computable general equilibrium (CGE) model of global production, consumption, trade and energy use – is used to assess the carbon leakage risks in the post-Paris-world.

The EU is an open economy, tightly integrated into world markets. This also applies to the eight sectors considered in this report. A discussion of the EU and its trade relations should be prefaced by the fact that the largest trading partner of the EU, by far, is the EU itself – the share of intra-EU trade far exceeds the share of extra-EU trade. Since the EU ETS and most other climate regulations are harmonized across the EU, the carbon leakage risk can be assumed to be zero for this part of European trade. Regarding extra-EU trade, for the eight sectors considered, the volume was highest for refineries and chemicals (with EUR 119 and 101 billion respectively), and much smaller for cement and lime with a trading volume of only EUR 1.6 billion. For each of these sectors, the EU as a whole is both an importer and an exporter: for non-ferrous metals, imports are higher than exports (65% of extra-EU trade), while exports are higher than imports for ceramics or for pulp and paper (63% and 64%). The trade of cement and lime is dominated by exports (85% of extra-EU trade).

Based on the overall trade volumes in the respective sectors, the United States continues to be the main trading partner of the EU, followed by Russia and China. For three of the eight sectors considered, the United States is the main trading partner, and takes the 2nd place in the other five industrial sectors. China is the main trading partner in three industrial sectors; the other spots are taken by Algeria (for cement and lime), and Russia (for refinery products).

To return to the original question – what does the EU's exposure to the carbon leakage risk looks like when taking account of the climate policies enacted by the EU's main trading partners – the following picture emerges: In all of the eight sectors analysed, the top two trading partners have a carbon constraint that is weaker than that of the EU. Among the 3rd or 4th largest trading partners, we find trading partners with a comparable, or even more stringent carbon constraint in most sectors.

- Two important EU trading partners are right in its neighbourhood: **Norway and Switzerland** have implemented climate policies that are largely identical to those of the EU. Norway's climate policy is even somewhat more ambitious than the EU's, as the country pursues complementary policies (including energy or carbon taxes on industry) in addition to their participation in the EU ETS (Norway). Hence, the carbon leakage risk between the EU and these two countries can be considered zero.

- For the other two main trading partners of the EU – the United States and China – the picture is more nuanced. Historically, while all attempts to establish a carbon price at the federal level in the United States have stalled, there have been some constraints from air quality and other standards as well as state-level climate policies. Yet, under the Trump administration, the future level of climate ambition for industry remains uncertain, depending on how resilient the existing environmental legislation will turn out to be. The federal level is not necessarily the main driver for action, however: at the regional level, the **Californian** ETS caps emissions and sets a carbon price for the selected industries. The price level is comparable to the EU ETS. While this system is only implemented in one state (the Regional Greenhouse Gas Initiative of 10 North-Eastern States does not cover industry emissions), California by itself already accounts for roughly 4% of the trade volumes between the United States and the EU. Whether other states follow California's lead remains to be seen – for the time being, there are encouraging signs from a number of states, as Washington State moves to introduce a carbon tax, New Jersey announced its intention to re-join RGGI (after having withdrawn in 2011), and Oregon discusses the introduction of a cap-and-trade system (Temple, 2017).

- In **China**, in terms of the legislation currently in place, carbon constraints are still much weaker. For several years, however, the Chinese leadership has been giving clear, strong and repeated signals that ambition will increase, not only through the incoming national ETS, but also through other environmental legislation, including on air quality. While the Chinese national ETS has officially been launched in 2017, it will initially only cover the power sector and it currently remains unclear how binding it will be. Yet the inclusion of industry emissions is foreseen for the coming years; it is therefore to be expected that a growing share of Chinese power production and industry will be facing increasingly tight carbon constraints in the coming years.

- As for other EU trading partners, there is wide variation. **South Korea** pursues an ambitious strategy that combines carbon pricing with air quality and energy efficiency policies that imply a level of ambition comparable to that of the EU. **Russia** and **Turkey** both show some ambition on paper, but also struggle with deficits in implementation and enforcement. In both countries, the current focus is on monitoring, reporting and verification (MRV) and data gathering as a basis for future climate policies. Yet the nature and design of concrete policy tools remain uncertain; in the absent of a strong political commitment there is no expectation that either would impose strong carbon constraints in the foreseeable future. **Algeria**, finally, has an NDC, but with little mitigation policy in place it appears to focus only on deployment of renewables, with little perspective for a meaningful carbon constraint in the foreseeable future. The assumption of a prima facie carbon leakage risk is thus justified not only for the United States and China, but also for Russia, Turkey and Algeria. To what extent this risk materialises, however, is another matter, and will also depend on other factors: European trade with Russia has declined substantially in recent years following the EU sanctions. Likewise, EU investments in Turkey or Russia have also stagnated or fallen in the wake of political tensions.

These observations could and should have implications for the European discussion on carbon leakage, and suggest possible adjustments to the carbon leakage provisions in the EU ETS. As a start, it makes sense to disregard all trade with countries that have comparable ambition levels in the trade intensity component of the carbon leakage risk assessment. For others, the analysis should differentiate between different levels of climate ambition. Going forward, a common metric for non-price-based-policies would be desirable.

In a further step, the country-level analysis was complemented by a model-based assessment of the current and future carbon leakage risk, based on the countries climate targets as laid out in their NDCs, and assuming that all countries will take the necessary steps to reach their NDCs. Thereby, four policy scenarios were analysed which differ regarding climate policies implemented in non-EU regions as well as regarding the issuance of freely allocated emission permits in energy-intensive sectors in the EU and non-EU regions. The most important findings are summarized below:

- The EU clearly benefits from multilateral action compared to the scenario where non-EU regions do not implement any climate policy. This holds for macroeconomic impacts, such as the GDP, as well as for sectoral impacts on output.

- Ambition levels of climate policies across the most important trading partners differ. Some countries, mostly some of those that implement reduction targets vis-à-vis carbon intensity levels (such as China) and some that have effectively non-binding NDCs according to our projections (such as Brazil or Turkey), can expect to see significant GDP gains if they

implement their NDCs. At the same time, resource abundant countries such as Russia or Norway stand to experience GDP losses. However, these losses are quite moderate until 2030 (below 2 % in the most severe case).

- Based on that, some EU trading partners can gain in macroeconomic and sectoral output terms at the expense of others until 2030. In this model analysis, such effects can be observed for China (where GDP as well as sectoral output increase) whereas the United States lose in both terms compared to the scenario without climate policy. This effect is due to the different ambition levels outlined above, but such effects can also be aggravated by different trade patterns of both countries.
- Free allocation of some allowances – modelled here as a subsidy for production output – can be beneficial for the respective sectors. This can be observed in the energy-intensive sectors of some of the EU's trading partners, for instance in the United States. If, however, the EU grants the same share of free allowances to these sectors, they become more competitive and hence benefit, whereas the sectors in the trading partner countries lose (but to a very small degree) compared to the situation in which only they receive free allowances. On the other hand, free allowances can also have adverse effects if only the EU's trading partners grant free allocation to their domestic producers. As EU-based producers reduce their output, they demand less intermediate products from abroad. If the respective sectors in the EU's trading partner regions export a lot to the EU sectors, they might even experience output losses. This is the case in some Chinese sectors. These observations however only apply to the analysis before 2050. Until that year free allocation is declining in line with the scenario assumptions and by 2050 no free allowances are implemented any more.

Therefore, the degree to which climate policies have an impact on the competitiveness of EU industries clearly depends on the climate action taken in other countries. Even if their climate action matches the ambition of their NDCs, impacts are very diverse also on the EU economies. Measures such as free allocation are capable of alleviating some of the adverse economic effects. However, when interpreting results, it is important to be mindful of the limitations of the PACE model, which for instance neither covers endogenous technological change nor includes CCS as an option. Both features would certainly dampen some negative effects. Finally, as most CGE models, the PACE model does not include gains from avoided climate change.

2.3 Work package 3 – Indirect carbon leakage

In addition to the work listed below, other advisory services have been provided under this work package which have not been included in this report. Among other issues the relevance of a power generation technology as a price-setting technology was also discussed. The results were published , see Germeshausen, R.; Wölfing, N. (2020): How marginal is lignite? Two simple approaches to determine price-setting technologies in power markets, In: Energy Policy, 2020, 124, 111482. (https://doi.org/10.1016/j.enpol.2020.111482)

2.3.1 National compensation schemes for indirect CO_2 Costs within the EU Emissions Trading Scheme

This report deals with national compensation schemes for indirect CO_2 costs in the context of the EU ETS. The so-called indirect CO_2 costs (or indirect EU ETS costs) for electricity consumers occur from a rise in electricity prices which are due to direct CO_2 costs in power generation. Electricity-intensive production processes can be expected to be the most vulnerable to indirect CO_2 costs. In the absence of a fully integrated European electricity market, those costs vary not only across sectors but also across EU Member States, depending on the underlying structure of the power generation sector. Under the EU ETS Directive (2003/87/EC) and its amendment in 2009 (2009/29/EC), national governments are allowed to provide direct state aid to compensate electricity-intensive production processes for indirect CO_2 costs due to the EU ETS from 2013 on. The European Commission issued guidelines for compensation schemes (European Commission, 2012a; EU Guidelines) that provide a general framework for the design of those schemes and put essentially a ceiling on the overall national compensation level. The implementation into national law is, however, optional and lies within the responsibility of each state subject to the EU ETS. National compensation schemes for indirect CO_2 costs within the EU ETS have been implemented so far in eight EU Member States and Norway. The eight Member States are Belgium (Flanders), Finland, France, Germany, Greece, the Netherlands, Spain, and the United Kingdom. Additionally, Lithuania (DG Competition, 2015b) and Slovakia (DG Competition, 2015a) are planning to establish one in the future. This report investigates the differences in implemented national compensation schemes and discusses these against the backdrop of the lack of a unified electricity market in the EU.

EU Guidelines on indirect CO_2 cost compensation put essentially a ceiling on overall national compensation level

The EU Guidelines provide a general framework for the compensation of indirect CO_2 costs, determining a maximum list of eligible sectors and a maximum level of state aid per installation. Essentially, these guidelines put a ceiling on the overall national compensation level since countries are solely allowed to deviate downwards within their national implementations (i.e. by excluding sectors or choosing a lower level of compensation). Furthermore, countries decide about budget and aid granting period of their support mechanism as well as the amount of retention (i.e. the amount of electricity consumption for which indirect costs are not compensated), the modalities of application for the state aid (i.e. requirements for additional measures) and of the processing of grants (i.e. institution responsible for processing). Important adjustments for the individual country within the EU Guidelines are the additional exclusion of eligible sectors, reduction of maximum aid intensity, CO_2 emission factors, the overall budget and additional requirements, such as mandatory energy efficiency plans or the absence of tax liabilities. However, the compensation schemes currently in place are largely in line with the EU Guidelines concerning the eligible sectors, aid intensity, and CO_2 emission factors.

Differences in existing national compensation schemes: budget, emission factor and amount of retention

Although the EU Commission issued general guidelines on compensation schemes and existing national schemes mainly use the maximum aid intensity (with the notable exception of Finland) and maximum number of sectors, they differ in particular along three dimensions. The main differences in national compensation schemes appear to be the budget size dedicated to compensation payments, the amount of retention, and the applicable emission factor. Whereas the maximum applicable emission factor is determined by the EU Commission (2012a), countries are able to decide on their budget and amount of retention. The amount of retention within national regulations on the compensation of indirect costs varies. Since such rules directly influence the amount of compensation for the individual eligible company within one country, this could be a potentially source of different compensation payments for (comparable) companies in different countries. The observed differences in budget allocated to the compensation of indirect cost across member states might be partly reflected by differences in industrial structure. However, comparing budgets relative to country's industrial electricity use shows that this might not be the only factor explaining differences in national budgets across countries. Those differences would be relevant for cross-country comparisons only if the overall applications for state aid within one country would sum up to a number which exceeds the national budget. In this case, the individual aid would be proportionally lowered for all successful applicants. In this case, companies in this country would receive a smaller state aid amount than a comparable company in a different country, in which the budget is not completely exhausted. Consequently, discrimination within the EU based on the allocated national budget for compensation would occur. So far, Spain appears to provide the only case where budget restrictions actually limit the amount of state aid granted. Given that actual compensation figures are only accessible for a limited number of countries and years, this finding is preliminary and should be treated with caution.

Emission factors in EU Guidelines based on average emission intensities of fossil-fuelled power plants within geographical areas

The CO_2 emission factors are specified in the national compensation schemes accordingly to the maximum regional emission factors that has been determined in the EU Guidelines. Within this guideline, the only partially integrated electricity market is considered in so far as the maximum emission factors vary across geographic regions. These geographic regions shall demonstrate the limited degree of integration of electricity markets within the EU. Thus, differences in emission intensities in regional electricity markets are likely to be important when assessing the impact of the different national compensation schemes. In addition to emission intensities, differences in pass-through rates in the respective countries or geographic areas need to be taken into account, i.e. the rate with which additional costs will be actually passed-through.

Emission intensities of marginal power plants crucial for actual indirect CO_2 costs

Average emission intensities are, however, only a rough approximation of the extent of indirect CO_2 costs as they also include CO_2 emissions and electricity generation from infra marginal power plants. Indirect CO_2 costs for electricity users are most likely determined by the marginal plants alone. The actual indirect CO_2 costs theoretically depend on the pass-through rate, i.e. the fraction of CO_2 price changes that is passed on to electricity prices as well as on the average emission intensities of the marginal power plants. We base our analysis on a descriptive analysis of the electricity market characteristics for the relevant geographic areas, i.e. in regions in which countries have already implemented a compensation scheme (Belgium, Germany, Greece, the Netherlands, Norway, Spain, and the United Kingdom) and a literature review of empirical

evidence on cost-pass through for those countries. This may give a first indication of differences in compensation schemes against the background of incompletely integrated EU-wide electricity market. To the best of our knowledge, there are no empirical studies on the estimation of pass-through of emission cost in Greece. For the United Kingdom there are no empirical studies on the emission intensity of the marginal power plant. The presented empirical literature on cost pass-through in Germany, Belgium, the Netherlands, and Spain as well as in the Nordic market area supports the notion of a complete pass-through of CO_2 emission costs. Thus, the issue of differences in the degree of competition appears to be negligible for the extent of indirect CO_2 costs. This leads to the conclusion that the average emission intensity of the marginal power plants should determine the amount of indirect CO_2 costs in each country and geographic area, respectively.

Emission factors in the EU Guidelines appear to be in line with existing empirical evidence

Based on the existing empirical evidence, Belgium, Germany, and the Netherlands have a comparable CO_2 cost-pass through in a range of 0.50 to one Euro per MWh. This could correspond to a complete pass-through of CO_2 costs with a mixture of gas and coal fired power plants being at the margin. An emission factor within this range appears to be reasonable and also coincides with the emission factor set for Central-West Europe (0.76). However, the range appears to be rather wide. Mokinski and Wölfing (2014) find on average a price effect of 0.64 Euro per MWh for an increase of one Euro per ton CO_2 for Germany and Austria. This would be lower than the emission factor for Central-West Europe. However, one has to keep in mind that those (point) estimates are subject to uncertainty and regional definitions may be different for the emission factors set out by the EU Commission and the empirical studies. The most striking deviation in the empirical literature from the emission factors specified in the EU Guidelines and implemented in the national compensation schemes is for Spain and the Iberian region. Fabra and Reguant (2014) find on average an emission factor of 0.70 to 0.75 depending on the hour of the day. This is larger than the 0.57 ton CO_2 per MWh, which is applied in the compensation scheme. One limitation, which needs to be taken into account for transferring this result to the Iberian Region, is that the analysed market area is only on a national level, whereas the geographic area in the EU Guidelines includes Portugal as well.

Only limited importance for firm specific differences in indirect emission costs likely

Firm specific variation of indirect CO_2 costs within the same market area and jurisdiction appears to be undetectable. Of the potential reasons – mainly differing emission intensities of suppliers, price discrimination, and procurement strategies – only one aspect appears to have continued relevance: the potential of different shares of peak load versus base load consumption across firms which gives them different exposition to the corresponding hourly prices. With different power plants being marginal along the load curve, such differences in the consumption pattern might indeed result in varied exposure to indirect CO_2 costs. Unfortunately, it does not appear to be feasible to identify the differences of the marginal carbon intensity along the load curve with sufficiently high precision to warrant a solid identification of such firm specific differences in indirect emission costs.

2.3.2 Compensation for Indirect CO_2 Costs within the EU Emissions Trading Scheme

With the preparation of the third phase of the EU ETS (2013-2020) and the associated introduction of auctioning as the guiding principle of allocating permits to Member States and sectors, the importance of measures to alleviate carbon leakage was acknowledged. Thereby, two main instruments were established to reduce adverse effects of both direct and indirect carbon leakage. To alleviate effects of indirect carbon leakage, which arises through passing

through increasing electricity generation costs caused by pricing GHG emissions to industrial sectors, those sectors may receive a compensation on their electricity price. This electricity price compensation (EPC) is the focus of this report.

The principal analysis is supported by the computable general equilibrium model PACE, a multi-sector, multi-region model of global production, consumption, trade and energy use, which is hence capable of finding effects of this policy caused by economic interrelations such as intermediate production and international trade. As this model is of rather macroeconomic nature, the design of the policy instruments are stylized to a certain degree.

Two design types of the electricity price compensation are examined within this report. On the one hand, the compensation level depends on the output level. The compensation in this case works as an output subsidy. On the other hand, it is assumed that the electricity price compensation level is based on current electricity consumption. In this case, the compensation works as an electricity consumption subsidy.

Within the modelling exercise, these two options will be examined in two different policy scenarios. In both scenarios, producers in energy-intensive and/or trade-exposed sectors are compensated by a certain share of increased electricity costs caused by GHG pricing. This share declines over time. The difference between both scenarios is in the amount of countries that apply the electricity price compensation. While in one scenario only producers in Germany, France and the United Kingdom receive the compensation, in the second scenario it is applied in all Member States. The results of these scenarios are compared to a baseline without the existence of such a compensation.

The following results emerge from the modelling exercise:

- At the macroeconomic level, no effects can be observed, for instance with respect to changes in GDP. The monetary amount used to compensate the affected sectors does not cause any severe distortion within the EU economies.
- Carbon prices increase slightly as a result of the compensation due to an increased output level in the sectors covered by the EPC which is induced by the subsidy.
- The metal producing sectors and the pulp and paper sector benefit most from the EPC in terms of relative sectoral output gains. This is due to their large share of electricity consumption and applies to all Member States. Also the chemical sectors gain, however to a lesser degree.
- Although there is no obvious tendency, sectors benefit to a larger extent from an EPC design which is based on output levels. This applies to the EPC rate for each sector, which is higher in many cases if an output based computation is used, but in particular to gains in the output of the sectors covered by the EPC.
- Not surprisingly, an extension of the EPC to all EU member states causes higher EPC rates in the covered sectors and, in particular, tremendous sectoral output gains which are more than twice as large as in the case where only Germany, France and the United Kingdom apply the EPC.
- The EPC causes shifts in the abatement efforts of EU Member States regarding emissions covered by the EU ETS. The overall level of course remains equal to a scenario without an EPC.

- All results are subject to the assumption that current design options, in particular a decline in the aid intensity, are maintained. Possible outcomes of the negotiations of the European Commission's State Aid Guidelines for the fourth EU ETS phase include either a decelerated decrease of the aid intensity to achieve a higher compensation level or a continuation of the policy – as modelled in this report – or even a completely new design of the EPC.

The report continues to describe options for the further development of EPC, pointing out key economic and legal considerations that underpin the EPC in its current form, and discusses options and constraints for the further evolution of the EPC.

In addition to the generic compensation options used in the modelling exercise, the legal discussion also includes design elements such as an adjustment / update of benchmarks, a continued lowering of the aid-intensity and a differentiated application of the EPC for borderline cases, which could be utilized to better target the compensation.

From a legal perspective, in particular the considerations in the EU Commission's state aid guidelines for measures in the context of the emission trading scheme need to be taken into account. These include the application of the general principles of necessity and proportionality to achieve the objects of minimizing the risk of carbon leakage, and to achieve cost-efficient decarbonisation while minimizing distortions of competition in the market.

The reports builds on these aspects and considers current trends and issues in their light, including the future electricity demand by industry, the falling carbon intensity of electricity generation, the development of economies' baseline output and regarding the future leakage risk, competitiveness and cost pass-through. Each of these elements factors into the calculation of the EPC and follows its own dynamics.

This report notes that these elements, take together, point to a falling level of compensation over time:

- The overall aid intensity falls over time in line with the temporary nature of the support, and to avoid aid dependence.
- The specific electricity demand in industry falls as the efficiency of production processes increases over time – although structural changes in the energy consumption (electrification of industrial processes, sector coupling) could eventually reverse this trend, and lead to stagnating rather than falling electricity consumption, if and when such changes take place at scale.
- What is less clear is the evolution of the fossil part of the electricity mix. While it is clear that the fossil part of electricity generation will shrink, and hence that the carbon intensity of the overall electricity mix will go down, it is uncertain how the residual fossil production will be composed, and hence how the carbon cost component in the compensation will evolve.

To account better for changing circumstances, the main parameters should be updated not only at the level of ETS trading periods, but at least every 4-5 years.

Given the importance of efficiency improvements for the overall progress, one consideration is to use funds that are no longer needed for compensation payments and instead channel them towards supporting and rewarding efficiency improvements in industry, e.g. through the Innovation Fund.

Uncertainties to be kept in mind for the re-evaluation of compensation levels include the future design of the electricity market(s) in Europe, and in what way they will transmit carbon costs to

final consumers; they also include the future demand for the products in question as Europe moves to a more circular, resource-efficient economy. Finally, international developments around climate action and carbon pricing need to be followed closely, and as a result the need for indirect leakage compensation in the first place

AP 1 - Begriffsabgrenzung “Carbon Leakage”

3 Forms and Channels of Carbon Leakage

Das Ergebnis des Arbeitspakets 1.1 "Forms and Channels of Carbon Leakage" wurde im Bericht 16/2018 der Serie „Climate Change“ des Umweltbundesamtes veröffentlicht. Es ist auf der Homepage des Umweltbundesamtes verfügbar:

Görlach, B. und Zelljadt, E.: Forms and Channels of Carbon Leakage, Climate Change 16/2018, Umweltbundesamt, Dessau-Roßlau. Verfügbar unter: https://www.umweltbundesamt.de/publikationen/forms-channels-of-carbon-leakage, zuletzt abgerufen am 20.11.2018

4 Investitionsverhalten in ausgewählten Industriebranchen im EU ETS – Empirische Analyse und Fallbeispiele

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Abkürzungsverzeichnis des Teilberichts

Abkürzung	Bedeutung
CDM	Clean Development Mechanism
CGE	Computable General Equilibrium (allgemeines Gleichgewichtsmodell)
DIHK	Deutsche Industrie- und Handelskammertag
EEA	European Economic Area (Europäischer Wirtschaftsraum)
EU	Europäische Union
EU ETS	EU Emissions Trading System (EU-Emissionshandel)
EUTL	EU Transaction Log
FDI	Foreign Direct Investment (Ausländische Direktinvestitionen)
MWh	Megawattstunde
NAFTA	North Atlantic Free Trade Area
NER	New Entrants' Reserve
OECD	Organisation for Economic Cooperation and Development
PTSC	Port Talbot Steel Company
RGGI	Greenhouse Gas Initiative
WCI	Western Climate Initiative

4.1 Einleitung und Hintergrund

Investitionsleakage bezeichnet einen Prozess, wonach Unternehmen – im Vergleich zu einer hypothetischen Alternative, in der alle Länder gleich ambitionierte Klimapolitik verfolgen – mehr in Produktionskapazitäten an solchen Standorten investieren, die weniger stark reguliert sind, und weniger an Standorten, die stärker reguliert sind (Marcu u. a. 2013, 4).[6] Im Vergleich zu Produktionsleakage (operational leakage) spielt sich Investitionsleakage in der mittleren Frist ab: Als Folge der unterschiedlich starken Regulierung entstehen vergleichsweise höhere Kosten für inländische Unternehmen. Dies verringert die Wettbewerbs- und Ertragsfähigkeit und führt zu geringeren Marktanteilen und suboptimaler Kapazitätsauslastung. Dies wiederum vermindert die Rendite der getätigten Investitionen im Inland – und macht es damit weniger attraktiv, im Inland zu investieren. Daher fließen (im Vergleich zur hypothetischen Alternative) mehr Investitionen an ausländische Standorte. In der Folge sind die Produktionskapazitäten im Ausland größer, und im Inland geringer (Sachverständigenrat für Umweltfragen 2016, 113). Die empirische Relevanz des Phänomens, gerade auch im Vergleich zu anderen Einflussgrößen mit Wirkung auf Standortwahl und Investitionsverhalten, bleibt jedoch umstritten. Das folgende Kapitel soll zunächst anhand statistischer Daten, anhand von Befragungsergebnissen sowie einer kurzen Übersicht der relevanten Literatur eine Einordnung vornehmen.

4.2 Empirische Befunde zur Investitionsleakage

Um sich der Frage der Investitionsleakage empirisch zu nähern, gibt das folgende Kapitel zunächst einen Überblick über die Trends und Größenordnungen im Bereich der Auslandsinvestitionen für die relevanten Sektoren. Um diese Trends zu illustrieren, werden Daten zum Investitionsverhalten für ausgesuchte Branchen (bspw. Eisen/Stahl, Chemie, Nichteisenmetalle, mineralverarbeitende Industrie, Papier- und Zellstoffindustrie sowie Raffinerien) dargestellt. Wesentliche Datenquelle hierfür ist die Bestandserhebung über Direktinvestitionen, die die Deutsche Bundesbank jährlich veröffentlicht. Diese Auswertung dient aber lediglich dazu, die Trends und Größenordnungen bei den deutschen Auslands-investitionen darzustellen, und somit den Rahmen abzustecken, innerhalb dessen sich Investitionsleakage, wenn und wo es sie gibt, abspielt. Die statistische Auswertung stellt keine Analyse möglicher Investitionsleakage dar, da diese sich allein anhand der statistischen Daten nicht von anderen Einflussfaktoren trennen ließe.

Im Abschnitt 2.2 werden anschließend die Ergebnisse mehrerer Befragungen unter Unternehmen dargestellt, in denen auch explizit die Motive für Investitionen erfragt wurden. Diese Daten lassen, im Unterschied zu den statistischen Analysen, somit auch Rückschlüsse auf die Gründe für Investitionen zu – decken aber dafür nur einen Teil der Unternehmen ab.

Statistische Daten: Jährlicher Bericht der Deutschen Bundesbank „Bestandsangaben zu Direktinvestitionen“

Die deutsche Bundesbank erstellt seit 1998 eine jährliche Sonderveröffentlichung zu Kapitalverflechtung mit dem Ausland (seit 2007 unter dem Namen „Bestandserhebung über Direktinvestitionen“), die weitgehend nach Sektor und Auslandsregion der Investitionsströme unterscheidet und daher ein detaillierteres Bild der Investitionsströme liefert. Hier wurde die Zeitspanne von 2003 (zwei Jahre vor Einführung des EU ETS) bis 2014 (aktuellste Angaben zum Zeitpunkt der Erstellung dieses Arbeitspakets) betrachtet. Dabei wird unterschieden zwischen

[6] Da die Diskussion um Carbon Leakage in der Regel nur in den Ländern geführt wird, die sich zu den stärker regulierten zählen, wird dieser Sachverhalt auch dargestellt als „stärkere Regulierung und daher geringere Investitionen im Inland / in der EU, schwächere Regulierung und daher höhere Investitionen im (nicht-EU-)Ausland.“

Investitionen ins *außereuropäische* Ausland (also Länder außerhalb der EU), und Investitionen in den Mitgliedsstaaten der EU – da letztere dem EU-Emissionshandelssystem unterliegen und man daher davon ausgehen kann, dass Investitionsleakage für diese Investitionen keine Rolle spielt. Die Entscheidung für bestimmte Parameter innerhalb der zur Verfügung gestellten Datensätze erklärt sich wie folgt:

Die Daten umfassen sowohl deutsche Direktinvestitionen im Ausland als auch ausländische Direktinvestitionen in Deutschland (sogenannte „passive Direktinvestition"), wobei jeweils nach Ziel- oder Anlageland der deutschen Investoren bzw. Herkunftsland der ausländischen Investoren unterschieden wird. Innerhalb dieser Einteilung wird (innerhalb der Kategorie „alle Wirtschaftszweige") zwischen verschiedenen Wirtschaftszweigen und deren Untergruppen unterschieden.[7] Hieraus wurden bei den *Inlandsinvestitionen* diejenigen Wirtschaftszweige ausgewählt, die besonders emissionsintensiv sind, und daher (größtenteils oder vollständig) in den Anwendungsbereich des ETS fallen, wie z.B. Papierherstellung, chemische Industrie („Herstellung chemischer Produkte"), Kokereien und Mineralölverarbeitung, Metallerzeugung und -bearbeitung, und Herstellung von Metallerzeugnissen.[8] Dies wird etwas kompliziert dadurch, dass im Betrachtungszeitraum die zugrundeliegende Klassifikation der Wirtschaftszweige angepasst wurde.[9] Die *Auslandsinvestitionen* jedoch sind nach Anlageland (Zwecks Leakage-Untersuchung in die Sammelrubriken „EU-Länder" und „nicht-EU-Länder" bearbeitet) *und* nach Wirtschaftszweig nur über eine Sonderauswertung seitens der Bundesbank und entsprechende Daten nur für die Branchen „Herstellung chemischer Produkte" und „Metallerzeugung und -bearbeitung" verfügbar.

Zusätzlich wird bei Auslandsinvestitionen zwischen dem Wirtschaftszweig *des Investitionsobjekts* (in welche Branche wurde investiert) und dem Wirtschaftszweig *der deutschen Investoren* (welcher Branche ist das investierende Unternehmen zuzuordnen) unterschieden. Zunächst mag hier der letztere Ansatz relevanter erscheinen, um sich der Frage anzunähern, ob der ETS das Investitionsverhalten deutscher Unternehmen beeinflusst hat. Allerdings wird die Aussagekraft dieser Statistik durch die Beteiligung von Holding-gesellschaften geschmälert, die nicht zum jeweiligen Wirtschaftszweig gezählt werden: Größere Investitionen in industrielle Infrastruktur werden aktuell (und zunehmend) über Holdinggesellschaften getätigt. Diese zählen in der Bundesbankkategorisierung zum *Finanzsektor* und werden deshalb nicht als Investoren im deutschen verarbeitenden Gewerbe erfasst.[10] Daher wurde für die folgende Analyse der erstere Ansatz verfolgt, d.h. die Klassifizierung nach dem Ziel der Investitionen.

Eine weitere Unterscheidung betrifft die Abgrenzung zwischen "unmittelbaren Direktinvestitionen" und "unmittelbaren und mittelbaren (konsolidierten) Direktinvestitionen".

[7] Beispielsweise zwischen „Erbringung von Finanz- und Versicherungsdienstleistungen" und „verarbeitendem Gewerbe", wobei unter letzterem wiederum zwischen u.a. „Nahrungsmittelherstellung" und „Herstellung chemischer Produkte" unterschieden wird.

[8] Die Wirtschaftszweigklassifikation der Bundesbank richtet sich in Gliederung nach Branchen und wirtschaftlichen Aktivitäten nach der "Klassifikation der Wirtschaftszweige (WZ 2008)" des Statistischen Bundesamtes, die ihrerseits auf der "Statistischen Systematik der Wirtschaftszweige in der Europäischen Gemeinschaft (NACE Rev. 2)" basiert. Beispielsweise umfasst „Metallerzeugung und -bearbeitung" (NACE C24) nach dieser Systematik die emissionsintensiven Prozesse der Erzeugung von Rohmetallen in Metallwerken sowie Blech-, Band-, Rohrherstellung, aber auch die Erzeugung und erste Bearbeitung von Nichteisenmetallen wie Aluminium. Die gesamte Systematik mit Erklärungen der einzelnen Wirtschaftszweige und -unterzweige wird in der Sonderveröffentlichung der deutschen Bundesbank „Bankstatistik Kundensystematik" vom Juli 2017 dargelegt.

[9] Inwiefern diese die Aussagekraft der Daten in einzelnen Sektoren mindert, konnte nicht festgestellt werden, da für eine Auflistung aller Wirtschaftsektorenabgrenzungen der Bundesbank und deren Veränderung über die Zeit eine umfassende Erklärung des zuständigen Bundesbankpersonals notwendig wäre. Ein solches Interview ist außerhalb des Umfangs dieses Arbeitspakets, aber spezifische Erläuterungen zu den Definitionsänderungen im Chemiesektor wurden bereitgestellt.

[10] Die nach Wirtschaftszweig der Investoren sortierten Investitionsmengen fallen bei der Kategorie „Erbringung von Finanz- und Versicherungsdienstleistungen" extrem hoch aus – Investitionen von Akteuren in einschlägigen Sektoren erfasst diese Menge nicht.

Bei letzteren handelt es sich einerseits um mittelbare Kapitalbeziehungen aus Beteiligungen von Inländern an ausländischen Unternehmen über abhängige Holdinggesellschaften mit Sitz im Ausland, und andererseits um mittelbare Kapitalbeziehungen aus Beteiligungen von Ausländern an inländischen Unternehmen über abhängige Holdinggesellschaften mit Sitz in Deutschland. Die folgende Auswertung nutzt bei Inlands- und Auslandsinvestitionsdaten jeweils die konsolidierte Variante, da diese über ausländische Holdinggesellschaften gehaltene Beteiligungen mit einschließt und somit das Endanlageinteresse besser herausstellt.

Zu beachten ist bei der Betrachtung der Daten, dass die Berechnungsweise ab 2010 umgestellt wurde, um neuen international harmonisierten Berechnungsvorgaben zu entsprechen.[11] Durch diesen methodischen Bruch sind die Werte nicht über den gesamten Zeitraum vergleichbar, sondern nur jeweils vor und nach dem Jahr 2010. Der Unterschied in der Berechnungsweise spiegelt sich in der plötzlichen Abnahme an Investitionsmengen von 2009 zu 2010 wieder, der besonders bei den Grafiken zu Inlandsinvestitionen deutlich zu erkennen ist.

Bei den **Auslandsinvestitionen** unterscheidet die Sonderauswertung sowohl nach *Anlageland der Investition* als auch nach *Wirtschaftszweig des Investitionsobjekts*. Bei letzterem wiederum lassen sich für zwei Unterzweige des Wirtschaftszweigs „verarbeitendes Gewerbe“ die Investitionsvolumina nach Anlageland aufteilen („Herstellung von chemischen Erzeugnissen“ und „Metallerzeugung und -bearbeitung“). Innerhalb der Länderkategorisierung werden alle EU Mitgliedstaaten gesondert ausgewiesen, sodass die Investitionsmengen innerhalb der EU mit denen außerhalb der EU verglichen werden können. Sollte Investitionsleakage stattgefunden haben, so müsste sich dies in einem starken Anstieg der außereuropäischen Investitionen im Vergleich zu den innereuropäischen Investitionen gleicher Art niederschlagen.[12]

In der Tat weisen die Ergebnisse in den emissionsintensiven Sektoren chemische Industrie und Metallerzeugung eine stärkere Zunahme der Investitionen außerhalb der EU auf, der für die Wirtschaft allgemein („alle Wirtschaftszweige“) in dieser Form nicht festzustellen ist: Von 2003 – 2009 nahm der Anteil an Investitionen außerhalb der EU für alle Wirtschaftszweige insgesamt ab, während er für Metall- und Chemieinvestitionen in dieser Zeit anstieg. Dieser Anstieg fand vor allem in der ersten Hälfte der Nuller Jahre statt, seither ist der Trend weniger eindeutig.

[11] In der 4. Auflage des "OECD Benchmark Definition of Foreign Direct Investment” werden, abweichend von der zuvor angewandten Bruttodarstellung, Kapitalbeziehungen innerhalb multinationaler Konzerne saldiert, Kredite an Kapitaleigner in Abzug gebracht und grenzüberschreitende Schwesterkredite in Abhängigkeit des Sitzes der Konzernzentrale zugeordnet.

[12] Im Prinzip ist für diese Bewertung zusätzlich auch die Entwicklung der Investitionen deutscher Unternehmen in Deutschland relevant. Jedoch sind diese in der hier erwähnten Statistik (jährliche statistische Sonderveroeffentlichung der Bundesbank "Bestandserhebung über Direktinvestitionen") nicht enthalten, da diese sich auf Auslandsinvestitionen konzentriert. Um diese zu ergänzen, müssten die Daten aus anderen Quellen herangezogen werden; der Aufwand einer damit verbundenen Prüfung auf Konsistenz, korrekte Sektorabgrenzung etc. überstiege jedoch den Umfang dieser Arbeiten.

Abbildung 1: Unmittelbare und mittelbare deutsche Direktinvestitionen im Ausland

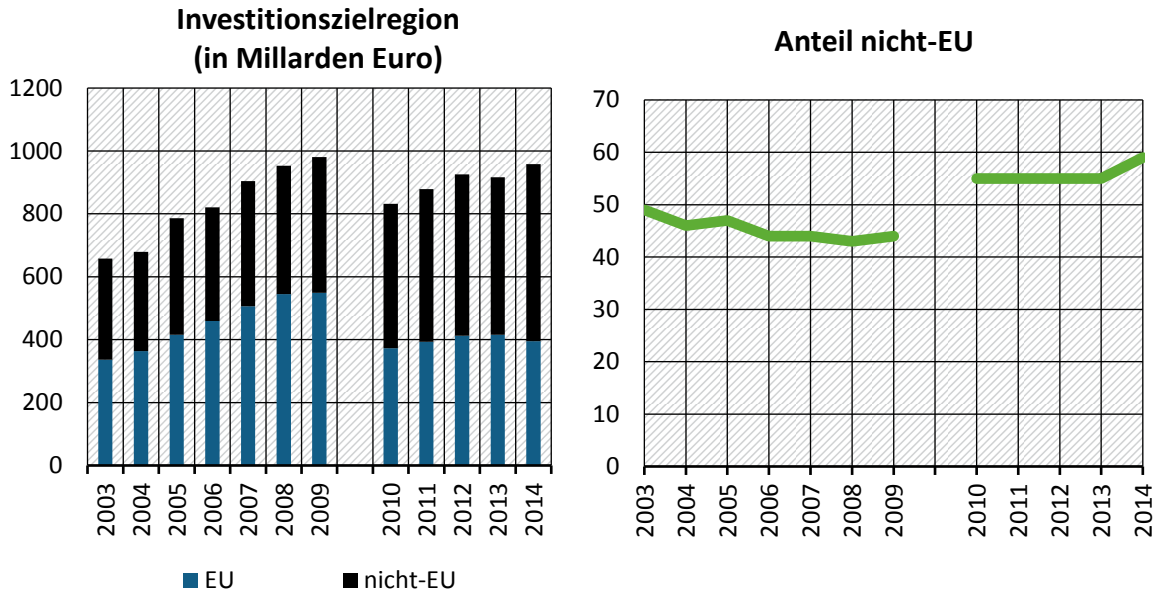


Abbildung 2: Unmittelbare und mittelbare deutsche Direktinvestitionen im Ausland, Metallindustrie

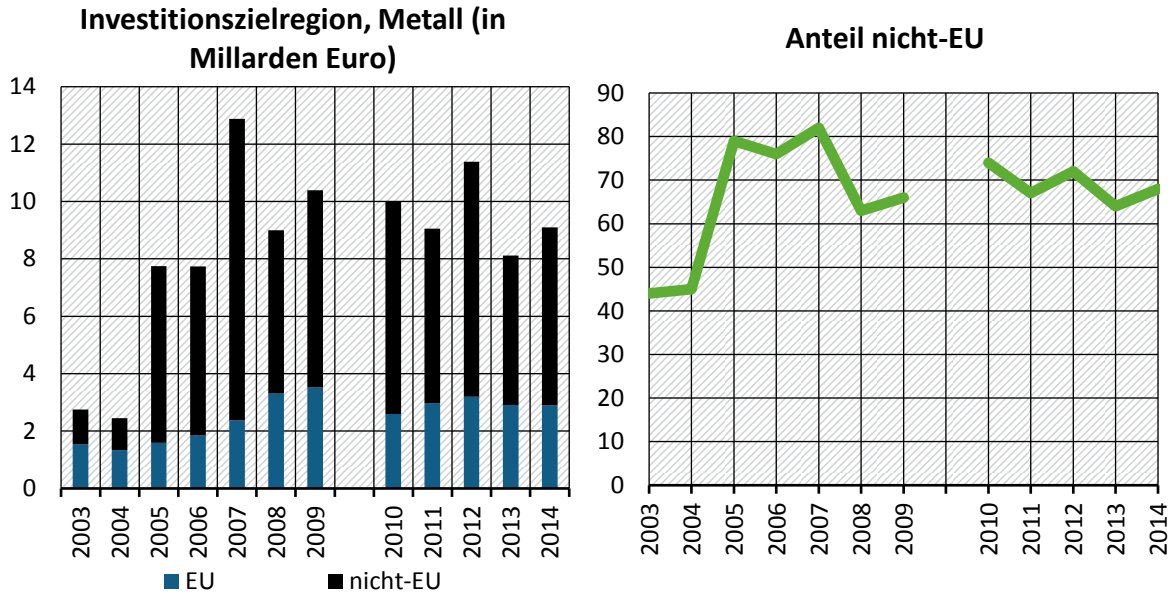
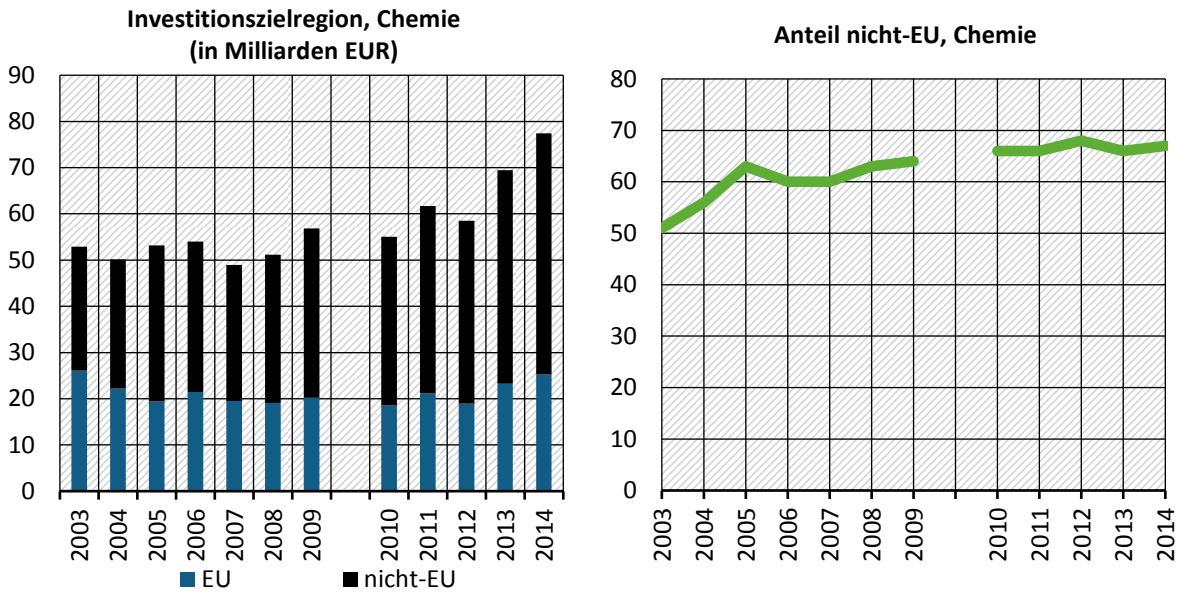


Abbildung 3: Unmittelbare und mittelbare deutsche Direktinvestitionen im Ausland, chemische Industrie



Datenquelle für Abbildungen 1-3: Eigene Darstellung, basierend auf: Deutsche Bundesbank Zentrale für außenwirtschaftliche Bestandsstatistiken, Sonderauswertung auf Anfrage bereitgestellt von Tim Thormeyer.

Bei den **Inlandsinvestitionen** steigen die Investitionsmengen ausländischer Investoren in Deutschland in der Gesamtwirtschaft deutlich an. In den Wirtschaftsbranchen Chemie und Metall weisen sie jedoch über den betrachteten Zeitraum insgesamt eine abnehmende Tendenz auf, obwohl die Anzahl der Unternehmen mit ausländischer Kapitalbeteiligung im jeweiligen Wirtschaftszweig steigt.

Abbildung 4: Unmittelbare und mittelbare ausländische Direktinvestitionen in Deutschland (konsolidiert), alle Wirtschaftszweige

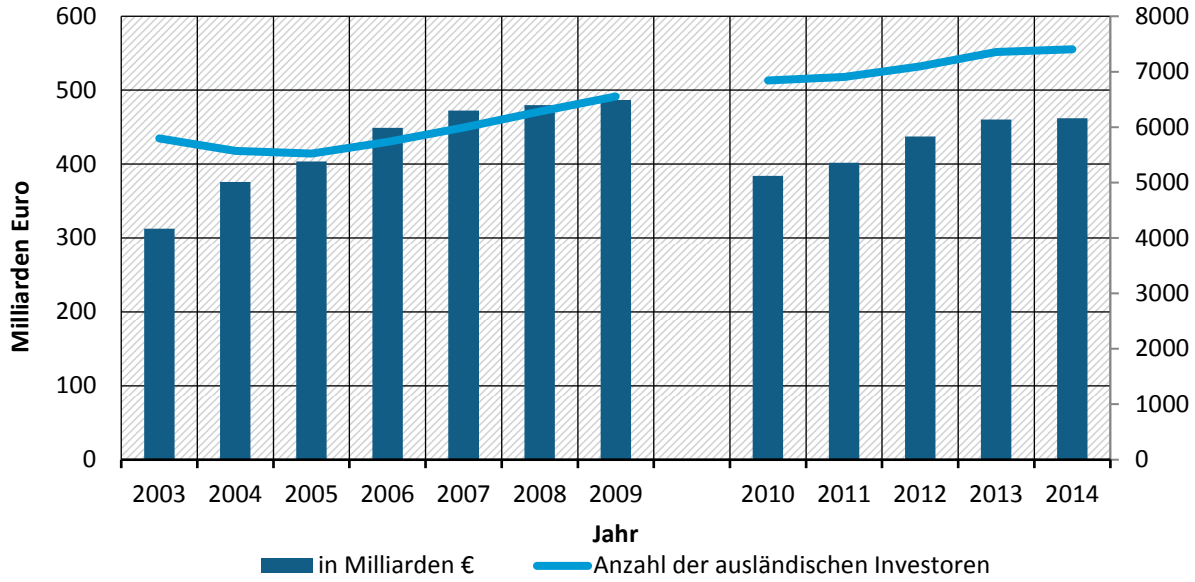


Abbildung 5: Unmittelbare und mittelbare ausländische Direktinvestitionen in Deutschland, Metallindustrie

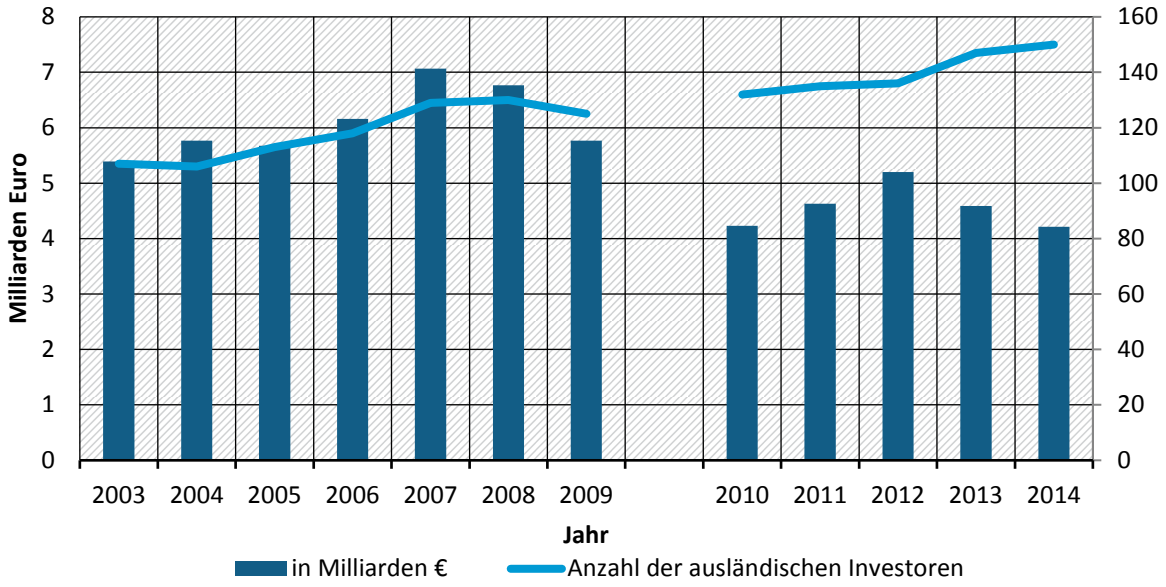
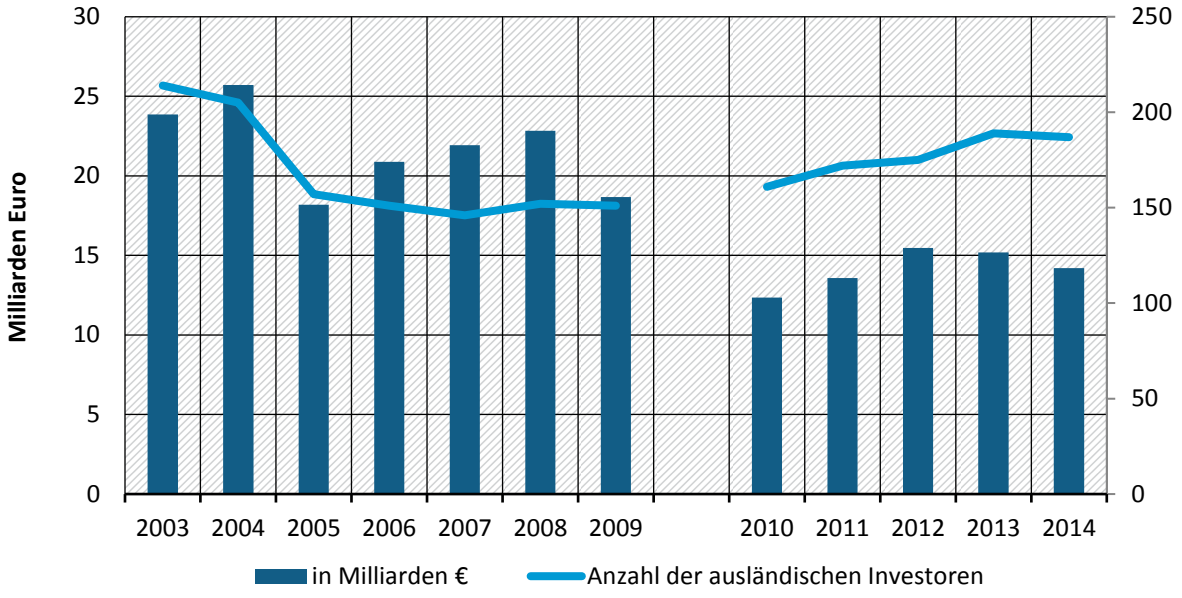


Abbildung 6: Unmittelbare und mittelbare ausländische Direktinvestitionen in Deutschland, chemische Industrie



Datenquelle Abbildungen 4-6: Eigene Darstellung, basierend auf: Jährliche statistische Sonderveröffentlichungen der Bundesbank „Bestandserhebung über Direktinvestitionen“ 2003-2016. Im PDF-Format jeweils online verfügbar unter https://www.bundesbank.de/Navigation/DE/Publikationen/Statistiken/Statistische_Sonderveroeffentlichungen/Statso_10/statistische_sonderveroeffentlichungen_10.html).

Neben dem erwähnten methodischen Bruch ab 2010 sind in der chemischen Industrie die Investitionsdaten der Jahre 2002-2004 nur eingeschränkt zu berücksichtigen, da der untersuchte Wirtschaftszweig „Herstellung von chemischen Erzeugnissen“ in den Jahren noch „Herstellung von pharmazeutischen Erzeugnissen" erfasste – ab 2005 wurde letzterer als eigener Wirtschafts(unter)zweig getrennt erfasst. Da er laut Bundesbanksystematik Aktivitäten

umfasst, die nicht zur Primärproduktion gehören,[13] wird die Herstellung von pharmazeutischen Erzeugnissen in den In- und Auslandsinvestitionsdaten des Bereichs Chemie ansonsten *nicht* erfasst.

Im Durchschnitt zeigen die Zeitreihen der Bundesbankdaten einen **Anstieg der Auslandsinvestitionen** seit 2003, sowohl in der Gesamtwirtschaft als auch in den emissionsintensiven Branchen Metall und Chemie, in denen gerade die Jahre 2005 – 2008 von einer Hochkonjunktur geprägt waren. Dabei **wachsen nicht-EU-Investitionen stärker** als solche innerhalb der EU; ein rückläufiger Trend des Anteils von nicht-EU-Investitionen ist bis 2009 festzustellen, hat sich in der Folge aber umgekehrt. Allgemein spiegeln die zwei emissionsintensiveren Sektoren in dieser Zeitspanne den Trend der Gesamtwirtschaft wider. Bei den **Inlandsinvestitionen** ausländischer Unternehmen (EU und nicht-EU) hingegen ist dies nicht der Fall: Während die Investitionen aus dem Ausland seit 2003 gesamtwirtschaftlich angestiegen sind, nahm die Menge ausländischer Investitionen in Metall und Chemie ab. Sowohl in der Gesamtwirtschaft als auch in den einschlägigen Wirtschaftszweigen nahm die *Anzahl* der investierenden Unternehmen mit ausländischer Beteiligung zu, was sich mit der zunehmenden Internationalisierung der Eigentümerschaft und der Firmenbeteiligungsverhältnisse in der Wirtschaft allgemein deckt, für die die für diesen Bericht analysierten jährlichen Finanzberichte einschlägiger Firmen Anhaltspunkte liefern.

4.3 Umfragen unter Unternehmen

4.3.1 Umfrage des Deutschen Industrie- und Handelskammertags zu Auslandsinvestitionen

Seit 2004 befragt der Deutsche Industrie- und Handelskammertag (DIHK) jährlich seine über sechstausend Mitglieder über ihre Auslandsinvestitionspläne – die Ergebnisse erscheinen jeden Sommer als Bericht (DIHK 2016) und die dazugehörigen Datensätze wurden auf Anfrage zur Verfügung gestellt. Obwohl die Sektoreinteilung dieser Umfrage nicht ausreichend detailliert ist, um besonders emissionsintensive Produktionsverfahren gezielt zu analysieren (sie unterscheidet zwar grob zwischen den Kategorien „chemische Industrie“ und „Metallerzeugung und -bearbeitung“ aber nicht zwischen Primärproduktion und Weiterverarbeitung), geben sie dennoch einen allgemeinen Überblick über Investitionstrends in der jeweiligen Branche. Gegenüber anderen Daten zu Auslandsinvestitionen der Industrie bieten die Umfrageergebnisse drei Vorteile:

- Die Umfrage wurde in fast identischer Form bei fast identischer Befragtengruppe (Mitglieder des DIHK, also Firmen) über 12 Jahre durchgeführt – dies erlaubt einen kohärenten Vergleich über die gesamte Zeitspanne.
- Die Fragestellung lässt Firmen geografische Regionen angeben, welches einen Einblick in den zu untersuchenden Trend zu Investitionen außerhalb der EU gewährt.
- Die Frage zum *Funktionsschwerpunkt* der Auslandsinvestitionen gibt zudem Informationen über das *Motiv* der Firma, im Ausland zu investieren, wie sie aus statistischen Daten nicht hervorgehen. Zwar sind die generischen Antwortkategorien (wie z.B. „Kostengründe“ noch zu allgemein, um einen Rückschluss auf Investitionsleakage zuzulassen, lassen aber zumindest einen Rückschluss darauf zu, welchen Stellenwert Kostengründe insgesamt (und

[13] Zum Beispiel Verarbeitung von Blut und Drüsen, Herstellung von medizinischer Watte, Gaze, Verbandszeug, usw. Siehe *Bankenstatistik Kundensystematik*, Seite 56.

als Teil dessen *auch* der CO_2-Preis) gegenüber anderen Kriterien für die Investitionsentscheidungen haben.

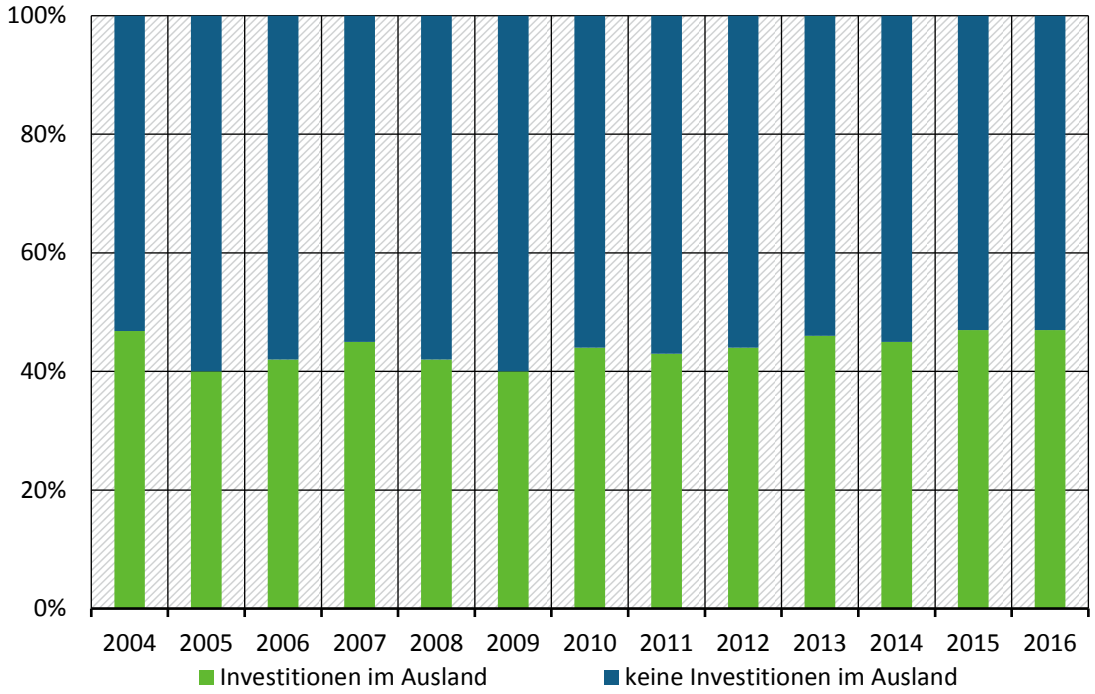
Einschränkend muss aber auch angemerkt werden, dass die – insgesamt gute – Fallzahl der Antworten geringer wird, wenn spezifische Fragen für einzelne Wirtschaftszweige betrachtet werden.[14] Das bedeutet, dass etwa ein Vergleich zur Motivlage für Investitionen über einzelne Branchen hinweg mit größeren Unsicherheiten behaftet ist.

Die drei Fragen, von denen die hier dargestellten Ergebnisse abgeleitet sind, erschienen wie folgt in der Umfrage:

1. Wie werden sich die Ausgaben Ihres Unternehmens für Investitionen im Ausland im Jahr xxxx im Vergleich zum Vorjahr entwickeln? (höher / gleich bleibend / geringer)
2. Wo plant Ihr Unternehmen im Jahr xxxx Auslandsinvestitionen zu tätigen? (EU-15 / Neue EU Mitgliedsländer seit 2004/2007 / Russland, Ukraine, Südosteuropa (ohne EU-Länder), Türkei / China / Asien ohne China / Nordamerika / Südamerika und andere)
3. Welchen Funktionsschwerpunkt haben die Auslandsinvestitionen Ihres Unternehmens im Jahr xxxx? (Produktion zwecks Kostenersparnis / Produktion zwecks Markterschließung / Vertrieb/Kundendienst)

Allgemein haben weniger als die Hälfte der befragten Firmen überhaupt Auslandsinvestitionspläne – während Firmen in der Metallerzeugung und -bearbeitung diesen Durchschnitt widerspiegeln, sind deutsche Chemieunternehmen überdurchschnittlich auslandsinvestitionsfreudig.

Abbildung 7: Auslandinvestitionspläne deutscher Unternehmen im Vergleich (6262 Antworten)



[14] Die Anzahl der befragten Firmen, bei denen zutrifft, dass sie (a) überhaupt Auslandsinvestitionen planten, (b) dies zwecks Kostenersparnis taten, (c) zu den Sektoren Chemie oder Metallerzeugung und -bearbeitung gehören, und (d) Investitionen in Regionen außerhalb der EU planten, sank bei den über 6000 befragten Firmen auf nur 28.

Abbildung 8: Investitionspläne der deutschen Metallerzeugungs- und -bearbeitungsunternehmen im Ausland (242 Antworten)

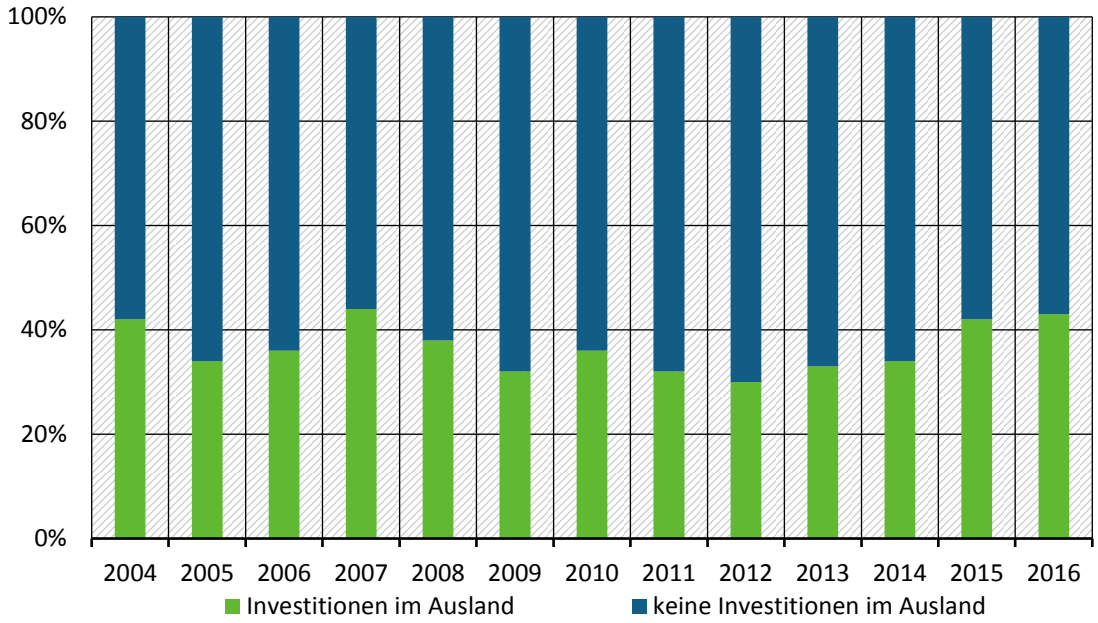
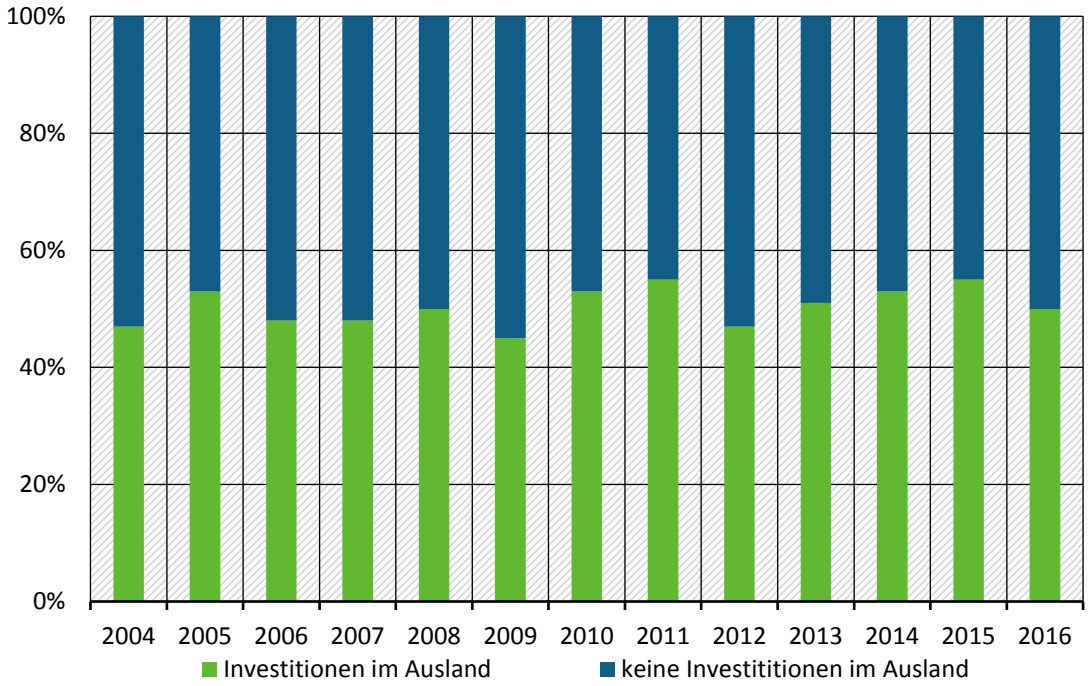


Abbildung 9: Investitionspläne der deutschen Chemieunternehmen im Ausland (291 Antworten)



Datenquelle Abbildungen 7-9: Deutscher Industrie- und Handelskammertag (2016): Umfrage "Auslandsinvestitionen in der Industrie 2016."

Bei der Frage zum Motiv der Auslandsinvestition hingegen nennen Firmen in der Metallindustrie überdurchschnittlich häufig „zwecks Kostenersparnis“ – das heißt, ein größerer Anteil sieht hohe Kosten in Deutschland als Grund, in anderen Regionen zu investieren.

Abbildung 10: Funktionsschwerpunkt der Auslandsinvestitionen deutscher Firmen im Vergleich, alle Wirtschaftszweige (Antworten = 1634)

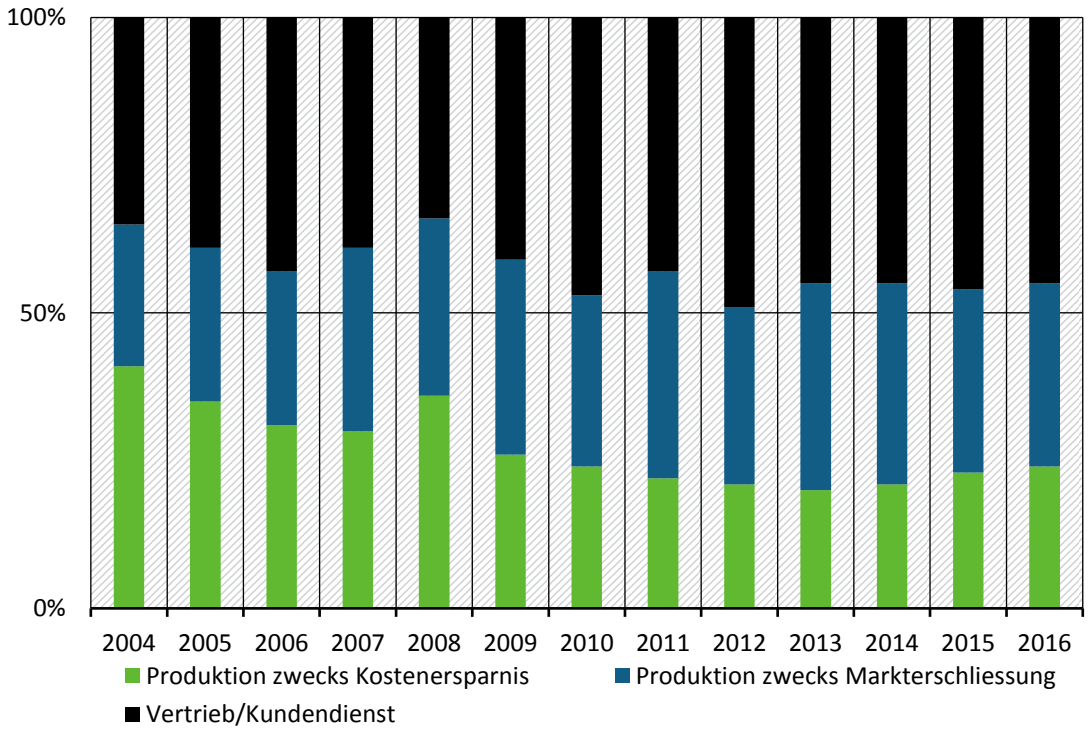


Abbildung 11: Funktionsschwerpunkt der Auslandsinvestitionen, Metallerzeugung und -bearbeitung (Antworten = 51)

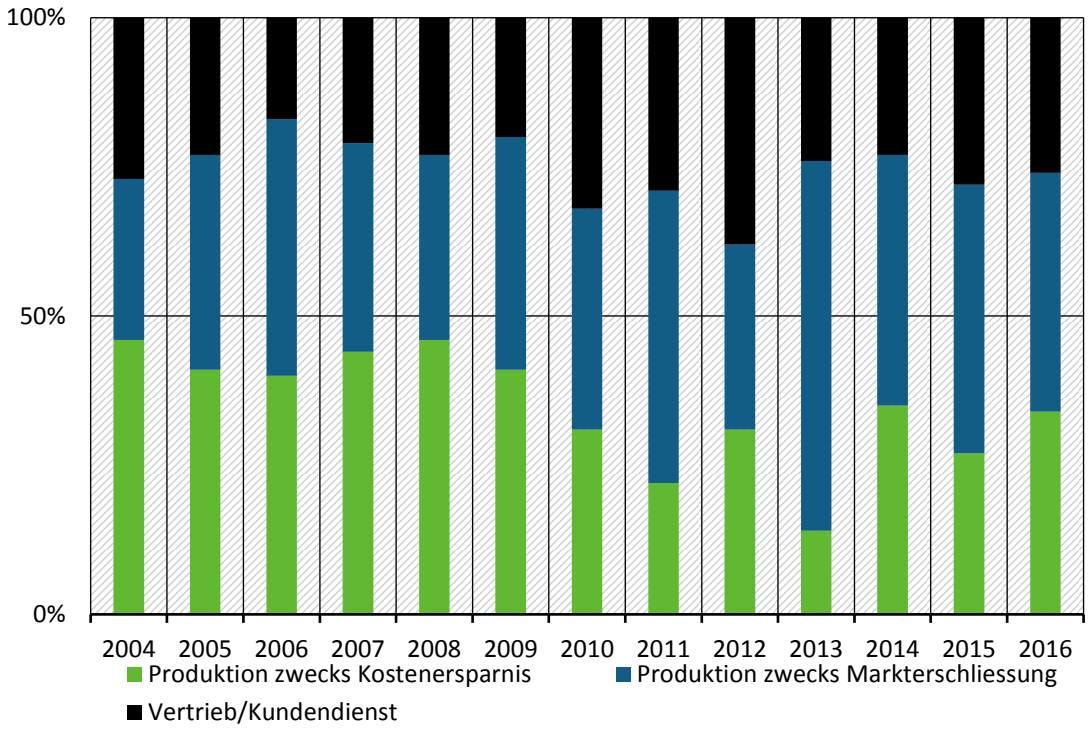
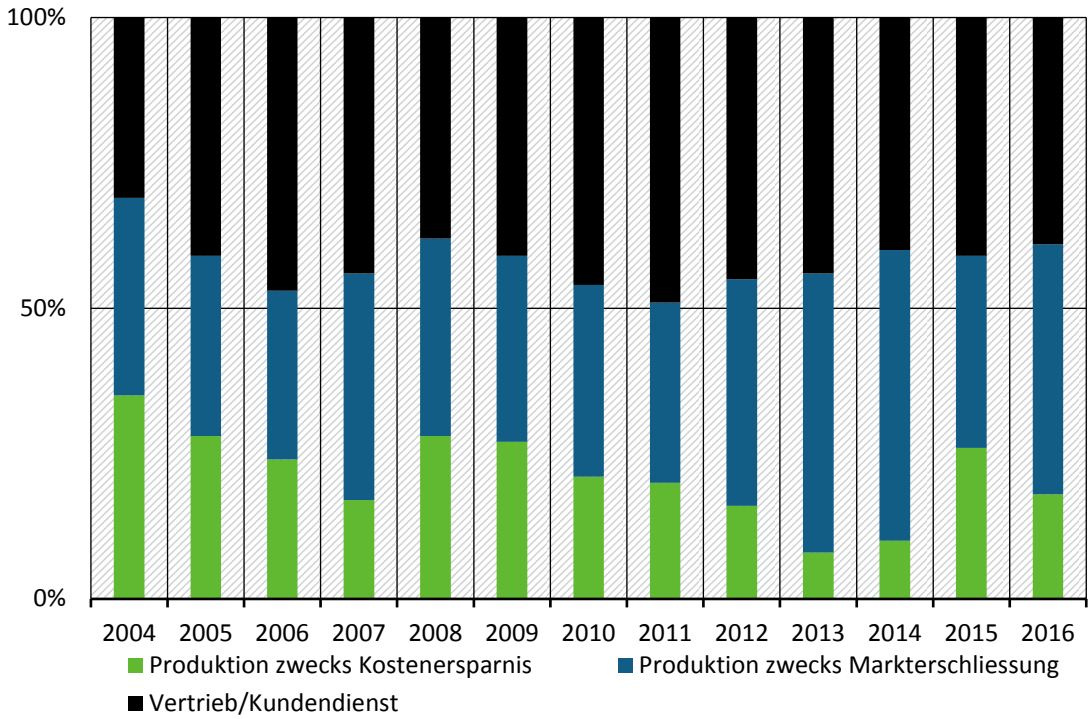


Abbildung 12: Funktionsschwerpunkt der Auslandsinvestitionen, chemische Industrie (Antworten = 95)



Datenquelle Abbildungen 10-12: Deutscher Industrie- und Handelskammertag (2016): Umfrage "Auslandsinvestitionen in der Industrie 2016."

Interessanterweise hat die Bedeutung Kostenerparnis als Motiv für Investitionen seit 2004 deutlich abgenommen – dies gilt sowohl allgemein, aber auch für die chemische und die Metallindustrie. Der Tiefpunkt lag für alle Branchen im Jahr 2013; in diesem Jahr gab nur jedes fünfte Unternehmen an, dass die Investition primär der Kostenersparnis dienen sollte; für Chemie und Metall lagen die Anteile sogar noch darunter. Danach hat die Bedeutung des Kriteriums wieder etwas zugenommen, liegt aber noch stets unter dem Stand der 2000er Jahre. Die steigende Bedeutung der Kostenersparnis seit 2013, wird in den Berichten des DIHK mit den hohen Energiekosten in Deutschland in Verbindung gebracht.[15]

Die **Unterscheidung nach Zielregionen** für die Unternehmen, die aus Kostengründen im Ausland investieren, liefert aktuell kaum Anhaltspunkte für Investitionsleakage: Die wichtigsten Investitionsziele in den Branchen Chemie und Metall sind die EU-Mitgliedstaaten, die Schweiz und Norwegen, und damit Länder die entweder Teil des EU ETS sind, oder einen vergleichbaren Kohlenstoffpreis eingeführt haben. Allerdings wird Nordamerika ebenfalls häufig genannt.

[15] Zitat aus dem Bericht: „Die weitere Öffnung der Energiekostenschere setzt deutsche Industrieunternehmen im internationalen Wettbewerb unter Druck – und gibt so oftmals den Ausschlag, Produktion ins Ausland zu verlagern."

Abbildung 13: Darstellung der Zielländer für Auslandsinvestitionen aus Kostengründen (chemische Industrie, n=14)

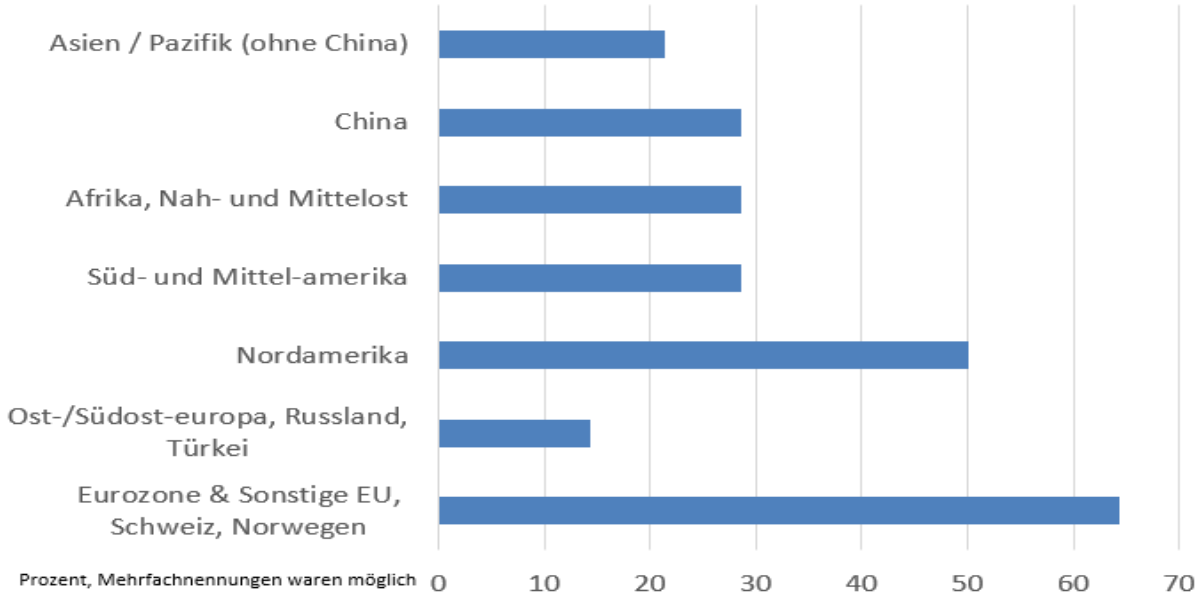
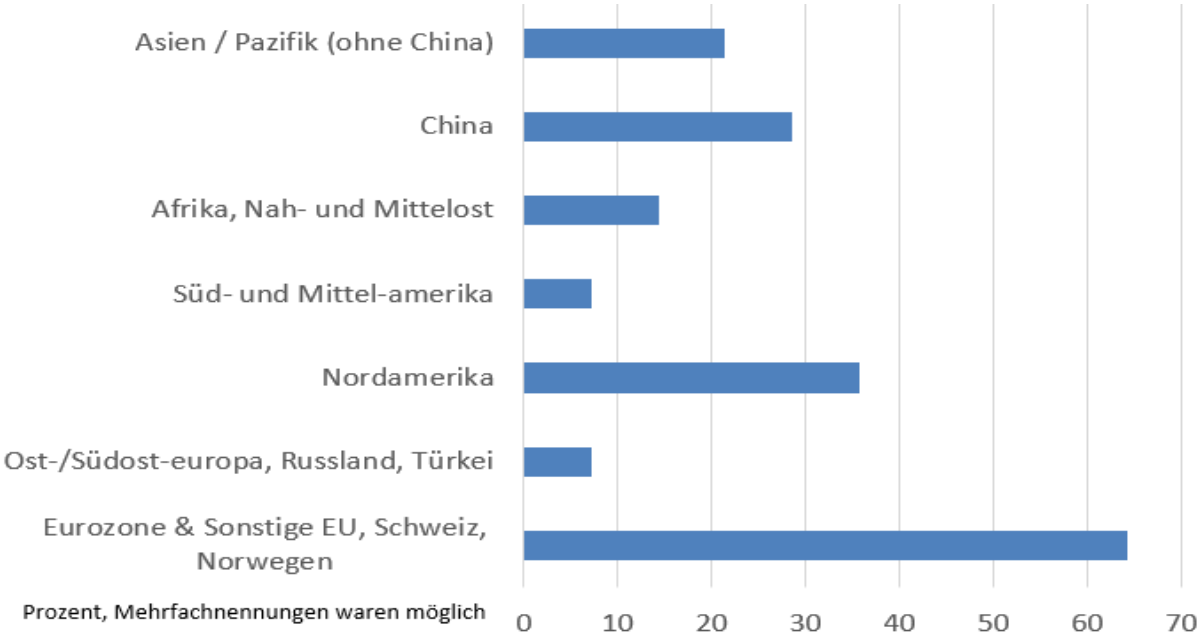


Abbildung 14: Darstellung der Zielländer für Auslandsinvestitionen aus Kostengründen (Metallerzeugung und –bearbeitung, n=14)



Datenquelle Abbildungen 13-14: Deutscher Industrie- und Handelskammertag (2016): Umfrage "Auslandsinvestitionen in der Industrie 2016."[16]

[16] Da diese Datenaufteilung eine zusätzliche Bearbeitung der DIHK erforderte, sind anstatt einer Zeitreihe seit 2004 nur die Aufteilungen für 2016 nach Region verfügbar.

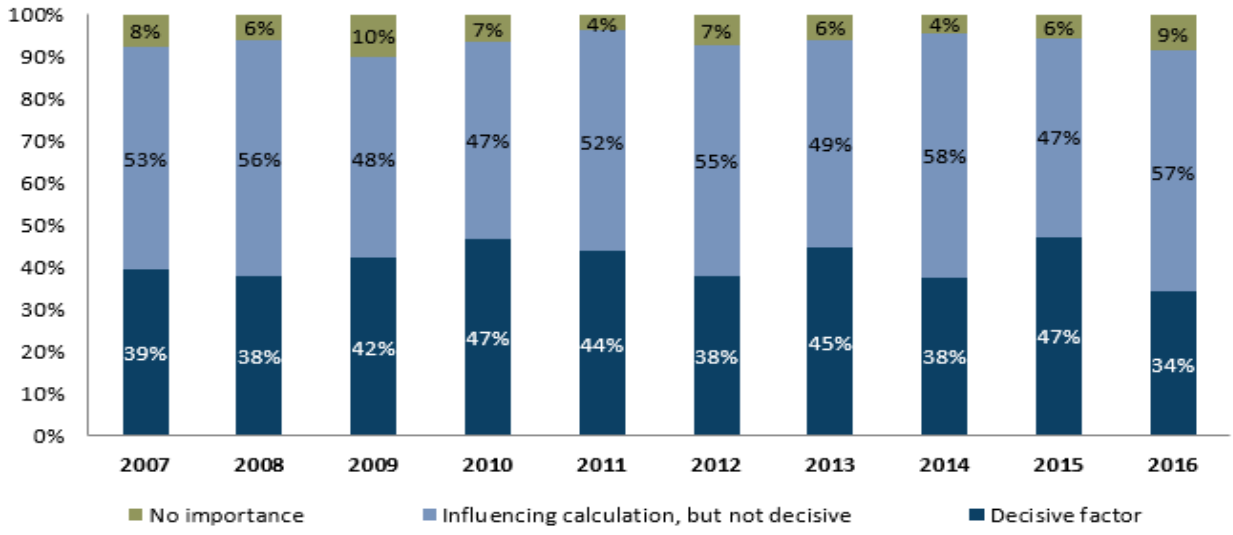
4.3.2 Umfrage von ThomsonReuters zum Einfluss des CO_2-Preis auf das Investitionsverhalten

Eine weitere Quelle relevanter Daten zu Investitionstätigkeit, den zugrundeliegenden Motivationen und möglicher Investitionsleakage ist die jährliche Umfrage von Thomson Reuters (vormals Point Carbon). Die Ergebnisse dieser Umfrage bilden die Grundlage für den Bericht „Carbon 20XX", der jährlich im März erscheint. Der jüngste Bericht „Carbon 2016" enthält gezielte Fragen zu getätigten Investitionen und zu Anhaltspunkten für Carbon Leakage (Nordeng und Kolos 2016). Da die einschlägigen Fragen über die Jahre hinweg nicht einheitlich genug gestellt wurden, eignen sich die Antworten leider nicht für eine Darstellung und Analyse als Zeitreihe. So wurden Fragen etwa von Jahr zu Jahr anders formuliert oder in einigen Jahren nicht gestellt. Die Ergebnisse sind dennoch aussagekräftig genug, um einen Einblick in das Investitionsverhalten industrieller Firmen und die Rolle der CO_2-Preise zu gewähren.

Die Frage „Wie wichtig ist der langfristige CO_2-Preis für die Investitionen Ihrer Firma?" wurde in annähernd gleicher Form seit 2007 gestellt. Dabei geht es allerdings allgemein um die Bedeutung des CO_2-Preises für jegliche Art von Investitionen – unabhängig von Ort und der Art der Investition. Dabei kann es also ebenso um Investitionen im Inland gehen, um die Effizienz bestehender Anlagen zu steigern, wie auch um Investitionen im Ausland, mit dem Ziel dem CO_2-Preis zu entgehen.

Abbildung 15 zeigt die (relativ stabile) Gliederung der Antworten über ein Jahrzehnt. Demnach war der CO_2-Preis Firmen in den Jahren 2010 und 2015 am wichtigsten. Zu beachten ist, dass die Anzahl der Antworten von Jahr zu Jahr sehr unterschiedlich ausfällt. Im Jahr 2016 waren dies 101, von denen 73 Firmen Teil des EU ETS sind (die anderen nehmen an RGGI und WCI teil). Für dieses Jahr stand auch die Aufteilung der Antworten in große und kleine Emittenten zur Verfügung, wobei die Definition von „klein" und „groß" in Bezug auf Emittentengröße nicht erörtert wurde. Nicht alle Befragten wollten oder konnten sich einem Sektor zuordnen, deshalb ist die Sektorgliederung (58 Antworten) im Vergleich zur Gesamtinformation (101 Antworten) weniger aussagekräftig.

Abbildung 15: Antworten auf die Frage "Wie wichtig ist der langfristige CO_2-Preis für Investitionen Ihrer Firma (n = 101)



Datenquelle für Abbildung 15: Umfrageergebnisse 2016, Berichtarchiv. Datenbasis für den Bericht „Carbon 2016." Excel-Dateien © Thomson Reuters. Bereitgestellt und Nutzung genehmigt 2016

Abbildung 16: Aufteilung der Antworten nach Größe des Emittenten (2016, n = 101)

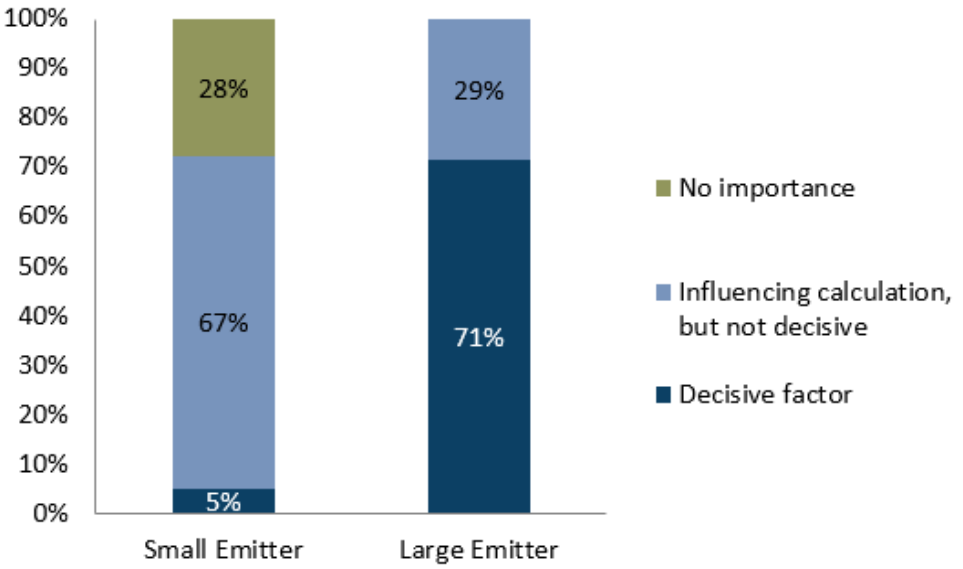
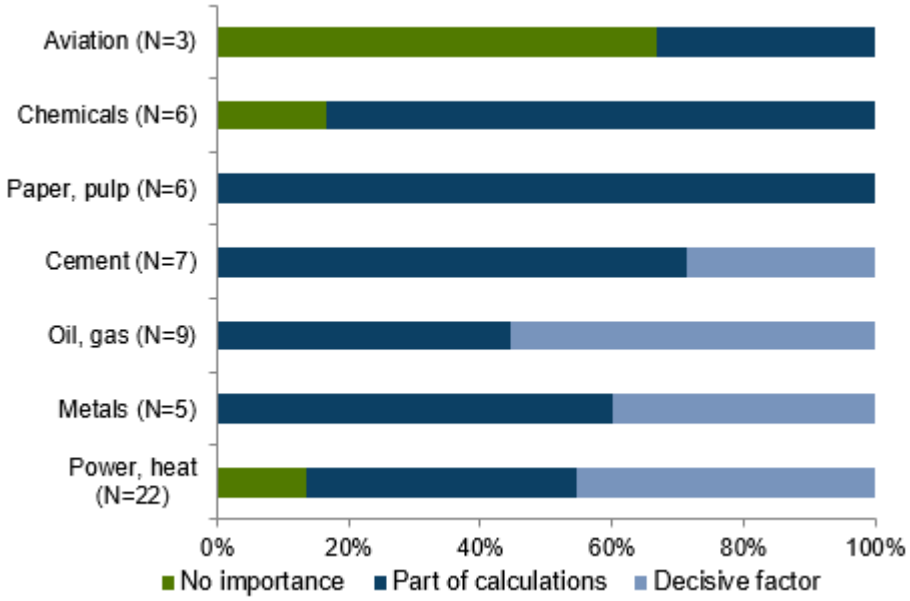


Abbildung 17: Aufteilung der Antworten nach Branche (2016, n = 58)



Datenquelle für Abbildungen 16-17: Umfrageergebnisse 2016, Berichtarchiv. Datenbasis für den Bericht „Carbon 2016." Excel-Dateien © Thomson Reuters. Bereitgestellt und Nutzung genehmigt 2016.Eine andere Frage zielt dagegen direkt auf Leakage ab: Dabei werden Unternehmen gefragt, ob sie in Betracht gezogen haben, wegen des CO_2-Preises ihre Produktion außerhalb der EU zu verlagern, oder ob sie dies bereits getan haben.[17] Dabei lässt die Frage allerdings offen, ob die Verlagerung durch Investition in neue Anlagen geschehen würde (Investitionsleakage), oder auch durch die Verlagerung von Produktionsanteilen zwischen Bestandsanlagen an verschiedenen Standorten innerhalb eines Unternehmens (operationelle Leakage).

[17] "Has your company considered moving production outside the EU ETS area because of carbon costs?"

Die Antworten wurden jedoch nur in einigen Berichtsjahren einzelnen Sektoren zugeordnet (2009, 2010 und 2016), soweit sich Antwortende einem Sektor zugeordnet haben. So wurde die Stahlindustrie in allen Berichten ausgewiesen, wohingegen „Chemie" bis 2016 unter die Kategorie „Sonstige" fiel. Da die Anzahl der Antworten insgesamt und nach Sektor von Jahr zu Jahr sehr unterschiedlich ausfiel, ist eine grafische Darstellung als Zeitreihenvergleich unter den drei Jahren, für die es eine Sektoraufteilung gibt tendenziell irreführend – stattdessen werden die Ergebnisse hier in Tabellenform gezeigt.

Tabelle 1: Produktionsverlagerungen außerhalb der EU nach Sektoren im Jahr 2009

Wirtschaftszweig	Haben bereits verlagert	Ziehen Verlagerung in Betracht	Nicht in Betracht gezogen	Summe
Elektrizität/Wärme	7 (6%)	2 (2%)	111 (93%)	120 (100%)
Metall	0 (0%)	7 (44%)	9 (56%)	16 (100%)
Öl/Gas	2 (5%)	5 (11%)	37 (84%)	44 (100%)
Zement/Kalk/Glas	2 (6%)	12 (38%)	18 (56%)	32 (100%)
Papierprodukte	0 (0%)	3 (20%)	12 (80%)	15 (100%)

Datenquelle: Umfrageergebnisse 2007-2016, Datenbasis für die jeweiligen „Carbon 20XX" Berichte, Excel-Dateien aus dem Thomson Reuters Berichtarchiv. Excel-Dateien. Bereitgestellt und Nutzung genehmigt 2016 von Thomson Reuters.

Tabelle 2: Produktionsverlagerung außerhalb der EU nach Sektoren im Jahr 2016

Wirtschaftszweig	Haben bereits verlagert	Ziehen Verlagerung in Betracht	Nicht in Betracht gezogen	Summe
Elektrizität/Wärme	1 (4%)	2 (9%)	20 (87%)	23 (100%)
Metall	0 (0%)	1 (20%)	4 (80%)	5 (100%)
Öl/Gas	1 (11%)	1 (11%)	7 (78%)	9 (100%)
Zement/Kalk/Glas	0 (0%)	2 (29%)	5 (71%)	7 (100%)
Papierprodukte	0 (0%)	1 (17%)	5 (83%)	6 (100%)

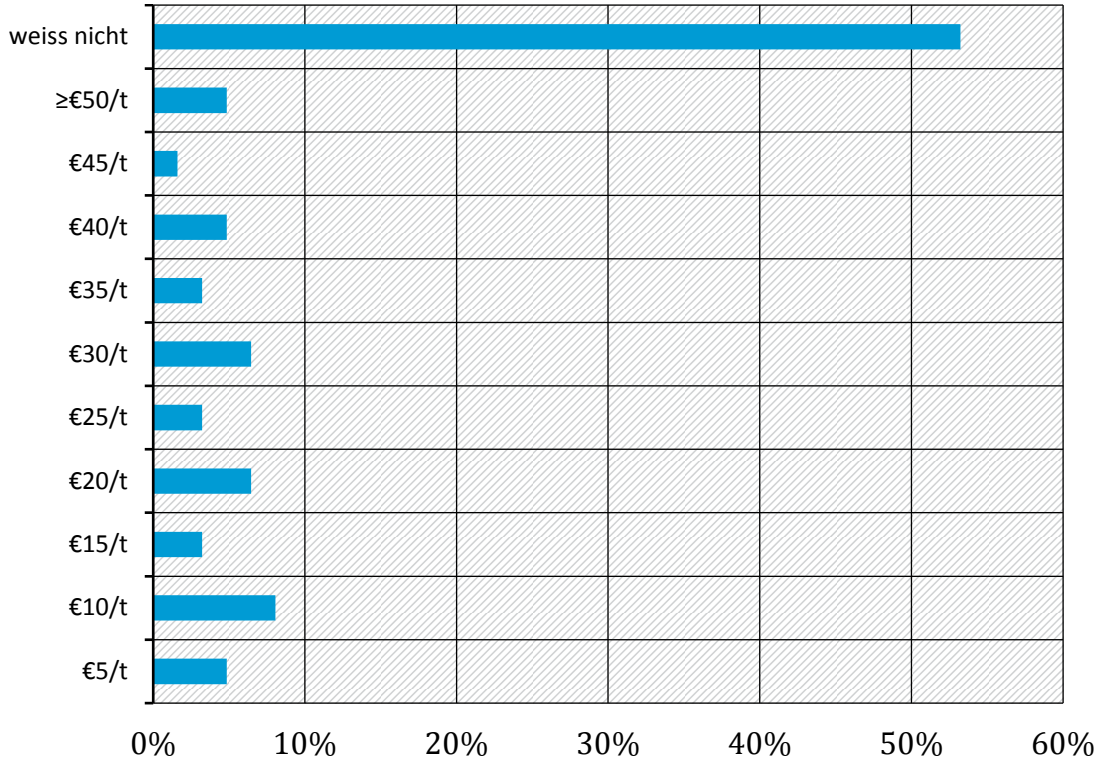
Datenquelle: Umfrageergebnisse 2007-2016, Datenbasis für die jeweiligen „Carbon 20XX" Berichte, Excel-Dateien aus dem Thomson Reuters Berichtarchiv. Excel-Dateien. Bereitgestellt und Nutzung genehmigt 2016 von ThomsonReuters.

Auffallend ist, dass branchenübergreifend für die Mehrzahl der Unternehmen eine Verlagerung der Produktion noch nicht einmal als Option betrachtet wird. Der Anteil der Unternehmen, die bekennen, Produktionsanteile verlagert zu haben, liegt fast durchgängig bei weniger als 10% der befragten Unternehmen. Am ehesten sind solche Tendenzen noch in der Stahl- und der Zementindustrie auszumachen („Ziehen Verlagerung in Betracht").

Eine weitere Frage, die allerdings nur in der jüngsten Umfrage (2016) gestellt wurde, bezieht sich auf die CO_2-Kosten und deren Einfluss auf Ertragsfähigkeit. Dabei wurde gefragt, ab welchem CO_2-Preis die Produktion in der EU für die jeweilige Firma nicht mehr gewinnbringend ist. Von den 62 diesbezüglich befragten Firmen (alle Emittenten mit Teilnahmepflicht am EU ETS) konnten oder wollten mehr als die Hälfte diese Frage nicht beantworten. 17% der

Antworten nannten einen relativ niedrigen (€10) Preis, wohingegen im Schnitt (Median) etwa 20 bis 25 Euro angegeben wurden.

Abbildung 18: Antworten auf die Frage „Bei welchem CO_2-Preis ist Ihre Produktion in Europa nicht mehr profitabel?“ (n = 62)



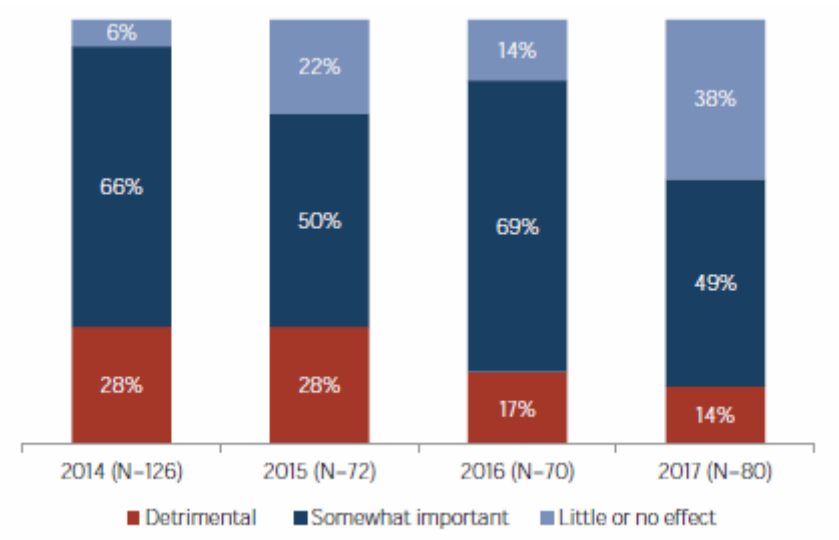
Datenquelle Abbildung 18: Eigene Darstellung, basierend auf: Umfrageergebnisse 2016, Berichtarchiv. Datenbasis für den Bericht „Carbon 2016.“ Excel-Dateien © Thomson Reuters. Bereitgestellt und Reproduktion genehmigt 2016.

Die Umfragen der letzten Jahre fragten auch direkt nach der Rolle der CO_2-Preise *im Vergleich zu anderen Faktoren*: Emittenten, die dem EU ETS unterliegen, wurden um eine Einschätzung gebeten, wie sehr der EU ETS ihrer Wettbewerbsfähigkeit abträglich sei – auf einer Skala von „schädlich“ (detrimental), „einigermaßen wichtig“ (somewhat important) bis zu „wenig bis kein Effekt“ (little to no importance). Der Frage voran ging eine Einleitung, um den Emissionshandel in Bezug zu anderen Faktoren zu stellen („Emissionshandel kann in manchen Fällen die Produktionskosten teilnehmender Firmen erhöhen. Wie empfinden Sie den Einfluß von CO_2-Kosten im Vergleich zu anderen Faktoren wie Energiepreisen, Steuern, Verfügbarkeit und Kosten qualifizierter Arbeitskräfte?“).[18]

Die geringe Fallzahl (80 Antworten auf diese Frage im Jahr 2017) erlaubt keine eingehende sektorale Untergliederung – von den 80 stammten bspw. nur fünf aus der Metallindustrie. Von diesen wiederum nannten drei (60%) den Einfluß der CO_2-Kosten als schädlich, was deutlich höher liegt als der Durchschnitt über alle Sektoren (14%).

[18] Originalversion: “Cap-and-trade of CO_2 emissions can in some cases increase compliance companies’ production costs. How do you perceive the impact of carbon cost against other factors such as energy prices, taxes, availability and cost of qualified labour?”

Abbildung 19: Antworten auf die Frage „Wie empfindet Ihre Firma den Einfluß von CO_2-Kosten im Vergleich zu anderen Faktoren wie Energiepreise, Steuern, Verfügbarkeit und Kosten qualifizierter Arbeitnehmer?“

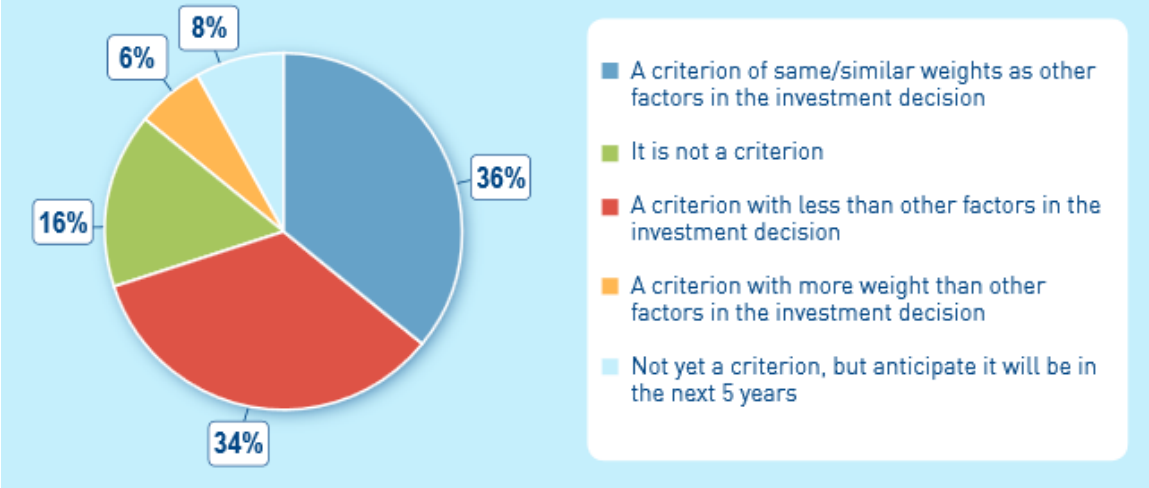


Datenquelle Abbildung 19: Umfrageergebnisse 2017, Berichtarchiv. Datenbasis für den Bericht „Carbon 2017“ Excel Dateien © Thomson Reuters. Nutzung genehmigt 2017.

4.3.3 Umfrage von Business Europe zum Einfluss des CO_2-Preises auf das Investitionsverhalten

Die europäische Verband nationaler Unternehmensverbände der einzelnen Mitgliedstaaten (Business Europe) führte 2016 unter seinen Mitgliedern eine Umfrage durch, deren Frage zum Einfluss des CO_2-Preises auf Investitionsverhalten der von ThomsonReuters sehr ähnlich ist: „Im Vergleich zu den Kosten für Arbeitskräfte, Rohmaterialien und Infrastruktur, wie wichtig ist der CO_2-Preis bis jetzt für Ihre Investitionsentscheidungen gewesen?“ Dabei standen den Teilnehmern der Business Europe-Umfrage fünf Antwortmöglichkeiten zur Verfügung („spielt keine Rolle,“ „weniger wichtig als andere Faktoren,“ „gleich wichtig wie andere Faktoren,“ „wichtiger als andere Faktoren“ und „noch nicht, aber wird in 5 Jahren ein Kriterium“), im Unterschied zu drei Antwortmöglichkeiten der ThomsonReuters-Umfrage („spielt keine Rolle,“ „wird in Betracht gezogen, aber ist nicht ausschlaggebend,“ und „ausschlaggebendes Kriterium“). Insofern sind die Ergebnisse nicht direkt vergleichbar. Auffallend ist jedoch, dass in der Business Europe-Umfrage der Anteil der Befragten, für den der CO_2-Preis keine Rolle spielt, wesentlich höher ist (im Durchschnitt mehr als doppelt so hoch), als bei den ThomsonReuters Antworten: Für 16 Prozent der von Business Europe befragten Unternehmen spielt der CO_2-Preis keine Rolle für Investitionsentscheidungen, wohingegen dies bei den ThomsonReuters-Umfragen über zehn Jahre im Durchschnitt nur bei 6,7 Prozent der Fall ist.

Abbildung 20: Antworten auf die Frage "Wie wichtig war der CO_2-Preis des EU ETS bisher für Ihre Investitionsentscheidungen, im Vergleich zu den Kosten für Arbeitskräfte, Rohstoffe und Infrastruktur?“ (n = 114)

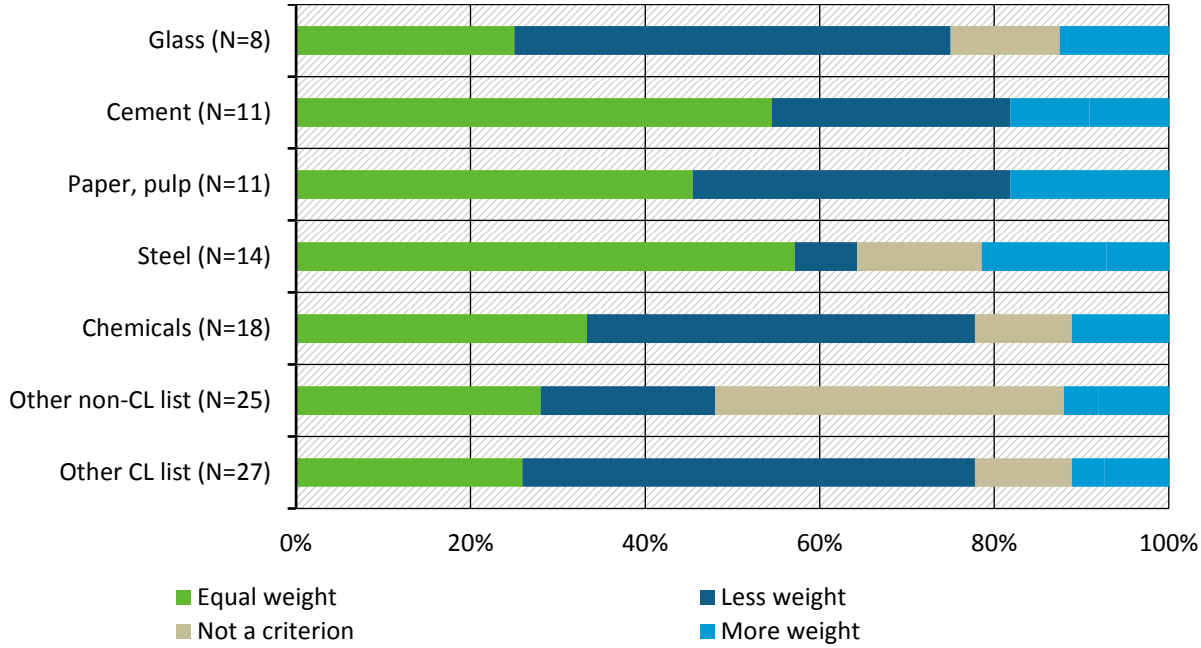


Datenquelle: BusinessEurope 2016 carbon pricing survey - What is the effect of the current and future EU-ETS carbon price on investment decisions by companies? Studie im Original verfügbar unter:https://goo.gl/EsULOV

Eine plausible Erklärung für diesen Unterschied ist die Zusammensetzung der befragten Unternehmen. Im Unterschied zur Befragung von ThomsonReuters richtete sich die von Business Europe an alle Unternehmen, die durch die Organisation vertreten werden – darunter auch solche, deren Emissionsintensität relativ niedrig ist. Auf Anfrage stellte Business Europe die Umfrageergebnisse nach Wirtschaftsbranche aufgeteilt zur Verfügung. Unter den Antworten sind ca. 20% von Unternehmen, deren Geschäftstätigkeit nicht auf der EU-Carbon-Leakage-Liste steht. Von diesen wiederum geben fast die Hälfte an, dass der Kohlenstoffpreis für ihre Investitionsentscheidungen keine Rolle spiele. Dabei wurde nur allgemein nach der Investitionstätigkeit im Europäischen Wirtschaftsraum gefragt – die Frage ging nicht gesondert auf die Höhe, den Gegenstand oder das Ziel der Investitionen ein, d.h. ob Unternehmen schlicht weniger investieren, oder stattdessen außerhalb der EWR-Staaten investieren.

Befragte aus emissionsintensiven Wirtschaftszweigen (denen auf der Carbon-Leakage-Liste der EU) dagegen messen dem CO_2-Preis eine höhere Bedeutung zu – insbesondere bei Papierproduzenten ist dies der Fall. Eine Mehrheit der Unternehmen der Papier-, Zement- und der Stahlindustrie betrachtet diesen Faktor als ebenso wichtig wie oder wichtiger als andere Investitionsfaktoren. In der chemischen und der Glasindustrie gab es keine Unternehmen, die dem CO_2-Preis einen besonders großen Einfluss auf Investitionsentscheidungen zuschreiben, der über andere Faktoren hinausgehen würde.

Abbildung 21: Antworten auf die Frage "Wie wichtig war der CO_2-Preis des EU ETS bisher für Ihre Investitionsentscheidungen, im Vergleich zu den Kosten für Arbeitskräfte, Rohstoffe und Infrastruktur?“ - Aufteilung nach Wirtschaftszweig (n = 114)



Datenquelle: Eigene Darstellung, basierend auf: BusinessEurope 2016 carbon pricing survey - What is the effect of the current and future EU-ETS carbon price on investment decisions by companies? Studie im Original verfügbar unter:https://goo.gl/EsULOV

Die Business Europe-Umfrage enthielt auch direkte Fragen zu den **Zukunftserwartungen** der Unternehmen in Bezug auf Investitionsleakage. Die große Mehrheit der Befragten erwartet einen *Anstieg* der direkten und indirekten CO_2-Preise, und eine Mehrheit erwartet sich davon einen *negativen* Einfluss auf die Investitionen innerhalb der EU.

Abbildung 22: Erwartungen bezüglich des zukünftigen europäischen CO_2-Preises

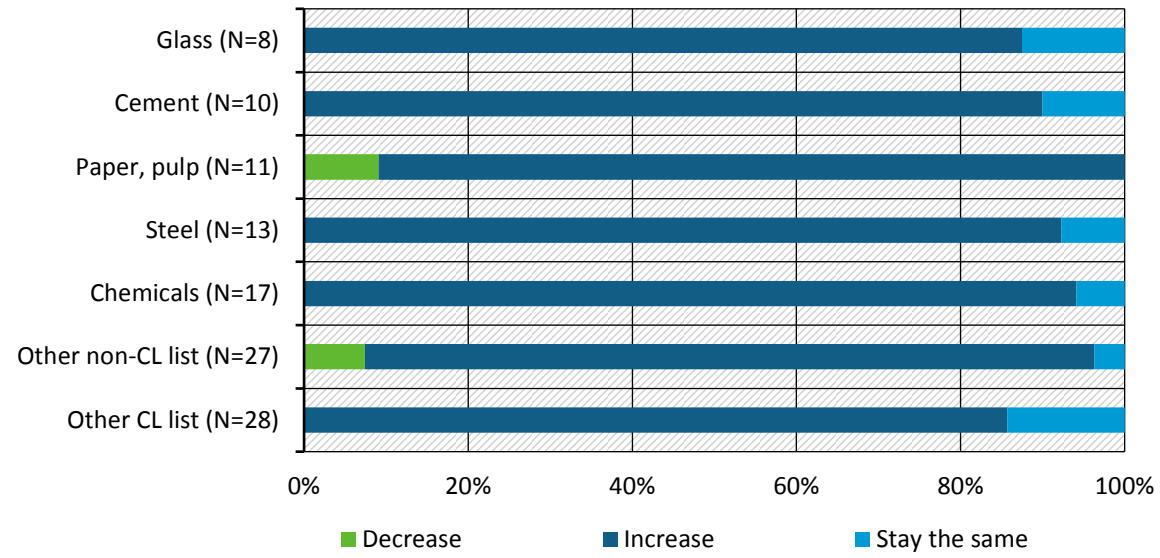
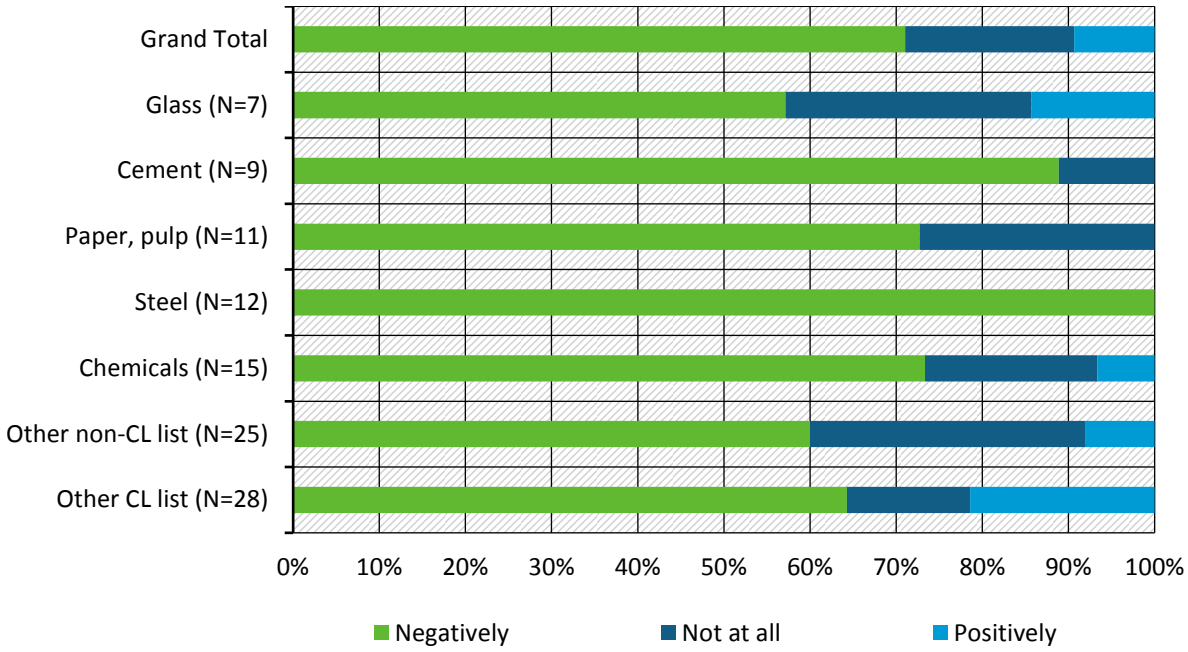


Abbildung 23: Erwartungen zu den Auswirkungen des zukünftigen CO_2-Preises auf Investitionen in Europa



Datenquelle Abbildungen 22-23: Eigene Darstellung, basierend auf: Business Europe, 2016. „Survey - What is the effect of the current and future EU-ETS carbon price on investment decisions by companies?"

Bemerkenswert ist hierbei der (kleine) Anteil derjenigen Unternehmen, die eine *positive* Auswirkung des CO_2-Preises auf ihr innereuropäisches Investitionsverhalten erwarten – so betrachten einzelne Unternehmen in den Branchen Glasherstellung, Chemie und sonstigen Branchen einen steigenden CO_2-Preis als potenziell *vorteilhaft* für ihre Investitionen in Europa. Unter den Glasherstellern z.B. erwarten alle Befragten gleichbleibende oder ansteigende CO_2-Preise, aber zwei von sieben Unternehmen erwarten deswegen keine negativen Auswirkungen auf ihr innereuropäisches Investitionsverhalten – und ein Unternehmen sogar positive Auswirkungen.

4.4 Literaturanalyse

4.4.1 Investmentleakage – alter Wein in neuen Schläuchen?

Die Diskussion um Carbon Leakage ist selbst nicht mehr neu, sondern wird seit mehr als einem Jahrzehnt geführt – zugleich knüpft sie an an ältere Diskussionen, wie etwa die um *Pollution Havens*, die seit den 70er Jahren geführt wird. Schon in dieser Diskussion wurde stets betont, dass – neben der Stringenz der umwelt- oder klimapolitischen Regulierung – eine Reihe anderer Faktoren für die Standortwahl von Unternehmen relevant ist. Die Diskussion um Investitionsleakage abstrahiert notwendigerweise davon – tatsächlich aber ist die Entscheidung, an welchem Standort ein Unternehmen in den Aufbau neuer oder die Erweiterung vorhandener Kapazitäten investiert, eine komplexe unternehmerische Entscheidung mit vielen Unbekannten (Kuik 2015; Jaffe et al. 1995). Zu den Erwägungen zählen unter anderem:

- Zugang zu Absatzmärkten (und Wachstumsaussichten dieser Märkte);
- Zugang zu Finanzmärkten und Kosten der Finanzierung;

- Steuerliche Behandlung der Erträge bzw. Investitionszuschüsse;
- Qualität der öffentlichen Verwaltung (Rechtssicherheit, funktionierende Institutionen, Ausmaß von Korruption und Bürokratie, Dauer von Genehmigungen, Transparenz);
- Gesetzliche Auflagen und damit verbundene Kosten (Arbeitsschutz, Umweltschutz (Lärm, Luft, Wasser, Klima));
- Zugang zu ausreichend qualifiziertem Personal, Lohnniveau;
- Zugang zu / Kosten von Rohstoffen, Elektrizität und anderen Inputs;
- Logistik- und Transportkosten.

Die Diskussion um „Investitionsleakage", d.h. die Verlagerung von Neuinvestitionen als Reaktion auf einen CO_2-Preis, stellt insofern eine Neuauflage der Pollution Haven-Diskussion (übersetzbar etwa als „Verschmutzungsparadies", analog zum Steuerparadies) dar, die in den USA bereits seit den 1970er Jahren geführt wurde. Gemäß der zugrundeliegenden Hypothese verteuern striktere Umweltauflagen die Produktionskosten, was Unternehmen dazu veranlasst, ihre Investitionen an Standorte mit geringeren Auflagen zu verlagern. Im Extremfall könnten pollution havens ihre Auflagen sogar absichtlich senken, um Investitionen anzuziehen. Die empirischen Befunde lassen jedoch zumindest daran zweifeln, ob der beschriebene Effekt in der Realität zu beobachten ist. In der weit überwiegenden Mehrzahl der Fälle sind die Kosten der Umweltgesetzgebung von allenfalls nachgeordneter Bedeutung im Vergleich zu den anderen standortspezifischen Faktoren (Jaffe u. a. 1995; Erdogan 2014; Borghesi, Franco, und Marin 2016). Tatsächlich zeigen Ederington et al. (2005) für die USA, dass die verschmutzungsintensivsten Industriezweige am *wenigsten* mobil sind: In diesen Branchen machen die fixen Kosten, um eine neue Anlage zu errichten, einen besonders hohen Teil der Gesamtkosten aus. Daher sind die Kosten, um die Produktion zu verlagern, in diesen Branchen besonders hoch (Ederington, Levinson, und Minier 2005).

4.4.2 Empirische Befunde zu Investmentleakage

Während das allgemeinere Thema Carbon Leakage insgesamt reichlich beforscht wurde, sowohl was konzeptionelle Studien als auch was empirische Untersuchungen angeht, so ist die Zahl der Untersuchungen zu Investitionsleakage noch vergleichsweise gering (Koch und Basse Mama 2016, 4). Bei der vorhandenen Literatur zu Investitionsleakage spiegelt sich dabei ein Befund wider, der auch für Carbon Leakage insgesamt zutrifft: Einerseits finden modellbasierte ex-ante Untersuchungen in der Regel Anhaltspunkte für ein Investmentleakage-Risiko; so etwa Böhringer et al. (2012), die anhand von Modellrechnungen mit allgemeinen Gleichgewichtsmodellen (CGE) auf Leakage-Raten von 5% bis 19% kommen (Böhringer, Balistreri, und Rutherford 2012). Andererseits finden ex-post-Studien dagegen mehrheitlich keine (signifikante) Evidenz dafür, dass Investitionsleakage stattgefunden hat (Vivid Economics und Ecofys 2013, 4).

In den vergangenen Jahren haben zwei Studien die Effekte des EU-Emissionshandels auf die Auslandsinvestitionen inländischer, emissionshandelspflichtiger Unternehmen untersucht: Koch und Basse Mama (2016) für Deutschland, und Borghesi et al. (2016) für Italien. Beide Studien kombinieren Mikrodaten zu Auslandsinvestitionen (Foreign Direct Investment, FDI) auf Firmenebene mit Daten zur Teilnahme am Emissionshandel aus dem EUTL. Für Deutschland finden Koch und Basse Mama insgesamt keine belastbare Evidenz dafür, dass der EU-Emissionshandel zu erhöhten Auslandsdirektinvestitionen der emissionshandelspflichtigen

Unternehmen geführt hätte. Bei der genaueren Betrachtung einzelner Untergruppen von Unternehmen stellen die Autoren fest, dass Investitionsverlagerungseffekte noch am ehesten für die Gruppe der Unternehmen zu beobachten sind, die in der zweiten und dritten Handelsperiode Zukaufsbedarf hatten bzw. haben.[19] Angesichts der insgesamt großzügigen Ausstattung schreiben die Autoren diesen Effekt aber eher der Erwartung einer möglichen Unterausstattung in Zukunft zu als dem akuten Mangel. Dies werten die Autoren als Beleg für die These, dass die Zuteilung einen Einfluss auf die Standortwahl hat – was grundsätzlich dafür spricht, dass kostenlose Zuteilung ein wirksames Instrument sein kann, um das Leakage-Risiko gefährdeter Unternehmen zu verringern. Eine interessante Beobachtung ergibt sich ferner für Unternehmen mit relativ hohen Emissionen und solchen, die als Leakage-gefährdet eingeordnet sind. Für diese finden sich Hinweise darauf, dass Unternehmen ihre Auslandsinvestitionen sogar reduziert haben könnten. Eine mögliche Erklärung hierfür ist aus Sicht der Autoren, dass Unternehmen in diesen Branchen einen Teil der (Opportunitäts-)Kosten der Emissionsberechtigungen überwälzen können, und die Aussicht auf kostenlose Zuteilung so inländische Investitionen attraktiver macht (Koch und Basse Mama 2016, 23).

Für Italien betrachteten Borghesi et al. (2016) einen Datensatz von 59.000 italienischen Unternehmen (darunter 371, die Anlagen im EU ETS betreiben) samt Angaben über deren internationale Verflechtungen über die Zeiträume 2002 – 2004, 2005 – 2007 und 2008 – 2010. Als Maß für die Auslandsinvestitionen diente dabei die Frage, ob diese Unternehmen Tochterunternehmen im EU-Ausland gegründet oder akquiriert bzw. geschlossen oder verkauft haben. Im Vergleich zu einer Kontrollgruppe von (ansonsten vergleichbaren) Unternehmen außerhalb des ETS zeigen sich keine deutlichen Abweichungen im Verhalten der ETS-Unternehmen; auch eine statistische Regressionsanalyse ergibt keinen signifikanten Effekt des EU ETS auf die Investition in ausländische Tochterunternehmen. Dies gilt auch, wenn die Auswahl der Unternehmen verengt wird auf diejenigen, die nach EU-Definition Leakage-gefährdet sind; auch hier hat der EU-Emissionshandel keinen signifikanten Effekt. Diese zeigen sich erst bei einer noch feineren Unterteilung: Dazu untergliedern die Autoren die beobachteten Unternehmen in solche, die aufgrund ihrer Handelsintensität zu den Leakge-gefährdeten zählen, und solche, die aufgrund ihrer Emissionsintensität dazu gerechnet werden. Dabei zeigt sich, dass bei Unternehmen mit hoher Handelsintensität der EU-Emissionshandel zu einer höheren Investitionstätigkeit geführt hat; bei emissionsintensiven Unternehmen dagegen ist die Investitionstätigkeit außerhalb der EU nach Einführung des EU-Emissionshandels zurückgegangen. Als mögliche Erklärungen für diesen Sachverhalt vermuten die Autoren, dass Unternehmen mit hoher Handelstätigkeit weniger in der Lage sind, die (Opportunitäts-)Kosten des Emissionshandels zu überwälzen, oder dass diese Unternehmen aufgrund ihrer Handelsverflechtungen bereits mit anderen Märkten vertraut sind, und daher die Hürden für Auslandsinvestitionen niedriger sind (Borghesi, Franco, und Marin 2016, 18).

4.4.3 Sektorale Perspektiven

Kuik (2015) legt eine modellbasierte ex-ante-Schätzung des Investitionsleakage-Risikos in der europäischen Stahlindustrie vor. Dabei geht der Autor von verschiedenen Szenarien für die Divergenz und Konvergenz der Klimapolitik zwischen der EU und dem Rest der Welt aus und untersucht mit dem multisektoriellen und multiregionalen Gleichgewichtsmodell GDynE, wie diese Szenarien sich auf Investitions- und Kapitalflüsse von 2015 bis 2050 auswirken. Die

[19] Interessanterweise finden die Autoren keine Anzeichen für ein höheres Investitionsleakage-Risiko in den energieintensiven Branchen wie Metall, Glas, Zement oder Chemie, also den „klassischen" Leakage-Sektoren. Vielmehr finden sie Anzeichen für höhere Auslandsinvestitionen in Branchen wie Maschinenbau oder elektronischen Erzeugnissen, die vom Emissionshandel nur geringüfig betroffen sind – die aber aufgrund ihrer verhältnismäßig geringeren Kapitalkosten mobiler sind (Koch und Basse Mama 2016, 22).

Autoren unterscheiden zwischen verschiedenen Leakage-Kanälen: Investitionsleakage, Leakage durch Veränderungen in den Weltmarktpreisen fossiler Ressourcen und Realaustauschverhältnis (terms of trade).[20] Er kommt zu dem Ergebnis, dass je nachdem, welches klimapolitische Ambitionsniveau im Rest der Welt unterstellt wird, ein erhebliches Investitionsleakage-Risiko besteht. Während anfangs das höchste Leakage-Risiko vom Energiemarkt ausgeht, nimmt das Investitionsleakage-Risiko im Gegensatz zu anderen Leakage-Risiken im Zeitverlauf zu und könnte bis Mitte des Jahrhunderts 60% des Leakage-Risikos ausmachen (Kuik 2015, 33).

Sartor (2013) diskutiert das Leakage-Risiko in der europäischen Aluminium-Industrie. Dabei liefert er eine empirische ex-post Analyse des Carbon Leakage insgesamt, geht darin aber nicht auf etwaiges Investitionsleakage ein, sondern beschränkt sich auf Einbußen der Wettbewerbsfähigkeit. Zu Investitionen findet sich lediglich anekdotische Evidenz; etwa den allgemeinen Hinweis darauf, dass seit den 1990ern keine neuen Aluminiumhütten in Europa in Betrieb genommen wurden und Investitionen in neue Kapazitäten nur im Ausland stattgefunden hätten. Dieser Umstand lässt sich jedoch nicht auf den Emissionshandel zurückführen. Ausschlaggebend sei vielmehr der Wunsch, sich gegen hohe und volatile Energiekosten abzusichern, indem Unternehmen auf lokal vorhandene Energieressourcen zurückgreifen, sowie die Nutzung spezieller Vereinbarungen zur Strompreisgestaltung, die in der EU nicht mehr möglich sind. Sartor argumentiert, dass die Investitionen den Energieressourcen folgen – etwa in Länder mit reichlich günstiger Wasserkraft wie Island, Norwegen und Russland, aber auch in den Nahen Osten. Eine andere Motivation für Investitionen sind geographische Vorteile: die Nähe zum Kunden, aber auch eine bessere Integration in Wertschöpfungsketten (Sartor 2013).

Für Zement weist Cook (2011) ebenfalls darauf hin, dass Kapazitätszuwächse praktisch nur noch außerhalb von Europa stattfinden, vor allem in China und Indien. Dies geschieht seiner Analyse zufolge schlicht deshalb, weil dort auch die Nachfrage konzentriert ist. In den reifen Märkten Europas wird insgesamt wenig investiert, und wenn, dann allenfalls um alte Anlagen zu ersetzen. Allerdings geht Cook auch auf Beispiele von überschüssigen Kapazitäten ein, etwa in der Türkei oder in Nordafrika. Diese können zustande kommen, weil der inländische Bedarf eingebrochen ist, oder weil er überschätzt wurde. Aus Cooks Sicht wäre es dagegen ein Fall von Investitionsleakage, wenn ein Land Kapazitäten aufbauen würde um Exporte zu steigern. Cook argumentiert, dass dies im Fall von Saudi-Arabien unterstellt werden könne; es sei allerdings schwierig bis unmöglich die Kausalität zu belegen (Cook 2011).

4.4.4 Investitionen in Emissionsminderung und Energieeffizienz

In der Diskussion zu Investitionsleakage geht es darum, ob Unternehmen ihre Investitionstätigkeit im Ausland erhöhen, um der Belastung durch den EU-Emissionshandel zu entgehen. Ein weiterer Zweig der Literatur – und eine ergänzende Facette der Diskussion – geht der Frage nach, ob der EU-Emissionshandel heimischen Unternehmen Anreize bietet, um in Emissionsminderung und Energieeffizienz an heimischen Standorten zu investieren und so die Belastung durch den EU-Emissionshandel zu mindern. Auch zu dieser Frage gibt es eine Reihe von empirischen Untersuchungen, mehrheitlich in Form von Befragungen.

So betrachten etwa Martin et al. 2011 das Verhalten von Firmen im Hinblick auf Investitionen in die Erforschung klimaschonender Technologien, sowohl auf Produkt- als auch auf Prozessebene. Durch Interviews mit rund 800 Unternehmen stellen sie zum einen fest, dass die Mehrzahl der

[20] Als Effekt der Carbon Leakage kommt es zu Kaptialflüssen zwischen den Weltregionen, etwa für die geleakten Investitionen. Diese Kapitalbewegungen beeinflussen ihrerseits die terms of trade. Daher weist das Modell dies als weiteren Leakage-Kanal aus, der jedoch quantitativ von geringerer Bedeutung ist.

Unternehmen bereits Investitionen getätigt haben, um die Energieeffizienz ihrer Fertigungsprozesse zu verbessern. Des Weiteren kommen sie zu dem Ergebnis, dass Firmen in Zukunft mehrheitlich einen steigenden CO_2-Preis erwarten und auch von einer zunehmenden Knappheit bei ihrer Ausstattung mit Emissionsberechtigungen ausgehen. Diejenigen Firmen, auf die beides zutrifft (sowohl Erwartung eines höheren CO_2-Preises als auch einer knapperen Ausstattung mit Emissionsberechtigungen), sind deutlich aktiver bezüglich Investitionen in Forschung zu klimaschonenden Technologien (Martin, Muûls, und Wagner 2011, 29).

Laing et al., (2013) geben einen Überblick über diese und sieben weitere empirische Analysen, die untersucht haben, wie der EU-Emissionshandel das Investitions- und Innovationsverhalten der Firmen im Bezug auf Energieeffizienz und Emissionsminderung beeinflusst hat. Bei den Studien handelt es sich überwiegend um Befragungen und Interviews in verschiedenen Mitgliedsstaaten. Das Ergebnis liefert ein gemischtes Bild: zwar finden alle Untersuchungen Hinweise dafür, dass der EU-Emissionshandel zu verstärkten Investitionen in Klimaschutz und Energieeffizienz geführt hat, und dass er geholfen hat, die Aufmerksamkeit des oberen Managements auf CO_2-Emissionen und –Kosten zu richten. Dies wird aber stets relativiert: Der EU-Emissionshandel sei nur ein nachgeordnetes Kriterium unter vielen, weil er nur kleine Investitionen mit kurzer Investitionszeit angereizt hat, der niedrige CO_2-Preis seine potenzielle Wirkung gemindert habe, oder weil die Wirkungen durch die Finanz- und Wirtschaftskrise überlagert wurden (Laing u. a. 2013, 12). Eine weitere, ähnliche Untersuchung zu belgischen Industrieunternehmen aus dem Jahr 2015 kommt zu vergleichbaren Ergebnissen: Obwohl die Befragten für ihre interne Entscheidungsfindung höhere CO_2-Preise ansetzen als den Marktpreis, bleibt der Einfluss auf Investitionsentscheidungen dennoch gering (Brohé und Burniaux 2015).

Löfgren et al. (2013) wenden eine andere Methodik an. Sie untersuchen anhand statistischer Daten das Investitionsverhalten von schwedischen Industrieunternehmen in den Jahren 2002 bis 2008. Die Daten umfassen sowohl die Industriezweige, die vom EU-Emissionshandel erfasst sind, als auch fünf weitere Branchen als Kontrollgruppe. Die Autoren kommen zu dem Ergebnis, dass der EU-Emissionshandel selbst keinen signifikanten Effekt darauf hatte, ob Unternehmen in die Minderung von CO_2-Emissionen investieren. Das Investitionsverhalten lässt sich vielmehr erklären durch die Energieintensität der Firmen und ihre vorangegangenen Investitionen in Umweltschutz und umweltbezogene Forschung (Löfgren u. a. 2013).

Insgesamt ist die empirische Literatur zu Investitionsleakage, sowie zum Investitionsverhalten insgesamt, somit überschaubar. Die vorhandenen Quellen kommen aber mehrheitlich zu einem Ergebnis, das auch den Befund der allgemeineren Leakage-Literatur widerspiegelt: demnach hat der EU-Emissionshandel nur eine geringe Wirkung auf das Investitionsverhalten von Unternehmen, sowohl was mögliches Investitionsleakage angeht (Aufbau / Erweiterung von Kapazitäten an außereuropäischen Standorten), als auch was Investitionen in Energieeffizienz und Emissionsminderung betrifft. Tatsächlich wird der Effekt des EU-Emissionshandels auf Investitionsentscheidungen in der Regel von anderen Faktoren überlagert; viel bedeutsamer sind etwa Energie- und Rohstoffpreise, vor allem aber Zugang zu Märkten und Rohstoffen. Dementsprechend findet sich auch kein eindeutiger Beleg für Fälle, in denen tatsächlich Investitionsleakage stattgefunden hätte. Deutliche Anzeichen für Investitionsleakage lassen sich demnach nur in modellbasierten Simulationen finden – und hier vor allem in solchen Simulationen, die nicht vom gegenwärtigen CO_2-Preis ausgehen, sondern von dem Preisniveau, das für eine Dekarbonisierung der europäischen Wirtschaft nötig wäre.

4.5 Fallbeispiele

Zur Auswahl möglicher Fallbeispiele diente zunächst eine Übersicht der Neuanlagen und signifikanten Kapazitätserweiterungein im European Transaction Log (EUTL) sowie eine Auswertung von Veröffentlichungen einschlägiger Branchendienste für verschiedene leakage-gefährdete Sektoren. In einem ersten Schritt wurden in Deutschland 16 Beispiele aus der chemischen Industrie, der Stahlindustrie und der Aluminiumindustrie identifiziert. Ergänzt wurde die Auswahl um 32 Neuanlagen und große Kapazitätserweiterungen in Europa in den genannten Branchen. Hinzu kamen fünf ausgewählte Investitionsprojekte außerhalb der EU von Unternehmen, die in Europa aktiv sind: diese reichten von 60 Millionen bis 5.2 Milliarden Euro in den Branchen Stahl, Chemie, Aluminium in Katar, Brasilien und den USA.

Für eine eingehende Analyse wurden schließlich fünf große Investitionsprojekte in der Stahlindustrie ausgewählt – eines in Deutschland, drei im EU-Ausland und eines außerhalb der EU. Die Recherche gibt dabei den Stand im September 2017 wieder.

- **Tata Steel** Stahlwerk **Port Talbot**, Rotherham, Großbritannien, 2013: Neuzustellung des Hochofens mit Abwärmenutzungsanlage im Wert von **290 Millionen Euro**;
- **ArcelorMittal** Stahlwerk in **Galati**, Rumänien, 2015: Modernisierung des Hochofen 5 im Wert von **90 Millionen Euro**;
- **Outokumpu Stainless Oy** in **Tornion**, Finnland, 2012: Inbetriebnahme eines neuen Ofens Ende 2012 zur Verdopplung der Produktion, Wert von **410 Millionen Euro**;
- **ThyssenKrupp, Duisburg-Schwelgern**, Deutschland, 2014: Neuzustellung des größten Hochofens Europas im Wert von **200 Millionen Euro**;
- **ThyssenKrupp, Rio de Janeiro**, Brasilien, 2008-2012: Neubau eines Stahlwerks, Produziert fünf Millionen Tonnen Rohstahl/Jahr seit 2010, im Wert von **5.2 Milliarden Euro**.

4.5.1 Tata Steel Stahlwerk in Port Talbot, Großbritanien

4.5.1.1 Allgemeines

Mit einer Jahresproduktionskapazität von 4,9 Millionen Tonnen Stahl ist der Port Talbot Standort der zweitgrößte von drei Stahlproduktionsstätten[21] des europäischen Geschäftszweigs Tatas (Tata Steel Europe) und der größte Stahlproduzent des vereinigten Königreichs. Der größte Standort von Tata Steel Europe, IJmuiden Steelworks in den Niederlanden, ist auch eine integrierte Einrichtung mit Hochöfen sowie Warm- und Kaltwalzanlagen – sie hat eine Produktionskapazität von 7,2 Millionen Tonnen pro Jahr. Tatas anderer europäischer Stahlproduktionsstandort – Rotherham in England, mit einer Kapazität von 1,2 Millionen Tonnen jährlich – ist eine "Mini-Mill" in der Stahl aus Schrott durch einen Lichtbogenofen hergestellt wird (Tata Steel Jahresbericht 2013-2014).

Bei der Investition am Port Talbot Standort handelte es sich um eine Modernisierung des existierenden Komplexes in und um einen der zwei Hochöfen (Blast Furnace Nr. 4, zuletzt neuzugestellt in 1992) in den Jahren 2012-2013. Diese Maßnahme ersetzte die alte Infrastruktur so weitgehend, dass das Projekt als „Rebuild“ (zu deutsch: Wiederaufbau oder Neubau)

[21] Zur Zeit der Investition waren es noch vier: Tata Steel verkaufte einen weiteren integrierten Stahlproduktionsstandort in England (Scunthorpe Steelworks, Jahreskapazität ca. 4,5 Millionen Tonnen) im Jahre 2016 für den symbolischen Preis von £1 an die Investitionsfirma Greybull Capital, welche das Unternehmen in British Steel umbenannte. Siehe Tovey & Davidson (2016)

bezeichnet wurde[22] anstatt wie Üblich als Hochofenneuzustellung oder normales Instandhaltungsverfahren.

Die Gesamtinvestition betrug ~£185 Millionen (~EUR 229 nach damaligem Wechselkurs)[23] und ihre Durchführung erfolgte in den acht Monaten zwischen Juni 2012 und Februar 2013 (Tata Steel Jahresbericht 2013-2014). Das Projekt war laut Tata das größte im Bereich Industrietechnik in Großbritanien im Jahr 2012 (Tata Steel 2013).

Tabelle 3: Tata Steel - jährliche Zuteilungsmenge an Emissionsberechtigung und Zuteilungen aus der New Entrant Reserve (2008 – 2020)

Jahr	Zuteilungsmenge (in Tonnen)	Zuteilung aus der New Entrant Reserve (NER)
2008	7.807.052	
2009	7.807.052	
2010	7.807.052	
2011	7.807.052	
2012	7.807.052	
2013	6.194.511	670.429
2014	6.086.918	739.842
2015	5.978.060	726.741
2016	5.868.067	713.639
2017	5.756.889	700.538
2018	5.644.629	687.437
2019	5.530.971	674.336
2020	5.416.917	661.235

Quelle: European Union Transaction Log (EUTL)

Die Anlage erhielt in der zweiten Handelsperiode des EU ETS über 7,8 Millionen Emissionsberechtigungen pro Jahr. Mit Beginn der dritten Handelsperiode sank die Zuteilungsmenge auf knapp unter 6,2 Millionen Berechtigungen und nimmt über die Handelsperiode weiter jährlich ab, bis sie 2020 ungefähr 5,4 Millionen ausmacht. Gleichzeitig wird die Zuteilungsmenge durch Emissionsberechtigungen aus der New Entrant Reserve (NER) ergänzt: In der Periode 2013-2020 empfängt sie über die NER durchschnittlich 696.774 Zertifikate/Jahr.

[22] Tata Steel Jahresbericht 2013-2014, Seite 11 („rebuilt Blast Furnace 4"). Bei der Ijmuiden-Anlage in den Niederlanden hingegen, wo 2012-2013 auch die Modernisierung eines Hochofens stattfand (siehe selber Jahresbericht, Seiten 20 und 52), wird diese als *Reparatur* („repair") bezeichnet

[23] Im Juni 2012 stand der Wechselkurs bei 1 GBP = 0,807 EUR. Nach dem Stand Juni 2013 (1 GBP = 0,849) hätte es sich um eine Investition von EUR 218 Million gehandelt. Quelle: X-rates online historical currency converter: http://www.x-rates.com/historical/?from=GBP&amount=185&date=2013-06-15 (accessed 12.09.2017)

4.5.1.2 Standort und Betreiber

In Wales etwickelten sich um heimische Erzablagerungen seit der Mitte des 19. Jahrhunderts mehrere Eisenwerke sowie Kupfer- und Stahlerzeugungsstätten. Die Port Talbot Steelworks wurden 1901-1902 gebaut und 1906 von der Firma Port Talbot Steel Company (PTSC) übernommen, mit finanzieller Beteiligung der Eigentümer der naheliegenden Kohleablagerungen, Anlegestelle, und Eisenbahnverbindung – Produktion wurde also mit Rohstoffzufuhr und Transport des fertigen Produkts kombiniert, der Standort bestand aus einem vernetzten Anlagenkomplex (Parry, 2011). Ein Jahrhundert später ist die Produktion immer noch integriert, sowohl innerhalb Port Talbots als auch mit dem ca. 80 Kilometer entfernten Llanwern Steelworks, wo in Port Talbot produzierte Brammen weiterverarbeitet werden durch u.a. Warm- und Kaltwalzen sowie Beiz- und Beschichtungsverfahren.[24] Produktion am Llanwern-Standort wurde seit der Übernahme Tatas wegen schlechter Marktverhältnisse mehrmals eingestellt, welches zum (teilweise vorübergehenden) Verlust von Arbeitsplätzen führte. Die letzte solche Stilllegung einzelner Betriebsteile in 2015 betraf die Warmwalzanlage – wegen verminderter Nachfrage wurde die Stahlcoilproduktion vom Llanwern-Standort nach Port Talbot verlegt, sodass die Llanwern Warmwalzanlage zeitweilig abgestellt werden konnte (Meechan, 2015).

Seit 1951 findet die Hauptproduktion des Standorts Port Talbot auf dem Gelände einer ehemaligen Abtei („Abbey“) statt, die damals durch die Zusammenlegung vieler kleiner walisischer Stahlhersteller eröffnet und betrieben wurde. Dieses Stahlwerk, das sogenannte „Abbey Works,“ war in den 1960iger und 1970iger Jahren der größte Arbeitgeber in Wales mit über 18.000 Mitarbeitern (Penny, 2016). Im Jahr 1967 wurde der Betreiber, Steel Company of Wales, vom Staat übernommen und in British Steel Corporation umbenannt. Nach einem Unternehmenszusammenschluss mit der niederländischen Stahlfirma Koninklijke Hoogovens wurde die daraus entstandene Einrichtung im Jahr 1999 privatisiert unter dem Namen Corus Group. Tata Steel erwarb 2007 sämtliche derer Aktien, sodass Firmenjahresberichte ab Geschäftsjahr 2007-2008 Daten zu Port Talbot und den anderen Corus-Produktionsstätten enthalten.[25] Im Jahre 2011 wurde Corus vollständig integriert und der Name geändert zum Geschäftszweig Tata Steel Europe (Tovey, 2016).

Die Hochofeninvestition wurde also fünf Jahre nach dem Eigentümerwechsel getätigt – wurde aber offenbar unter der Führung von Corus (vor 2007) schon geplant, im Zusammenhang mit der 2010 getätigten Investition in eine Anlage zur Energierückgewinnung aus Prozessgas. Geschäftsberichte Tatas aus den Jahren unmittelbar vor und nach der Übernahme erwähnen jene Investition, die wegen des Resultats des Neubaus von Hochofen 4 (erweiterte Produktion) noch zielführender wurde.[26]

Im März 2016 entschied der Vorstand Tata Steels, die Standorte der europäischen Firmen-abteilung im Vereinigten Königreich (Tata Steel UK) zu verkaufen (Tata Steel 30.03.2016). Im Dezember 2016 jedoch kam es zu einer Einigung zwischen der Firma und der Gewerkschaft, die

[24] Tata Steel (2017): Sustainability performance at our sites – Llanwern. Available online at https://www.tatasteelconstruction.com/en_GB/sustainability/Sustainability-performance-at-our-sites/llanwern/Llanwern (accessed 12.09.2017)

[25] Im Tata Steel Jahresbericht 2007-2008 zum Beispiel sind zu Corus gehörende Anlagen Teil der Konzernrechnung, aber Vorstandsmitglieder und Firmenunterteilungen (und die einzelnen Management-berichte letzterer) werden noch unter Corus aufgeführt.

[26] “The Port Talbot BOS gas recovery and energy management investment will significantly reduce natural gas and electricity purchases, and materially reduce carbon dioxide emissions at the site, through the utilization of gas generated inside the Basic Oxygen Steel plant” - Tatas Jahresbericht 2007-2008, Seite 42. “A BOS gas recovery plant and an energy management system are being set up at Port Talbot to reduce emissions and energy costs” – Tata Jahresbericht 2008-2009, Seite 59.

wegen dem extremen Verlust an Arbeitsplätzen gegen den Verkauf protestiert hatte: Der Standort Port Talbot bleibt Vorläufig im Besitz Tata Steels, aber unter veränderten Zahlungsverhältnissen in die Rentenkasse der Arbeiter des Standorts (Dickins, 2016). Seit dieser Beilegung erstrebt Tata Steel Medienberichten zu folge einen Zusammenschluss seines europäischen Geschäftsbereichs mit ThyssenKrupp, wobei die Übernahme der Zahlungen an die Altersversorgung der britischen Arbeiter – aufgestellt als die Firma noch zu British Steel gehörte – von längeren Verhandlungen mit der Regulierungsbehörde der staatlichen Rentenkassen abhängt.

4.5.1.3 Unternehmen weltweit

Außer an den europäischen Standorten betreibt Tata Stahlproduktions- und –verarbeitungsanlagen in Indien, Singapur und Thailand.[27] Nur die indischen Standorte – die Hauptproduktionsstätte in Jamshedpur und eine neue Anlage in Kalinganagar – sind von ihrer Ausgestaltung vergleichbar mit Port Talbot, da nur dort Rohstahl in Hochöfen produziert wird (Tata Steel Jahresbericht 2015-2016, Seite 4). Mit 7 Millionen Tonnen pro Jahr hat der Hochofen Jamshedpur die größte Produktionskapazität von allen Tata Standorten.

Zeitgleich mit der Investition am Port Talbot Standort fand eine Kapazitätsexpansion am Standort Jamshedpur statt, zu dem der Bau eines neuen Hochofens (Blast Furnace I) gehörte (Tata Steel Jahresbericht 2012-2013, Seite 17).

Unterdessen fand der Bau des obenerwähnten komplett neuen indischen Standorts statt: Ein Stahlproduktions- und Verarbeitungskomplex in Kalinganagar (Kalinganagar Industrial Complex im Jajpur-Bezirk vom Landesteil Odisha) mit einem neuen Hochofen (Kapazität ca. 4 Millionen Tonnen pro Jahr), einer Kokerei, einer Sinteranlage und Walzanlagen. Diese neuen Kapazitäten werden über mehrere Jahre hochgefahren – Produktion für den Außenmarkt begann im Mai 2016 mit einer Jahresproduktion von 3 Millionen Tonnen (Tata Steel Jahresbericht 2015-2016, Seite 14).

4.5.1.4 Angaben zur getätigten Investition und ihrem Effizienzgrad

Port Talbots Hochofen Nr. 4 wurde 1992 zuletzt neu zugestellt, war also im Jahr der Modernisierung am Ende seiner (für Stahlhochöfen üblichen) 20-jährigen Laufzeit. Statt einer Neuzustellung wurde der Ofen neu gebaut mit Erweiterungsmaßnahmen, die die Kapazität des Hochofens von ca. 4 auf die heutigen fast 5 Millionen Tonnen pro Jahr erhöhten (Sinha, 2013). Der neue Ofen enthielt u.a. eine neue Verbrennungsluftführung, einen neuen Ringraum für Vermischungsvorgänge bei der Erzzufuhr, eine neue Turmstruktur, einen neuen Schrägaufzug und ein neues automatisiertes Kontrollsystem (New Steel Construction, 2012). Parallel zum Ofenneubau wurde das Wasserabgaskühlungssystem mit einem Verdunstungskühlungssystem (für weitere £53 Millionen) ersetzt, das den durch Kühlung entstehenden Dampf durch Turbinen leitet, welche daraus Elektrizität generieren (Tata Steel 26.04.2011) und den Verbrauch von extern zugekaufter Elektrizität um 15% reduzieren (Tata Steel Jahresbericht 2012-2013, Seite 24).

Es konnte kein Beleg dafür gefunden werden, daß der Hochofenkomplex Port Talbots im Zuge dieses Neubaus mit zusätzlicher Effizienzmaßnahme auf einen *höheren* Effizienzstandard gebracht wurde als die vergleichbare Anlage in Jamshedpur. Im Gegenteil wird in Firmenberichten aus Jahren vor der Investition als Beispiel von „best practice sharing“ eine

[27] Tata Steel company profile: http://www.tatasteel.com/corporate/our-organisation/company-profile/ (accessed 12.09.2017)

Übertragung der in Indien üblichen Energiemanagement-Technologien auf die britische Anlage berichtet.[28]

Im Jahresbericht 2008-2009 wurde an mehreren Stellen auf Emissionsintensitätsreduktionsziele hingewiesen. Der indische Zweig erzielte damals eine CO_2-Intensität von 1,5 Tonnen CO_2 pro Tonne Stahl bis zum Jahr 2015 (vom damaligen Niveau von 2,1 t CO_2/t Stahl - Tata Steel Jahresbericht 2008-2009, Seite 108) wohingegen der europäische Zweig anzielte, das 1,5 t CO_2/t Stahl -Niveau erst 2020 zu erreichen– allerdings war dieses 2020-Ziel noch unter der Führung von Corus gesetzt worden (Tata Steel Jahresbericht 2008-2009, Seite 89). Zudem wurden einige Effizienzmaßnahmen der indischen Anlage extern finanziert, da sie als CDM Projekt gestaltet wurden (Tata Steel Jahresbericht 2008-2009, Seite 108). Der Nachhaltigkeitsbericht 2015-2016 gibt jedoch die Treibhausgasintensität von Tatas Stahlproduktion weltweit (nicht nach Firmensegment aufgeteilt) als 2 Tonnen CO_2 pro Tonne Stahl im Geschäftsjahr 2014-2015 und 1,91 t CO_2/t Stahl in 2015-2016 an (Tata Steel in the UK Sustainability Report 2015-2016, Seite 20).

4.5.1.5 Entscheidungsfindung zur Investition

Trotz mehrmaliger Kommunikation mit Angestellten Tata Steel Europes gelang es nicht, Verbindung zu einem Ansprechpartner zu erhalten, der bereit war Informationen über Investitionen am Port Talbot Standort zur Verfügung zu stellen.

Tatas Jahresbericht 2010-2011 beschreibt die dann schon vorgesehene Investition in den Neubau des Hochofens 4 primär als produktivitätssteigernde Maßnahme, da die modernisierte Anlage eine 0,4 Millionen Tonnen höhere Kapazität hat und deshalb Produktionskosten senkt. Energiemanagement allgemein und die Optimierung sowohl des Energieverbrauchs als auch der Energiekosten war in dem Jahr Ziel der Kapitalausgaben an allen Standorten weltweit (Tata Steel Jahresbericht 2010-2011, Seite 18). Im Bericht des Jahres, in dem die Investition stattfand, wurde sie als Verbesserung der Wettbewerbsfähigkeit des Standorts trotz schlechter Marktbedingungen gekennzeichnet – auf die *Art* des Wettbewerbsvorteils (etwa Kostenersparnisse durch Senkung der CO_2-Emissionen) wurde nicht eingegangen.[29] Eine Analyse energieeffizienter Investitionen an europäischen Industriestandorten der Europäischen Kommission aus dem Jahr 2015, in der das parallel zur Hochofenmodernisierung installierte energiekostensenkende Kühlungssystem (£53 Millionen) als Fallstudie beschrieben wird (nicht aber die Hochofeninvestition selber), bestätigte durch Interviews mit Firmenmitarbeitern, dass der Emissionshandel und CO_2-Preise keine bedeutende Rolle in der Entscheidungsfindung spielten.[30]

Nach der Bekanntmachung Tatas im März 2016, den gesamten britischen Geschäftszweig verkaufen zu wollen, wurde die Frage zum Einfluss von CO_2-Preisen auf die Wettbewerbsfähigkeit britischer (und im übertragenen Sinne europäischer – obwohl die niederländischen Standorte Tata Steel Europes nicht verkauft werden sollten) Industrien erneut aufgeworfen. Kommentatoren zeichneten die Stahlindustrie als Opfer der Klimaschutzpolitik aus wegen zusätzlicher CO_2-Preise (im Vereinigten Königreich umfassen diese auch den als ‚climate levy' bekannten CO_2Mindestpreis), denen andere stahlproduzierende Länder nicht ausgesetzt sind

[28] "Process Improvement Teams have been set up with the aim to ensure that best practice in process technology is applied throughout the Group. This involves among other things, transferring technology that has been proven in one plant to similar other installations. An example of this is an investment at Port Talbot steelworks in energy management technology similar to systems that already exist at other plants, including TSL's Jamshedpur plant." Tata Steel Jahresbericht 2008-2009, Seite 72

[29] "Rebuild of blast furnace at Port Talbot should improve competitiveness of European operations even though the market is expected to remain challenging." Tata Steel Jahresbericht 2012-2013, Seite 4.

[30] "The company argues that the EU ETS and carbon prices did not play a major role in these decisions." European Commission (February 2015), Seite 45.

(Lawson, 2016). Berechnungen des britischen Committee on Climate Change aus dem Jahre 2015 ergaben jedoch, dass ungefähr zwei Prozent der Produktionskosten der Tata Steel Standorte im vereinigten Königreich auf *klima*spezifische Auflagen zurückzuführen sind, da Elektrizitätspreise sechs Prozent der Hochofenproduktionskosten betragen und Klimapolitiken wie die climate levy etwa ein Drittel des Strompreises ausmachen (The Committee on Climate Change, 2015 und Bassi & Duffy, 2016). Tatas eigene Begründung für den Verkauf der britischen Standorte enthällt keinen Bezug zu Klimaschutzmaßnahmen oder CO_2-Preisen, sondern verweist auf "strukturelle Faktoren:" globales Überangebot an Stahl, steigende Stahlimporte aus Drittländern, hohe Betriebskosten, anhaltend schwache einheimische Stahlnachfrage und volatile Wechselkurse.[31]

4.5.2 ArcelorMittal Stahlwerk in Galati, Rumänien

4.5.2.1 Allgemeines

Die Anlage im Südosten Rumäniens ist der größte Stahlstandort des Landes, mit einer Produktionskapazität von 3 Millionen Tonnen Stahl pro Jahr. ArcelorMittal betreibt darüber hinaus fünf andere Standorte in Rumänien.

In der Anlage wurden zunächst noch zwei von fünf Hochöfen betrieben (Nr. 4 und 5), wovon Nr. 4 im Jahre 2010 für 2,7 Millionen Euro neu zugestellt wurde (Mediafax, 2010). Im Jahr 2010 begann ein kompletter Austausch der Innenverkleidung („relining") von Hochofen 5; im Januar 2010 wurden die Kosten dieser Maßnahme auf EUR 53 Millionen geschätzt und der Zeitaufwand auf 12 Monate.[32] Die tatsächlichen Kosten beliefen sich auf EUR 80 Millionen und die Arbeit wurde erst im Oktober 2011 abgeschlossen.[33] Diese Reparatur war Teil eines 90-Millionen-Euro-Investitionspakets für den Hochofen 5, zu dem auch zwei effizienzsteigernde Techniken gehören, die 2013 installiert und eingesetzt wurden: Ein glockenloses Ladungssystem und ein Profilmessgerät. Die neue Innenverkleidung machte den Großteil des EUR 90 Millionen-Investitionspakets aus, wohingegen in die zusätzlichen Effizienzmaßnahmen zusammen ca. EUR 7 Millionen investiert wurden (ArcelorMittal Galati, 2014).

Im März 2015 wurde in eine weitere energiesparende Maßnahme investiert: Für 8,25 Millionen Euro wurden die Turbinen, die kalte Luft in Hochofen 5 blasen, modernisiert – der Dampfverbrauch wurde so halbiert (von 70 auf 32-40 Tonnen Dampf pro Stunde) so dass der restliche Dampf zur Stromherstellung genutzt werden kann; ein Turbogenerator kann auf diese Weise bis zu 5,000 MWh Strom herstellen (ArcelorMittal Galati, März 2015 und ArcelorMittal Galati, 2016).

Die Anlage erhielt in der zweiten Handelsperiode des EU ETS über 11 Millionen Emissionsberechtigungen pro Jahr. Mit Beginn der dritten Handelsperiode sank die Zuteilungsmenge auf 3,5 Millionen Berechtigungen. Ab 2016 wiederum stieg die Zuteilung wieder deutlich an, auf durchschnittlich 6,1 Millionen in den Jahren 2016-2020.

[31] "structural factors including global oversupply of steel, significant increase in third country exports into Europe, high manufacturing costs, continued weakness in domestic market demand in steel and a volatile currency" – Tata Steel Pressemitteilung 30.03.2016

[32] In ArcelorMittals Jahresbericht 2010 wird diese Investition nicht erwähnt. In folgenden Medienberichten aus Anfang 2010 werden erwartete Kosten und Andauer der Raparatur angegeben: SteelGuru (26.01.2010), Actmedia (20.01.2010), Steel Business Briefing (16.12.2010)

[33] Im ArcelorMittal Jahresbericht 2011 wird auf Seite 24 ein "revamp of blast furnace no. 5 in Galati, in the 4th quarter" erwähnt und folgende Medienberichte erfassen die Kosten: Steel Business Briefing (06.07.2011), SeeNews (01.11.2010)

Tabelle 4: ArcelorMittal - jährliche Zuteilungsmenge an Emissionsberechtigunen und Emissionen (2008 – 2020)

Jahr	Zuteilungsmenge (in Tonnen)	Emissionen
2008	11.335.574	7.586.062
2009	11.335.573	11.385.252
2010	11.335.573	15.968.727
2011	11.335.573	20.217.309
2012	11.335.573	23.944.652
2013	3.504.190	3.808.207
2014	3.443.304	7.437.189
2015	3.337.833	11.725.916
2016	6.346.174	15.963.612
2017	6.225.916	
2018	6.104.492	
2019	5.981.555	
2020	5.858.191	

Quelle: European Union Transaction Log (EUTL)

4.5.2.2 Standort und Betreiber

Die Entscheidung, in Galati ein Stahlwerk zu bauen, wurde 1960 von der damals regierenden rumänischen Arbeiterpartei getroffen. Im Jahr 1966 wurde die Anlage eröffnet, die integrierte Produktion begann 1968. Im Jahr 1991 wurde das Staatseigentum zu einer Aktiengesellschaft unter dem Namen Sidex Galati. Diese wurde 2001 erworben von LNM Holdings, einem Tochterunternehmen ArcelorMittals (damals noch Mittal Steel Company) und gehört seit der Fusion Mittals mit Arcelor in 2006 zur Betriebsabteilung „Flat Products Europe“ innerhalb ArcelorMittals (OECD Steel Committee, 2015).

Mit ca. 50.000 Mitarbeitern während der 1970iger Jahre stellte das Galati Stahlwerk den Hauptarbeitgeber der Region dar. Heute sind ca. 6.200 Personen dort angestellt - die jährliche Stahlproduktion, deren Höhepunkt in den späten 1980ern über 8 Millionen Tonnen erreichte (Dumitriu und Stefanescu, 2016), liegt aktuell bei ca. 3 Millionen Tonnen - 2016 waren es genau 2,2 Millionen Tonnen (ArcelorMittal, 2016).

Zu dem Standort, der im Sinne des Emissionshandels als *eine* Anlage fungiert (RO-155-2013), gehören derzeit neben den zwei aktiven Hochöfen (Nr. 4 und 5, von denen nur Nr. 5 durchgehend betrieben wird) auch eine Sinteranlage, eine Dreistrang-Brammenstranggießanlage, ein Grobblechwalzwerk, ein Warmwalzwerk, ein Kaltwalzwerk, und eine Verzinkungsanlage (Galvanisierungslinie). Am gleichen Standort betreibt zudem der Energieversorger Termoelectrica SA ein mittelgroßes Kraftwerk, das allerdings separat genehmigt und als eigene Anlage geführt wird (RO-95-2013),

4.5.2.3 Unternehmen weltweit

ArcelorMittal ist volumenmäßig der größte Stahlproduzent in Nord- und Südamerika, Afrika und Europa – die Firma produziert an Standorten in 18 Ländern und beschäftigt weltweit ca. 200.000 Mitarbeiter. Die Stahlproduktion ist geografisch verteilt, jedoch mit Schwerpunkt in Europa: 47% der Gesamtproduktion von Rohstahl findet in Europa statt, 37% in Nord- und Südamerika, und 16% in anderen Ländern wie Kasachstan, Südafrika und Ukraine (ArcelorMittal 2017, Seite 4). Die Stahlproduktionsstandorte ArcelorMittals weltweit emittieren jährlich knapp unter 200 Millionen Tonnen CO_2:

Tabelle 5: Arcelor Mittal CO_2 Emissionen (in Millionen Tonnen) für die Jahre 2013 - 2016

Jahr	Emissionen CO_2-äquivalent (in Millionen Tonnen)
2013	195
2014	195
2015	198
2016	194

Quelle: ArcelorMittal Annual Review 2016 „our carbon emissions" – online verfügbar unter: annualreview2016.arcelormittal.com

Um die Investitionen in Hochofen 5 am Standort Galati mit denen an ähnlichen Standorte ArcelorMittals außerhalb Europas vergleichen zu können, muss die firmeninterne Unterscheidung nach Produktart berücksichtigt werden. ArcelorMittal gab Daten zu Kapitalausgaben nicht nach Anlage und Land an, sondern nach Herstellungskategorie (Firmensegment: z.B. Minen, Vertrieb, Langstahlproduktion und Flachstahlproduktion) und Weltregion. Galati gehört zum Firmensegment Flachstahl Europa („Flat Carbon Europe"). Ausgaben in vergleichbarer Größenordnung wurden in den Anlagen im Firmensegment Flachstahl Amerika („Flat Carbon Americas") getätigt. In den Jahren der hier berichteten Investitionen (2011 – 2013) lagen die Ausgaben in Europa höher als im entsprechenden Firmensegment Nord- und Südamerikas.

Tabelle 6: Arcelor Mittal Kapitalausgaben nach Firmensegment (in US$ Millionen)

Firmensegment	2011	2012	2013
„Flat Carbon Europe"	1.004	818	606
„Flat Carbon Americas"	664	648	404

Quelle: Kapitalausgabentabelle der 2012 und 2013 Online-jahresberichte ArcelorMittals: http://annualreview2012.arcelormittal.com/fact-book/operations/capital-expenditure und http://annualreview2013.arcelormittal.com/fact-book/operations/capital-expenditure

Ab 2014 werden Firmensegmente wiederum anders definiert - Kapitalausgaben beziehen sich 2014-2016 auf geografische Regionen unabhängig von der Produktart, mit Ausnahme von Minen. Amerika wird in die NAFTA-Zone (Kanada, USA, Mexiko) und Brasilien aufgeteilt. Nach dieser Aufteilung betragen Kapitalausgaben in Millionen US$ wie folgt:

Tabelle 7: Arcelor Mittal Kapitalausgaben nach Firmensegment (in US$ Millionen)

Firmensegment	2014	2015	2016
NAFTA	505	392	445
Brasilien	497	422	237
Europa	1.052	1.045	951

Quelle: Kapitalausgabentabelle der 2012 und 2013 Online-jahresberichte ArcelorMittals: http://annualreview2012.arcelormittal.com/fact-book/operations/capital-expenditure und http://annualreview2013.arcelormittal.com/fact-book/operations/capital-expenditure

Im Unternehmensverantwortungsbericht für das Jahr 2012 (das Jahr nach der Innenverkleidung und vor den zusätzlichen Energieeffizienzmaßnahmen an Hochofen 5 in Galati) werden weitere Hauptenergieeffizienzinvestitionen weltweit beschrieben. Zwei davon (zusammen $43 Millionen) fanden an Standorten in Polen statt, mehrere kleinere am Hamburger Standort, und ein $63 Millionen Kraft-Wärme-Kopplungsprojekt wurde am Standort Indiana in den USA eingesetzt.

Unter den explizit in Jahresberichten als „Hauptwachstums- und Optimierungsprojekte mit erheblichen Investitionsausgaben“ bezeichneten Kapitalausgaben in den Jahren der Investitionen an Hochofen 5 in Galati befinden sich fast ausschließlich Projekte an Standorten *außerhalb* Europas: Im Jahre 2012 werden beispielsweise sieben Investitionsprojekte porträtiert; alle diese betreffen Standorte in Brasilien, Kanada oder Liberia. Jedoch handelt es sich dabei vor allem um Minen; nur zwei der Projekte sind im Bereich Flachstahl.

4.5.2.4 Angaben zur getätigten Investition und ihrem Effizienzgrad

Die Erneuerung seiner Innenbeschichtung brachte Hochofen Nr. 5 auf ein höheres Effizienzniveau als Galatis Hochofen Nr. 4, weswegen letzterer aktuell nicht durchgehend im Einsatz ist. Die zusätzlichen Investitionen an Hochofen Nr. 5 (glockenloses Ladungssystem und Profilmessgerät 2013, Blasturbinenmodernisierung 2015) verbesserten die Effizienz der Anlage, indem sie den Energieverbrauch verringerten, und trugen so zur Minderung der CO_2-Emissionsintensität der Anlage bei:

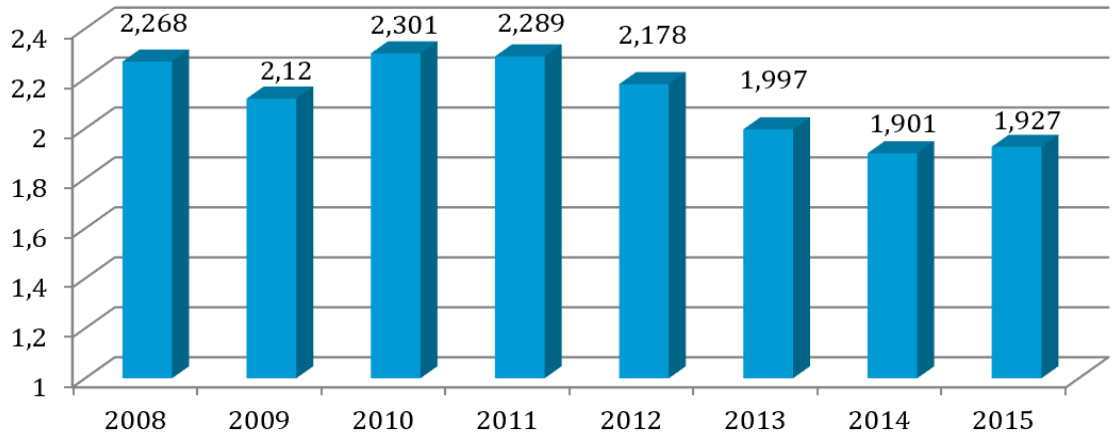
Das glockenlose Ladungssystem (“bell less top” charging equipment) ermöglicht eine homogenere Verteilung des Rohmaterials innerhalb des Hochofens. Dies verringert den Brennstoffverbrauch bei erhöhter Produktivität und erweitert die Lebensdauer der Geräte durch reduzierten Verschleiß. Das Profilmessgerät erhöht die Effizienz durch geringere Wärmeschwankungen, sodass der Hochofen mit einer niedrigeren Koksrate und optimaleren Gasverteilung betrieben werden kann (ArcelorMittal, 2015).

Die Modernisierung der Blasturbinen in 2015 bestand aus einer Neugestaltung der Rotoren und Membranen sowohl in den zwei Turbinen als auch deren Kompressoren – das neue System automatisiert die Kontrolle der zwei Blasturbinen und halbiert den Dampfverbrauch des Hochofens (ArcelorMittal Galati, März 2015). Ein Turbogenerator, angetrieben von diesem überschüssigen Dampf, produziert bis zu 5,000 Megawattstunden Elektrizitat, die intern genutzt wird und den externen Zukaufsbedarf an Strom reduziert (ArcelorMittal Galati, 2016, Seite 33).

Der Nachhaltigkeitsbericht für den Standort Galati für 2015 führt die Modernisierungen des Hochofens 5 als Grund für die erreichten Verbesserungen der CO_2-Emissionsintensität zwischen 2008-2015 an, im Zusammenhang mit Minderung des Rohstoffverbrauchs wegen der Schließung von Galatis Kokereianlage in den Jahren 2008-2009. Welcher Anteil der Verbesserung der CO_2-

Intensität der Anlage ab 2012 auf die Investitionen in Hochofen 5 zurückzuführen ist (also getrennt von der weniger kohlenstoffintensiven Rohstoffzufuhr), bleibt unklar. Laut Nachhaltigkeitsbericht 2014 sanken die absoluten CO_2-Emissionen der Gesamtanlage zwischen 2013 und 2014 um 15% (ArcelorMittal Galati, 2015, Seite 26). Laut Nachhaltigkeitsbericht 2015 lagen die direkten Emissionen der Anlage 2015 bei 4,3 Millionen Tonnen CO_2 (ArcelorMittal Galati, 2016, Seite 31).[34]

Abbildung 24: ArcelorMittal Galatis CO_2-Emissionen pro Tonne Stahl, 2008-2015



Quelle: ArcelorMittal Galati Nachhaltigkeitsbericht 2015, Seite 32. Online verfügbar unter http://corporate.arcelormittal.com/~/media/Files/A/ArcelorMittal/sdr-2015/country-reports/arcelormittal-galati-2015-sustainable-development-report.pdf

Die derzeitige CO_2-Intensität am Standort Galati (knapp unter 2 Tonnen CO_2 pro Tonne erzeugten Stahls) liegt unter dem Durchschnittsniveau für ArcelorMittal weltweit: In den Jahren 2016 und 2015 lag der Durchschnitt aller Anlagen im Besitz ArcelorMittals bei 2,14 Tonnen CO_2 pro Tonne Stahl (ArcelorMittal 2016). Der Durchschnitt für Stahlproduktion weltweit (aller Firmen) liegt bei 1,8 Tonnen CO_2/Tonne Stahl (World Steel Association, 2017).

Zur Zeit der Investition betrieb ArcelorMittal weltweit 60 Hochöfen, davon 22 in Europa. Die gesamte Kapazität der Firma für die Produktion von Rohstahl betrug 119 Millionen Tonnen weltweit (ArcelorMittal 2014, operating footprint). Die Produktionskapazität aus Hochöfen allein belief sich auf 98 Millionen Tonnen, und die tatsächliche Produktion in dem Jahr betrug 66 Millionen Tonnen im Jahr 2013 (ArcelorMittal 2014, plants, property and equipment). Die Stahlproduktionskapazität der Hochöfen in der Galati-Anlage betrug 2013 und 2014 4,23 Millionen Tonnen, die tatsächliche Produktion in den Jahren jedoch nur 1,6 Millionen Tonnen, weil Hochofen 4 nicht vollständig ausgelastet operierte (ArcelorMittal 2014, Romania - Galati). In den Jahresberichten 2015 und 2016 befinden sich Produktionsangaben nur für den Gesamtstandort (inklusive Sinteranlage, usw.) – diese waren in beiden Jahren 2,2 Millionen Tonnen (ArcelorMittal 2016).

[34] Die direkten CO_2-Emissionen in Höhe von 4,3 Millionen Tonnen, die der Nachhaltigkeitsbericht für 2015 ausweist, sind deutlich geringer als die Emissionen von 11,7 Millionen Tonnen, die die Anlage als verifizierte Emissionen im EU ETS für das gleiche Jahr ausweist. Der Grund für diese Differenz ist nicht unmittelbar ersichtlich, könnte jedoch durch eine unterschiedlichen Abgrenzung der Emissionen, auch im Verhältnis zum benachbarten Kraftwerk bedingt sein (Weiterleitung von Kuppelgasen).

4.5.2.5 Entscheidungsfindung zur Investition

Leider war trotz mehrfacher Anfragen kein Mitarbeiter von ArcelorMittal bereit, Angaben zur Investitionsentscheidung am Standort Galati zu machen. Öffentlich verfügbare Dokumente, die Informationen über die einschlägigen Investitionen enthalten, gehen nicht explizit auf die zu Grunde liegende Entscheidungsfindung ein, sondern betonen das Ziel (und in rückblickenden Dokumenten die Resultate) der jeweiligen Investitionen. Als vorrangiges Ziel wird dort der reduzierte Energieverbrauch des integrierten Standorts genannt.

Das online verfügbare Pressemitteilungsarchiv der Medienabteilung Galatis geht nur bis 2014, also können damalige Firmenaussagen zu den in 2010 (neue Innenverkleidung) und 2012 (Effizienzmaßnahmen) getätigten Investitionen nur durch Zitierung in heute noch auffindbaren damaligen Medienberichten gefunden werden. In einem solchen Medienbericht der rumänischen englischsprachigen Nachrichtenquelle „actmedia“ aus Januar 2010 wird auf ein statement ArcelorMittals verwiesen, dem zufolge die Modernisierung des Hochofens Nr. 5 dem Ziel diene, den Abstand der variablen Kosten zwischen Galati und ArcelorMittals besten Anlagen in Westeuropa zu verringern – und so Galatis Wettbewerbsfähigkeit zu stärken.[35]

Aus den öffentlich zugänglichen Dokumenten ergeben sich keine Angaben, die eine direkte Verbindung zwischen einzelnen Investitionsentscheidungen und den CO_2-Emissionen der Anlage zuließen. Viele kleinere Effizienzmaßnahmen (z.B. Modernisierungen in der Stahlschmelzerei für 3 Millionen Euro im Jahr 2015) sind Teil eines Gesamtprojekts von ArcelorMittal Europe (das “Energize” Projekt), das den Energieverbrauch (nicht Emissionen) bis 2016 um 15% gegenüber 2011 mindern wollte (ArcelorMittal Galati, 2016 Seite 33).

Die Resultate der Blasturbineninvestition für EUR 8,25 Millionen im Jahr 2015 waren laut Nachhaltigkeitsbericht Energiekostenminderung und Verkleinerung des „environmental footprints“ – ArcelorMittal ging 2015 von einer Amortisationszeit von ca. 3 Jahren aus. Treibhausgasmissionen werden nicht explizit erwähnt, und der Bericht enthält keinen Verweis auf Zuteilungen oder CO_2-Kosten.

4.5.3 Outokumpu Ferrochromanlage in Tornio, Finland

4.5.3.1 Allgemeines

Die Anlage gehört zu 100% dem finnischen Edelstahlproduzenten Outokumpu.

Die Investition – ein zusätzlicher Ferrochrom-Ofen am Standort Tornio – wurde ursprünglich im Juni 2008 beschlossen, aber im Dezember 2008 zunächst auf Eis gelegt, wegen der Finanzkrise und den damit verbundenen instabilen Marktverhältnissen. Im Juni 2009 entschied Outukumpu, doch mit dem Projekt fortzufahren – damals wurde die Investition auf EUR 440 Million geschätzt und eine Fertigstellung Anfang 2013 erwartet (Outokumpu, 09.06.2010). Tatsächlich erfolgte die Fertigstellung schon Ende 2012 und die Investition betrug EUR 410 Millionen (Outokumpu, 05.06.2013). Mit der Investition verdoppelte der Standort die Kapazitäten für die Ferrochromproduktion (auf 530 000 Tonnen pro Jahr); dieses Volumen wurde im Jahr 2015 nach einer mehrjährigen Hochlaufphase erreicht.

Die Anlage (Outokumpu Stainless Oy, Tornion Teehtat) erhielt in der zweiten Handelsperiode des EU ETS über 1 Millionen Emissionberechtigungen pro Jahr und im Jahr der Fertigstellung des Ofens (2012) rund 10.000 zusätzliche. Mit Beginn der dritten Handelsperiode sank die

[35] “reducing the variable cost gap with our best plants in Western Europe and hence to reinforce the competitiveness of the plant” (Actmedia, 20.01.2010)

Zuteilungsmenge für die Bestandsanlage auf unter 660 Tausend Berechtigungen, gleichzeitig wird diese Menge durch Emissionsberechtigungen aus der New Entrant Reserve (NER) ergänzt.

Tabelle 8: Outokumpu Ferrochromanlage - jährliche Zuteilungsmenge an Emissionsberechtigung und Zuteilungen aus der New Entrant Reserve (2008 – 2020)

Jahr	Zuteilungsmenge (in Tonnen)	Zuteilung aus der New Entrant Reserve (NER)
2008	1.006.039	
2009	1.006.038	
2010	1.006.038	
2011	1.006.038	
2012	1.006.030	
2013	659.284	129.360
2014	647.834	127.109
2015	636.248	124.858
2016	624.541	122.608
2017	612.709	120.357
2018	600.760	118.106
2019	588.663	115.855
2020	576.526	113.604

Quelle: European Union Transaction Log (EUTL)

4.5.3.2 Standort und Betreiber

Outokumpus Metalproduktion und -verarbeitung begann nach der Entdeckung eines Kupferbergs in Ostfinnland im Jahre 1910 – die Firma durchlief über die nächsten Jahrzehnte verschiedene Eigentumsverhältnisse, von staatseigenem Konzern zu mehreren Privateigentümern, und erweiterte ihre Produktion ausschließlich im Kupferbereich.

Erst 1960 begann die Firma, Chromablagerungen im nordfinnischen Kemi auszunutzen und stieg damit in die Edelstahlproduktion ein, da Chrom dem Stahl seine rostfreie Eigenschaft verleiht und somit ein essentieller Rohstoff für Edelstahl ist. Im Jahr 1976 begann die Firma, am Standort Tornio Stahl zu schmelzen. Ein zweiter Ferrochromschmelzofen wurde 1985 hinzugefügt, sowie Kapazitäten zur Pelletierung und Sinterung in 1989 (Kaitue, 2010). Tornio ist eine der weltweit integriertesten Edelstahlproduktionsstätten. Sie umfasst sowohl Warm- und Kaltwalzwerke als auch eine Schmelzanlage und die Chrommine im naheliegenden Kemi.[36]

Nach mehreren Jahrzehnten als „Multi-Metall-Betrieb“ mit Minen und Verarbeitungsstätten weltweit für Kupfer und Zink, in denen es zu einem börsennotierten Unternehmen wurde (seit 1988 als OUT1V an der Börse Helsinki gelistet) setzte Outokumpu ab dem Jahr 2000 ausschließlich auf Edelstahl. Ziel war eine Verdoppelung der Produktion, gleichzeitig wurde die Beteiligung an anderen Geschäftsbereichen abgewickelt. Es folgten mehrere Fusionen und

[36] http://www.outokumpu.com/en/company/outokumpu-in-europe-middle-east-and-africa/production-sites/Tornio/Pages/Outokumpu-production-site-Tornio-Works-Finland.aspx

Übernahmen einschlägiger Betriebe im Metallsektor – inklusive die Akquise von Inoxum GmbH, dem Edelstahlarm von ThyssenKrupp, im Jahr 2012.

4.5.3.3 Unternehmen weltweit

Heute stellt Outukumpu an mehr als 10 Standorten in Finland, Schweden, England, Deutschland, Mexiko und den USA jährlich über 2,4 Millionen Tonnen Stahl her. Der Jahresumsatz 2016 betrug 5,9 Milliarden Euro.[37] In Europa beschäftigte die Firma ende 2015 7.778 Mitarbeiter und hatte einen Jahresumsatz von 4,3 Milliarden Euro.[38] Bei den Produktionsstätten außerhalb Europas (San Luis Potosi in Mexiko und Calvert, Alabama in USA – siehe unten) handelt es sich um integrierte Warm- und Kaltwalzwerke ohne Rohstahlproduktion aus Hochöfen. Das Operationssegment „Americas" beschäftigt 2265 Mitarbeiter und hatte 2015 einen Umsatz von 1,2 Milliarden Euro.[39]

Durch die Übernahme der Inoxum GmbH von ThyssenKrupp gehören wesentliche Teile des 2007 von ThyssenKrupp für $4.5 Milliarden gebauten Stahlkomplexes in den USA (Calvert, Alabama), der 2010 in Betrieb genommen wurde, seit 2012 zu Outokumpu. Andere Teile (u.a. ein Warmwalzwerk, ein Kaltwalzwerk und vier Beschichtungsanlagen) gehören seit 2014 einer Partnerschaft zwischen ArcelorMittal and Nippon Steel.

Dieser Nordamerikanische Standort ähnelt dem in Tornio, da es sich um eine integrierte Anlage mit sowohl Schmelz- als auch Kalt- und Warmwalzwerken handelt. Andere von Outokumpu als ähnlich „integriert" bezeichnete Produktionsstätten befinden sich in Europa, nämlich an den Standorten in Schweden (Avesta und Nyby) und England (Sheffield) (Hautala, 2015). Die Akquise der Nordamerikanischen Produktionsstätte fand *nach* der Investition in den neuen Ofen in Tornio statt, wurde aber abgeschlossen noch bevor die Investition abgeschlossen wurde.

4.5.3.4 Angaben zur getätigten Investition und ihrem Effizienzgrad

Der neue Ferrochromofen ist besonders energieeffizient, da die Nähe zum Erzeugungsort die Nutzung von Ferrochromschmelze und (Nebenprodukt) Kohlenstoffmonoxid als Energierohstoffe ermöglicht. Pelletisierung und Vorzerkleinerung des Ausgangsmaterials reduzieren die Brennzeit im Ofen und dadurch den Stromverbrauch. Da das flüssige Chromeisenerz auf dem kurzen Weg von Erzeugung zu Verarbeitung nicht erhärtet, werden Abwärme- und Prozessgas optimal genutzt.

Auch andere Produzenten mit neueren Einrichtungen nutzen das Kohlenstoffmonoxid und wenden das Vorzerkleinerungsverfahren mit Pelletisierung an.[40] Am Standort Tornio kommt CO_2-freier Strom zum Einsatz (Wasserkraft und Atomkraft), wohingegen (ansonsten vergleichbare) Ferrochromanlagen in Südafrika und Kasachstan auf fossile Brennstoffe angewiesen sind.[41]

[37] http://www.outokumpu.com/en/company/Pages/default.aspx

[38] http://www.outokumpu.com/en/company/organization/Europe/Pages/default.aspx

[39] http://www.outokumpu.com/en/company/organization/Americas/Pages/default.aspx

[40] Zum Beispiel der Lion Ferrochrome Smelter in Südafrika, betrieben vom Rohstoffriesen Glencore in einem Gemeinschaftsprojekt mit Metallproduzent Merafe (Creamer, 2014)

[41] Entsprechend ist Outokumpu Miteigentümer an Fennovoima, dem finnischen Firmenkonsortium das den Bau eines 1200 MV Atomkraftwerks in Pyhäjoki durchführt. Der Tornio-Standort, dessen Stromverbrauch sich nach der Instandsetzung der neuen Anlage auf 3.3 Terrawattstunden jährlich erhöht hat, wird der größte industrielle Stromkunde dieses neuen Kraftwerks, dessen Inbetriebnahme für 2024 vorgesehen ist (Outokumpu, 2011 Seite 17)

4.5.3.5 Entscheidungsfindung zur Investition

Firmenvertreterin Katri Saari bestätigte schriftlich, dass *standortspezifische Vorteile* – Nähe der Chromitmine zur Produktionsstätte – ausschlaggebend waren.[42] Die Minimierung der Erztransportkosten sei der wichtigste Entscheidungsfaktor gewesen, gefolgt von der am europäischen Standort bestehenden Expertise der Mitarbeiter. Der CO_2-Preis, bzw. die zukünftige Höhe der kostenlosen Zuteilung, wurde nicht genannt in der Antwort auf die Interviewfrage, was die Hauptüberlegungen hinter der Investition gewesen seien.

Im Jahr 2010 informierte Outokumpu die Anleger über die Investitionsentscheidung (Outokumpu, 2010).In der Information wurde hauptsächlich auf die Wettbewerbsvorteile durch die erhöhte Produktion abgestellt, da damals mit wachsender Nachfrage (insbesondere aus China) gerechnet wurde. Stark steigende Elektrizitätspreise in Südafrika, das 40% des Ferrochroms herstellt, würden in Outokumpus Rechnung zu anhaltenden Produktionsengpässen führen. Angesichts dessen würde eine Produktion*serhöhung* in Europa zu Wettbewerbsvorteilen in Form von langfristiger Lieferverträge führen. Der EU Emissionshandel wird im Zusammenhang mit der Investitionsentscheidung nicht erwähnt.

In der allgemeinen Kommunikation des Unternehmens wird lediglich darauf verwiesen, dass für die Zukunft von strikteren Emissionsminderungszielen auszugehen sei, und dass Outokumpu sich durch entsprechende Arbeitsgruppen auf diese Herausforderung vorbereiten werden (Outokumpu, 2011, S. 149). Bei der Diskussion der Faktoren, die einen Einfluss auf die Profitabilität des Unternehmens haben, werden Klimaschutzkosten allgemein oder CO_2-Preise im Besonderen nicht erwähnt (Outokumpu, 2011, S. 21). Vielmehr wird dort (S. 35) hervorgehoben, dass Tornio eine der kosteneffizientesten Anlagen zur Herstellung von Edelstahl weltweit sei.

4.5.4 ThyssenKrupp neuer Hochofen in Duisburg, Deutschland

4.5.4.1 Allgemeines

Am Standort Duisburg baute ThyssenKrupp 2007 einen neuen Hochofen. Die Anlage (Integriertes Hüttenwerk Duisburg) erhielt in der zweiten Handelsperiode des EU ETS über doppelt so viele Emissionberechtigungen pro Jahr wie in der ersten. Dies ist im Wesentlichen geänderten Zuteilungsregeln für Kuppelgase; die Emissionen der Anlage selbst sind mit der Inbetriebnahme des neuen Hochofens nur wenig angestiegen.

Tabelle 9: Jährliche Zuteilungsmenge an Emissionsberechtigunen und Emissionen (2005 – 2020)

Jahr	Zuteilungsmenge (in Tonnen)	Emissionen
2005	7.066.338	7.741.698
2006	7.066.338	7.736.930
2007	7.066.338	7.766.516
2008	19.622.025	8.811.249

[42] Firmenberichte bestätigen dies: Der Jahresbericht 2008 etwa verbindet die Wettbewerbsvorteile des Standorts direkt mit Nähe zur Mine. „Outokumpu is in a unique position and has a clear competitive edge due to its captive chromite mine in Kemi in Northern Finland and nearby its own ferrochrome production located at the same site as the stainless steel plant, Tornio Works." (Outokumpu 2015, Seite 31)

Jahr	Zuteilungsmenge (in Tonnen)	Emissionen
2009	19.622.025	6.605.535
2010	19.622.025	8.695.288
2011	19.979.757	8.128.041
2012	19.711.458	7.596.751
2013	16.854.896	8.221.179
2014	16.561.709	7.952.211
2015	16.265.093	8.202.034
2016	15.965.407	8.449.823
2017	15.662.510	
2018	15.356.688	
2019	15.047.075	
2020	14.736.405	

Quelle: European Union Transaction Log (EUTL)

4.5.4.2 Standort und Betreiber

In Duisburg wird seit über 100 Jahren Stahl produziert: 2016 feierte ThyssenKrupp 125 Jahre Stahlproduktion an dem Standort, der mehrere Unterstandorte umfasst, darunter die Produktionsstätte Hamborn mit dem neuen Hochofen. Neben fünf Werken, die jeden Schritt der Stahlherstellung abdecken (Produktionsbetriebe für Roheisen und Rohstahl sowie verschiedene Walzwerk- und Weiterverarbeitungsanlagen) befindet sich die Hauptverwaltung der ThyssenKrupp Steel in Duisburg. Wegen seiner Schlüsselrolle in der integrierten Produktionskette und seiner Lage als Transportknotenpunkt direkt am Rhein ist der Standort Duisburg einer der wichtigsten für ThyssenKrupp Steel.

Zur Zeit der Investition war der Standort schon Teil der aktuellen Firmenkonstellation: Durch den Erwerb des Thyssen-Konzerns durch die Krupp AG im Jahr 1997 entstand die gemeinsame Flachstahlgesellschaft Thyssen Krupp Stahl AG, welche im September 1997 ihren Geschäftsbetrieb aufnahm.

Die Jahresproduktion des gesamten Duisburg-Standorts liegt bei ungefähr 12 Millionen Tonnen, die aktuelle Belegschaft bei 14.300 Mitarbeitern. Damit hatte sich die Jahresproduktion seit 1966 verdreifacht, die Belegschaft dagegen lag um 13% niedriger (Kirschbaum, 2016).

4.5.4.3 Unternehmen weltweit

Zum ThyssenKrupp-Konzern gehören 471 Unternehmen sowie 25 Beteiligungen aus insgesamt 78 Ländern, mit einem kollektiven Jahresumsatz von 39,2 Milliarden Euro in 2015/2016. Im Gegensatz zu den anderen großen Firmen im Stahlbereich handelt es sich bei ThyssenKrupp um einen integrierten Konzern. Viele der Geschäftsbereiche, haben nur wenig direkten Bezug zur Stahlproduktion: Nach Kundengruppen aufgeteilt machten „Stahl und stahlnahe Verarbeitung“ im Geschäftsjahr 2015/2016 nur 14% des Firmenumsatzes aus (ThyssenKrupp, 2016). Das operative Geschäft ThyssenKrupps gliedert sich laut Firmenwebseite und jüngstem Jahresbericht in sechs „Business Areas,“ von denen nur zwei mit Stahlproduktion verbunden

sind: Steel Europe und Steel Americas.[43] Da sowohl der nordamerikanische Standort in Alamaba als auch der südamerikanische in Brasilien verkauft wurden (siehe unten), ist der Bereich Steel Americas faktisch in Auflösung. Trotz der globalen Ausrichtung der Firma insgesamt findet heute ThyssenKrupps *Primärproduktion* von Stahl ausschließlich an europäischen Standorten statt.

Die „Americas"-Abteilung entstand parallel zur Investition in den neuen Hochofen am Standort Duisburg-Schwelgern: Im Mai 2007 gab Thyssenkrupp bekannt, ein neues Walzwerk im US-Bundesstaat Alabama zu bauen. Das Werk in Alabama sollte Rohstahl aus der damals schon entstehenden neuen Produktionsstätte in Brasilien weiterverarbeiten. Es sollte Stahlplatten, Kohlenstoffstahl und gerollten Edelstahl für die Auto-, Geräte- und Bauindustrie der Nordamerikanischen Freihandelszone (USA, Canada und Mexiko) produzieren.[44] Um diese Investition hatten sich zuvor mehrere US-Standorte beworben (Steel Technology, 2007). Nach dreijähriger Bauzeit wurde die Anlage im Dezember 2010 als Teil der damaligen Firmensegmente ThyssenKrupp Steel USA und ThyssenKrupp Stainless USA offiziell eingeweiht und war zu der Zeit mit 5 Milliarden US-Dollar eine der größten ausländischen Investitionen in den USA (ThyssenKrupp, 12.10.2010). Im Jahre 2013 verkaufte ThyssenKrupp das Werk für nur USD 1,5 Milliarden an ein Gemeinschaftsunternehmen der Firmen ArcelorMittal und Nippon Steel & Sumitomo Metal Corp.

Das schon vor der Hochofeninvestition in Duisburg geplante neue Stahlwerk in Brasilien (siehe auch Abschnitt 3.5 für Details) wurde in den Jahren 2006 – 2010 gebaut und firmierte unter dem Namen ThyssenKrupp CSA (TKCSA) - ThyssenKrupp war mit 73% an TKCSA beteiligt. Dort produzierte Stahlbrammen gingen zur Weiterverarbeitung an europäische Standorte und an das nordamerikanische Werk in Alabama – auch nach dessen Verkauf im Jahr 2013. Anfang 2017 wurde TKCSA für 1,5 Milliarden Euro an den argentinischen Stahlkonzern Ternium verkauft.

4.5.4.4 Angaben zur getätigten Investition und ihrem Effizienzgrad

Bei der Investition am Standort Duisburg handelte es sich um den Umbau eines ganzen Stahlkomplexes. Dabei machte der Bau eines neuen Ofens den größten Anteil aus (Hochofen 8 in Duisburg-Hamborn, an der Stelle eines 1991 stillgelegten Ofens). Zusätzlich zum Neubau wurde am selben Standort der Hochofen 9 (gebaut im Jahre 1987) nach den üblichen 20 Jahren Laufzeit neu zugestellt, und ein anderer Hochofen (4) ganz außer Betrieb genommen. Das gesamte Investitionsvolumen betrug 340 Millionen Euro (ThyssenKrupp, 24.04.2006).

Es konnten keine Informationen zum spezifischen Effizienzgrad des neuen Hochofens gefunden werden. Der Umbau des Gesamtkomplexes führte jedoch zu Energieeinsparungen im Vergleich zum Materialfluß vor der Investition wegen der damit verbundenen Logistikoptimierung und Produktivitätsverbesserung (ThyssenKrupp 2006, Seite 88).

4.5.4.5 Entscheidungsfindung zur Investition

Da ThyssenKrupp auf mehrfache Nachfrage keinen Kontakt zu Ansprechpartnern vermittelte, kann die Diskussion der damaligen Entscheidungsfindung lediglich auf Grundlage öffentlich verfügbarer Dokumente erfolgen.

Die Investition wird im damaligen Geschäftsbericht als logistische Notwendigkeit begründet – die gesamte Umgestaltung des Komplexes (inklusive Neuzustellung des Hochofens 9) diente

[43] Umsatzanteile siehe Seite 53, Unternehmensbereiche siehe Seite 34 in ThyssenKrupp (2016)

[44] Aus dem Jahr 2005 der Firmenchronik ThyssenKrupps: „Entschluss zum Bau eines Stahlwerks in Brasilien" – available online at: https://www.thyssenkrupp-steel.com/de/unternehmen/historie/chronik/chronik.html (accessed 22.09.2017)

hauptsächlich der „Rationalisierung des Produktionsflusses," indem es die Versorgung mit Roheisen in Duisburg für die weitere Stahlerzeugung und -weiterverarbeitung in den deutschen Werken stabilisierte (ThyssenKrupp 2006).

Pressemeldungen legen nahe, dass CO_2-Emissionen bei der Entscheidungsfindung keine wichtige Rolle spielten, wohl aber andere Umweltauswirkungen wie Feinstaub und Lärm: Bei der Erläuterung der „Umweltmaßnahmen" des neuen Anlagekomplexes in Duisburg werden Maßnahmen zur Minderung von Staubausstoß und Lärm ausführlich erklärt und als besonders fortschrittlich geschildert. Treibhausgasemissionen dagegen werden nicht erwähnt.[45] Der Geschäftsbericht aus dem Jahr 2004/2005 erwähnt die Investition sogar explizit in Bezug auf Staubminderung: „Bei vielen Investitionsprojekten, beispielsweise dem Bau des neuen Hochofens 8 im Segment Steel, entfällt ein sehr hoher Anteil auf Maßnahmen zur Staubminderung" (ThyssenKrupp, 2005).

Aus den Geschäftsberichten zur Zeit der Investition geht allerdings hervor, dass ThyssenKrupp den damals gerade eingeführten EU-Emissionshandel als potenziellen zukünftigen Kostenfaktor betrachtete – Emissionsberechtigungen und deren Wert wurden (mit anderen ähnlichen Variablen wie Strompreisen) in der Geschäftsplanung mitbetrachtet:

„Hinzu kommen beim Strom die weiterhin erheblichen Unsicherheiten über die Kosten für CO_2-Zertifikate, was hohe Strompreise stützt. Dies verteuert ebenfalls energieintensive Produkte wie die Technischen Gase. Gemeinsam mit unseren Verbänden und anderen großen Verbrauchern arbeiten wir deshalb daran, mehr Transparenz in die Marktsituation zu bringen – beispielsweise in der Frage, wie die kostenlos zugeteilten CO_2-Zertifikate in den Strompreisen zu berücksichtigen sind" (ThyssenKrupp 2005, Seite 53).

Die Kosten des Emissionshandels werden insofern in der Geschäftsplanung als Kostenfaktor für den Energiebezug und dessen Auswirkung auf Beschaffungskosten thematisiert – nicht jedoch in direkter Verbindung mit dem eigentlichen Investitionsvorhaben. In den Jahresberichten 2005/2006 und 2006/2007 werden ebenfalls Emissionsberechtigungen in Bezug auf Energiekosten thematisiert und die Notwendigkeit des Zukaufs von Emissionsberechtigungen erläutert – dies wird jedoch nicht auf Investitionsvorhaben bezogen.[46]

[45] Laut Pressemeldung wurden sowohl der neue Hochofen als auch der neuzugestellte Hochofen „mit einer neuartigen Entstaubung der Waggonentleerung mit einem Investitionsvolumen von mehr als 20 Millionen Euro ausgerüstet." Zusätzlich wurde die Kühlanlage des Hochofens 8 mit einem „besonders geräuscharmen, mit niedriger Drehzahl arbeitenden Ventilator ausgestattet" – durch diese Maßmahmen wurden die damaligen gesetzlichen Grenzwerte für Feinstaubemissionen „teilweise deutlich unterschritten" und Lärm reduziert (ThyssenKrupp, 24.04.2006)

[46] „Für Energie haben wir 2005/2006 mehr zahlen müssen als im Jahr zuvor. Die weiter steigende Nachfrage in Asien hat Mineralöl und die daraus hergestellten Produkte drastisch verteuert […] Zum Anstieg der Stromkosten hat auch die Einführung des Handels mit CO_2-Emissionen beigetragen. Die Preisaufschläge konnten nicht durch den Verkauf von Berechtigungen im Emissionshandel ausgeglichen werden, den ThyssenKrupp 2005/2006 erstmals aufgenommen hat. Insgesamt waren unseren Konzernunternehmen Berechtigungen für die Emission von 18,7 Mio t CO_2 pro Jahr für die erste Handelsperiode 2005-2007 zugeteilt worden. Durch Emissionseinsparungen in der Produktion und auf die erste Handelsperiode beschränkte Regelungen bei der Zuteilung ergab sich ein Überschuss an Emissionsberechtigungen, der im Handel abgegeben werden konnte" (ThyssenKrupp, 2006).

Im Geschäftsjahr 2007-2008 (Geschäftsbericht 2007-2008, Seite 85) werden CO_2-Preise wieder unter allgemeinen Energiekosten erwähnt, diesmal wird aber das Defizit an Zertifikaten in der 2. Handelsperiode erwähnt „Angesichts der hohen Stahlproduktion reichen uns die von der Bundesregierung zugeteilten CO_2-Emissionsrechte in der jetzt begonnenen zweiten Handelsperiode des EU-Emissionshandels (2008 – 2012) nicht aus: Wir werden deshalb Emissionsrechte oder vergleichbare Zertifikate zukaufen müssen. Durch konzernweite Energieeinsparungen, die Beteiligung an CO_2-Fonds und eine effiziente Beschaffungsstrategie konnten wir bisher den Aufwand begrenzen. Aber zusätzlich erhöhen sich unsere Energieaufwendungen auch dadurch, dass die Kosten für CO_2-Emissionsrechte in den Strompreis vollständig einbezogen sind. Bei steigenden Preisen für Emissionsberechtigungen in der zweiten Handelsperiode nehmen somit auch die Kosten der Strombeschaffung zu."

4.5.5 ThyssenKrupp integriertes Stahlwerk in Santa Cruz, Brasilien

4.5.5.1 Allgemeines

CSA Siderúrgica do Atlântico Ltda., eine Tochtergesellschaft von Thyssenkrupp Slab International B.V., welche wiederum zu ThyssenKrupp AG gehört (Marketwatch, 21.02.2017) – ist ein integriertes Stahlwerk, das zwischen 2006-2010 auf „grüner Wiese" im Staat Rio de Janeiro in Brasilien gebaut wurde. Die Entscheidung zum Bau wurde 2005 finalisiert – ThyssenKrupp rechnete damals mit einer Investition von 3 Milliarden Euro (ThyssenKrupp, 2006, Seite 87). Wegen unvorhergesehener technischer Probleme beliefen sich die tatsächlichen Kosten für den Bau (rückblickend ein Jahrzehnt später, kumulativ) auf über 8 Milliarden Euro (Dierig, 2017). Das Werk umfasst eine Kokerei, eine Sinteranlage, zwei Hochöfen, ein Oxygenstahlwerk, zwei Stranggießanlagen, ein eigenes 490 MW Kraftwerk und einen eigenen Hafen. Es produziert hauptsächlich Stahlbrammen zur Weiterverarbeitung an Standorten in Europa und Nordamerika und hat eine Kapazität von 5 Millionen Tonnen pro Jahr (Fischer, 2013).

4.5.5.2 Standort und Betreiber

Der Standort liegt 70 Kilometer vom Zentrum von Rio de Janeiro entfernt im Stadtteil Santa Cruz, in der Bucht von Sepetiba. Alle Anlagen sind in einem Stahlproduktionskomplex miteinander verbunden und liegen maximal 6,5 Kilometer voneinander entfernt (Fischer, 2013).

Im Februar 2017 machte ThyssenKrupp bekannt, dass die Anlage an den argentinischen Stahlkonzern Ternium S.A. verkauft wird. Bei der Wertermittlung des Verkaufs im September 2016 wurde von einer Finalisierung der Übergabe an Ternium spätestens Ende September 2017 ausgegangen (Marketwatch, 2017). Bis dahin gehört die Anlage zum Geschäftsteil Steel Americas als ThyssenKrupp CSA. Mit Produktionsstätten in Argentinien, Mexiko, Guatemala, Kolumbien und den USA ist Ternium der größte Hersteller von Lang- und Flachstahlprodukten in Lateinamerika. Die jährliche Stahlproduktionskapazität des Konzerns beträgt 11 Millionen Tonnen und der Jahresumsatz 2016 lag bei 8,7 Milliarden US Dollar.[47]

4.5.5.3 Unternehmen weltweit

(siehe hierzu Abschnitt 5.5.4.3)

4.5.5.4 Angaben zur getätigten Investition und ihrem Effizienzgrad

Die Sinteranlage hat eine Kapazität von 5,7 Millionen Tonnen/Jahr, die Kokerei 1,9 Millionen Tonnen/Jahr, die zwei Hochöfen haben zusammen eine Gesamtproduktionskapazität von 5,3 Millionen Tonnen Stahl/Jahr, und die zwei Stranggießanlagen können pro Jahr 5 Millionen Tonnen Stahl verarbeiten. Das 490 MW Kraftwerk erzeugt aus Prozessgasen der Hochöfen und Dampf aus Kokerei und Stranggießanlage Strom: 200 MW werden intern genutzt, und decken so den Elektrizitätsbedarf der Anlage ab, der Rest wird in das Stromnetz des Stadtteils Santa Cruz geleitet, d.h. im Strommarkt verkauft (Fischer, 2013, 10-11).

Aus den ThyssenKrupp-Geschäftsberichten der Jahre unmittelbar vor dem Bau der neuen Anlage – also während der Entscheidung zur Investition – geht hervor, dass der Effizienzgrad des brasilianischen Standorts mindestens das Niveau vergleichbarer europäischer Anlagen erreichen sollte. Im Geschäftsbericht 2004/2005 wird betont, dass Umweltstandards firmeneinheitlich seien und damit auch für den Neubau in Brasilien gelten:

[47] http://www.ternium.com/en/about-us/

„Auch in den ausländischen Werken gilt unser konzerneinheitlich hoher Umweltschutz, mit dem wir unsere Fertigungen nachhaltig umweltverträglich betreiben. So sollen beispielsweise die Anlagen des geplanten Stahlwerks in Brasilien nach den höchsten europäischen Umweltstandards ausgelegt werden“ (ThyssenKrupp, 2005, Seite 54).

Der in der brasilianischen Anlage eingesetzte Kraft-Wärme-Kopplungsprozess wurde wegen seines besonders hohen Wirkungsgrads gewählt – dies bestätigt ein in der Fachzeitschrift „Energize“ veröffentlichter Beitrag der Firma Alstom, die den Bauauftrag des Kraftwerkskomplexes gerade wegen seiner Energieeffizienz gewann.[48] Die Kraftwerksgestaltung kombiniert die Prinzipien eines Gasturbinen- mit denen eines Dampfkraftwerks: Wärme (in Form von Dampf) wird aus Kokerei und Schmelzbetrieb zurückgewonnen, und sowohl Prozessgase der Hochöfen als auch Konvertergas des Schmelzbetriebs werden als Einsatzgut für die Elektrizitätserzeugung genutzt.

Vor allem letztere Technik (Nutzung der Hochofengase) ging bei dieser Anlage über konventionelle Effizienzmaßstäbe hinaus: Turbinen, die Hochofengas zur Elektrizitätserzeugung nutzen, brauchen wegen seines relativ niedrigen Brennwerts zusätzlich extern erzeugtes Erdgas oder Kokereigas. Da die brasilianische Anlage nur anlageneigene Prozessgase verwendet, müssen weder externen Brennstoff zugekauft, noch überschüßige Prozessgase abgefackelt werden (Hyman, 2012). Laut Alstom war dies eine Bedingung der Ausschreibung des Kraftwerkbauvertrags. Im Jahre 2008 gab ThyssenKrupp an, dass dieses Kraftwerk „das erste seiner Art in ganz Amerika sein“ werde (ThyssenKrupp, 2008, Seite 113). Fast ein Jahrzehnt später wird es in der Beschreibung der Energieeffizienz des brasilianischen Standorts auf der aktuellen Firmenwebseite (September 2017) als einmalig in Brasilien bezeichnet.[49]

Daß die am brasilianischen Standort verwendete Technik von ThyssenKrupp für überdurchschnittlich effizient gehalten wurde, zeigt das im Geschäftsbericht 2007/2008 geschilderte Vorhaben, für diese Investition im Rahmen des UN Mechanismus für umweltverträgliche Entwicklung („Clean Development Mechanism,“ CDM) Emissionszertifikate zu gewinnen. Solche CDM-Projekte erzeugen in der Klimarahmenkonvention zertifizierte Emissionsminderungen (CERs) als handelbare Einheit. Emittenten können diese kaufen, um damit rechnerisch ihre eigenen Emissionen auszugleichen. ThyssenKrupp erhoffte sich in der zweiten Handelsperiode des EU ETS einen Zufluss an Zertifikaten durch CDM-Projekte am brasilianischen Standort:

„Die Projekte durchlaufen zurzeit das vorgeschriebene Verfahren zur UN-Anerkennung und werden voraussichtlich Emissionen im Volumen von 4,7 Mio t CO_2 während der zehnjährigen Laufzeit vermeiden. Für diese Minderungen können handelbare Emissionsgutschriften ausgestellt werden“ (ThyssenKrupp, 2008, Seite 113).

Um die Projekte anzuerkennen, muss der Betreiber nachweisen, dass durch den Einsatz der jeweilige Technik projektweit netto weniger Treibhausgase ausgestoßen werden, als dies ohne den Einsatz der Technik der Fall gewesen wäre. Allerdings stellt der Vergleich in einem CDM-Projekt typischerweise auf den Technikstandard in der *Einsatzregion* – die Emissionsgutschriften entstehen also nur aufgrund der Tatsache, dass die brasilianische Anlage effizienter (und somit emissionsärmer) produziert als vergleichbare Anlagen in Lateinamerika. Ob der Effizienzgrad höher ist als der Standard vergleichbarer Anlagen in Europa, ist dagegen

[48] “High efficiency and flexibility of operation were key considerations in opting for the Alstom power plant solution” (Hyman, 2012, Seite 16).

[49] “This kind of technology, which is still not used in other steel mills in Brazil, allows for up to 10% efficiency gain when compared with traditional technology” https://www.thyssenkrupp-csa.com.br/en/sustainability/environment/energy-efficiency/#

unerheblich. Hinzu kommt, dass das Verfahren zur UN-Anerkennung des Projektes im Rahmen des CDM entweder gescheitert ist oder von seiten des Antragstellers abgebrochen wurde: In der öffentlich verfügbaren Datei aller CDM-Projekte ist ThyssenKrupp CSA Siderúrgica do Atlântico nicht zu finden.[50]

4.5.5.5 Entscheidungsfindung zur Investition

Da ThyssenKrupp auf mehrfache Nachfrage keinen Kontakt zu Ansprechpartnern vermittelte, kann die Diskussion der damaligen Entscheidungsfindung lediglich auf Grundlage öffentlich verfügbarer Dokumente erfolgen.

Laut Firmenchronik[51] beruhte der Entschluss zum Bau eines Stahlwerks in Brasilien auf den Annahmen einer weltweit steigenden Stahlnachfrage, explodierenden Rohstoffpreisen und einem zunehmend global agierendem Wettbewerb zwischen den Stahlproduzenten (ThyssenKrupp, 29.09.2006). Als regionaler Kostenvorteil werden nur Nähe zu den Erzvorkommen und Wachstumschancen in der NAFTA-Region explizit erwähnt. Umwelt- oder energiespezifische Faktoren – wie z.B. günstigere Energiepreise in Lateinamerika oder niedrigere Umweltstandards werden dagegen nicht erwähnt. Insbesondere werden CO_2-Emissionen, einschlägige Regulierung oder etwa die Bepreisung von Emissionen nicht als Einflussfaktoren genannt.

4.6 Schlussfolgerungen

Dieser Bericht bestätigt im Wesentlichen den Befund anderer Autoren: Investitionsleakage mag zwar politisch hoch relevant sein – empirisch lässt es sich bislang nicht feststellen, weder in Deutschland noch in Europa.

Allenfalls bei den statistischen Daten zu deutschen Direktinvestitionen im Ausland und ausländischen Direktinvestitionen im Inland lassen sich Konstellationen erkennen, die grundsätzlich kompatibel wären mit der Investitionsleakage-Hypothese. Dies trifft etwa für die Beobachtung zu, dass von 2003 bis 2009 in der Metall- und Chemieindustrie entgegen dem Trend für die Gesamtwirtschaft der Anteil der außereuropäischen Investitionen zugenommen hat. Aufgrund der mangelnden Trennschärfe bei der statistischen Abgrenzung und der geringen Anzahl der Datenpunkte lässt sich hieraus jedoch kein Beleg in die eine oder andere Richtung herleiten.

In Befragungen von Unternehmen gibt regelmäßig nur eine kleine Minderheit von Unternehmen an, dass der CO_2-Preis überhaupt einen Einfluss auf ihre Investitionsentscheidungen habe, und dass sie als Reaktion auf den erwarteten, in Zukunft höheren CO_2-Preis erwägen, in größerem Umfang im Ausland zu investitieren. Dies gilt auch für Befragungen von ausschließlich emissionshandelspflichtigen Unternehmen und für die Antworten von Unternehmen aus klassischen Leakage-Sektoren wie Stahl, Zement oder Chemie.

Ähnliche Befunde ergeben sich auch aus der einschlägigen Literatur: in der jüngeren Vergangenheit haben sich verschiedene Autoren mit unterschiedlichen Methoden der Frage genähert und dabei ebenfalls kaum Anhaltspunkte dafür gefunden, dass Investitionsleakage existiert. Die Literatur gibt ebenfalls wenig Anhaltspunkte dafür, dass der CO_2-Preis überhaupt einen Einfluss auf Investitionsentscheidungen hat, weder im Sinne von Standortverlagerung, noch im Sinne von Investitionen in Energieeinsparung und Emissionsminderung.

[50] http://cdm.unfccc.int/Projects/projsearch.html

[51] https://www.thyssenkrupp-steel.com/de/unternehmen/historie/chronik/chronik.html

Auch die Fallstudien zu großen Investitionsprojekten haben allenfalls bestätigt, dass andere Faktoren den Ausschlag für Investitionsentscheidungen geben. Energieeffizienz und Einsparung von Enerigekosten scheinen noch eine gewissen Rolle zu spielen, während CO_2-Preise entweder nicht genannt oder (in einem Fall) explizit als unerheblich bezeichnet werden.

Bedeutet das also, dass Investitionsleakage nur eine Chimäre ist?

Nicht unbedingt. Zum einen beziehen sich die beschriebenen Befunde auf die Vergangenheit – und damit auf eine Zeit mit überwiegend geringen CO_2-Preisen, bei gleichzeitig großzügiger Ausstattung der Anlagen mit Emissionsberechtigungen. Modellrechnungen legen nahe, dass dies anders aussähe, wenn CO_2-Preise auf das Niveau stiegen, das für eine echte Dekarbonisierung nötig wäre. Auch im Fall einer zunehmend knappen kostenlose Zuteilung könnte sich die Situation ändern.

Andererseits legen mehrere Befunde aus Umfragen, Fallstudien und der Literatur nahe, dass Investitionsleakage als Reaktion auf den EU-Emissionshandel *im Vergleich zu anderen Einflussfaktoren* kein erhebliches Problem ist. Investitionsentscheidungen scheinen stärker von Zugang zu wachsenden Märkten, Rohstoffen, qualifizierten Mitarbeitern, Infrastruktur etc. getrieben zu sein. Viele dieser anderen Einflussfaktoren wirken allerdings ebenfalls darauf hin, dass tendenziell weniger Investitionen in Europa und mehr Investitionen in Schwellenländern getätigt werden. Anders gesagt: Auch wenn sich die Investitionen nicht wegen des EU-Emissionshandels verlagern, tun sie es am Ende trotzdem.

Schließlich lässt sich auch argumentieren, dass in Europa – und gerade auch in Deutschland – insgesamt zu wenig investiert wird. Radikale Maßnahmen zur Emissionsminderung, also ein Systemwechsel hin zur Dekarbonisierung, erfordern erhebliche Investitionen in Infrastruktur, neue Technologien und neue Geschäftsmodelle. Gleichzeitig gilt es, den nötigen Strukturwandel zu begleiten. Auch dies wird Investitionen in den betroffenen Regionen erfordern. Allein die Erwartung eines etwaigen, höheren CO_2-Preises in der Zukunft wird allein nicht ausreichen um einen Anreiz für diese Investitionen zu schaffen; vielmehr bedarf es hier gezielter Investitionsanreize für Schlüsseltechnologien (Duwe und Ostwald 2018).

Insgesamt aber legen die Befunde in diesem Bericht nahe, der Diskussion um Investitions-leakage mit einer gewissen Entspanntheit zu begegnen; dringlicher und spannender erscheint die Frage, wie sich Investitionen in emissionsarme Technologien und disruptive Innovationen fördern lassen, und wie die Risiken bei diesen Investitionen verteilt werden können.

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5 The Innovation Fund: how can it support low-carbon industry in Europe?

Das Ergebnis des Arbeitspakets 1.3 "The Innovation Fund: how can it support low-carbon industry in Europe?" wurde im Bericht 06/2018 der Serie „Climate Change“ des Umweltbundesamtes veröffentlicht. Es ist auf der Homepage des Umweltbundesamtes verfügbar.

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AP 2 – Carbon Leakage Risks in a World of Converging Carbon Prices

6 Carbon Leakage Risks in a World of Converging Carbon Prices

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List of abbreviations

Abbrevation	Meaning
AQI	Air Quality Index
CAFE	Clean Air for Europe
CCS	Carbon capture and storage
CDM	Clean Development Mechanism
C-ETS	California Emissions Trading Scheme
CH ETS	Swiss Emissions Trading Scheme
CH_4	Methane
CO_2	Carbon dioxide
CPA	Statistical Classification of Products by Activity
EED	Energy efficiency directive
ESP	Energy savings program
ETS	Emissions Trading Scheme

Abbrevation	Meaning
EU ETS	European Emissions Trading Scheme
EUR	Euro
FYDP	Five Year Development Plan
GHG	Greenhouse gas
HFCs	Hydrofluorocarbons
INDC	Intended Nationally Determined Contribution
ktoe	Kiloton of oil equivalent
MACs	Maximum allowable concentrations
MEPS	Minimum energy performance standards
MRV	Measurement, reporting and verification
mtoe	Megaton of oil equivalent
NACE	European Classification of Economic Activities
NDC	Nationally Determined Contribution
NF3	Nitrogen trifluoride
NOR	Norwegian krone
NRDC	National Development and Reform Commission
N_2O	Nitrous oxide
OAPC	Ordinance on air pollution control
PFCs	Perfluorocarbons
SF6	Sulphur hexafluoride
SK ETS	South Korean Emissions Trading Scheme
RGGI	Regional Greenhouse Gas Initiative
Tce	Tonne of coal equivalent
toe	Ton of oil equivalent
TSELs	Tentatively save exposure levels
TSP	Total suspected particulates
Twh	Terawatt hour
USD	US Dollar

6.1 Introduction

The current debate on carbon leakage in Europe centres around the (implicit or explicit) assumption that the EU is pursuing a more ambitious climate policy than its major trading partners, putting its industries – particularly carbon-intensive ones – at a competitive disadvantage. This premise was justifiable a decade ago, but by now has become questionable.

At the time of its introduction in 2005, the European Emission Trading System (EU ETS) was virtually the only instrument with the explicit goal of introducing a price on CO_2 emissions. At that time, emissions from EU Member States made up about 4% of global greenhouse gas (GHG) emissions. Since then, however, there has been a proliferation of carbon pricing tools around the world. Examples include the North American cap-and-trade systems (the Regional Greenhouse Gas Initiative (RGGI) comprising ten North-Eastern US states, California, Quebec), the ETS in New Zealand, Switzerland, Kazakhstan and South Korea, two regional schemes in Japan (Tokyo, Saitama) and seven Chinese pilot ETS. China is in the process of rolling out its national ETS; further ETS are under preparation or in the legislative process in Mexico and Colombia.

In addition, a number of countries and jurisdictions have introduced a carbon tax (e.g. Chile, Mexico, British Columbia) or are in the process of doing so (South Africa). Finally, a number of jurisdictions around the world have been investigating the different options for carbon pricing, or have at least stated their intentions to use such tools in the future (including, among others, Vietnam, Thailand, Turkey and Ukraine). As a result, the global share of emissions that is covered by some type of carbon price has increased to 12% (Marcu et al., 2013). Interestingly, the price level in the majority of cases is comparable to the EU ETS: in most instances, the CO_2 prices in the different ETS around the world range between 6 and 12 Euro, and in the case of some CO_2 taxes also significantly higher (World Bank and Ecofys, 2017).

This suggests that a fundamental premise of the European carbon leakage debate may need to be revisited. From a competitiveness angle, the question however is not so much what proportion of global emissions is covered by some kind of carbon price – but rather whether the direct competitors of European companies face a carbon constraint that is comparable to the EU ETS price.

The key questions are therefore:

- Which countries and jurisdictions outside the EU are relevant for European companies that are most exposed to carbon price risks and where are their competitors based? This is approximated through the sectoral trade intensities of the EU with non-EU countries including import and export values for the relevant products (see Chapter 3).
- What proportion of foreign competitors faces some kind of carbon constraint and/or carbon price and how does this compare to the constraint imposed by the EU ETS? In particular: how does the level of the carbon price compare? For those that currently do not face a carbon constraint: is there any indication that a carbon constraint or price will be imposed in the future and are there any other relevant policies and measures in place that have a significant effect on industrial emissions?

This is assessed by checking the policy framework for countries outside of the EU being relevant trade partners with respect to carbon capping and pricing as well as with respect to other measures that have an effect on industrial emissions.

6.2 Carbon pricing worldwide

Carbon pricing instruments put a price on emissions of CO_2, and possibly other greenhouse gases. By doing so, they give emitters an incentive to reduce their emissions. Ideally, these initiatives would price emissions in line with their full external cost (i.e. the social cost of carbon), in order to maximize efficiency and overall welfare (Cramton et al., 2017; ICAP, 2017a; Pizer, 1997). The two most common carbon pricing mechanisms are emissions trading systems (ETS) and carbon taxes. In theory, the two mechanisms lead to the same output at almost equal costs, and in both cases would minimize the cost of achieving a given emission reduction target.[52] An **ETS** sets a cap on the total volume of emissions that may be emitted by all participating entities and creates tradable allowances or "permits" to emit a certain amount of carbon dioxide equivalent. A **carbon tax** puts a direct price on CO_2 and/or other GHG emissions. The tax does not place a limit on the amount of carbon emitted but rather limits emissions through the financial disincentive.

Carbon pricing around the world

A number of carbon pricing instruments have been introduced globally since 1990 at all levels of governance, from municipal to supranational. The introduction of the EU ETS in 2005 marked the start of a period of rapid expansion, regarding both the number of instruments and the share of emissions they cover. A decade later, in 2014, 26 new initiatives had been implemented, almost tripling the share of global emissions covered by pricing initiatives from less than 4% to around 11%. Since 2015, another eight new instruments, including the South Korean national ETS and carbon taxes in Mexico and Chile, were launched. China currently prepares the launch of its national ETS which, if and when launched could then be the largest carbon pricing initiative globally (ICAP, 2017a).

As of 2016, there are 46 carbon pricing instruments in operation, covering around 15% of total global GHG emissions. Of these initiatives, 27 are carbon taxes and 19 are emissions trading systems, with the emissions trading systems accounting for more than two-thirds of the covered emissions (World Bank and Ecofys, 2015). Various other countries currently have taken steps to introduce a carbon tax or an ETS; besides China this also includes Brazil, Thailand, South Africa, Ukraine and Canada. If implemented, these initiatives would significantly increase the share of GHG emissions covered by a carbon price; the Chinese ETS alone would already increase this share by around 8%.

Prices differ significantly among the carbon pricing initiatives. They range from less than 1 USD/tCO_2e in Mexico, Poland and Ukraine to 126 USD/tCO_2e in Sweden. These differences are partly due to the different sectors that the instruments cover - with different abatement costs, abatement potentials and price sensitivities. A large majority of instruments imposes carbon prices of less than 10 USD/tCO_2e (World Bank and Ecofys, 2017). These instruments delivered USD 22 billion in revenues for the respective governments in 2016, down from USD 26 billion in 2015. According to World Bank and Ecofys (2017), this drop is largely due to the lower allowance prices in the EU ETS and RGGI and a large amount of unsold allowances in California and Québec as well as a drop in revenues from some carbon taxes, in particular the UK carbon price floor. The trend towards lower prices causes global concern because prices are generally considered being too low to incentivize investment in low carbon solutions, and since they are not perceived to adequately reflect the environmental costs of GHG emissions.

[52] For a detailed analysis and comparison of ETS and carbon taxes see Cramton et al. (2017) or Pizer (1997).

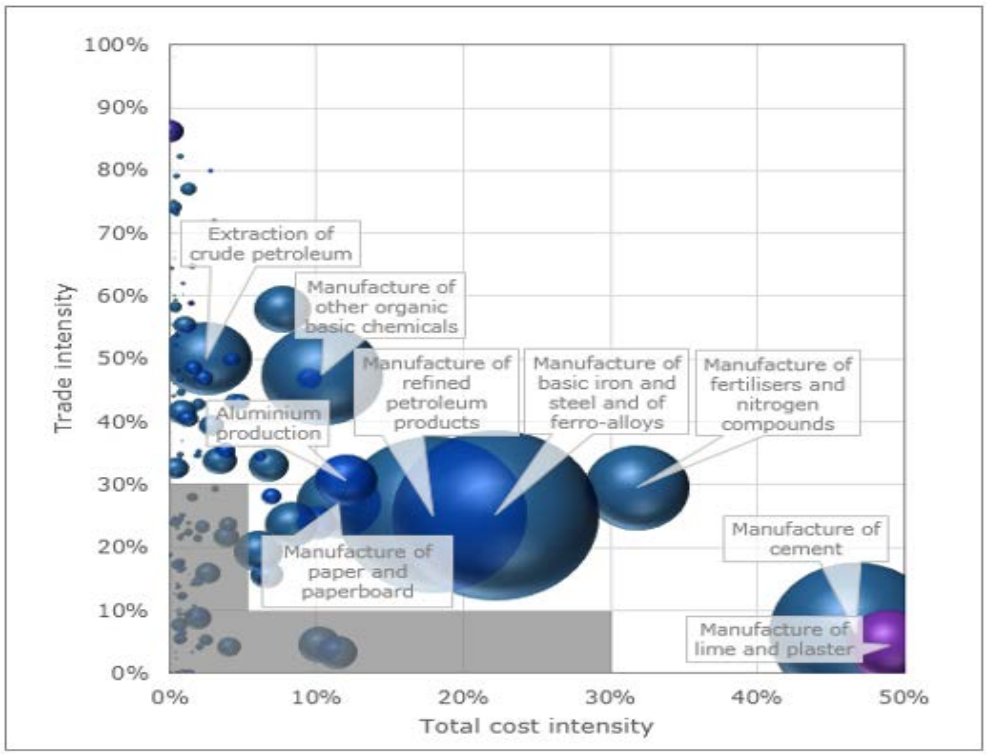
Carbon pricing after Paris – ETS and carbon taxes in NDC's

The Paris Agreement of 2015 plays a critical role in catalyzing the development of domestic climate action across the world, including carbon pricing instruments by encouraging countries to develop national plans for reducing their carbon emissions. Parties to the Paris Agreement need to define their "Nationally Determined Contribution" (NDC) to achieving the goals of the agreement, in which they describe their climate strategy. About two thirds of the currently submitted NDCs, accounting for approximately 58% of global GHG emissions, state that the respective country aims to make use of carbon markets as part of their climate efforts (World Bank and Ecofys, 2017). However, it should be noted that this figure includes a number of least developed countries, who presumably would expect to participate in carbon markets as a provider of offset certificates (CDM or a successor mechanism), and not by pricing emissions domestically.

6.3 Trade profiles in selected carbon-intensive commodities

The analysis focuses on selected industrial sectors that are covered by the EU ETS and that are exposed to international competition, namely (i) manufacturing of iron and steel; (ii) manufacturing of organic and inorganic chemicals including fertilisers; (iii) manufacturing of non-ferrous metals such as copper and aluminium; mineral processing industries producing (iv) cement and lime, (v) glass, or (vi) ceramics; (vii) manufacturing of pulp and paper and (viii) manufacturing of refined petroleum products. These sectors are considered to be at risk of carbon leakage according to Commission Decision 2014/746/EU.

Figure 25: Potential exposure of EU industries to carbon costs



Total costs intensity is the carbon costs as share of value added; trade intensity is the value of imports and exports in relation to turnover; the size of the bubbles indicates the respective industries' total CO2 emissions in 2014. The area shaded grey includes those sectors that, according to the current EU legislation, are not considered as exposed to the risk of carbon leakage.

Source: Ecofys (2015) based on preliminary matching of installations to sectors

Figure 25 gives an overview of these industrial sectors and their exposure to climate-related costs on the basis of their energy intensity (carbon costs as share of value added) and their trade intensity (value of imports and exports in relation to turnover) (Ecofys, 2015).

For these industrial sectors, we analyse exposure to international competition by identifying (a) import and export volumes of their products, and (b) the top ten external (i.e. non-EU) trade partners and their respective trade shares. This allows us to obtain a good outline on the most important target markets of European exporters from the industry sectors covered by the EU ETS, as well as the countries where the most important competitors of European industries covered by the EU ETS are located.[53]

6.3.1 Classification of products from industrial sectors

Trade volumes are provided by Eurostat via its external trade database (Eurostat, 2016). Trade volumes are given for different products that are classified using the Statistical Classification of Products by Activity (CPA).

Commission Decision 2014/746/EU lists the industrial activities covered under the EU ETS that are deemed to be at risk of carbon leakage with their respective NACE (European Classification of Economic Activities) code. The NACE code corresponds to the CPA code (see e.g. Eurostat, 2008) so that respective trade volumes for the selected industrial sectors can be identified. Table 10 gives an overview of the selected industries, the NACE codes that correspond to the CPA code and the related products.

Table 10: Most important sectors at risk of carbon leakage, their NACE/CPA codes and respective products

Sectors	NACE and CPA code	Product name
Iron and steel	2410	Iron and steel
Chemicals	2013, 2014, 2015	Inorganic and organic chemicals, fertilisers
Non-ferrous metals	2442, 2443, 2444, 2445	Copper, aluminium, lead, zinc and tin, others
Cement and lime	2351, 2352	Cement, lime and plaster
Glass	2311, 2313, 2314, 2319	Glass and glassware
Ceramics	2331, 2341 - 2344, 2349	Ceramic products
Pulp and Paper	1711, 1712, 1724	Pulp, paper and paperboard, wallpaper
Refineries	1920[54]	Refined petroleum products

Source: Own compilation based on Commission Decision 2014/746/EU stating NACE codes for activities at risk of carbon leakage

[53] As benefits were considered marginal compared to the significant additional workload, this analysis does not take into account the competitive situation in third markets. Therefore, countries that play a decisive role in global industrial trade and thus are potential competitors may fall outside the scope.

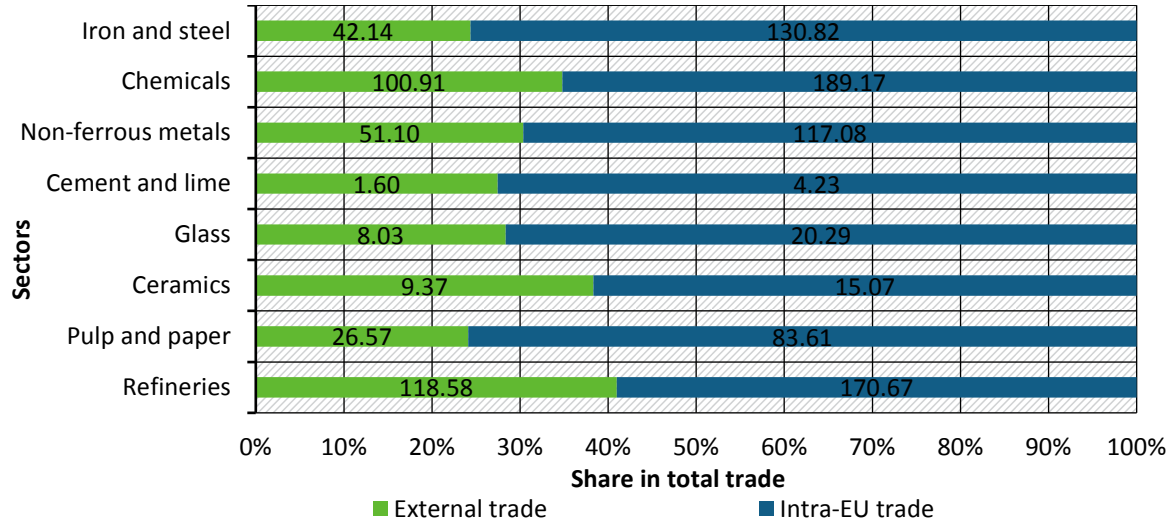
[54] Excluding coke and semi-coke of coal, of lignite or of peat; retort carbon; tar distilled from coal, lignite or peat; other mineral tars; pitch and pitch coke; briquettes, ovoids and similar solid fuels manufactured from coal or lignite. In addition, light petroleum oils for undergoing a specific process and gaseous hydrocarbons were excluded as these products are mainly produced during crude oil and natural gas extraction and are rather unimportant products of refineries.

6.3.2 Trade volumes in the selected industries

Of the selected industrial sectors, and for the year 2016, products from the chemical industry account for the highest trade value of more than EUR 290 billion, followed by refinery products with EUR 289 billion, then iron and steel with EUR 173 billion and pulp and paper with EUR 110 billion. The trading volume of each of the other industrial products is less than EUR 50 billion. Trade in glass products amounts to EUR 28 billion, ceramics with EUR 24 billion and cement and lime with EUR 6 billion (see Figure 26).

Two thirds of the trade in goods from the selected industrial sectors takes place within the EU[55]; about a third is traded with countries outside the EU. Intra-EU trade is particularly high for pulp and paper and for iron and steel: of the total trading volume only 22% and 23%, respectively, are traded with countries outside the EU. Refinery products have the highest share of external (non-EU) trade with 41% of total trade (Figure 26).

Figure 26: Intra-EU trade volumes compared to external trade volumes in 2016 (numbers in billion EUR)

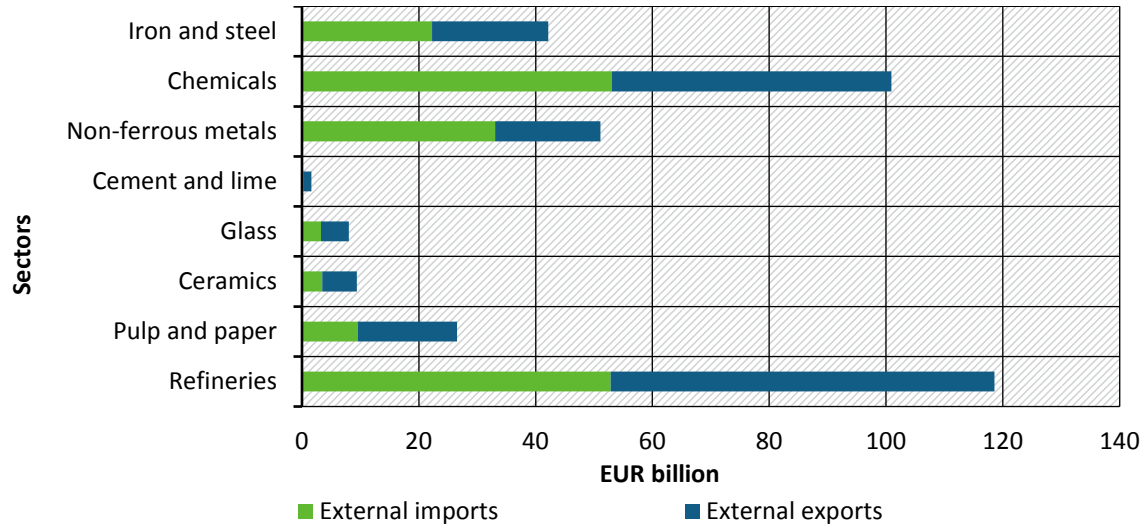


Source: own compilation based on Eurostat (2016)

In terms of absolute volumes, the external trade volume is highest for refinery products with EUR 119 billion followed by chemicals with EUR 101 billion. Non-ferrous metals (EUR 51 billion) and iron and steel trade (EUR 42 billion) are followed by pulp and paper (EUR 27 billion), ceramics (EUR 9 billion), glass (EUR 8 billion) and cement (EUR 2 billion). Overall, imports and exports are fairly balanced: while imports make up 53% of total trade for iron and steel and chemicals and 65% for non-ferrous metals, in other sectors export volumes exceed imports, ranging from 55% of total trade of refinery products, 59% for glass, 63% and 64% for ceramics and pulp and paper. The export share in total trade is by far the highest with 85% for cement and lime (albeit on the basis of a limited trade volume) (see Figure 27 and 0 A: Trade volumes and partners in the selected industrial sectorsTrade volumes and partners in the iron and steel sector).

[55] Intra-EU trade is the trade between Member States, i.e. exports or imports of one Member State with one of the other 27 Member States. Intra-EU imports do not equal intra-EU exports (although one would expect this) as exports are given with the free-on board (FOB) value (at the frontier of the exporting country) while imports are given with the cost, insurance and freight (CIF) price (at the frontier of the importing country). Thus, intra-EU imports should be slightly higher than the exports; however, coverage of intra-EU exports is generally better resulting in higher export values (Eurostat, 2017a).

Figure 27: Imports and exports of the EU with external trading partners for the different industrial products



Source: own presentation based on Eurostat (2016)

6.3.3 Most relevant trading partners

Regarding the most important trading partners outside the EU, a handful of major economies dominate EU trade statistics: not surprisingly, these are the largest economies in the world (China, the United States, Russia), as well as the EU's closest neighbours (Switzerland, Turkey and Norway) (Eurostat, 2017a). Table 11 presents the main trading partners and the respective trade volume, in 2016, for the selected industrial sectors and their products. The United States ranks highest with a trading volume of EUR 61 billion, 50% more than the second placed Russia. China trades around EUR 27 billion with the EU in the selected industrial sectors followed by Switzerland with EUR 21 billion, Turkey with EUR 15 billion and Norway with EUR 13 billion. India and Saudi Arabia both trade EUR 9 billion worth of products with the EU. South Korea and Brazil trade products worth EUR 8 billion with the EU.

These trading patterns are remarkably stable. A comparison of all merchandise trade (i.e. not only for the eight sectors above) shows that eight of the countries above are also among the EU's top 10 trading partners for all merchandise trade (with Brazil ranking 11th and Saudi Arabia 13th). Moreover, the choice of countries is also stable over time: comparing the most recent data (2017) with that from 2011 shows that 9 of the EU's top ten trading partners remained the same (with Canada replacing Brazil on the 10th place) (European Commission - DG Trade, 2018, 2012). The ranking itself also stays similar – changes are mostly confined to two or three countries swapping positions. Also, the volume of trade with the EU has grown in all countries between 2011 and 2017 – with the exception of Russia, presumably as a result of EU sanctions, or lower commodity prices, or both.

Table 11: Top 10 trade partners of the EU for the selected industrial sectors

	Trade partner	Trade volume (EUR million)
1	USA	61,426
2	Russia	39,822
3	China	27,275
4	Switzerland	20,653
5	Turkey	15,321
6	Norway	12,890
7	India	9,454
8	Saudi Arabia	9,362
9	South Korea	8,442
10	Brazil	8,212

Source: calculations based on Eurostat (2016). The trade volume is the sum of the trade volumes of the selected industrial sectors

Looking at the individual industrial sectors, the United States is the most important trading partner for three of the selected eight industrial sectors (chemicals, non-ferrous metals, and pulp and paper) and the second most important trading partner for the five other selected sectors. China is the most important trading partner for iron and steel, glass, and ceramics. Algeria is the most important trading partner for cement and lime. Russia is the most important trading partner for refinery products (see also the Annex, which presents detailed information about trade volumes for each of the industrial sectors and trading partners).

Based on Table 11 and Table 12 which give an overview of the top 10 trading partners for each of the industrial sectors, we selected eight countries for the analysis of carbon constraints and pricing as these represent a significant share of the EU trade in the selected industrial sectors:

1. United States
2. Russia
3. China
4. Switzerland
5. Turkey
6. Norway
7. South Korea
8. Algeria

Table 12: Top 10 trading partners in the selected industrial sectors and respective trading volume (in EUR billion)

	Iron & steel	Chemicals	Non-ferrous metals	Cement & lime	Glass	Ceramics	Pulp & paper	Refineries
1	CHN: 5.44	USA: 24.78	USA: 5.99	DZA: 0.21	CHN: 1.70	CHN: 1.82	USA: 4.36	RUS: 20.26
2	USA: 4.18	CHN: 10.73	RUS: 5.76	USA: 0.18	USA: 1.64	USA: 1.49	BRA: 2.74	USA: 18.81
3	RUS: 4.07	CHE: 8.79	CHN: 4.86	CHE: 0.10	CHE: 0.53	TUR: 0.49	CHN: 2.05	SAU: 5.67
4	TUR: 3.71	RUS: 7.35	NOR: 4.48	ISR: 0.08	TUR: 0.43	CHE: 0.43	RUS: 1.69	CHE: 4.41
5	UKR: 2.60	SGP: 4.76	CHE: 3.18	TUR: 0.08	JPN: 0.31	RUS: 0.36	TUR: 1.66	NGA: 4.17
6	KOR: 2.05	JPN: 4.51	TUR: 2.92	NOR: 0.07	RUS: 0.27	JPN: 0.34	CHE: 1.43	TUR: 3.39
7	DZA: 1.90	IND: 3.80	CHL: 1.95	GHA: 0.06	NOR: 0.22	SAU: 0.34	NOR: 0.86	NOR: 3.21
8	BRA: 1.84	KOR: 2.91	UAE: 1.37	RUS: 0.06	IND: 0.19	KOR: 0.23	CHL: 0.76	TGO: 3.08
9	IND: 1.84	NOR: 2.70	CDN: 1.28	COL: 0.06	UAE: 0.18	UAE: 0.23	IND: 0.66	UAE: 3.05
10	CHE: 1.79	TUR: 2.64	SAU: 0.94	BIH: 0.04	CDN: 0.14	ISR: 0.18	URY: 0.59	SGP: 3.01

3-letter country abbreviations: ARE: United Arab Emirates, BIH: Bosnia and Herzegovina; BRA: Brazil, CDN: Canada; CHE: Switzerland, CHL: Chile , CHN: China, COL: Colombia; DZA: Algeria, EGY: Egypt, IND: India, ISR: Israel; JPN: Japan, KOR: South Korea, NGA: Nigeria, NOR: Norway, RUS: Russia, SAU: Saudi Arabia, SGP: Singapore, TGO: Togo; TUR: Turkey, TWN: Taiwan, UKR: Ukraine, URY: Uruguay; USA: United States of America, ZAF: South Africa

Source: calculations based on Eurostat (2016)

6.4 Carbon pricing and other carbon constraints in the selected countries

This chapter analyses the carbon constraints applying in the selected countries, i.e. the most important trading partners of the EU. Carbon constraints refer to carbon pricing as well as to other policy instruments that are applied to limit GHG emissions in the selected industrial sectors. To facilitate comparison, analyses for all selected countries follow the same structure.

Analysis of existing and planned carbon pricing initiatives

In a first step, the analysis focuses on a national ETS and/or a national carbon tax that applies to the selected industrial sectors. In addition, it also considers specific taxes on energy use by taking into consideration the **effective carbon rates** as defined in OECD (2016): "effective carbon rates […] are the total price that applies to CO_2 emissions from energy use as a result of market-based instruments" (OECD, 2016, p.21).

Effective carbon rates vary significantly between the EU Member States, which mainly results from different tax levels on energy use: in Denmark and in Austria, for example, taxes of EUR 50 and EUR 44 apply to 46% and 47% of the industrial emissions that are also part of the EU ETS, respectively. On the other side, taxes of less than EUR 2 or EUR 3 apply to 51% of the industrial emissions that are also part of the EU ETS in Belgium and in Luxembourg, respectively. Energy taxes in other Member States such as Germany, Italy, France or Poland are located within this spectrum.

Due to the differences in EU Member States' effective carbon rates, selected countries' effective carbon rates cannot directly be compared to one EU counterpart. Moreover, the effective carbon rates cannot be broken down into specific industrial sectors. Therefore, they are considered only as a secondary indicator for assessing the ambition level of a country's carbon constraint, providing additional information, while the focus is on the existing or, e.g. in the case of China, planned **ETS design** with respect to the selected industrial sectors. This includes their coverage, existence and design of free allocation to these sectors and the general price development of emission allowances.

Where there is no national system, we checked for **sub-national carbon constraints**. As there was sufficient information on the Chinese national ETS, this analysis accounts for only one case where the selected industrial sectors are partly constrained, namely the United States. Here, we checked for the share of traded goods from the selected industrial sectors covered by a carbon price.

We also analysed proposals for future developments of existing carbon pricing initiatives as well as the likelihood and the ambition of a constraint being implemented in cases where there is no one in place yet.

Check of other measures

In a second step, our analysis focuses on other measures that possibly impact industrial emissions. These measures include industrial consumer energy prices as well as standards for air quality and energy efficiency[56].

The **energy prices** depend on the overall value of the fuel (indicated by the price) as well as on the countries' specific taxes and levies. This analysis is limited to natural gas and electricity, as

[56] Due to time constraints, the analysis of other measures does not include an analysis of subsidies or overcapacities. However, such analysis could, be interesting for further research

they are the main energy carriers consumed by industrial facilities (Eurostat, 2018)[57]. It includes a comparison with average EU energy prices, but it should be noted that the end-consumer energy prices including taxes and levies vary quite substantially in the different EU Member States and depending on the volume of energy purchased. For example, a small consumer of electricity in the EU with a consumption of below of 20 MWh pays on average more than twice the price of a large consumer with more than 70,000 MWh (203 vs. 95 EUR/MWh). Moreover, a small consumer in Bulgaria pays significantly less than a small consumer in Spain (115 vs. 343 EUR/MWh) and a large consumer in Bulgaria pays less than half of a large consumer in Cyprus (64 vs. 184 EUR/MWh) (Eurostat, 2017)[58].

In further sections about **air quality standards and energy efficiency standards**, we assess the respective measures in place compared to the measures set by the EU's legal framework which includes the Cleaner Air for Europe Directive (Directive 2008/50/EC) and the revised Emission Ceiling Directive (Directive 2016/2284/EU) as well as the Ecodesign Directive (Directive 2009/125/EC) and the Energy Efficiency Directive (Directive 2012/27/EU). These directives set performance standards, rules and obligations for air quality and energy efficiency in the EU.

Comparative assessment

The most important findings from our analysis are summarised in a summary table. The status quo as well as the expected development of the respective carbon constraint is broadly classified into one out of five categories:

1. Carbon constraint is tighter (i.e. more ambitious) than in the EU
2. Carbon constraint is comparable to the one in the EU
3. Carbon constraint is somewhat laxer (i.e. less ambitious) than in the EU
4. Carbon constraint is significantly laxer than in the EU
5. No carbon constraint

Different factors complicate the comparison of carbon constraints. In some cases, for example, enforcement deficits create a mismatch between the instruments as laid out in legislation and the actual practice. In others, assumptions are necessary on the implementation and ambition level of planned measures. Then again, the credibility of announcements as well as the priority of certain measures (e.g. ETS) varies between countries.

The comparison of carbon constraints follows an inductive approach. Where possible, single measures in the selected countries are first compared one -on-one to their EU counterpart. This way, measures that have an equal or at least similar estimated impact on selected industries can be identified and set aside. The remaining measures are then aggregated into two categories: "carbon pricing measures" and "other measures". Comparing these two aggregates to the corresponding EU aggregates yields a better comparison than directly comparing the overall carbon constraints, because it avoids the need to transpose e.g. energy efficiency standards into a carbon price-equivalent, which would inevitably need to involve strong assumptions. Yet, due to the challenges described above, the resulting comparison should be interpreted with caution.

[57] Please note, that for certain energy intensive industries, e.g. iron and steel, solid fuels are also a relevant factor which can be just as or even more important than natural gas and electricity as main energy carriers.

[58] It is worth noting that here is no single and agreed value for electricity prices for industrial consumers. Moreover, transparency is limited. Prices differ depending on the size / annual consumption of the installation and the contractual conditions; some sources cite much lower prices than others.

6.4.1 Carbon constraints in the United States of America

In the US, to this day, there is no federal policy that would price greenhouse gas emissions, such as a carbon tax or an emission trading system. Various attempts to introduce such a policy at the federal level have failed. There is nothing in the way of other instruments that would function as an effective carbon rate for industrial facilities such as a tax on energy either (OECD, 2016).

One of the most important national efforts to reduce GHG emissions was the Clean Power Plan, a measure introduced by then President Barack Obama in 2015 under section 111 of the Clean Air Act.

The Plan, however, would only apply to power generation and not to industrial facilities. It is currently on hold due to a ruling of the United States Supreme Court (EPA, 2017a), and faces an uncertain future under the Trump administration.

It is worth mentioning that United States federal agencies apply a monetary value for carbon emissions to consider the social benefits of reducing CO_2 emissions. These "social costs of carbon" are used in impact assessments of new or revised rules and regulations and are included in the respective cost-benefit assessments. Depending on the assumed discount rate, the social cost of CO_2 amounted to USD 36/tCO_2 (in 2007 dollars, with a 3% discount rate) in 2015 (EPA, 2017b; IWG on SCC, 2016). More recently, however, the United States Congress discussed stopping federal agencies from using the social cost of carbon in their impact assessment calculations (Yeo, 2017).

6.4.1.1 Partial coverage: the ETS in California

At the regional level, two emission trading systems operate in the United States: the Californian ETS (C ETS), which is linked to the ETS of the Canadian province of Quebec, and the Regional Greenhouse Gas Initiative (RGGI) on the United States east coast, which covers nine North-Eastern US States (Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island and Vermont). RGGI, however, only applies to CO_2 emissions from electricity generation (ICAP, 2017a)[59]. The Californian ETS covers inter alia emissions from industrial operations;[60] industrial emissions covered in the system amounted to 4.4% of United States industrial GHG emissions in 2016.

Basic principles of the Californian ETS

The Californian ETS was initiated in 2012 and began its first compliance period on 1 January 2013. After one year, in 2014, the C ETS was formally linked to the Québec ETS. In 2018, linking with the Ontario ETS is foreseen (Brown, 2017; ICAP, 2017b).

Participants include large industrial facilities, generators and first deliverers of electricity, and as of the scheme's second compliance period (2015-2017) also suppliers of fuels to cover emissions from the transport sector. The ETS covers carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF6), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), nitrogen trifluoride (NF_3) and other fluorinated greenhouse gases (Cap-and-Trade

[59] For industry, it is therefore only of indirect relevance: while it does not create a price signal for direct emissions from industry, it does introduce a carbon price element in the price of electricity. This element, however, appears negligible: due to the low price of allowances in RGGI, the carbon price signal would appear negligible in comparison to other factors – above all the general level of energy prices, which is significantly lower in the United States.

[60] In addition, the Californian ETS also covers sectors that are of less relevant for this investigation, i.e. electricity generation and transport fuels, making it the ETS with highest coverage of emissions worldwide.

Regulation). Altogether, it covers approximately 85% of Californian GHG emissions (ICAP, 2017c).

The target is to reduce California's emissions from covered sectors to their 1990 levels by the end of the third compliance period in 2020. That target, 334 $MtCO_2eq$, means a reduction of 15% compared to 2015 when the second compliance period started (ICAP, 2017c). In 2016, a bill passed state legislature to ensure continuation of the ETS past 2020. Further details for the corresponding fourth compliance period are yet to be determined.

Looking at the industrial sectors, the C ETS includes all industrial facilities with GHG emissions of at least 25,000 tCO_2eq (§ 95812 of the Cap-and-Trade Regulation). For the industrial sectors considered in this analysis, up to 96% of their emissions are covered by the C ETS (own calculation based on CEPA, 2016).

The distribution of allowances is based on auction or free allocation. An industry assistance factor indicates the share of freely allocated allowances. This factor is determined by sector-specific benchmarks and by the carbon leakage risk classification. The latter is determined by the same two criteria used within the EU ETS: emissions intensity and trade exposure (ICAP, 2017c). The final decision on the distribution of free allowances can be found in the Cap-and-Trade Regulation, Table 8-1. Until 2018, all industrial sectors receive 100% of their benchmark allowances for free. After 2018, this share decreases for all sectors that are not considered to be at high risk of carbon leakage, which includes petroleum refineries and glass manufacturing (receiving 75% free of charge) and non-ferrous metal forging (receiving 50%) (Cap-and-Trade Regulation). Benchmarks amount to either 90% of a sector's average GHG emissions per unit-product or – when no facility can meet the 90% average benchmark – to best in class (CARB, 2014).

Price development

The California Air Resources Board (CARB) auctions allowances quarterly. The minimum or reserve price increases at predetermined levels (5% plus inflation, see Figure 28): between November 2012 and August 2014, before linking with the Québec ETS, there had been eight auctions. At these eight auctions, settlement prices for emission allowances ranged from EUR 7.78 (USD 10) to EUR 8.57 (USD 11.38). The average price per emission allowance was EUR 8.28 (USD 10.95)[61]. Eleven joint auctions have been held since California and Quebec linked their ETS, with clearing prices ranging from EUR 8.93 (USD 11.86) to EUR 12.77 (USD 13.57). Thus, the average allowance price after the link was around EUR 11.

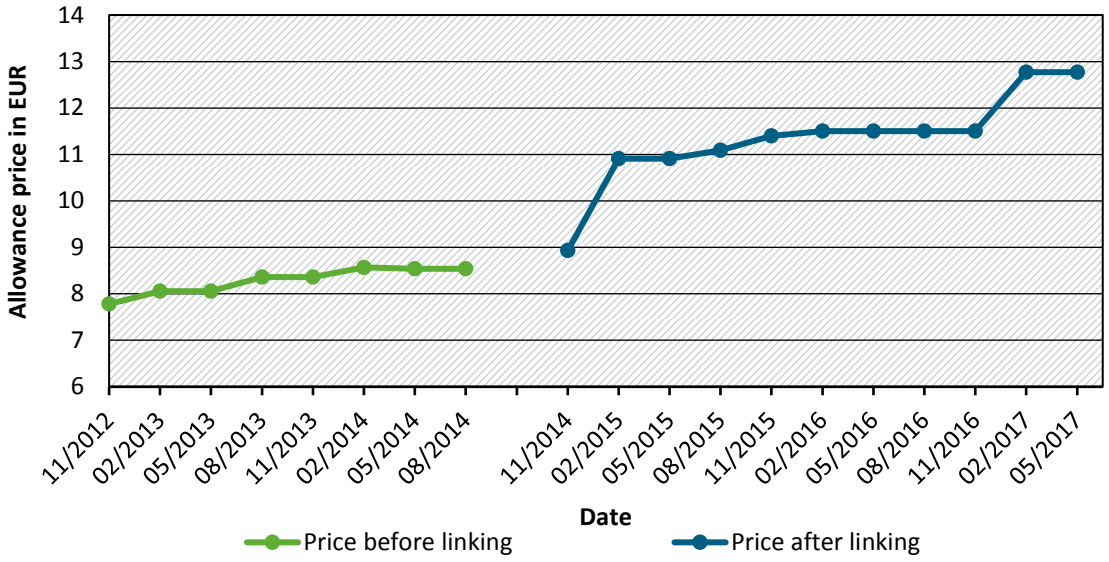
Assembly Bill No. 398, approved by Governor Brown on July 25th, 2017, gave certainty over the continuation of the market past 2020 (State of California, 2017). This certainty led to a renewed rise in allowance prices, reaching EUR 14.05 (USD 14.93) on August 8th, 2017 (ICE, 2017).

Due to the uncertainty about the design of the ETS after 2020, estimations on the price development are to be treated with extra caution. However, Chandan Kumar, lead economist at CalofirniaCarbon.info, expects allowance prices to rise continuously from EUR 16.65 (USD 17.70) in 2021, to EUR 69.77 (USD 74.15) in 2030 (Carbon Pulse, 2017)[62].

[61] Exchange rates published by the European Central Bank (annual average of the year in question) (Eurostat, 2017b).

[62] Exchange rates published by the European Central Bank (current levels) (Eurostat, 2017b).

Figure 28: Allowance auction clearing price in the Californian ETS



Source: CARB (2017)

On the secondary market, prices are slightly higher than the auction clearing prices, ranging from EUR 9.32 to 12.79 (USD 11.67-13.8) since the linking in 2014 (California Carbon, 2017; CPI, 2016).

Coverage of United States -EU trade volumes by the Californian ETS

Since the carbon price only applies at the sub-national level, only a part of United States industrial production is covered – and therefore only a small proportion of United States foreign trade in the respective sectors is covered by a carbon price. In total, for the selected industrial sectors, the EU traded products worth EUR 61 billion with the United States in 2015 (see Table 13). About 4% of this trade took place between California and the EU, a slight increase from 2015 to 2016.

Thus, in terms of the exposure to a carbon price, only a small share of United States companies is exposed to similar carbon constraint as their European competitors.

Table 13: Shares of Californian goods in total United States trade with the EU for the selected industrial products

Product	Imports 2015	Exports 2015	Total trade 2015	Imports 2016	Exports 2016	Total trade 2016
Pulp and paper	3.4%	1.6%	2.5%	3.4%	1.6%	2.5%
Refinery products	2.8%	2.0%	2.4%	2.8%	1.8%	2.3%
Chemicals	2.8%	5.0%	4.1%	3.2%	5.6%	4.5%
Ceramics	9.7%	4.7%	8.6%	11.7%	4.3%	10.1%
Glass	9.4%	3.5%	6.7%	10.2%	4.0%	7.3%
Cement and lime	2.3%	4.9%	2.7%	2.5%	3.7%	2.6%
Other non-metallic mineral products	14.3%	4.5%	11.8%	12.6%	4.1%	10.4%
Iron and steel	1.1%	3.2%	1.4%	1.5%	3.7%	1.8%
Non-ferrous metals	5.8%	3.8%	4.6%	9.4%	6.0%	7.2%
Average	**3.7%**	**3.7%**	**3.7%**	**4.4%**	**4.4%**	**4.4%**

Selection of products based on NASIC 4-digit codes[63], which differ from NACE codes so that product categories according to NASIC can include additional products.
Source: own calculations based on 2015 and 2016 trade data from U.S. Census Bureau, Economic Indicators Division.

Proposals for setting carbon constraints or a carbon price

In general, the outlook for (ambitious) climate policies at the federal level is rather bleak under the Trump administration and the current Congress. Somewhat surprisingly, senior Republican congressmen have called for a carbon tax, starting at USD 40 per ton and increasing over time. The revenues from the tax would be distributed to the citizens in form of a dividend. This measure would also coincide with the abolishment of the Clean Power Plan and the introduction of border-tax adjustments (CLC, 2017; Kotchen, 2017). Whether the initiative has any chance of passing congress is, however, uncertain.

At the regional level, several states have proposed state-wide carbon taxes, such as Massachusetts, Rhode Island, Vermont and Washington. Washington is the state where a carbon tax bill has made it the farthest as the governor proposed it after an initiative (I-732) failed. The proposed tax level is at USD 25/tCO_2 (CTC, 2017; O'Sullivan, 2016). Massachusetts and Rhode Island are seeing strong interest with even multiple legislative proposals in their state legislatures. The proposed tax level in Massachusetts is USD 10/tCO_2 which should increase by USD 5/y up to a maximum of USD 40/tCO_2 while Rhode Island would start with USD 15/tCO_2 to increase by USD 5/y (Szabo, 2017a).

[63] NAICS codes: pulp, paper and paperboard mill products, and converted paper products (NAICS: 3221, 3222); petroleum and coke products as no further trade data was available for subcategories (NAICS: 3241); basic chemicals, pesticides, fertilizers and other agricultural chemicals, soaps, cleaning compounds and toilet preparations and other chemical products and preparations (NAICS: 3251, 3253, 3256, 3259); clay and refractory products (NAICS: 3271); glass and glass products (NAICS: 3272); cement and concrete products and lime and gypsum products (NAICS: 3273, 3274); other non-metallic mineral products with are products of ceramics, glass and cement and lime (NAICS: 3279); iron and steel and ferroalloy (NAICS: 3311); alumina and aluminum and processing, and other non-ferrous and processing (NAICS: 3313, 3314).

In Oregon, formal discussions have begun about introducing a cap-and-trade system for CO_2 emissions based on a study about the effects of a carbon market on the state's industry commissioned by the legislature and which was presented in February 2017 (Szabo, 2017b).

6.4.1.2 Energy prices and other measures

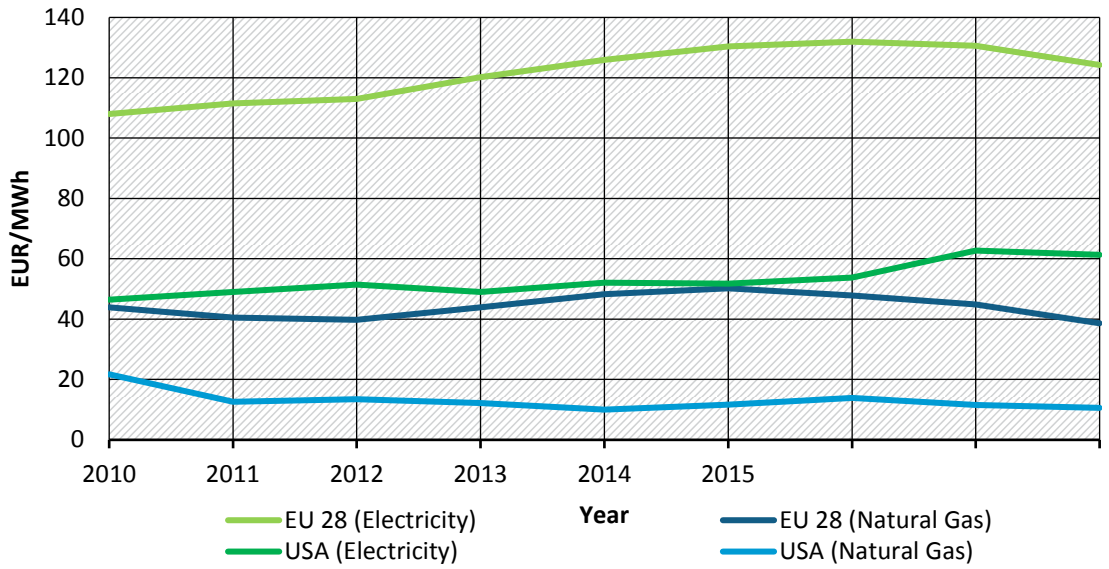
This section gives a short overview of energy prices and other policy instruments possibly affecting industrial production sites and investment decisions of the selected industrial sectors in the United States. The list is not exhaustive but should give a rough idea of relevant policies.

Industrial consumer energy prices

Average natural gas prices for industrial consumer including taxes and levies ranged from about 10 to 14 EUR/MWh over the period of 2010 to 2015 in the United States (IEA, 2016a), which is well below of the EU average of 40 to 50 EUR/MWh over the same period of time (Eurostat, 2017c; comparable also to data presented by IEA, 2016).

Average electricity prices for industrial consumers including taxes and levies ranged from 49 to 62 EUR/MWh over the period of 2010 to 2015 in the United States (IEA, 2016a), less than half of the average price that EU industrial consumers paid for electricity, which ranged from 113 to 132 EUR/MWh (Eurostat, 2017d; comparable also to data presented by IEA, 2016).[64]

Figure 29: Energy prices for industrial consumers in the United States and in the EU (incl. all taxes and levies)



Source: Eurostat (2017d, 2017c); OECD/IEA (2017)

[64] Please note that for large-scale, energy-intensive electricity consumers in several EU Member States (especially in Germany), exemptions are granted from taxes/levies and from contributions to the promotion of renewable energy. These components, as well as the often lower purchasing prices resulting from the purchasing power of these companies, significantly influence their effective electricity prices. (Grave et al., 2015) present a comparison for the year 2014.

Air quality standards for industrial facilities

The Clean Air Act regulates air emissions from stationary and mobile sources. It authorises the United States Environmental Protection Agency (EPA) to set National Ambient Air Quality Standards (section 109). Standards are given for the main air pollutants ("criteria pollutants") including carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO2), ozone (O3), particle matter (PM2,5 and PM10) and sulphur dioxide (SO2) (see 40 CFR part 50). The limits for these pollutants are generally lower than the corresponding limits in EU legislation (under Directive 2008/50/EC) but the United States has much stricter enforcement, to ensure that limits are adhered to. While in the EU, emitters are allowed to exceed the air pollution limits eight times per year, this can only happen once a year in the United States e.g. for CO_2 (Kuklinska et al., 2015).

For mercury and other hazardous air pollutants, the Clean Air Act (section 112) authorizes the EPA to set standards that "require the maximum degree of reduction in emissions of hazardous air pollutants" (EPA, 2017c), standards are therefore referred to as maximum achievable control technology (MACT) standards. In general, industrial facilities adhere to the standards through regular maintenance and performance tests (EIA, 2017). Mercury standards are an efficacious lever significantly influencing the costs of coal-fired electricity generation.

The Clean Air Act (section 111) further empowers the EPA to set standards for new, modified or reconstructed facilities with respect to fluid and gaseous emissions (SO2, NOX, CO, volatile organic components including methane (VOC), PM, fluorides and acid mist) (see 40 CFR 60) including requirements for monitoring and reporting of these emissions. They are known as New Source Performance Standards. Standards exist for industrial steam generation units and industrial production units including all eight industrial sectors considered in this analysis.

Next to these standards, the Clean Air Act sets an annual cap on industrial SO2 emissions of 5.6 million tons per year (section 406) and authorises the EPA to take actions when the cap is exceeded. However, estimates up to 2020 show that emissions will stay below the cap, inter alia, due to reduced coal use in industry (EIA, 2017; EPA, 2000).

Energy efficiency standards for industrial facilities

Energy efficiency standards apply to newly manufactured or imported electric motors (Energy Independence and Security Act, Section 313) and for boilers and furnaces (Energy Policy Act). Other programmes support industrial energy efficiency increases through voluntary participation in a certification programme (Superior Energy Performance Programme) or in a partnership programme that encourages the companies to set their own efficiency targets or to introduce energy management systems including monitoring (Better Buildings/Better Plants Programme; Energy Star for Industry Programme) (IIP, 2016).

6.4.1.3 Comparative assessment of different carbon constraints and related policies

Table 14: Carbon constraints and pricing in the United States for the selected industrial sectors

	Assessment	Overview
Carbon constraints and pricing	Comparable in California; no federal instrument	There is no federal instrument to put a price on CO2 emissions from the selected industrial sectors. The Californian ETS covers GHG emissions incl. from industrial production.
Coverage …of selec. industries …of GHG emissions …by regional constraint	Only for C ETS Comparable Comparable 4% of trade	The C ETS covers all important industrial facilities from the selected industrial sectors as well as the same GHGs as the EU ETS. However, only about 4% of the trade between the United States and the EU in the relevant sectors is covered by the C ETS.
ETS price level	Only for C ETS Well above EU ETS prices	Since the linking in 2014, the average price for one allowance is about EUR 11. The price level is thus well above that of the EU ETS.
Proposals	---	There are non-governmental proposals for a federal carbon tax as well as regional carbon taxation is under discussion.
Energy prices	Well below EU prices	Industrial end-consumers in the United States pay considerably less for natural gas and electricity than in the EU.
Other measures	Somewhat laxer standards for air quality and energy efficiency	Comparable/somewhat laxer standards for air quality and energy efficiency. Consideration of “social costs of carbon” when setting e.g. energy efficiency standards.
Summary	Current status: Significantly laxer carbon constraint Expected development: Significantly laxer carbon constraint	There is no explicit or implicit national carbon pricing. The regional ETS in California covers only 4% of the trade between the United States and the EU. Energy prices are below of those in the EU and standards for air quality and energy efficiency are somewhat comparable. Proposals for a national carbon tax exist, but the chances for ambitious climate policies under the Trump administration are rather bleak. Only regional actors are expected to push for ambitious climate policies.

Source: own assessment

6.4.2 Carbon constraints in Russia

There is no explicit carbon pricing tool in Russia, neither as an emission trading system (ETS) nor in the form of a carbon tax. There is an energy tax, but this only applies to 5% of industrial emissions, and amounts to an implicit carbon price of only EUR 0.04/tCO_2 (OECD, 2016).

6.4.2.1 Proposals for setting carbon constraints or a carbon price

In its intended nationally determined contribution (INDC), Russia announces to reduce its GHG emissions by 25% by 2020 and by 25-30% by 2030 compared to 1990 levels. In addition, the Russian president in 2013 issued a decree requesting the government to develop measures that would facilitate these planned GHG emission reductions (IEA, 2014).

In April 2014, the Russian government issued a corresponding decree, which includes an action plan assessing emission reduction targets by 2020 and 2030, earmarking yearly reports on progress and developing as well as introducing an MRV system at company level. This MRV system was adopted in 2015 by the Ministry of Natural Resources and Ecology, which at the same time also adopted revised methodological guidelines for the GHG emissions assessment by a draft amendment of the Law on Environmental Protection. This revised law will be submitted to the parliament for consideration. If accepted, it creates a legal basis for the Russian government to list all types of GHGs that will be regulated and to set rules for MRV of GHG emissions at company level (ICAP, 2017a,)

The MRV system determines that in 2017-2018, at the second stage of implementation, organisations that emit more than 50,000 tonnes CO_2-eq/year (including indirect energy GHG emissions) have to report their GHG emissions. Government Directive No 877-r, which was developed by the Russian Ministry of Development in May 2016, emphasizes the need for a well-functioning MRV and for an efficient implementation of measures to reduce GHG emissions. It supplements the action plan with new provisions, including the development of guidelines to quantify the volume of indirect energy GHG emissions (The Russian Government, 2016).

6.4.2.2 Energy prices and other measures

This section gives a short overview of energy prices and other policy instruments possibly affecting operation and investment decisions in the selected industrial sectors in Russia. The list is not exhaustive but provides an idea of the most relevant policies.

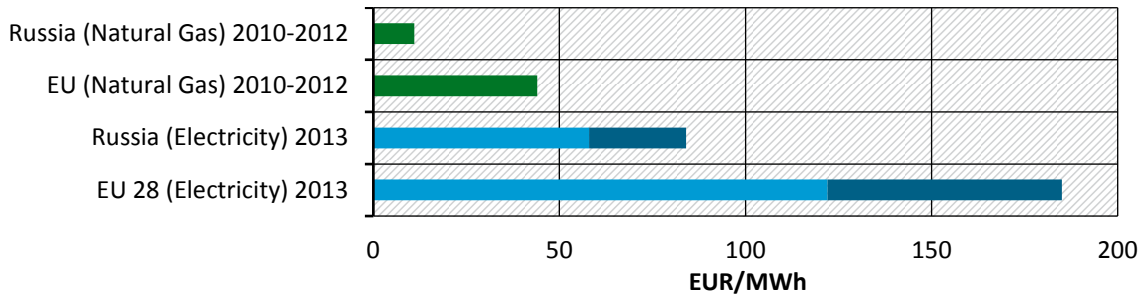
Industrial consumer energy prices

In Russia, industrial consumers pay considerably less for natural gas and electricity than their competitors in the EU. The average natural gas price for industrial consumers was roughly 11 EUR /MWh (IEA, 2014) in 2013, which is about one fourth of the EU average price of about 44 EUR /MWh in the same year (Eurostat, 2017c). Marcu et al. (2016) maintain that this large difference of natural gas prices could be observed for individual industrial sectors such as the steel and ceramic sector over the period 2010 to 2015. In 2015, selected steel manufactures in Russia reported to have paid about 6 EUR/MWh for natural gas while those in the EU reported prices of about 26 EUR/MWh. The ceramic manufactures reported similar values.

Russian electricity prices for large industrial consumers amounted to an average of roughly EUR 58/MWh and for small industrial consumers to 84 EUR/MWh over the period from 2010 to 2012 (IEA, 2014). This is about half of the average price that industrial consumers had to paid in the EU in these years: large consumers paid roughly 115 EUR/MWh increasing to 129 EUR/MWh and small consumers EUR 176/MWh increasing to 194 EUR/MWh over the same period of time (Eurostat, 2017d). Marcu et al. (2016) also report average electricity prices in the

EU about twice as high as compared to Russia over the period of 2010 to 2015 for selected steel and ceramic manufacturers. However, this situation has changed markedly – due mostly to changes in fossil fuel prices. Increasing electricity prices in Russia up to 2012 and decreases in the EU since 2012 lead to a temporary equalisation of electricity prices in 2014. In 2015, the Russian price dropped by more than 25% to EUR 38/MWh, while the EU price only dropped by 5%. Thus, the Russian price was around 28% below the EU price in 2015.

Figure 30: Energy prices for industrial consumers in Russia and in the EU (incl. all taxes and levies)



Source: Eurostat (2017d, 2017c); IEA (2014)

Environmental standards for industrial facilities

The first environmental quality standards in Russia date back to the beginning of the Soviet period almost 100 years ago. These standards determine the limits of pollution in both industrial and residential areas. By 2003, 625 maximum allowable concentrations (MACs) and 1945 "tentatively safe exposure levels" (TSELs) existed for the ambient air. Most of these standards were derived to ensure "zero risk for human health". Many of the MACs are much more ambitious than EU requirements or even WHO reference values and therefore often considered to be overly ambitious or even unachievable (OECD, 2006). However, compliance with the environmental standards has always been low, and as a result pollution continues to be a major problem in Russia (Digges, 2014; OECD, 2004).

Energy efficiency standards for industrial facilities

Several target-oriented programmes addressing energy efficiency for industrial sectors were adopted after Decree No. 730-p of President Putin approved the Climate Doctrine of the Russian Federation in 2009 (President of Russia, 2009). This included a major programme for energy saving and energy efficiency improvement, which started in 2010 and runs until 2020 (Decree No. 2446-r). The programme covers around 45-55% of total Russian energy consumption, 90% of industrial energy use and nearly all energy intensive sectors in Russia. The programme aims to reduce the energy intensity of industrial production (per unit GDP) by 40% from 2007 to 2020 (IIP, 2012). It is supported by Federal Law No. 261-FZ on energy conservation and energy efficiency (Government of the Russian Federation, 2009; IIP, 2012b). Among other things, the law includes timeframes, responsibilities and specific implementation requirements, such as the implementation of technical measures for energy conservation and energy efficiency in nearly all energy intensive sectors. All industrial enterprises targeted by the programme are required to (Gusev, 2013; IIP, 2012b):

- Have meters monitoring their energy and resource consumption by 2012;

- Obtain an energy performance certificate (energy efficiency passport) and have a certified energy manager;
- Implement energy management systems and reach the respective ISO 50001 energy system standard to undertake energy audits by 2013; and
- Develop a programme to reduce resource consumption by 2013.

Fines are modest and run up to EUR 11.295 (RUR 710.000)[65] if targeted entities fail to meet their obligations (IIP, 2012c). However, many enterprises delayed the implementation of energy audits and submitted audits were mostly of poor quality (IEA, 2014). The government supports entities by co-financing the best regional energy efficiency programmes, through state guarantees to ensure loans for energy efficiency projects and through an investment tax credit (IIP, 2012a, 2012b). And yet, companies only rarely make use of the support measures, due to a lack of information and poor incentives (IEA, 2014). There are no industry-related energy efficiency standards in place e.g. for electric motors (Gusev, 2013; Siemens, 2016).

6.4.2.3 Comparative assessment of different carbon constraints and related policies

Table 15: Carbon constraints and pricing in Russia for the selected industrial sectors

	Assessment	Overview
Carbon constraint	Significantly laxer carbon constraint	Russia has no ETS or a carbon tax. An energy tax applies covering a limited share of industrial emissions (5%) with a low rate (EUR 0.04/tCO_2).
Coverage	---	Not applicable
ETS price level	---	Not applicable
Proposals	---	No specific proposals for implementing a carbon pricing instrument
Energy prices	Well below EU prices	Industrial consumers in Russia pay roughly a fourth for natural gas and half for electricity in comparison to their EU counterparts
Other measures	Standards in some areas, but with severe implementation deficits	Russian standards for air emissions are stricter than they are in the EU, but compliance is low. Energy audits are mandatory for almost all industrial enterprises, yet these are rarely implemented. There are no industrial energy efficiency standards e.g. for electric motors.
Summary	Current status: Significantly laxer than in the EU Expected development: Uncertain	Russia has no direct carbon constraint and the energy tax for industries is only marginal. Energy prices are below of those in the EU. Standards for air quality and energy auditing exist, but are rarely enforced. There are no industrial energy efficiency standards. In its NDC, Russia states that it aims to reduce its GHG emissions by 25% by 2020 and by 25-30% by 2030. In addition, the Russian government initiated legislation which could create a legal basis to list all types of GHGs that will be regulated and to set rules for MRV of GHG emissions at company level. However, the implementation is still in its early stages, and focuses on basic elements. There is, as yet, no indication of more ambitious domestic policies.

[65] Exchange rate for 2017 published by the European Central Bank (Eurostat, 2017b).

Source: own assessment

6.4.3 Carbon constraints in China

In China, seven regional "pilot" emission trading systems (ETS) have been operating since 2013/2014, five at the level of cities and two at the provincial level. At the end of 2016, the province of Fujian announced the start of an ETS in 2017, making it the eighth pilot ETS. These pilots serve as a stepping stone for a nationwide ETS system that is scheduled to start in the second half of 2017.

Next to the ETS, China taxes energy use leading to an average implicit carbon pricing of roughly EUR 35/tCO_2 for around 3% of industrial emissions which are not covered by the regional ETS systems (OECD, 2016).

6.4.3.1 Partial coverage: regional ETS in China

Seven regional pilot ETS started their first trading period between 2013 and 2014. These pilots are located in five cities (Beijing, Shanghai, Shenzhen, Tianjin and Chongqing) and two provinces (Hubei and Guangdong) that together represent 26.7% of China's 2014 GDP (Swartz, 2016). According to OECD estimates, these regional pilot ETS cover roughly 10% of Chinese industrial emissions (OECD, 2016). A further pilot system was started in Fujian in 2017. Initially, the seven regional ETS were planned to transit into a national ETS in 2016. However, as the start of the national ETS was delayed, pilots continue operating until then and probably also beyond. Shanghai has specifically indicated a second phase to run until 2018.

Allowance prices in the seven ETS ranged from around EUR 1 (USD 1) per tonne CO_2 in Shanghai and Chongqing in 2016 to slightly below EUR 14 (USD 18) per tonne CO_2 in Shenzhen in 2013 (Wenbo and Noi, 2016)[66]. In the majority of pilot ETS, prices peaked shortly after establishment in 2013 and 2014 and then declined continuously. Current prices exceed USD 7 in only one province (Bejing), in the other provinces prices are between 1 and 4 USD (De Boer et al., 2015; Wenbo and Noi, 2016).

Since all pilot ETS were designed locally and regional circumstances were taken into account, they differ in various design aspects. Compliance thresholds for industrial facilities range from 3,000 and 5,000 tCO_2 per year in Shenzhen and Beijing (respectively) to 60,000 tCO_2 per year in Hubei[67]. All other ETS set their thresholds for industrial facilities at 20,000 tCO_2 or 10,000 tons of coal equivalent (tce) per year[68]. Carbon Offsets (China Certified Emission Reduction credits) are allowed in all pilots, but their share is limited to 5% in Beijing and Shanghai, to 8% in Chongqing and to 10% in all other pilots[69]. Banking within the trading period is allowed in all pilots, while borrowing is not. Moreover, all pilot ETS oblige their entities to report their emissions annually and require third-party verification. Table 16 displays other key policy features, highlighting similarities and differences between the seven ETS.

[66] Exchange rates published by the European Central Bank (annual average of the year in question) (European Central Bank, 2017).

[67] There are different thresholds for the different industrial sectors in Hubei. For power, iron and steel, non-ferrous metals, chemicals, petrochemicals, building sectors and pulp and paper sectors, the thresholds are at 10,000 tCO2 per year. For remaining sectors, the above mentioned threshold of 60,000 tCO2 per year applies (ICAP, 2017a).

[68] Only in Shanghai, industries are included at around 10,000 tCO2 per year or 5,000 tce/year if they participated in the 2013-2015 pilot phase.

[69] For a more detailed description of thresholds and offsets see (ICAP, 2017d, 2017e, 2017f, 2017g, 2017h, 2017i, 2017j).

Table 16: Regional ETS in China

	Beijing	Chongqing	Guangdong	Hubei	Shanghai	Shenzhen	Tianjin
Reduction goal (intensity-based)	20.5% over 2015 levels; absolute cap: ~46 $MtCO_2eq$	19.5% over 2015 levels; absolute cap: 100.4 $MtCO_2eq$	20.5% over 2015 levels; absolute cap: ~422 $MtCO_2eq$ (excl. white cement)	19.5% over 2015 levels; absolute cap: ~253 $MtCO_2eq$	20.5% over 2015 levels; absolute cap: ~155$MtCO_2eq$	45% over 2005 levels; absolute cap: ~31.45 $MtCO_2eq$ Peak GHG emissions by 2022	20.5% over 2015 levels; absolute cap: ~160-170 $MtCO_2eq$
GHG covered	CO_2 (direct and indirect)[70]	CO_2 (direct and indirect), CH_4, N_2O, HFCs, PFCs, SF_6	CO_2 (direct and indirect)	CO_2 (direct and indirect)	CO_2 (direct and indirect)	CO_2 (direct and indirect)	CO_2 (direct and indirect)
Sectors covered	Power and heat, cement, petrochemicals, manufacturers, other industrial enterprises, the service sector and public transport	Power, electrolytic aluminum, ferroalloys, calcium carbide, cement, caustic soda, iron and steel.	Power, iron and steel, cement, petrochemicals, aviation, paper and white cement	Power and heat, iron and steel, non-ferrous metals, petrochemicals, chemicals, chemical fiber, cement, glass and other building materials, pulp and paper, ceramics, manufacturing, food, beverage and medicine producers	Airports, aviation, chemical fiber, chemicals, commercial, power and heat, water suppliers, commercial, hotels, financial, iron and steel, petrochemicals, ports, shipping, non-ferrous metals, building materials, paper, railways, rubber, and textiles.	Power, water, gas, manufacturing sectors, buildings, port and subway sectors, public buses and other non-transport sectors	Heat and electricity production, iron and steel, petrochemicals, chemicals, exploration of oil and gas.

[70] In contrast to the EU ETS, entities in the Chinese pilot ETS are liable not only at the point of emission, but also upstream in case the energy source they use is electricity or heat. For a more detailed explanation of this procedure see (Healy et al., 2016).

	Beijing	Chongqing	Guangdong	Hubei	Shanghai	Shenzhen	Tianjin
Cap coverage (in percent of total emissions)	45%; ~600 entities	40%; ~230 entities	60%; ~280 entities (excl. white cement)	35%; ~236 entities	Cap coverage (in percent of total emissions)	45%; ~600 entities	40%; ~230 entities
Allowance Allocation	Mainly free allocation through grandfathering; baseline years: 2009-2012 (stationary sources) or 2011-2014 (mobile sources) Benchmarking for entities with expanded capacity and new entrants	Free allocation through grandfathering; baseline years: 2008-2012 If sum of allocated emissions exceeds cap, reduction factor is applied Ex-post adjustments possible	Mainly free allocation (95% for power sector, 97% for remaining sectors) through grandfathering; baseline years: 2013-2015; annual emissions reduction factor (2016 vintage): 0.99 Benchmarking for coal or gas fired electricity generators (incl. heat and combined heat and power), certain cement and industrial iron and steel processes and relevant for new entrants	Free allocation (2016 vintage) through benchmarks for power, heat, co-generation and cement (except entities using outsourced clinker) Historical carbon intensity method for glass and other building material and ceramics sectors Grandfathering (baseline years: 2013-2015) for all other sectors Ex-post adjustments possible	Free allocation based on sector-specific benchmarks for power, heat, car glass manufacturers Historic emissions intensity for industry, aviation, ports, shipping and water suppliers; mainly based on 2013-2015 data Ex-post adjustments possible	Mainly free allocation Benchmarking for water, power and gas sectors based on sectoral historical carbon intensity Grandfathering based historical carbon intensity for port and subway sectors, public buses and other non-transport sectors At least 3% of allowances are to be auctioned	Mainly free allocation through grandfathering Baseline years: 2009-2012 Benchmarking for expanded capacity and new entrants

Source: based on IETA (2016) and ICAP (2017d, 2017e, 2017f, 2017g, 2017h, 2017i, 2017j)

6.4.3.2 National ETS

The Chinese national ETS is considered as one among many policies that the central government uses to combat direct and indirect CO_2 emissions. The ETS formally launched on 19 December 2017. When fully operational, it will overtake the EU ETS as the largest carbon market globally. A 'Master Plan' for the start of the ETS was approved and issued on 19 December 2017. this Master Plan defines a three-phase roadmap for the roll-out of the national carbon market. In phase one and two, the ETS covers the power sector only – which already comprises 1,700 power generators with annual emissions of 3.5 Gt CO_2 (ThomsonReuters, 2018, p. 12). Phase one (2018) focuses on establishing a functioning carbon market infrastructure, including reporting system, registry and an exchange. Phase two (2019) focuses on simulation and mock trading, where covered entities would conduct test trades without contracts or allowances actually changing hands, in order to familiarise participants with the elements of the system (ThomsonReuters, 2018). Phase three, which is intended to start in mid-2019 or 2020, will include spot trading for compliance and a broader sectoral coverage (ICAP, 2018a, 2018b). At the time of writing, it is still unclear when power companies will be required to surrender allowances for the first compliance period. In phase three, the Chinese government also plans to add more sectors such as:

- Cement
- Aluminium
- Aviation
- Petrochemicals (incl. crude oil refining, processing and ethylene);
- Chemicals (incl. methanol, ammonia and carbide);
- Iron and steel;
- Non-ferrous metals (incl. copper smelting and electrolytic aluminium);
- Building production and materials (incl. clinker and plate glass; probably also ceramics);
- Pulp and paper.

As there is no clear definition of "building materials", the glass and ceramics manufacturing industry might be (partly) covered by the national ETS.[71] While the national ETS is expected to start with a narrower scope, with further sectors to be added to the system over time, it currently appears that the pilot systems will continue to operate for those sectors and installations that are not covered by the national ETS. All installations covered by the national systems would be exempted from the pilots, but the others would remain in the pilots.

According to ICAP, (2017k), companies consuming over 10 ktoe (ton of oil equivalent) per year will be obliged to participate in the Chinese national ETS in 2017-2019. Post 2020, this threshold may be halved to include more entities. The NDRC expressed its intention to introduce and gradually increase the share of auctioning. Nevertheless, ICAP (2017k) expects free allocation to dominate in the first compliance period from 2017-2019, based on either benchmarking or historic emissions intensity.

[71] China is the EU's main trading partner for both, ceramics and glass.

In 2020, China's national ETS will most likely be the largest carbon market globally, covering 3-5 billion tons of CO_2eq. The trading volume is expected to range from EUR 150 to 1,000 million (CNY 1.2-8 billion) and may expand to as much as EUR 8-50 billion (CNY 60-400 billion) when carbon futures enter the market (ICAP, 2017l).[72]

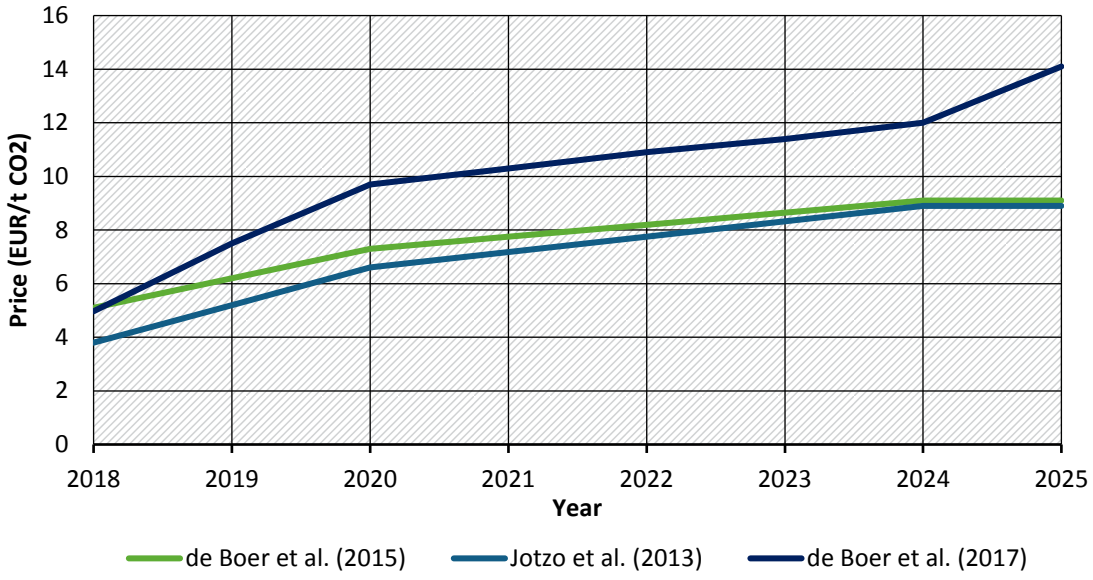
Expected price development

Given the current price levels in the seven regional ETS, price expectations for the national ETS may be very low. However, as there will be no smooth transition from the regional to the national level, we see these instruments as completely different and as not comparable to each other.

In order to obtain a collective "best guess" on the carbon price of China's national ETS, De Boer et al. (2017), De Boer et al. (2015) and Jotzo et al. (2013) carried out surveys providing an indication of stakeholder views. Although neither of these surveys is representative, they still provide indications on the price development of the Chinese national ETS. Respondents from both surveys were carbon pricing experts from academia and research institutes, industry, consultancies, carbon trading companies, NGO's and from national or local governments. The surveys received 86 (Jotzo et al. 2013),304 (De Boer et al. 2015) and 260 (De Boer et al. 2017) answers.

Results suggest that the carbon price level is expected to rise over time (see Figure 31) and that the ETS will increasingly affect investment decisions. Right after its establishment in late 2017, respondents expected a CO_2 price of EUR 3.80 (CNY 29) on average in the survey by Jotzo et al., EUR 5.10 (CNY 39) per tonne of CO_2 in de Boer et al. (2015), or EUR 4.97 (CNY 38) in de Boer et al. (2017). From there on, survey respondents expect the carbon price to rise constantly to EUR 6.60 (CNY 51),EUR 7.30 (CNY 56) or EUR 9.68 (CNY 74) in 2020 (respectively) and to EUR 8,90 (CNY 68), EUR 9.1 (CNY 70) or EUR 14,12 (CNY 108) in 2025 (respectively).

Figure 31: Survey results on the expected average price in the Chinese national ETS



Source: own figure based on data from de Boer et al. (2017, 2015) and Jotzo et al. (2013)

[72] Actual exchange rates published by the European Central Bank on 29/05/2017; EUR 1 = CNY 7.6714 (ECB, 2017).

While all surveys show that experts expect a rising price over time, the wide spread of individual responses indicates high uncertainty, especially for the distant future.[73] In addition, 37% of respondents did not provide any price estimates for 2025 at all in Boer et al. (2017), down from 43% in Boer et al. (2015). It is worth noting that expected prices rise with the up-to-dateness of the surveys (numbers are highest in the most recent, and lowest in the oldest survey).

6.4.3.3 Further proposals for setting carbon constraints or a carbon price

After 2020, the National Development and Reform Commission (NDRC) also considers introducing a carbon tax for companies that do not participate in the national ETS (ICAP, 2017f). This would be relevant for the glass and ceramics manufacturing industry, which, according to current announcements, would not be covered by the national ETS.

6.4.3.4 Energy prices and other measures

This section gives a short overview of energy prices and other policy instruments possibly affecting operation and investment decisions in the selected industrial sectors in China. The list is not exhaustive but provides an idea of the most relevant policies.

Industrial consumer energy prices

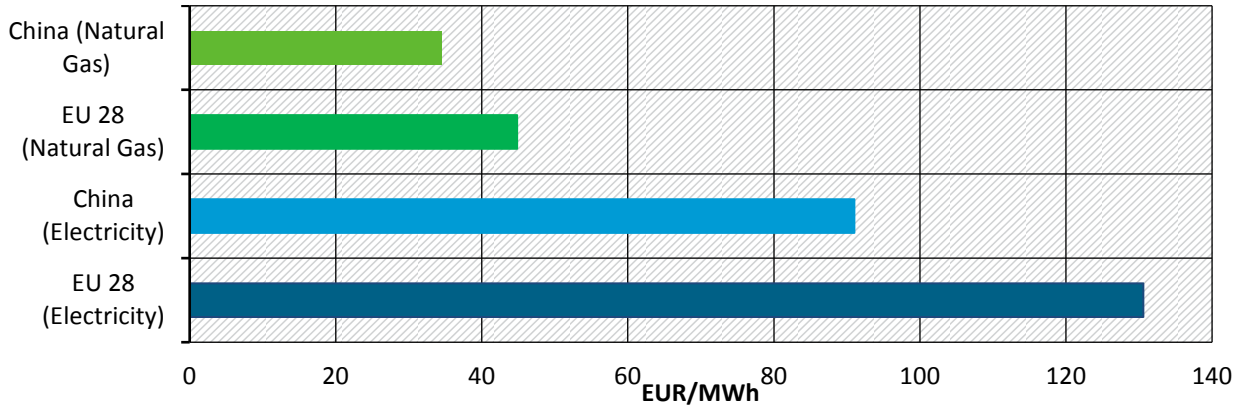
Before 2013, Chinese natural gas prices were determined by a complex formulation process involving the NDRC, the central government pricing authority, local government pricing agencies, producers, transmission operators and gas users.[74] In 2010, a new pricing reform allowed a stronger role for the market in forming the gas price. The main rationale for the new pricing system was to have the value of natural gas be largely driven by its two main substitutes as energy fuels – fuel oil used in the industrial sector and liquefied petroleum gas (LPG) used in the residential sector (Zhang, 2008). The new, more market-based approach delivered an average natural gas price for the Chinese industry of 34.56 EUR/MWh (38.35 USD/MWh) in the first half of 2015, down 18.5% from the second half of 2014 (Li et al., 2014). Compared to EU prices, which were at around 50 EUR/MWh in the same period, Chinese prices were around 23% lower.

With the aim to phase out (energy) inefficient enterprises and to encourage efficient ones, the Chinese National Development Reform Commission (NDRC) established a policy in 2004 to differentiate electricity prices for industrial companies. Industrial companies were grouped into four categories based on their level of energy efficiency: “encouraged”, “permitted”, “restricted” and “eliminated” (IIP, 2017). In 2013, companies in the “encouraged” and “permitted” categories pay the regular price applicable to their respective geographical area, which is highly regulated by the NDRC. Companies classified “restricted” or “eliminated” pay this regular price plus an additional fee of EUR 0.013 per kWh (0.1 CNY/kWh) or EUR 0.039 per kWh (0.3 CNY/kWh) respectively (Grave et al., 2015). The average electricity price for industrial consumers in 2014 was 91 EUR/MWh, 69% of what industrial consumers in the EU paid at the same time (Bloomberg new energy finance, 2016).

[73] Responses from the de Boer et al. (2017) survey exemplify this uncertainty: For 2025, the 20th percentile is at EUR 6.54 (CNY 50) and the 80th percentile is at EUR 26.15 (CNY 200).

[74] For an in-depth analysis of China’s natural gas pricing approaches see Zhang (2016).

Figure 32: Energy prices for industrial consumers in China and in the EU in 2014 (incl. all taxes and levies)



Source: Bloomberg new energy finance (2016); Eurostat (2017d, 2017c)

Air quality standards for industrial facilities

China started regulating ambient air quality in 1982, when the first limits for total suspended particulates (TSP), SO2, NO2, lead and benzopyrene (B[a]P) were defined. In 1996, these standards were strengthened and expanded under the first national standard, GB 3095-1996, which covers SO2, TSP, particulate matter (PM10), NOx, NO2, CO, O3, Pb, B[a]P and Fo (Ministry of Environmental Protection of the People's Republic in China, 1996). In 2000, the standard was updated with less stringent limits for specific pollutants through MEP Announcement No.1 (TransportPolicy.net, 2017).

In September 2012, a new Air Quality Index (AQI), HJ 633-2012, was introduced. For the first time, this AQI covers both PM2.5 and ozone (Ministry of Environmental Protection of the People's Republic in China, 2012). The AQI was supplemented in September 2013 by the Air Pollution Prevention and Control Action Plan, which requests 15-25% PM2.5 reductions in key cities and 10% PM10 reductions in all other cities by 2017 compared to 2012 levels (TransportPolicy.net, 2017).

Next to the AQI, the current nationwide ambient air quality standard, GB 3095-2012, was introduced in 2012. It took effect nationwide in 2016, but different cities and regions were required to implement it earlier than the national timeline:

- 2012: mayor cities in Beijing-Tianjin-Hebei, in the Yangtze River Delta and Pearly River Delta regions, and provincial capitals
- 2013: key environmental protection cities
- 2015: all prefecture-level cities

GB 3095-2012 defines a Class 1 standard for special regions such as national parks etc. and a Class 2 standard for all other areas. Compared to the uniform EU standard, most Chinese Class 1 standards are slightly more ambitious, while most Class 2 standards are less ambitious.

Yet while air quality standards exist, they lack both ambition and enforcement, resulting in the low air quality observed across China in recent years. In March 2014, the Chinese Ministry of Environmental Protection announced that only three out of 74 monitored cities managed to meet the official standards for air quality in 2013. According to the announcement, air quality

standards in the broad northern region that includes the large cities of Beijing and Tianjin, and the province Hebei, were met on only 37% of the days in 2013 (Wong, 2014).

A Greenpeace study came to conclude that in 2014, 80% of the then monitored 367 cities failed to meet national air quality standards. Especially the average level of PM2.5 was very high – more than five times the maximum recommended by the World Health Organization (WHO) (AFP, 2016).

Energy efficiency standards for industrial facilities

The Chinese Government made energy efficiency one of the main priorities during the last decades, decoupling energy consumption from economic growth. While the economy increased 18-fold between 1980 and 2010, energy consumption increased only 5-fold and energy intensity per unit of GDP declined by about 70% (The World Bank, 2014). Between 2000 and 2015, energy intensity improved by 30%, with energy efficiency gains playing a large role; efficiency across the main energy-consuming sectors improved by 19% (IEA/ OECD, 2016).

Energy efficiency measures between 1970 and 2000

The first energy efficiency policies started in the late 1970's. At the time, China experienced a dramatic energy shortage to which the Government responded to by implementing various energy efficiency measures such as an energy quota system. In the period between 1970 and 1990, energy efficiency policies were generally characterized by government led investments, a focus on state-owned industrial enterprises and a favorable fiscal policy for energy efficiency projects (Wang, 2006).

After 1989, China started to convert to a more market based economy. In 1989, the Government introduced Minimum Energy Performance Standards (MEPS) covering eight categories of appliances, including industrial equipment such as motors, compressors, pumps, transformers, vehicles etc. (IEA, 2017a). To ensure that the MEPS are achieved, the China State Council enforced the National Standardization Law of 1989, which highlights the importance of energy efficiency and promotes the use of energy labeling. However, mandatory efficiency standards for energy consuming products were not fully endorsed legally until 1997, when the National Conservation Law of China was enforced. It defines the initial legal framework for national energy efficiency improvements (IEA, 2017b).

Energy efficiency measures after 2000

Since the turn of the millennium, Chinese energy efficiency measures mostly follow the Five-Year Development Plans (FYDPs). Since the 10th FYDP, published in 2001, energy efficiency and renewables have featured in these plans: the 10th plan included measures to promote renewable energy sources by significantly reducing their value added taxes; as of 2004, a trial policy for differential pricing in high energy-intensive industries that was found to have reduced electricity consumption in industry by 115 TWh between 2004 and 2012 (Hu et al., 2012); as well as 10 energy conservation programs and an Energy Label Law. In 2006, the 11th FYDP outlined binding commitments for inter alia economic growth, resources and the environment, establishing the target to lower energy consumption per unit of GDP by 20% between 2005 and 2010.

The 12th FYDP of 2011 builds up on its predecessors by incorporating a deployment target for renewable energies of 11.4%, an additional target of reducing energy intensity by 16%, and a 17% carbon intensity reduction target by 2015 compared to 2010 levels (Lewis, 2011). In order to reach these targets, the 12th FYDP included the Top 10.000 Program targeting the most energy-intensive industrial installations. The Top 10.000 Program targeted approximately

15.000 energy consuming industrial enterprises and aimed at reaching an energy-saving target of 250Mtce by 2015, which is 37% of the total national energy saving target (IIP, 2017b).

In the 13th FYDP, the Chinese Government reaffirms and strengthens its ambition for a low carbon future. It sets the goal to raise the national share of non-fossil energy as percentage of primary energy consumption by 3% between 2015 and 2020, leading to a total share of 15% in 2020 (compared to 20% in the EU) (The Central People's Government of the People's Republic of China, 2016)

The 13th FYDP further mandates to reduce the energy consumption per unit of GDP by 15% and CO_2 emissions per unit of GDP by 18% by 2020 compared to 2015 levels. However, even with rapidly improving energy efficiency levels between 2000-2010 and with current ambitious reduction targets , China will not reach EU energy efficiency levels by 2020; In 2014, the Chinese economy needed double the amount of energy to produce the same amount of GDP (World Bank, 2018).[75]

For the first time, the 13th FYDP also includes an absolute limit for energy consumption: against a planned annual growth rate of 6.5%, total Chinese energy consumption must not exceed 5 billion tons of coal equivalent (tce) in 2020, which translates to around 3500 mtoe (Hall, 2017). This absolute target compares to an absolute EU-target of 1474 mtoe; With a Chinese population almost 2.5 times as big as its EU counterpart, this leads to lower energy per capita levels in China than in the EU in 2020.

6.4.3.5 Comparative assessment of different carbon constraints and related policies

Table 17: Carbon constraints and pricing in China for the selected industrial sectors

	Assessment	Overview
Carbon constraints and pricing	Currently lower; comparable when the national system is fully operational	Eight regional ETS are currently in operation and planned to transit into a national ETS, which started in late 2017 with a voluntary pilot phase for the power sector. The national ETS is the largest carbon market globally.
Coverage …of selec. industries …of GHG emissions	Somewhat laxer w/o glass, ceramics CO_2 only	The national ETS is expected not to cover the glass and ceramics sectors and hence include less industrial sectors than the EU ETS. Moreover, it is expected to cover CO_2 emissions only.
ETS price level	Currently lower; with national system possibly somewhat below	Prices are expected to be somewhat below expected EU ETS prices. However, estimates of future prices in the Chinese national ETS are highly uncertain.
Proposals	---	Possibly a carbon tax for industries not covered by the national ETS post-2020.

[75] In 2014, GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent) was 11.4 in the EU and 5.7 in China. (World Bank, 2018).

	Assessment	Overview
Energy prices	considerably lower energy prices	Both electricity and natural gas prices for industrial consumers are lower than their EU counterparts. In 2014, average natural gas prices for industrial consumers in China were about a quarter below average EU prices. In the first half of 2015, average industrial consumers in China paid 30% less for electricity than their EU counterparts.
Other measures	Somewhat laxer air quality and energy efficiency standards	Air quality standards in China are categorized into two classes: Class 1, which covers special areas such as national parks, defines somewhat more ambitious standards than the EU standard. Class 2, which covers all other areas, defines somewhat lower air quality standards. In 2013 and 2014, most Chinese countries failed to meet the Class 2 standards. Within the last decades, China has improved remarkably when it comes to energy efficiency. However, current levels in China are still somewhat laxer than their EU counterparts.
Summary	Current situation: Significantly laxer than in the EU Expected development: Somewhat laxer carbon constraint	Roughly 10% of total industrial emissions in China are currently priced through regional ETS; Prices in these ETS are considerably lower than prices in the EU ETS. Energy prices are comparable. The Chinese ETS will at start include less industrial sectors and GHGs than the EU ETS; however, more sectors shall be added before and after 2020. After 2020, sectors are expected to be comparable to EU ETS sectors. Prices are expected to be somewhat lower than in the EU ETS.

Source: own assessment

6.4.4 Carbon constraints in Switzerland

Switzerland has an emission trading system (CH ETS) that covers industrial facilities and heat generation. In addition, there is a carbon tax on fossil fuels. However, operators covered under the ETS are exempt from the tax. There are additional taxes on energy which result in an implicit carbon pricing of EUR 19/tCO_2 for parts of the industrial facilities also covered under the CH ETS: 43% of industrial emissions that are covered under the ETS are also taxed (OECD, 2016; analysing data of 2012).

6.4.4.1 Basic principles of the Swiss ETS

In general, the CH ETS covers the same industrial sectors as the EU ETS. This means that all sectors covered by this analysis are included in the CH ETS. Moreover, it considers the following greenhouse gases (GHG): carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF6) and nitrogen trifluoride (NF3). Taken together, the CH ETS covers 11% of total Swiss emissions (ICAP, 2017m) and 40% of industrial emissions (OECD, 2016).

A first five-year voluntary phase of the CH ETS went from 1 January 2008 to 31 December 2012. In this phase, participants from all participating sectors received their own entity-specific reduction targets. Following this voluntary phase, a mandatory phase started on 1 January 2013 and continues until 31 December 2020. This mandatory phase aims at reducing GHG emissions from 5.63 MtCO_2eq in 2013 to 4.9 MtCO_2eq in 2020, following a constant linear reduction factor of 1.74% and reducing emissions by 20% below 1990 levels in 2020 (ICAP, 2017m).

The CH ETS in its second phase covers industries and heat production plants that generally have a total rated thermal input of >20MW or exceed specific capacity thresholds given in tonnes per day. The industries (25 sub-sectors) and respective thresholds are listed in Annex 6 of the CO_2 Ordinance. Allowances are allocated free of charge based on the same product benchmarks used in the EU ETS. For sectors not considered to be at risk of carbon leakage, free allocation diminishes from 80% in 2013 to 30% in 2020. Sectors considered to be at risk of carbon leakage are those listed in the EU's Commission Decision 2014/746/EU on carbon leakage (see Annex 9 of the CO_2 Ordinance).

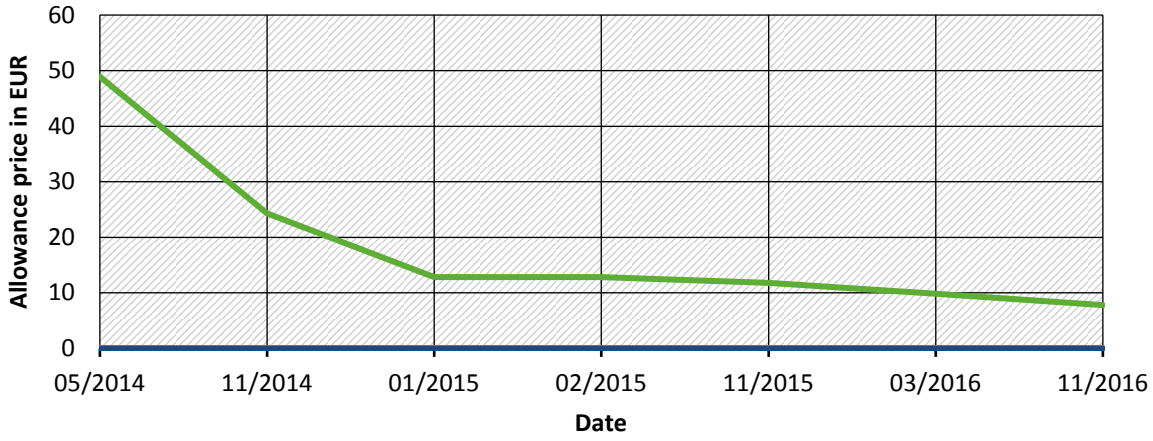
Price development

Ever since the start of the mandatory phase in 2013, fourteen auctions (seven competitive and seven non-competitive) of emission allowances have been performed at the Swiss Emission Trading Registry. Outside of these auctions, no trading of allowances took place.

At the first auction in May 2014, 135,000 allowances were traded at a clearing price of EUR 48.89 (CHF 40.25).[76] As displayed in Figure 33, the price diminished constantly, reaching EUR 7.79 (CHF 7.15) in November 2016. Across all fourteen auctions, the average price per allowance was EUR 16.10 while it was EUR 9.68 if only the last two years are considered.

[76] Exchange rates published by the European Central Bank (annual average) (Eurostat, 2017b).

Figure 33: Development of allowance prices in the CH ETS



Source: FOEN (2017)

Planned update of reduction factor and linking

Switzerland plans to increase the linear emission reduction factor to 2.2% in the upcoming period from 2021 to 2030 (ICAP, 2017m), which is in line with the adapted EU reform and with the council conclusions from 2014 (EC, 2014). In January 2016, the European Commission and the Swiss Government concluded negotiations on linking the EU ETS and the CH ETS (ICAP, 2017m). The linking will allow the participation in auctions and the trading of allowances between participants of both systems (FOEN, 2016) which should lead to converging prices in both systems. After signing the linking agreement by both parties in November 2017, and due to some delays, the link could come into effect on January 1st, 2020.

6.4.4.2 Energy prices and other measures

This section gives a short overview of energy prices and other policy instruments possibly affecting operation and investment decisions in the selected industrial sectors in Switzerland. The list is not exhaustive but provides an idea of the most relevant policies.

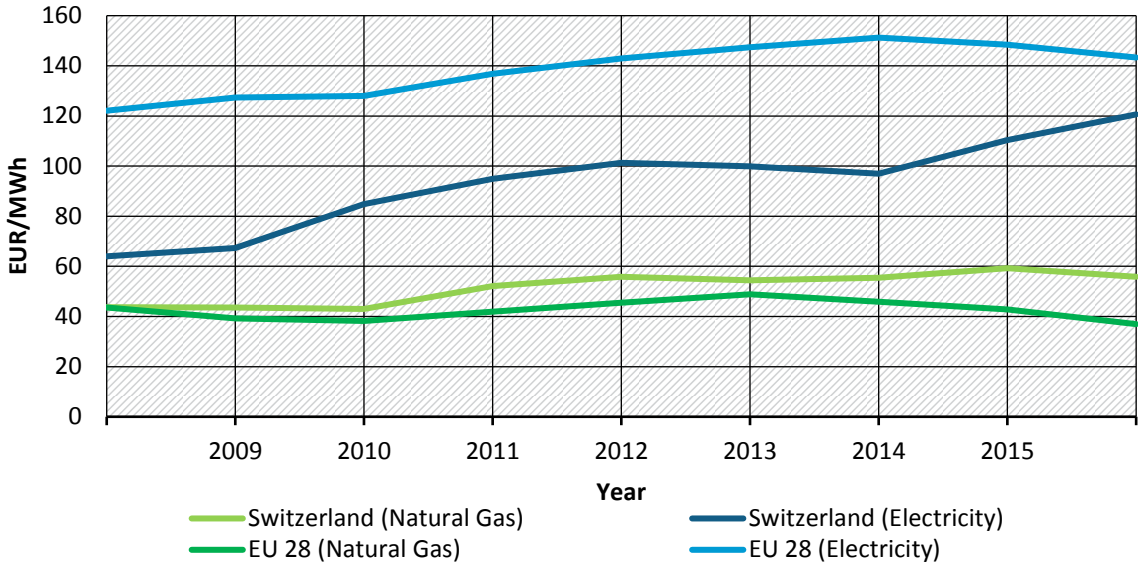
Industrial consumer energy prices

Both electricity and natural gas prices in Switzerland increased over the last decade, but at different rates. A large part of this rise can be explained by the EUR-CHF exchange rate which decreased constantly from 2006 to 2011, stabilized between 2011 and 2014 and then continued to decrease in early 2015.[77] Figure 34 displays the development of electricity and natural gas prices for industrial consumers in Switzerland between 2010 and 2015.

In comparison to average EU industrial consumer electricity prices, which ranged from EUR 113 to EUR 132 per MWh in the last decade (Eurostat, 2017d), Swiss prices were considerably lower. By contrast, for natural gas, where average EU prices for industrial consumers ranged from EUR 40 to EUR 50 in 2010-2015 (Eurostat, 2017c), Swiss prices were slightly higher.

[77] In 2011, the Swiss Government decided to introduce a peg to stabilize the CHF-EUR exchange rate. In 2015, the country decided to abruptly abandon it. For more information the peg and for an analysis on why the Swiss Government pegged (and then unpegged) the Swiss franc, see The Economist (2015).

Figure 34: Energy prices for industrial consumers in Switzerland and in the EU (incl. all taxes and levies; values represent averages across all available consumption bands)



Source: Eurostat (2017d, 2017c); OECD/IEA (2017)

Air quality standards for industrial facilities

Swiss national legislation covering air quality consists of the Federal Environmental Protection Act (EPA), the Ordinance on Air Pollution Control (OAPC), the Air Pollution Control Strategy, the Ordinance on the VOC tax, the Ordinance on the Reduction of CO_2 Emissions, and the Ordinance on the Technical Standards for Motor Vehicles. The EPA, introduced in 1983, determines the general principles of air quality in Switzerland. The OAPC defines concrete standards for emission sources such as stationary installations, whereas the Air Pollution Control Strategy includes emission targets as well as actions and measures to achieve them. Both the OAPC and the Air Pollution Control Strategy have been amended several times since their introduction to reflect technological developments (Amann and Cofala, 2015). Today, air quality in Switzerland is mostly regulated at the national level, but some cantons have also developed action plans to protect the air by reducing pollution at the local level (FOEN, 2015).

Air quality in Switzerland has improved steadily since the mid-1980s. Nevertheless, pollution from particulate matter (PM10), ozone (O3) and nitrogen oxides (NOx) continues to exceed the legally ambient limit values (FOEN, 2017). The current Swiss air quality standard for PM10 is equal to its EU counterpart, and standards are more ambitious for SO2, NO2, CO and O3.

Energy efficiency standards for industrial facilities

For decades, the cantons and municipalities traditionally held a strong role for shaping Switzerland's energy policy. In 1991, a constitutional amendment empowered the federal government to introduce nationwide legislation in this field. Although the federal government now has increased competences, the cantons still play an important role with regard to implementing energy policy measures.[78] The Decree on Energy Use of 14 December 1990 and the Decree on Efficient Energy Use of 1 May 1991 established the legal basis for Switzerland's federal energy policy (Meyer, 2003, p. 2).

[78] In 2012, the government of the Canton de Vaud started an audit programme that aims at improving the energy efficiency of medium and large energy consumers (de Vaud, 2017; European Commission, 2016).

The national CO_2 law from 2000 aimed at reducing Switzerland's CO_2 emissions by 10% compared to 1990 levels by reducing the consumption of combustibles and motor fuels by 15% and 8% respectively (Gerigk et al., 2012). Since 2001, the industry was mainly involved via voluntary commitments and voluntary agreements that included targets for energy efficiency (European Commission, 2016). The voluntary measures alone were not able to bring about the desired CO_2 reduction and in 2008 the federal government introduced a carbon tax as a complimentary measure. The tax is imposed on fossil heating and process fuels. Since 2008, the government has raised the tax from EUR 19 (CHF 12) to EUR 92 (CHF 84) per ton of CO_2 (as of 1 January 2016) (European Commission, 2016; Le News, 2017). In 2013, a new CO_2 law has entered into force. The new CO_2 law maintains the CO_2 tax and sets a new emission reduction target of reducing all Kyoto GHG emissions by 20% by 2020 (Gerigk et al., 2012).

Energy intensive industries and companies that consume large amounts of stationary fuels have the option of becoming exempted from the CO_2 tax. In return, companies are obliged to either fully compensate their emissions or participate in the CH ETS. For some companies it is also possible to choose between participating in the CH ETS or to enter into emission reduction commitments. These commitments are binding. They are determined individually between a company and the Energy Agency of the Economy (Gerigk et al., 2012) and can oblige the company to reduce its energy consumption (Meyer, 2003). SMEs can apply for funds from the Swiss Climate Foundation, to offset some of the costs from implementing energy efficiency measures (Swiss Climate Foundation, 2017). The European Commission estimates that improvements in energy efficiency are able to reduce the energy consumption of Switzerland's economy significantly (30-35% saving potential for process heat; 20-25% for processes and drives) (European Commission, 2016).

In 2007, the Federal Council adopted a new energy strategy, with corresponding action plans targeting different sectors, including industry. The action plans were introduced to achieve the following objectives by 2020: reduce fossil fuel consumption by 20 percent, increase the share of renewable energy in energy consumption by 50 percent, and limit the increase in electricity consumption to 5% (compared to 2010). A fourth target is to stabilise electricity consumption after 2020 (Gerigk et al., 2012) .

6.4.4.3 Comparative assessment of different carbon constraints and related policies

Table 18: Carbon constraints and pricing in Switzerland for the selected industrial sectors

	Assessment	Overview
Carbon constraints and pricing	Comparable	A national ETS is implemented to reduce GHG emissions from industry and heat generation covering around 11% of Swiss total emissions. In addition, parts of the industry covered by the ETS are also taxed with roughly EUR 19/tCO_2.
Coverage …of selec. industries …of GHG emissions	 Comparable Comparable	The Swiss ETS covers the same industrial sectors and GHGs as the EU ETS.
ETS price level	Comparable	The average allowance price of 2014 - 2016 of EUR 16 is significantly higher than the prices observed in the EU ETS. However, prices dropped after 2014 and are now similar to the ones in the EU ETS. The envisaged linking of the two ETS will lead to complete price convergence.

	Assessment	Overview
Proposals		Negotiations between the Swiss Government and the COM were finalized in 01/2016. The agreement was signed in November 2017 so that the link is expected to be operational from 2020 on.
Energy prices	Lower (electricity prices) or comparable (natural gas)	Electricity prices for industry are considerably lower than in the EU, but natural gas prices are slightly higher.
Other measures	Somewhat stricter air quality standards, but low enforcement Comparable energy efficiency standards	The current Swiss air quality standard for PM10 is equal to its EU counterpart; standards are more ambitious for SO_2, NO_2, CO and O_3,. However, pollution from particulate matter (PM10), ozone (O_3) and nitrogen oxides (NOx) continues to exceed the legally ambient limit values. Swiss energy efficiency standards are comparable to their EU counterparts.
Summary	Current situation: Comparable carbon constraint Expected development: Comparable carbon constraint	The Swiss ETS covers the same industrial sectors and GHGs and the current price level is comparable to the EU ETS. Implicit pricing of parts of the industry is comparable to other EU countries such as Germany and the UK. Thus, the carbon constraint is comparable to the carbon constraint found in the EU. Switzerland's carbon constraint is expected to stay similar to the EU's carbon constraint; Linking the two ETS may lead to further convergence.

Source: own assessment

6.4.5 Carbon constraints in Turkey

In Turkey, neither an emission trading system (ETS) nor a carbon tax is in place. An energy tax results in an implicit carbon price of EUR 9/tCO_2 for parts of the industry as it implicitly taxes 43% of the total industrial emissions (OECD, 2016; analysing data of 2012).

Turkey adopted a regulatory framework for a comprehensive and mandatory monitoring, reporting and verification (MRV) system on April 25th, 2012, which is a prerequisite for implementing an emission trading system or a company-level carbon tax. After a revision process, the MRV entered into force on May 17th, 2014. The MRV Regulation is adapted from Commission Regulations 600/2012/EC and 601/2012/EC excluding carbon capture and storage (CCS) and aviation. By December 2014, almost 700 monitoring plans were submitted for the first time. The 2015 and 2016 emissions reports must be submitted by October 31, 2017.

In this context, Turkey received a USD 3.35 million grant from the World Bank Partnership for Market Readiness (PMR) to enhance the implementation of the MRV regulation through pilot studies in the energy, cement and refinery sector and to explore options for market based instruments in May 2013 (PMR, 2017). Several studies investigate mitigation options including an ETS and other market based instruments for the sectors already covered by the MRV regulation. As part of this work, Turkey plans to submit a synthesis report outlining its carbon market policy options to the Climate Change Air Management Coordination Board (ICAP, 2017a).

6.4.5.1 Proposals for setting carbon constraints or a carbon price

Turkey is a candidate country to EU accession and thus works with the EU to complete the EU obligations in the field of climate and environment. This includes, inter alia, the requirements set by the EU ETS Directive. As stated in the EU position paper, Turkey was planning to complete the full transposition of the EU ETS in 2019. However, the accession negotiations between Turkey and the EU are currently on hold due to political disputes (Tournier, 2016), which might also influence Turkey's process to fulfill the EU environmental obligations.

Next to the possibility of being included in the EU ETS, Turkey also explores national options in order to reach its 2030 climate mitigation target, to reduce GHG emissions up to 21% below the BAU level as pledged in the Turkish NDC (ICAP, 2017a). The national climate action plan and the corresponding climate change strategy document describe Turkey's medium-term goal as developing "voluntary domestic carbon markets which provide financial assistance for reduction of GHG emissions" (TR Ministry of Environment and Urbanization, 2012, 2010). Nevertheless, so far government has shown no politic will at upper levels to introduce any ambitious instruments or targets.

6.4.5.2 Energy prices and other measures

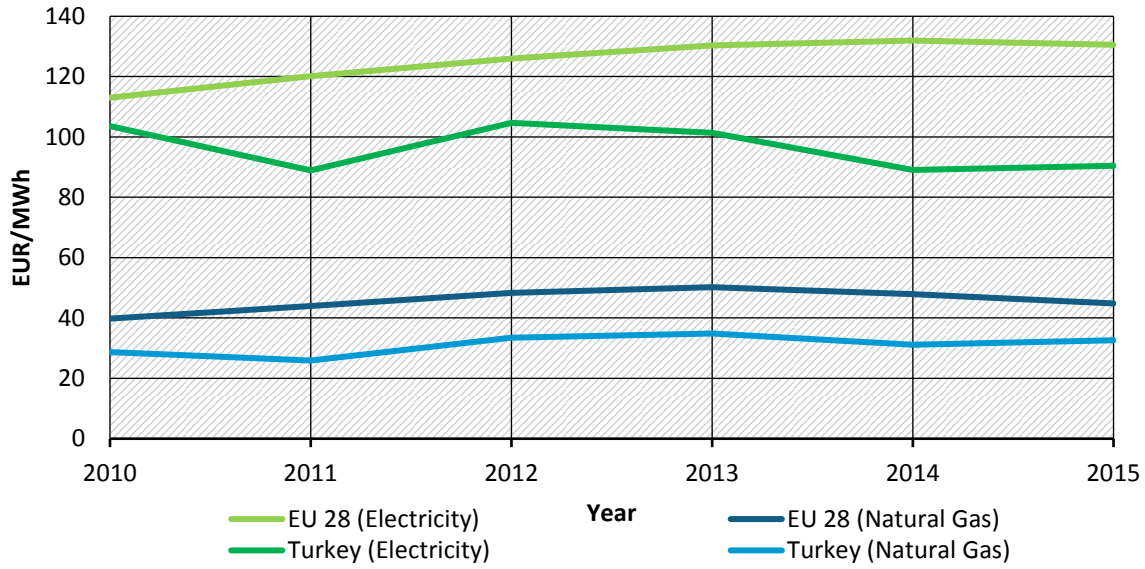
This section gives a short overview of energy prices and other policy instruments possibly affecting operation and investment decisions in the selected industrial sectors in Turkey. The list is not exhaustive but provides an idea of the most relevant policies.

Industrial consumer energy prices

Both electricity and natural gas are cheaper for industrial consumers in Turkey than for their EU counterparts (see Figure 35). The average natural gas prices for industrial consumers, including taxes and levies ranged from about 26 to 35 EUR/MWh over the period of 2010 to 2015. This is well below the EU average, which ranges from 40 to 50 EUR/MWh over the same period of time (Eurostat, 2017d). The average electricity prices for industrial consumers including taxes and levies ranged from 89 to 105 EUR/MWh in Turkey, which is somewhat lower than what

industrial consumers paid in the EU during the same period (Eurostat, 2017d). Turkish prices for both electricity and natural gas excluding taxes and levies are significantly closer to their EU counterparts, indicating that the difference is mainly due to the higher share of policy-induced costs of energy resources in the EU.

Figure 35: Energy prices for industrial consumers in Turkey and in the EU (incl. all taxes and levies; values represent averages across all available consumption bands)



Sources: Eurostat (2017d, 2017c)

Air quality standards for industrial facilities

Air quality is a major concern in Turkey, as around 97% of its urban population is exposed to levels of particulate matter (PM10, PM2.5), which are the highest in Europe and which exceed the limits set by the European Union and the WHO (IEA, 2016b). According to OECD estimates, 28924 people in Turkey died prematurely from ambient particulate matter and ozone exposure (OECD, 2014).

Turkey first addressed the problem of air pollution in 1986, when the regulation on 'Protection of Air Quality' entered into force. Among other things, the regulation set standards for air quality and for emissions of plants that require an emission permit. In 2004, the government issued a more concrete regulation on industrial and energy producing facilities, the 'Industrial Air Pollution Regulation'. It was repealed in 2009 by the 'Regulation on Air Pollution Caused by Industry', which was again amended in 2010, 2011 and 2012. The regulation sets standards and establishes controlling measures for air pollutants including carbon monoxide, sulphur dioxide, nitrogen dioxide, volatile organic compounds and hazardous gases such as hydrogen fluoride, chlorine and inorganic chloride compounds. It further defines criteria and procedures for production, usage, storage and transportation of fuels and raw materials (FAO, 2017; Ministry of Environment and Forestry, 2009).

The EU and Turkey are currently establishing ways to harmonize emission controls. Within its National Climate Action Plan, Turkey aims to transpose the EU Environmental Impact Assessment Directive and the EU Sulphur in Fuels Directive into national legislation. Moreover, all new power plans must comply with both the EU Large Combustion Plant Directive (LCPD)

and the Industrial Emission Directive. Existing power plants need to comply by 2019, implicating that inefficient power plants either need to be closed or upgraded (IEA, 2016b).

Energy efficiency standards for industrial facilities

The Turkish Energy Efficiency Law (No. 5627) was released in May 2007 (revised in 2011) in order to increase energy efficiency of the Turkish economy and thereby limiting energy costs, avoid waste and protect the environment (Turkish Government, 2007). Among other things, the law provides the legal basis to set requirements for industry and businesses as well as for buildings above a certain threshold. These requirements include annual reporting of energy consumption to the Turkish General Directorate of Renewable Energy (CYGM, 2011). Moreover, it obliges industrial facilities with an energy consumption of at least 5.000 toe annually to conduct energy surveys every four years, starting in 2015 (Turkish Government, 2011).

In addition to the energy efficiency law, Turkey published its Energy Efficiency Strategy in 2012 that aims at reducing the energy intensity of the Turkish economy and sets a long-term energy intensity target of 20% reduction by 2023 in comparison to 2011 figures. Each industrial sub-sector is required to reduce its energy consumption by at least 10% until 2023(IIP, 2017c; Ministry of Energy and Natural Resources, 2012). The goals of the Energy Efficiency Strategy are detailed in the Energy Efficiency Action Plan, which was published in November 2014.

The Turkish government transposed most of the EU Ecodesign Framework Directive (2009/129/EC), which provides mandatory minimum requirements for improving the environmental performance of products in industry and in households. It aims not only at improving energy efficiency, but also at harmonizing standards with the EU legislature in order to access Turkish products to the EU appliances market (Coskun et al., 2011; IEA, 2016b). Turkey also transposed the Directive on Energy End-Use Efficiency and Energy Services (2002/91/EC and recast as 2010/31/EU). However, the process of aligning all energy efficiency standards with EU legislation is not finalized. For this, Turkey needs to transpose the Directive on Energy End-Use Efficiency and Energy Services (2006/32/EC) and the Energy Efficiency Directive 2012/27/EC (IEA, 2016b).

6.4.5.3 Comparative assessment of different carbon constraints and related policies

Table 19: Carbon constraints and pricing in Turkey for the selected industrial sectors

	Assessment	Overview
Carbon constraint	Significantly laxer than in the EU	Turkey has no ETS or carbon tax in place but adopted the regulatory framework for a mandatory MRV system in April 2012. An energy tax results in implicit carbon pricing of EUR 9/tCO_2 covering 43% of the industrial emissions.
Coverage …of selec. industries …of GHG emissions		Coverage of the MRV is based on the activities in the EU ETS, but excluding aviation.
ETS price level	---	
Proposals		As an EU candidate country, Turkey aims to complete the requirements set by the EU ETS Directive. Next to the possibility of being included in the EU ETS, Turkey currently also explores national options. However, so far government has shown no politic will at upper levels to introduce any ambitious instruments or targets.

	Assessment	Overview
Energy prices	Below EU prices	In Turkey, industrial consumers pay on average about a third less for natural gas and electricity compared to their EU counterparts.
Other measures	Significantly laxer air quality standards Somewhat laxer energy efficiency standards	Air pollution is a major problem in Turkey. The country slowly started to implement EU standards on national level. However, current air quality standards in Turkey are somewhat laxer then they are in the EU. Turkey implemented the Ecodesign Directive and the Directive on Energy End-Use Efficiency and Energy Services. However, Turkey needs to transpose the Directive on Energy End-Use Efficiency and Energy Services (2006/32/EC) and the Energy Efficiency Directive 2012/27/EC (EED) to match EU energy efficiency standards.
Summary	Current situation: Significantly laxer than in the EU Expected development: Uncertain, mainly depending on chances of EU accession	There is neither an ETS nor a carbon tax in place. Energy prices are below of those in the EU, standards for air quality exist and energy efficiency standards are comparable to the EU's. Turkey aims at raising its environmental standards, but progress within the last years has been slow. Overall, development seems to be closely linked to the chances of EU accession. Thus, the development is uncertain.

Source: own assessment

6.4.6 Carbon constraints in Norway

In order to meet its emission reduction targets defined by the Kyoto Protocol, Norway implemented a national ETS in 2005 which was designed to be compatible with the EU ETS (IETA, 2015). Together with Liechtenstein and Iceland, Norway officially joined the EU ETS in 2007 (full harmonisation of the Norwegian ETS and the EU ETS was established at the beginning of the third phase in 2008) (EU Business Ltd., 2007). In the current phase the EU ETS covers 83% of Norway's industrial emissions.

Next to the EU ETS, Norway taxes its industry through a carbon tax and a mineral oil tax. The carbon tax applies to oil products and natural gas across all sectors (OECD, 2016). The CO_2 tax does not apply to coal, which makes up about a fifth of energy-related emissions from industry (OECD, 2018). In addition, a mineral oil tax applies to oil products used in the manufacturing industry (as well as fisheries). As both the carbon tax and the mineral oil tax are levied on fuels, they do not include process emissions, e.g. from the cement or steel sector. The carbon tax is currently set at a general rate of EUR 35/tCO_2e (NOK 337), but statutory and effective rates vary across fuels and users (OECD, 2018). While a general rate applies to oil products, oil products used in the wood and food industry face a lower rate. Natural gas tax rates differ between users: if used in oil and gas extraction, natural gas is subject to a carbon tax of EUR 44.3 (NOK 427). If used in manufacturing that is already covered by the EU ETS, natural gas is subject to a tax of only EUR 2.6 (NOK 25). In total, this means that 54% of industrial emissions are covered both by the EU ETS and by the carbon tax (and another 30% by the EU ETS only, but not by the carbon tax (OECD, 2016, p. 115). The resulting price differs – for natural gas used in manufacturing plants that are also covered in the EU ETS, the total carbon price comes to roughly EUR 7.80/tCO_2eq (assuming an EU ETS price of NOK 50 / EUR 4.20 and a carbon tax of EUR 2.60 / NOK 25) (International Energy Agency, 2017, p. 35), whereas other parts of industry (including extractive industries) face a much higher carbon price (OECD, 2016, p. 115). 30 of the remaining 46% of industrial emissions are covered by the EU ETS only, and thus face a much lower price. This includes process emissions from certain industry processes, which are covered by the EU ETS but not the carbon tax. Only 16% of industry emissions in Norway do not face any carbon price, which is one of the lowest shares in all OECD countries. In total, the OECD calculates the average effective carbon rates in the industry sector at EUR 35 /tCO_2e, of which some 83% are due to the carbon tax (OECD, 2016, p. 63).

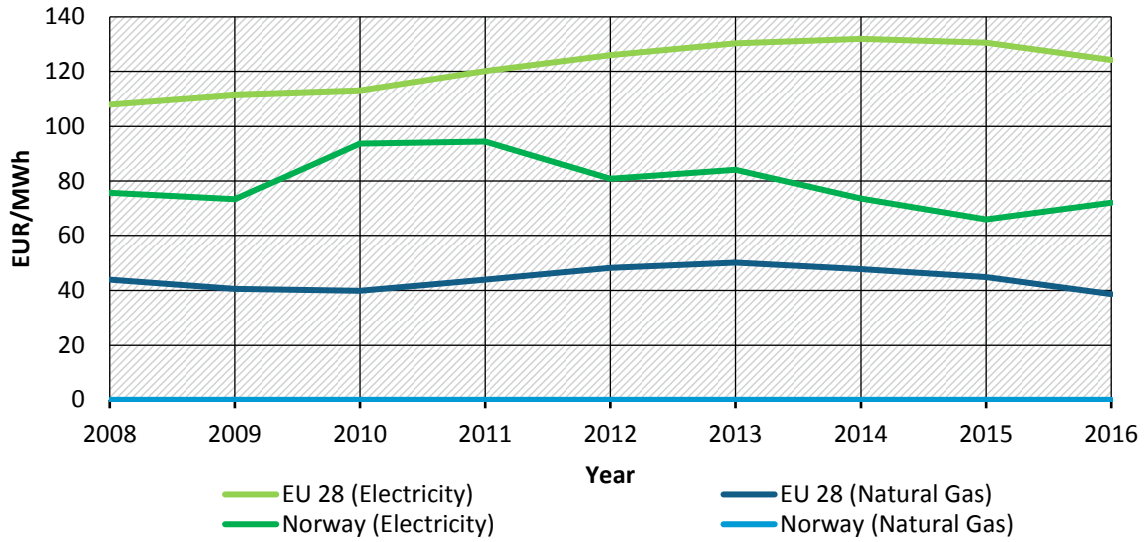
6.4.6.1 Energy prices and other measures

This section gives a short overview of energy prices and other policy instruments possibly affecting industrial production sites and investment decisions of the selected industrial sectors in Norway. The list is not exhaustive but should give a rough idea of relevant policies.

Industrial consumer energy prices

Electricity prices in Norway (including all taxes and levies) have stayed relatively constant over the last decade—ranging from 84 EUR/MWh to 99 EUR/MWh (Eurostat, 2017d). Figure 36 displays the development of electricity and natural gas prices for industrial consumers in Norway between 2008 and 2016 compared to the EU average. Natural gas prices (for both industry and households) are not available, as its use for electricity and heat generation is insignificant (IEA, 2017c). Half of all energy end use in Norway is electricity, and given the high share of hydropower in generation (96.1%), historically prices have remained relatively low (IFE, 2015, p. 201). Compared to the EU average, which ranges from 108 EUR/MWh to EUR 132 EUR/MWh between 2008 and 2016, Norwegian industrial consumers pay considerably less for electricity.

Figure 36: Energy prices for industrial consumers in Norway (incl. all taxes and levies; values represent averages across all available consumption bands)



Source: Eurostat (2017d, 2017c)

Air quality standards for industrial facilities

As a party to the European Economic Area (EEA), statutory limits are established in the Norwegian Pollution Regulation (Ch. 7) for particulate matter, nitrogen dioxide, sulphur dioxide, benzene and carbon monoxide originating primarily from industry and transport. These are based on the EU air quality directives—Clean Air for Europe (CAFE) Directive (COM/2013/0918) and the Fourth Daughter Directive (2004/107/EC)—and also pursuant to Norway's Pollution Control Act of 1981. As of January 2016, Norway introduced tighter domestic controls on air pollution, making national standards stricter than those set forth by the EU.

Energy efficiency standards for industrial facilities

In 2001, the Government of Norway established Enova SF under the auspices of the Ministry of Petroleum and Energy with the goal of driving a transition towards the sustainable production and consumption of energy. While the EU Energy Efficiency Directive (EED) from 2012 is not yet implemented as national policy and no domestic strategy or plan has been set forth, in 2016 the Norwegian government set a national target to reduce energy intensity 30% by 2030. Emissions intensive industry is covered by the EU ETS, which in theory drives energy efficiency investment, and as such there are no specific efficiency standards for these installations. Limits on the CO_2 intensity of passenger cars exist in the transport sector, and there is a planned ban on the use of fossil fuels for space heating by 2020 (IEA, 2017c).

In the industry sector, among other instruments, voluntary agreements have been used for decades. For example, the Programme for Energy Efficiency in Energy Intensive Industry encourages investment in efficiency by entitling participants to electricity tax exemptions. Further funding support schemes exist through Enova, including inter alia support for the incorporation of energy management systems in industry and infrastructure, pre-project energy efficiency measures in industry, support for central heating systems and support for the use of new energy and climate innovations in industry (IFE, 2015). These funds are only available for projects that potentially impact more than 0.1GWh of generation. Companies taking advantage of support policies must report energy consumption and production values to Enova for a

minimum of five years following project completion. These figures may be used to establish benchmarks within specific industries.

6.4.6.2 Comparative assessment of different carbon constraints and related policies

Table 20: Carbon constraints and pricing in Norway for the selected industrial sectors

	Assessment	Overview
Carbon constraints and pricing	Somewhat tighter	Norway is part of the EU ETS, which covers 83% of Norway's industrial emissions. In addition, Norway has a carbon tax and a mineral oil tax in place, which results in an average implicit carbon pricing of roughly EUR 35/tCO_2eq for 54% of the industrial emissions. In the EU, the OECD reports a higher carbon rate for industry emissions only for Sweden and Finland, albeit with a much smaller coverage in both cases.
Coverage …of selec. industries …of GHG emissions	 Comparable Comparable	Norway is part of the EU ETS so that the coverage of selected industries and GHG emissions is the same. Industrial energy emissions to which the carbon tax applies are also part of the EU ETS.
ETS price level	Comparable	The ETS price level for Norwegian emitters is the same as those in the EU.
Proposals		
Energy prices	Electricity: below EU prices	Due to high levels of electrification and a majority share of hydropower in generation, Norway's electricity prices (incl. all taxes and levies) are lower than the EU average. No data available for gas prices in Norway.
Other measures	Comparable	Norway has not implemented the EU Energy Efficiency Directive (EED) and relies on the ETS price signal and support schemes rather than standards to induce efficiency investments. As of January 2016, air quality measures have surpassed EU regulations.
Summary	Current situation: More ambitious than the EU Expected development: More ambitious than the EU	Norway is part of the EU ETS and has an average implicit carbon pricing of EUR 35/tCO_2e which is substantially higher than the implicit carbon price of almost all EU countries. The situation is not expected to change significantly in the coming years.

Source: own assessment

6.4.7 Carbon constraints in South Korea

South Korea has both a national ETS and a carbon tax in place to reduce its GHG emissions. Launched in January 2015, the ETS is currently the only nationwide ETS in force in Asia and the second largest ETS in the world in terms of GHG emissions covered. Covering 525 of the country's heaviest emitters as well as five domestic airlines, the ETS captures roughly 77% of Koreas national and 91% of its industrial emissions (ICAP, 2017m). 19% of the industrial sectors covered under the South Korean ETS (KETS) face an additional tax. This tax yields a carbon price of EUR 14.2/tCO_2 (OECD, 2016).

6.4.7.1 Basic Principles of the South Korean ETS

The KETS covers emissions from industry, power generation, energy, building, transportation, waste and aviation. Within these sectors, companies whose total annual emissions exceed 125,000 tCO_2-eq or businesses whose annual emissions were 25,000 tCO_2-eq or more have to participate in the KETS. All other entities are not obliged, but can choose to participate voluntarily. The current scheme covers all six of the Kyoto gases, and 68% of the nation's total greenhouse gas emissions (ICAP, 2017n).

Implementation is divided into three distinct phases to achieve a 37% reduction from business-as-usual levels by 2030, which represents a 22% reduction below 2012 GHG levels (ICAP, 2017n). The first two compliance periods span for three years each (2015-2017, 2018-2020), whilst the third spans for five (2021-2025). In the first phase, the total amount of allowed emissions was capped at 1.687 $MtCO_2$-eq, and included a reserve of 89 $MtCO_2$-eq for market stabilization measures. 100% of allowances in this phase were allocated for free (ICAP, 2017n). With the exception of three sectors – aviation services, cement, and oil refining – whose allocations followed a benchmarking method, most sectors received their free allowances based on a 'grandfathering' method. In the second period, 97% of allowances will be freely distributed and the remaining 3% will be auctioned. From 2021 onwards, a minimum of 10% will be auctioned (ICAP, 2017n).[79] The caps for Phases II and III are yet to be determined.

Companies at risk of carbon leakage, facing either increased production costs that exceed 30%, trade intensity levels greater than 30%, or both high production costs (>5%) as well high trade intensity levels (>10%), are subject to receive 100% of their allocations for free throughout all three phases (ICAP, 2017n). Although the KETS and the EU ETS use similar wording to describe their quantitative thresholds, they differ in the definition of 'increased production costs'. While the EU carbon leakage lists includes both direct and indirect costs, the KETS expresses production costs solely in terms of direct costs: the price of allowances times annual emissions of the sector (Marcu et al., 2013). There is no carbon leakage list publicly available for the KETS. However, the above discussed differences in definitions of 'increased production costs' suggests that less sectors are considered to be at risk of carbon leakage in South Korea than in the EU.

Allowances are bankable under the current system. However, to address the reluctance of companies to sell, the government is planning on only allowing 20,000 tons and 10% of the yearly quota from Phase I to be carried over into Phase II. The limitation on banked emissions is expected to stabilize the carbon credit exchange (Jun-ho 2017). Moreover, entities can achieve up to 10% of their allowance submission obligations via domestic offsets. In Phase III, up to 50% of these offsets can be sourced internationally (IETA, 2016b).

[79] Production costs are expressed as annual emissions of the sector times the price of allowances and divided by the annual value of that sector. Trade intensity per sector is calculated as value of imports plus value of exports over total revenue of the sector plus value of imports (Marcu et al., 2013).

Price development

On January 12th 2015, the first day of trading, 1,040 allowances were put on the Korea Exchange (KRX) at EUR 6.15 (7,860 won) before climbing to EUR 6.75 (8,640 won) (Reuters, 2015). After the first four days, however, a shortage of tradable carbon allowances put a temporary halt on carbon trading. In fact, low volumes of trade on the allowance market are characteristic for the KETS ever since its launch.

In 2015, only a tiny share (0.3 $MtCO_2e$) of the total cap (573 $MtCO_2e$) was traded. The bankability of allowances has resulted in a market in which sellers refuse to release their surplus allowances. In May 2016, this drove prices up to EUR 14.03/tCO_2e. Moreover, the lacking supply of allowances has inadvertently increased the demand for Korean offset credits, which are now priced the same as Korean allowances (World Bank et al., 2016).

In early April 2017, the price of carbon allowances rose to an all-time high of EUR 23.20 (28,000 won) when the government suggested that an appropriate standard price for carbon allowances was EUR 8.23 (10,000 won) (Jun-ho, 2017).

6.4.7.2 Energy prices and other measures

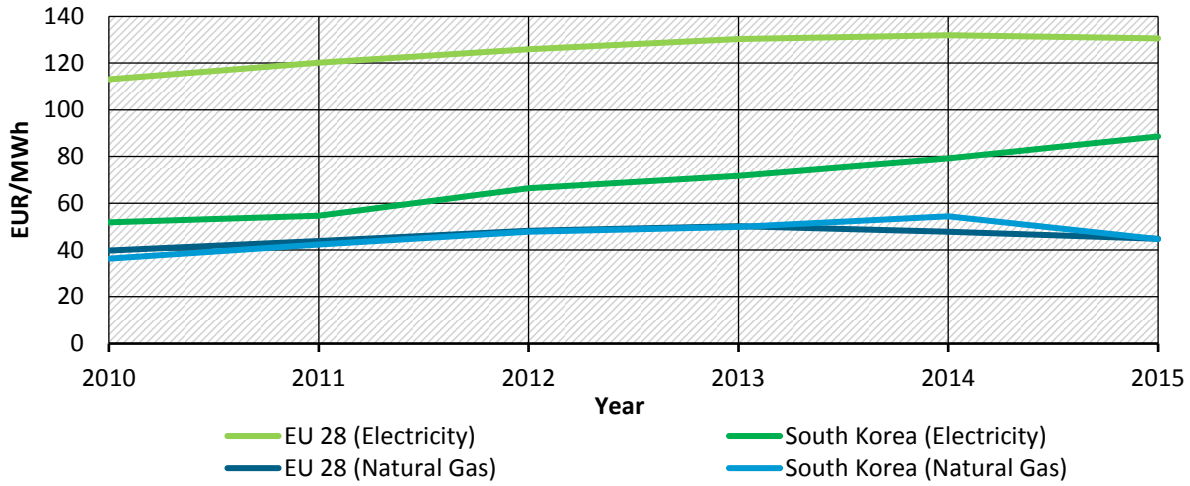
This section gives a short overview of energy prices and other policy instruments possibly affecting industrial production sites and investment decisions of the selected industrial sectors in South Korea. The list is not exhaustive but should give a rough idea of relevant policies.

Industrial consumer energy prices

Average natural gas prices for industrial consumer including taxes and levies ranged from about 36 to 54 EUR/MWh (55,654 to 76,148 Won/MWh) over the period of 2010 to 2015 in South Korea (IEA, 2016a), which is comparable to the EU average of 40 to 50 EUR/MWh over the same period of time (Eurostat, 2017c; comparable also to data presented by IEA, 2016a).

Average electricity prices for industrial consumers including taxes and levies ranged from 54 to 92 EUR/MWh (79,465 to 111,384 Won/MWh) over the period of 2010 to 2015 in South Korea (IEA, 2016a). Thus, prices were well below the prices that EU consumers paid for electricity, which ranged from 113 to 132 EUR/MWh over the same period of time (Eurostat, 2017d; comparable also to data presented by IEA, 2016a).

Figure 37: Energy prices for industrial consumers in South Korea and in the EU (incl. all taxes and levies; values represent averages across all available consumption bands)



Source: Eurostat (2017d, 2017c); OECD/IEA (2017)

Air quality standards for industrial facilities

The Yale Environmental Performance Index 2016 ranked South Korea near the very end, at position 173 out of 180 nations in terms of air quality (Hsu et al., 2016), despite the fact that South Korea has a long history of air quality standards.

Limits for specific pollutants in South Korea date back to 1978, when a standard for sulfur dioxide was first put into place. In 1983, standards for carbon monoxide, nitrogen dioxide, total suspended particles (TSP), ozone, and hydrocarbons followed (Ministry of Environment, 2016). Comprehensive policy that addressed ambient air quality, however, was not addressed until August 1990 with the enactment of the 'Clean Air Conservation Act'. The regulation designated 61 gaseous or granular materials that caused air pollution as 'pollutants', and required them to be both managed and monitored. Under this Act, air pollutant-emitting facilities were required to be permitted and to report their emissions. Additionally, the regulation established permissible emission levels for 26 substances.

Depending on the air quality of a particular industrial complex or area, the permissible level of emissions varied. Naturally, more heavily polluted regions were more strictly managed, faced stricter standards and had lower permissible levels of emissions. Moreover, these levels were periodically tightened in proportion to the development rate and emissions reduction ability of industrial technologies. Routine inspections ensured that the necessary installations were put in place and that facilities that operated without the proper installations were subject to suspension. Those that failed to stay within established levels of emissions were subject to emission charges (Ministry of Environment, 2016).

South Korea added lead onto its list of criteria pollutants in 1991, and particulate matter in 1995; limits on benzene and volatile organic compounds are also enforced (Huh, 2017). Standards for SO2 were increased in 1993, and yet again in 1995. Standards for CO_2 became more stringent in 1995, for particulate matter and lead in 2001, and for NO2 in 2007 (Morgan, 2013).

Energy efficiency standards for industrial facilities

The Korean Energy Management Corporation (KEMCO) was established in 1980 to assist with the implementation of energy efficiency programs (ABB, 2013). One of which rewards industry groups that either enter into voluntary agreements to reduce energy use or invest in energy-efficient technologies with technical support or tax credits that cover up to 20% of the investment costs (ABB, 2013). The Integrated Energy Supply Act, for example, provides tax reductions for industries that invest in CHP plants to supply their own heat.

In August 2008, the South Korean government declared 'Low Carbon Green Growth' as a focus of its national development (Ministry of Knowledge Economy and KEMCO, 2011). To achieve this vision, South Korea introduced the National Energy Master Plan. Aimed at the development of green technologies to spur growth, the plan encouraged energy efficiency improvements. Paired with increased deployment of non-fossil energy, South Korea set targets to decrease final energy consumption by 13% from BAU levels (IEA, 2016a). Revised and re-implemented every 5 years, the fulfillment of the Master Plan would reduce energy intensity by 46% by 2030 compared to 2006 levels. Industry shall account for the largest share (47%) of these reductions, followed by transportation (36%) and commerce (9%) (Ministry of Trade, Industry & Energy, 2014). In absolute terms, industry is expected to reduce energy use by roughly 17 Mtoe by 2030 (ABB, 2013).

In order to ensure that industry is on track to meet its targets, larger energy consumers (those consuming 2 ktoe/year) are required to carry out energy audits every 5 years. Additionally, those that consume over 20 ktoe can participate in the Energy Saving Partnership Program (ESP), a program that facilitates the sharing of energy-saving technologies amongst the industrial sector. As of 2007, 195 companies were active participants of ESP, yielding 285 ktoe of fuel and 393 GWh of electricity saved between 2000 and 2007. Facilities consuming less than 5ktoe/year could qualify for subsidies that cover up to 90% of audit costs. These consumers, however, cannot participate in the ESP (ABB, 2013). Since 2010, the Korean government has operated the "greenhouse gas and energy target management system" as a tool to achieve greenhouse gas reduction goals by large GHG emitters and large energy consumers. Each entity is assigned a goal for greenhouse gas emission reduction and energy savings goal. In reaching this goal, there is an element of flexibility between operators (i.e. trading). The system applies to businesses with greenhouse gas emissions above 50,000 tCO_2 or energy consumption above 200TJ, as well as to individual installations if they exceed certain thresholds. Since the start of the KETS, companies that are part of emissions trading have been exempted from the target management system.

6.4.7.3 Comparative assessment of different carbon constraints and related policies

Table 21: Carbon constraint and pricing in South Korea

	Assessment	Overview
Carbon constraints and pricing	Comparable	The KETS covers around 91% of industry emissions. In addition, 19% of the South Korean industrial sector is taxed, yielding an average implicit carbon price of EUR 14.2/tCO_2.
Coverage …of selec. industries …of GHG emissions	 Comparable Comparable	The KETS covers industry, power generation, energy, building, transportation, waste, and aviation This accounts for roughly 694.5 $MtCO_2e$.
ETS price level	higher	Driven by a shortage in supply, allowance prices in the KETS almost doubled from EUR 6.15 in January 2015 to EUR 16.69 (US$ 18.53) in October 2017. While the price must be interpreted with caution due to the low liquidity, the observed price is higher than that of the EU ETS.
Proposals	---	There has been expressed interest in linking systems with other international ETS. However, there are no discussions or developments currently taking place.
Energy prices	Natural Gas: comparable Electricity: markedly below EU prices	Natural gas prices ranged from 34 to 38 EUR/MWh between 2010 and 2016, comparable to average EU prices. Electricity prices were markedly lower, ranging from 54 to 92 EUR/MWh between 2010 and 2015.
Other measures	Somewhat laxer	Despite significant step-ups in recent years, both air quality and energy efficiency standards are still somewhat laxer than their EU counterparts. However, South Korea is on a good track to achieve EU sustainability standards in the mid or long term.

	Assessment	Overview
Summary	Current situation: Comparable carbon constraint Expected development: Comparable carbon constraint	The KETS covers the same industrial sectors and GHGs as the EU ETS; the current price level is considerably higher than the EU ETS. Energy prices for both natural gas and electricity are below EU prices; energy efficiency and air quality standards are still somewhat laxer than their EU counterparts. Energy efficiency and air quality standards are stepping up levels but they will most likely not reach EU levels in the near future. As the Korean government is actively trying to decrease the price of allowances, prices are not expected to rise considerably in the near future.

Source: own assessment

6.4.8 Carbon constraints in Algeria

Algeria has neither implemented an emission trading system (ETS), nor a carbon tax. The country ratified the Kyoto Protocol in 2005 and a decade later, on September 28th, 2015, submitted its instrument of acceptance of the Doha amendment to the Kyoto Protocol (UNFCCC, 2017, 2015). In its NDC, Algeria set the goal to reduce GHG emissions by 7% by 2030 compared to BAU levels. It aims to achieve this reduction with national means and through increased usage of renewable energies and carbon capture and storage.

6.4.8.1 Proposals for setting carbon constraints or a carbon price

There are no proposals to set a carbon constraint or a carbon price at the time.

6.4.8.2 Energy prices and other measures

This section gives a short overview of energy prices and other policy instruments possibly affecting industrial production sites and investment decisions of the selected industrial sectors. The list is not exhaustive but should give a rough idea of relevant policies besides the fact that there is no carbon price.

Industrial consumer energy prices

A combination of individual tax assessments and unclear guidelines, together with a lack of documentation complicates a comparison of EU and Algerian energy prices (Enerdata, 2016; KPMG Algeria, 2007). For this reason, we decided to compare electricity prices excluding taxes or levies to their EU equivalent. There was no information on natural gas prices for industrial consumers in Algeria.

Due to stagnating supply and rising domestic consumption, Algerian gas exports decreased significantly since the turn of the millennium. After 2000, the share of domestic consumption from total natural gas sales doubled, taking up 47.9% in 2015 (Enerdata, 2016). This development, in combination with the current financial crisis, has opened the opportunity for the first, long-due, increase in both electricity and natural gas tariffs since 2005.

Despite the fact that the Algerian Electricity and Gas Regulation Commission CREG increased the electricity tariff by 20% in 2015, electricity prices for industrial consumers have decreased ever since 2008. In 2016, industrial consumers paid approximately 26 EUR/MWh (excl. taxes and levies). This is significantly below the average prices for industrial consumers in the EU (excl. taxes and levies), which amounted to 85 EUR/MWh in the same year (Enerdata, 2017; Eurostat, 2017d).

Air quality standards for industrial facilities

Algeria attempted to address the problem of air pollution in 2005, when the government issued Executive Decree No. 2005-138 to regulate the emission of gases, fumes, liquids and solid particles. While the decree places limits on different GHG's (incl. nitrous oxide), it fails to include CO_2, methane and tropospheric ozone. Industrial facilities are required to monitor emissions and develop registries as a proof of compliance (Nachmany et al., 2015). However, the regulation seems rather lax and more focused on research than on restricting emissions (Abdessamad, 2015; EEA, 2012).

Energy efficiency standards for industrial facilities

Algerian history of promoting renewable energy as well as energy efficiency dates back to 1999. The then published Algerian law on energy management (Law 1999-09) provides a framework for improvements in energy efficiency and the promotion of renewable technology development

(Ghezloun et al., 2011; Nachmany et al., 2015). It emphasizes three goals: using energy rationally, developing renewable energy, and protecting the environment from negative externalities of the energy system. Further, it establishes a national agency for energy management (APRUE), an intersectoral Council for energy management (ICEM) and a national Fund for energy management (NFEM).

In 2002, the National Plan of Action for the Environment and Sustainable Development (PNAE-DD-2002) was the first among various action plans issued to support sustainable development. Next to establishing a legislative basis for further regulation, PNAE-DD-2002 was also used to stipulate programs and measures addressing climate change. Building up on this National Plan of Action and on Law 1999-09 on energy management, Law 2004-09 on renewable energies defines main policy objectives of promoting the national development of renewable energy sources (ICCG, 2017; on the basis of Bouteflika, 2004).

In December of 2005, the Algerian government issued an Executive Decree establishing mandatory energy audits for large consumers. These audits are performed every three years for industrial consumers and include energy performances of facilities and units, analysis of energy consumption, energy efficiency of operation based on consumer standards, identification of opportunities for energy savings, and development of corrective action plan (Nachmany et al., 2015).

In 2011, Algeria joined with the Regional Centre for Renewable Energy and Efficiency (RCREEE) to develop specific standards for energy efficiency. Through collaboration with the RCREEE, the country developed a National Energy Efficiency Action Plan in 2011, focusing on energy efficiency and the deployment of RES in the period 2011-2013. In 2014, the plan was updated and a second period from 2014-2017 as well as goals for 2020 and 2030 were established (RCREEE, 2014, 2012). The National Energy Efficiency Action Plan initially only required general reductions for energy demand in industry (APRUE, 2015a), but the updated plan in 2015 added 20 feasibility studies and 30 energy efficiency projects to provide specific tools to achieve reductions in energy efficiency (APRUE, 2015b). Moreover, it aims to install 22GW of renewable power generation capacity by 2030 (Aissaoui, 2016; Algerian Ministry of Energy, 2015).

6.4.8.3 Comparative assessment of different carbon constraints and related policies

Table 22: Carbon constraint and pricing in Algeria

	In short	Further information
Carbon constraints and pricing	No carbon constraint	Algeria has neither implemented an emission trading system (ETS), nor a carbon tax.
Coverage …of selec. industries …of GHG emissions	 --- ---	Not applicable
ETS price level	---	Not applicable
Proposals	---	There are no proposals to set a carbon constraint or a carbon price at the time.
Energy prices	Electricity: considerably below EU prices	Electricity prices in Algeria are significantly lower than their EU counterparts. No information is provided on natural gas prices for industrial consumers in Algeria.

	In short	Further information
Other measures	Significantly laxer	Air quality standards seem to be rather lax and they do not include some of the most important GHG's. In recent years, Algeria strongly promoted energy efficiency and RES. However, standards are still low or not existent.
Summary	Current situation: No carbon constraint Expected development: Significantly laxer carbon constraint	Besides some lax measures to increase the share of renewable energies, air quality and energy efficiency standards, few is being done to price carbon in Algeria. Algeria emphasizes its role as a developing country, thereby justifying the few measures taken to combat climate change. However, slow step ups in ambition can be observed and will probably continue in the mid future.

Source: own assessment

6.5 Effective carbon leakage risks in a world of converging carbon prices

6.5.1 Carbon leakage risks based on current policies and trade patterns

The following Table 23 andTable 24 summarize the findings of the previous investigation on carbon constraints in the EU's eight main trading partners, for a selection of eight energy-intensive industrial sectors that are generally considered to be at risk of carbon leakage. Based on the analysis, the comparative stringency (with the EU ETS as the reference point) of the respective carbon constraints is classified into five broad categories. This classification is consistent to the classification from section four:

Table 23: Findings of the previous investigation on carbon constraints in the EU's eight main trading partners

1	Carbon constraint that is tighter (i.e. more ambitious) than in the EU	Norway
2	Carbon constraint that is comparable to the one in the EU	Switzerland, South Korea
3	Carbon constraint is somewhat laxer (i.e. less ambitious) than in the EU	
4	Some carbon constraint exists, but is significantly laxer than the EU ETS, expected to remain so, and /or is weakened by ineffective and incomplete enforcement	China, United States, Turkey, Russia
5	No carbon constraint	Algeria

Source: own assessment

Table 25 displays the top 10 trading partners in the selected industrial sectors and the respective trading volume. For each of the eight sectors, it presents the top 10 trading partners of the EU, with colour-coding to indicate which of these apply what kind of carbon constraint. As the table shows, the top two trading partners in all sectors have a carbon constraint that is weaker than that of the EU. Trading partners with a comparable, or even more stringent carbon constraint, appear as the 3rd or 4th largest trading partners in most sectors.

The graphs on Table 26 indicate graphically, for each sector, how much of the total trade (including intra-EU trade) is conducted with countries that have a stricter, comparable, weaker or non-existent carbon constraint in the different sectors.

Table 24: Comparison of the carbon constraints applicable in eight main EU trading partners

Category\Country	USA	Russia	China	Switzerland	Turkey	Norway	South Korea	Algeria
Carbon constraint (compared to the EU ETS)	Comparable in California; no federal instrument	Significantly laxer	Currently laxer	Comparable	Significantly laxer	Somewhat tighter	Comparable	No carbon constraint
Coverage - selec. industries - GHG emissions - regional constraint	*Only for C ETS* Comparable Comparable 4% of trade	---	*Currently*: only electricity covered and national ETS non-binding; *Planned:* Like EU ETS, but w/o glass, ceramics and CO_2 emissions only	Comparable Comparable	---	Comparable Comparable	Comparable Comparable	---
ETS price level	*Only for C ETS* Well above EU ETS prices	---	Currently lower or somewhat below	Comparable	---	Comparable	Above EU ETS prices	---
Proposals	Non-governmental proposals for federal carbon tax and for regional carbon taxation	---	Carbon tax for industries not covered by the national ETS post-2020	Linking to the EU ETS	Complete requirements of the EU ETS Directive	---	Expressed interest in linking with other international ETS	---

Category\Country	USA	Russia	China	Switzerland	Turkey	Norway	South Korea	Algeria
Energy prices	Well below EU prices	Well below EU prices	Well below EU prices	Lower electricity and comparable natural gas prices	Well below EU prices	Electricity: Below EU prices	Natural Gas: comparable Electricity: Well below EU	Electricity: Well below EU prices
Other measures	Somewhat laxer	Strict standards in some areas, but with severe implementation deficits	Somewhat laxer for air quality and for energy efficiency standards	Somewhat stricter for air quality, but low enforcement; Comparable for energy efficiency	Significantly laxer for air quality; Somewhat laxer for energy efficiency	Comparable	Somewhat laxer	Significantly laxer
Summary Current status (compared to EU) **Expected development**	**Significantly laxer Significantly laxer**	**Significantly laxer Uncertain**	**Significantly laxer than in the EU** **Somewhat laxer**	**Comparable Comparable**	**Significantly laxer than in the EU** **Uncertain, depends on EU accession**	**More ambitious More ambitious**	**Comparable Comparable**	**No carbon constraint Significantly laxer**

Table 25: Carbon constraints of the top 10 trading partners in the selected industrial sectors and respective trading volume (in EUR billion)

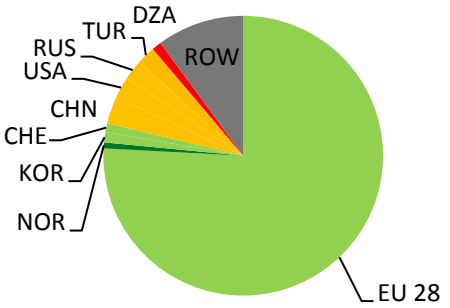
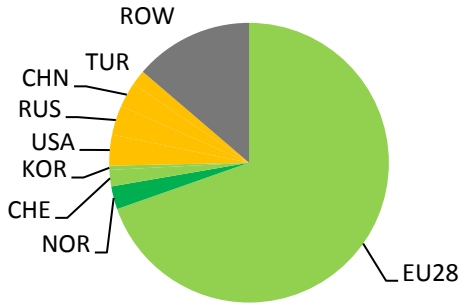
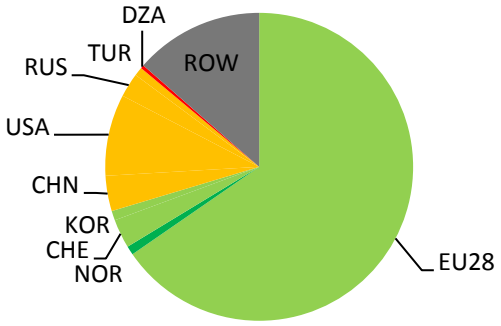
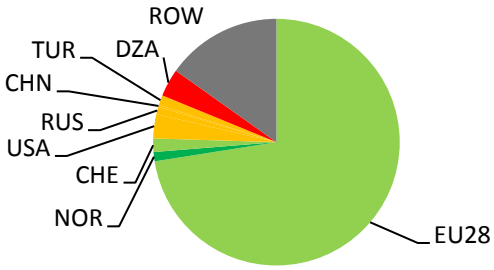
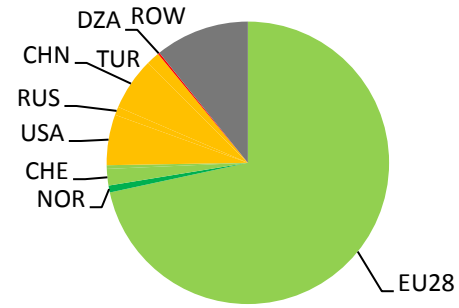
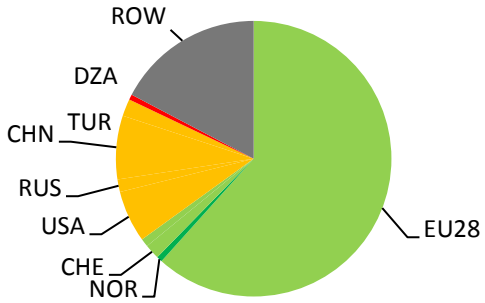
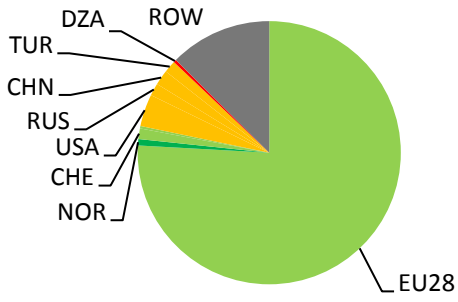
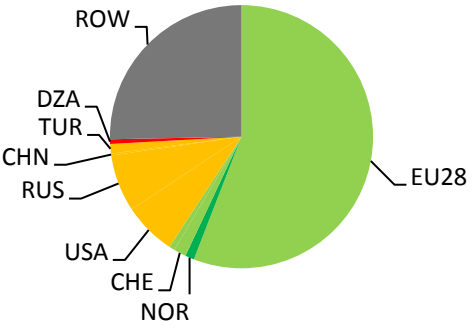
	Iron & steel	Chemicals	Non-ferrous metals	Cement & lime	Glass	Ceramics	Pulp & paper	Refineries
1	CHN: 5.44	USA: 24.78	USA: 5.99	DZA: 0.21	CHN: 1.70	CHN: 1.82	USA: 4.36	RUS: 20.26
2	USA: 4.18	CHN: 10.73	RUS: 5.76	USA: 0.18	USA: 1.64	USA: 1.49	BRA: 2.74	USA: 18.81
3	RUS: 4.07	CHE: 8.79	CHN: 4.86	CHE: 0.10	CHE: 0.53	TUR: 0.49	CHN: 2.05	SAU: 5.67
4	TUR: 3.71	RUS: 7.35	NOR: 4.48	ISR: 0.08	TUR: 0.43	CHE: 0.43	RUS: 1.69	CHE: 4.41
5	UKR: 2.60	SGP: 4.76	CHE: 3.18	TUR: 0.08	JPN: 0.31	RUS: 0.36	TUR: 1.66	NGA: 4.17
6	KOR: 2.05	JPN: 4.51	TUR: 2.92	NOR: 0.07	RUS: 0.27	JPN: 0.34	CHE: 1.43	TUR: 3.39
7	DZA: 1.90	IND: 3.80	CHL: 1.95	GHA: 0.06	NOR: 0.22	SAU: 0.34	NOR: 0.86	NOR: 3.21
8	BRA: 1.84	KOR: 2.91	UAE: 1.37	RUS: 0.06	IND: 0.19	KOR: 0.23	CHL: 0.76	TGO: 3.08
9	IND: 1.84	NOR: 2.70	CDN: 1.28	COL: 0.06	UAE: 0.18	UAE: 0.23	IND: 0.66	UAE: 3.05
10	CHE: 1.79	TUR: 2.64	SAU: 0.94	BIH: 0.04	CDN: 0.14	ISR: 0.18	URY: 0.59	SGP: 3.01

3-letter country abbreviations: ARE: United Arab Emirates, BIH: Bosnia and Herzegovina; BRA: Brazil, CDN: Canada; CHE: Switzerland, CHL: Chile , CHN: China, COL: Colombia; DZA: Algeria, EGY: Egypt, IND: India, ISR: Israel; JPN: Japan, KOR: South Korea, NGA: Nigeria, NOR: Norway, RUS: Russia, SAU: Saudi Arabia, SGP: Singapore, TGO: Togo; TUR: Turkey, TWN: Taiwan, UKR: Ukraine, URY: Uruguay; USA: United States of America, ZAF: South Africa

The colour coding indicates the stringency of the carbon constraint, compared to the EU ETS, see previous pages for a detailed explanation.

Source: calculations based on Eurostat (2016)

Table 26: Total EU trade in the selected industrial sectors (relative shares)

Iron and steel	Non-ferrous metals
	
Chemicals	**Cement and Lime**
	
Glass	**Ceramics**
	
Pulp and paper	**Refinery products**
	

Source: own calculations, based on Eurostat (2016)

6.5.2 Trends in carbon pricing and future carbon leakage risks

This study investigated the carbon constraints that currently apply in the EU's main trading partners. To what extent does the assessment of carbon leakage risks change when future carbon pricing trends are incorporated? For the discussion of the carbon leakage risk, timing matters a lot:

- In the short run, there is the risk of operational carbon leakage based on existing capacities – something that would happen in a matter of months. Whether carbon leakage occurs or not will therefore depend on the availability of spare capacities in third countries, which could be used on a short notice to serve export markets. This, in turn, will depend more than anything else on domestic demand in third countries – as witnessed e.g. in the Chinese steel and cement sectors, as the Chinese building boom seems to be coming to an end. This shortfall in domestic demand is one main reason that there is surplus capacity in the Chinese steel sector, depressing global steel prices and exacerbating the risk of carbon leakage.

- In the longer run, the dominant risk is that of investment leakage – i.e. companies expanding their production capacity in order to exploit weaker carbon constraints abroad; this would occur over a number of years. For investment leakage to become an issue, the questions are a) not whether a carbon constraint exists now, but whether it will exist during the economic lifetime of the investment; b) if carbon leakage creates an incentive to invest abroad, rather than at home – how this incentive compares against other considerations that figure in the investment decision; c) whether an investor will want to be seen as exploiting differences in climate policy – e.g. in the case of the Trump administration's withdrawal from the Paris Agreement, which was widely criticised also by business leaders from the EU and the United States, it could be argued that a pure "leakage investment", exploiting the policy change in the United States could eventually create a reputational risk.

Prognoses are always risky – particularly where they concern the future. Nonetheless, to evaluate the long-term risk of investment leakage, it is necessary to form a reasoned expectation about the future carbon constraint. For the countries investigated here, the following developments can be anticipated over the coming years:

- For the **United States**, not much should be expected at the federal level: any significant additional action under the Trump administration would come as a surprise; the question is rather to what extent the judicial and the legislative branch will prevent the Trump administration from rolling back existing climate policy. There is considerable activity at state-level, which can be expected to continue – yet the focus appears to be more on electricity and transport, less on emissions from industry. State-level action will continue: California has recently extended its climate policy programmes (including the ETS) to 2030 and beyond, in this endeavour it could possibly be joined by Oregon. Based on the design of the Californian system (with a carbon reserve price increasing over time), carbon prices are certain to increase by at least 5% annually. On the east coast, the Regional Greenhouse Gas Initiative (RGGI) considers extending its activities to transport, yet industry emissions do not seem to be a focus area. One development with potential implications on the carbon leakage debate is the threat of trade sanctions against steel imports. While it is uncertain when these will come, what form they will take and what impact they will have, this development has the potential to significantly affect the trade relations between the United States, Europe and China, particularly for steel.

In **China**, commitments to price carbon through the national ETS – timing of the introduction and the coverage remains to be seen. For the time being, it is unclear when and which industrial sectors will be covered. China remains fully committed to the Paris Agreement and its NDC, and has declared that meeting its NDC is in its own national interest, irrespective of what other countries do or say. Despite

the fact that the NDC requires some effort to meet, experts expect that China could even exceed its NDC.[80] The expectation of more stringent emission reduction policies is further strengthened by a range of different policy initiatives at different levels, which are well aligned with China's climate policy efforts. This includes, in particular, policies to reduce coal use, particularly in urban areas, and other policies to enhance air quality. Furthermore, Chinese climate policies are embedded in the notion of creating an "ecological civilisation", the Chinese interpretation of a competitive and yet sustainable economy, and delivering sustainable welfare to its citizens.

- For **Norway, Switzerland and South Korea**, there is every reason to assume that they will continue to pursue their climate efforts – or at least no compelling reason to assume otherwise. All these countries have repeatedly emphasised internationally (including Norway and Korea in the context of the G20) that they remain fully committed to the Paris Agreement and to meeting their NDCs. For all of them, meeting their NDCs will require some efforts, which means that they are unlikely to scale back existing climate policies, but will rather be required to consider additional measures and intensify existing policies.
- In **Turkey, Russia and Algeria**, developments remain uncertain. As of October 2017, Algeria is the only of the three to have signed and ratified the Paris Agreement. Turkey and Russia have signed the Agreement and have submitted their NDCs, but have not ratified it. Both have also expressed their commitment to the Paris Agreement, including in the context of the G20 – albeit in the case of Turkey with additional qualifications regarding Turkey's access to funds from the Green Climate Fund. In either case, it is unclear to what extent the NDC will become relevant, or even provide guidance, for domestic policy decisions.

[80] http://climateactiontracker.org/news/278/China-India-slow-global-emissions-growth-Trumps-polices-will-flatten-US-emissions.html

6.6 Changing policies, changing trade patterns – a dynamic analysis

6.6.1 Model description

The quantitative assessment of direct carbon leakage against the background of different international climate policy scenarios is carried out with PACE (Policy Analysis based on Computable Equilibrium), a multi-sector, multi-region computable general equilibrium (CGE) model of global production, consumption, trade and energy use. PACE is established in economic research and policy consulting and has, for instance, been employed in various previous studies, in particular with respect to the analysis of different design options of the EU ETS in Phase 3 and Phase 4. The following gives a short overview of PACE's features.

6.6.1.1 The PACE model

The PACE model includes representations of production sectors, consumption, taxation, and trade calibrated to a globally balanced set of social accounting matrices (SAMs). Production sectors take market prices as given and choose input factors (capital, labour, energy, intermediates) such that production costs are minimal. Perfect market competition forces them to sell their produced goods at zero profit. Similarly, representative consumers take market prices as given and choose their consumption such that they get maximum utility out of their budget. The representative households receive revenues from offering the production factors they own (labour, capital, and resources) to the production sectors. In the model version used in this study, we assume one representative household per region. Prices of all produced commodities and production factors are set such that markets for the respective goods clear. Governments raise taxes to finance fixed amounts of government services and transfer net surpluses to households.

In order to discuss climate policy, the PACE model tracks the value flows of energy commodities: crude oil, refined oil, natural gas, coal, nuclear power, renewable energy sources and electricity. The use of the fossil fuels refined oil, natural gas, and coal in production and consumption are linked to CO_2 emissions from burning those fuels for the production of energy. The model thus only considers CO_2 emissions, namely those from fossil fuel combustion and process emissions. PACE adds emission permits as a resource owned by the governments and lets market clearance conditions determine the price at which the fixed supply meets demand. In case of the EU ETS, permits may be traded across the EU for use by industrial sectors included in the EU ETS. Emissions in non-EU countries are governed by national policies and are non-tradable across regions. For the sake of comparability, we assume for all policy scenarios, which are described below, that a split into ETS and non-ETS sectors applies also to non-EU regions. Thereby, the ETS covers the same sectors as in the EU. Free markets guarantee that all emitters face the same carbon price within each country and market segment. In order to best represent the Effort Sharing Decision of the European Commission, we assume trading of fictitious non-ETS permits across EU regions so that marginal abatement costs in those sectors are equalized.

Unless otherwise stated, revenues from non-ETS carbon pricing (through endogenous carbon taxes) go to the government and are refunded to the national representative households. Revenues from EU ETS permit auctions also accrue to the government, but freely allocated ETS permits are handed to the owners of the respective production facilities. Production with these freely allocated permits is not assumed to generate windfall profits for their owners due to perfect competition within the respective sectors.

6.6.1.2 Data

Social Accounting Matrices (SAMs) for the reference year 2011 provided in the GTAP 9.1 data set of the global trade analysis project (GTAP). Regional and sectoral coverage used for the model are given by Table 27 and Table 28, respectively.

Within the European Union we consider the five largest economies of the Western European Member States (Germany, France, the United Kingdom, Italy and Spain) as well as Poland as the largest economy of the Central and Eastern European Member States as separate regions. The remaining EU countries are gathered in two groups: "Rest of Western MS", "Rest of Central and Eastern MS".[81]

Table 27: Regional coverage of the PACE model

Acronym	Region
DEU	Germany
FRA	France
GBR	United Kingdom
ITA	Italy
ESP	Spain
POL	Poland
XWE	Rest of Western MS (Denmark, Sweden, Finland, Austria, Belgium, Netherlands Luxembourg, Ireland, Portugal, Greece, Malta, Cyprus)
XEE	Rest of Central and Eastern MS (Czech Republic, Slovakia, Hungary, Slovenia, Bulgaria, Romania, Croatia, Estonia, Latvia, Lithuania)
USA	United States of America
RUS	Russia
CHE	Switzerland
NOR	Norway
TUR	Turkey
RAX	Switzerland, Norway, Iceland, Liechtenstein, Ukraine, Belarus, New Zealand
CHN	China (incl. Hong Kong, excl. Taiwan)
IND	India
BRA	Brazil
KOR	South Korea
ROW	Rest of the World

The most significant developed and developing economies outside the EU are included as separate regions as well. Here, we focus on the most important European trading partners.

Regarding the sectoral coverage, the model version used distinguishes 36 production sectors, which include five for extractive activities, 26 for industrial activities and five for services.

Where sectoral coverage of the GTAP 9.1 database was not sufficient, we disaggregated the sectors using additional data sources.

[81] In the model, this means that the data for all countries in each of these two regions are aggregated.

Table 28: Sectoral coverage of the PACE model

Main aggregates	Sectors
Extractive activities	Agriculture, forestry and fishing
	Coal production
	Crude oil extraction
	Natural gas extraction
	Mining, n.e.c.
Industry covered by EU ETS	Pulp and paper
	Refineries and coke oven production
	Fertiliser production
	Organic chemical production
	Inorganic chemical production
	Cement production
	Bricks and tiles production
	Glass production
	Ceramics production
	Basic iron and steel production
	Further processing of iron and steel
	Aluminium production
	Production of other non-ferrous metals
	Air transport
	Electricity
Industry not covered by ETS	Food production
	Manufacture of textiles, wearing apparel and leather
	Manufacture of wood and wood products
	Other chemicals, rubber, plastics production
	Production of other non-metallic minerals
	Manufacture of electrical and electronic equipment
	Manufacture of machinery and equipment, n.e.c.
	Motor vehicles and parts
	Other transport equipment

Main aggregates	Sectors
	Other manufacturing
	Construction
Other services	Inland transport
	Water transport
	Business services
	Private services
	Public services

Please note: Industry covered by EU ETS: In the actual EU ETS, these industries are covered only partly and to a different degree. Nevertheless, the sectoral disaggregation tries to represent the ETS segment as precisely as possible.

To account for economic growth, we scaled the national endowments of production factors according to country specific GDP growth projections. To account for technological progress, we modelled energy efficiency increases as declining energy requirements for production in different industries and in consumption.

All simulation runs are conducted for the model periods 2010 to 2050 using five-year time steps.[82]

In the case of the EU, the EU Reference Scenario 2016[83] was used to calibrate GDP, industrial energy efficiency improvements and developments in consumption of specific fuels by the power sector. On the policy side, the results from the Reference 2016 Scenario informed the assumptions about ETS permit prices. Projections of fossil fuel prices in the Reference 2016 Scenario were used to inform global market prices for fuels. GDP and energy efficiency improvements of non-EU countries were projected according to the International Energy Outlook of the United States Department of Energy (International Energy Outlook –IEO- 2013). At the sectoral level, the projections provided by the Reference 2016 Scenario are not as detailed as the PACE version used for this project. Therefore, Reference 2016 parameters with sectoral detail are disaggregated according to the corresponding shares of each PACE sector within the respective aggregate Reference 2016 sector. In particular, data on energy demand are considerably more detailed in the 2013 IEO and in GTAP than in the aggregated Reference 2016 projections used for the calibration of the PACE model. CO_2 profiles of each sector and of households are computed using their demand for fossil fuels. To combine the advantages of both data sources, we use the growth rates of sectoral energy demands, not their absolute values, from Reference 2016 projections, whereas the fuel mix in each sector is computed according to IEO information. Nevertheless, we decompose the aggregate information on fossil fuel use provided in Reference 2016 using consumption shares from the IEO projections. To this end, we use energy inputs of the Reference 2016 scenario for the base year 2010 which are provided by fuel type for aggregate sectors (e.g. industry, electricity). To achieve such a sectoral coverage as in the PACE model we use sectoral shares from GTAP and the IEO to decompose them for all model sectors. The temporal development, however, follows that of the model since it is identified endogenously.

Process emissions were included for all model sectors in all model regions. To this end, we made use of process emissions data from the World Input Output Database (WIOD)[84]. The advantage of this

[82] In the remainder, the results will be presented as ten-year time steps between 2020 and 2050 in order to avoid an information overload.

[83] For reasons of readability, EU Reference Scenario 2016 and Reference 2016 will be used analogously.

[84] http://www.wiod.org/home

database is that the sectors are relatively similar to the PACE sectors and can thus be translated in a relatively straightforward fashion.

6.6.2 Scenario description

This section introduces the baseline scenario as well as the policy scenarios used in this study. Most of the results are presented as changes vis-à-vis the baseline scenario.

6.6.2.1 Baseline scenario

The starting point is a baseline, which assumes compliance with the 2030 Framework in the EU and with the Copenhagen Pledges in non-EU countries. It includes:

In the EU: 40% carbon dioxide emissions reduction (energy and non-energy related emissions) by 2030 compared to 1990 level (corresponds to respectively 43% and 30% in the ETS and non-ETS sectors below 2005 levels) and 80% reduction by 2050 compared to the 1990 level.[85]

In the EU: 20% renewable energy share in gross final energy consumption by 2020, which corresponds to 35% in the electricity sector; 27% renewable energy share in gross final energy consumption by 2030, which corresponds to 45% in the electricity sector. The targets are reflected at the Member State level by an increase in the share of renewable energy in the electricity sector (RES-E), in line with the potential contribution of the electricity sector to the overall RES share (regarding the split per Member State, the assumptions are based on the EUCO30 Scenario. However, it should be noted that this split is purely indicative, since Member States will have the possibility to propose national contributions towards the EU RES target in their forthcoming national energy and climate plans).

In the EU: Distribution of efforts in the non-ETS sectors among Member States according to the new Effort Sharing Regulation.[86]

- In non-EU regions: Emissions reductions are implemented according to Copenhagen Pledges by 2020 and kept constant thereafter.
- Permits are fully auctioned in all sectors of all model regions. Auctioning revenues are handed back to the households as a lump-sum transfer.

The time horizon of this baseline is the period up to 2050. The surplus of emissions allowances – which has accumulated in recent years – and the Market Stability Reserve are imposed in an exogenous manner.

Table 29 summarizes the renewable energy targets for the EU translated for the electricity sector based on the EUCO30 Scenario. The targets for the aggregate regions (Rest of Western MS, Rest of Central and Eastern MS) were identified by computing the weighted average with electricity demand.

Table 29: Assumed renewable energy targets in electricity sector based on EUCO30 Scenario

Model region	2020	2025	2030
France	31.5	36.4	37.2

[85] The EU has proposed a total emission reduction of 80 to 95 % until the year 2050 compared to the 1990 level. Because of the limitations of the model, results for a 95 % emissions reduction scenario could overestimate costs to a high extent. For further explanations see Section 6.3.1. Note that the PACE model only considers CO2 emissions. Policy targets are set for GHG emissions in general. In this study, we assume that the respective targets apply to CO2 emissions.

[86] In practice we do not fully represent each MS target but the reductions in the non-ETS sectors are simulated by carbon trading between those sectors, in order to represent the fact that the Effort Sharing Regulation is driven by an attempt to equalize costs between Member States. This explains why we report a carbon price for the non-ETS sectors in the report.

Model region	2020	2025	2030
Germany	34.9	37.6	45.6
Italy	32.5	44.9	51.9
Poland	14.3	20.7	26.5
Spain	38.5	54.9	68.8
United Kingdom	41.1	46.7	49.9
Rest of Western MS	47.5	53.1	62.1
Rest of Central and Eastern MS	23.0	28.3	36.3

The specific emission reduction targets for each model year are given in Table 30 and follow the EU Decarbonisation Roadmap.

In the policy scenarios, which are described below, the ratio between issued ETS permits and non-ETS emissions is kept at the level given by the Baseline Scenario.[87] Within the ETS sectors, full trade of allowances between all EU Member States is implemented such that the cost efficient allocation of permits to each member state and sector is eventually achieved. As mentioned previously, in order to mimic the Effort Sharing Regulation, carbon trading between Member States in non-ETS sectors is also implemented.

Table 30: Pathway to achieve emission reduction targets in the EU

Year	Reduction targets vs. 1990 (%)
2005	7
2010	12
2015	18
2020	25
2025	33
2030	40
2035	49
2040	62
2045	73
2050	80

6.6.2.2 Policy scenarios

The project team has developed and analysed four stylized policy scenarios to assess the impact of different policy options on the competitiveness of the European and international industries, while taking into account the latest development of the EU ETS, the new Effort Sharing Regulation and

[87] This assumption leads to a CO2 emissions reduction in ETS and non-ETS sectors close to that foreseen in the Impact Assessment of the 2030 Framework: 42% in ETS sectors vs. the 2005 level and 30% in non-ETS sectors vs. the 2005 level.

international climate negotiations (Paris Agreement). The analysis examines policy impacts at the regional and sectoral level.

For the EU, all policy scenarios include the features as described in the Baseline Scenario.

The policy scenarios are described with respect to their assumptions for the non-EU regions below:

Scenario 1 (no non-EU climate policy):

- Non-EU regions do not implement any CO_2 reduction policy. This also applies to Norway and Switzerland.

Scenario 2 (NDCs as non-EU climate policy):

Non-EU regions comply with their NDC objectives by the respective announced year (2025/2030). Annex I regions[88] have the same reduction targets by 2050 as the EU (80% compared to the 1990 level) while non-Annex I regions[89] achieve their 1990 CO_2 emission levels by 2050.

- In non-EU regions, a split into ETS and non-ETS market segments equal to that in the EU is installed.[90] Percentage CO_2 reduction targets in ETS and non-ETS sectors are the same.
- Permits are fully auctioned in all sectors of the non-EU economies.

Scenario 3 (non-EU free allocation)[91]:

- Non-EU regions comply with their NDC objectives and 2050 emission targets as in Scenario 2.
- In non-EU regions, a split into ETS and non-ETS market segments is installed as in Scenario 2.
- In the **non-EU regions**, sectors that are on the carbon leakage list in the EU receive free allowances which amount to a share of 95% in 2020; this is reduced to 0% until 2050 in a linear fashion.

Scenario 4 (non-EU and EU free allocation):

- Non-EU regions comply with their NDC objectives and 2050 emission targets as in Scenarios 2 and 3.
- In non-EU regions, a split into ETS and non-ETS market segments is installed as in Scenarios 2 and 3.
- In the **EU and non-EU regions**, sectors that are on the carbon leakage list in the EU receive free allowances which amount to a share of 95% in 2020; this is reduced to 0% until 2050 in a linear fashion.

The emission paths for three aggregated country groups, the EU, other Annex I countries and non-Annex I countries are depicted in Figure 38, Figure 39 and Figure 40 for the Baseline Scenario, Scenario 1 and Scenario 2, respectively. An important finding, which will determine the results of the policy scenarios at least up to 2030, is that freezing emissions at the 2020 level in non-Annex I regions is more restrictive until 2030 than complying with the NDCs since many of those regions, e.g. China

[88] Of the main trading partner countries, the following are Annex I regions: Norway, Russia, Switzerland, Turkey, United States.

[89] Of the main trading partner countries, the following are non-Annex I regions: Brazil, China, India, South Korea.

[90] This means that it is assumed that economic sectors that are covered in the EU-ETS are also covered by an ETS-like policy in non-EU-regions.

[91] In the sectoral coverage of the model, sectors on the carbon leakage list include all EU ETS sectors except further processing of iron and steel, other non-ferrous metals and air transport.

and India, determine their NDCs as a reduction in intensity levels (emissions per GDP unit). This usually results in a growing emissions path which peaks around 2030 according to their NDCs. Hence, emissions are higher in Scenarios 2, 3 and 4 than in the Baseline Scenario that assumes a constant emissions level from 2020 onwards. For instance, China has CO_2 emissions levels in 2030 of 11.6 Gt in Scenario 2 (cf. Table 50 in Appendix B) and only 7.9 Gt in the Baseline Scenario (cf.

Table 46 in Appendix B). From 2030 onwards, emissions levels decrease in the non-EU regions and they are below the Baseline Scenario before 2040.

When a reduction range was given in the respective NDC, we implemented the lower reduction target. The specific NDCs and adjusted targets for each model region are depicted in Table 44 in Appendix B. As the European Union expresses its CO_2 emissions reduction targets in comparison to 1990 levels, we implement the reduction policies in non-EU regions for the different scenarios in this manner.[92]

Unless otherwise stated, the results will be presented as changes vis-à-vis the reference baseline scenario outlined in the previous subsection.

Figure 38: CO_2 emission paths relative to the 1990 levels in the Baseline Scenario

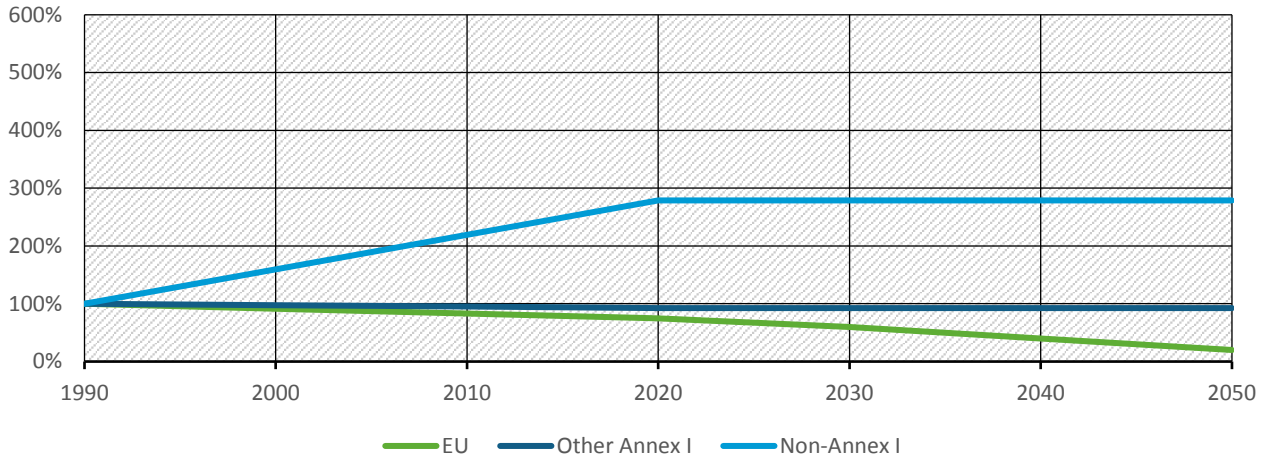
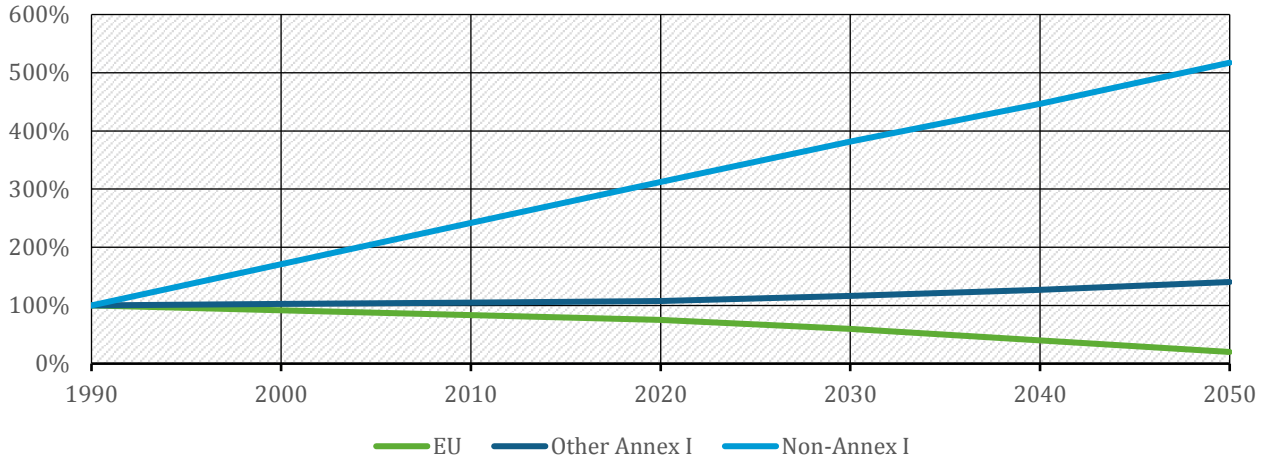
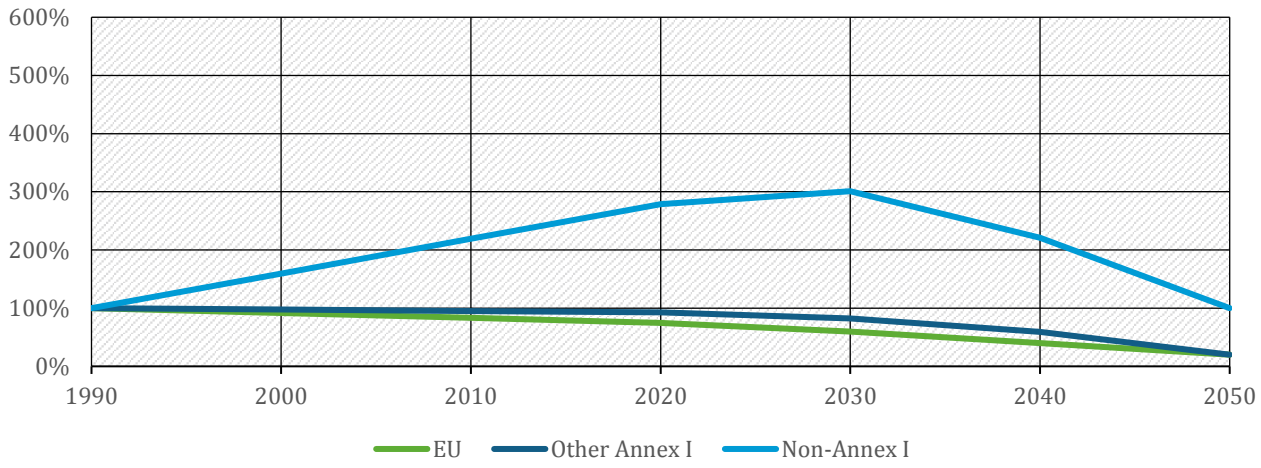


Figure 39: CO_2 emission paths relative to the 1990 levels in Scenario 1



[92] To this end, the NDCs were converted such that the targets vis-à-vis the 1990 level could be implemented into the model.

Figure 40: CO_2 emission paths relative to the 1990 levels in Scenario 2



6.6.3 Modelling results

Economic and environmental indicators in the Baseline Scenario are presented in Table 45 to Table 48 in Appendix B for the model regions in 2020, 2030, 2040 and 2050, respectively. These will serve as the reference point for the policy scenarios analysed in this section. This section is structured as follows. Section 6.6.3.1 deals with CO_2 prices, emissions and GDP impacts. Section 6.6.3.2 examines impacts on the sectoral production levels while Section 6.6.3.3 analyses the effects on energy carrier prices. In Section 6.6.3.4, a closer look at economic impacts within the EU is taken.

6.6.3.1 CO_2-prices, CO_2-emissions and GDP

Figure 41 shows the development of the EU ETS allowance price. Please note that a CGE framework is not appropriate to make predictions on the exact indicator values – empirical methods are the more suitable tool for this task – but rather to allow for comparative analyses between different potential policy settings. The allowance price for 2050 might hence seem unreasonably high. On the one hand, this is due to some model limitations: the model incorporates neither endogenous technological change nor the use of CCS which obviously drives the prices to a high level. On the other hand however, the results show that an 80% GHG emissions reduction target by 2050 is a rather ambitious task.[93] We also observe this when examining other macroeconomic indicators below.

[93] The EU has proposed a total emission reduction of 80 to 95 % until the year 2050 compared to the 1990 level. As emission reductions of 80 % lead to high CO2 prices, reductions of 95 % are even more likely to do so. They require new technologies with high individual abatement potentials. Because of the limitations of the model, results for a 95 % emissions reduction scenario could overestimate costs to a high extent.

Figure 41: Development of allowance prices in the EU ETS (2010 €)

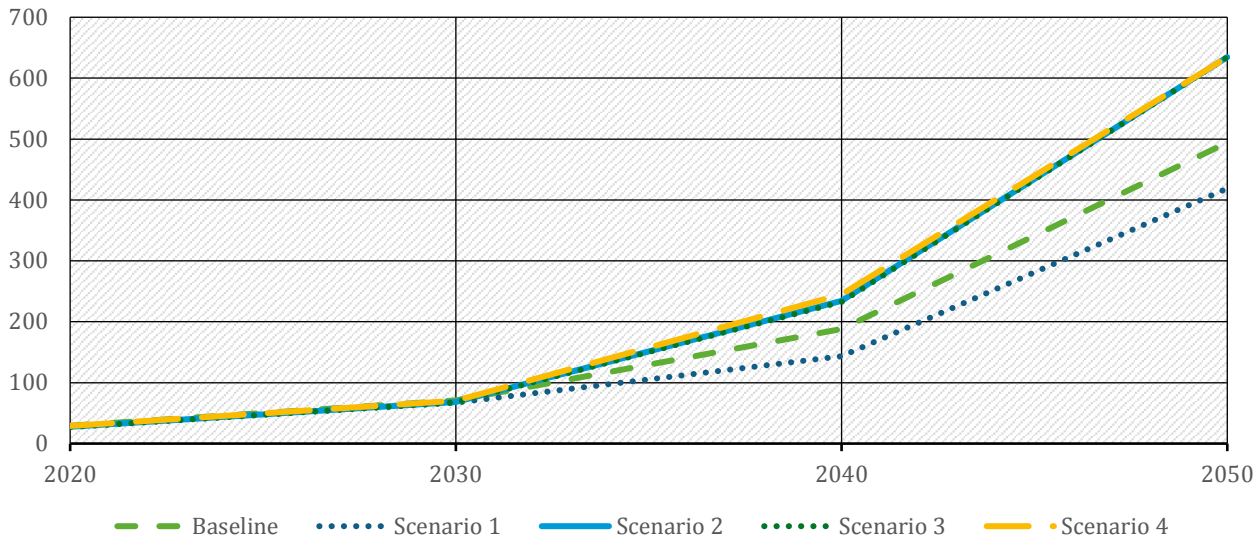


Table 31 to Table 34 present macroeconomic and environmental indicators for the EU between 2020 and 2050. Let us first look at the EU ETS allowance price again. In 2020, we observe a lower price in Scenario 1 compared to the Baseline Scenario. This is due to the non-existence of CO_2 caps in the non-EU regions in Scenario 1, while in the Baseline Scenario, the Copenhagen pledges (until 2020) and constant emissions thereafter effectively restrict emissions. In the case of a CO_2 cap in non-EU regions, worldwide restrictions on emissions levels increase, resulting in higher CO_2 prices also in the EU: Increased reduction efforts in non-EU regions decrease demand for energy generated by fossil fuels and hence reduce energy prices globally. This would tend to induce higher emissions in the EU, thus requiring higher carbon prices to achieve the same reduction. Also, production of carbon-intensive goods outside the EU decreases due to higher production costs as a result of a more restrictive climate policy. This in turn raises production levels in the EU as domestic carbon-intensive goods become less costly relative to imported carbon-intensive goods.

Also, we observe lower CO_2 prices in the EU ETS in Scenario 2 compared to the Baseline Scenario in 2020 and 2030. As outlined previously, the Baseline Scenario assumption of freezing emissions at the 2020 level is more restrictive in 2030 than the Scenario 2 assumption of complying with the NDCs in those countries having intensity targets. Since India and, above all, China, as one of the largest emitters drive global CO_2 emissions to a high extent, EU ETS CO_2 prices are lower.

Scenario 3, on the other hand, assumes free allowances in the energy-intensive sectors in non-EU regions. This increases industry production in non-EU regions (note also that the free allocations are modelled as output-based subsidies here) at the expense of EU industry production. Hence, also the demand for the (auctioned) CO_2 allowances in the EU ETS is lower and consequently the CO_2 prices are lower than in Scenario 2. This effect is stronger in 2020 than in 2030 since a higher share of allowances is freely allocated in non-EU regions.

In Scenario 4 also EU energy-intensive sectors receive free allowances. Hence, conditions for EU and non-EU regions are similar. EU ETS CO_2 prices in Scenario 4 are higher than in Scenario 3, which is due to increased industry production also in the EU since EU ETS sectors now also receive freely allocated allowances (modelled as an output-based subsidy) which in turn raises EU ETS allowance prices. They are also higher than in Scenario 2 since that scenario assumes no free allocation (and thereby no output subsidy) in the EU and in the non-EU regions, so that production is lower in both these regions.

In contrast, by 2050, allowance prices in Scenarios 2, 3 and 4 are equal since no free allowances are provided anymore and hence the conditions in these scenarios are the same.

The hypothetical carbon price in non-ETS sectors which mirrors also marginal abatement costs is higher than the ETS allowance price. This is due to higher abatement costs as these sectors are not as energy-intensive and thus abatement options are more limited.[94]

The impact on EU GDP is moderate until 2040. The most striking observation is the benefit of international action (Scenarios 2, 3 and 4) compared to a rather unilateral policy (Baseline Scenario and Scenario 1). This is due to the fact that non-EU regions comply with their NDCs in the international Scenarios 2, 3 and 4. Unilateral EU action dampens the competitiveness of the EU industry. Hence, if action is taken in non-EU regions, the EU benefits because domestic production of carbon-intensive goods is comparatively higher.

This effect increases, so that by 2050 a tremendous GDP gain in the EU follows from international emissions reduction efforts, compared to a baseline in which non-EU regions keep their emissions at the 2020 level. Once again, the reader should keep in mind the above mentioned limitations of the model (no endogenous technological change, no use of CCS) which are one reason for the very high impacts in 2050.

Due to the large number of results we will focus on 2030 and 2050 in the remainder of this report. Further results are however available on request.

Complete results on macroeconomic and environmental indicators in non-EU regions and the EU aggregate for 2030 and 2050 can be found in Annex 2.

Table 31: Selected macroeconomic and environmental indicators for policy scenarios – EU in 2020

Macroeconomic and environmental ind.	Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4
CO_2 emissions (Gt)	2.960	2.960	2.960	2.960	2.960
ETS	1.380	1.380	1.380	1.380	1.380
CO_2 price ETS (2010 €)	29.4	27.8	27.5	26.9	29.0
CO_2 price non-ETS (2010 €)	47.3	38.5	53.1	52.7	54.2
GDP (% change vs. baseline)	0.0	-0.2	0.1	0.1	0.1
CO_2 emissions (% change vs. baseline)	0.0	0.1	0.0	0.0	0.0
ETS	0.0	0.3	0.0	0.0	0.0

Table 32: Selected macroeconomic and environmental indicators for policy scenarios – EU in 2030

Macroeconomic and environmental ind.	Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4
CO_2 emissions (Gt)	2.365	2.365	2.365	2.365	2.365
ETS	0.975	0.975	0.975	0.974	0.974
CO_2 price ETS (2010 €)	70.9	67.1	68.2	67.9	70.3

[94] Other reasons for higher CO_2 prices in non-ETS sectors might include, for instance, a lower willingness to pay or other habits. These features are, however, not represented in the model, hence within the model analysis the energy and emissions intensity is the main reason for higher prices.

Macroeconomic and environmental ind.	Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4
CO_2 price non-ETS (2010 €)	115.7	95.8	124.3	123.7	127.3
GDP (% change vs. baseline)	0.0	-0.4	0.1	0.0	0.1
CO_2 emissions (% change vs. baseline)	0.0	0.2	-0.1	-0.1	-0.1
ETS	0.0	0.4	-0.2	-0.3	-0.3

Table 33: Selected macroeconomic and environmental indicators for policy scenarios – EU in 2040

Macroeconomic and environmental ind.	Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4
CO_2 emissions (Gt)	1.600	1.600	1.600	1.599	1.600
ETS	0.631	0.631	0.631	0.631	0.631
CO_2 price ETS (2010 €)	188.1	143.4	234.3	232.6	245.1
CO_2 price non-ETS (2010 €)	508.3	458.3	595.0	594.6	604.6
GDP (% change vs. baseline)	0.0	-0.3	0.5	0.5	0.5
CO_2 emissions (% change vs. baseline)	0.0	0.2	-0.4	-0.4	-0.4
ETS	0.0	0.5	-0.9	-0.9	-0.9

Table 34: Selected macroeconomic and environmental indicators for policy scenarios – EU in 2050

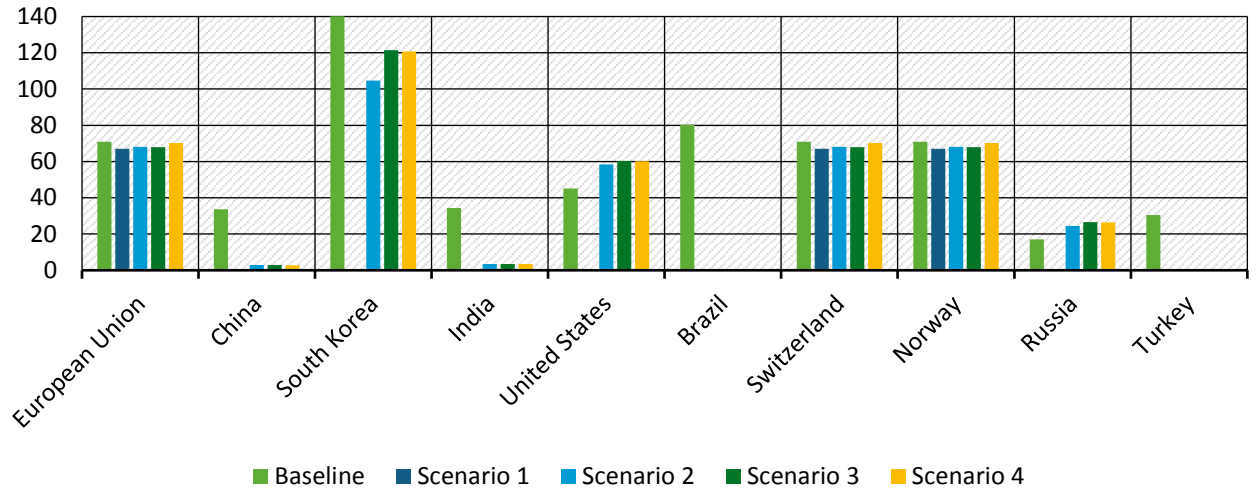
Macroeconomic and environmental ind.	Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4
CO_2 emissions (Gt)	0.889	0.889	0.889	0.889	0.889
ETS	0.346	0.346	0.346	0.346	0.346
CO_2 price ETS (2010 €)	494.3	418.8	634.5	634.5	634.5
CO_2 price non-ETS (2010 €)	1802.6	1707.7	2049.3	2049.3	2049.3
GDP (% change vs. baseline)	0.0	-0.2	1.2	1.2	1.2
CO_2 emissions (% change vs. baseline)	0.0	0.4	-1.1	-1.1	-1.1
ETS	0.0	1.1	-2.7	-2.7	-2.7

Turning to the impacts on macroeconomic and environmental indicators in the trading partner regions, we depict the 2030 and 2050 results in Figure 42 to Figure 47 which also include the EU for reasons of comparability.

As presented in Figure 42 and Figure 43 for 2030 and 2050, respectively, we observe very diverse CO_2 prices among countries, suggesting a rather different restrictiveness of their respective NDCs (and also different degrees of impact by the assumption of constant emissions in the Baseline Scenario). In Scenarios 2, 3 and 4, which assume a split in ETS and non-ETS sectors, we present only the ETS prices. However, we see a similar pattern as in the EU, i.e. higher prices in the non-ETS sectors. Note that we assume full integration of Norway and Switzerland into the EU ETS, hence allowance prices are the same as in the EU in these countries and the explanations given for the EU ETS allowance price hold. In

2030 (cf. Figure 42), in South Korea, the United States and Russia CO_2 prices behave as expected. CO_2 prices are higher in Scenario 3 compared to Scenario 2 due to the existence of free allowances in several sectors. These free allowances are modelled as an output-based subsidy as explained above. In Scenario 4 CO_2 prices decline compared to Scenario 3. As the same sectors receive free allowances also in the EU, the sectors lose competitiveness in non-EU regions. Hence, their production level declines and so does the CO_2 price. The same pattern holds also for China and India. However, low CO_2 prices suggest that the NDCs in these countries are relatively unambitious.[95] Hence, differences between Scenarios 2, 3 and 4 are hardly visible in Figure 42. In Brazil and Turkey, the CO_2 price in the ETS sector is zero since in the model the NDCs in those countries are not binding with respect to these sectors.[96] In 2050 (cf. Figure 43), no differences between Scenarios 2, 3 and 4 can be observed since we assume that no free allowances are provided by that year. Hence, in these scenarios all other assumptions are equal. Moreover, the NDCs of India, Brazil and Turkey are now much more ambitious resulting in high ETS CO_2 prices (in some cases even higher than in the EU).

Figure 42: CO_2 prices (2010 €) in the model regions in 2030. (For Scenarios 2, 3 and 4 the ETS segment is shown.)

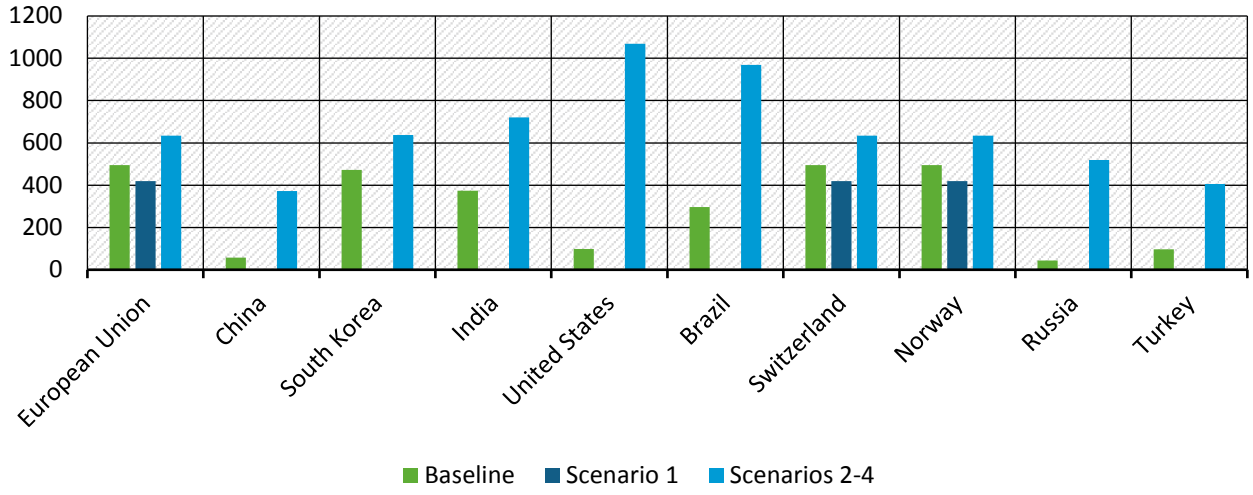


Note: In order to ensure a better visibility, only CO_2 price values up to 140 € are shown. In South Korea, the CO_2 price in the Baseline Scenario is 268.5 €.

[95] One reason for unambitious NDCs at least in the model analysis could be the assumptions for economic growth. As, for example, China's NDC is a reduction target vis-à-vis the carbon intensity level, and the GDP growth rates in this analysis are on average 11 % p.a. for 2005 to 2010, 6.5 % p.a. for 2010 to 2020 and 4.9 % p.a. for 2020 to 2030, this leads also to high emissions growth and a low emission reduction in the year 2030 compared to 1990 in absolute terms as well as low CO2 prices (2.8 Euro in the EU-ETS) in the year 2030.

[96] Note however that particularly in Brazil many abatement activities, such as afforestation or reduced deforestation are not covered in the model. Hence, this statement can explicitly only be made for the industrial sectors covered by the ETS.

Figure 43: CO_2 prices (2010 €) in the model regions in 2050. (For Scenarios 2-4 the ETS segment is shown.)



As a matter of course, in order to assess how restrictive the NDCs are, several criteria need to be taken into account. One of them are the CO_2 prices which have been analysed above. Other criteria include effects on GDP and sectoral production which will be examined in the following. The impacts of the different scenarios on GDP are presented in Figure 44 and Figure 45 for both years.

As outlined previously, the EU loses in the strictly unilateral Scenario 1 compared to the baseline due to a lower competitiveness relative to the rest of the world. In the multilateral scenarios, the EU shows slight gains compared to Scenario 1 and even to the Baseline Scenario. In Scenario 3 the EU GDP decreases compared to Scenario 2, as some sectors – those that receive free allowances in non-EU regions – lose competitiveness. They gain competitiveness in Scenario 4 when the same sectors receive free allowances also in the EU, resulting in an increasing GDP compared to Scenario 3.[97]

Turning to the non-EU regions, the majority of them is clearly better off in Scenario 1 compared to the other scenarios. This could be expected as they transfer from a no-policy scenario to more restrictive emissions reduction scenarios. However, China, India, Switzerland and Turkey benefit from the introduction of reduction targets. In 2030, but particularly in 2050, we observe in these non-EU regions that their losses are higher or their gains are lower, in the strictly unilateral Scenario 1 compared to the other scenarios. This is due to a high amount of exports from these countries to the EU so that they are worse off when only the EU implements a restrictive GHG reduction target and benefit from the implementation of such targets. A further reason could be a relatively low ambition in their NDCs attracting production from other non-EU regions in Scenarios 2 to 4 (as shown at least for China in Section 6.3.2). Most non-EU regions show an increasing GDP in Scenario 3 compared to Scenario 2 and a declining GDP in Scenario 4 compared to Scenario 3. As outlined, some sectors receive free allowances in Scenario 3 which raises their competitiveness and hence their production. This effect vanishes in Scenario 4 when also the same EU sectors receive free allowances. In China, however, we observe a slight GDP decline in Scenario 3 compared to Scenario 2. In this case, the positive influence of the free allowances on China's GDP is smaller than the negative influence of decreasing exports to the EU. The EU demands less intermediate products as its production is declining due to a lower competitiveness which may result in decreasing imports from non-EU regions. In China this effect dominates the positive effect from receiving free allowances.

[97] Note that although Norway and Switzerland are part of the EU ETS by assumption, in the policy scenarios we do assume CO2 reduction targets and the receipt of free allowances according to non-EU regions. Hence, the behaviour of GDP is different as explanations for non-EU regions apply.

One striking observation is the large GDP gain in Scenario 1 in Norway and Russia. As outlined previously, global energy prices are higher in Scenario 1 due to a higher demand relative to the other policy scenarios. Since Norway and Russia have abundant fossil fuel resources, they benefit from a no-policy scenario in non-EU regions (in comparison to the Baseline Scenario which includes reduction targets of non-EU regions). In contrast, in Scenarios 2 to 4 they are among the countries with highest GDP losses in 2030 because they suffer, from negative trade impacts.

The results for 2050 (cf. Figure 45) confirm the findings for 2030 in qualitative terms. However, we also observe GDP increases in South Korea, in addition to China, India, Switzerland and Turkey, in Scenarios 2, 3 and 4 compared to Scenario 1. Again, this is due to exports from those countries to the EU. Note again that by assumption Scenarios 2, 3 and 4 do not differ in 2050, hence the results are equal.

Figure 44: Percentage changes in GDP vs. baseline in the model regions in 2030

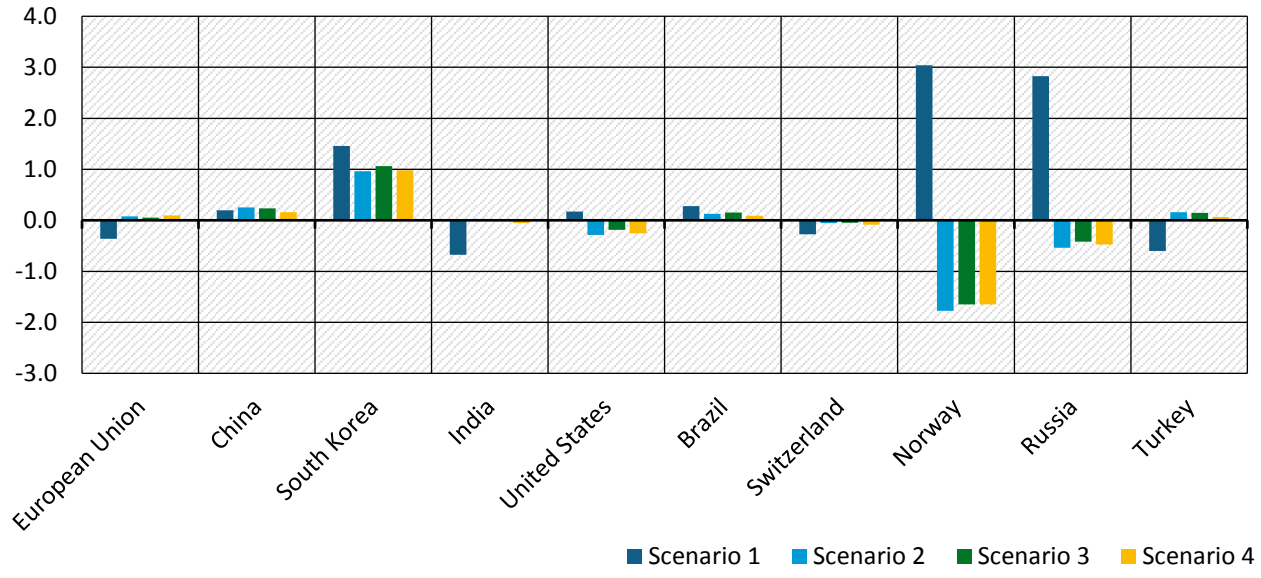


Figure 45: Percentage changes in GDP vs. baseline in the model regions in 2050

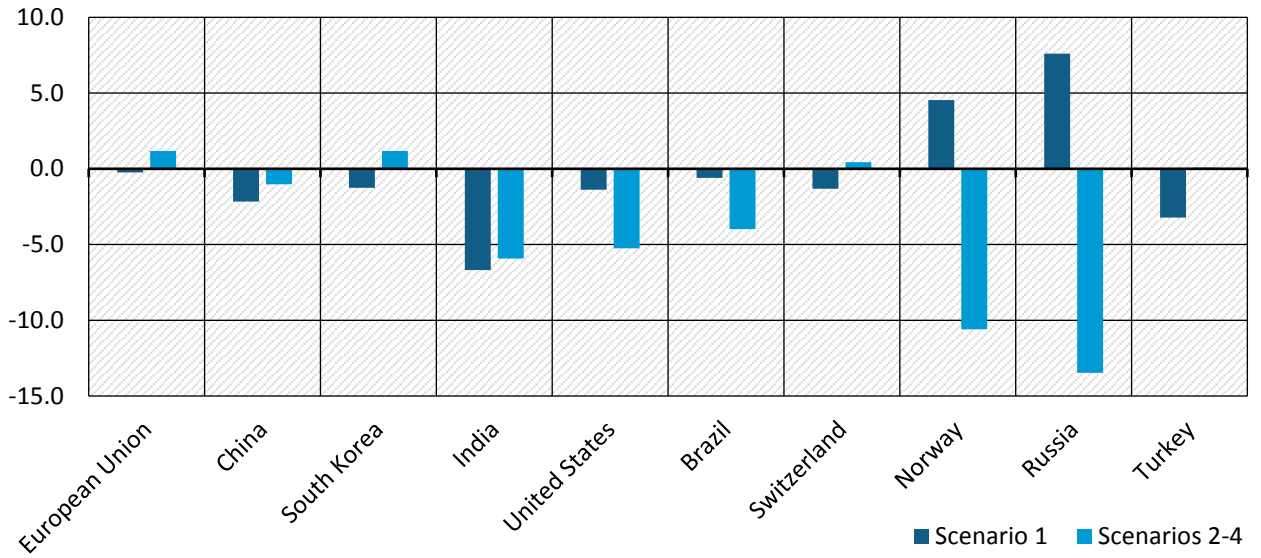


Table 35: CO_2 emission in Gt for model regions

	EU	China	South Korea	India	United States	Brazil	Switz-erland	Nor-way	Russia	Turkey
2020										
Scenario 1	2.960	9.808	0.703	2.493	5.517	0.522	0.040	0.050	2.018	0.324
Scenarios 2-4	2.960	7.875	0.356	2.200	4.475	0.471	0.032	0.041	2.029	0.305
2030										
Scenario 1	2.365	11.954	0.769	3.375	5.828	0.604	0.040	0.050	2.313	0.344
Scenarios 2-4	2.365	11.601	0.423	3.267	3.660	0.632	0.026	0.035	1.816	0.379
2040										
Scenario 1	1.600	13.018	0.868	4.495	6.308	0.738	0.039	0.049	2.448	0.369
Scenarios 2-4	1.600	6.943	0.339	1.933	2.323	0.425	0.018	0.025	1.143	0.279
2050										
Scenario 1	0.889	13.411	1.023	5.995	6.973	0.938	0.037	0.046	2.519	0.405
Scenarios 2-4	0.889	2.285	0.256	0.600	0.986	0.195	0.010	0.015	0.470	0.145

Figure 46: Percentage changes in CO_2 emissions vs. baseline in the model regions in 2030

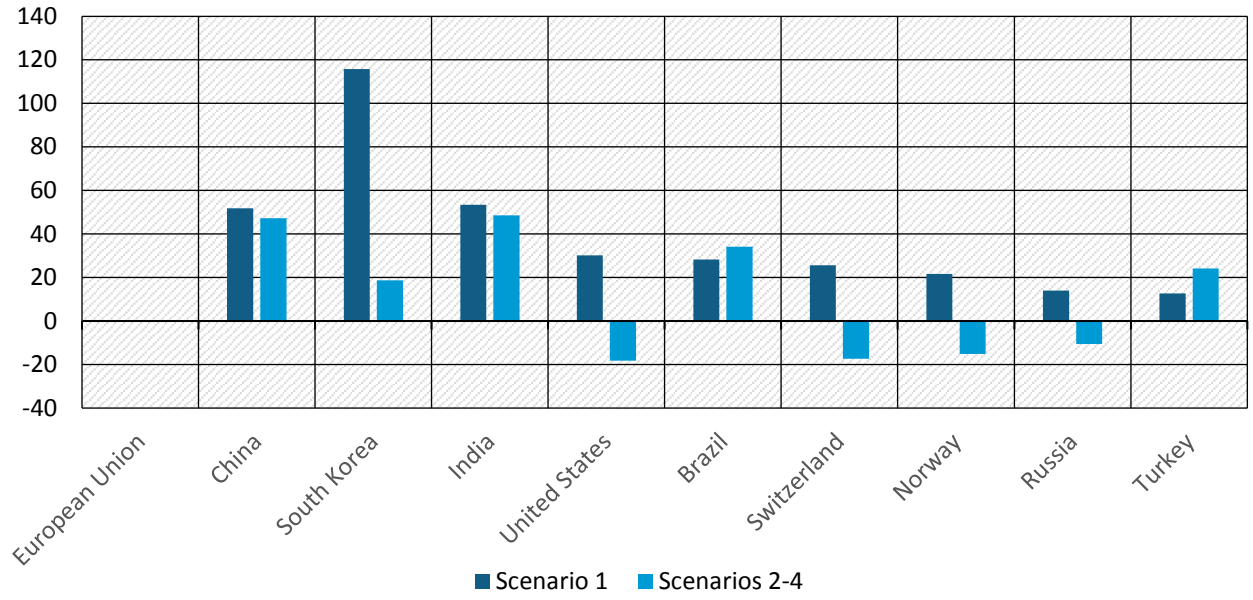
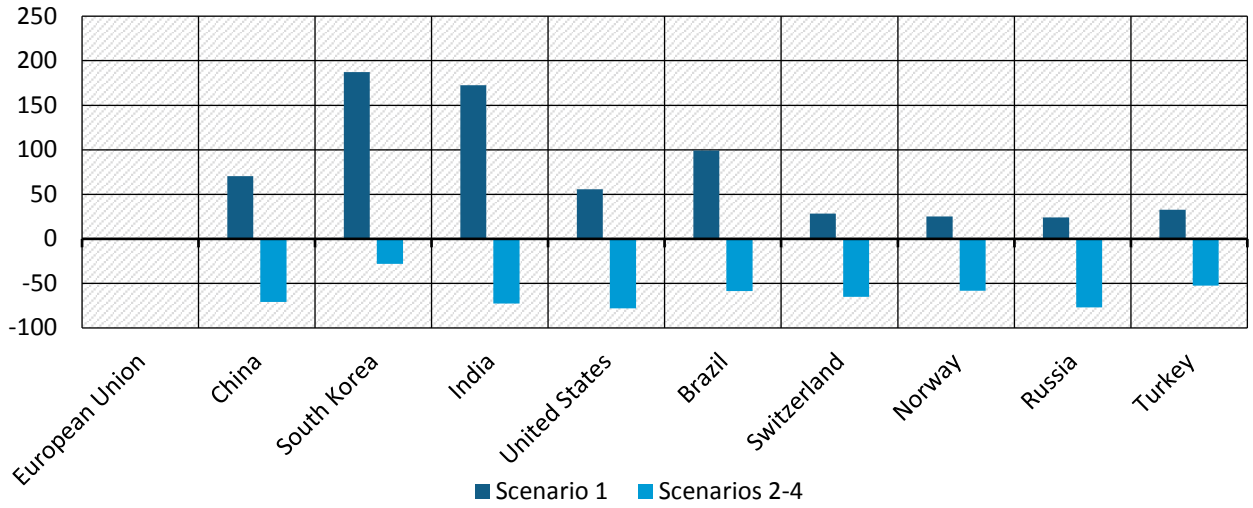


Figure 47: Percentage changes in CO_2 emissions vs. baseline in the model regions in 2050



One dimension of carbon leakage is the amount of GHG emissions in scenarios assuming international action compared to scenarios assuming unilateral action. Table 35 presents the absolute emissions levels in the trading partner regions in 2020, 2030, 2040 and 2050. Note that by assumption the development of CO_2 emissions is the same in Scenarios 2, 3 and 4. As outlined previously, countries with intensity targets have higher emissions levels until 2030 when they comply with their NDCs (Scenarios 2, 3 and 4) in contrast to freezing their emissions levels at the Copenhagen Pledge level (Baseline Scenario). This applies to China, South Korea, India, Brazil and Turkey.

2030 CO_2 emissions of non-EU regions compared to the Baseline Scenario, as presented in Figure 46, more or less reflect their respective CO_2 prices. Figure 47 depicts the same indicator in 2050. The findings are in line in qualitative terms with those for 2030. The increase of CO_2 emissions in Scenario 1 (no climate policies outside the EU) compared to the Baseline Scenario can be interpreted as carbon leakage. The assumption of binding NDCs in non-EU regions leads to decreasing CO_2 emissions in Scenarios 2 to 4 compared to Scenario 1. This can be interpreted as a reduction of carbon leakage. Since the NDC of Brazil as implemented in this model is in effect non-binding in 2030, in this year emissions in Scenarios 2 to 4 are higher than in Scenario 1.

In summary, as outlined previously, it is important to note that the assessment of the ambition level of the NDCs depends on the examination of various – rather than only one – economic and environmental indicators. In this subsection, we analysed the impact on CO_2 prices, emissions levels and GDP. Further below, we will also examine impacts on sectoral production in order to assess the ambition level.

6.6.3.2 Sectoral production

A second, more significant, dimension of carbon leakage (next to changes in CO_2-emissions) is related to relocation of sectoral production. Figure 48 shows changes in sectoral output compared to the baseline scenario in 2030 for all ETS sectors in the EU. Many sectors are better off in a policy scenario involving international action (Scenarios 2-4), in particular compared to Scenario 1 where non-EU regions do not implement any climate policy. This suggests the existence of carbon leakage (international shift also of emissions) in a scenario of unilateral climate policy by the EU. Several sectors such as organic chemicals and other non-ferrous metals, on the other hand, lose in all scenarios compared to the Baseline Scenario. This is due to a decreasing demand from non-EU regions resulting from more restrictive policies. This effect outbalances the positive competitiveness effects in the case of these sectors. In addition, the reader should once again keep in mind that freezing emissions at their 2020 level (as in the Baseline Scenario) is in many regions more restrictive than complying with their

NDCs (as in Scenarios 2, 3 and 4). Hence, in 2030 in Scenarios 2, 3 and 4 these sectors lose in the EU compared to the baseline as these scenarios are closer to a unilateral case than the Baseline Scenario. Two sectors, namely aluminium and crude oil even lose in most international scenarios compared to the purely unilateral Scenario 1. These sectors are particularly dependent on exports to non-EU regions and the effect of declining exports clearly dominates the effect of increased competitiveness in the case of the multilateral scenarios.

Turning to the differences between Scenarios 2, 3 and 4, the expected result is that sectors receiving free allowances in non-EU regions in Scenario 3 lose competitiveness in the EU and hence EU production levels decrease compared to Scenario 2. In Scenario 4, these sectors also receive free allowances in the EU. Therefore, we expect them to increase their production levels compared to Scenario 3. The production levels in Scenario 4 are also higher than the ones in Scenario 2 because (as explained before) the free allocation is modelled as an output-based subsidy.

Except for crude oil, these differences in production levels apply to all sectors on the carbon leakage list (which receive free allowances). The EU exports more crude oil in Scenario 3 as a higher amount is demanded as an intermediate product by sectors outside the EU. Therefore it increases its production level of crude oil compared to Scenario 2 and in contrast to the other sectors on the carbon leakage list. In Scenario 4 it increases production even more since it receives free allowances itself.

Note that some sectors with a different behaviour than expected, namely other chemicals, rubber, plastics and other non-metallic minerals are not in the EU ETS (in our model assumptions) and hence they do not receive free allowances.[98] These sectors do not suffer directly from a loss in competitiveness in Scenario 3. Moreover, they are able to increase exports to non-EU sectors receiving free allowances which results in higher production levels. This also applies to electricity; the sector is able to increase exports to non-EU regions (mainly in Europe).

Figure 49 shows sectoral impacts in 2050. In qualitative terms, these results show similar effects as in 2030 for Scenario 1. However, in Scenarios 2, 3 and 4 almost each sector gains since reduction levels in non-EU regions are now very restrictive and the EU sectors benefit from that. Nonetheless, crude oil and electricity exhibit tremendous production losses in Scenarios 2, 3 and 4. In the case of crude oil, restrictive emissions reductions all over the world induce an enormous decline in demand for fossil fuels including crude oil causing losses in production of those sectors. This also has a direct effect on electricity production all over the world. Moreover, since non-EU regions exhibit tremendous production losses in almost each sector, as will be presented below, demand for electricity imports from the EU decrease to a high extent.[99] As no free allocation is provided in 2050, results for Scenarios 2, 3 and 4 are equal.

[98] As mentioned previously, the sectoral resolution of the model is still too broad to represent the complete sectoral coverage of the EU ETS.

[99] Note again the limitations of the model. Neither endogenous technological change nor CCS is included which leads to an overestimation of the quantitative impacts. In qualitative terms, however, these results remain valid.

Figure 48: Selected results of changes in sectoral output (% change vs. baseline) – EU in 2030

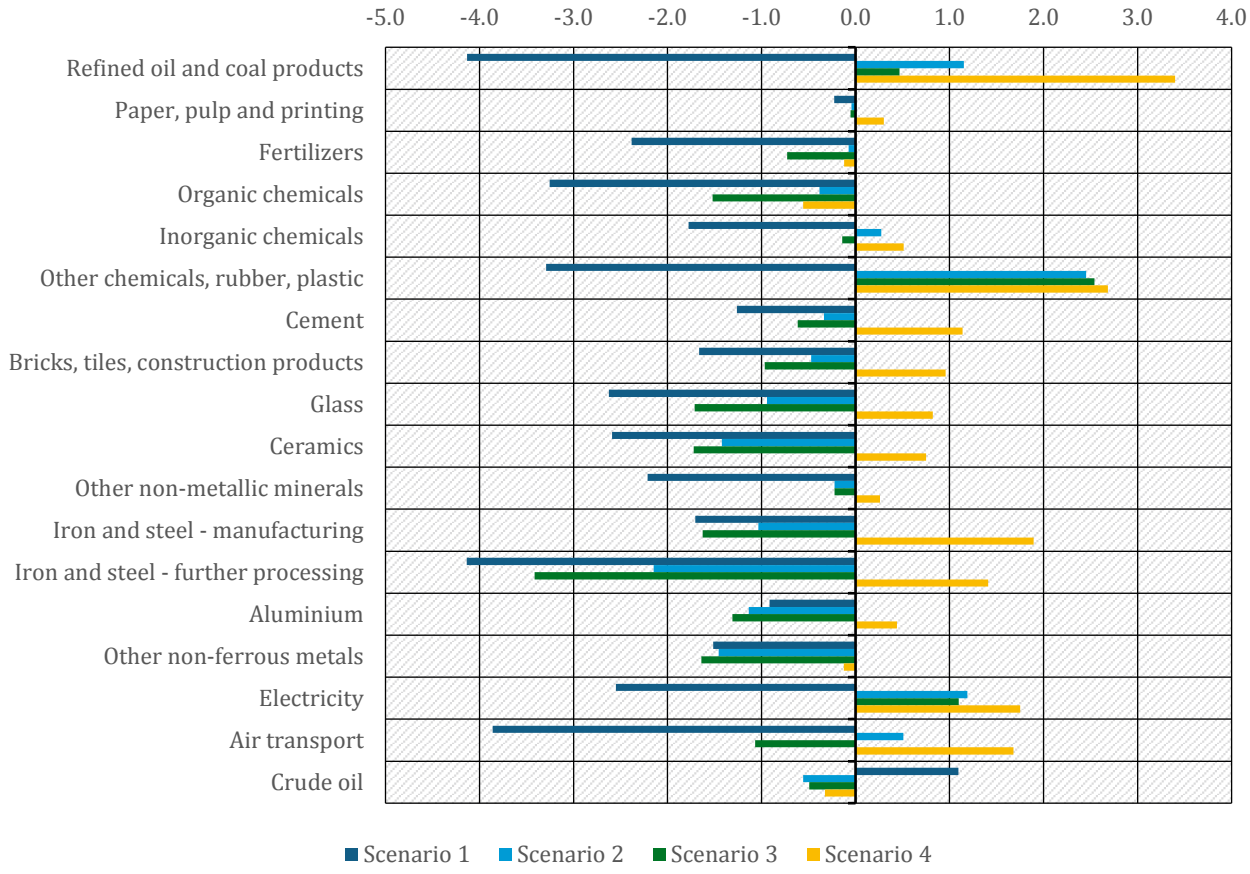


Figure 49: Selected results of changes in sectoral output (% change vs. baseline) – EU in 2050

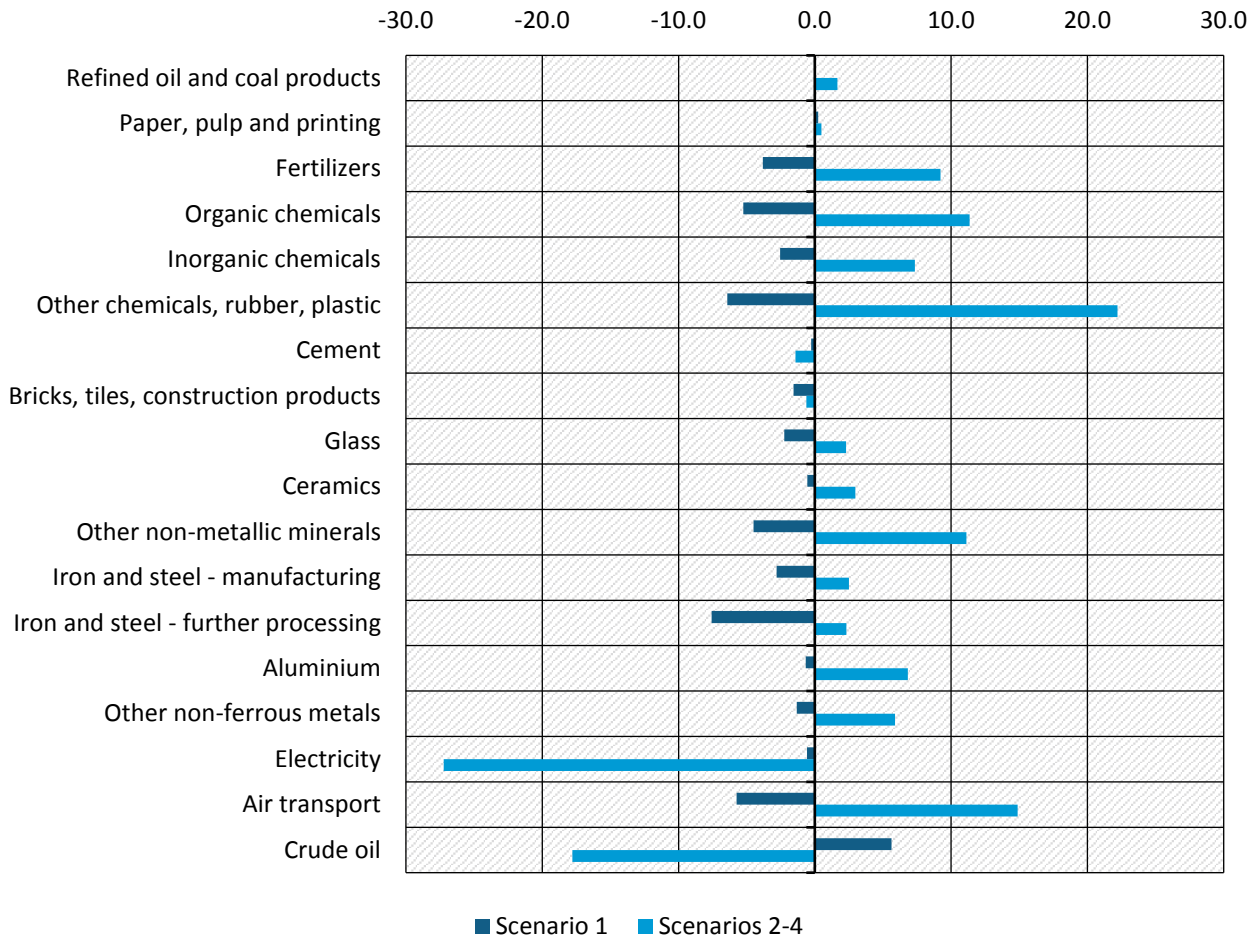


Figure 50 and Figure 51 present sectoral output changes in 2030 for the United States and China, respectively. A complete overview is given in to Table 60 in Appendix B. In the United States, in the unilateral Scenario 1 almost all sectors gain which is another hint for the existence of carbon leakage. However, in most sectors this gain is rather moderate apart from very energy-intensive sectors (electricity, refineries, aluminium). In the scenarios involving international action (Scenarios 2 to 4) the impression of very diverse ambition levels of the NDCs is confirmed. China benefits in many sectors. It may gain from rising production costs of many carbon-intensive products relative to their own production costs. Hence, this increases China's own competitiveness. In Scenarios 3 and 4, as in the EU, most sectors that receive free allowances benefit from that in the United States (compared to Scenario 2). However, when also EU sectors receive free allowances (Scenario 4), this effect is smaller in many sectors. This is due to rising competitiveness of EU sectors.

Nonetheless, in the United States crude oil shows a somewhat different behaviour. Production levels increase slightly in Scenario 3 compared to Scenario 2 and increases slightly in Scenario 4 compared to Scenario 3. As in the EU, the effect of declining exports (mainly to the EU and countries that are not listed here) clearly dominates the effect of increased competitiveness due to the receipt of free allowances.

China exhibits different results. Many sectors even gain from a more restrictive climate policy in Scenarios 2, 3 and 4. This is due to relatively mild emissions reduction targets compared to other countries such as the United States. Hence, many sectors in China are able to attract more production. With respect to differences among Scenarios 2, 3 and 4, only a few sectors, namely paper, pulp and printing, cement, bricks, tiles and construction products and crude oil show the expected behavior, i.e.

increasing production in Scenario 3 compared to Scenario 2 and decreasing production in Scenario 4 compared to Scenario 3. The other sectors receiving free allowances – refined oil, fertilizers, organic chemicals, inorganic chemicals, glass, ceramics, iron and steel manufacturing and aluminium – exhibit decreasing production levels in Scenario 3 compared to Scenario 2, albeit to a small extent. As in the case of China's GDP development which is caused also by sectoral production, these sectors suffer from declining exports to the EU. EU sectors demand less intermediate products from their non-EU counterparts as their production is declining due to a lower competitiveness which may result in decreasing imports from non-EU regions. In the respective Chinese sectors this effect outbalances positive impacts from receiving free allowances. Moreover, the extent of the positive impacts on the Chinese electricity sector is striking. It serves as an intermediate input to many sectors and hence results from the production increase in almost each sector.

Sectoral impacts in the United States and China for 2050 are as expected and in line with the findings for 2030 for the United States in qualitative terms, meaning that sectoral production for all sectors is higher in Scenario 1 than in the Baseline Scenario and lower in Scenarios 2 to 4. Nevertheless, in many sectors we calculate substantial losses in quantitative terms. Full results for all countries and scenarios can be found in Table 61 to Table 64 in Appendix B.

Figure 50: Selected results of changes in sectoral output (% change vs. baseline) – USA in 2030

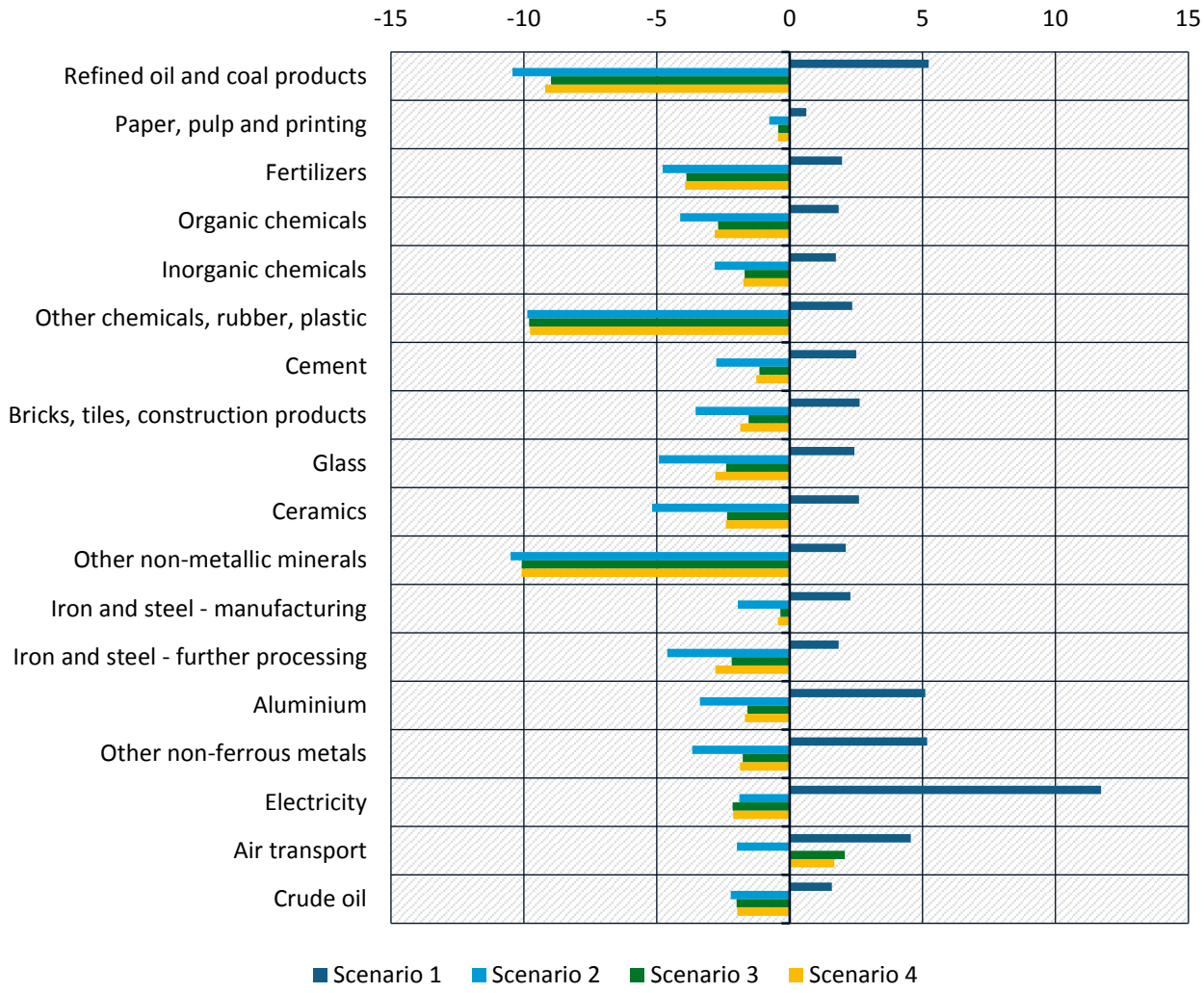
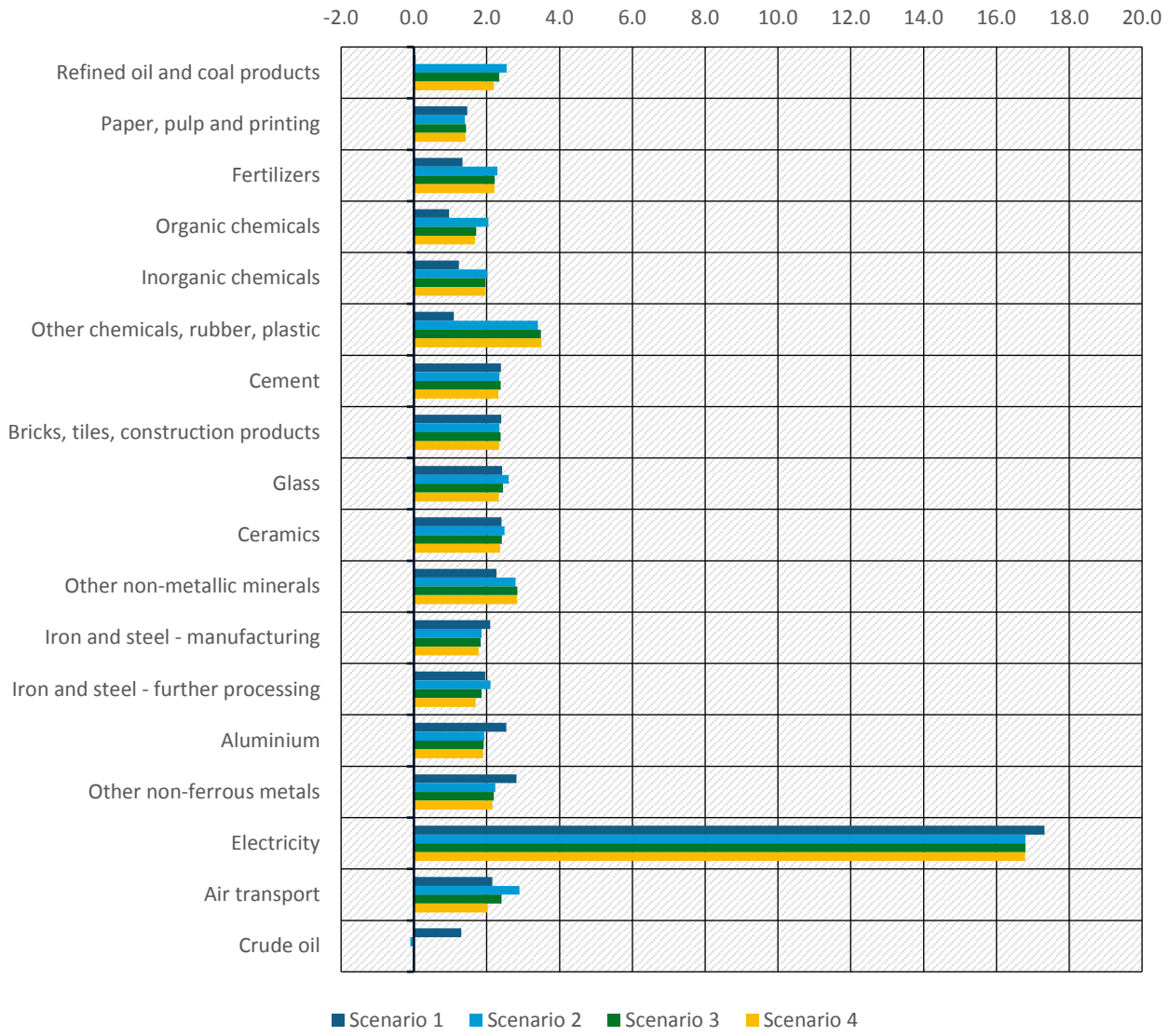


Figure 51: Selected results of changes in sectoral output (% change vs. baseline) – China in 2030



6.6.3.3 Energy carrier prices

Figure 52 and Figure 53 present energy carrier price for the baseline and the policy scenarios in 2030 and 2050, respectively, as a weighted average of the EU model regions.[100] Not surprisingly, in 2030 they are highest in the purely unilateral Scenario 1. In Scenarios 2, 3 and 4 which assume compliance with the NDCs in non-EU regions, energy carrier prices are lower than in the other scenarios. Due to more restrictive climate policies, demand for energy (in particular for fossil fuels) declines. In 2050 the results are more diverse. Whereas electricity becomes more expensive once international action is taken, the other energy carriers react similarly as in 2030. The increase of electricity prices between the less restrictive Baseline Scenario and the unilateral Scenario 1, on the one hand, and the international Scenarios 2, 3 and 4, on the other hand, is based on substitution effects between fossil fuels and electricity (relying to a high extent on renewable sources), for instance through the electrification of the transport sector, resulting in a higher demand for electricity.

[100] As outlined previously, assumptions for Scenarios 2, 3 and 4 are the same in 2050. Therefore, the results of these scenarios are shown in aggregate manner for 2050.

Figure 54 and Figure 55 present energy carrier prices in 2030 in the United States and in China, respectively. The patterns are different in both countries. Fossil fuel prices (not electricity) in the United States behave in a similar way as in the EU. In China, however, electricity prices are higher in the Baseline Scenario (where 2020 emissions levels are frozen) than in all other scenarios. The coal price behaves contrarily: here, the price in the Baseline Scenario is lower than in all other scenarios. In 2050, as presented in Figure 56 and Figure 57 for the United States and China, respectively, electricity prices are higher in the scenarios involving international action (Scenarios 2 - 4) for similar reasons as in the EU.

Figure 52: Energy carrier prices in the EU in 2030 (weighted average)

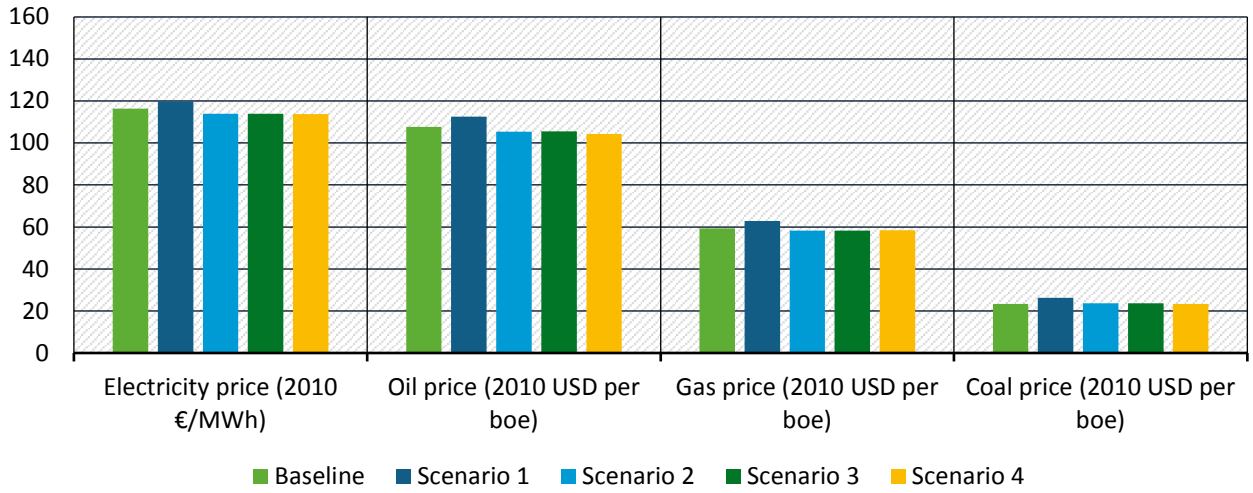


Figure 53: Energy carrier prices in the EU in 2050 (weighted average)

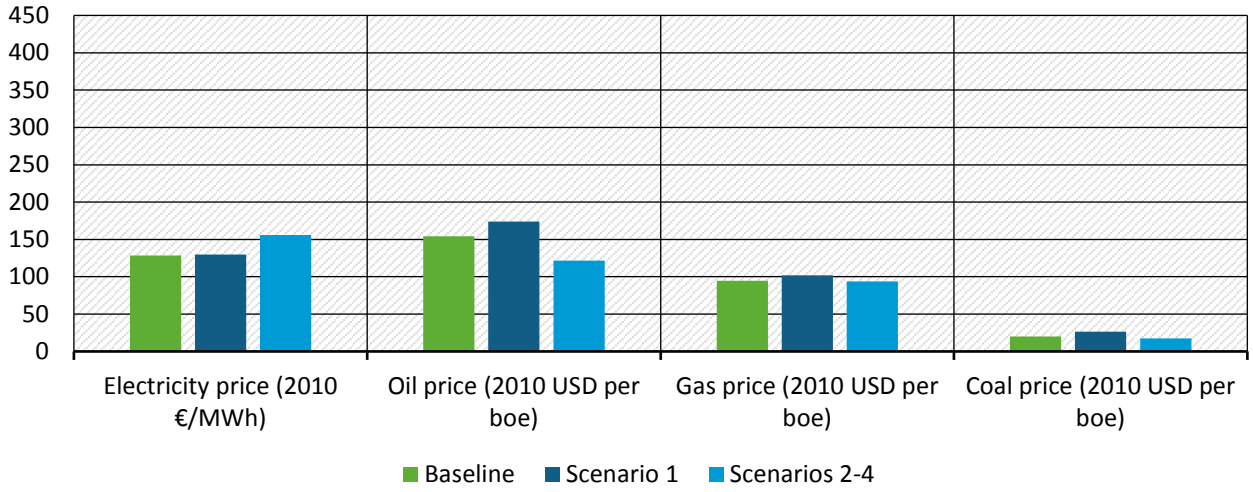


Figure 54: Energy carrier prices in the United States in 2030

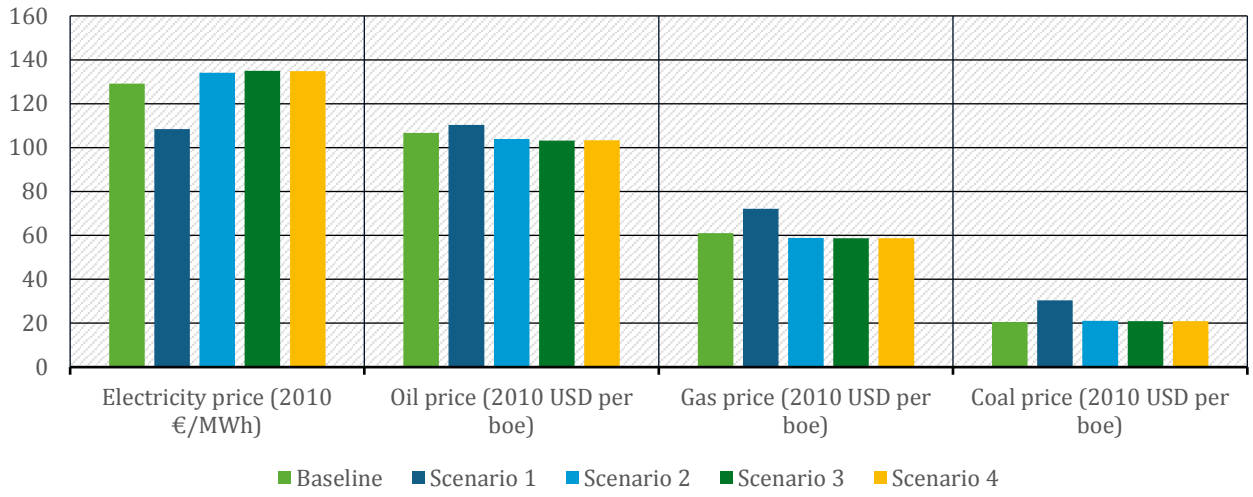


Figure 55: Energy carrier prices in China in 2030

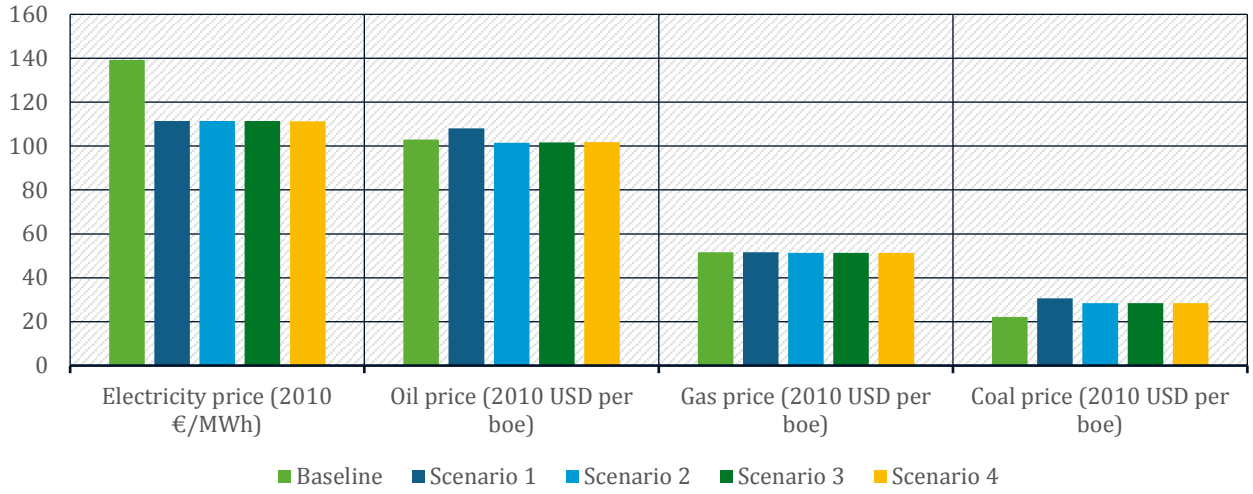


Figure 56: Energy carrier prices in the United States in 2050

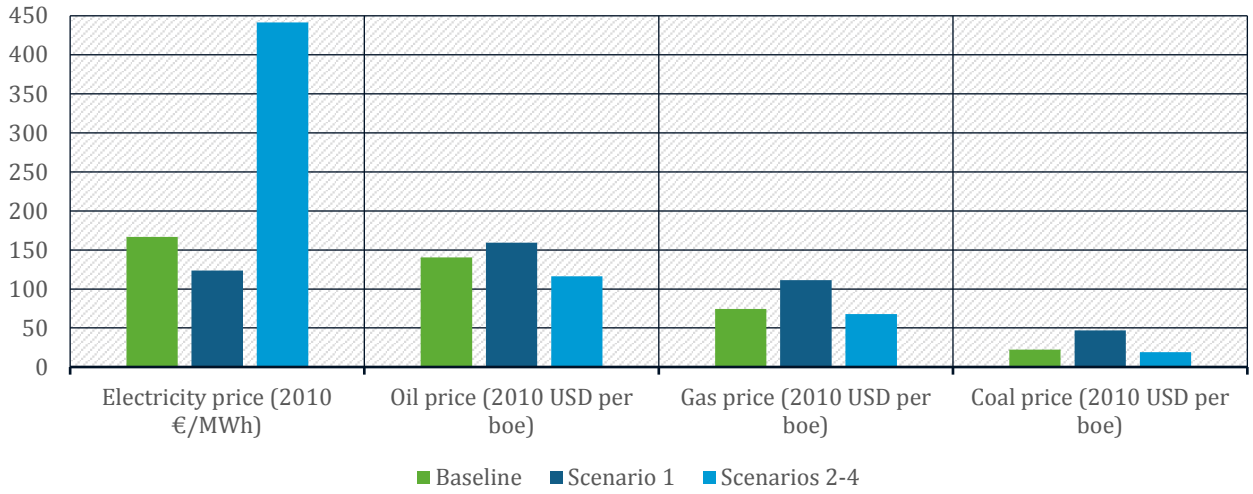
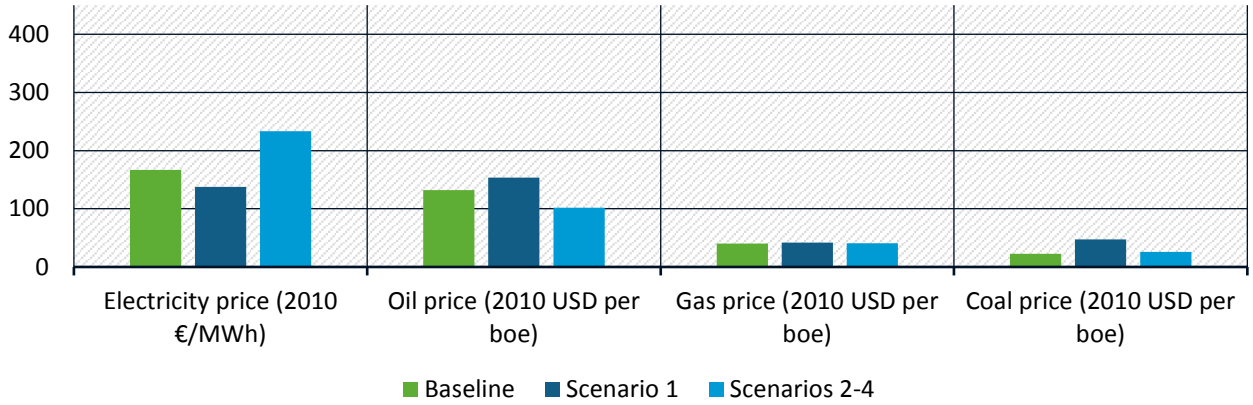


Figure 57: Energy carrier prices in China in 2050



6.6.3.4 Impacts within the EU

Although the focus of this report is the carbon leakage risk of the EU aggregate, some findings of impacts in EU member states are interesting. This subsection will shed light on this issue. Figure shows GDP changes compared to the Baseline Scenario for all EU model regions in 2030. Almost all regions exhibit the same pattern when international action is implemented, i.e. they benefit in Scenarios 2, 3 and 4 in comparison to unilateral action in Scenario 1. Poland shows the largest gains compared to the Baseline Scenario. All EU countries show slightly less positive effects in Scenario 3 than in Scenario 2 (or, in the case of Germany and "Rest of Central and Eastern Member States", even negative compared to the Baseline Scenario) if non-EU energy-intensive sectors receive free allowances. Most EU countries – especially Germany, Poland and the UK – gain, if their energy-intensive sectors also receive free allowances (Scenario 4 compared to Scenario 3, but also compared to Scenario 2, i.e. the situation without free allocation at all). Figure 59 presents the same impacts for 2050. Besides larger GDP losses due to higher reduction targets, the results are qualitatively in line with those of 2030 with one exception. France actually is better off if non-EU countries have lax climate policies (Scenario 1) and worse than the baseline under all other policy scenarios. The country thus seems to be able to export goods to non-EU regions, mainly electricity which is based to a high degree on nuclear power and goods produced using electricity based on nuclear generation.

Figure 58: Percentage changes in GDP vs. baseline in EU regions in 2030

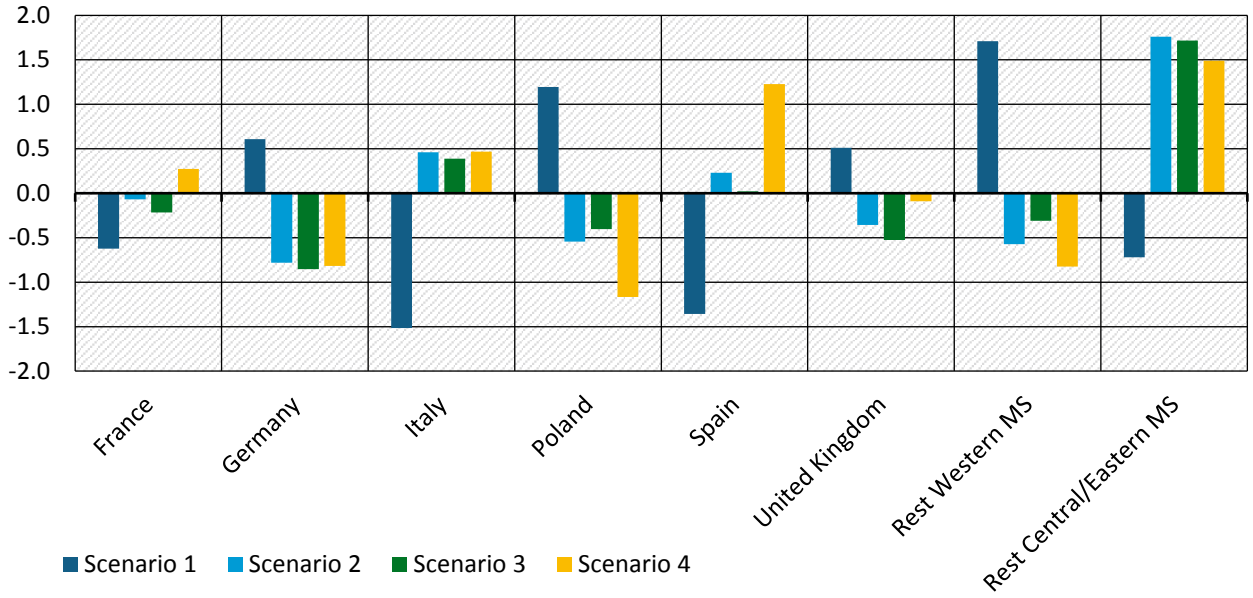


Figure 59: Percentage changes in GDP vs. baseline in EU regions in 2050

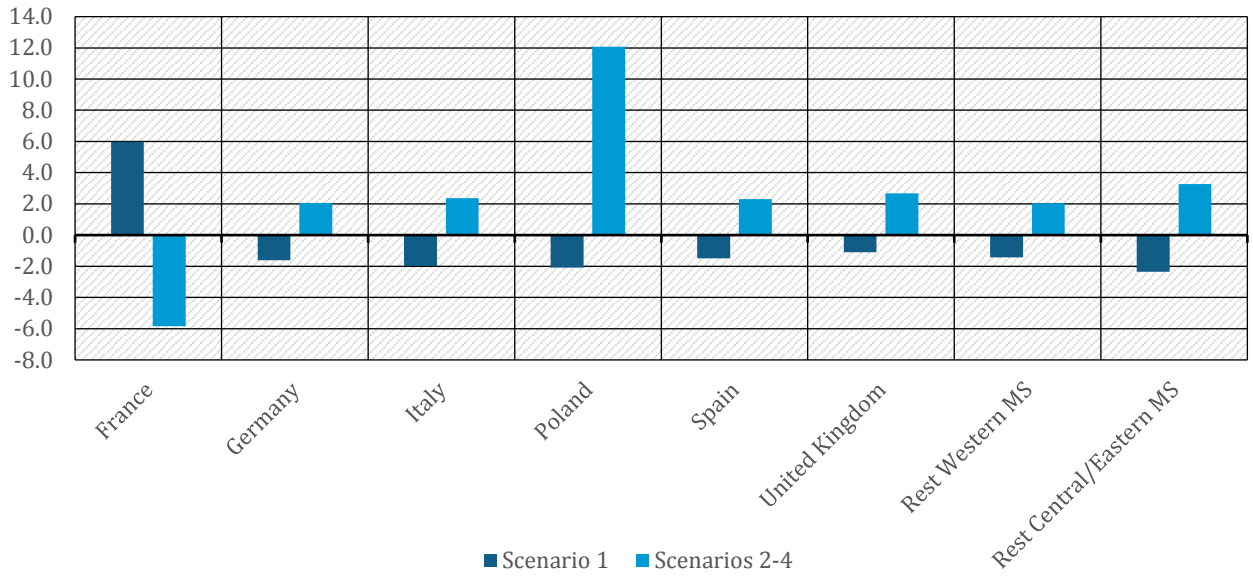


Figure 60 shows absolute emissions levels in the EU model regions in 2030 and Figure 61 depicts CO_2 emissions compared to the Baseline Scenario in 2030. In many regions the differences between international and unilateral action are quite pronounced. However, since we impose the same CO_2 cap for the EU in all scenarios, this is merely an intra-EU shift of emissions from countries with higher abatement costs to those with lower abatement costs. Countries with decreasing emission levels compared to the Baseline Scenario also exhibit rising shares of renewable energy sources. Results on emission levels in absolute and relative terms for 2050 are depicted in Figure 62 and Figure 63, respectively.

Figure 60: CO_2 emissions levels in Gt in EU regions in 2030

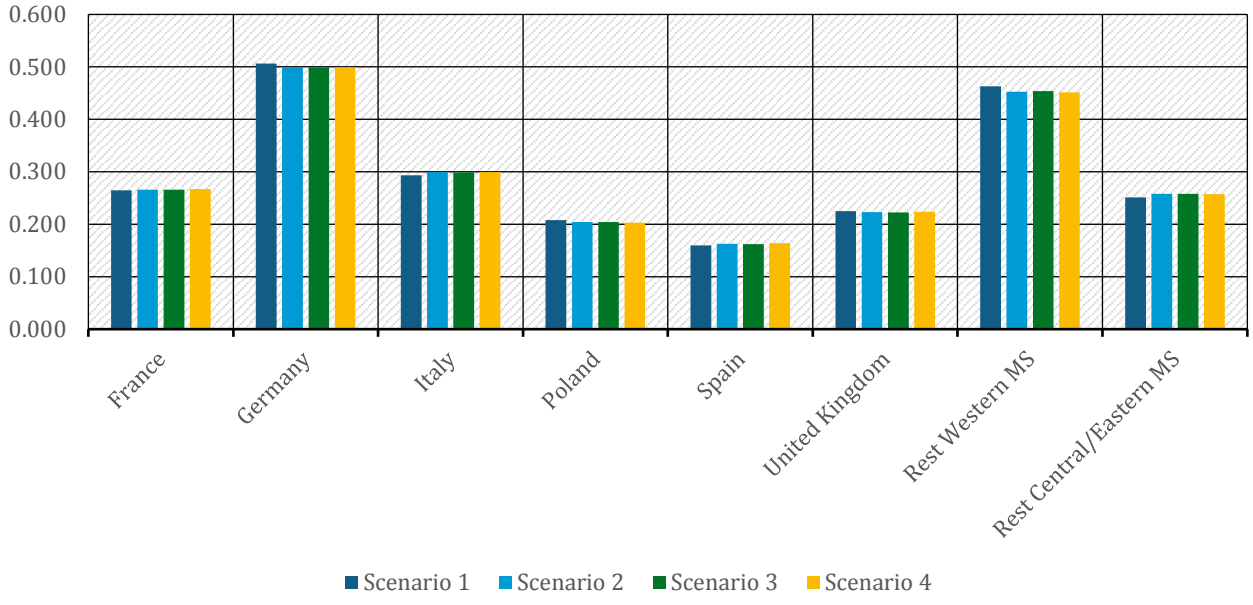


Figure 61: Percentage changes in CO_2 emissions vs. baseline in EU regions in 2030

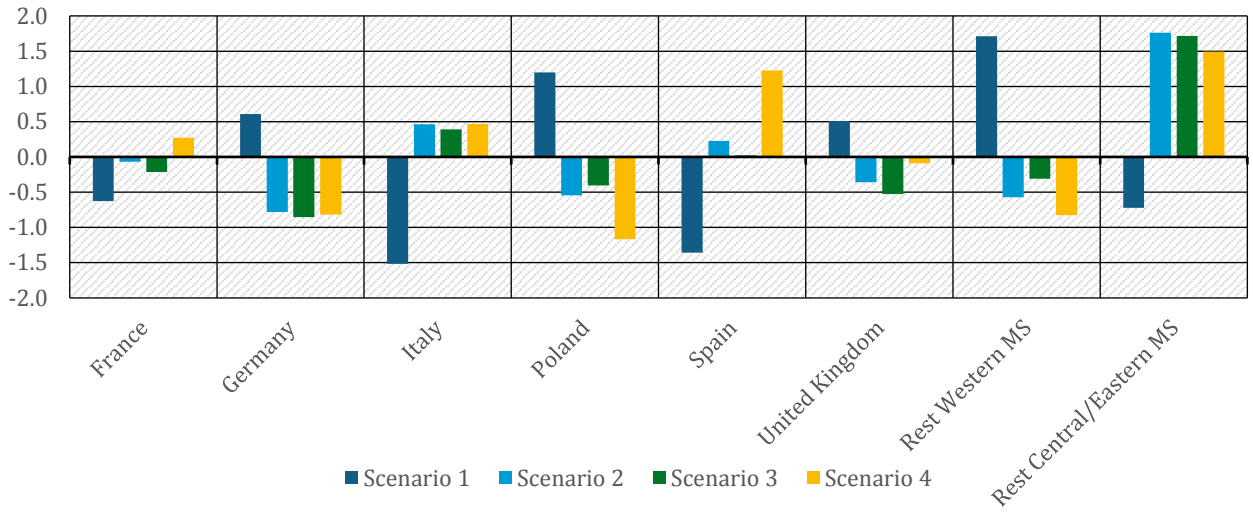


Figure 62: CO_2 emissions levels in Gt in EU regions in 2050

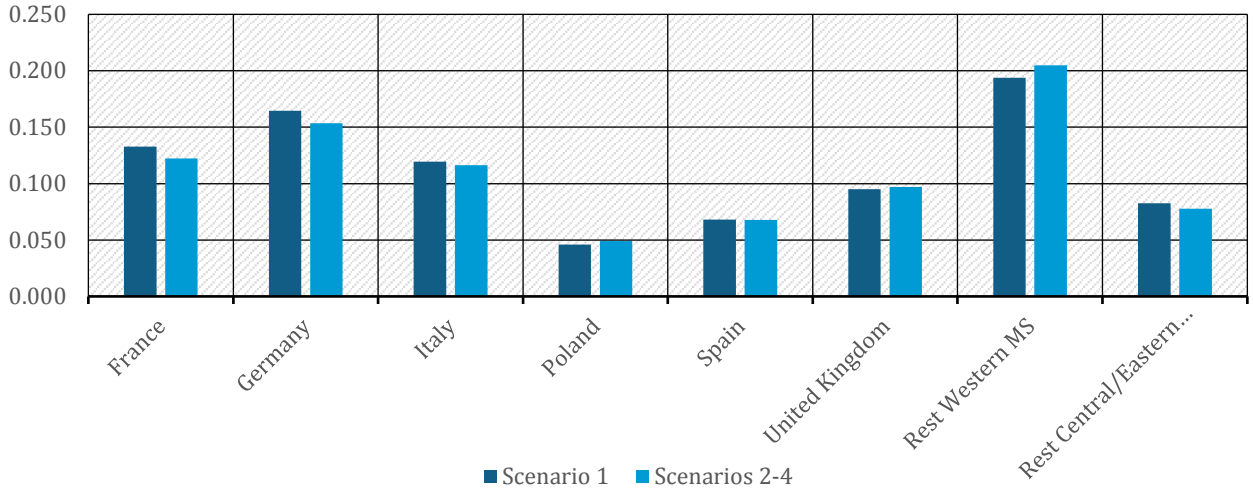
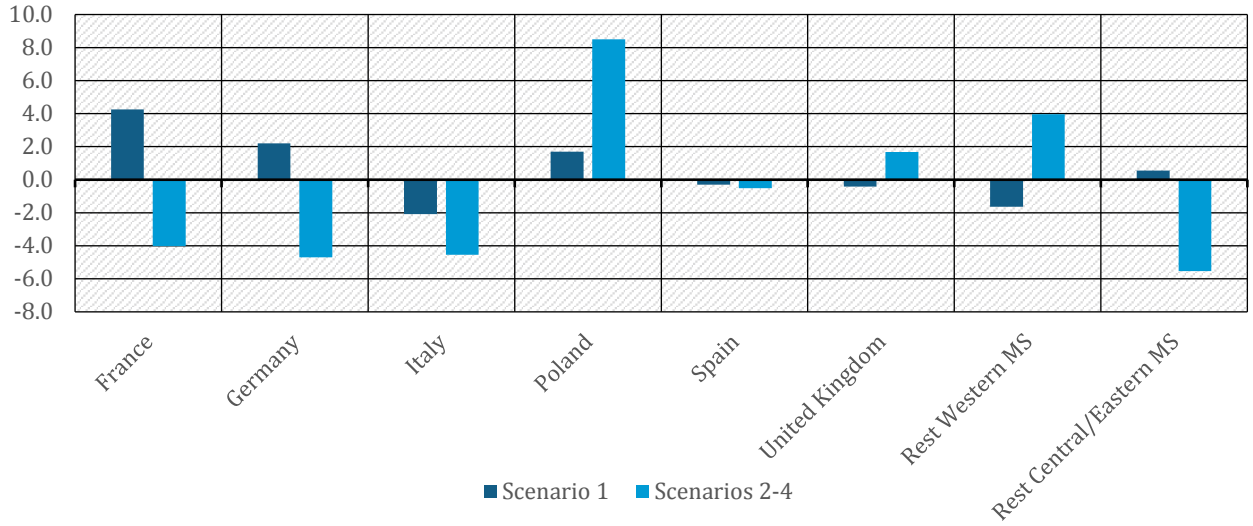


Figure 63: Percentage changes in CO_2 emissions vs. baseline in EU regions in 2050



6.7 Conclusions

6.7.1 Conclusions from the comparative analysis of climate policy related ambition levels in the EU and its main trading partners

The EU is an open economy, tightly integrated into world markets. This also applies to the eight sectors considered in this report. For those sectors, the volume of extra-EU trade was highest for refineries and chemicals (with EUR 119 and 101 billion respectively), and much smaller for cement and lime with a trading volume of only EUR 1.6 billion. For each of these sectors, the EU as a whole is both an importer and an exporter: for non-ferrous metals, imports are higher than exports (65% of total trade), while exports are higher than imports for ceramics or for pulp and paper (63% and 64%). The trade of cement and lime is dominated by exports (85% of total trade).

Based on the overall trade volumes in the respective sectors, the United States continues to be the main trading partner of the EU, followed by Russia and China. For three of the eight sectors considered, the United States is the main trading partner, and takes the 2nd place in the other five industrial sectors. China is the main trading partner in three industrial sectors; the other spots are taken by Algeria (for cement and lime), and Russia (for refinery products).

To return to the original question – what does the EU's exposure to the carbon leakage risk looks like when taking account of the climate policies enacted by the EU's main trading partners – the picture could be summarised as follows:

- The largest trading partner of the EU, by far, is the **EU itself** – intra-EU trade exceeds extra-EU trade by far. Since the EU ETS and most other climate regulation is identical across the EU, the carbon leakage risk is zero for this part of European trade.
- Two other important EU trading partners in the EU periphery – **Norway and Switzerland** – enact climate policies that are largely identical to those of the EU. Norway's climate policy is even somewhat more ambitious than the EU, as the country pursues complementary policies (including energy or carbon taxes on industry) in addition to their participation in the EU ETS (Norway) / their upcoming link to the EU ETS (Switzerland). In terms of carbon leakage risk, it is safe to say that there is none between the EU and these two countries.
- For the other two main trading partners of the EU – the United States and China – the picture is more nuanced. Historically, while all attempts to establish a carbon price at the federal level in the **United States** have stalled, there have been some constraints from air quality and other standards as well as state-level climate policies. Yet, under the Trump administration, the future level of climate ambition for industry remains uncertain, depending on how resilient the existing environmental legislation will turn out to be. But the federal level is not necessarily the main driver for action: at the regional level, the **Californian** ETS caps emissions and sets a carbon price for the selected industries. The coverage of GHGs and the price level is comparable to the EU ETS. While this system applies in only one state, California by itself accounts for roughly 4% of the trade volumes between the United States and the EU. Whether other states follow California's lead remains to be seen – for the time being, there are encouraging signs from a number of states, as Washington State moves to introduce a carbon tax, New Jersey announced its intention to re-join RGGI (after having withdrawn in 2011), and Oregon discusses the introduction of a cap-and-trade system (Temple, 2017).

- In **China**, in terms of the legislation currently in place, carbon constraints are much weaker still. But for several years, the Chinese leadership has been giving clear, strong and repeated signals that ambition will increase, not only through the incoming national emissions trading scheme, but also through other environmental legislation, including on air quality. While the Chinese national ETS has officially been launched in 2017, it will first only cover the power sector and currently remains unclear how binding it will be. Yet the inclusion of industry emissions is foreseen for the coming years; it is therefore clear that a growing share of Chinese power production and industry will be facing increasingly tight carbon constraints in the coming years.
- As for other EU trading partners, there is wide variation. **South Korea** pursues an ambitious strategy that combines carbon pricing with air quality and energy efficiency policies. **Russia** and **Turkey** both show some ambition on paper, but also struggle with deficits in implementation and enforcement. In both countries, the current focus is on MRV and data gathering as a basis for future climate policies. Yet the nature and design of concrete policy tools remains uncertain; absent of a strong political commitment there is no expectation that either would impose strong carbon constraints in the foreseeable future. **Algeria**, finally, is in the situation that it has an NDC, but what little mitigation policy there is in place appears to focus only on deployment of renewables, with little perspective for a meaningful carbon constraint in the foreseeable future. For Russia, Turkey and Algeria, the assumption of a *prima facie* carbon leakage risk is thus justified. To what extent this risk materialises, however, is another matter, and will also depend on other factors: European trade with Russia has declined substantially in recent years following the EU sanctions. Likewise, EU investments in Turkey or Russia have also stagnated or fallen in the wake of political tensions.

These observations could and should have implications for the European discussion on carbon leakage, and suggest possible adjustments to the carbon leakage provisions in the EU ETS.

a) **Disregard countries with comparable ambition levels in the carbon leakage risk assessment**

Above all, the observations above call for more differentiation in the assessment of carbon leakage risk. The current treatment of third country's climate efforts relative to the EU ETS is very simplified: in essence, all trade with countries that are not part of the EU ETS counts towards a possible carbon leakage risk, irrespective of whether this trade is conducted with a country that pursues ambitious climate policy or not. As a starting point, the trade intensity criterion should clearly disregard trade with countries that have a comparable carbon constraint. At the current stage, for most sectors, this would represent a marginal change, which is unlikely to change the overall assessment of the carbon leakage risk. Following the findings in this report, Switzerland and South Korea can be considered as at least comparable to the EU ETS (Norway is already disregarded in the carbon leakage assessment).

While the change would be marginal at current, the periodic reviews of the carbon leakage list should then also incorporate a periodic re-assessment of how trading partners' climate policies have changed, and how this affects the effective carbon leakage risk. As the Paris Agreement calls upon its signatories to periodically review and increase the ambition of their nationally determined contributions to the objectives of the agreement, there is reason to expect that an increasing number of EU trading partners will show increasing ambition.[101] This will eventually

[101] This expectation is indeed recognised in recital 24 of the revised EU ETS Directive (2018/410), which stipulates that the provisions for installations at risk of carbon leakage "should also be kept under review in the light of climate policy measures in

also change the assessment of the carbon leakage risk – as the two fictitious, but not plausible thought experiments suggest:

- For instance, if the Chinese national ETS has been implemented, covers (by and large) the sectors that are also part of the EU ETS, and sets a price signal that is comparable to the EU ETS, this in and of itself would change the picture considerably: at current trading shares, 20-25% of non-EU-trade would then be disregarded for the carbon leakage assessment in most sectors – ranging from 8% for refinery products to 32% for glass.
- If, in addition to the above, a future United States administration should reassume their responsibility and impose a carbon constraint that is comparable to the EU ETS, this would mean that, at current trading shares, up to half of non-EU trade would be disregarded for chemicals and for glass, and more than a third of non-EU trade for iron and steel, non-ferrous metals and ceramics.

b) **Differentiate between different levels of climate ambition**

The Paris Agreement – and the spirit of the Agreement – have so far survived the announced withdrawal of the United States from the Agreement, as countries continue to fulfil their obligations. For many developing countries, this marks the first time that they have to develop a mitigation strategy, and implement instruments for climate mitigation. In doing so, and in the spirit of the Paris Agreement, countries rely on a broad number of policy instruments: an increasing number implements carbon prices as the tool of choice, others rely on standards or other incentives.

It is also in the spirit of the agreement that ambition levels will continue to differ. However, the logic of the current carbon leakage criteria – and the rationality of large parts of the political debate – remains binary: they only distinguish between countries with climate policy (the EU), and those without (basically everyone else). A more nuanced understanding of carbon leakage risk should recognise that most countries will have some kind of mitigation policy (and thus carbon constraint) in place, but that they will differ in ambition and the choice of instrument. For pragmatic purposes, and recognising the difficulty of comparing different types of carbon constraints (see following), it would seem justifiable and feasible to sort countries into broad categories, and to assign correction factors to the volume of trade conducted with these countries in the carbon leakage risk assessment. As argued, if the climate mitigation policy in country A is found to be equally or more ambitious than the EU, trade with this country should be excluded from the assessment. If the country has a mitigation policy in place that is somewhat less ambitious than the EU, trade volumes could be discounted by 75%; by 50% if the mitigation policy is significantly less ambitious, and 100% if there is no climate mitigation policy in place. While this would obviously be a simplification of the actual situation, it would be still be more differentiated than the current, binary distinction. Also, it is important that the perfect should not be the enemy of the good here: a "perfect" comparison of climate efforts would consider all relevant regulations (climate, air quality, energy efficiency etc.) at any point in time – meaning that any policy change, any movement of carbon prices, or even exchange rate fluctuations would have an effect on the carbon leakage risk assessment; which is hardly feasible to implement in practice.

other major economies", explicitly linking these reviews to the outcomes of each global stocktake under the Paris Agreement and the 2018 Facilitative Dialogue

c) **Improve the information basis and the sectoral detail on carbon pricing policies**

In doing so, however, the comparability of ambition remains a challenge. Various initiatives have been mapping developments in carbon pricing around the world – the OECD's work on effective carbon rates, the World Bank's reports on the State and Trends of Carbon Pricing, or the annual ICAP status reports. In addition, the EU Commission has recently awarded a project to monitor carbon market developments, and private analysts (ThomsonReuters, Tschach/ICIS, Carbon Pulse) produce information in various formats and intervals. While they are helpful to provide a general orientation, none of these efforts by themselves allows a comparison of ambition levels: of the existing efforts, the OECD goes furthest in aiming for comparability between countries and across instruments – but alas lacks sectoral detail, i.e. does not provide information for specific industrial sectors, let alone on different design elements, such as allocation rules. The ICAP status reports currently provide the most detailed resolution in terms of sector coverage, including to some extent allocation rules – but these are restricted to emissions trading only.

To improve the information basis for carbon leakage assessments, it would be highly commendable if either of the publicly funded reporting series (OECD, World Bank, ICAP, EU Commission) were to include the necessary detail to compare the effective carbon constraints per sector and country, irrespective of the instrument applied. Alternatively, this exercise could be instituted as a new, separate activity. An interesting option would be to have the analysis jointly procured by different jurisdictions, e.g. through ICAP, PMR or the CPLC – as the information contained would be of interest to all jurisdictions that apply a carbon prices to industry, and are concerned about carbon leakage risks. As this analysis has shown (for the case of the EU), there is considerable scope for concentration and synergies: this study analysed the climate policies of eight countries, which allowed to cover between 44 and 61% of non-EU trade. With an analysis of 25-30 countries, this would increase to 85-95% per sector.

d) **Develop a common metric for non-price-based-policies**

The comparison of different types of instruments, other than carbon pricing, presents a conceptual challenge, for which there is no satisfactory solution. Ideally, a measure of policy ambition should be able to digest other climate instruments beyond pricing (including as standards or limit values) – and possibly even other environmental regulation (e.g. air quality), other energy policy measures (e.g. fuel subsidies or price controls), or even the more general considerations about the regulatory framework. This reflects the fact that when comparing the levelness of the playing field carbon pricing is only one piece of the puzzle. In addition – as this analysis has also recalled – an analysis should ideally not only consider the paper form of regulations in place, but should also consider the actual implementation and enforcement. Finally, interactions between policies would need to be considered, as well as the role of the carbon price in the climate policy mix. Thus, in a setting with fewer complementary instruments, the carbon price would be relied upon to achieve more reduction, requiring a higher carbon price to achieve the same level of abatement. Alternatively, an equally ambitious climate policy package that relies on more complementary instruments would see a lower carbon price – simply because the complementary instruments already incentivise some of the necessary abatement, leaving less to do for the carbon price.

Unfortunately, including these factors in a comparison, and doing so in a balanced and objective way, remains a methodological challenge.

e) **Cooperate in phasing out free allocation**

Continued free allocation – possibly justified by the need to manage the risk of carbon leakage – is in the interest of the covered companies. But it also presents a relatively easy way to the regulator to reduce or circumvent resistance from industry stakeholders. As more and more jurisdictions around the world turn towards carbon pricing, and as virtually all of them rely on free allocation to mitigate the risk of carbon leakage, this may eventually lead to a situation where a majority of countries have introduced a carbon constraint, and still all of them continue to provide free allocation on the basis of the fact that not everyone takes action. This suggests that there is a collective action problem at work – and that there is a need to cooperate in phasing out carbon leakage support, e.g. by agreeing to joint schedules. Such endeavour could be modelled on existing efforts to phase out fossil subsidies, as spearheaded by the G7 and G20 – where this happens through national action, but in a concerted and coordinated way, with common reporting, mutual (voluntary) peer review, and a shared common goal.

6.7.2 Conclusions from macroeconomic modelling

The analysis has shown several impacts of different policy designs in the EU and the rest of the world. The most important findings are summarized in the following:

- The EU clearly benefits from multilateral action. This holds for macroeconomic impacts, such as the GDP, as well as for sectoral impacts on output.
- Ambition levels of climate policies across the most important trading partners differ. Some countries, mostly some of those that implement reduction targets vis-à-vis carbon intensity levels (such as China) and some that have effectively non-binding NDCs according to our projections (such as Brazil or Turkey) benefit from significant GDP gains. On the other hand, mostly resource abundant countries such as Russia or Norway exhibit GDP losses. However, these losses are quite moderate until 2030 (below 2 % in the most severe case).
- Based on that, some EU trading partners can gain in macroeconomic and sectoral output terms at the expense of others until 2030. In this model analysis, such effects can be observed for China which exhibits GDP and also sectoral output gains whereas the United States lose in both terms. This is determined by the different ambition levels outlined above, but such effects can also be aggravated by different trade patterns of both countries.
- Free allocation of some allowances – modelled here as a subsidy for production output – can be beneficial for the respective sectors. This can be observed in the energy-intensive sectors of some of the EU's trading partners, for instance in the United States. Once these sectors in the EU also receive the same share of free allowances, they gain competitiveness and hence benefit, whereas the sectors in the trading partner countries lose (but to a very small degree) compared to the situation in which only they receive free allowances. On the other hand, free allowances can also have adverse effects if they are allocated only to the EU's trading partners. As the EU sectors reduce their output, they demand less intermediate products from abroad. If the respective sectors in the EU's trading partner regions have a high export volume to the EU sectors, they hence might even experience output losses. This is the case in some Chinese sectors. These observations however only apply to the analysis before 2050. By that year no free allowances are implemented any more, according to the scenario assumptions.

Therefore, the policy design in the EU is clearly dependent on the actions taken in other countries. Even if they comply with their NDCs, impacts are very diverse also on the EU

economies. Measures such as free allocation are capable of alleviating some of the adverse economic effects. However, it is important to keep in mind the limitations of the PACE model which has been used for this analysis. It does neither cover endogenous technological change nor CCS. Both features would certainly dampen some negative effects. Also, model assumptions on the substitutability of the products in the ETS sectors influence the results, not least between the Scenarios 2 and 4 (which assume either full auctioning versus free allocation in all analysed countries). Moreover, the model (as most CGE models) does not include gains from avoided climate change.

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A: Trade volumes and partners in the selected industrial sectors

A.1 Trade volumes and partners in the iron and steel sector

In 2016, the EU exports of iron and steel products (CPA code 2410: iron and steel) amounted to EUR 85 billion. Imports in the same year came to EUR 88 billion, resulting in an overall trade volume of EUR 173 billion. Of this, the vast majority was inner-EU trade, accounting for 76% of total trade.

Table 36 lists the trade volumes with the 10 most important external trading partners in 2016. For the selection, countries were ranked by overall trade volume. It shows that the six largest trade partners account for 13% of overall EU trade (or 52% of all EU trade to non-EU countries). If this is extended to include the 10 largest trading partners, the shares increase to 17% for overall EU trade and 70% for EU trade with non-EU countries.

Table 36: Top 10 trading partners of the EU and respective trade volumes and shares for iron and steel

	Largest trading partners	Overall trade volume (EUR million)	Total imports (EUR million)	Total exports (EUR million)	Share of total EU trade	Share of external trade
1	China	5,435	4,121	1,314	3.1%	12.9%
2	United States	4,180	510	3,670	2.4%	9.9%
3	Russian Federation	4,075	3,506	569	2.4%	9.7%
4	Turkey	3,707	914	2,793	2.1%	8.8%
5	United Arab Emirates	2,598	2,418	180	1.5%	6.2%
6	South Korea	2,046	1,591	455	1.2%	4.9%
7	Algeria	1,902	5	1,897	1.1%	4.5%
8	Brazil	1,839	1,501	338	1.1%	4.4%
9	India	1,837	1,191	646	1.1%	4.4%
10	Switzerland	1,786	526	1,261	1.0%	4.2%
	the six largest trade partners				12.7%	52.3%
	the ten largest trade partners				17.0%	69.8%

Total EU trade includes import and exports within the EU and to external partners

Source: own calculations based on Eurostat (2016)

A.2 Trade volumes and partners in the chemical sector

In 2016, the EU exports of chemical products (CPA code 2013, 2014, 2015: inorganic and organic chemicals and fertilisers) amounted to EUR 137 billion. Imports in the same year came to EUR 153 billion, resulting in an overall trade volume of EUR 290 billion. Of this, the vast majority was inner-EU trade, accounting for 65% of both imports and exports.

Table 37 lists the trade volumes with the 10 most important external trading partners in 2016. For the selection, countries were ranked by overall trade volume. It shows that the six largest trade partners account for 21% of overall EU trade (or 60% of all EU trade to non-EU countries). If this is extended to include the 10 largest trading partners, the shares increase to 25% for overall EU trade and 72% for EU trade with non-EU countries.

Table 37: Top 10 trading partners of the EU and respective trade volumes and shares for chemical products

	Largest trading partners	Overall trade volume (EUR million)	Total imports (EUR million)	Total exports (EUR million)	Share of total EU trade	Share of external trade
1	United States	24,781	8,273	16,508	8.5%	24.6%
2	China	10,727	6,655	4,073	3.7%	10.6%
3	Switzerland	8,789	5,437	3,352	3.0%	8.7%
4	Russian Federation	7,350	6,345	1,005	2.5%	7.3%
5	Singapore	4,757	3,697	1,060	1.6%	4.7%
6	Japan	4,508	2,117	2,391	1.6%	4.5%
7	India	3,799	2,554	1,245	1.3%	3.8%
8	South Korea	2,914	1,091	1,823	1.0%	2.9%
9	Norway	2,698	1,817	881	0.9%	2.7%
10	Turkey	2,640	784	1,856	0.9%	2.6%
	the six largest trade partners				21.0%	60.4%
	the ten largest trade partners				25.2%	72.3%

Total EU trade includes import and exports within the EU and to external partners
Source: own calculations based on Eurostat (2016)

A.3 Trade volumes and partners in the non-ferrous metals sector

In 2016, the EU exports of non-ferrous metals (CPA code 2442, 2443, 2444, 2445: copper, aluminium, lead, zinc and tin and others) amounted to EUR 78 billion. Imports in the same year came to EUR 90 billion, resulting in an overall trade volume of EUR 168 billion. Of this, the vast majority was inner-EU trade, accounting for 70% of total trade.

Table 38 lists the trade volumes with the 10 most important external trading partners in 2016. For the selection, countries were ranked by overall trade volume. The table shows that the six largest trade partners account for 16% of overall EU trade (or 53% of all EU trade to non-EU countries). If this is extended to include the 10 largest trading partners, the shares increase to 20% for overall EU trade and 64% for EU trade with non-EU countries.

Table 38: Top 10 trading partners of the EU and respective trade volumes and shares for non-ferrous metals products

	Largest trading partners	Overall trade volume (EUR million)	Total imports (EUR million)	Total exports (EUR million)	Share of total EU trade	Share of external trade
1	United States	5,991	2,772	3,219	3.6%	11.7%
2	Russian Federation	5,758	5,382	376	3.4%	11.3%
3	China	4,856	2,695	2,161	2.9%	9.5%
4	Norway	4,480	3,960	520	2.7%	8.8%
5	Switzerland	3,179	1,433	1,746	1.9%	6.2%
6	Turkey	2,921	1,443	1,478	1.7%	5.7%
7	Chile	1,955	1,907	48	1.2%	3.8%
8	United Arab Emirates	1,371	1,111	260	0.8%	2.7%
9	Canada	1,283	980	303	0.8%	2.5%
10	Saudi Arabia	940	126	814	0.6%	1.8%
	the six largest trade partners				16.2%	53.2%
	the ten largest trade partners				19.5%	64.1%

Total EU trade includes import and exports within the EU and to external partners

Source: own calculations based on Eurostat (2016)

A.4 Trade volumes and partners in the cement and lime sector

In 2016, the EU exports of cement and lime (CPA code 2351, 2352: cement, lime and plaster) amounted to EUR 2 billion. Imports in the same year came to EUR 4 billion, resulting in an overall trade volume of EUR 6 billion. Of this, the vast majority was inner-EU trade, accounting for 73% of total trade.

Table 39 lists the trade volumes with the 10 most important external trading partners in 2016. For the selection, countries were ranked by overall trade volume. It shows that the six largest trade partners account for 12% of overall EU trade (or 45% of all EU trade to non-EU countries). If this is extended to include the 10 largest trading partners, the shares increase to 16% for overall EU trade and 59% for EU trade with non-EU countries.

Table 39: Top 10 trading partners of the EU and respective trade volumes and shares for cement and lime products

	Largest trading partners	Overall trade volume (EUR million)	Total imports (EUR million)	Total exports (EUR million)	Share of total EU trade	Share of external trade
1	Algeria	212	0	212	3.6%	13.2%
2	United States	185	18	167	3.2%	11.5%
3	Switzerland	102	16	86	1.8%	6.4%
4	Israel	78	0	78	1.3%	4.9%
5	Turkey	78	73	4	1.3%	4.8%
6	Norway	70	30	41	1.2%	4.4%
7	Ghana	59	0	59	1.0%	3.7%
8	Russian Federation	57	0	57	1.0%	3.5%
9	Columbia	55	26	29	0.9%	3.4%
10	Bosnia	41	7	33	0.7%	2.5%
	the six largest trade partners				12.4%	45.3%
	the ten largest trade partners				16.1%	58.5%

Total EU trade includes import and exports within the EU and to external partners
Source: own calculations based on Eurostat (2016)

A.5 Trade volumes and partners in the glass sector

In 2016, the EU exports of glass (CPA code 2311, 2313, 2314, 2319: glass and glassware) amounted to EUR 24 billion. Imports in the same year came to EUR 13 billion, resulting in an overall trade volume of EUR 15 billion. Of this, the vast majority was inner-EU trade, accounting for 72% of total trade.

Table 40 lists the trade volumes with the 10 most important external trading partners in 2016. For the selection, countries were ranked by overall trade volume. It shows that the six largest trade partners account for 17% of overall EU trade (or 61% of all EU trade to non-EU countries). If this is extended to include the 10 largest trading partners, the shares increase to 20% for overall EU trade and 70 % for EU trade with non-EU countries.

Table 40: Top 10 trading partners of the EU and respective trade volumes and shares for glass products

	Largest trading partners	Overall trade volume (EUR million)	Total imports (EUR million)	Total exports (EUR million)	Share of total EU trade	Share of external trade
1	China	1,702	1,302	399	6.0%	21.2%
2	United States	1,639	484	1,155	5.8%	20.4%
3	Switzerland	534	149	385	1.9%	6.6%
4	Turkey	435	246	189	1.5%	5.4%
5	Japan	307	142	165	1.1%	3.8%
6	Russian Federation	269	64	205	0.9%	3.3%
7	Norway	223	58	165	0.8%	2.8%
8	India	188	110	78	0.7%	2.3%
9	United Arab Emirates	179	38	142	0.6%	2.2%
10	Canada	144	16	128	0.5%	1.8%
	the six largest trade partners				17.3%	60.8%
	the ten largest trade partners				19.8%	70.0%

Total EU trade includes import and exports within the EU and to external partners

Source: own calculations based on Eurostat (2016)

A.6 Trade volumes and partners in the ceramics sector

In 2016, the EU exports of ceramics (CPA code 2331, 2341-2344, 2349: Ceramic products) amounted to EUR 14 billion. Imports in the same year came to EUR 10 billion, resulting in an overall trade volume of EUR 24 billion. Of this, the vast majority was inner-EU trade, accounting for 62% of total trade.

Table 41 lists the trade volumes with the 10 most important external trading partners in 2016. For the selection, countries were ranked by overall trade volume. It shows that the six largest trade partners account for 20% of overall EU trade (or 53% of all EU trade to non-EU countries). If this is extended to include the 10 largest trading partners, the shares increase to 24% for overall EU trade and 63% for EU trade with non-EU countries.

Table 41: Top 10 trading partners of the EU and respective trade volumes and shares for ceramics products

	Largest trading partners	Overall trade volume (EUR million)	Total imports (EUR million)	Total exports (EUR million)	Share of total EU trade	Share of external trade
1	China	1,824	1,683	141	7.5%	19.5%
2	United States	1,487	310	1,177	6.1%	15.9%
3	Turkey	493	400	93	2.0%	5.3%
4	Switzerland	427	38	388	1.7%	4.6%
5	Russian Federation	360	11	349	1.5%	3.8%
6	Japan	339	204	135	1.4%	3.6%
7	Saudi Arabia	335	1	334	1.4%	3.6%
8	South Korea	235	63	172	1.0%	2.5%
9	United Arab Emirates	229	93	136	0.9%	2.4%
10	Israel	179	5	174	0.7%	1.9%
	the six largest trade partners				20.2%	52.6%
	the ten largest trade partners				24.2%	63.0%

Total EU trade includes import and exports within the EU and to external partners

Source: own calculations based on Eurostat (2016)

A.7 Trade volumes and partners in the pulp and paper sector

In 2016, the EU exports of pulp and paper (CPA 1711, 1712, 1724: pulp, paper and paperboard, wallpaper) amounted to EUR 59 billion. Imports in the same year came to EUR 52 billion, resulting in an overall trade volume of EUR 110 billion. Of this, the vast majority was inner-EU trade, accounting for 76% of total trade.

Table 42 lists the trade volumes with the 10 most important external trading partners in 2016. For the selection, countries were ranked by overall trade volume. It shows that the six largest trade partners account for 13% of overall EU trade (or 52% of all EU trade to non-EU countries). If this is extended to include the 10 largest trading partners, the shares increase to 15% for overall EU trade and 63% for EU trade with non-EU countries.

Table 42: Top 10 trading partners of the EU and respective trade volumes and shares for pulp and paper products

	Largest trading partners	Overall trade volume (EUR million)	Total imports (EUR million)	Total exports (EUR million)	Share of total EU trade	Share of external trade
1	United States	4,356	2,267	2,089	4.0%	16.4%
2	Brazil	2,740	2,445	295	2.5%	10.3%
3	China	2,048	412	1,636	1.9%	7.7%
4	Russian Federation	1,689	507	1,183	1.5%	6.4%
5	Turkey	1,658	209	1,448	1.5%	6.2%
6	Switzerland	1,427	583	844	1.3%	5.4%
7	Norway	857	498	359	0.8%	3.2%
8	Chile	760	585	175	0.7%	2.9%
9	India	660	32	628	0.6%	2.5%
10	Uruguay	588	572	16	0.5%	2.2%
	the six largest trade partners				12.6%	52.4%
	the ten largest trade partners				15.2%	63.2%

Total EU trade includes import and exports within the EU and to external partners

Source: own calculations based on Eurostat (2016)

A.8 Trade volumes and partners in the refinery sector

In 2016, the EU exports of refineries (CPA code 1920: refined petroleum products) amounted to EUR 153 billion. Imports in the same year came to EUR 137 billion, resulting in an overall trade volume of EUR 289 billion. Of this, the vast majority was inner-EU trade, accounting for 59% of total trade.

Table 43 lists the trade volumes with the 10 most important external trading partners in 2016. For the selection, countries were ranked by overall trade volume. It shows that the six largest trade partners account for 20% of overall EU trade (or 48% of all EU trade to non-EU countries). If this is extended to include the 10 largest trading partners, the shares increase to 24% for overall EU trade and 58% for EU trade with non-EU countries.

Table 43: Top 10 trading partners of the EU and respective trade volumes and shares for refinery products

	Largest trading partners	Overall trade volume (EUR million)	Total imports (EUR million)	Total exports (EUR million)	Share of total EU trade	Share of external trade
1	Russian Federation	20,264	19,696	569	7.0%	17.1%
2	United States	18,808	8,295	10,513	6.5%	15.9%
3	Saudi Arabia	5,667	3,775	1,892	2.0%	4.8%
4	Switzerland	4,408	97	4,311	1.5%	3.7%
5	Nigeria	4,169	88	4,080	1.4%	3.5%
6	Turkey	3,389	371	3,018	1.2%	2.9%
7	Norway	3,213	1,810	1,404	1.1%	2.7%
8	Togo	3,083	0	3,083	1.1%	2.6%
9	United Arab Emirates	3,053	2,119	934	1.1%	2.6%
10	Singapore	3,013	730	2,283	1.0%	2.5%
	the six largest trade partners				19.6%	47.8%
	the ten largest trade partners				23.9%	58.2%

Total EU trade includes import and exports within the EU and to external partners

Source: own calculations based on Eurostat (2016)

B: Additional results from the simulations with PACE

Table 44: NDCs and adjusted reduction targets of CO_2 emissions

	Base year or reference	Target year	CO_2 from fuel combustion in 1990	NDC	GECO 2015 Emissions Target - Total CO_2	GECO 2015 Emissions Target - fuel combustion	GECO 2015 Emissions Target - Share	POLES Total CO_2 Base year	Emissions in target year, scenario with NDCs in PACE - Total CO_2	Emissions in target year, scenario with NDCs in PACE - fuel combustion	Reduction target 2030 vs 1990 for PACE (% change 2030 vs. 1990)	Comments
EU	1990	2030		40 %								
Australia	2005	2030	285	26-28 %	688	523	0,7598	643	475,630	361,402	26,98	
Japan	2005	2030	1015	25,4 %	1102	985	0,8942	1339	998,529	892,946	-11,99	
Canada	2005	2030	428	30 %	785	646	0,8226	760	532,149	437,771	2,31	
United States	2005	2025	4908	26-28 %	5924	4979	0,8406	6950	5142,808	4323,124	-11,92	
Brazil	2005	2025	187	37 %	1415	631	0,4461	2343	1475,872	658,419	251,61	For 2030, use of indicative NDC (43% vs. 2005)
Russia	1990	2030	2306	25-30 %	2344	1692	0,7216	3292	2468,666	1782,276	-22,71	
Korea	BAU	2030	225	37 %	697	590	0,8452	697	439,415	371,407	65,33	
Indonesia	BAU	2030	166	29 % uncond.	1413	524	0,3710	1413	1003,374	372,242	123,98	

	Base year or reference	Target year	CO_2 from fuel combustion in 1990	NDC	GECO 2015 Emissions Target - Total CO_2	GECO 2015 Emissions Target - fuel combustion	GECO 2015 Emissions Target - Share	POLES Total CO_2 Base year	Emissions in target year, scenario with NDCs in PACE - Total CO_2	Emissions in target year, scenario with NDCs in PACE - fuel combustion	Reduction target 2030 vs 1990 for PACE (% change 2030 vs. 1990)	Comments
Mexico	BAU	2030	281	25 % uncondi.	795	566	0,7121	795	596,508	424,790	51,20	
Turkey	BAU	2030	122	21 %	615	440	0,7150	615	485,878	347,426	184,50	
South Africa	-	2025	281	614 $MtCO_2e$	575	470	0,8174	-	575	470	67,27	use of baseline as higher cap is above baseline
China	2005	2030	2300	60-65 % carbon intensity	15644	12881	0,8234	5893	14177	11673,402	407,54	
India	2005	2030	553	33-35 % carbon intensity	3973	2671	0,6723	2089		3014	445,03	higher than POLES and GECO baseline; thus use of GECO baseline
Rest of Annex I											-40	For most countries, especially large ones
ROW	BAU	2030	6205		14753	9137	0,6194	14753	14015,064	8680,5864	39,89	

Table 45: Selected macroeconomic and environmental indicators in Baseline Scenario – 2020

Macroeconomic and environmental ind.	European Union	China	South Korea	India	United States	Brazil	Switzer-land	Norway	Russia	Turkey
GDP (trillion 2010 €)	14.282	9.483	1.159	2.164	13.901	2.505	0.570	0.379	1.703	0.648
Consumption (trillion 2010 €)	8.620	3.546	0.628	1.234	9.533	1.493	0.347	0.179	0.912	0.457
CO_2 emissions (Gt)	2.960	7.875	0.356	2.200	4.475	0.471	0.032	0.041	2.029	0.305
ETS	1.380	5.394	0.184	1.396	2.212	0.153	0.006	0.012	1.364	0.154
CO_2 price ETS (2010 €)	29.4	0.0	0.0	0.0	0.0	0.0	29.4	29.4	0.0	0.0
CO_2 price non-ETS (2010 €)	47.3	15.2	204.5	7.4	33.3	30.9	227.5	864.1	2.8	14.5
Electricity price (2010 €/MWh)	109.1	118.2	182.4	100.6	118.2	102.3	104.8	90.3	107.2	108.6
Oil price (2010 USD per boe)	91.2	89.1	93.2	88.9	90.9	90.0	91.3	89.8	89.5	90.0
Gas price (2010 USD per boe)	53.4	52.4	72.2	59.6	52.7	49.9	81.8	54.7	56.6	56.5
Coal price (2010 USD per boe)	22.2	21.3	18.8	21.0	19.2	20.6	22.2	21.2	21.5	21.1

Table 46: Selected macroeconomic and environmental indicators in Baseline Scenario – 2030

Macroeconomic and environmental ind.	European Union	China	South Korea	India	United States	Brazil	Switzer-land	Norway	Russia	Turkey
GDP (trillion 2010 €)	16.017	14.994	1.497	3.362	16.895	3.295	0.689	0.451	2.167	0.746
Consumption (trillion 2010 €)	9.647	5.422	0.805	1.759	11.399	1.964	0.429	0.225	1.205	0.510
CO_2 emissions (Gt)	2.365	7.875	0.356	2.200	4.475	0.471	0.032	0.041	2.029	0.305

Macroeconomic and environmental ind.	European Union	China	South Korea	India	United States	Brazil	Switzer-land	Norway	Russia	Turkey
ETS	0.975	5.125	0.182	1.056	2.240	0.149	0.006	0.012	1.325	0.154
CO_2 price ETS (2010 €)	70.9	0.0	0.0	0.0	0.0	0.0	70.9	70.9	0.0	0.0
CO_2 price non-ETS (2010 €)	115.7	33.7	268.5	34.3	45.1	80.4	241.9	814.6	17.0	30.5
Electricity price (2010 €/MWh)	116.4	139.2	207.9	112.2	129.1	106.0	109.3	91.6	132.3	121.6
Oil price (2010 USD per boe)	107.7	102.9	108.8	103.3	106.6	105.5	108.4	103.8	104.3	104.8
Gas price (2010 USD per boe)	59.3	51.6	85.1	75.4	61.1	54.6	86.8	59.2	64.9	66.9
Coal price (2010 USD per boe)	23.4	22.1	20.8	17.4	20.5	21.1	21.8	22.6	22.2	22.2

Table 47: Selected macroeconomic and environmental indicators in Baseline Scenario – 2040

Macroeconomic and environmental ind.	European Union	China	South Korea	India	United States	Brazil	Switzer-land	Norway	Russia	Turkey
GDP (trillion 2010 €)	17.785	20.412	1.844	4.917	20.397	4.293	0.813	0.518	2.489	0.842
Consumption (trillion 2010 €)	10.662	7.139	0.980	2.408	13.562	2.549	0.515	0.270	1.411	0.561
CO_2 emissions (Gt)	1.600	7.875	0.356	2.200	4.475	0.471	0.031	0.039	2.029	0.305
ETS	0.631	4.753	0.183	0.731	2.198	0.151	0.005	0.011	1.344	0.153
CO_2 price ETS (2010 €)	188.1	0.0	0.0	0.0	0.0	0.0	188.1	188.1	0.0	0.0
CO_2 price non-ETS (2010 €)	508.3	46.7	356.5	135.5	67.0	168.6	297.1	804.7	30.9	57.1
Electricity price (2010 €/MWh)	131.2	154.7	254.6	136.8	145.6	109.1	114.4	95.3	159.3	139.7
Oil price (2010 USD per boe)	127.4	118.0	125.6	119.4	124.0	123.0	128.5	116.6	119.4	121.2

Macroeconomic and environmental ind.	European Union	China	South Korea	India	United States	Brazil	Switzer-land	Norway	Russia	Turkey
Gas price (2010 USD per boe)	69.4	50.6	101.3	83.8	69.4	58.2	98.4	61.9	74.0	79.3
Coal price (2010 USD per boe)	23.3	23.0	23.3	13.1	21.2	21.0	21.4	22.5	23.8	21.8

Table 48: Selected macroeconomic and environmental indicators in Baseline Scenario – 2050

Macroeconomic and environmental ind.	European Union	China	South Korea	India	United States	Brazil	Switzer-land	Norway	Russia	Turkey
GDP (trillion 2010 €)	19.056	24.935	2.195	6.859	23.768	5.316	0.926	0.560	2.629	0.924
Consumption (trillion 2010 €)	12.058	8.490	1.149	3.186	15.604	3.132	0.594	0.299	1.508	0.601
CO_2 emissions (Gt)	0.889	7.875	0.356	2.200	4.475	0.471	0.029	0.036	2.029	0.305
ETS	0.346	4.205	0.183	0.570	2.117	0.153	0.004	0.009	1.360	0.152
CO_2 price ETS (2010 €)	494.3	0.0	0.0	0.0	0.0	0.0	494.3	494.3	0.0	0.0
CO_2 price non-ETS (2010 €)	1802.6	56.6	471.6	374.5	98.0	296.1	332.9	708.6	43.5	97.0
Electricity price (2010 €/MWh)	128.3	166.6	330.5	184.6	166.6	111.7	120.2	101.3	186.0	163.9
Oil price (2010 USD per boe)	154.1	132.1	141.7	133.2	140.5	140.0	150.5	123.5	133.8	137.7
Gas price (2010 USD per boe)	94.6	40.2	122.1	76.8	74.4	53.5	106.6	53.6	82.4	91.9
Coal price (2010 USD per boe)	20.2	22.7	25.5	13.6	22.3	20.0	17.0	21.3	25.9	18.2

Table 49: Selected macroeconomic and environmental indicators for Scenario 1 –2030

Macroeconomic and environmental ind.	European Union	China	South Korea	India	United States	Brazil	Switzer-land	Norway	Russia	Turkey
CO_2 emissions (Gt)	2.365	11.954	0.769	3.375	5.828	0.604	0.040	0.050	2.313	0.344
ETS	0.975	8.591	0.458	2.103	3.238	0.215	0.006	0.012	1.567	0.181
CO_2 price non-ETS (2010 €)	95.8	0.0	0.0	0.0	0.0	0.0	11.7	342.8	0.0	0.0
CO_2 price ETS (2010€)	67.1	0.0	0.0	0.0	0.0	0.0	67.1	67.1	0.0	0.0
GDP (% change vs. baseline)	-0.4	0.2	1.5	-0.7	0.2	0.3	-0.3	3.0	2.8	-0.6
CO_2 emissions (% change vs. baseline)	0.2	51.8	115.8	53.4	30.2	28.3	26.1	23.3	-0.5	6.2
ETS	0.4	67.6	151.2	99.2	44.6	44.1	1.0	-1.2	18.3	17.3

Table 50: Selected macroeconomic and environmental indicators for Scenario 2 – 2030

Macroeconomic and environmental ind.	European Union	China	South Korea	India	United States	Brazil	Switzer-land	Norway	Russia	Turkey
CO_2 emissions (Gt)	2.365	11.601	0.423	3.267	3.660	0.632	0.026	0.035	1.816	0.379
ETS	0.975	8.337	0.253	2.037	2.029	0.229	0.006	0.012	1.229	0.204
CO_2 price non-ETS (2010 €)	124.3	6.9	309.1	17.2	182.3	0.0	537.4	1451.3	60.1	0.0
CO_2 price ETS (2010€)	68.2	2.8	104.6	3.4	58.4	0.0	68.2	68.2	24.5	0.0
GDP (% change vs. baseline)	0.1	0.3	1.0	0.0	-0.3	0.1	-0.1	-1.8	-0.5	0.2
CO_2 emissions (% change vs. baseline)	-0.1	47.3	18.8	48.5	-18.2	34.2	1.2	1.3	0.0	0.0
ETS	-0.2	62.7	38.6	92.9	-9.4	53.5	-2.1	-1.6	-7.3	32.5

Table 51: Selected macroeconomic and environmental indicators for Scenario 3 – 2030

Macroeconomic and environmental ind.	European Union	China	South Korea	India	United States	Brazil	Switzer-land	Norway	Russia	Turkey
CO_2 emissions (Gt)	2.365	11.601	0.423	3.267	3.660	0.631	0.026	0.035	1.816	0.379
ETS	0.974	8.337	0.253	2.037	2.029	0.229	0.006	0.012	1.229	0.204
CO_2 price non-ETS (2010 €)	123.7	6.9	316.4	17.0	184.3	0.0	538.6	1458.6	60.5	0.0
CO_2 price ETS (2010€)	67.9	2.8	121.4	3.5	60.4	0.0	67.9	67.9	26.6	0.0
GDP (% change vs. baseline)	0.0	0.2	1.1	0.0	-0.2	0.2	0.0	-1.7	-0.4	0.1
CO_2 emissions (% change vs. baseline)	-0.1	47.3	18.8	48.5	-18.2	34.1	1.3	1.8	0.0	0.0
ETS	-0.3	62.7	38.6	92.9	-9.4	53.3	-1.2	0.4	-7.3	32.2

Table 52: Selected macroeconomic and environmental indicators for Scenario 4 – 2030

Macroeconomic and environmental ind.	European Union	China	South Korea	India	United States	Brazil	Switzer-land	Norway	Russia	Turkey
CO_2 emissions (Gt)	2.365	11.601	0.423	3.267	3.661	0.631	0.026	0.035	1.816	0.378
ETS	0.974	8.337	0.253	2.037	2.029	0.228	0.006	0.012	1.229	0.203
CO_2 price non-ETS (2010 €)	127.3	6.8	315.8	16.8	184.0	0.0	541.0	1454.9	60.3	0.0
CO_2 price ETS (2010€)	70.3	2.8	120.8	3.4	60.2	0.0	70.3	70.3	26.5	0.0
GDP (% change vs. baseline)	0.1	0.2	1.0	-0.1	-0.3	0.1	-0.1	-1.6	-0.5	0.1
CO_2 emissions (% change vs. baseline)	-0.1	47.3	18.8	48.5	-18.2	34.0	1.1	1.5	0.0	0.0
ETS	-0.3	62.7	38.6	92.9	-9.4	53.1	-2.1	-0.5	-7.3	31.9

Table 53: Selected macroeconomic and environmental indicators for Scenario 1 – 2050

Macroeconomic and environmental ind.	European Union	China	South Korea	India	United States	Brazil	Switzer-land	Norway	Russia	Turkey
CO_2 emissions (Gt)	0.889	13.411	1.023	5.995	6.973	0.938	0.037	0.046	2.519	0.405
ETS	0.346	9.097	0.618	3.130	3.898	0.374	0.004	0.009	1.767	0.220
CO_2 price non-ETS (2010 €)	1707.7	0.0	0.0	0.0	0.0	0.0	81.6	328.2	0.0	0.0
CO_2 price ETS (2010€)	418.8	0.0	0.0	0.0	0.0	0.0	418.8	418.8	0.0	0.0
GDP (% change vs. baseline)	-0.2	-2.2	-1.3	-6.7	-1.4	-0.6	-1.3	4.5	7.6	-3.2
CO_2 emissions (% change vs. baseline)	0.4	70.3	187.3	172.5	55.8	99.3	28.2	25.2	24.2	32.8
ETS	1.1	116.3	237.5	448.6	84.1	145.1	6.1	4.3	29.9	45.1

Table 54: Selected macroeconomic and environmental indicators for Scenario 2 – 2050

Macroeconomic and environmental ind.	European Union	China	South Korea	India	United States	Brazil	Switzer-land	Norway	Russia	Turkey
CO_2 emissions (Gt)	0.889	2.285	0.256	0.600	0.986	0.195	0.010	0.015	0.470	0.145
ETS	0.346	1.562	0.157	0.317	0.552	0.078	0.003	0.008	0.330	0.080
CO_2 price non-ETS (2010 €)	2049.3	2271.3	1234.0	3973.0	2173.4	1747.0	3798.6	6363.8	1013.3	905.1
CO_2 price ETS (2010€)	634.5	371.9	637.7	720.6	1068.3	968.7	634.5	634.5	519.0	405.7
GDP (% change vs. baseline)	1.2	-1.0	1.2	-5.9	-5.3	-4.0	0.4	-10.6	-13.5	0.1
CO_2 emissions (% change vs. baseline)	-1.1	-71.0	-28.2	-72.7	-78.0	-58.6	-65.1	-58.4	-76.8	-52.5
ETS	-2.7	-62.8	-14.2	-44.4	-73.9	-49.0	-8.1	-8.3	-75.7	-47.6

Table 55: Selected macroeconomic and environmental indicators for Scenario 3 – 2050

Macroeconomic and environmental ind.	European Union	China	South Korea	India	United States	Brazil	Switzer-land	Norway	Russia	Turkey
CO_2 emissions (Gt)	0.889	2.285	0.256	0.600	0.986	0.195	0.010	0.015	0.470	0.145
ETS	0.346	1.562	0.157	0.317	0.552	0.078	0.003	0.008	0.330	0.080
CO_2 price non-ETS (2010 €)	2049.3	2271.3	1234.0	3973.0	2173.4	1747.0	3798.6	6363.8	1013.3	905.1
CO_2 price ETS (2010€)	634.5	371.9	637.7	720.6	1068.3	968.7	634.5	634.5	519.0	405.7
GDP (% change vs. baseline)	1.2	-1.0	1.2	-5.9	-5.3	-4.0	0.4	-10.6	-13.5	0.1
CO_2 emissions (% change vs. baseline)	-1.1	-71.0	-28.2	-72.7	-78.0	-58.6	-65.1	-58.4	-76.8	-52.5
ETS	-2.7	-62.8	-14.2	-44.4	-73.9	-49.0	-8.1	-8.3	-75.7	-47.6

Table 56: Selected macroeconomic and environmental indicators for Scenario 4 – 2050

Macroeconomic and environmental ind.	European Union	China	South Korea	India	United States	Brazil	Switzer-land	Norway	Russia	Turkey
CO_2 emissions (Gt)	0.889	2.285	0.256	0.600	0.986	0.195	0.010	0.015	0.470	0.145
ETS	0.346	1.562	0.157	0.317	0.552	0.078	0.003	0.008	0.330	0.080
CO_2 price non-ETS (2010 €)	2049.3	2271.3	1234.0	3973.0	2173.4	1747.0	3798.6	6363.8	1013.3	905.1
CO_2 price ETS (2010€)	634.5	371.9	637.7	720.6	1068.3	968.7	634.5	634.5	519.0	405.7
GDP (% change vs. baseline)	1.2	-1.0	1.2	-5.9	-5.3	-4.0	0.4	-10.6	-13.5	0.1
CO_2 emissions (% change vs. baseline)	-1.1	-71.0	-28.2	-72.7	-78.0	-58.6	-65.1	-58.4	-76.8	-52.5
ETS	-2.7	-62.8	-14.2	-44.4	-73.9	-49.0	-8.1	-8.3	-75.7	-47.6

Table 57: Selected results of changes in sectoral output (% change vs. baseline) in Scenario 1 – 2030

Sectoral output	European Union	China	South Korea	India	United States	Brazil	Switzer-land	Norway	Russia	Turkey
Refined oil and coal products	-4.1	0.0	44.9	1.7	5.2	11.8	17.7	8.0	0.5	-0.1
Paper, pulp and printing	-0.2	1.5	10.0	3.2	0.6	0.8	0.2	-1.0	0.3	0.5
Fertilizers	-2.4	1.3	56.2	4.6	2.0	2.3	-2.3	-0.5	6.7	0.6
Organic chemicals	-3.3	1.0	79.8	4.5	1.8	2.3	-3.3	-0.9	7.4	0.4
Inorganic chemicals	-1.8	1.2	47.8	3.5	1.7	2.1	-2.0	2.3	4.6	0.6
Other chemicals, rubber, plastic	-3.3	1.1	86.5	4.7	2.4	2.5	-0.7	38.5	5.8	0.6
Cement	-1.3	2.4	27.6	6.1	2.5	4.8	-0.2	0.7	2.8	6.1
Bricks, tiles, construction products	-1.7	2.4	24.2	6.2	2.6	5.9	0.0	1.2	3.0	8.2
Glass	-2.6	2.4	47.0	11.0	2.4	6.1	-1.6	-0.8	2.2	7.9
Ceramics	-2.6	2.4	31.2	7.0	2.6	6.4	-1.3	-1.1	1.7	5.0
Other non-metallic minerals	-2.2	2.3	36.3	12.2	2.1	6.2	1.7	6.2	2.5	5.6
Iron and steel - manufacturing	-1.7	2.1	12.7	4.4	2.3	3.9	-0.1	-7.6	-0.2	2.0
Iron and steel - further processing	-4.1	2.0	18.8	6.9	1.8	4.0	-2.0	-10.5	-1.7	0.5
Aluminium	-0.9	2.5	5.2	5.7	5.1	21.3	-0.2	-9.5	-8.2	5.2
Other non-ferrous metals	-1.5	2.8	9.2	5.4	5.2	19.3	-1.1	-5.9	-7.9	4.8
Electricity	-2.5	17.3	55.4	10.7	11.7	3.6	1.1	-7.1	4.4	6.5
Air transport	-3.9	2.2	17.9	1.9	4.6	5.0	0.7	1.4	0.2	0.5
Crude oil	1.1	1.3	0.0	1.8	1.6	2.3	0.0	1.6	0.6	1.1

Table 58: Selected results of changes in sectoral output (% change vs. baseline) in Scenario 2 – 2030

Sectoral output (% change vs. baseline)	European Union	China	South Korea	India	United States	Brazil	Switzer-land	Norway	Russia	Turkey
Refined oil and coal products	1.2	2.5	10.3	3.8	-10.4	15.3	-14.9	-10.8	-5.9	5.1
Paper, pulp and printing	0.0	1.4	4.1	3.2	-0.8	0.8	-0.3	0.2	-0.7	0.6
Fertilizers	-0.1	2.3	13.6	5.5	-4.8	3.1	-1.3	-2.5	-3.7	2.2
Organic chemicals	-0.4	2.0	28.3	5.5	-4.1	3.1	-1.9	-3.7	-4.6	1.9
Inorganic chemicals	0.3	2.0	14.7	4.1	-2.8	2.6	-0.8	-3.5	-2.6	1.7
Other chemicals, rubber, plastic	2.5	3.4	4.6	6.1	-9.9	4.5	0.8	-28.2	-29.2	4.2
Cement	-0.3	2.4	12.2	5.9	-2.8	5.4	-1.1	-1.6	-2.7	7.1
Bricks, tiles, construction products	-0.5	2.3	11.0	6.0	-3.5	7.2	-1.0	-1.7	-2.7	9.3
Glass	-0.9	2.6	21.3	10.8	-4.9	7.4	-1.7	-1.4	-3.6	9.3
Ceramics	-1.4	2.5	11.9	6.8	-5.2	7.5	-2.2	-2.6	-5.8	6.2
Other non-metallic minerals	-0.2	2.8	2.7	7.8	-10.5	8.6	-4.2	-7.2	-6.5	8.5
Iron and steel - manufacturing	-1.0	1.9	5.6	4.1	-1.9	5.0	-1.2	2.1	-3.5	4.2
Iron and steel - further processing	-2.1	2.1	9.4	7.6	-4.6	5.8	-2.4	2.2	-4.5	5.9
Aluminium	-1.1	1.9	1.8	4.7	-3.4	25.6	-0.5	7.8	-0.3	6.0
Other non-ferrous metals	-1.5	2.2	4.0	4.3	-3.7	23.1	-0.7	6.9	-0.4	5.6
Electricity	1.2	16.8	24.9	11.4	-1.9	4.0	-1.3	1.8	-2.7	10.9
Air transport	0.5	2.9	10.8	2.1	-2.0	5.7	-2.0	-1.8	-0.6	1.5
Crude oil	-0.6	-0.1	0.0	-0.1	-2.2	0.7	0.0	-2.1	-0.6	-0.6

Table 59: Selected results of changes in sectoral output (% change vs. baseline) in Scenario 3 – 2030

Sectoral output (% change vs. baseline)	European Union	China	South Korea	India	United States	Brazil	Switzer-land	Norway	Russia	Turkey
Refined oil and coal products	0.5	2.3	13.0	3.5	-9.0	15.0	-13.2	-9.9	-5.2	4.6
Paper, pulp and printing	-0.1	1.4	4.9	3.3	-0.4	0.8	-0.1	0.2	-0.9	0.6
Fertilizers	-0.7	2.2	20.7	5.5	-3.9	3.0	-2.1	1.4	6.0	1.9
Organic chemicals	-1.5	1.7	44.8	5.2	-2.7	2.9	-3.5	-0.1	6.4	1.4
Inorganic chemicals	-0.1	2.0	22.3	4.1	-1.7	2.5	-1.6	-1.5	2.2	1.6
Other chemicals, rubber, plastic	2.5	3.5	6.7	6.2	-9.8	4.6	1.0	-28.1	-29.7	4.3
Cement	-0.6	2.4	17.8	6.3	-1.1	5.3	-0.6	-0.5	-0.3	6.7
Bricks, tiles, construction products	-1.0	2.4	15.5	6.4	-1.5	6.7	-0.4	-0.8	-0.1	8.5
Glass	-1.7	2.4	31.1	11.3	-2.4	6.9	-1.3	-0.2	-0.4	8.5
Ceramics	-1.7	2.4	17.8	7.3	-2.4	7.3	-1.9	-1.6	-1.8	6.0
Other non-metallic minerals	-0.2	2.8	3.7	7.9	-10.1	8.6	-4.1	-7.1	-5.9	8.5
Iron and steel - manufacturing	-1.6	1.8	8.4	4.4	-0.3	4.5	-1.1	5.6	0.0	3.5
Iron and steel - further processing	-3.4	1.9	12.3	7.4	-2.2	5.0	-2.6	6.8	-0.2	4.3
Aluminium	-1.3	1.9	2.4	4.7	-1.6	25.2	-0.6	9.3	-1.5	6.4
Other non-ferrous metals	-1.6	2.2	4.7	4.3	-1.8	22.7	-0.7	8.3	-1.5	6.1
Electricity	1.1	16.8	22.7	11.4	-2.1	3.9	-1.3	2.1	-2.9	10.8
Air transport	-1.1	2.4	14.7	1.6	2.1	5.4	-0.5	1.0	0.5	0.1
Crude oil	-0.5	0.0	0.0	0.0	-2.0	0.8	0.0	-2.0	-0.5	-0.5

Table 60: Selected results of changes in sectoral output (% change vs. baseline) in Scenario 4 – 2030

Sectoral output (% change vs. baseline)	European Union	China	South Korea	India	United States	Brazil	Switzer-land	Norway	Russia	Turkey
Refined oil and coal products	3.4	2.2	12.7	3.3	-9.2	14.9	-14.4	-10.9	-5.8	4.2
Paper, pulp and printing	0.3	1.4	4.9	3.2	-0.4	0.8	-0.3	0.1	-0.9	0.6
Fertilizers	-0.1	2.2	20.7	5.5	-3.9	2.9	-2.5	1.1	5.7	1.9
Organic chemicals	-0.6	1.7	44.7	5.1	-2.8	2.8	-4.4	-0.8	5.9	1.3
Inorganic chemicals	0.5	2.0	22.3	4.1	-1.7	2.5	-2.3	-1.8	2.0	1.5
Other chemicals, rubber, plastic	2.7	3.5	6.7	6.2	-9.8	4.6	1.1	-28.0	-29.7	4.4
Cement	1.1	2.3	17.7	6.3	-1.3	5.3	-1.9	-1.3	-0.4	6.0
Bricks, tiles, construction products	1.0	2.3	15.5	6.3	-1.9	6.4	-1.7	-1.3	-0.3	7.3
Glass	0.8	2.3	30.9	11.1	-2.8	6.7	-3.1	-1.2	-0.7	7.7
Ceramics	0.8	2.4	17.9	7.2	-2.4	7.2	-1.9	-1.7	-1.8	6.0
Other non-metallic minerals	0.3	2.8	3.7	8.0	-10.1	8.6	-4.0	-7.0	-5.8	8.5
Iron and steel - manufacturing	1.9	1.8	8.2	4.3	-0.4	4.3	-1.8	3.6	-0.5	3.2
Iron and steel - further processing	1.4	1.7	11.7	6.8	-2.8	4.6	-5.3	3.9	-1.4	3.2
Aluminium	0.4	1.9	2.5	4.6	-1.7	24.9	-0.7	8.9	-1.7	6.9
Other non-ferrous metals	-0.1	2.2	4.7	4.1	-1.9	22.5	-0.5	8.1	-1.6	6.5
Electricity	1.7	16.8	22.8	11.4	-2.1	3.9	-1.5	1.6	-2.9	10.7
Air transport	1.7	2.0	14.3	1.0	1.7	5.2	-1.2	0.7	-0.1	-1.0
Crude oil	-0.3	0.0	0.0	0.1	-2.0	0.8	0.0	-1.9	-0.4	-0.5

Table 61: Selected results of changes in sectoral output (% change vs. baseline) in Scenario 1 – 2050

Sectoral output (% change vs. baseline)	European Union	China	South Korea	India	United States	Brazil	Switzer-land	Norway	Russia	Turkey
Refined oil and coal products	0.0	-2.8	67.2	49.6	7.1	51.0	9.0	8.1	0.0	1.8
Paper, pulp and printing	0.3	1.1	17.6	24.8	1.3	3.7	0.5	-0.7	-0.4	2.0
Fertilizers	-3.8	0.9	79.2	47.1	3.6	10.4	-2.4	0.2	12.8	3.7
Organic chemicals	-5.3	0.5	118.9	50.3	3.5	10.8	-4.0	-0.3	13.3	3.7
Inorganic chemicals	-2.5	0.8	70.8	36.1	3.2	9.1	-2.7	2.4	10.5	3.0
Other chemicals, rubber, plastic	-6.4	0.8	129.7	55.6	4.3	11.5	-1.4	23.7	0.9	4.9
Cement	-0.3	1.8	45.3	44.7	5.6	23.2	-1.4	0.1	8.1	25.7
Bricks, tiles, construction products	-1.6	1.8	39.1	45.0	4.5	27.6	-1.5	0.9	8.3	30.5
Glass	-2.2	1.2	68.3	80.6	5.3	29.5	-3.5	-1.8	6.6	31.5
Ceramics	-0.6	1.6	49.4	52.5	7.5	34.3	-1.3	-0.9	8.3	24.6
Other non-metallic minerals	-4.5	0.9	54.5	79.9	4.2	30.5	-4.7	2.5	7.7	23.8
Iron and steel - manufacturing	-2.8	1.3	20.7	22.7	4.7	17.0	-1.8	-8.5	-1.3	7.3
Iron and steel - further processing	-7.6	0.4	25.1	32.5	3.2	18.2	-6.5	-12.7	-5.0	5.1
Aluminium	-0.7	2.0	11.3	35.9	9.4	82.8	2.8	-6.4	-22.0	17.6
Other non-ferrous metals	-1.3	2.1	19.3	35.9	9.5	72.5	1.3	-0.2	-21.3	16.9
Electricity	-0.6	18.8	113.1	67.7	29.6	11.9	4.2	-9.7	8.7	24.3
Air transport	-5.7	2.2	22.5	36.8	6.3	15.6	2.2	3.3	-1.2	2.3
Crude oil	5.6	4.0	0.0	13.4	4.8	8.4	0.0	4.4	2.2	3.9

Table 62: Selected results of changes in sectoral output (% change vs. baseline) in Scenario 2 – 2050

Sectoral output (% change vs. baseline)	European Union	China	South Korea	India	United States	Brazil	Switzer-land	Norway	Russia	Turkey
Refined oil and coal products	1.7	-63.2	-24.8	-69.0	-58.3	-58.3	-49.5	-44.1	-47.3	-34.7
Paper, pulp and printing	0.5	-15.1	-5.5	-43.4	-12.5	-6.7	-3.3	-2.2	-45.0	-7.7
Fertilizers	9.2	-22.3	-16.5	-51.7	-35.6	-17.4	4.2	-13.4	-91.7	-16.1
Organic chemicals	11.4	-23.1	-17.7	-53.1	-38.2	-17.9	4.7	-16.2	-93.5	-17.7
Inorganic chemicals	7.4	-21.3	-14.2	-48.3	-30.4	-16.3	6.4	-15.3	-80.0	-14.9
Other chemicals, rubber, plastic	22.2	-30.0	-33.5	-71.7	-49.0	-21.9	3.7	-71.3	-98.0	-29.9
Cement	-1.4	-20.0	-9.1	-45.0	-38.5	-31.5	-1.0	-6.2	-64.0	-38.6
Bricks, tiles, construction products	-0.6	-20.2	-10.6	-45.1	-43.1	-33.6	-1.2	-8.0	-64.3	-44.9
Glass	2.3	-20.4	-13.5	-55.0	-51.4	-35.1	2.2	-2.8	-72.3	-45.7
Ceramics	3.0	-19.2	-9.1	-47.4	-47.7	-38.2	1.2	-2.7	-79.3	-43.6
Other non-metallic minerals	11.1	-29.3	-25.9	-85.3	-57.8	-45.1	2.4	-23.9	-73.4	-59.1
Iron and steel - manufacturing	2.5	-15.2	-5.7	-25.1	-29.3	-17.8	-2.0	17.6	-70.2	-21.5
Iron and steel - further processing	2.3	-16.7	-7.6	-28.7	-46.5	-20.4	1.9	24.9	-82.5	-30.3
Aluminium	6.8	-11.7	-4.5	-51.8	-40.7	-45.1	-7.3	46.3	-58.0	-30.8
Other non-ferrous metals	5.9	-12.5	-5.1	-51.4	-42.1	-41.5	-9.7	36.3	-55.1	-30.9
Electricity	-27.2	-29.7	-9.2	-33.5	-58.8	-9.4	26.2	52.7	-61.8	-39.8
Air transport	14.9	-28.1	0.5	-33.0	-41.4	-20.9	-7.3	-12.0	-30.0	-6.3
Crude oil	-17.8	-27.4	0.0	-50.2	-31.5	-27.8	0.0	-32.0	-12.9	-10.0

Table 63: Selected results of changes in sectoral output (% change vs. baseline) in Scenario 3 – 2050

Sectoral output (% change vs. baseline)	European Union	China	South Korea	India	United States	Brazil	Switzer-land	Norway	Russia	Turkey
Refined oil and coal products	1.7	-63.2	-24.8	-69.0	-58.3	-58.3	-49.5	-44.1	-47.3	-34.7
Paper, pulp and printing	0.5	-15.1	-5.5	-43.4	-12.5	-6.7	-3.3	-2.2	-45.0	-7.7
Fertilizers	9.2	-22.3	-16.5	-51.7	-35.6	-17.4	4.2	-13.4	-91.7	-16.1
Organic chemicals	11.4	-23.1	-17.7	-53.1	-38.2	-17.9	4.7	-16.2	-93.5	-17.7
Inorganic chemicals	7.4	-21.3	-14.2	-48.3	-30.4	-16.3	6.4	-15.3	-80.0	-14.9
Other chemicals, rubber, plastic	22.2	-30.0	-33.5	-71.7	-49.0	-21.9	3.7	-71.3	-98.0	-29.9
Cement	-1.4	-20.0	-9.1	-45.0	-38.5	-31.5	-1.0	-6.2	-64.0	-38.6
Bricks, tiles, construction products	-0.6	-20.2	-10.6	-45.1	-43.1	-33.6	-1.2	-8.0	-64.3	-44.9
Glass	2.3	-20.4	-13.5	-55.0	-51.4	-35.1	2.2	-2.8	-72.3	-45.7
Ceramics	3.0	-19.2	-9.1	-47.4	-47.7	-38.2	1.2	-2.7	-79.3	-43.6
Other non-metallic minerals	11.1	-29.3	-25.9	-85.3	-57.8	-45.1	2.4	-23.9	-73.4	-59.1
Iron and steel - manufacturing	2.5	-15.2	-5.7	-25.1	-29.3	-17.8	-2.0	17.6	-70.2	-21.5
Iron and steel - further processing	2.3	-16.7	-7.6	-28.7	-46.5	-20.4	1.9	24.9	-82.5	-30.3
Aluminium	6.8	-11.7	-4.5	-51.8	-40.7	-45.1	-7.3	46.3	-58.0	-30.8
Other non-ferrous metals	5.9	-12.5	-5.1	-51.4	-42.1	-41.5	-9.7	36.3	-55.1	-30.9
Electricity	-27.2	-29.7	-9.2	-33.5	-58.8	-9.4	26.2	52.7	-61.8	-39.8
Air transport	14.9	-28.1	0.5	-33.0	-41.4	-20.9	-7.3	-12.0	-30.0	-6.3
Crude oil	-17.8	-27.4	0.0	-50.2	-31.5	-27.8	0.0	-32.0	-12.9	-10.0

Table 64: Selected results of changes in sectoral output (% change vs. baseline) in Scenario 4 – 2050

Sectoral output (% change vs. baseline)	European Union	China	South Korea	India	United States	Brazil	Switzer-land	Norway	Russia	Turkey
Refined oil and coal products	1.7	-63.2	-24.8	-69.0	-58.3	-58.3	-49.5	-44.1	-47.3	-34.7
Paper, pulp and printing	0.5	-15.1	-5.5	-43.4	-12.5	-6.7	-3.3	-2.2	-45.0	-7.7
Fertilizers	9.2	-22.3	-16.5	-51.7	-35.6	-17.4	4.2	-13.4	-91.7	-16.1
Organic chemicals	11.4	-23.1	-17.7	-53.1	-38.2	-17.9	4.7	-16.2	-93.5	-17.7
Inorganic chemicals	7.4	-21.3	-14.2	-48.3	-30.4	-16.3	6.4	-15.3	-80.0	-14.9
Other chemicals, rubber, plastic	22.2	-30.0	-33.5	-71.7	-49.0	-21.9	3.7	-71.3	-98.0	-29.9
Cement	-1.4	-20.0	-9.1	-45.0	-38.5	-31.5	-1.0	-6.2	-64.0	-38.6
Bricks, tiles, construction products	-0.6	-20.2	-10.6	-45.1	-43.1	-33.6	-1.2	-8.0	-64.3	-44.9
Glass	2.3	-20.4	-13.5	-55.0	-51.4	-35.1	2.2	-2.8	-72.3	-45.7
Ceramics	3.0	-19.2	-9.1	-47.4	-47.7	-38.2	1.2	-2.7	-79.3	-43.6
Other non-metallic minerals	11.1	-29.3	-25.9	-85.3	-57.8	-45.1	2.4	-23.9	-73.4	-59.1
Iron and steel - manufacturing	2.5	-15.2	-5.7	-25.1	-29.3	-17.8	-2.0	17.6	-70.2	-21.5
Iron and steel - further processing	2.3	-16.7	-7.6	-28.7	-46.5	-20.4	1.9	24.9	-82.5	-30.3
Aluminium	6.8	-11.7	-4.5	-51.8	-40.7	-45.1	-7.3	46.3	-58.0	-30.8
Other non-ferrous metals	5.9	-12.5	-5.1	-51.4	-42.1	-41.5	-9.7	36.3	-55.1	-30.9
Electricity	-27.2	-29.7	-9.2	-33.5	-58.8	-9.4	26.2	52.7	-61.8	-39.8
Air transport	14.9	-28.1	0.5	-33.0	-41.4	-20.9	-7.3	-12.0	-30.0	-6.3
Crude oil	-17.8	-27.4	0.0	-50.2	-31.5	-27.8	0.0	-32.0	-12.9	-10.0

AP 3 – Indirektes Carbon Leakage

7 National compensation schemes for indirect CO_2 costs within the EU Emissions Trading Scheme

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List of Abbreviations

Abbrevation	Meaning
BIS	Department for Business Innovation and Skills in the United Kingdom
BME	Association Supply Chain Management, Procurement and Logistics
CO_2	Carbon dioxide
CPF	Carbon price floor
CPS	Carbon price support
DEHSt	German Emissions Trading Authority at the Federal Environment Agency
EBITDA	Earnings before interest, taxes, depreciation and amortization
ECB	European Central Bank
EU	European Union
EU-ETS	EU Emissions Trading Scheme
EUA	European Emission Allowances
EWI	Flemish Ministry of Economy, Science and Innovation
GBP	Pound Sterling
GW	Gigawatt
GWh	Gigawatt hours (measuring units for energy)
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
Klif	Norwegian Climate and Pollution Agency
LAGIE	Operator of Electricity Market in Greece
MWh	Megawatt hours (measuring units for energy)
NACE	Statistical Classification of Economic Activities in the European Community
NOK	Norwegian Krone
RVO	Netherlands Enterprise Agency
TWh	Terawatt hours (measuring units for energy)
VLAIO	Flanders Innovation and Entrepreneurship (government agency in Flanders)
WTO	World Trade Organization

7.1 Introduction: Compensation for Indirect CO_2 Costs within the EU ETS

In the presence of unilateral climate policies or differing stringency of greenhouse gas regulation across regions, carbon leakage might put the effectiveness of these policies at stake. The term carbon leakage describes an increase of greenhouse gas emissions in unregulated or less stringently regulated areas due to the relocation of emission-intensive production processes, offsetting (part of) the greenhouse gas emission reductions attributable to the domestic climate regulation. Carbon leakage therefore undermines the effectiveness of the unilateral (domestic) regulation.

The European Union Emissions Trading Scheme (EU ETS) was the first international greenhouse gas emissions trading scheme, establishing a price for greenhouse gas emissions in regulated energy and industrial sectors. Installations regulated under the EU ETS face direct compliance cost, i.e. the cost of the allowances needed for covering emissions (direct EU ETS costs). The main instrument chosen to ease the risk of carbon leakage resulting from direct costs is free allocation of emission allowances for specific sectors supposed to be the most vulnerable.

The focus of this report is on the so-called indirect EU ETS costs for electricity consumers, occurring from a rise in electricity prices which are due to direct CO_2 costs in power generation. Electricity-intensive production processes can be expected to be the most vulnerable to indirect CO_2 costs. In the absence of a fully integrated European electricity market, those costs vary not only across sectors but also across EU Member States, depending on the underlying structure of the power generation sector.

Under the EU ETS Directive (2003/87/EC) and its amendment in 2009 (2009/29/EC), national governments are allowed to provide direct state aid to compensate electricity-intensive production processes for indirect CO_2 costs due to the EU ETS from 2013 on.[102] The European Commission issued guidelines for compensation schemes (European Commission, 2012a; EU Guidelines) that provide a general framework for the design of those schemes and put a ceiling on the overall national compensation level. The implementation into national law is, however, optional and lies within the responsibility of each state subject to the EU ETS.

7.2 Comparison of Existing National Compensation Schemes

National compensation schemes for indirect CO_2 costs within the EU ETS have been implemented so far in eight EU Member States and Norway. The eight Member States are Belgium (Flanders), Finland, France, Germany, Greece, the Netherlands, Spain, and the United Kingdom. Most schemes are implemented for the period from 2013 to 2020. Spain had a test phase until the end of 2015 (Boletín Oficial del Estado, 2014). In mid-2017, the compensation scheme was extended beyond this period until 2020 (Boletín Oficial del Estado n°165, 2017). France implemented a scheme starting in 2016 with compensations for the year 2015 and extending until 2020. Finland implemented a scheme for the period from 2016 to 2020. In addition to the countries that have already implemented a scheme, Lithuania (DG Competition, 2015b) and Slovakia (DG Competition, 2015a) are planning to establish one in the future.

The EU Guidelines provide a general framework for the compensation of indirect CO_2 costs, determining a maximum list of eligible sectors and a maximum level of state aid per installation. Essentially, these guidelines put a ceiling on the overall national compensation level since

[102] From 2013 on, free allocation of emission allowances to the power generation sector was in general replaced by full auctioning with reference to the power producer's ability to pass on CO2 costs to their customers. Under Article 10c of the EU ETS Directive (2009/29/EC), eight Member States were allowed to continue free allocation to power generators (to a limited extent) until 2019.

countries are solely allowed to deviate downwards within their national implementations (i.e. by excluding sectors or choosing a lower level of compensation). Furthermore, countries decide about budget and aid granting period of their support mechanism as well as the amount of retention (i.e. the amount of electricity consumption for which indirect costs are not compensated), the modalities of application for the state aid (i.e. requirements for additional measures) and of the processing of grants (i.e. institution responsible for processing).

In the following, differences in national compensation schemes will be outlined along the following categories: institutions accountable for implementation of the compensation scheme and the application mechanism, national budgets and durations of the schemes, eligible sectors, calculation of state aid, and related figures such as aid intensity and proportionality. Finally, a brief conclusion about the actual implementation status of countries and an outlook on probable new states implementing such a scheme will be presented.

7.2.1 National Institutions Responsible for Indirect Cost Compensation

The affiliation of the institutions responsible for implementing, monitoring, and conducting the compensation scheme varies across countries. In Belgium, Finland, Germany, the Netherlands, Norway, and the United Kingdom, the institution in charge of conducting the affairs of the scheme is connected either to the (federal) department of Energy and/or Environment or to the Ministry for Economic Affairs and/or Energy and/or Environment. In Spain, the competences are divided between the Ministry of Economy, Industry and Competitiveness and the General Directorate for Small and Medium-Sized Businesses (Boletín Oficial del Estado, 2015). Whereas the former is in charge of announcements and decisions regarding the concession of state aid, the latter is responsible for proceedings in the granting process within the scheme (Boletín Oficial del Estado, 2015). In France, the following ministries directly carry out the procedures: the Ministry for the Environment, Energy and the Sea is responsible in the year 2016, while the Ministry for the Economy, Industry and Digitisation takes over the responsibility for the following years. In Greece, the state-owned power market operator is responsible for the budget and coordination of the compensation procedure (European Commission, 2014).

Table 65: National institutions responsible for compensation schemes

Country	Responsible Institution	Corresponding ministry / agency
Belgium	Flanders Innovation and Entrepreneurship (VLAIO), government agency for economic, innovation and enterprise policy in Flanders	Flemish Ministry of Economy, Science and Innovation (EWI)
Finland	Finnish Energy Authority (Energiavirasto)	Ministry of Employment and the Economy
France	The ministries	Min. of Environment, Energy and the Sea (2016); Min. of the Economy, Industry and Digitisation (2017-2020)
Germany	German Emissions Trading Authority (DEHSt) at the Federal Environment Agency	Ministry for Economic Affairs / Ministry for Environment
Greece	Operator of Electricity Market (LAGIE), State-owned electricity market operator	Ministry of Environment, Energy and Climate Change
Netherlands	Netherlands Enterprise Agency (RVO)	Ministry of Economic Affairs
Norway	Norwegian Climate and Pollution Agency (Klif)	Ministry for Climate and Environment
Spain	Ministry of Economy, Industry and Competitiveness, General Directorate for Small and Medium-Sized Businesses	Ministry of Economy, Industry and Competitiveness
United Kingdom	Department for Business Innovation and Skills (BIS)	UK Department for Energy and Climate Change

Notes: Own illustration based on European Commission (2012b, 2013a-2013d, 2014a, 2016, 2017), DEHSt (2015), ESA (2013), VLAIO (2016) and LAGIE (2016a).

7.2.2 Application Procedures

Companies may only apply for compensation of indirect CO_2 costs that occurred in the production of eligible products (EU Commission 2012a, Point 28). The application process works similarly in Belgium, Finland, France, Germany, the Netherlands, Norway, Spain, and the United Kingdom. The applicants have to submit a form to the institution that is accountable for carrying out the application and granting process (see table above). This form must contain data on production output, electricity consumption, and adjustments in production capacity as well as sources of electricity. Companies can apply for all of their installations collectively.

The **United Kingdom** introduced a carbon price floor (CPF) mechanism in 2013, which leads to a specific minimum price per ton of CO_2 in electricity generation.[103] The carbon price support

[103] The Carbon Price Support rate started at 16 Pound Sterling (GBP) per ton CO2 and is planned to be 18 GBP per ton CO2 from 2016 to 2020 (HM Revenue and Customs, 2014).

(CPS) is the difference between the carbon price floor and the EUA price. If the CPS is positive, i.e. the minimum price is binding, firms face an indirect cost that is higher than the sole EUA price as in other countries participating in the EU ETS. Therefore, the United Kingdom has introduced a compensation scheme to cover part of these indirect CPS costs additionally to the compensation of indirect EU ETS costs. The United Kingdom employs an additional test on the individual company level as a prerequisite for state aid. This test is based on the share of indirect CO_2 costs (sum of ETS and CPS costs) in gross value added (earnings before interest, taxes, depreciation and amortization (EBITDA) plus staff cost) on a company level, using a price of 19 Pound Sterling (GBP) per ton CO_2 (BIS, 2015).[104] Companies that apply for compensation of indirect CO_2 costs have to prove that this share would have been at least five percent on average for the period from 2005 to 2011 and above five percent in at least three years within this period (European Commission, 2012b; BIS, 2015). The aim of this additional test of eligibility is to account for companies that operate within the eligible sectors outlined by the carbon leakage list but are less exposed to electricity price increases (BIS, 2015). Furthermore, a quarterly submission and declaration about alterations in production capacity is an additional prerequisite for receiving state aid, which is also paid at a quarterly rate (BIS, 2015). The amount of compensation granted and received will be adjusted according to the level of production. Furthermore, the Department for Business Innovation and Skills (BIS) is allowed to carry out audits as well as checks of installations and businesses (BIS, 2015).

In the case of **Belgium**, companies send their application to a specific verification office and to Flanders Innovation and Entrepreneurship (VLAIO). The first body verifies the data and sends the final application as well as an audit report to VLAIO. The latter then makes the final decision about the grant application and calculates the amount of the state aid to be granted (VLAIO, 2016).

In **Germany**, the application is additionally examined by a chartered accountant before being sent to the German Emissions Trading Authority (DEHSt). Payment of granted aid occurs directly and on a yearly basis in arrears (DEHSt, 2015).

In the case of **Spain**, applicants must submit the application including relevant documents about electricity consumption and a filled questionnaire to the General Directorate for Small and Medium-Sized Enterprises. The Ministry of Economy, Industry and Competitiveness then decides about the amount of aid to be granted, and the decision is published on the Ministry's portal. The General Directorate for Small and Medium Sized Enterprises is responsible for completing the remaining process, i.e. actual payment of state aid (Boletín Oficial del Estado, 2015)

In **Greece**, the application procedure and processing is different compared to other countries. Companies apply for compensation to verification bodies that have been assigned to administer eligibility checks and notify the beneficiary's electricity supplier (see LAGIE, 2016b). The electricity supplier then charges the net retail tariff to the beneficiary. The tariff includes indirect CO_2 costs, but the calculated aid amount is already deducted. The electricity supplier then applies to the state owned wholesale market operator LAGIE for recovery of this aid amount (European Commission, 2014a).

In **France,** the application has to be submitted in electronic form directly to the responsible ministry which then checks the submitted demands and decides on the aid. The granting decision takes the form of a ministerial decree (European Commission, 2016).

[104] Monetary values are specified in real terms using 2007 as base year (BIS, 2015).

In **Finland**, the beneficiary has to provide all relevant information to the agency verified by an authorised independent verifier. The cost for the verifier thus lies with the beneficiary who moreover has to pay an application fee to the agency for handling the application. The application fee is estimated at 600 Euro and increases to 1900 Euro if the authority gives a decision on the baseline output, the baseline electricity consumption, or a significant capacity extension (European Commission, 2017).

7.2.3 Budget and Aid Granting Period

All countries with a compensation scheme with the exception of Spain, Finland, and France adopted an aid granting period from 2013 to 2020 as proposed in the EU Guidelines. Spain had a testing phase from 2013 to 2015 (Boletín Oficial del Estado, 2015) and later continued the scheme until the year 2020. The additional compensation scheme for indirect CPS costs in the United Kingdom is offered from 2014 to 2020. In 2016 France started to compensate for eligible costs incurred in 2015. Finland started its compensation scheme for the year 2016 and it extends until 2020.

The allocated budgets for the national compensation scheme of the respective states vary by size and financing source. Germany, the United Kingdom, Spain, and Norway each define the potential (maximum) state aid as a fixed absolute amount financed by the national budget.[105] Spain states a fixed budget financed by auction revenues of emission allowances. The Belgian and the Greece budget for compensation payments are financed by revenues from the auction of emission allowances and vary with the price for emission allowances. Consequently, Belgium and Greece do not refer to a specific budget in its national regulation document (European Commission, 2013a, 2014a). France provides aids directly out of the State budget. Finland provides an estimation of the necessary budget but does not fix a maximum amount. The aid is financed from EUA auction revenues, which are, however, treated similar to any other State revenue and cannot be bound to a specific purpose.

In the case of **Belgium**, the revenues from emission allowances auctions constitute the Flemish Climate Fund. This fund shall finance several measures for climate change mitigation and implementation of the Flemish Climate Policy (IEA, 2014a). The budget for the Belgian compensation scheme varies with the price of emission allowances between seven million Euros at an EUA price of one Euro per ton CO_2 and 113 million Euros at an EUA price of 15 Euros per ton CO_2 (European Commission, 2013a). To obtain a rough estimate of the Belgian budget for the compensation scheme in 2013 and 2014, the estimated number of emission allowances dedicated for the financing of the compensation scheme is multiplied with the respective average price in the previous year. From the budget range specified in European Commission (2013a), one can conclude that the revenue from approximately seven million auctioned emission allowances shall be used for the compensation mechanism. Multiplied with an average price per allowance of 7.93 Euro per ton CO_2 for 2013 and 4.68 Euro per ton CO_2 for 2014 (VLAIO, 2016), the estimated budget for the compensation scheme is approximately 56 million Euros in 2013 and approximately 30 million Euros in 2014. This is very close to the amount actually granted in those years, which corresponds to 49 million Euros in 2013 and 30 million Euros in 2014 according to VLAIO (2016).

[105] In Germany, the compensation scheme is financed by the Energy and Climate Fund, in which auction revenues are channeled as well. However, the fund can be supported by government contributions from the national budget.

The **United Kingdom** established a fund of 100 million GBP, which amounts to about 79 million Euros[106], for the spending period 2014 to 2015 to compensate certain energy-intensive enterprises from the additional indirect costs due to the implementation of the carbon floor price (European Commission, 2014c).

In **Greece**, at most 20 percent of annual revenues from emission allowance auctions are used for the compensation scheme (Government Gazette of the Greek Republic, 2014, Article 6). Therefore, the budget varies with the CO_2 price and is estimated to be between 14 million Euros at a CO_2 price of five Euro per ton CO_2 and 20 million Euros at a CO_2 price of 7.50 Euro per ton (European Commission, 2014a). Given that data on the actual annual budget is currently not available, it is estimated for 2013 and 2014 by means of an approach similar to the one presented for Belgium, with a price of 7.93 Euro per ton CO_2 in 2013 and 4.68 Euro per ton CO_2 in 2014. The price is multiplied by a factor of 2.7 million, which is the amount of auctioned allowances dedicated for the budget specified in the previous mentioned range at a price of 7.50 Euro per ton CO_2. Such an approximation leads to estimated budgets of around 21 million Euros for 2013 and about 13 million Euros for 2014.[107]

Table 66: Budget and financing sources for compensation of indirect costs from 2013-2015

Country	Financing	Budget (in million Euros)
Belgium	Revenue from EUA auctions	2013 – 2015: 7 – 113 per year depending on EUA price[108]
Finland	Revenue from EUA auctions	compensation started only for 2016
France	National budget	Estimated total for 2015-2018: ~364; Ø per year: ~91; no binding limit.
Germany[109]	Revenue from EUA auctions / National budget[110]	2013: 350; 2014: 203; 2015: 245
Greece	Revenue from EUA auctions	5 – 20 per year depending on EUA price
Netherlands	Revenue from EUA auctions	2013: 77[111]; 2014: 50[112]; 2015: 50
Norway[113]	National budget	Total 2013-2020: ~302; Ø per year: ~38
Spain	National budget	2013: 1; 2014: 1; 2015: 4
United Kingdom[114]	National budget	2013: 10; 2014: 79; 2015: 79

[106] The exchange rate is from ECB (2016a) retrieved on 22 March 2016

[107] Note that the prices used for 2013 and 2014 are very similar to those specifying the budget range in European Commission (2014a).

[108] 49 million Euros were granted in 2013 and 30 million Euros in 2014 (VLAIO, 2016).

[109] 312 million Euros were granted in 2013 and 186 million Euros were granted in 2014 (DEHSt, 2016).

[110] The compensation scheme is financed by the Energy and Climate Fund, in which auction revenues are channeled as well. However, the fund can be supported by contributions of the government from the national budget.

[111] 55 million Euros were officially granted (WTO, 2015).

[112] An amount of around 32 million Euros was actually paid (RVO, 2016b).

[113] The exchange rate from ECB (2016b) is used retrieved on 18 March 2016.

[114] The budget refers to ETS and CPS compensation schemes. The annual budget for the CPS compensation is the annual average of the overall budget. The CPS has not been introduced in Northern Ireland. Consequently, the compensation scheme targets only Great Britain. The exchange rate from ECB (2016a) was retrieved on 22 March 2016.

Source: European Commission (2012b, 2013a-2013d, 2014a, 2014c, 2016, 2017), DEHSt (2015), ESA (2013), IPYME (2016), RVO (2016a)

The **Dutch** budget for 2013, according to the World Trade Organization (WTO), amounted to 77 million Euros. However, only 55 million Euros were actually granted (WTO, 2015). The budget for 2014 amounts to 50 million Euros according to RVO (2016a).

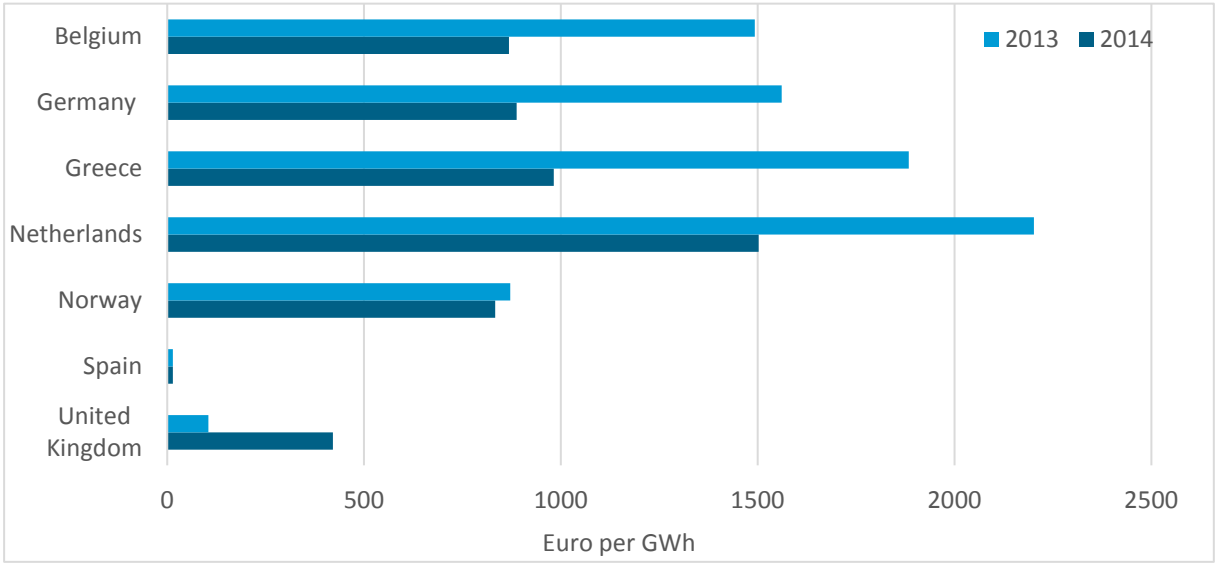
The **Finnish** estimated budget is approximately 149 million Euros for the period 2016 to 2020. The annual costs incurred vary from 22 million Euros for 2018 to 43 million Euros for 2016. The aid will be funded by Finland's EU allowance (EUA) auctioning revenues, which are estimated to exceed the maximum amount of aid in the period 2016-2021 (European Commission, 2017).

The provisional **French** budget is set to an amount of 364 million Euros for the years 2015 to 2018 and is granted in the form of direct State aid (European Commission, 2016).

The **Norwegian** budget is expressed for the whole period from 2013 to 2020 and amounts to 2,840 Norwegian Krone (NOK) in total (ESA, 2013), which is approximately 302 million Euros. This is equivalent to 355 NOK (approx. 38 million Euros) on average per year (ECB, 2016b; retrieved on 18 March 2016).

For **Spain**, so far six million Euros have been attributed in the national budget for 2016 (Boletín Oficial del Estado n°182, 2017). The budget is therefore smaller by more than a magnitude compared to the estimated maximum amount that could have been granted according to the EU guidelines (European Commission, 2013d, paragraph 2.5 -8-b, p. 3).

Figure 64: National budget for indirect EU ETS cost compensation relative to industrial electricity consumption



Notes: Own illustration based on European Commission (2012b, 2013a-2013d, 2014a), DEHSt (2015), ESA (2013), RVO (2016a) and data obtained from Eurostat (2016). Belgian budget is estimated as described and Norwegian budget is equal to the annual average of the total budget for 2013 to 2020. The budget of the United Kingdom is the budget dedicated to ETS compensation only. The latter is assumed to be equal to the annual average. The annual Greece budget is estimated as described in the main text. Note that Spain had only a test phase until 2015.

A comparison of the absolute budgets is not particularly meaningful given the national differences in industry sizes and accordingly, the industrial electricity consumption. Therefore,

the absolute budget relative to industrial electricity consumption will be compared in the following. The annual absolute budgets are divided by the industry electricity consumption in each year stemming from Eurostat (2016). Industry electricity consumption encompasses the electricity consumption by all industrial sectors, except for energy production (i.e. refineries, power plants and coke ovens).[115] This figure is used to focus on the potentially compensated industrial electricity consumption. The aggregate includes electricity consumption of eligible and non-eligible sectors. Optimally, one would like to use only electricity consumption from eligible sectors. However, this data is not available for all countries. Nonetheless, budgets relative to industrial electricity consumption should account to a certain degree for the relative size of the industrial sector in each country. The relative budgets appear to be rather similar in Germany, Belgium, Norway, Greece, and the Netherlands, with the latter two having the largest relative budget in 2013 and 2014, respectively. The United Kingdom and Spain provide smaller relative budgets. The decrease in relative budgets from 2013 to 2014 reflects the decrease in absolute budgets that followed the underlying emission allowances price development. This observation hints at the mechanism that budgets are often financed by auction revenues. Hence, the source of funding varies by the emission allowances prices.

National budgets determine the maximum compensation amount for eligible companies. The actual uptake by firms depends on the extent of eligible installations within each country and the carbon cost that companies can be compensated for, which again depends on the emission allowance price (however the price in the previous year, see Section 1.1.5 for details).

7.2.4 Eligible Sectors

All countries studied here that have introduced a national compensation scheme comply apply the full list of sectors stated in the EU Guideline (Annex II) without exceptions.[116] This list refers to energy-intensive sectors that are most exposed to the risk of carbon leakage due to indirect CO_2 costs of the EU ETS. Quantitative criteria for the selection are trade intensity (larger than 10 percent) and indirect CO_2 costs relative to gross value added (larger than five percent) of the sectors. Trade intensity is defined in the EU Guideline (Annex II) as the ratio of the value of exports and imports from non-EU states relative to the total size of the EU-market for a particular sector (annual turnover from EU companies). Although countries are prohibited to amend the list of eligible sectors, they are allowed to exclude certain sectors, and as long as it does not interfere with the European state aid rules (European Commission 2012c; European Commission 2012a, Annex II).

Electricity supply contracts that do not contain indirect CO_2 costs are not considered eligible in the application process (EU Guidelines, European Commission 2012a, Point 11). Additionally, Germany, Norway (ESA, 2013), and the United Kingdom explicitly state that self-generated electricity from plants not under regulation of the EU ETS is not eligible for the application for state aid. Self-generated electricity produced by fossil fuels in installations regulated under the EU ETS, however, is eligible for compensation and is valued with the same emission factor as electricity purchased “from the grid”. Furthermore, Germany explicitly excludes self-generated electricity from installations which have a claim to remuneration under the German Renewable Energy Act in order to avoid accumulation of aid and over-compensation of installations.

[115] Refineries are also eligible to receive indirect EU ETS cost compensation incurred in the production of chemical products, e.g., manufacturing of other organic basic chemicals under NACE Rev. 1.1, code 2414 (EU Commission, 2012a).

[116] To operate in at least one of these sectors is also a prerequisite for companies in the United Kingdom taking the additional test on the company level (European Commission, 2014b).

There are some additional restrictions for eligibility and the application process that vary across countries. Germany explicitly excludes companies that are undertaking an insolvency process or any kind of legal enforcement procedure. Spain explicitly states that companies that bear tax liabilities are excluded from the application process and therefore are not eligible for compensation.

Belgium and the Netherlands refer to energy efficiency measures that need to be taken in order to apply for compensation. In case of the Netherlands, companies must commit to long-term agreements on energy-efficiency ("MEE" for EU ETS installations and "MJA" for non-ETS installations). This long-term agreement is negotiated between the government and the respective companies and is intended to promote energy savings. The energy-efficiency agreement includes developing an energy efficiency plan, implementation and further investigation of energy saving measures (RVO, 2016b). The Belgian regulation on the compensation of indirect CO_2 costs refers to (not-specific to this aid) measures for improvement of energy-efficiency (European Commission, 2013a). These include agreements within the Third Flemish Energy Efficiency Action Plan (Belgian NEEAP, 2014, Annex III) among other things regular "energy audits", energy efficiency requirements for industrial installations (building standards), or an energy efficiency investment that is eligible for the "ecological premium", i.e. a subsidy that is granted depending on characteristics of the specific investment (IEA 2014b).

7.2.5 Calculation of State Aid

The maximum amount of state aid for an individual installation is calculated using the following formula as stated in the EU Guidelines, which is applied by all countries.

$$A_{max,t} = AI_t \times C_t \times P_{t-1} \times E \times BO$$

The maximum aid amount per installation for products in the eligible sectors for period t ($A_{max,t}$) is calculated by multiplying the aid intensity (AI_t) with the applicable CO_2 emission factor (C_t), the previous year's EUA price (P_{t-1}), the applicable electricity efficiency benchmark (E) and the baseline output (BO). Hereby, maximum aid intensity is defined as the share of costs eligible for state aid. The CO_2 emission factor is set by each country studied here up to the maximum emission factor specified in the EU Guidelines. The EUA price is defined as the average of the previous year's (t-1) daily EUA forward prices for delivery in December of year t[117]. The electricity efficiency benchmark is defined as the product-specific electricity consumption per ton of output (MWh per ton) using the most efficient production method and has been determined on a product basis by the EU Commission (European Commission, 2012d). The baseline output is defined as the installation's average output in the period 2005 to 2011 for the products eligible for state aid. In cases where there is no specified energy efficiency benchmark, a fallback energy efficiency benchmark is used and multiplied with basis electricity consumption, which is the average electricity consumption in the period 2005 to 2011. This fallback energy efficiency benchmark is set at 0.8.

Germany employs a slight alteration regarding the values used for calculation. This refers to a possible deviation of the actual output from the baseline output (average of annual output) in a specific year. If actual output falls below baseline output, actual output is used to calculate the maximum amount of aid (European Commission, 2013b; point 11a + 11b). **Belgium** uses such an approach as well (VLAIO, 2016).

[117] For the compensation of CPS costs in the United Kingdom, the EUA price is substituted by the CPS rate in the respective year (European Commission, 2014b). The CPS thus operates as a scaling factor for eligible companies within the United Kingdom.

Generally, if the country's budget is not sufficient to compensate all applicants, the budget will be distributed proportionally across the beneficiaries. Therefore, it is possible that an installation actually receives less compensation than it should theoretically get according to the formula provided by the guideline. This underlines the importance of the national budget sizes. These will only matter for cross-country comparisons, if national budgets are not sufficient to cover all valid compensation applications, i.e. the national budget constraint is binding. Among the countries studied here, Spain appears to be the only country with such a case.

7.2.6 Aid Intensities, Proportionality, Compatibility, and Monitoring

With the objective of maintaining incentive compatibility and encouraging further energy efficiency measures, the EU Guidelines limit the maximum amount of compensation to 85 percent of the costs eligible for the compensation. This corresponds to the (maximum) aid intensity and is further lowered to 80 percent of eligible costs in the years from 2016 to 2018 and to 75 percent of eligible costs in 2019 and 2020. With objective justification, countries are free to choose smaller aid intensities. However, almost all countries apply the maximum amount of aid intensity as stated in the EU Guidelines (European Commission, 2012a, Point 26), with Finland being the only exception. Finland in contrast chose to apply a maximum aid intensity of 40 percent of the eligible costs incurred in 2016, 2017, and 2018, and 37.5 percent of the eligible cost incurred in 2019 and 2020 (European Commission, 2017).

All studied countries with a compensation scheme use the maximum emission factors for the respective region as specified in the EU Guidelines. Consequently, in Belgium, France, Germany and the Netherlands (Central-West Europe region), the applied emission factor is 0.76 ton CO_2 per MWh. For Spain (Iberian region) the emission factor is 0.57 ton CO_2 per MWh, whereas for Norway and Finland (Nordic region) it is 0.67 ton CO_2 per MWh. In the case of Greece and the United Kingdom, the emission factors are 0.82 and 0.58, respectively. This differentiation among the regions according to the regional emission factor occurs due to the differences across the countries in their electricity generation mix. According to the EU Guidelines, the regional CO_2 factor is defined as the weighted average of CO_2 intensity from electricity that is generated from fossil fuels in different geographic areas.

Differences across national compensation schemes, however, exist in the amount of retention. Finland, Germany, Belgium, and the Netherlands only grant compensation for installations with an annual electricity consumption of more than one Gigawatt hour (GWh). Norway sets this threshold even higher to 10 GWh per year per installation. Furthermore, the exact definition differs. Whereas in Germany the complete indirect CO_2 costs up to one GWh have to be borne by the installation (DEHSt, 2016), the amount of retention as specified in the Dutch rules makes use of the aid calculation formula and hence, takes the aid intensity into account (RVO, 2016a). This means that the individual installation in the Netherlands does not have to carry the complete indirect CO_2 costs of the first GWh but only up to the aid intensity. Spain, the United Kingdom, and Greece do not specify an amount of retention.

It is explicitly stated in the EU Guidelines that state aid is limited to the least amount necessary (European Commission 2012a, Point 5). In order to minimize distortions in competitiveness, the state aid is designed to be as small as possible but as large as necessary (proportionality). The maximum amount of state aid must not (independent of the source (state aid, European aid)) exceed 85 percent of total CO_2 costs. This percentage decreases further over time to avoid aid dependency and to preserve incentives of the EU ETS. Consequently, cumulation of state aid payments (i.e. due to additional local aid) is not possible. Otherwise aid is deducted or not granted at all. In the national implementations, there are no exceptions to this rule.

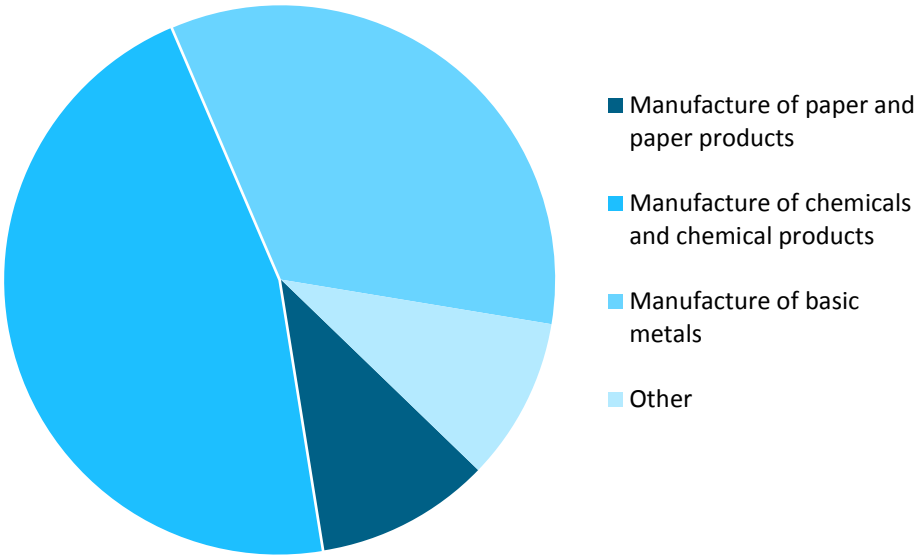
According to the EU Guidelines, countries with a national compensation scheme are obliged to submit annual reports to the European Commission. These reports must include a list of sectors and applicants, reports on capacity amendments or reductions, the baseline production for each installation in each sector, and relevant key figures used for calculation of the aid amount (such as the EUA forward price used, aid intensity and the applied emission factor).

7.2.7 State of Implementation as of 2016

A final report or assessment on the compensation for indirect CO_2 costs in **Germany** is available (DEHSt, 2016).

For **Belgium**, there is data on the distribution of compensation payments across aggregated industries from VLAIO (2016). In 2013, the sector "Manufacturing of chemicals and chemical products" (NACE Rev. 2 code C20) has the highest share with 46 percent, followed by "Manufacture of basic metals" (NACE Rev. 2 code C24) with 34 percent and "Manufacture of paper and paper products" (NACE Rev. 2 code C17) with 10 percent. Overall, these three aggregated sectors account for over 90 percent of the total compensation payments.

Figure 65: Share of aggregated industries in total compensation payments in Belgium in 2013



Source: Own illustration based on data from VLAIO (2016).

In the case of **Greece**, annual reports for 2013 and 2014 have been submitted to the European Commission, but are not publicly available (LAGIE, 2016c). LAGIE (2014) and LAGIE (2015) offer a list of companies that have been compensated. This allows to concluding roughly on a distribution of sectors from which firms are applying for compensation in 2013 and 2014. The majority of firms are from the sector "Manufacture of base metals" (NACE Rev. 1.1 D27) with a share of 51 percent in 2013 and 53 percent in 2014 of all applicants. The sector "Manufacture of pulp, paper and paper products" (NACE Rev. 1.1 D21) and the sector "Manufacture of chemical and chemical products" (NACE Rev. 1.1 D24) have a share of 21 (24) and 17 (18) percent in 2014 (2013), respectively. The rest of the firms applying for compensation are from the sector "Manufacturing of textiles" (NACE Rev. 1.1 D17).

According to the **Netherlands** Enterprise Agency (RVO) the scheme opened for the first time in 2014 for costs incurred in 2013. In 2014 RVO received applications for compensation from 82 firms (83 in 2015). There is no information about the distribution of applicants available (RVO, 2016b).

Upon request, the **Spanish** General Directorate for Industry and Small and Medium-sized Businesses replied that the application and concession process has not come to an end yet. Therefore, neither a final report concerning the results of the application process nor any more details regarding the actual implementation of the compensation scheme have been published.

Upon request, the **UK** Department of Business Innovation and Skills (BIS) replied that the BIS provides annual statements exclusively for the European Commission and not for the public due to confidentiality reasons.

7.2.8 Prospects of Additional States Compensating Indirect CO_2 Costs as of 2016

In addition to the seven countries that have already implemented a compensation scheme, two more countries plan to introduce such a scheme, namely Lithuania and Slovakia.

Slovakia submitted a proposal for a compensation scheme for energy-intensive industries to the European Commission in November 2015. Although the European Commission decided not to raise any objections after scrutinizing the legislative draft, the public version of the decision is not yet available. The Slovakian compensation scheme covers the same industry sectors as specified in Annex II of the EU Guidelines and is planned to endure until 2020 (DG Competition, 2015a).

Lithuania has submitted a proposal in May 2015. The compensation scheme is planned for a duration until 2020. In December 2015, the European Commission refused to raise any objections after scrutinizing the legislative draft (DG Competition, 2015b).

7.2.9 Summary: Comparison of Existing National Compensation Schemes

The following table summarizes the differences in national compensation schemes across countries. Although the EU Commission issued general guidelines on compensation schemes and existing national schemes mainly use the maximum aid intensity (with the notable exception of Finland) and maximum number of sectors, they differ in particular along three dimensions. These include the available budget, the (maximum) emission factor and the amount of retention. Whereas the maximum emission factor is determined by the EU Commission (2012a), countries are able to decide on their budget and amount of retention. Differences in retention may lead to differences in compensation payments for comparable companies depending on in which country they are located. The differences in available budget might be partly reflected by differences in industrial structure. However, comparing budgets relative to country's industrial electricity use shows that this might not be the only factor explaining differences in national budgets across countries. Given that compensation payments will be curtailed, if the sum of it surpasses the annual budget, comparable companies may receive different compensation payments depending on whether or not the budget in the respective state is exhausted.

Table 67: Summary: Comparison of national compensation schemes

	DE	BE	NL	NO	ES	UK	EL	FR	FI
Maximum aid intensity granted	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Additional sectors excluded	No	No	No	No	No	No*	No	No	No
Emission factor (t CO_2 per MWh)	0.76	0.76	0.76	0.67	0.57	0.58	0.82	0.76	0.67
Retention (GWh per installation)	1	1	1	10	n.a.	n.a.	n.a.	n.a	1
Aid granting period	2013 - 2020	2013 - 2020	2013 - 2020	2013 - 2020	2013 - 2015	2013 - 2020	2013 – 2020	2015- 2020	2016- 2020
Financing: EUA auctions or National Budgets	Auc-tion; Budget	Auc-tion; Budget	Auc-tion	Budget	Budget	Budget	Auc-tion	Budget	Auc-tion
Mandatory energy efficiency plan	No	Yes	Yes	No	No	No	No	n.a.	n.a.

Notes: Germany: Company must not be in insolvency or legal procedure. Spain: Company must not have any tax liabilities. *Companies have to pass an additional test.; ** Test phase with the option of extension (Boletín Oficial del Estado, 2014); *** Compensation for indirect CPS costs started in 2014.
Own illustration based on European Commission (2012b, 2013a-2013d, 2014a, 2014c,2016, 2017), DEHSt (2015), ESA (2013). "n.a." denotes that it is not specified in the national scheme.

7.3 Regional Differences in Compensation Schemes against the Backdrop of Regional Electricity Markets

The previous section provides a comparison of the current national compensation schemes. This section discusses the implication of different schemes against the background of the lack of a united, fully integrated EU-wide electricity market. Important adjustments for the individual country within the EU Guidelines are the additional exclusion of eligible sectors, reduction of maximum aid intensity, CO_2 emission factors, the overall budget and additional requirements, such as mandatory energy efficiency plans or the absence of tax liabilities. However, the compensation schemes currently in place are largely in line with the EU Guidelines concerning the eligible sectors, aid intensity, and CO_2 emission factors. Whereas the first two items do not differ across countries, the CO_2 emission factors are specified accordingly to the maximum regional emission factors that has been determined in the EU Guidelines. Within this guideline, the only partially integrated electricity market is considered in so far as the maximum emission factors vary across geographic regions. These geographic regions shall demonstrate the limited degree of integration of electricity markets within the EU.

Thus, differences in emission intensities in regional electricity markets are likely to be important when assessing the impact of the different national compensation schemes. In addition to emission intensities, differences in pass-through rates in the respective countries or geographic areas need to be taken into account, i.e. the rate with which additional costs will be actually passed-through.

First, the economic background of CO_2 cost pass-through is presented. Second, a descriptive analysis of the electricity market characteristics for the relevant geographic areas is conducted, i.e. in regions in which countries have already implemented a compensation scheme (Belgium, Germany, Greece, the Netherlands, Norway, Spain, and the United Kingdom). Third, the descriptive analysis is complemented by a literature review of empirical evidence on cost-pass through in countries with a compensation scheme. This may give a first indication of differences in compensation schemes against the background of incompletely integrated EU-wide electricity market.

7.3.1 Pass-through of Emission Costs: Economic Background

The indirect emission costs, which are in the focus of this report, can be derived from the pass-through of emission allowance prices on electricity wholesale markets. Indeed, the idea of emissions trading is to make pollutant emissions costly such that economic agents consider this cost in their decision making. Limiting the emissions from economic activities to the volume of issued emission allowances has the potential to make these allowances scarce. The scarcity leads to a price which makes allowances valuable. Firms will reflect this value when polluting, so the emission price becomes a cost, even if it might be just the opportunity cost of foregone revenues from selling the allowance.

The pass-through of opportunity costs can be studied as any other pass-through of input costs in similar industries. The economic rationale of those agents which finally determine the price in markets further down the production chain should be at the core of the analysis. The electricity industry is in no way any special in that respect as long as the cost structure and price formation process is correctly studied.

The non-storability of electricity requires that demand and supply are equal in virtually every point in time. Electricity demand varies throughout the day, and (wholesale) prices fluctuate accordingly from hour to hour. Because demand is very insensitive to prices, the price typically rises just to the necessary level such that the owner of the last plant, necessary to satisfy demand, is also willing to produce. This is widely referred to as the “marginal plant”.

The term “cost pass-through” often refers to the effect of a cost increase in the industry on market prices. In the electricity sector, however, the price of emission allowances affects the production costs of technologies very differently, depending on the emission intensity of the corresponding fuel. The different cost structure of plants, however, also determines that not all plants are equally likely to be the marginal plant. Those plants which produce without being marginal – the “infra marginal plants” – are not price setting. Therefore, their emission cost should not affect the pass-through rate on the market.

If cost pass-through is to be studied on the market level, the focus should be set on the emission intensity and the resulting emissions costs of those plants which are marginal in most of the hours throughout the year. Setting the average emission intensity of the sector as the benchmark will therefore necessarily lead to an inconsistent measure of the price effect of emission costs in power markets. The sign of this bias depends on the structure of electricity production. When the marginal plant has a lower emission intensity than most of the infra marginal plants, the cost effect for this plant and, therefore, the effect on the market price should as well be lower than the cost effect for the average plant. Assuming a price effect according to the average intensity of electricity production will overstate the actual price effect which should realize under such conditions.

In most European electricity markets, the typical marginal plant is either coal or gas fired. As a rule of thumb[118], one could assume an approximate emission intensity of one ton CO_2 per MWh for electricity produced from hard coal and 0.40 to 0.50 ton CO_2 per MWh respectively for natural gas. Thus, one can expect that an increase of one Euro per ton CO_2 would increase the marginal cost of a coal plant by one Euro per MWh, whereas only 40 to 50 Eurocents per MWh for a natural gas plant. Aside of this rule of thumb for the effect on marginal costs, another open question concerns the rate of pass-through, which – theoretically – depends crucially on the level of competition in the market.

So the empirical questions to answer are the following. What plants are marginal and how large is the pass-through rate for these plants?

7.3.2 Characteristics of Regional Electricity Markets

In the EU Guidelines, geographic areas for regional electricity markets are outlined. Those areas were selected based on two criteria: market coupling of power exchanges and no declared congestions prevail. Furthermore, hourly day-ahead wholesale prices may diverge only by maximum one percent in a "significant number of all hours in a year" (European Commission, 2012a, Annex I).

Table 68: Geographic areas in the EU Guidelines and emission factors in national compensation schemes

Geographic Area	Countries	Emission factor (t CO_2 per MWh)
Central-West Europe	Austria, **Belgium**, France, **Germany**, **Netherlands**, Luxembourg	0.76
Iberia	Portugal, **Spain**	0.57
Nordic	Denmark, Sweden, Finland, **Norway**	0.67
Greece	**Greece**	0.82
United Kingdom	**United Kingdom**	0.58

Notes: Own illustration based on European Commission (2012a). Countries with national compensation schemes for indirect CO_2 costs in place before 2016 are in bold letters.

The emission factors per region were defined by the European Commission based on the weighted average of the CO_2 intensity of electricity produced from fossil fuels in different geographic areas. The weight reflects the share of each fossil fuel in gross electricity generation based on fossil fuels. Thus, the emission factors are not based on the CO_2 intensity of the marginal plants.

In the following, the structure of electricity generation within the geographic areas of countries that introduced a compensation scheme will be presented. This is important for the emission intensity of the marginal plants within each geographic area.

A first look at the share of installed capacity for the three main fossil fuels used in power generation reveals some differences across areas. In Central-West Europe, Iberia, and the United

[118] E.g. an average emission intensity of 93.6 tCO2 / MWh thermal has been reported for hard coal in Germany for 2011. With an efficiency rate of 33% at the plant level, this would translate into approximately 1 tCO2/MWh electric. For the very efficient hard coal plants with efficiency rates of 46%, the same fuel would translate into approximately 0.73 tCO2/MWh electric

Kingdom, natural gas-fired power plants form the largest part of the fossil capacities. Greece has a large stake (25 percent) in lignite, with the other fossil fuels being less prominent. Installed capacity of fossil fuels in the Nordic region is relatively sparse. Traditionally, Sweden, Finland, and Norway are relying on a large share of hydro power. The sum of installed capacity of fossil fuels vary across geographic areas, starting with 23 percent for the Nordic region, with a range from 30 to 50 percent for Greece (31 percent), Central-West Europe (38 percent) and Iberia (45 percent) to the United Kingdom with the largest share of 73 percent.

Table 69: Share of fossil fuels in total installed capacity for power generation

Geographic Area	Installed Capacity (GW)	Natural Gas	Hard Coal	Lignite	Other fossil	Total share of fossil fuels
Central-West Europe	398	18%	10%	5%	5%	38%
Iberia	124	31%	10%	1%	3%	45%
Nordic	105	7%	8%	0%	8%	23%
Greece	18	2%	0%	25%	4%	31%
United Kingdom	82	40%	30%	0%	3%	73%

Notes: Own illustration based on ENTSO-E (2014). Numbers are rounded to integers.

However, figures about installed capacity give only an indication on the potential CO_2 intensity of power generation. The actual emission intensity depends on the actual usage rates of power plants which are depicted in Table 70. Whereas the share of fossil fuels in power generation is similar to its share in installed capacity in Central-West Europe (34 percent) and Iberia (37 percent), it deviates in the other three regions. Fossil fuels contribute only nine percent to total net generation in the Nordic region and in the United Kingdom fossil fuels account for 59 percent. A special case is Greece having a share of 72 percent and where actual production relies heavily on lignite, although it just accounts for a quarter of installed capacity. The disparity of installed and used capacity is due to the different cost structure of base load plants, such as the lignite plants in Greece, and the more expensive peak load plants which are typically gas fired.

Table 70: Share of fossil fuels in total net power generation

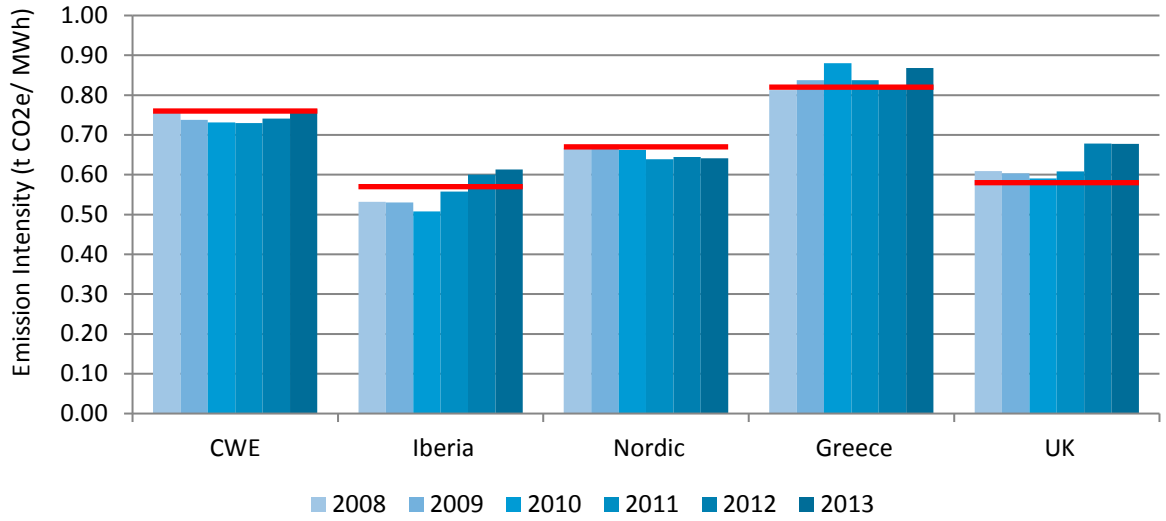
Geographic Area	Total Generation (TWh)	Natural Gas	Hard Coal	Lignite	Other fossil	Total share of fossil fuels
Central-West Europe	1,322	6%	9%	11%	8%	34%
Iberia	316	17%	16%	1%	3%	37%
Nordic	390	3%	5%	0%	1%	9%
Greece	41	16%	0%	56%	0%	72%
United Kingdom	372	25%	28%	0%	6%	59%

Notes: Own illustration based on ENTSO-E (2014). Numbers are rounded to integers.

Based on data from IEA (2009-2016), emission intensities of gross electricity generation by fossil fuels are calculated for the years 2008 to 2013.[119] Those intensities exhibit differences across the geographic areas as well as across time within the areas. Compared to the emission factor used in the national compensation schemes, it becomes clear that for Central-West Europe and the Nordic region the emission factors are set at the maximum of the calculated emission intensities. For Iberia, Greece, and the United Kingdom, the emission intensities appear to be higher in certain years than the specified emission factor.

However, one has to keep in mind that those figures are average values taking into account CO_2 emissions and electricity generation from all fossil power plants. The simple share of fossil fuels in electricity generation may be less relevant for the indirect carbon costs than it seems. The price relevant emission intensity – which would determine indirect carbon costs – would be determined by the emission intensity of the (supposedly price setting) marginal power plant. According to the classic merit order model, renewable energy sources, nuclear power plants, or lignite fired plants are most likely not marginal, while hard coal, natural gas, or oil fired plants typically are. Thus, a closer look at the generation portfolios is advisable to get a better picture of the actual indirect carbon costs. Furthermore, the emission intensity is only equal to the cost burden if the cost-pass through is complete. Thus, these technically derived figures can only provide a first approximation to the economically relevant indirect CO_2 costs within the different geographic areas.

Figure 66: Average emission intensity of electricity generation by fossil fuels in geographic areas



Notes: Own illustration based on data from IEA (2009, 2010, 2011, 2012, 2013, 2014c, 2015) and IEA (2016). Red horizontal lines depict the respective maximum emission factor as specified in the EU Guidelines.

[119] Emission intensity is the sum of CO2 emissions in electricity and heat generation within the geographic area divided by the gross electricity generation from fossil fuel power plants in the respective area. CO_2 emission data are taken from IEA (2009-201). The emission factors for different fuels used by the IEA are from IPCC (1996) for years up to 2013, and from IPCC (2006) for years from 2013 onwards. Data on electricity generation is from IEA (2016).

7.3.3 Empirical Findings on the Cost Pass-through of Emission Allowance Prices

7.3.3.1 General overview on empirical studies on cost pass-through

A number of empirical studies on the cost pass-through of emission allowance prices in Europe have been published, some of them in highly renowned scholarly journals. Many of the studies are mainly interested in the rate of pass-through for the marginal plant (e.g. Fabra and Reguant, 2014; Hintermann, 2016). Other studies rather focus on elasticities, meaning a percentage change of power prices in response to a one percent change in the EUA price (Lo Prete & Norman, 2013; Kirat & Ahamada, 2015). Thus, it is not always straightforward to conclude what effect in Euro per MWh one can expect from a change in the CO_2 price. The following paragraphs screen this literature for evidence on pass-through in electricity markets of the relevant countries with compensation schemes for indirect CO_2 costs.

Wherever possible, we focus on contributions which consider pass-through in phase II of the EU-ETS and which express their results in Euro per MWh. If such evidence is available, we dare to skip the literature that only considers phase I or which provides results that do not translate easily into evident pass-through rates.

7.3.3.2 Germany

A number of researchers have studied cost pass-through for the German power market (in fact, the German-Austrian price zone). Mokinski and Wölfing (2014), while focusing on phase I, also provide evidence for the effect of emission allowance forward prices on electricity futures for the time period of 2009 to 2012. They find that an increase of one Euro per ton CO_2 causes an increase of about 0.64 Euro per MWh base load electricity. A symmetric response is found for a corresponding decrease. The 90 percent confidence bands range from about 0.50 to 0.80 Euro per MWh. Fell et al. (2015), using a slightly different data set and methodology, find a pass-through of about 0.90 Euro per MWh for an increase of one Euro per ton CO_2 for base load electricity prices, and even higher pass-through rates for peak load prices. The latter result is especially unintuitive as peak load plants in the German electricity system are typically less carbon intensive compared to base load plants. Confidence bands are not provided. Hintermann (2016) employs a stylised merit order model to identify the emission intensity of the marginal plant, and finds for the period from 2010 to 2013 a pass-through rate of 0.8 to about unity, but with strong dependence on the load level, again with higher cost pass-through during peak hours which is quite counter-intuitive. While the marginal emission intensity is estimated and used by the author, it is not reported, thus not allowing expressing price effects in Euro per ton of CO_2.

Taken together, a pass-through of 0.50 to almost 1 Euro per MWh for each Euro per ton of CO_2 for base load electricity is a range of pass-through which is supported by the empirical literature. The upper bound of this range would be equivalent to a complete cost pass-through of a coal fired power plant while the lower bound could result from a complete cost pass-through with mainly gas and sometimes coal fired plants being at the margin. The composition of the German power system would indeed rather support the latter scenario. Thus, a pass-through rate towards the lower end of this span appears plausible. Corresponding modelling evidence is provided by Sijm et al. (2008, p. 207).

7.3.3.3 Scandinavian Countries

Both, Norway and Finland, belong to the Nordic market which integrated their electricity markets very early on in the deregulation process. While on short term, price differences

between the national markets might exist in some hours, the wholesale market operator still provides a common system price which has been studied for pass-through by Fell (2010). The author finds short run price effects for a one Euro increase of the price for CO_2 between 0.7 and 0.9 Euro per MWh for base load and lower levels during peak load hours, which is consistent with less carbon intensive plants being at the margin. The author moreover reports a counter movement in the longer run which reduces the overall impact of a one Euro per ton CO_2 increase in the price of carbon rather to the level of 0.40 to 0.60 Euro per MWh. Fell et al. (2015) report higher pass-through rates for the Nordic market of about 0.50 and one Euro per MWh for one Euro per ton CO_2 for peak load and base load, respectively. As before, the latter research article stands out with higher estimates compared to other findings. Overall, the literature is in line with the view that a complete pass-through of marginal costs occurs with mainly gas plants, and sometimes coal plants setting the price.

7.3.3.4 Spain

Fabra and Reguant (2014) provide the most complete and methodologically most advanced study of carbon cost pass-through at hand of Spanish firm level data.[120] They can separate the effect of a change in the price of CO_2 on marginal costs from the effect on mark ups of firms and moreover are also able to identify what plant is price setting during a specific hour. Overall, they find pass-through rates which are indistinguishable from one and almost no change in the mark ups of firms. They moreover report the average marginal emission rates over different hours of the day which vary from about 0.83 ton CO_2 per MWh at 6am to around 0.64 ton CO_2 per MWh at 10pm. The average over the day would be about 0.70 to 0.75 ton CO_2 per MWh. With a hundred percent cost pass-through, these average marginal emission rates are equivalent to the average effect of emission prices on power prices.[121]

7.3.3.5 United Kingdom

Fezzi and Bunn (2009) provide estimation results for the interaction between the day-ahead prices for CO_2, natural gas, and electricity in the United Kingdom. Unfortunately, the authors opt to estimate elasticities which do not allow concluding on the pass-through rate. The effect of an increase in emission prices is expressed in relative terms: a one percent increase in the price of emission allowances leads to an increase in about 0.32 percent in the price for electricity (Fezzi and Bunn, 2009). Obviously, such a measure translates into very different average effect of emission prices on power prices in monetary terms at an emission prices of around 10 Euro per ton CO_2 (as in June 2006) compared to a price of almost 30 Euro per ton CO_2 (as in April 2006). While the level of pass-through is already unclear within sample, extrapolating pass-through levels out of sample for this study is not advisable.

7.3.3.6 Netherlands and Belgium

Fell et al. (2015) report pass-through rates also for the Netherlands which are close to what they find for Germany, but even higher. Here, base load electricity prices react with an increase of one Euro per MWh for every Euro increase in emission allowance prices. The findings for peak load prices are even above one Euro which would imply that a gas plant which is likely to be marginal in the Dutch energy system most of the time would adjust prices by the double of its actual cost shock. From an economic point of view, this could only be plausible when other factor co-vary

[120] The authors have microdata on firm's individual bids, technical information and market results which allows them to identify the marginal plant together with its heat rate and to estimate a structural econometric model which captures strategic considerations on mark-up adjustments.

[121] The results hold for the wholesale electricity market in Spain. The extent of a CO2 cost pass-through on end-use prices remains unclear since end-use prices are regulated to a certain extent according to European Commission (2014d).

with emission prices, i.e. the market power of the price setting plant. Lo Prete and Norman (2013) also estimate the interaction of CO_2 and energy prices for a couple of countries, but again with a different methodology which makes comparisons difficult. Moreover, the authors do not provide estimates for the aggregate impact in form of impulse responses as most other time series studies do. Thus, we refrain to read out any exact numbers from this study. Nevertheless, as a cross check, one can compare the individual parameters of the estimation of Lo Prete and Norman (2013) across countries, and find that the long run effect of an increase in CO_2 prices on Dutch and Belgium electricity prices compares to the effect they observe for the German market. Their study therefore supports the approach to consider the cost pass-through in Germany, the Netherlands, and Belgium to be quite similar.

7.3.4 Summary: Regional Differences in Compensation Schemes against the Backdrop of Regional Electricity Markets

The EU Guidelines specify for each geographic area a maximum emission factor used in the calculation of the individual maximum state aid. Within the national compensation schemes, the emission factor is found to be set to this maximum value. Thus, the choice of the maximum emission factors appears to be crucial.

The emission factors on the Guidelines are based on average emission intensities of fossil fuel generated electricity in geographic areas. This report provides corresponding average emission intensities from 2008 to 2013, and finds indeed that they are largely in line with the emission factors set in the EU Guidelines and adopted from the individual countries in their compensation scheme. Exceptions are Iberia, Greece, and the United Kingdom where electricity generated from fossil fuels appears on average to be a bit more emission intensive than the emission factor specified in the EU Guidelines.

Table 71: Empirical studies on cost pass-through in electricity markets

Country / Region	Studies	Period	Price Elasticity (log(EUR/MWh) / log (EUR/tCO_2))	Cost pass-through rate (Δ cost / Δ price)	Price pass-through ([EUR/MWh] / [EUR/tCO_2])
Germany	Mokinski & Wölfing, 2014	2009-2012	n.a.	n.a	0.64 (base)
	Fell et al., 2015	2008-2011	n.a.	n.a	≈0.9 (base); ≈ 1.1 (peak)
	Hintermann, 2016	2010-2013	n.a.	≈ 0.9 but varying with load	n.a.
Scandi-navia	Fell, 2010	2005-2008	n.a.	n.a	≈0.4-0.6 in the longer run
	Fell et al., 2015	2008-2011	n.a.	n.a	1 (base); 0.5 (peak)
Spain	Fabra, & Reguant 2014	2004-2006	n.a.	1	0.63 - 0.84 depending on hour
	Fell et al., 2015	2008-2011			0.4 (base)

Country / Region	Studies	Period	Price Elasticity (log(EUR/MWh) / log (EUR/tCO₂))	Cost pass-through rate (Δ cost / Δ price)	Price pass-through ([EUR/MWh] / [EUR/tCO₂])
United Kingdom	Fezzi & Bunn, 2009	2005-2006	0.32	n.a	n.a.
Nether-lands	Lo Prete, & Norman, 2013	2007-2010	similar to Germany		similar to Germany
	Fell et al., 2015	2008-2011			for NL: 1 (base) 1.1-1.2 (peak)
Belgium	Lo Prete, & Norman, 2013	2007-2010	similar to Germany		similar to Germany

However, these average emission intensities are only a rough approximation of the extent of indirect CO_2 costs as they also include CO_2 emissions and electricity generation from infra marginal power plants. Indirect CO_2 costs for electricity users are most likely determined by the marginal plants alone. We have screened the literature for empirical findings on the price effect from CO_2 prices on electricity prices and found a variety of approaches and results. One way of identification is to search for the marginal plants and their emission intensity, and then to study the cost pass-through of these plants. Another approach is to skip the stage of cost calculation and marginal plants, and to study the interaction of CO_2 prices and electricity prices directly. The findings can then be compared to the emission intensity of 'typical' marginal technologies such as hard coal or gas fired plants. Overall, there is little evidence that costs are not passed-through completely, but the exact judgement could only be made when the marginal plants are known. Only one study for Spain succeeds in doing so convincingly (Fabra and Reguant, 2014).

To the best of our knowledge, there are no empirical studies on the estimation of pass-through of emission cost in Greece. For the United Kingdom there are no empirical studies on the emission intensity of the marginal power plant. The presented empirical literature on cost pass-through in Germany, Belgium, the Netherlands, and Spain as well as in the Nordic market area supports the notion of a complete pass-through of CO_2 emission costs. Thus, the issue of differences in the degree of competition appears to be negligible for the extent of indirect CO_2 costs. This leads to the conclusion that the average emission intensity of the marginal power plants should determine the amount of indirect CO_2 costs in each country and geographic area, respectively.[122] Put differently, the indirect CO_2 costs should reflect the marginal emission intensity.

Comparing the emission factors with the estimated levels of pass-through in the empirical literature, some deviations are apparent. Belgium, Germany, and the Netherlands have a comparable CO_2 cost-pass through in a range of 0.50 to one Euro per MWh. This could correspond to a complete pass-through of CO_2 costs with a mixture of gas and coal fired power plants being at the margin. An emission factor within this range appears to be reasonable and also coincides with the emission factor set for Central-West Europe (0.76). However, the range appears to be rather wide. Mokinski and Wölfing (2014) find on average a price effect of 0.64

[122] As there is no evidence for the United Kingdom and Greece on this matter, caution should be applied when transferring this result to these two countries.

Euro per MWh for an increase of one Euro per ton CO_2 for Germany and Austria. This would be lower than the emission factor for Central-West Europe.

The most striking deviation in the empirical literature from the emission factors specified in the EU Guidelines and implemented in the national compensation schemes is for Spain and the Iberian region. Fabra and Reguant (2014) find on average an emission factor of 0.70 to 0.75 depending on the hour of the day. This is larger than the 0.57 ton CO_2 per MWh, which is applied in the compensation scheme. Even the lower bound of the estimated emission intensity of about 0.64 ton CO_2 per MWh is larger than this emission factor. One limitation, which needs to be taken into account for transferring this result to the Iberian Region, is that the analysed market area is only on a national level, whereas the geographic area in the EU Guidelines includes Portugal as well.

7.4 Potential Sources of Firm Specific Variation of Indirect CO_2 Costs

Aside of the general eligibility criteria, the compensation schemes for indirect CO_2 costs in the EU do not account for firm specific factors. The following pages discuss in how firm characteristics might affect the appropriateness of possible compensation payments from the current uniform schemes. When firms within the same jurisdiction differ in terms of the CO_2 cost per MWh they bear, and when such factors are not taken into account in the design of the compensation scheme, this might result in significant under- or overcompensation of different firms, and thus impose a distortion between firms and sectors.

The determinants of indirect CO_2 costs that have been discussed throughout this report can be categorised into four main factors:

- The CO_2 price paid by the power producer
- The CO_2 intensity of power production
- The rate of pass-through of CO_2 costs to electricity customers
- The procurement and consumption portfolio of electricity consumers

The previous sections of this report have evaluated potential differences along the first three of the named factors across member states. The first point, i.e. the CO_2 price paid by power producers, has been argued to be the same across the EU (with an exception for the UK which has a carbon price floor at work) due to a highly integrated and flexible market for emission allowances. Even more so, it is safe to argue that CO_2 prices do not exhibit any systemic differences for different power producers of relevant size within the same member state. The second and third point, i.e. CO_2 intensity of power productions and the rate of pass-through to electricity consumers, has been discussed on the aggregated level, but not yet on the firm level. The following pages take this discussion together with the fourth point, the procurement portfolio of electricity consumers, to the firm level, considering potential differences across firms within the same jurisdiction. The arguments made in the following should largely apply to the situation in most member states, but they are mainly exemplified based on the situation in Germany.

7.4.1 Emission Intensity of Power Production and Pass-through of Emission Costs

The CO_2 intensity of power producers varies across production technologies and fuels. This, however, does not necessarily imply that two producers with differing emission intensities adjust prices according to their individual emission intensity when CO_2 prices change. Electricity

produced from fossil fuels is a homogenous product, meaning that the output of fundamentally different technologies is a perfect substitute from the consumers' perspective. From an economic point of view, this is a strong indication that the law of one price should govern such a market. If prices between two producers differ, either consumers could do better by buying from the cheaper supplier or one of the producers could do better by adjusting its price upwards to a price just slightly below the price of the competitor. In essence, one can expect that all trades within such a market will close at the same price. Thus, when two gas-fired plants with comparable technology are competing, they will lower prices to their marginal costs, which just reflect their emission intensity. Thus, the emission intensity of the marginal plant will determine the amount of carbon cost that is priced in. Taking this argument one step further, when producers with different CO_2 intensities would adjust their output prices according to their individual emissions costs, this would result in differing electricity prices, and thus in a situation which contradicts economic intuition. More explicitly: a coal fired power plant with higher emission intensity might experience a different shock to its marginal cost when carbon prices increase. But as long as it is not becoming marginal, the price it earns on the market will still be determined by the emission intensity of the marginal plant.

This theoretically evident argument, however, still has to withstand an empirical assessment. There is plenty of empirical evidence for price dispersion and/or price discrimination even for seemingly homogeneous product markets. A straightforward example are electricity prices on the household consumer level which vary greatly across different suppliers while very little switching from consumers is seen in these markets. Apparently, even in homogeneous product markets certain market frictions can lead to a divergence from the law of one price. For household consumers, an evident friction is individual costs for searching a new supplier and the paperwork involved which keeps households from switching to better offers. This gives rise to a certain level of market power on the supplier's side that can be used to depart from a uniform market price (see e.g. Heim, 2016, or Gugler et al., 2016).

Switching costs of this kind are unlikely to be relevant on the level of industrial consumers where the procurement is carried out by professionals. Still, there are other possible reasons for market power, which might allow for price discrimination between industrial consumers. A salient example of price discrimination with respect to CO_2 cost dates back to the first phase of the EU-ETS in 2007 when emission allowances where grandfathered free to electricity producers. Deutsche Bahn AG, the largest electric power consumer in Germany, negotiated procurement contracts for the railway electrification system which contained specific clauses for dynamic price adjustments. Interestingly, according to Deutsche Bahn officials, these contracts explicitly forbid the supplier to price the opportunity costs of emission allowances (see Bühler et al. 2009, p. 69). This was in stark contrast to the power exchange market where CO_2 costs were very well reflected in the overall price level (see Mokinski and Wölfing, 2014). This is an evident example of price discrimination favouring Deutsche Bahn over wholesale customers procuring their electricity on the exchange market. The privilege of Deutsche Bahn AG to spare these costs was gone with the end of the free allocation in 2012.

The case of Deutsche Bahn AG witnesses two forms of market power: On one hand, there must be some mark-up in the general price level which allows suppliers to sell with a discount to a privileged customer and still stay profitable. On the other hand, Deutsche Bahn AG apparently was able to use its market power as the largest electricity consumer in the country to appropriate parts of the rents from the power producers. While such a case was apparently possible up to 2009 (see Bühler et al. 2009), it appears to be very unlikely most recently. The reason is a dramatic change of the market conditions. With overcapacities in power production,

increasing shares of renewable energies and a weakened position of formerly dominant oligopolists, the market for electric power became ever more competitive (see e.g. Monopolkommission, 2015). In 2016, wholesale prices were on a level which puts conventional generators partly out of business. Such a market situation can easily be classified as price competition in homogenous products which wipes out profit margins for most power generators. Lacking sufficient margin on top of their costs, power producers cannot afford to discriminate between customers. The law of one price applies again which makes firm specific variation in the rate of CO_2 cost pass-through very unlikely.

7.4.2 Electricity Prices in Dependence of the Consumption Portfolio of Electricity Consumers

Having argued that the law of one price most likely applies on the wholesale market and in bilateral contracts, one might still wonder if consumption portfolios and different procurement strategies result in different indirect carbon costs across firms. While the law of one price rules within a market for a homogenous good, electric power is indeed homogenous only when being consumed at the very same time in a very comparable contract. Different consumption patterns could lead to different exposure of firms to peak load versus base load prices. One might wonder if firms with different load profiles are exposed to different indirect carbon costs. The difficulty that prevails is to separate the actual carbon costs that are reflected in the different hourly prices. The literature review presented before shows that such a differentiation appears to be empirically challenging.

Another concern which could be raised is that there are differences in the type of procurement contract that firms sign which might be relevant for the indirect carbon cost. Firms might buy directly on the wholesale market, they might negotiate with generators or trading firms on indexed contracts, or they might conclude simple bilateral service contracts with a supplier, resembling the service contracts for household or small enterprises. Average prices for these different strategies will obviously differ, because all these strategies differ substantially in the distribution of price and volume risks between the consumer and the supplier. Differentiated energy prices (even before charges and taxes) are thus not necessarily an indication for price discrimination, but could also reflect risk hedging services that come with one contract but not with the other.

Empirically, actual procurement strategies of firms would be hard to observe in reality. Such information is kept secretly for competitive reasons. On a more sectoral level, however, it is possible to evaluate the information on procurement strategies that consulting firms, electricity suppliers, or industry associations provide to their potential clients or members, thus getting a more indirect perspective on what procurement strategies and motives might guide the electricity consuming firms. The "Association Supply Chain Management, Procurement and Logistics" ("Bundesverband für Materialwirtschaft, Einkauf und Logistik"), for example, publishes as a service to its members a brochure on energy procurement strategies (BME, 2014). The document states that the "bargaining potential for the procurement officer is limited to the fraction of the energy price which constitutes the profit margin for the provider" (BME, 2014, p. 45).[123] A number of constituents of this margin are named, but emission costs are clearly not part of it. Emission costs, in contrast, are mentioned as a part of the drivers of the wholesale price for electricity (BME, 2014, p. 47) which is said to be not disputable. In summary,

[123] „Das Verhandlungspotential des Energieeinkäufers ist auf den ‚im Energiepreis enthaltenen Margenanteil' des Lieferanten begrenzt.", ibidem

the BME states that mainly the profit margin, the share of peak and base load and the flexibility and risk of the contract are negotiable variables for the procurement costs of electricity.

7.4.3 Summary: Firm Specific Factors

Firm specific variation of indirect CO_2 costs within the same market area and jurisdiction appears to be undetectable. Of the potential reasons that have been discussed – mainly differing emission intensities of suppliers, price discrimination, and procurement strategies – only one aspect appears to have continued relevance: the potential of different shares of peak load versus base load consumption across firms which gives them different exposition to the corresponding hourly prices. With different power plants being marginal along the load curve, such differences in the consumption pattern might indeed result in varied exposure to indirect CO_2 costs. Unfortunately, it does not appear to be feasible to identify the differences of the marginal carbon intensity along the load curve with sufficiently high precision to warrant a solid identification of such firm specific differences in indirect emission costs.

7.5 Conclusion

This report presented the different national compensation schemes for indirect CO_2 costs in the context of the EU ETS and assessed several potentially aid-determining factors. The EU Guidelines provide a general framework for individual countries that must be complied with. The main differences in national compensation schemes appear to be the budget size dedicated to compensation payments (in absolute terms as well as in relation to national industrial electricity consumption), the amount of retention (electricity consumption per installation that is not compensated), the aid intensity, and the applicable emission factor.

Differences in national budgets would be relevant for cross-country comparisons only if the overall applications for state aid within one country would sum up to a number which exceeds the national budget. In this case, the individual aid would be proportionally lowered for all successful applicants. In this case, companies in this country would receive a smaller state aid amount than a comparable company in a different country, in which the budget is not completely exhausted. Consequently, discrimination within the EU based on the allocated national budget for compensation would occur. So far, Spain appears to provide the only case where budget restrictions actually limit the amount of state aid granted. Given that actual compensation figures are only accessible for a limited number of countries and years, this finding is preliminary and should be treated with caution.

Furthermore, the amount of retention within national regulations on the compensation of indirect costs varies. Since such rules directly influence the amount of compensation for the individual eligible company within one country, this could be a potentially source of different compensation payments for (comparable) companies in different countries.

Concerning aid intensity, Finland provides the only example of a compensation scheme which does not grant the maximum, but limits aid intensity to about half of this maximum. All other countries exhaust the potential aid intensity as specified in the guidelines.

Related to the emission factors that vary across defined geographical areas within the EU, differences in cost pass-through across countries and geographic areas appear to be crucial. The actual indirect CO_2 costs theoretically depend on the pass-through rate, i.e. the fraction of CO_2 price changes that is passed on to electricity prices as well as on the average emission intensities of the marginal power plants. The empirical literature supports the view of an almost complete pass-through rate. Hence, the indirect carbon cost within each region should by reflected by the

(average) CO_2 intensity of the marginal power plant(s). The estimated values in the empirical literature in some cases diverge from the emission factors set out in the EU Guidelines (EU Commission, 2012a). For Germany and Austria, Mokinski and Wölfing (2014) find an average price effect of 0.64 EUR/MWh per EUR/tCO_2, which would be lower than the emission factor for Central-West Europe. However, one has to keep in mind that those (point) estimates are subject to uncertainty and regional definitions may be different for the emission factors set out by the EU Commission and the empirical studies. Thus, except for the case of Spain/Iberia, the emission factors in the EU Guidelines appear to remain within a reasonable range.

The legal framework does not account for potential firm specific differences in the need for compensation. The report argues that such differences would matter if firms would be faced with substantially different degrees of indirect tCO_2 cost internalisation. It is argued based on theoretical considerations and actual observations that such firm specific factors are indeed not of higher relevance and the omission of such firm specifics does not reflect any shortcoming of the general framework for indirect emission cost compensation.

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8 Compensation for indirect CO_2 Costs within the EU Emissions Trading Scheme

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List of abbreviations

Abbrevation	Meaning
CO_2	Carbon dioxide
COP	Conference of the Parties
EPC	Electricity price compensation
EU-ETS	EU Emissions Trading Scheme
F-gases	Fluorinated greenhouse gases
FTIP	Federal Transport Infrastructure Plan
GHG	Greenhouse gas
HGV	Heavy goods vehicle
ICAO	International Civil Aviation Organization
IMO	International Maritime Organization
KSBV	UBA-study Klimaschutzbeitrag des Verkehrs bis 2050 [UBA, 2016a]
NDC	Nationally Determined Contributions (in Paris-Agreement)
NEDC	New European Driving Cycle
N2O	Nitrous oxide (laughing gas)
PJ	Petajoule (energy measuring unit)
PtG	Power-to-Gas (any power-based gaseous fuels)
PtL	Power-to-Liquid (any power-based liquid fuels)
RDE	Real Driving Emissions
TWh	Terawatt hours (measuring units for energy)
UNFCCC	United Nations Framework Convention on Climate Change
WLTP	Worldwide Harmonized Light-Duty Vehicles Test Procedure

8.1 Introduction

With the preparation of the third phase of the EU ETS (2013-2020) and the associated introduction of auctioning as the guiding principle of allocating permits to Member States and sectors, the importance of measures to alleviate carbon leakage was acknowledged. Thereby, two main instruments were established. In order to combat direct carbon leakage, which emerges through GHG emissions arising directly in the sectors covered by the EU ETS, those sectors being particularly at risk of carbon leakage (due to their high energy intensity and/or trade exposure) may receive a certain amount of their permits by means of free allocation. On the other hand, to alleviate effects of indirect carbon leakage, which arises through passing through increasing electricity generation costs caused by pricing GHG emissions to industrial sectors, those sectors may receive a compensation on their electricity price.

This report focuses on the latter type of carbon leakage and on policy measures relating to it. Its aim is twofold.

1. Existing and potential future designs of the electricity price compensation will be examined with the support of a computable general equilibrium model in order to be capable of finding effects of this policy caused by economic interrelation such as intermediate production and international trade. As this model is of rather macroeconomic nature, the design of the policy instruments are stylized to a certain degree.
2. Options for the further development of the electricity price compensation will be presented. Thereby, a special emphasis will be put on economic and legal aspects.

The analysis draws on information presented in section “AP3 Teil 1” (“National compensation schemes for indirect CO_2 costs within the EU Emissions Trading Scheme”) of this report .

The remainder of this report is structured as follows. Section 2 describes the PACE model, which is used to analyse impacts of different policy design options, and its extensions introduced to perform this analysis. Section 8.3 introduces the different policy scenarios to be examined. Section 8.4 presents and interprets the results of the modelling analysis. Section 8.5 presents options for further developing the compensation, and Section 8.6 summarizes and concludes.

8.2 Model description

The quantitative assessment of the electricity price compensation for sectors affected by indirect carbon leakage is carried out with PACE (Policy Analysis based on Computable Equilibrium), a multi-sector, multi-region computable general equilibrium (CGE) model of global production, consumption, trade and energy use. PACE is established in economic research and policy consulting and has, for instance, been employed in various previous studies, in particular with respect to the analysis of different design options of the EU ETS in Phase 3 and Phase 4. The following gives a short overview of PACE’s features.

8.2.1 The PACE model

The PACE model includes representations of production sectors, consumption, taxation, and trade calibrated to a globally balanced set of social accounting matrices (SAMs). Production sectors take market prices as given and choose input factors (capital, labour, energy, intermediates) such that production costs are minimized. Perfect market competition forces them to sell their produced goods at zero profit. Similarly, representative consumers take market prices as given and choose their consumption such that they get maximum utility out of their budget. The representative households receive revenues from offering the production

factors they own (labour, capital, and resources) to the production sectors. In the model version used in this study, we assume one representative household per region. Prices of all produced commodities and production factors are set such that markets for the respective goods clear. Governments raise taxes to finance fixed amounts of government services and transfer net surpluses to households.

In order to discuss climate policy, the PACE model tracks the value flows of energy commodities: crude oil, refined oil, natural gas, coal, nuclear power, renewable energy sources and electricity. The use of the fossil fuels refined oil, natural gas, and coal in production and consumption are linked to CO_2 emissions from burning those fuels for the production of energy. The model thus only considers CO_2 emissions, namely those from fossil fuel combustion and process emissions. PACE adds emission permits as a resource owned by the governments and lets market clearance conditions determine the price at which the fixed supply meets demand. In case of the EU ETS, permits may be traded across the EU for use by industrial sectors included in the EU ETS. Emissions in non-EU countries are governed by national policies and are non-tradable across regions, but free markets guarantee that all emitters face the same carbon price within each country. In order to best represent the Effort Sharing Decision, we assume trading of fictitious non-ETS permits across regions so that marginal abatement costs in those sectors are equalized.

In the exercises performed in this report, revenues from carbon pricing go to the government and are refunded to the national representative households.

8.2.2 Extension: Electricity price compensation

The work in this report builds upon AP3, Task 3.1 of this project (see p. 254 ff.) in which the reader can also find the respective explanations on the calculation of the electricity price compensation. For the sake of this study, the model is enhanced with a subsidy on the output of selected sectors to represent the electricity price compensation. This subsidy takes one of the following two forms.

Aid intensity x Emission factor x EUA price x Benchmark x Electricity efficiency x Output

or

Aid intensity x Emission factor x EUA price x 0.8 x Electricity consumption.

In the former representation, the compensation level depends on the current output level which is translated to electricity consumption by multiplying it with the electricity efficiency (electricity consumption divided by output level, both in the base year 2010). The compensation in this case works as an output subsidy. In order to represent adjustments in the output level, we use current output levels for each model year. In reality, however, output levels of a base year are used which are subject to adjustments if a reasonable increase or decrease of those levels occurs. The output based electricity consumption is multiplied with a sector-specific benchmark (represented by the ratio of the compensated electricity consumption within actual electricity consumption), which was provided by the client. The emission allowance price (EUA price) is taken directly from the model and is an (endogenous) result of the model simulations. The emission factors were provided through the work carried out in project task 3.1 and are based on the guidelines on certain State aid measures published by the European Commission.[124] The aid intensity is the share of electricity costs caused by carbon pricing that is eligible for state aid (determined by the formulas above) which the sectors are compensated for and decreases until 2030.

[124] Communication from the Commission: Guidelines on certain State aid measures in the context of the greenhouse gas emission allowance trading scheme post-2012. SWD(2012) 130 final, SWD(2012) 131 final, 2012/C 158/04.

The latter formulation assumes that the electricity price compensation level is based on current electricity consumption. In this case, the compensation works as an electricity consumption subsidy. Here, we assume that 80% of electricity consumption are compensated (fallback factor).

The values of the parameters are depicted in the scenario descriptions in Section 8.3 where scenario variants with both formulations are introduced.

8.2.3 Data and calibration

For this report, the PACE model is calibrated using the globally harmonized Social Accounting Matrices (SAMs) for the reference year 2011 provided in the GTAP 9.1 data set of the global trade analysis project (GTAP). Regional and sectoral coverage used for the model are given by Table 72 and Table 73, respectively.

Within the European Union we consider the five largest economies of the Western European Member States (Germany, France, the United Kingdom, Italy and Spain) as well as Poland as the largest economy of the Central and Eastern European Member States as separate regions. The remaining EU countries are gathered in two groups: "Rest of Western MS", "Rest of Central and Eastern MS".[125]

The most significant developed and developing economies outside the EU are included as separate regions as well. Here, we focus on the most important German trading partners.

Table 72: Regional coverage of the PACE model

Acronym	Region
DEU	Germany
FRA	France
GBR	United Kingdom
ITA	Italy
ESP	Spain
POL	Poland
XWE	Rest of Western MS (Denmark, Sweden, Finland, Austria, Belgium, Netherlands Luxembourg, Ireland, Portugal, Greece, Malta, Cyprus)
XEE	Rest of Central and Eastern MS (Czech Republic, Slovakia, Hungary, Slovenia, Bulgaria, Romania, Croatia, Estonia, Latvia, Lithuania)
USA	United States of America
RUS	Russia
CHE	Switzerland
NOR	Norway
TUR	Turkey
RAX	Switzerland, Norway, Iceland, Liechtenstein, Ukraine, Belarus, New Zealand

[125] In the model, this means that the data for all countries in each of these two regions are aggregated.

Acronym	Region
CHN	China (incl. Hong Kong, excl. Taiwan)
IND	India
BRA	Brazil
KOR	South Korea
ROW	Rest of the World

Regarding the sectoral coverage, the model version used distinguishes 36 production sectors, which include five for extractive activities, 26 for industrial activities and five for services.

Where sectoral coverage of the GTAP 9.1 database was not sufficient, we disaggregated the sectors using additional data sources.

To account for economic growth, we scale the national endowments of production factors according to country specific GDP growth projections. To account for technological progress, we model energy efficiency increases as declining energy requirements for production in different industries and in consumption. For different assumptions about the prices of energy goods, the availability of resources for the production of the energy goods is adjusted until the market prices were in line with the baseline projections. A baseline scenario is thus established for the model periods 2010 to 2050 using five-year time steps.[126]

In the case of the EU, the EU Reference Scenario 2016[127] is used to calibrate GDP, industrial energy efficiency improvements and developments in consumption of specific fuels by the power sector. On the policy side, the results from the Reference 2016 Scenario inform the assumptions about ETS permit prices in the baseline. Projections of fossil fuel prices in the Reference 2016 Scenario are used to inform global market prices for fuels. GDP and energy efficiency improvements of non-EU countries are projected according to the International Energy Outlook of the US Department of Energy (International Energy Outlook –IEO- 2013). At the sectoral level, the projections provided by the Reference 2016 Scenario are not as detailed as the PACE version used for this project. Therefore, Reference 2016 parameters with sectoral detail are disaggregated according to the corresponding shares of each PACE sector within the respective aggregate Reference 2016 sector. In particular, data on energy demand are considerably more detailed in the 2013 IEO and in GTAP than in the aggregated Reference 2016 projections used for the calibration of the PACE model. CO_2 profiles are computed using demand for fossil fuels. To combine the advantages of both data sources, we use the growth rates of sectoral energy demands, not their absolute values, from Reference 2016 projections, whereas the fuel mix in each sector is computed according to IEO information. Nevertheless, we decompose the aggregate information on fossil fuel use provided in Reference 2016 using consumption shares from the IEO projections. To this end, we use energy inputs of the Reference 2016 scenario for the base year 2010 which are provided by fuel type for aggregate sectors (e.g. industry, electricity). To achieve a sectoral coverage as provided in the PACE model we use sectoral shares from GTAP and the IEO to decompose them for all model sectors. The temporal development, however, follows that of the model since it is identified endogenously.

[126] In the remainder, we will present ten-year time steps and only consider the time period until 2030.

[127] For reasons of readability, EU Reference Scenario 2016 and Reference 2016 will be used analogously.

Note, however, that emissions in the PACE baseline scenario cannot completely match with the Reference 2016 emissions. This is due to the fact that CO_2 emissions rely not only on input values from external data sources but are endogenously computed within the model by using intermediate inputs from fossil fuels to the model sectors. Hence, the final outcome for this model variable depends on many other endogenous model variables and interrelations.

Process emissions are included for all model sectors in all model regions. To this end, we make use of process emissions data from the World Input Output Database (WIOD).[128] The advantage of this database is that the sectors are relatively similar to the PACE sectors and can thus be translated in a relatively straightforward fashion.

Table 73: Sectoral coverage of the PACE model

Main aggregates	Sectors
Extractive activities	Agriculture, forestry and fishing
	Coal production
	Crude oil extraction
	Natural gas extraction
	Mining, n.e.c.
Industry covered by EU ETS	Pulp and paper
	Refineries and coke oven production
	Fertiliser production
	Organic chemical production
	Inorganic chemical production
	Cement production
	Bricks and tiles production
	Glass production
	Ceramics production
	Basic iron and steel production
	Further processing of iron and steel
	Aluminium production
	Production of other non-ferrous metals
	Air transport
	Electricity

[128] http://www.wiod.org/home

Main aggregates	Sectors
Industry not covered by ETS	Food production
	Manufacture of textiles, wearing apparel and leather
	Manufacture of wood and wood products
	Other chemicals, rubber, plastics production
	Production of other non-metallic minerals
	Manufacture of electrical and electronic equipment
	Manufacture of machinery and equipment, n.e.c.
	Motor vehicles and parts
	Other transport equipment
	Other manufacturing
	Construction
Other services	Inland transport
	Water transport
	Business services
	Private services
	Public services

8.3 Scenario description

This section introduces the baseline scenario as well as the policy scenarios used in this study. Most of the results are presented as changes vis-à-vis the baseline scenario. The time horizon in this project task is the period up to 2030.

8.3.1 Scenario 1 (Baseline scenario)

The starting point is a baseline, which assumes compliance with the 2030 Framework in the EU and with the Nationally Determined Contributions (NDCs) in non-EU countries. This scenario corresponds with Scenario 2a in the model runs of work package 2 of this project. It includes:

EU CO_2 emissions reduction of 40% by 2030 compared to 1990 levels (corresponds to respectively 43% and 30% in the ETS and non-ETS sectors below 2005 levels)[129].

[129] Note that the PACE model only considers CO2 emissions. Policy targets are set for GHG emissions in general. In this study, we assume that the respective targets apply to CO2 emissions.

Distribution of efforts in the non-ETS sectors among Member States according to the new Effort Sharing Regulation.[130]

- Emissions reductions in other regions according to their NDCs by 2030,
- Lump-sum transfer of auctioning revenues to households.
- In non-EU regions, a split into ETS and non-ETS market segments equal to that of the EU is installed. Percentage CO_2 reduction targets in ETS and non-ETS sectors are the same.
- Emission permits are fully auctioned in all sectors in all regions.
- No electricity price compensation is implemented.
- In the EU, a target of 20% renewable energy share in gross final energy consumption by 2020 applies, which corresponds to 35% in the electricity sector; 27% renewable energy share in gross final energy consumption by 2030, which corresponds to 45% in the electricity sector.
- Table 74 summarizes the renewable energy targets translated for the electricity sector based on the EUCO30 scenario. The targets for the aggregate regions (Rest of Western MS, Rest of Central and Eastern MS) are identified by computing the weighted average with electricity demand.

Table 74: Assumed renewable energy targets in electricity sector based on EUCO30 scenario

Model region	2020	2025	2030
France	31.5	36.4	37.2
Germany	34.9	37.6	45.6
Italy	32.5	44.9	51.9
Poland	14.3	20.7	26.5
Spain	38.5	54.9	68.8
United Kingdom	41.1	46.7	49.9
Rest of Western MS	47.5	53.1	62.1
Rest of Central and Eastern MS	23.0	28.3	36.3

This baseline scenario is built on GTAP 9.1 data and the EU Reference 2016 Scenario, so that EU energy and emissions figures are as close as possible to those of the latter.

- The surplus of emissions allowances – which has accumulated in recent years – and the Market Stability Reserve are imposed in an exogenous manner.
- The specific reduction targets for each model year are given in
- Table 75 and follow the EU Decarbonisation Roadmap.

[130] In practice we do not fully represent each MS target but the reductions in the non-ETS sectors are simulated by carbon trading between those sectors, in order to represent the fact that the Effort Sharing Regulation is driven by an attempt to equalize costs between Member States. This explains why we report a carbon price for the non-ETS sectors in the report.

Table 75: Pathway to achieve reduction targets in the EU

Year	Reduction targets vs. 1990 (%)
2005	7
2010	12
2015	18
2020	25
2025	33
2030	40

The ratio between issued ETS permits and non-ETS emissions is kept at the level given by the baseline scenario.[131] Within the ETS sectors, full trade of allowances between all EU Member States is implemented such that the cost efficient allocation of permits to each member state and sector is eventually achieved. As mentioned previously, in order to mimic the Effort Sharing Regulation, carbon trading between Member States in non-ETS sectors is also implemented.

8.3.2 Policy scenarios

In order to analyse the effects of different design options of the electricity price compensation (EPC), two additional scenarios with two variants of each have been developed. They differ in the way the EPC is implemented in the EU regions as well as in the measure the EPC is based on as depicted in Section 8.2.2, i.e. output or electricity consumption.

In this report, the EPC and, in particular, the declining aid intensity are modelled such that their current design options are maintained. However, this need not be the case. The European Commission's State Aid Guidelines for the fourth EU ETS phase still have to be negotiated. It is possible that either a decelerated decrease of the aid intensity to achieve a higher compensation level or a continuation of the policy as modelled in this report or even a completely new design of the EPC is implemented.[132]

All assumptions not related to the design of the EPC are the same as in Scenario 1. In the following, the assumptions on Scenarios 2 and 3 are described.

Scenario 2:

- The EPC is implemented only in Germany, France and in the United Kingdom (as the only Member States represented as single countries in PACE which have implemented an EPC).
- The aid intensity is decreasing with time. We assume a linear decline until 2030 based on the development until 2020. Therefore, we implement an intensity of 75% in 2020, 65% in 2025 and 60% in 2030.

[131] This assumption leads to a CO2 emissions reduction in ETS and non-ETS sectors close to that foreseen in the Impact Assessment of the 2030 Framework: 42% in ETS sectors vs. the 2005 level and 30% in non-ETS sectors vs. the 2005 level.

[132] This follows from Article 10a (6) of the revised EU emissions trading directive of March 14, 2018 (Directive 2018/410) which states that "financial measures […] in favour of sectors or subsectors which are exposed to a genuine risk of carbon leakage due to significant indirect costs that are actually incurred from greenhouse gas emission costs passed on in electricity prices […]shall be such as to ensure that there is adequate protection against the risk of carbon leakage, based on ex-ante benchmarks for the indirect emissions of CO2 per unit of production. Those ex-ante benchmarks shall be calculated for a given sector or subsector as the product of the electricity consumption per unit of production corresponding to the most efficient available technologies and of the CO2 emissions of the relevant European electricity production mix."

Emission factors (in t CO_2/MWh) are taken from AP3, Task 3.1 of this project (see p. 254 ff.) based on the guidelines of the European Commission, as stated previously, and adjusted to the model regions. They are depicted in Table 76.[133]

Table 76: Emission factors of model regions in t CO_2 / MWh

Region	Emission factor
DEU	0.76
FRA	0.76
GBR	0.58
ITA	0.60
ESP	0.57
POL	0.88
XWE	0.71
XEE	0.83

Variant a:

- The EPC is implemented based on current **output** levels of the respective sectors, i.e. inorganic chemical production, organic chemical production, fertilizer production, basic iron and steel production, aluminium production, production of other non-ferrous metals, pulp and paper.
- Sector-specific benchmarks as the ratio of compensated electricity consumption within actual electricity consumption have been provided by the client and are presented in Table 77. For the sector pulp and paper no benchmarks exist. Therefore, we use the fallback factor of 80%.

Table 77: Sector-specific benchmarks

Model sector	Ratio of compensated and actual electricity consumption
Inorganic chemical production	96%
Organic chemical production	88%
Fertilizer production	79%
Basic iron and steel production	84%
Aluminium production	92%
Production of other non-ferrous metals	85%

Source: Umweltbundesamt, Deutsche Emissionshandelsstelle (2018)

[133] In Scenario 2, only the emission factors of Germany, France and the United Kingdom are relevant. In Scenario 3, the emission factors of all Member States are required.

Variant b:

- Identical with Variant a, but the EPC is implemented based on current **electricity consumption** levels.[134]

Scenario 3:

Variant a:

- Same as Scenario 2a but all EU regions implement the EPC according to the same principles as described in Section 8.2.2.

Variant b:

- Same as Scenario 2b but all EU regions implement the EPC according to the same principles as described in Section 8.2.2.

Unless otherwise stated, the results will be presented as changes vis-à-vis the baseline scenario (Scenario 1) outlined in the previous section.

8.4 Modelling results

8.4.1 Scenario 1 (Baseline scenario)

Table 78 and Table 79 present macroeconomic and environmental indicators for the EU model regions and the EU28 aggregate in 2020 and 2030, respectively, for the baseline scenario 1 (without any EPC implementation). These figures will serve as the reference point for the policy scenarios analysed in the following subsection. As there are no substantial changes in the non-EU regions, we will focus on the EU regions in the entire analysis. Results for non-EU model regions are however available upon request.

Table 78: Selected macroeconomic and environmental indicators in Scenario 1 – EU regions 2020

Macroeconomic and environmental ind.	France	Ger-many	Italy	Poland	Spain	UK	Rest W- MS	Rest CE-MS	EU28
GDP (trillion 2010 €)	2.244	2.970	1.699	0.462	1.171	2.010	2.984	0.760	**14.299**
Consumption (trillion 2010 €)	1.309	1.766	1.054	0.295	0.704	1.364	1.671	0.474	**8.636**
CO_2 emissions (Gt)	0.277	0.646	0.341	0.267	0.235	0.328	0.539	0.327	**2.960**
ETS	0.065	0.354	0.155	0.166	0.114	0.126	0.221	0.178	**1.380**
CO_2 price ETS (2010 €)	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	**27.5**
CO_2 price non-ETS (2010 €)	53.1	53.1	53.1	53.1	53.1	53.1	53.1	53.1	**53.1**

[134] In the model, the electricity price compensation is implemented according to the formulae presented in Section 2.2, i.e. while in Variant a sectoral output multiplied by sectoral electricity efficiency serves as the basis, in Variant b we directly implement electricity consumption.

Macroeconomic and environmental ind.	France	Ger-many	Italy	Poland	Spain	UK	Rest W- MS	Rest CE-MS	EU28
Electricity price (2010 €/MWh)	106.5	108.3	107.6	113.2	106.7	104.2	106.5	105.5	**107.1**
Oil price (2010 USD per boe)	89.5	89.3	89.3	89.4	89.8	90.1	89.3	89.5	**89.5**
Gas price (2010 USD per boe)	51.3	51.5	54.4	53.4	64.1	50.5	50.5	51.6	**52.6**
Coal price (2010 USD per boe)	22.2	22.5	22.2	22.4	22.4	22.1	22.3	22.5	**22.3**

Table 79: Selected macroeconomic and environmental indicators in Scenario 1 – EU regions 2030

Macroeconomic and environmental ind.	France	Ger-many	Italy	Poland	Spain	UK	Rest W-MS	Rest CE-MS	EU28
GDP (trillion 2010 €)	2.518	3.232	1.868	0.554	1.358	2.248	3.384	0.867	**16.030**
Consumption (trillion 2010 €)	1.460	1.950	1.149	0.347	0.803	1.513	1.910	0.530	**9.660**
CO_2 emissions (Gt)	0.266	0.499	0.299	0.204	0.162	0.223	0.453	0.258	**2.365**
ETS	0.081	0.252	0.128	0.114	0.054	0.056	0.169	0.121	**0.975**
CO_2 price ETS (2010 €)	68.2	68.2	68.2	68.2	68.2	68.2	68.2	68.2	**68.2**
CO_2 price non-ETS (2010 €)	124.3	124.3	124.3	124.3	124.3	124.3	124.3	124.3	**124.3**
Electricity price (2010 €/MWh)	107.0	119.1	118.5	115.9	112.1	111.1	115.1	110.6	**114.0**
Oil price (2010 USD per boe)	106.1	104.7	104.6	103.5	106.7	107.7	105.1	104.6	**105.3**
Gas price (2010 USD per boe)	55.6	56.5	60.4	49.6	85.5	54.8	54.8	58.4	**58.3**
Coal price (2010 USD per boe)	21.7	25.1	21.7	24.5	19.2	24.3	25.2	24.9	**23.7**

8.4.2 Policy scenarios

Figure 67 to Figure 70 present the level of the EPC as a percentage share of sectoral revenues for Scenarios 2a, 2b, 3a and 3b in the years 2020 and 2030. The following observations can be made.

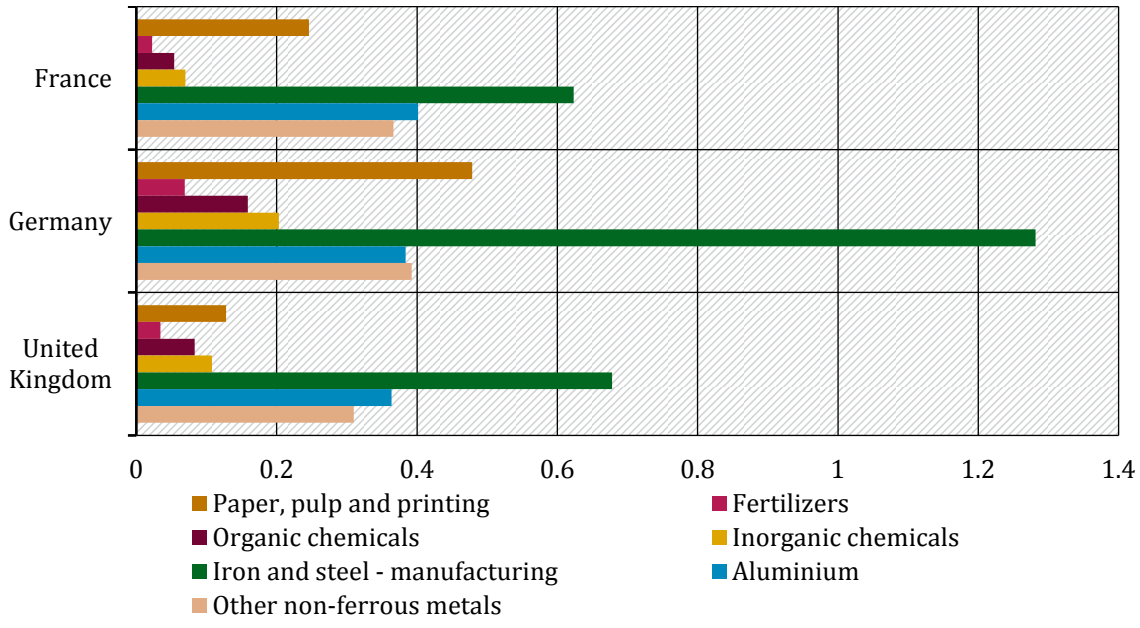
In almost each sector, the EPC as a share of sectoral revenues[135] increases from 2020 to 2030 despite a declining aid intensity. This is driven by a rising EUA price which more than doubles between 2020 and 2030 (cf. Table 80 and Table 811).

In all countries subject to the EPC in Scenarios 2a and 2b, the highest EPC rate is awarded in the sector iron and steel manufacturing, regardless whether the EPC is based on the current output level or on current electricity consumption. This can be clearly attributed to the high electricity consumption of this sector. Moreover, in most scenarios the metal producing sectors as well as the pulp and paper sector also receive a relatively high EPC rate compared to the chemical sectors due to their high electricity consumption.[136]

In Scenario 2, the effects of the basis of the EPC (output or electricity consumption) differ to some extent. However, we cannot identify a definite direction whether a sector benefits from one computational basis or the other. For instance, the aluminium and other non-ferrous metal sectors in the UK benefit from an output based EPC in 2020 whereas the pulp and paper sector in France benefits from an electricity consumption based EPC. Nevertheless, in many cases the output based EPC seems to be the more desirable option.

Turning to the variants of Scenario 3, these confirm more or less the findings of Scenario 2. In many regions the sector iron and steel manufacturing receives the highest EPC rate. Only the Rest of the Western Member States shows a somewhat different picture. Here, the pulp and paper and the aluminium sectors are those with the highest EPC rate. However, in all regions the metal producing and the pulp and paper sectors receive the larger EPC rates than the chemical sectors. With respect to the differences between both variants, the picture is less obvious than in Scenario 2.

Figure 67: Electricity price compensation as a percentage share of sectoral revenues for Scenario 2a in 2020 (upper panel) and 2030 (lower panel)



[135] Sectoral revenues depict physical output of the sector multipled by the price level of the sector.

[136] It is important to note, that several chemical products, in particular various plastics, which in reality are eligible for the electricity price consumption are not covered by the subsidy in this study. This is due to the fact that they are part of the model sector "Other chemicals, rubber and plastics" which however comprises many other products that are not eligible for state aid. Therefore, this sector was not included in the list of sectors covered by the electricicty price consumption. However, this might cause underestimated effects for the aggregate of chemical products. In Germany, for instance, the chemical industry receives a higher share of state aid than the iron and steel industry.

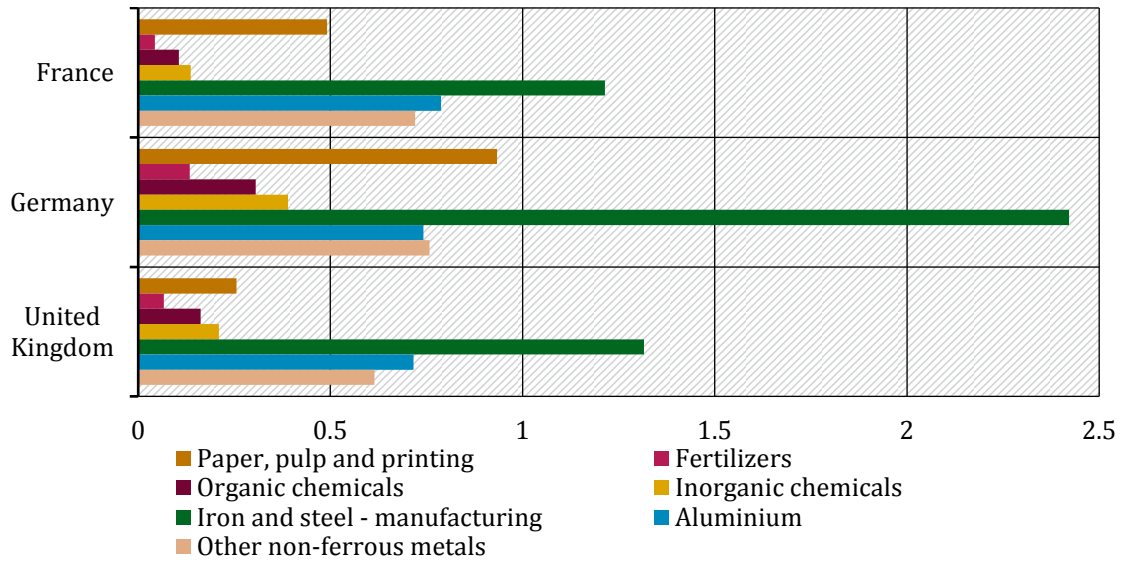


Figure 68: Electricity price compensation as a percentage share of sectoral revenues for Scenario 2b in 2020 (upper panel) and 2030 (lower panel)

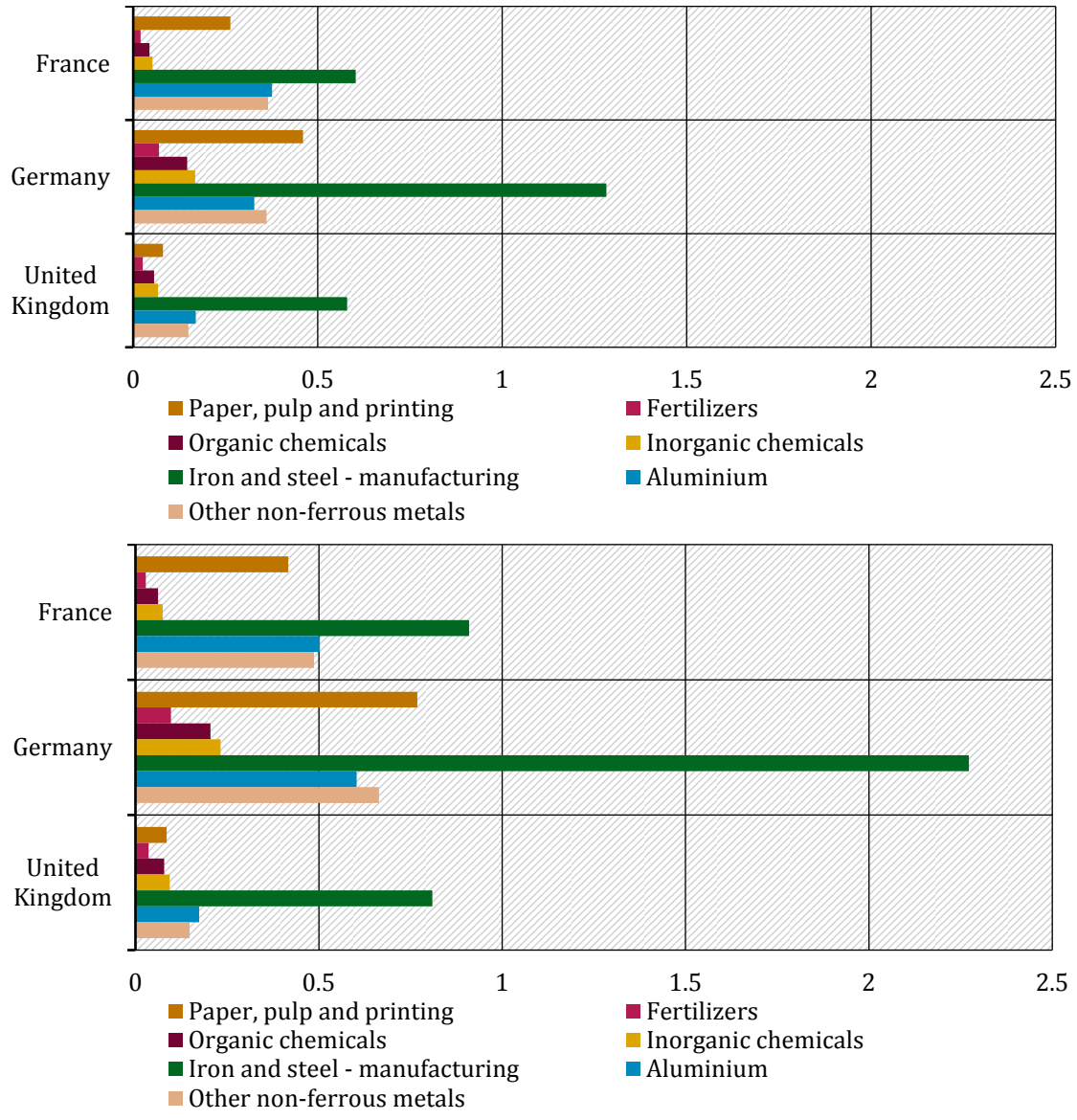
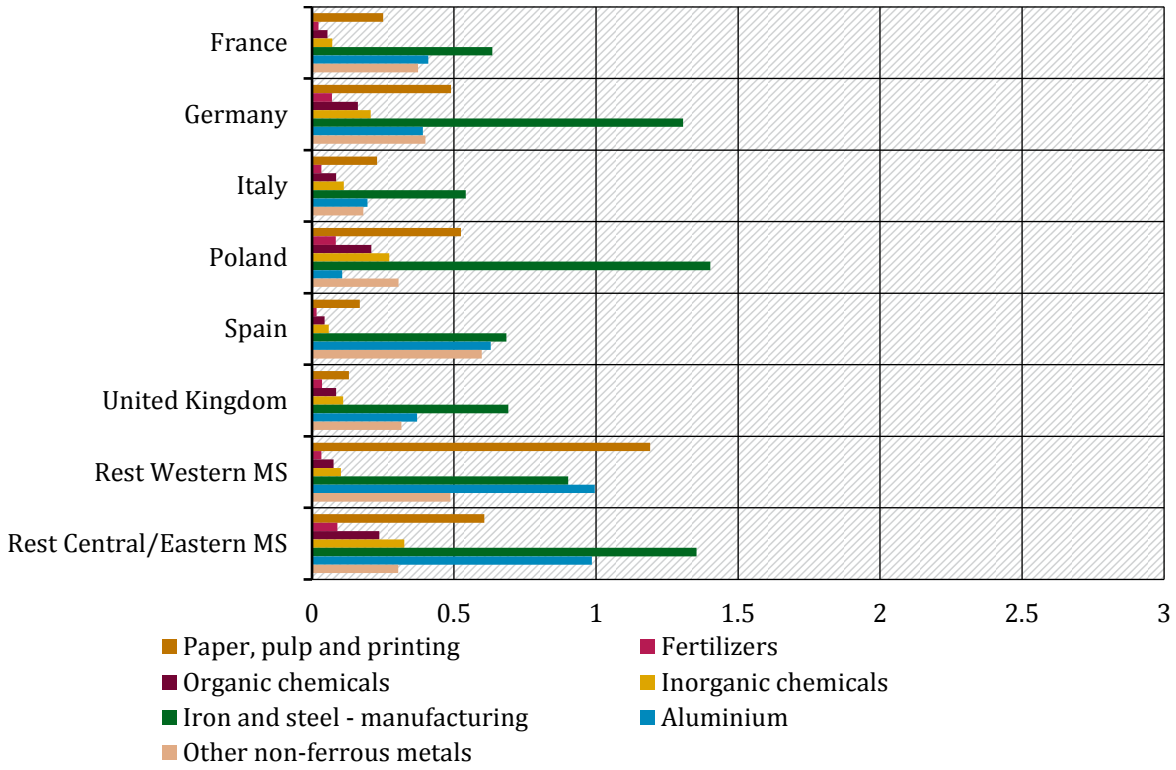


Figure 69: Electricity price compensation as a percentage share of sectoral revenues for Scenario 3a in 2020 (upper panel) and 2030 (lower panel)



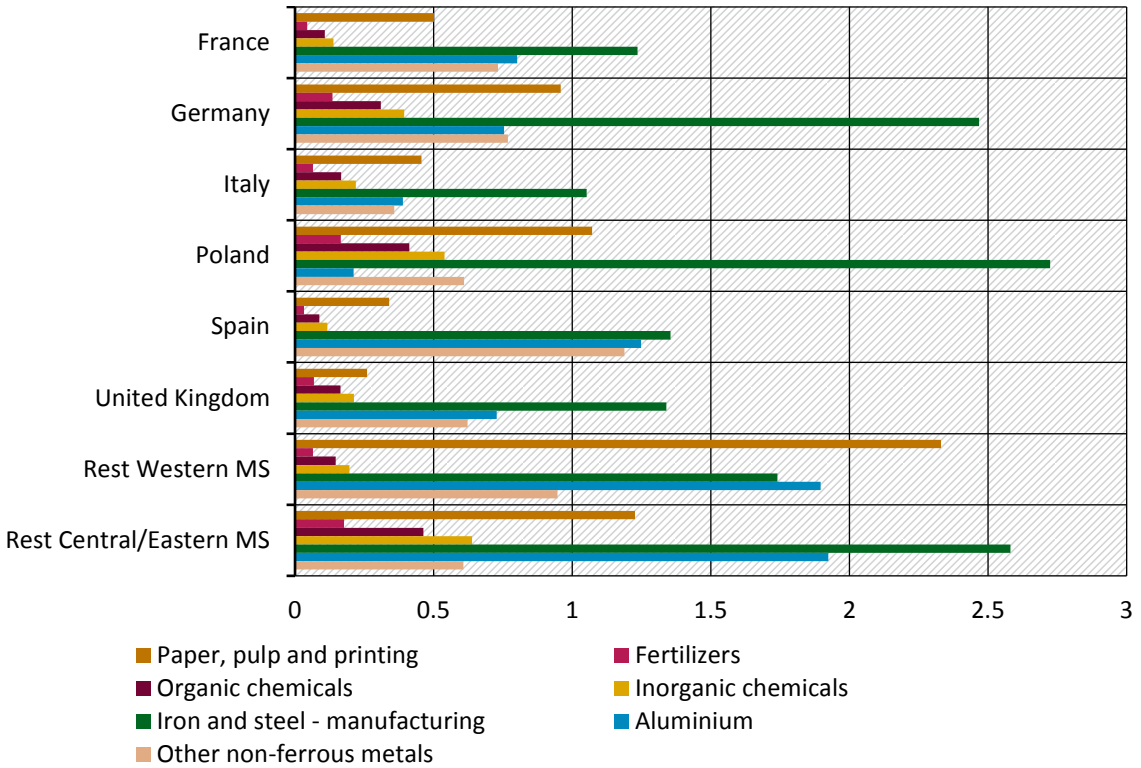
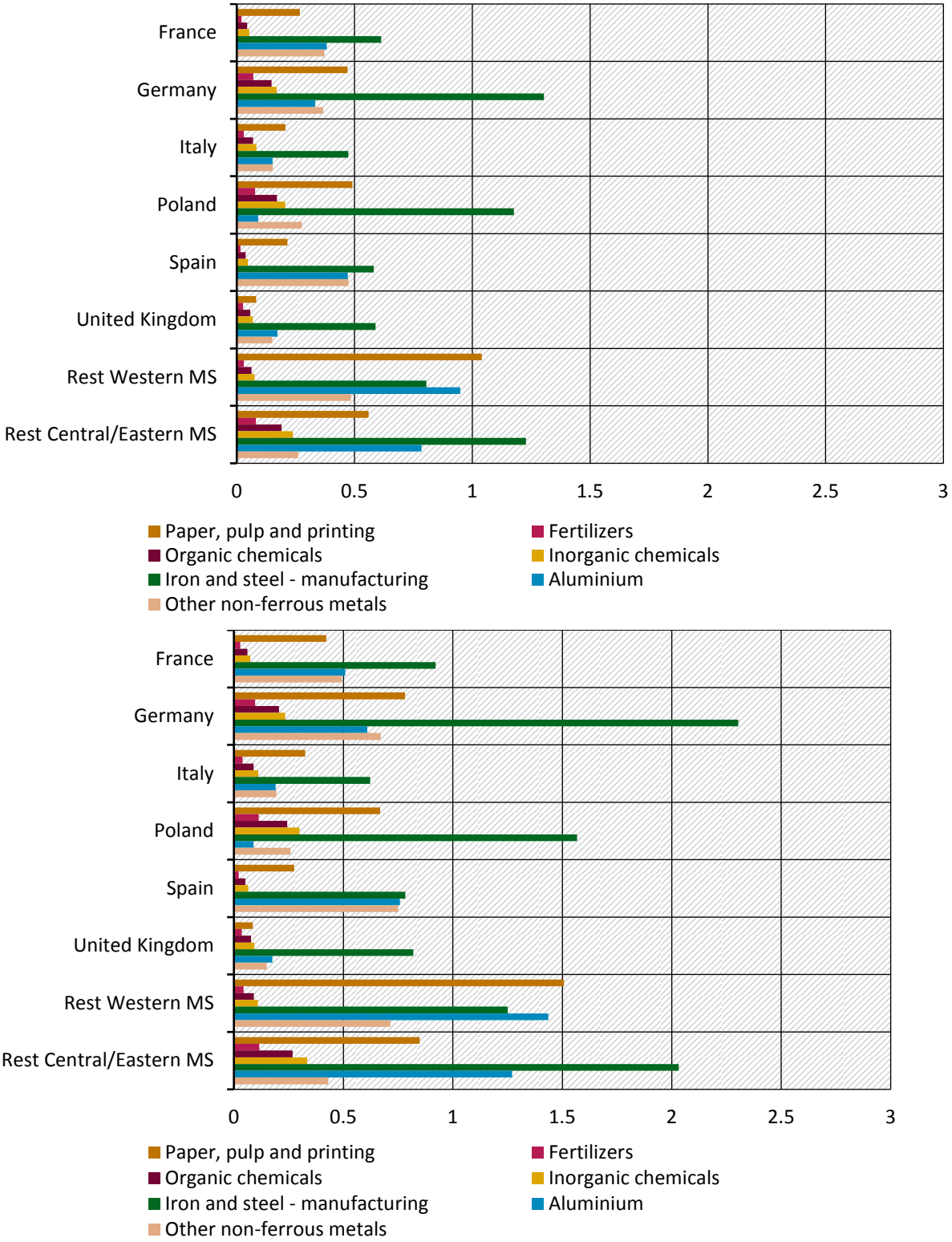


Figure 70: Electricity price compensation as a percentage share of sectoral revenues for Scenario 3b in 2020 (upper panel) and 2030 (lower panel)



For the sake of completeness, Table 80 and Table 81 present macroeconomic and environmental indicators for the EU in the years 2020 and 2030. However, not surprisingly, there are no macroeconomic effects caused by the EPC in terms of GDP changes. The monetary compensation, which is low relative to the EU's GDP, does not result in severe distortions in the

EU economy. Also changes in the carbon price are negligible. They are slightly higher than in the baseline scenario. This is due to an increased production level caused by the subsidy and hence in slightly larger marginal abatement costs reflected by the higher CO_2 price. The higher CO_2 price in Scenario 3 can be attributed to a similar reason: more countries implement the EPC, and thus the overall EU production level in the respective sectors increases to a higher extent. The slightly lower CO_2 price in Scenario 3b compared to Scenario 3a results from a higher overall subsidy volume in the latter case compared to the former case (cf. Figure 69, lower panel, and Figure 70, lower panel). Hence, production levels are lower in Scenario 3b which causes lower CO_2 prices.

Figure 71 and Figure 72 present changes in CO_2 emissions covered by the EU ETS. These results show that an internal relocation of emission abatement occurs. In Scenario 2 the countries implementing an EPC increase their emissions levels slightly and the other EU regions show a higher reduction effort because abatement becomes relatively cheaper in the latter regions. In Scenario 3, when all EU regions implement the EPC, we observe that in 2020 the Rest of the Western and Central and Eastern MSs augment their emissions levels and France reduces most. In 2030, this situation becomes more balanced.

Table 80: Selected macroeconomic and environmental indicators – EU in 2020

Macroeconomic and environmental ind.	Scenario 2a	Scenario 2b	Scenario 3a	Scenario 3b
CO_2 emissions (Gt)	2.960	2.960	2.960	2.960
ETS	1.380	1.380	1.380	1.380
CO_2 price ETS (2010 €)	27.7	27.7	28.0	28.0
CO_2 price non-ETS (2010 €)	53.1	53.1	53.1	53.1
GDP (% change vs. baseline)	0.0	0.0	0.0	0.0
CO_2 emissions (% change vs. baseline)	0.0	0.0	0.0	0.0
ETS	0.0	0.0	0.0	0.0

Table 81: Selected macroeconomic and environmental indicators – EU in 2030

Macroeconomic and environmental ind.	Scenario 2a	Scenario 2b	Scenario 3a	Scenario 3b
CO_2 emissions (Gt)	2.365	2.365	2.365	2.365
ETS	0.975	0.975	0.975	0.975
CO_2 price ETS (2010 €)	68.4	68.4	69.1	68.9
CO_2 price non-ETS (2010 €)	124.3	124.3	124.4	124.4
GDP (% change vs. baseline)	0.0	0.0	0.0	0.0
CO_2 emissions (% change vs. baseline)	0.0	0.0	0.0	0.0
ETS	0.0	0.0	0.0	0.0

Figure 71: Percentage changes in CO_2 emissions covered by EU ETS vs. Scenario 1 in EU regions in 2020

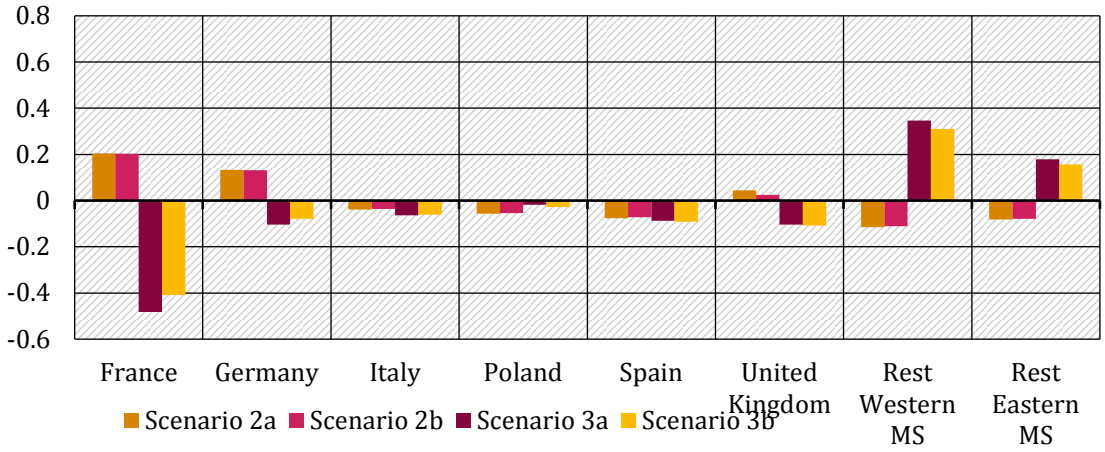


Figure 72: Percentage changes in CO_2 emissions covered by EU ETS vs. Scenario 1 in EU regions in 2030

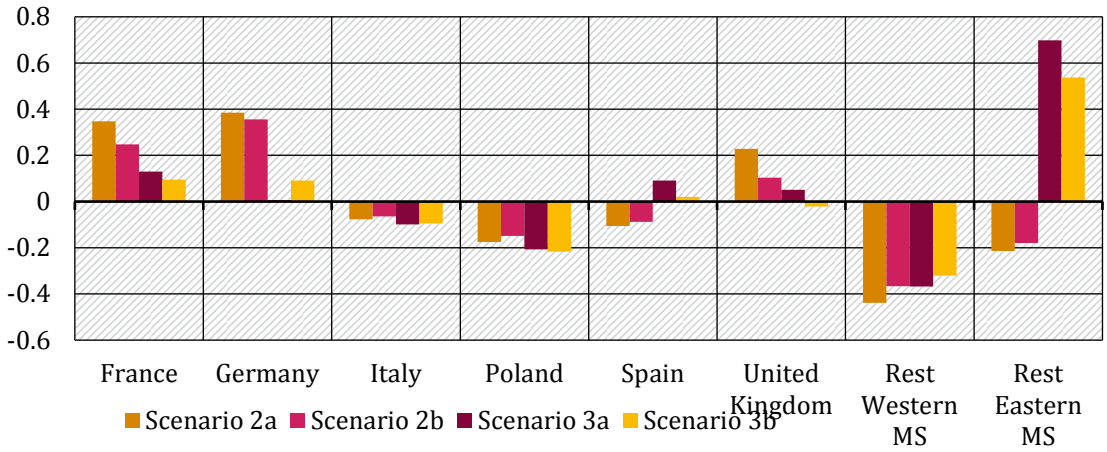


Figure 73 and Figure 74 present changes in sectoral output levels for the policy scenarios in 2020 and 2030, respectively, at the aggregate EU level. Sectors receiving an EPC gain in output. This effect more than doubles if the EPC is enhanced to all EU Member States (Scenario 3). The levels more or less correlate with their EPC rate shown previously. The metal producing sectors and pulp and paper benefit most, but also the chemical sectors show some gains. Moreover, due to the sectoral interrelations some other sectors also benefit from the implementation of the EPC. For instance, the sector refined oil and coal products is able to sell additional intermediate products to the sectors covered by the EPC and benefits slightly. On the other hand, the sector further procession of iron and steel benefits from an increased amount of intermediate products from the manufacturing of iron and steel sector. These results provide an indication that the EPC can be an effective policy measure to alleviate indirect carbon leakage effects for several sectors not directly eligible for state aid under the assumptions of the model. In some non-EU regions, we observe slight losses in those sectors. Due to the very small effects, we do not report non-EU results here. They are available however upon request.

Regarding the differences concerning the computational basis of the EPC (output vs. electricity consumption), we observe that most sectors covered by the EPC benefit from the output based

allocation (Scenarios 2a and 3a) at the aggregate EU level compared to the electricity consumption based allocation (Scenarios 2b and 3b).

Figure 73: Selected results of changes in sectoral output (% change vs. Scenario 1) – EU in 2020

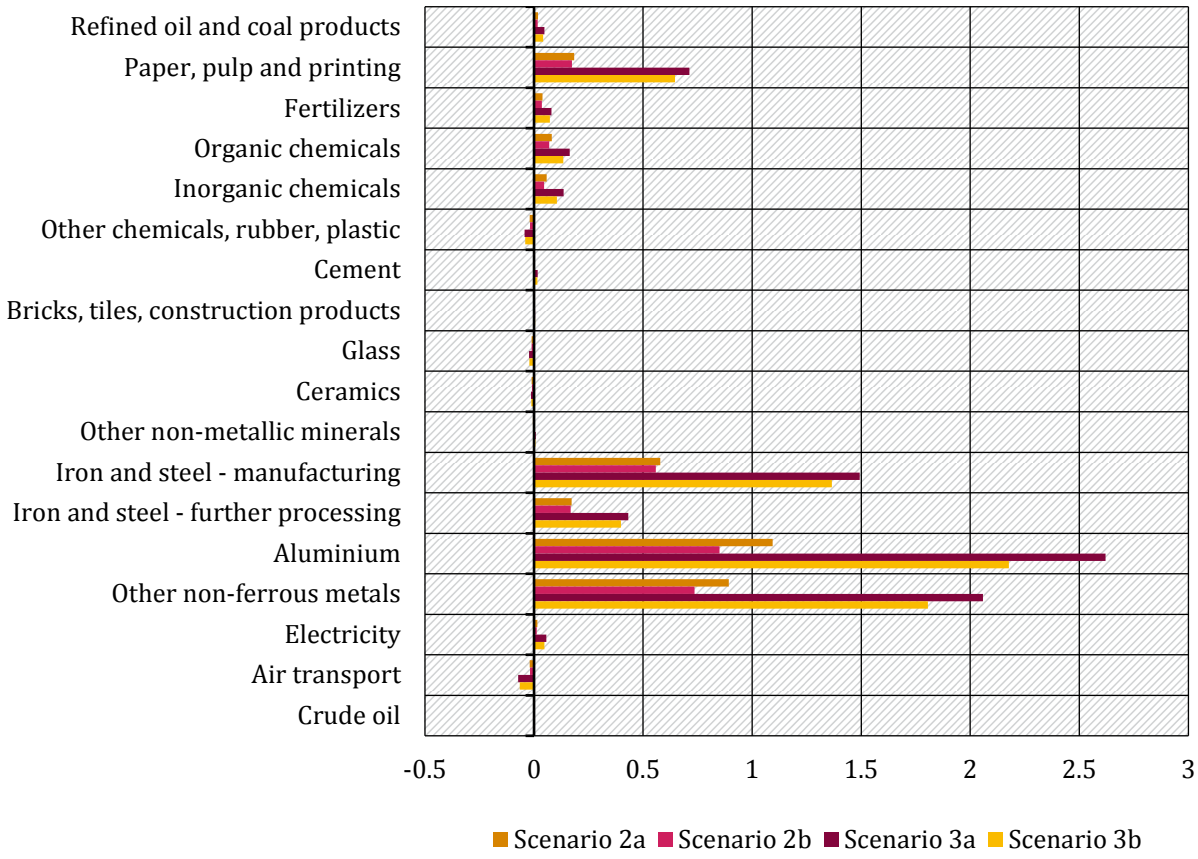


Figure 74: Selected results of changes in sectoral output (% change vs. Scenario 1) – EU in 2030

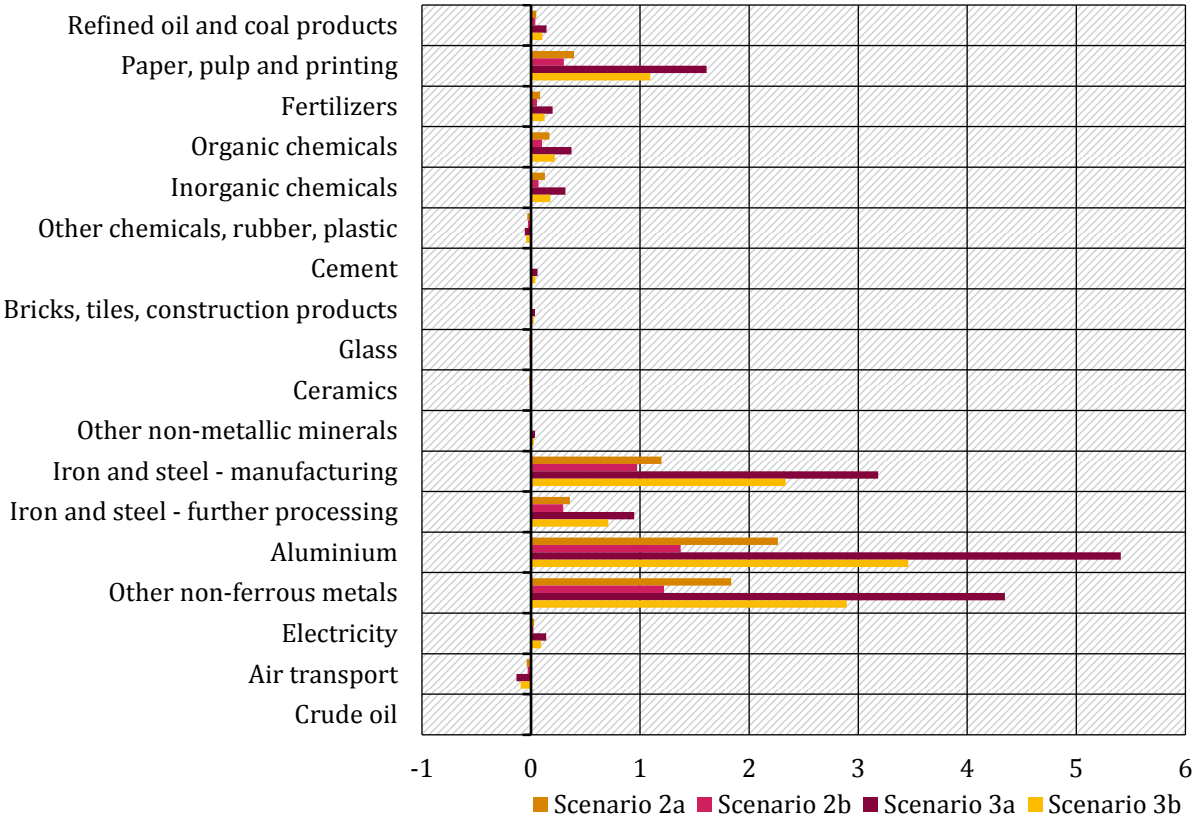


Figure 75 and Figure 76 present sectoral output changes by region in Scenarios 3a and 3b compared to Scenarios 2a and 2b, respectively. In both cases the sectors aluminium, other non-ferrous metals, iron and steel manufacturing and pulp and paper in the regions which introduce the electricity price compensation benefit most from this subsidy. These benefits are most pronounced in the regions Rest of the Western Member States, Rest of the Central and Eastern Member States and in Spain. On the other hand, these sectors show non-negligible losses in France, Germany and the UK. In these countries, the sectors covered by the electricity price compensation, lose their competitive advantage that was existent in Scenario 2, when only sectors in France, Germany and the UK received the subsidy.

Figure 75: Selected results of changes in sectoral output in Scenario 3a (% change vs. Scenario 2a) – EU model regions in 2030

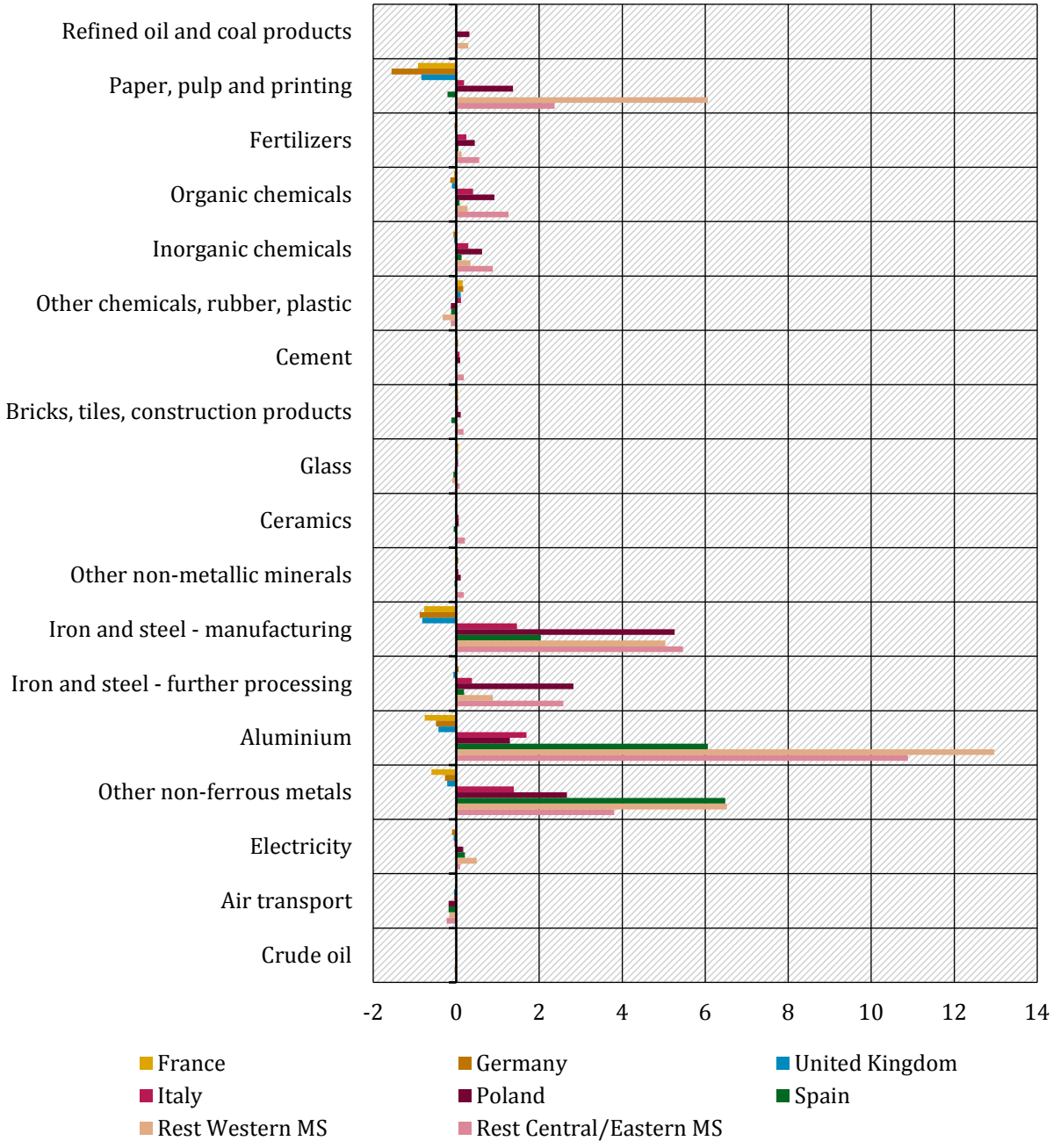


Figure 76: Selected results of changes in sectoral output in Scenario 3b (% change vs. Scenario 2b) – EU model regions in 2030

8.5 Options for the further development of compensation: economic and legal aspects

8.5.1 Overview: Status quo for compensation of indirect costs

Art 10a (6) of the EU ETS Directive allows for compensation of indirect costs to affected sectors, but leaves it to the Member States to decide whether they want to compensate indirect costs in the first place, and which mechanism they want to implement. If Member States decide to pay compensation, they must do so in line with the parameters laid out in the Directive: compensation shall be based on ex-ante benchmarks for the electricity consumption per unit of output, reflecting the most efficient technology available, and the CO_2 emissions of the relevant European electricity production mix. The EU Guidelines for state aid measures in the context of the emission trading scheme (issued in 2012 and applicable until the end of 2020) further specify the criteria to which compensation should conform.

So far, compensation of indirect costs has not been applied equally across the EU – as of 2017, only nine Member States have implemented compensation schemes, and those that have differ in their application and in the budget that is available for compensation.[137]

The latest revision of the EU ETS Directive , which entered into force in April 2018, specified the language on compensation of indirect costs: while the previous text spoke of compensation for those sectors or subsectors "determined to be exposed to a significant risk of carbon leakage due to costs relating to greenhouse gas emissions passed on in electricity prices" the text changed to sectors or subsectors that "are exposed to a ***genuine*** risk of carbon leakage due to ***significant indirect*** costs that are ***actually*** incurred from greenhouse gas emission costs passed on in electricity prices" (emphasis added). Yet, at this stage, it remains to be seen how the stronger language will be transposed into a more stringent application of the rules. Beyond that, the changes that were introduced in the 2018 revision also included a new qualification that Member States should use no more than 25% of their EU ETS auctioning revenues to pay for the compensation, and where they did so, introduced an obligation that they have to publish a report explaining the reasons for doing so.[138]

There are several issues with the way that the compensation is currently applied, and which will need to be addressed going forward:

- The **unequal implementation** of the compensation across the Member States (where some opt to pay compensation and others do not) means that the compensation can distort competition on the internal market;
- Any compensation that depends on electricity consumption will mute the effect of the carbon price signal, **thus imposing a higher reduction burden on other sectors and reducing the overall efficiency** of the system, and ultimately driving up the costs of achieving a given emission reduction. In this way, compensation reduces the efficiency of the EU ETS. This efficiency loss can be justified with the fact that compensation reduces the risk of carbon leakage / actually prevents carbon leakage – which, in itself, is inefficient at another level, as it distorts the distribution of mitigation efforts between the EU and the rest

[137] See also AP3, Task 3.1 of this project (p. 254 ff.): "National compensation schemes for indirect CO_2 costs within the EU Emissions Trading Scheme".

[138] A further change was the addition of a half sentence specifying that "Those measures [i.e. the compensation] shall ensure an adequate protection against the risk of carbon leakage". This is understood to relate to the question of an eventual reduction in the level of compensation, in the sense that also if compensation were to go down, it would still need to maintain adequate protection.

of the world. Yet the question remains how realistic the leakage risk actually is, as also evidenced by the insertion of a "genuine" leakage risk in the latest revision?

- Any support measure from the government to private companies should be **temporary** in nature, it should encourage adaptation but must **not lead to permanent dependence** on the support. This is both inherent to the nature of state aids, generally considered to distort competition unless specifically justified and approved, and a principle found in other parts of the EU ETS legal rules (among other things, the free allocation granted to industrial emitters under the EU ETS continues to be considered as "transitional").

8.5.2 Different options for the compensation of indirect costs from the EU ETS

To assess the actual carbon leakage risk going forward, and to understand which impact the compensation has on the leakage risk, the previous chapter elaborated the following basic options for the compensation with the help of the PACE model:

- No compensation
- Status quo (selected MS only)
- Equal application according to EU State Aid guidelines

Beyond these fairly fundamental choices, there are a number of specific design elements that could be adjusted to better target the compensation, but which could not be covered in the modelling, or not in sufficient detail:

Adjustment / update of benchmarks: to reflect improvements in the efficiency of production technologies, the question arises how and when benchmarks need to be updated. This update could either be executed as a flat-rate adjustment, by applying a uniform correction factor to all benchmarks across the board, or as a re-calculation based on new data.[139]

- **Aid intensity:** the premise is that overall levels of support should fall over time – the question is whether this is already achieved through the update of benchmarks and production volumes – which is expected to lead to a falling level of support over time – or whether a continued lowering of the aid intensity (applied as a uniform correction factor across the board) is also warranted, and at what pace.
- **Differentiated application:** as opposed to the current uniform application, where products are either in or out, different categories to account for borderline problems, e.g. borderline cases receive 25% - 50% - 75% of the compensation.

8.5.3 Evaluation of the different options

8.5.3.1 Criteria based on state aid guidelines

Under the Treaty for the Functioning of the EU (TFEU), the EU Commission is the relevant authority to assess and approve the compatibility of state aid measures with the internal market (Art. 108 paras. 1 and 3 TFEU). In the context of ETS measures, the Commission can consider in particular an exemption to facilitate the development of economic activities or areas (Art. 107 para. 3 TFEU). To increase predictability for market participants and state representatives alike,

[139] This echoes a discussion that was also led in the context of the benchmarks used to determine the level of free allocation, and where it was ultimately decided that the benchmarks would be updated by re-calculating them (within lower and upper boundaries). Some allocation benchmarks are also relevant for the compensation of indirect costs (for processes where heat and electricity can substitute each other). It would appear sensible and is likely that, in these cases, the updated re-calculated free allocation benchmarks will also be used to calculate the compensation.

the EU Commission exercises its discretion on the approval compensations in light of its own guidelines on state aid measures in the context of the emission trading scheme guide (state aid guidelines for the ETS). The guidelines thus provide several general considerations on the level and the need for compensation going forward:

At a general level, the state aid guidelines for the ETS set out three objectives to balance with regard to the compensation of indirect CO_2 costs (para. 8): (i) **minimise the risk of carbon leakage**, (ii) preserve the EU ETS objective to **achieve cost-efficient decarbonisation** and (iii) **minimise competition distortions** in the internal market.

The state aid guidelines for the ETS further specify (para. 5) that state aid must be necessary to achieve the environmental objective of the EU ETS (**necessity**), but at the same time must be limited to the minimum needed to achieve the environmental protection sought (**proportionality**) without creating undue distortions of competition and trade in the internal market.

Leakage risk is only material if "competitors from third countries do not face similar CO_2 costs in their electricity prices and the beneficiary is unable to pass on those costs to product prices without losing significant market share" (para. 24); if these conditions are not met there is no need to compensate. A significant leakage risk is considered only for sectors and subsectors listed in Annex II of the guidelines (para. 25).

Regarding the benchmark to be applied, the product-specific electricity consumption benchmarks should reflect the most electricity-efficient method of production for the product considered (Annex I of the state aid guidelines for the ETS), i.e. should be based on the best-performing production technologies available. While the guidelines do not provide any guidance as to when and how benchmarks need to be updated as production technologies become more efficient over time, the need for such an update follows logically: if they were not updated, they would eventually fail to meet the starting premise (that they should reflect the most electricity-efficient method). Furthermore, depending on how far and how quickly costs come down, a compensation based on outdated benchmarks could violate the requirement that compensation must be less than the costs incurred (see following).

Regarding the level of state aid, para. 12 of the state aid guidelines for the ETS specifies general requirements for the level of state aid: first, state aid must be lower than the actual costs incurred ("must not fully compensate for the costs of EUAs in electricity prices"). Second, para. 12 specifies that compensation must fall over time, in order to avoid dependency, but also as reflection of the fact that the assistance is temporary and limited, and to preserve the long-term incentive towards decarbonisation. In reflection of this, para. 26 specifies for aid for indirect emission costs that the aid intensity should fall over time: starting from 85% of the eligible costs incurred in 2013-2015, to 80% of the eligible costs incurred in 2016-2018, and to 75% for 2019 and 2020.[140]

8.5.3.2 Considerations going forward – relevant trends and issues

Regarding the **future electricity demand by industry**: the default assumption, in line with energy efficiency targets set at national and EU levels, is that of a falling electricity consumption

[140] The 2012 State Aid guidelines for the ETS do not specify how the aid intensity should evolve beyond 2020 because the duration of an aid scheme must not be longer than the duration of the guidelines themselves (para. 22). Assuming, the levels of aid intensity were to continue the decrease at the same pace (5% every three years) in revised guidelines post-2020, the compensation would fall to zero as late as 2065; even in 2050, the aid intensity would still be at 25%. Of course, in most scenarios the electricity generation in Europe would be mostly or entirely carbon-neutral long before this date, as a result the emission factor would decline faster than the aid intensity.

per unit of output as production processes become more efficient.[141] Going forward, though, situations may arise where low-carbon solutions in industry will involve increasing electricity consumption, for instance as low-carbon electricity replaces fossil energy. These include sector coupling, the electrification of industrial processes, particularly heat, or power-to-X-technologies, but also structural changes and the closing of material cycles to increase the share of recycled materials. Where such technological or organisational changes promise to lower overall GHG emissions significantly even though they increase electricity consumption, compensation should not discourage them.

Falling carbon intensity of electricity generation as renewable electricity sources expand, and as coal is replaced by lower-carbon fuels: In all scenarios that meet the EU's long-run climate goals, the European power sector will be entirely or largely decarbonised by 2050; where fossil fuels remain part of the power generation mix, they would be equipped with CCS. Some of the more ambitious scenarios point out that a renewable share in electricity approaching 100% could also be achieved well ahead of 2050. At any rate, the carbon intensity of all electricity generation is expected to fall markedly in the coming decades. What is less clear is how this affects the price of electricity: in a future market with an ever-higher share of renewables, it remains to be seen for how many hours of the year, the marginal, price-setting power plant will be a renewable power source with effectively zero marginal cost, a modern gas plant (on the merit of its technical capacity for quick ramping, or because the plant has to run anyway to provide heat) or an old but cheap coal-fired plant (simply on the merit of its relatively low short-run marginal cost). It has to be noted, however, that under the current rules, the compensation for indirect carbon costs is based on the *average* carbon intensity of the *fossil* power generation in the region in question. In line with these rules, the trend towards falling carbon intensity *could* translate into a falling compensation amount. Whether this is the case will depend on how the reduction of fossil generation capacity takes place, e.g. whether it is a managed process (in which, subject to physical and economic constraints, older and less efficient plants would generally be retired earlier, e.g. in a managed coal phase-out), or whether the exit of fossil generation capacity takes place purely as a market-driven process on the basis of short-run marginal costs (in which case emission-intensive but cheap generation sources could continue to play a larger role).

What is less clear is the evolution of **baseline output** over time – the factors that need to be balanced here are (a) growth of the overall economy, which drives output demand, vs. (b) improvements in resource efficiency, which mean that the same value can be produced with less consumption of material resources – by recycling material resources, by using less of them per product, and by minimising waste.

Finally, regarding the **future leakage risk, competitiveness and cost pass-through**, it is worth noting that according to the EU guidelines for state aid measures in the context of the emission trading scheme, any compensation is only justified if "competitors from third countries do not face similar CO_2 costs in their electricity prices" and if the recipient of the compensation "is unable to pass on those costs to product prices without losing significant market share" (para. 24 of the Guidelines).

- As for the first condition, it is unclear if this condition is already rejected if a single competitor anywhere faces a similar CO_2 cost, if the majority of competitors face this cost, or if all (potential) competitors in all (possible) locations face a similar cost. However, as the

[141] For all industrial energy demand (rather than electricity only), final energy consumption of industry in the EU has decreased from 328 Mtoe in 2005 to 275 Mtoe in 2015, which corresponds to a drop of 16%. Since industrial activity has increased over this time, the improvement in energy intensity (energy use per gross value added) is even more pronounced, with an improvement of 19% between 2005 and 2015, or almost 2% per year (European Commission 2017).

first extreme is already fulfilled, and as the other extreme is unlikely ever to be fulfilled, a middle route seems most appropriate.

- This is also relevant in view of the second criterion: to have the CO_2 costs passed through does not require that ***every*** producer has to face a CO_2 price signal (let alone an identical one), but that the ***marginal*** producer that sets the world market price includes a CO_2 price signal. In particular, this applies to China, which accounts for the bulk of production capacity in many of the relevant sectors.

- In this context, it should be noted that the coverage of the electricity sector in existing carbon pricing systems is higher than for industry emissions. Virtually all ETS and other carbon pricing mechanisms include power generation, even if they do not include industry (this applies e.g. to the nascent Chinese national ETS, but also to the Regional Greenhouse Gas Initiative in the US). While it needs to be seen to what extent this also results in carbon costs being passed on through the electricity price, there is reason to assume that the indirect leakage risk will be reduced faster through international climate action than the direct leakage risk.

8.5.3.3 Putting the different trends into perspective

The preceding discussion shows that there are different trends at work that influence the level of compensation, as calculated according to the formula laid out in the state aid guidelines. Importantly, of these trends all point more or less into the same direction – towards a lowering of the calculated compensation level.

As for the carbon intensity of the average fossil generation, it is unclear what will happen as the fossil part of electricity generation shrinks. But to the extent that countries manage this process, e.g. in the form of a coal phase-out, the carbon intensity of the average fossil generation would be expected to fall over time.

Electricity demand in industry is expected to fall due to efficiency improvements, which will be reflected in lower benchmarks. In the medium to longer term, electricity demand could rebound as sector coupling and electrification take hold. But this is likely to play a greater role at a time when the electricity sector is already well advanced towards a decarbonised generation mix, and when temporarily abundant renewable electricity needs to be put to sensible use. Finally, aid intensity could continue to fall. Thus, while the extent and speed of the process is not known, the direction is clear – if two or three factors decline, the product itself will also decline.

8.6 Summary and conclusions

8.6.1 Main findings from the model-based analysis

The model-based analysis conducted in this report gives several insights regarding the design and the effects of the electricity price compensation on the EU economies at the regional and sectoral scale. These are summarized in the following.

- At the macroeconomic level, no effects can be observed, for instance with respect to changes in GDP. The monetary amount used to compensate the affected sectors does not cause any severe distortion within the EU economies.

- Carbon prices increase slightly as a result of the compensation due to an increased output level in the sectors covered by the EPC which is induced by the subsidy.

- The metal producing sectors and the pulp and paper sector benefit most from the EPC in terms of relative sectoral output gains. This is due to their large share of electricity consumption and applies to all countries. Also the chemical sectors gain, however to a lesser degree. The latter effects might however be underestimated.
- Although there is no obvious tendency, sectors benefit to a larger extent from an EPC design which is based on current output levels. This applies to the EPC rate for each sector, which is higher in many cases if an output based computation is used, but in particular to gains in the output of the sectors covered by the EPC.
- Not surprisingly, an extension of the EPC to all EU member states causes higher EPC rates in the covered sectors and, in particular, tremendous sectoral output gains which are more than twice as large as in the case where only Germany, France and the United Kingdom apply the EPC.
- The EPC causes shifts in the abatement efforts of EU Member States regarding emissions covered by the EU ETS. The overall level of course remains equal to a scenario without an EPC.
- As stated previously, all results are subject to the assumption that current design options, in particular a decline in the aid intensity, are maintained. Possible outcomes of the negotiations of the European Commission's State Aid Guidelines for the fourth EU ETS phase include either a decelerated decrease of the aid intensity to achieve a higher compensation level or a continuation of the policy – as modelled in this report – or even a completely new design of the EPC.

8.6.2 Conclusions for the further development of the EPC

The compensation for indirect CO_2 costs involves different components – each of them has their own justification and their own dynamics. Importantly, except for the CO_2 price, they all point in the same direction: down. Under the current set of rules, the overall aid intensity (being determined independently from the CO_2 price) falls over time in line with the temporary nature of the support, and to avoid aid dependence. The specific electricity demand in industry falls as the efficiency of production processes increases over time – although structural changes in the energy consumption (electrification of industrial processes, sector coupling) could eventually reverse this trend, and lead to stagnating rather than falling electricity consumption, if and when such changes take place at scale. What is less clear is the evolution of the fossil part of the electricity mix. While it is clear that the fossil part of electricity generation will shrink, and hence that the carbon intensity of the overall electricity mix will go down, it is uncertain how the residual fossil production will be composed, and hence how the carbon cost component in the compensation will evolve.

As the different components, which together determine the appropriate level of compensation, all exhibit their own dynamics, there is a case for regular updates to the main parameters. In the authors' opinion, the degression of the appropriate level of compensation will happen sooner rather than later, i.e. in the 2020s and 2030s, which suggests that updates and revisions should not only happen at the level of ETS trading periods, but at least every 4-5 years.

The second key parameter are efficiency improvements – where there is unfortunately less of a history of self-reinforcing trends and target overachievement. Given the importance of efficiency improvements for the overall progress, it is debatable whether some of the funds that may no longer be used for compensation payments might instead be channelled towards supporting and rewarding efficiency improvements in industry, e.g. through the Innovation Fund.

Obviously, there are a number of uncertainties (technological, economic and regulatory) that need to be kept in mind, and which further underline the need to re-evaluate the appropriate compensation levels. Uncertainties include the future design of the electricity market(s) in Europe, and in what way they will transmit carbon costs to final consumers; they include the future demand for the products in question as Europe moves to a more circular, resource-efficient economy. And, importantly, they include international developments around climate action and carbon pricing, and as a result the need for indirect leakage compensation in the first place.

8.7 References

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European Commission (2012): Guidelines on certain State aid measures in the context of the greenhouse gas emission allowance trading scheme post-2012. SWD(2012) 130 final. Brussels, 5.6.2012