CLIMATE CHANGE
21/2017

Further Development of Energy Efficiency Policies for the Achieve-ment of the European Climate Protection Targets for 2050

Summary

For our Environment

Umwelt Bundesamt

CLIMATE CHANGE 21/2017

Environmental Research of the
Federal Ministry for the
Environment, Nature Conservation,
Building and Nuclear Safety

Project No. (FKZ) 3714 41 111 0
Report No. (UBA-FB) 002510

Further Development of Energy Efficiency Policies for the Achieve-ment of the European Climate Protection Targets for 2050

Summary

by

Katja Dinges, Sonja Förster, Daniel Becker, Mandana Hazrat,
Sarah Gül, Doris Johnson
Ecofys, Berlin

Urda Eichhorst, Ulrich Jansen, Dr. Stefan Thomas, Lena Tholen,
Carolin Schäfer-Sparenberg, Felix Suerkemper,
unter Mitarbeit von David Knor
Wuppertal Institut, Wuppertal

Uta Weiß, Benjamin Schmolck, Leon Leuser, Dr. Martin Pehnt, Markus Duscha,
unter Mitarbeit von Johannes Fehr und Alexander Woywode
IFEU, Heidelberg

On behalf of the German Environment Agency

Imprint

Publisher:
Umweltbundesamt
Wörlitzer Platz 1
06844 Dessau-Roßlau
Tel: +49 340-2103-0
Fax: +49 340-2103-2285
info@umweltbundesamt.de
Internet: www.umweltbundesamt.de

/umweltbundesamt.de
/umweltbundesamt

Study performed by:
Ecofys Germany
Albrechtstraße 10 c
10117 Berlin

Study completed in:
March 2017

Edited by:
Section I 2.2 Climate Protection
Ulla Strenge

Publication as pdf:
http://www.umweltbundesamt.de/publikationen

ISSN 1862-4359

Dessau-Roßlau, September 2017

The project underlying this report was financed by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear safety under project number FKZ 3714 41 111 0. The responsibility for the content of this publication lies with the author(s).

Kurzbeschreibung

Energieeffizienz spielt eine tragende Rolle für das Erreichen der langfristigen Klimaschutzziele der Europäischen Union (EU). Allerdings muss dafür auf EU-Ebene ein geeigneter politischer Rahmen geschaffen werden. Auch müssen die einzelnen EU-Mitgliedstaaten (MS) einen konsistenten und ambitionierten Politik- und Instrumenten-Ansatz verfolgen, um die Energieeffizienz in allen Bereichen zu stärken.

Zielsetzung dieses Forschungsauftrages ist es, Weiterentwicklungsoptionen der Energieeffizienzpolitiken auf der Ebene der Mitgliedstaaten und der EU vor dem Hintergrund der Dekarbonisierung der Wirtschaft und der europäischen Klimaschutzziele bis 2030 und 2050 zu erarbeiten. Gegenstand des Vorhabens sind die Sektoren Industrie, Private Haushalte und Verkehr und ihre Versorgung mit Strom, Wärme/Kälte und Kraftstoffen einschließlich Kopplungsmöglichkeiten in allen genannten Bereichen. Geographisch konzentriert sich die Untersuchung auf die EU-28, wobei sowohl der nationale Rechtsrahmen und nationale politische Strategien und Instrumente in ausgewählten Mitgliedstaaten als auch der europäische Regelungsbereich und die EU-Effizienzpolitiken betrachtet werden.

Zunächst wurden 19 Best-Practice-Beispiele für besonders zukunftsfähige und übertragbare Instrumente der Mitgliedstaaten zur Steigerung der Energieeffizienz ermittelt und aufbereitet. Anschließend wurden jeweils zwei verschiedene europäische Mitgliedstaaten exemplarisch ausgewählt, um in den Sektoren private Haushalte (Polen und Frankreich), Industrie (Polen und Deutschland) und Verkehr (Deutschland und Italien) zugrundeliegende Transformationspfade und Potenziale zu untersuchen und daraus abzuleiten welche Politiken und Instrumente zur Steigerung der Energieeffizienz im jeweiligen Sektor vorliegen, welche Defizite diese aufweisen und welche Optionen der (Weiter-)Entwicklung bestehen. Insgesamt zeigen die Länderstudien, dass wesentliche Hebel für eine Steigerung der Energieeffizienz in den einzelnen Sektoren insbesondere bei den regulatorischen Instrumenten, bei sektoralen Effizienzzielen und -strategien, der Finanzierung und der an den Energie- und CO_2-Gehalt angepassten Besteuerung fossiler Energieträger liegen. Sowohl eine deutlich ambitioniertere Umsetzung von bestehenden Instrumenten als auch weitere Instrumente sind bei allen untersuchten Ländern notwendig, um die in den Länderstudien beschriebenen länderspezifischen Zielszenarien zu erreichen.

In einem abschließenden Schritt wurden Empfehlungen für die Weiterentwicklung der EU-Politik sowohl zum übergeordneten förderlichen Rahmen als auch zu den einzelnen Sektoren gegeben. Dies umfasst u.a. verbindliche Ziele, Anpassung der Energiesteuern, verbindliche Umsetzung von Verpflichtungssystemen, die Entwicklung einer Gebäudestrategie, die Verschärfung der Anforderungen an Energieaudits für Nicht-KMU (EED) mit einer Umsetzungsverpflichtung von ausgewählten Maßnahmen, eine verpflichtende Berücksichtigung des Verkehrssektors in Artikel 7 EED und die Änderung der Bemessungsgrundlage für Flottenzielwerte und bei der Energieverbrauchskennzeichnung.

Abstract

Energy efficiency plays a key role in achieving the long-term climate protection targets of the European Union (EU). However, an appropriate political framework must be created at EU level. In addition, all EU Member States (MS) must individually adopt a consistent and ambitious policy and instruments package to strengthen energy efficiency in all sectors.

The aim of this research work is to develop further options for energy efficiency policies at a Member State and EU level, in the context of the decarbonisation of the economy towards the European climate protection targets by 2030 and 2050. The project covers the sectors of industry, households and transport and their supply of electricity, heat/cooling and fuels, including the possibility of coupling between the sectors mentioned. Geographically, the study focuses on the EU-28, considering the national legal framework and the national policies and instruments in selected MS as well as the European regulatory framework and the EU's energy efficiency policies.

Initially, there were identified and elaborated 19 best practice examples of viable and transferable instruments for increasing energy efficiency in Member States. Two different European MS were then selected as examples to investigate the underlying transformation pathways and potentials in the sectors of private households (Poland and France), industry (Poland and Germany) and transport (Germany and Italy). Based on these studies, it was analysed which policies and instruments drive to an energy efficiency improvement, which ones have some deficits and which options would lead to a (further) development of the energy efficiency in the respective sector. Overall, the country studies show that there are key leverages for increasing energy efficiency in the individual sectors, particularly regulatory instruments; sectoral efficiency targets and strategies; financing and the taxation of fossil fuels adapted to the energy and CO_2 content. However, a much more ambitious implementation of existing instruments as well as new instruments are necessary in all Member States under investigation to achieve the country-specific target scenarios described in the country studies.

In a final step, there were made recommendations for the further development of EU policies at both levels, an overarching and individual sectors level. This includes, among others, binding targets, adjustment of energy taxes, mandatory implementation of energy efficiency obligation schemes, the development of a building strategy, the tightening of the requirements for energy audits for non-SMEs (EED) with an obligation to implement the identified savings measures, a compulsory consideration of the transport sector in Article 7 EED and the revision of the assessment base for fleet target values and energy labelling.

Inhaltsverzeichnis

Summary

Tasks and methodology of the research project

With the 20-20-20 goals, the European Union (EU) has set climate protection targets for the reduction of energy consumption and greenhouse gas emissions and the increase of renewable energies. By 2020, greenhouse gas emissions should be reduced by 20 % compared to 1990, the share of renewable energies should increase to at least 20 %, and efficiency improvements should save at least 20 % of the primary and final energy consumption forecast for 2020.

At the EU level, the European Council agreed in October 2030 to increase energy efficiency by at least 27 % by 2030 compared to a business-as-usual scenario (PRIMES 2007) under the Energy and Climate Pact 2030. In addition, in its "Winter Package" at the end of 2016, the European Commission proposed to raise binding energy efficiency target at EU level to 30 %. In the framework strategy for an Energy Union, energy efficiency is anchored as one of the five essential dimensions. In autumn 2016, the proposals for the revision of the European Energy Efficiency Directive and the Building Directive were presented. The proposal of the revised Energy Efficiency Directive states that Member States should voluntarily contribute to the 30 % target and report to the Commission. Article 7 of the Directive, which encourages Member States to pursue annual energy efficiency progress, should remain flexible and continue to be pursued after 2020. The proposed reforms of the building directive are focused on the introduction of a ‘Smartness Indicator’ that ensures that buildings are connected to the residents and the electrical grid.

In addition, the EU should change to a "competitive, low-carbon" economic system by 2050 and reduce greenhouse gas emissions by 80 % to 95 % compared to 1990 levels. Energy efficiency is thus a key building block in the transformation process leading to a decarbonized and sustainable way of doing business.

Energy efficiency plays a key role in achieving the EU's long-term climate protection targets. Energy efficiency measures (supply side and demand side) can reduce greenhouse gas emissions by 75 % in 2050 compared to 1990 (Fraunhofer ISI 2012). This means that the EU's climate protection target for 2050 can be reached almost exclusively through the combination of energy efficiency and the use of renewable energies. This highlights the importance of reducing energy-related greenhouse gas emissions to protect the climate. Energy efficiency improvements are also associated with other positive synergies with regard to security of supply, reduction of import dependency, energy cost reductions, the facilitation of economic development and employment, as well as the protection of the environment and resources. Therefore an appropriate framework for energy efficiency must be created at EU level. It also requires a consistent and ambitious approach to policies and instruments in the EU Member States. Increasing energy efficiency in all fields, from energy supply to consumption in all sectors (industry, tradeand services, households, and transport), is indispensable.

The objective of this study is to develop further options for energy efficiency policies at Member State (MS) and EU level against the background of the decarbonisation of economy and in the context of European climate protection targets for 2030 and 2050. The project covers the sectors of industry, households, and transport, as well as their supply of electricity, heat/cooling and fuels, including coupling opportunities in all of these areas. Geographically, the study focuses on the EU-28, with both the national legal framework and national policy strategies and instruments in selected MS, as well as the European regulatory framework and EU efficiency policy are considered to achieve the EU's long-term climate protection targets.

In the sector of industry, the energy-intensive sectors or those with high energy efficiency potentials were examined. In the case of private households, buildings and energy-intensive product groups

were considered. In the transport sector, all transport modes, including national air and maritime transport, were studied. International air and maritime transport are not part of the project.

The research project is divided into three work packages:

- Work package 1 - Best practice examples for increasing energy efficiency in the EU-28
- Work package 2 - Country studies on increasing energy efficiency
- Work package 3 - Further development options for European efficiency policies

In work package 1, 19 **best practice examples** of particularly future-oriented and transferable instruments for increasing energy efficiency in the Member States were identified and analysed. To ensure a transparent and consistent selection of best practice examples, different selection criteria were taken into account. The main focus was on the future viability and the transferability of the instruments and measures. Data was derived from, among other things, the National Energy Efficiency Action Plans (NEEAP), reports submitted by Member States under Art. 7 EED, the MURE database, and the reports of the "Energy Efficiency Watch" project. At the same time, approaches at various levels were considered that are, for example, of a technical, organizational, institutional, or legal. In order to assess the transferability of instruments to other Member States, contextual conditions based on selected indicators were also identified, e.g. the energy mix, the energy efficiency potential, specifics and the energy efficiency strategy of the particular sector, and taken into account in the assessment. For this purpose, a data analysis was carried out on the basis of existing (energy efficiency) databases (Odyssey database, PRIMES database, Eurostat etc.) upon which the indicators were determined. However, the indicators could only be used to assess transferability to a limited extent, since the significance of individual indicators relative to a single instrument is small.

The policy instruments were allocated to the sectors private households, industry and trade, and transport and were also identified as cross sectoral instruments. They were also classified according to the type of instrument, such as regulation, economic incentive, and subsequently described in detail. Finally, a semi-qualitative assessment of the instruments was carried out according to the criteria of cost-effectiveness and transferability. For many of the listed examples, the evaluation was based on assessments from experts since no data on cost efficiency exists. The energy saving effects of the instruments were also taken into account for the prioritisation.

The instruments outlined were partially taken into account in the country studies, but were mainly used for the further development of the European efficiency policies in the work package 3. It also examined which instruments should be implemented at national level and which should be implemented at the European level.

In work package 2 **exemplary country studies** about increasing energy efficiency with high transferability were elaborated upon. As the energy situation in each Member State is very different and the transformation process in these sectors is dependent not only on country-specific conditions, but also on the energy mix of the country, these different constellations were considered in the project. The following criteria were therefore closely considered when selecting the Member States to be examined:

- high absolute or relative energy efficiency potential until 2030,
- different energy supply strategies,
- different transformation pathways and targets,
- broad coverage of the various energy-intensive industries by the selected Member States,
- further sector-specific criteria (space heating requirement per m^2, energy intensity of the industry, etc.)
- In the transport sector, a broad set of indicators was used to characterize the current energy efficiency of the different means of transport and the modal split.

- the transferability of the sectors under investigation to as many Member States as possible.
- For the individual sectors, the criteria were therefore weighted differently and supplemented as required with additional information.

In the next step, two different European Member States were selected as examples in the sectors of private households, industry and transport. In the private households sector, the focus is on residential buildings and energy-intensive product groups. In the industrial sector, the energy-intensive industries are analysed. Due to its limited importance, space heating was not considered here. In the transport sector, international aviation and shipping were excluded.

The following steps were carried out during the preparation of the country studies:

- status quo analysis of the sector and the national energy efficiency policy,
- broad scenario for the development of energy supply systems,
- transformation targets and pathways of each sector,
- sectoral energy efficiency potential,
- barriers to increasing energy efficiency in the sector, as well as deficits of existing (types of) policy instruments
- further development of policy instruments by 2030.

In the development of policy instruments, both the conducive, overarching framework as well as the sectoral policy instruments, which are strengthened by cooperation and addressed by all relevant actors and technologies, are included. The conducive framework contains, in particular, overarching instruments (strategies, objectives, funding, etc.) that need to be implemented to successfully implement sector-specific policy instruments aimed at increasing the energy efficiency of certain sectors/technologies, etc.

The sectoral country studies help to present a broad picture of successful policy instruments and develop them under the specific circumstances of the transformation in the respective country to 2030. In addition, implications for the efficiency policies until 2050 are considered. The country studies are an example of the specific characteristics of the respective countries. However, there are also very different policy approaches in the Member States, which must be taken into account in the further development of the EU's efficiency policies.

The climate protection scenarios of the Öko-Institut and Fraunhofer ISI (2014) as well as the UBA study "Greenhouse Gas Neutral Germany in 2050" (2014) were used as a basis for the development of energy supply, the transformation path and the analysis of energy efficiency potentials for the industry and transport sectors in Germany. For the other countries, available national scenarios and potential studies were used. However, the quality of the individual scenarios and the transparency of the underlying assumptions vary greatly. In addition to the literature research, interviews with selected national representatives were conducted for the barrier and deficit analysis as well as for the further development of policy instruments.

The temporal focus of the research project is the period 2020 to 2030 with a view to 2050. In particular, the policy instruments considered up to 2050 could only be touched upon lightly, due to the time horizon and the associated uncertainty as well as the limited availability of studies. Therefore, future-oriented topics such as, for example, sector coupling options and optimization by digitisation, have been taken into account, but have not yet been substantiated by concrete measures. The decarbonisation in all sectors could therefore only be shown to a limited extent by the policy instruments outlined. In the future, energy efficiency and energy supply (from renewable energies) must be jointly considered.

The objective of the work package 3 was to further develop **options for energy efficiency policies at EU level** in the context of climate protection targets by 2050. In spite of the policy intervention, studies show that the potential is not yet fully exploited (BMUB 2012, Ecofys 2016, Wuppertal Institute/Ecofys 2015) and further efforts are needed to reach the climate mitigation targets.

Against this background, the transformation pathways for the private households, industry and transport sectors were first presented and followed by a description of the highly efficient target situations. For this purpose, the Fraunhofer in 2012 and 2014 studies were mainly used. Subsequently, prototypical policy packages (eg Thomas et al., 2015, Thomas et al., 2016, ifeu 2012) were identified for these sectors, and in a deficit analysis, the existing EU instrument mix was aligned with these policy packages.

In addition to the three sectors, the conducive framework was also examined. On the basis of the identified deficits, proposals for appropriate options for further development for the sectoral and EU-wide policies were established and prioritised. The most effective tools to be implemented at national level are also highlighted.

The results of the country studies as well as the EU strategy were presented at an **expert workshop** in the Federal Environment Agency in Dessau on 20.09.2016 and discussed with about 30 participants. Participants came from, for example, the Federal Ministry for Economy and Energy, the Federal Ministry for Environment, Nature Conservation, Building and Nuclear Safety, the Federal Environment Agency, and various non-governmental organizations and scientific institutions. Based on the comments, results were verified and adjusted when necessary.

Best-Practice-Examples for increasing the energy efficiency in the EU-28

The Figure 1 shows an overview of the geographical distribution of the 19 Best-Practice-Examples and Table 1 lists them according to certain criteria.

Figure 1: Overview from the chosen countries.

Source: own illustration.

Altogether, only a small number of examples from Eastern European member countries are represented. It is due not only to the insufficient data and information available, but also to the current state of implementation of the energy efficiency policies in these countries.

Table 1: Best-Practice-Examples for increasing energy efficiency in the Member States

Instrument	Member State	Type of Instrument	Cost-efficiency	Transferability
Households				
Tax credit for sustainable development (Crédit d´impot développement durable, CIDD) in combination with energy information centers (Espace Info-Energie, EIE)	France	Financing, Information and Consultancy	medium	medium
KfW-Sponsorship	Germany	Financing, Information	medium	medium
Better Homes (Bedre bolig) Building standards on a voluntary basis	Denmark	Information Standards	high	medium
Energy saving in households - SEH Program	Greece	Financing	medium	medium
Building energy rating	Ireland	Regulation, Information	high	high
More with Less, Building renovation	The Netherlands	Voluntary Agreement, Financing	medium	medium
Industry and trade				
Climate Change Agreement (CCA) coupled with Climate Change Levy (CCL), Program for Energy Efficiency (PFE)	Great Britain (Sweden)	Voluntary Agreement coupled with Financing mechanisms (Regulation)	high	high
Large industry energy network (LIEN)	Ireland	Information and Consultancy	medium	high
Accelerated capital allowance	Ireland	Financing	high	high
Transport				
Environmental bonus-malus-scheme	France	Economic incentive	medium	high
Licence taxation, as well as comparative study of further examples (CO_2-related registration and vehicle taxation (Ireland) and car registration taxation (Latvia))	Denmark (Ireland, Latvia)	Regulation	high	high
Company cars regulation	Sweden	Economic incentive, Regulation	high	medium
Voluntary commitment to reduce CO_2-Emissions (Road	France	Voluntary Agreement, Regulation	high	high

Instrument	Member State	Type of Instrument	Cost-efficiency	Transferability
transport and passenger transport)				
Sustainable mobility concept	Spain	Regulation	low	high
Cross-sectoral				
Commitment systems couple with energy audits	Denmark	Regulation	high	high
Energy manager and white certificates	Italy	Regulation	high	high
Slovakian Facility for Energy Efficiency and Renewable Energies (SLOVSEFF), Bulgarian energy efficiency funds (EERSF)	Slovakia (Bulgaria)	Financing	medium	medium
Active: Climate (KLIMA:AKTIV)	Austria	Information, Consultancy	medium	high
Bundling demand	Sweden	Economic incentive	low	medium

Country studies on energy efficiency

Selection of the country studies

The selected countries were chosen based on the aforementioned criteria. The following countries were chosen for the sector analysis:

Table 2: Selected countries by sector

Private House-holds	Industry	Transport
France	Germany	Germany
Poland	Poland	Italy

With the selection of these member countries for the analysis of the sectors named above, the different current and future energy supply priorities were also considered:

Germany: Renewable Energy

France: Nuclear Power

Poland: Coal

Italy: Natural Gas.

Selection for the private households sector

France

In comparison with the rest of Europe, the private household sector in France has the second highest absolute energy efficiency potential with 13,020 ktoe in 2030, and with 31 %, the relative energy efficiency potential of France is puts it in the leading group of countries (Fraunhofer ISI et al. 2014). The space heating demand from French buildings is slightly above the EU average. In addition, in France inside insulation is often used und in many cases is heated with electricity, meaning that there is a considerable potential for innovation in the French building sector. France continues to employ interesting political approaches to energy efficiency, such as a bonus malus regulation for the building sector; however, a corresponding draft bill was rejected. The existing measures, such as energy information centres (EIE) and tax credits for sustainable development (CIDD), are also interesting approaches. The Energy Transition Law that was published in August 2015 provides important stimulus, including for energy efficiency policy in the building sector, and is particularly interesting because of its possible transferability to other countries.

Poland

With 27 % Poland is ranked seventh in the EU related in regards to relative energy efficiency potential and fifth in terms of absolute energy potential with 3,920 ktoe in 2030 (Fraunhofer ISI et al. 2014). The space heating demand per square meter in residential buildings is the third highest in the EU. It is also striking that 40 % of the buildings are heated with coal. Due to its past, Poland has many energetically inefficient buildings. In recent years however, the building stock has been supplemented by many new, efficient buildings. As a CEE country, Poland offers a number of characteristics such as a high portion of district heating that are applicable to other CEE countries and it should also be interesting for western Europe (see the example of expansion in Western Europe of the district heating in Denmark).

Selection for the industry sector

Germany

With 5,300 ktoe of absolute energy efficiency potential in 2030 for the industrial sector, Germany has the highest one. The relative energy efficiency potential remains at 10 % low and only falls around the European average (Fraunhofer ISI et al. 2014). The energy intensity per purchasing power parity is also near the average with 0.1 koe/€ 2005p; however, the higher price in Germany leads to a higher energy intensity with this indicator than would be the case if referenced to GDP ((Odyssey 2015) in the appendix). In the framework of the Energy Transition Germany is shifting its electricity supply to primarily renewable energies although large proportions of coal-fired electricity remains in the production mix at present.

Poland

In regards to absolute energy efficiency potential, the polish industrial sector is ranked sixth in Europe in 2030 with 2,110 ktoe. Like Germany, Poland is near the European average for relative energy efficiency potential with 10 %, (Fraunhofer ISI et al. 2014). With the chemical, steel and non-metallic minerals industries, Poland covers the most important energy-intensive industries. At the same time, the energy intensity of the Polish industry is particularly low in terms of purchasing power, which is also linked to the relatively low prices in Poland (Odyssey 2015). The main feature of power generation in Poland is the long-term concentration on coal as a source of energy and the planned entry into nuclear power. Overall, the analysis of Polish energy efficiency policy in the industrial sector presents interesting contrasts to the situation in Germany.

Selection for the transport sector

Germany

With 6,580 ktoe in 2030 Germany has the second highest absolute energy efficiency potential of the transport sectors of Europe, but with a relative energy efficiency potential of 14 %, Germany falls around the European average (Fraunhofer ISI et al. 2014, own calculation). In comparison with the rest of Europe, the German passenger vehicles consume more fuel than the European average with 7.18 L/100 km. For new passenger vehicles Germany is among the five worst values with 5.86 L/100 km. In freight transport, the situation in Germany is better: the road freight transport reaches a comparatively low value 32 oe/tkm, while rail and inland waterway transport reach an above-average portion of 27 % in the modal split of freight traffic (Odyssee 2015).

Italy

With 15 % relative energy efficiency potential until 2030 (Fraunhofer ISI et al. 2014, own calculation) the Italian transport sector falls around the European average. The absolute energy efficiency potential is ranked fourth in the region. In terms of passenger vehicles, Italy achieves excellent values. With an average of 6.06 L/100 km, the specific fuel consumption of passenger vehicles in Italy is among the lowest in Europe (Odyssee 2015). The share of public passenger transport related to the total passenger transport is with 21 % among the top five EU countries. Only with the consumption of road freight traffic is Italy with 96 oe/tkm among the five worst values - but is exactly complementary to Germany.

After the selection of the Member States to be studied, sectoral energy efficiency strategies for these exemplary Member States were developed and appropriate continuing and newly established policies and instruments are recommended.

Private households sector

Poland

The analysis shows a difficult initial situation in Poland: The energy demand of private households for heating and hot water is high because the buildings are poorly insulated and furnaces and boilers are usually inefficient. At the same time, the heating systems are often of the simplest nature and often even temperature control options are lacking in the home. As economic growth increases, so too does the number of dwellings and residential spaces. The electricity consumption of Polish households is low compared to other European countries, but many appliances are inefficient and the increasing amount of equipment used in the home indicates growing power consumption. Energy prices are low compared to other European countries, especially coal prices.

The heat protection requirements in new construction of residential housing are comparatively low. In addition, for half of the new buildings that do not comply with the legal requirements, implementation by the building supervisory authorities does not take place in practice. In the case of refurbishments, only heating systems are usually replaced or modernized, while energy-efficient windows are rarely installed, and exterior walls are only rarely insulated.

Poland is also closely linked to the coal industry today: over 75 % of the total final energy for space heating and hot water (including district heating) is generated with coal. This is unique in Europe and is highly problematic from a climate protection point of view.

Yet the political will for a clear energy efficiency strategy is missing in Poland. The Energy Strategy 2030, for example, provides only a few concrete measures for energy efficiency and conveys the clear message that coal and lignite will continue to be the first priority in power generation and that even new lignite open-cast mining will be developed from 2030 onwards. Renewable energies are only included to a limited extent and are planned primarily in the form of biomass. Both in politics as well as in large parts of the population, hardly any motivation for a transformation to a sustainable economy in 2050 is recognizable.

This difficult initial situation becomes clearer against the background of the description of a target scenario. The analysed scenario 2050.pl remains behind more ambitious scenarios with a radical policy change and change to renewable energies and does not permit the necessary transformation to be carried out in 2050. Nonetheless it goes far beyond the current Polish policy. The scenario envisages a sharp decline in coal in electricity production (flanked by CCS), as well as an entry into the use of nuclear power and a significant increase in the share of fluctuating renewable energies. Furthermore, extensive building refurbishments and energy efficiency increases are planned for appliances [Bukowski, et al., 2013].

In the private households sector, the greatest energy efficiency potentials are in energetic building renovation. This is also a great benefit for the residents, as many apartments are in very bad condition. An additional move away from coal would significantly reduce greenhouse gas emissions.

However, there are a number of obstacles to the energy efficiency measures: lack of awareness, lack of capital and profitability, inadequate market for energy services and complicated ownership structures. On the other hand, today's political instruments for addressing these obstacles are incomplete. There is a lack of a dedicated approach, for example, to raise awareness among the population. In addition, there are weaknesses in the implementation, for example in the case of energy certifications for buildings. In some cases, funding programs do not sufficiently address actors, although gaps, such as those for the owners of single family homes, have recently been partially closed, albeit with very little funding. The abandonment of coal in heat generation is still not addressed at the national level at all. A positive signal, however, is the Anti-Smog Law adopted at the end of 2015, on the basis

of which the city of Krakow introduced a combustion ban for coal in households and offices from 2019 onwards.

The investigation shows that the political instruments must be further developed and supplemented. It is advisable to expand energy consulting and information, to significantly strengthen the building energy certificate and to make energy consulting the gateway to energy-oriented refurbishment. Financial support should be targeted in terms of both stakeholders and content. Regulatory measures should be ambitious, for example by demanding nearly zero-energy building standards for new buildings and mandatory redevelopment procedures for existing buildings. At the same time market monitoring and supervision of construction should be strengthened. In addition, renovation of residential buildings is also of immense importance for social reasons: this should absolutely be linked to an ambitious energetic renovation. In addition, a bundle of measures should allow for the gradual removal of coal furnaces and boilers. Poland's strength is the large district heating network, which could be used for a transformation to a sustainable system. To date, no decarbonisation of the district heating has been planned - a package of measures should provide a remedy for this.

Furthermore, the long-term goal of a transformation to a sustainable system in 2050 will, considering today's policies, require real system change. It is also necessary to consider the coupling of the sectors, which allows the integration of large quantities of fluctuating electricity and facilitates further decarbonisation of heat generation (and mobility).

France

For the private households sector in France, this study has shown several problem areas: the building stock is old and households have a high energy consumption for space heating and water heating. Although renovation measures are frequently conducted, they are done at small depth and the recommendations from the energy certificates are only partially implemented. Energetically inefficient, electrical direct heating systems are common both in existing and new buildings. The other built-in boilers are relatively young on average, but the share of energy-inefficient constant-temperature boilers is still very high. Electricity consumption has also risen sharply for electrical equipment in recent years, mainly due to the growing number of small appliances.

The analysed target scenario négaWatt shows a possible way to transform to a sustainable system. In order to reduce the CO_2 emissions of France by 75 % by 2050 compared to 1990, the négaWatt scenario provides a number of approaches for the private sector: from 2025 onwards 750,000 deep renovations are necessary each year, reducing the primary energy consumption to 40- 45 kWh / (m^2 a), while at the same time the primary energy demand for new buildings should be reduced to below 15 kWh / (m^2 a). Accompanying measures are also expected to reduce the growth of residential spaces compared to the reference scenario. In the scenario, the heat supply is converted as far as possible to renewable energies so that it covers 94 % of the heat requirement in 2050. In addition, a withdrawal from the technology of direct electric heating systems will be required, which will be almost entirely replaced by electric heat pumps. For multi-family houses, local and district heating networks are also being expanded. In addition to efficiency improvements, electrical equipment also requires behavioural changes, which means that the amount of equipment only increases slightly and even decreases with some devices. As the generation of electricity in the scenario is largely based on fluctuating energy production, it is also crucial to integrate the individual sectors into the overall system and electricity generation. [négaWatt, 2014]

Possible energy efficiency measures in France are faced a number of obstacles. In particular, there is a lack of information on the extent to which refurbishments and target conditions of residential buildings are aimed at climate protection targets. Insufficient capital also inhibits goal-oriented renovations. Individual heat metering systems for hot water are often missing in multi-family houses, which is why households are not sensitized to their consumption and also have few economic incen-

tives for savings. A key obstacle to savings in electricity consumption is the political objective of keeping consumer prices for electricity as low as possible. This leads to a very high proportion of new, electrical direct heating systems, especially in new buildings. The low electricity price inhibits the motivation to reduce their own electricity consumption in the case of electrical appliances as well. Especially in the case of electricity consumption, there is often little awareness of the problem because nuclear power is viewed as a particularly cost-effective and climate-friendly solution. This is also a consequence of the political framework conditions.

This situation is already being addressed in France, especially for residential buildings, through a wide range of policy instruments. Particularly in connection with the COP 21 climate conference, France is striving for ambitious policies. However, some instruments have gaps that should be closed in order to increase the energy efficiency potential on a large scale. In the building sector, minimum efficiency requirements for new buildings have been stagnating for a long time and have only been tightened in 2012 with the thermal insulation regulation. Since then, however, no further tightening has taken place and the nearly zero-energy buildings, which are to be constructed from 2020/21 are not yet subject to ambitious requirements. Funding programs for renovations have thus far not adequately covered target-compliant deep sanitation and the Habiter Mieux program is mainly geared towards reaching "low hanging fruit", which can result in lock-in effects.

Overarching strategies and timetables therefore need to focus even more on the long-term goal-setting. In addition, new instruments must pay more attention to the target compatibility of measures. The planned renovation certificate should be designed as an individual rehabilitation plan in as far as possible. The certification of nearly zero-energy and plus energy buildings should be more closely linked with funding in order to allow these buildings to be distributed more rapidly on the market. By means of stepped subsidies, sophisticated renovations and highly efficient components should be preferred. In addition, neighbourhood concepts can create new opportunities in heat supply, such as the expansion of local and district heating networks. The shift to renewable energies in heating and cooling should be promoted more strongly and supported by more stringent regulatory requirements.

In the medium term, it is advisable to strive for an electricity price level that reflects the real costs for the dismantling of the nuclear power plants and disposal costs as well as improves the profitability of electricity savings for end customers. A phase-out for direct electric heaters should be introduced and an associated switch to heat pumps should be encouraged. The prerequisite for the promotion of energy-saving renovations should be that the statutory obligation for the accounting of individual consumption is met. In the case of energy-consuming appliances, measures should be aimed more at reducing energy consumption and not just improving energy efficiency. To do so, the issue of economical user behaviour but also the choice of the right device size or the appropriate range of services should be addressed.

The long-term goal of a transformation to a sustainable system in 2050 will also require further adjustments, which will also involve a stronger coupling of the sectors and thus the integration of highly fluctuating electricity generation.

Industry sector

Germany

The total final energy consumption in Germany in 2013 amounted to 9,269 PJ. The industrial sector contributed 2,640 PJ in 2013, corresponding to 28.48 % (AGEB 2014, Table 5). The final energy consumption of the individual industrial sectors varies greatly. The most energy-intensive individual industrial sectors in Germany are the metal, chemical, mineral, and paper and pulp industries (see UBA 2013b, p. 138). Two different scenarios, the UBA study "A greenhouse gas-neutral Germany in

2050" (THGND) and the climate protection scenarios (KS 90) of Öko-Institut/Fraunhofer ISI were considered for the decarbonisation path of Germany. The THGND is based on an assumption of 100 % electricity generation from renewable energy and an increase in the application of PtX technologies. Fossil fuels are no longer used (UBA 2014a, p. 49ff.). The KS 90 scenarios assumes a 94 % renewable energy supply. In addition, a small share of fossil fuels is used. Furthermore, CCS will be used in KS 90 from 2030 onwards (Öko-Institut et al., 2014a, p. X-XI).

Both scenarios determine a similar final energy consumption of the industry in the year 2050 reaching 1,343 PJ (THGND) and 1,587 PJ (KS 90) (UBA, 2014a, p.79, Öko-Institut/Fraunhofer ISI 2014a, p 138). Heat recovery, consistent waste heat utilisation and process optimization represent the central efficiency measures that must be implemented in all sectors according to the transformation pathway.

In the determination of energy efficiency potentials, a final energy savings potential of around 1,249 PJ by 2050 is assumed (compared to the baseline year 2010) under the THGND scenario. This value corresponds to a relative saving of 48 % in 2050 (UBA 2014a, p. 125/126). When using the KS 90 study, there is a final energy saving potential obtained of 596 PJ (compared to a reference scenario) or 816 PJ (compared to baseline year 2010). These values correspond to a relative savings of 27 % and 34 %, respectively in 2050 (Öko-Institut/Fraunhofer ISI 2014a: p. 124ff., own calculations). The largest absolute, industry-specific savings potentials are found for both scenarios in the basic chemicals, metal, and paper industries. In addition to the process technologies, cross-sectional technologies such as engine applications, pumps, compressed air and ventilation, as well as systems for heat recovery and heat pumps all play an important role.

The main obstacles to enhance these potentials are economic obstacles such as expectations from short amortization periods as well as other obstacles such as conditional derogations as a result of low energy prices for industry actors and informational barriers. In addition, there are also sector-specific barriers (see Fraunhofer ISI et al. 2012).

Energy efficiency is considered as the second pillar of energy transition. Germany has set itself the target of reducing primary energy consumption 20 % by 2020 and 50 % by 2050 compared to the base year 2008, as well as increasing energy productivity of 2.1 % per year (NAPE 2014, p. 8). Contrary to the buildings sector (heat) and transport sector, there are no national, partial or sector-specific targets for the industrial sector. With the National Action Plan Energy Efficiency (NAPE), Germany adopted an energy efficiency strategy with a package of measures for the first time.

To overcome barriers, Germany employs a number of policy instruments and types partially strengthen each other (e.g. in the framework of energy efficiency networks, identified energy efficiency measures can be implemented using funding instruments) or function in a complementary manner (e.g. information). However, there are still instruments that, in cooperation, have a negative impact on energy efficiency. One example is the exemption from the Renewable Energies Act levy. Companies whose energy consumption is just above the threshold according to §§ 63 et seq. EEG 2014, have no incentive to implement further energy efficiency measures and thus no longer fall under the exemption.

However, a focus of the instrumentation is on financial incentives. Nevertheless, it is clear that efficiency measures are not being implemented sufficiently in industry and that that a contribution from the industrial sector to closing the gap to the 2020 target is required. It is therefore necessary that in addition to further developing existing instruments, price and quantity-controlling elements as well as stronger regulatory interventions be considered in the mix of policy instruments. In addition, future, new instruments must be aligned more closely with the transformation pathway. As a result, issues such as sector coupling and the flexibility of demand in power systems with a high share of renewable energies must be considered in a policy package to be developed by 2050.

Poland

To date, a clear energy efficiency strategy has been lacking in Poland. In the Polish Energy Strategy up to 2030 "Energy Policy of Poland until 2030" (Polish Ministry of Economy 2009) the improvement of energy efficiency is mentioned as the first goal, but only with a few concrete measures. There is also no efficiency strategy for industry, although it accounts for about a quarter of national final energy consumption. The three most energy-intensive sectors are chemicals and petrochemicals, iron and steel, and the non-metal industry. The decarbonisation of Poland should take place in the context of an expected, positive economic development and, above all, an increase in the standard of living, which is in contrast with most Western European countries. However, the industrial sector should play only a secondary role. Also in 2050, coal and gas power plants will continue supply more than a third of electricity generation. Renewable energies generate slightly less than half and the rest of the electricity comes from nuclear power plants (Bukowski et al., 2013, p. 142). In addition, CCS is considered a key mitigation measure. Against the background of such a scenario, the decarbonisation of Poland cannot be achieved by 2050.

Centralized efficiency measures in industry are process and plant optimization as well as material efficiency and waste heat utilisation. The largest energy efficiency potential is about 71 % and is for cross-sectional technologies. If the individual industries are studied, it is clear that the chemical industry, non-metallic minerals and the food industry have the highest absolute savings potential (Fraunhofer ISI 2014, Country Annex 3: Modelling Analysis, p. 45/46).

The main obstacles to enhance these potentials are a lack of awareness and information, as well as financial barriers (availability of capital, economic efficiency, low electricity prices) (Bukowski et al., 2013, p. 101). These obstacles are not yet sufficiently addressed by existing policy instruments. An important aspect to highlight is that a large part of the efficiency measures are financed by the EU operational programs. The White Certificates System, which is a major efficiency instrument, has so far been considered a non-functioning system in Poland. The obligated actors (suppliers of electricity, heat or gas) have no interest in the improvement of energy efficiency.

To achieve decarbonisation in Poland, it is important to pursue an ambitious efficiency policy, to diversify the supply of energy and to strengthen the awareness of energy efficiency. It is essential that a policy package include market-based instruments (reducing the administrative burden of the White Certificates system by removing the trading component), regulatory instruments (strengthening the ESCO market, reducing environmentally unfriendly subsidies), targeted information campaigns for the industrial sector, and financial instruments (e.g. the introduction of capital allowance). With a view to 2050, process and innovation technologies should be supported in the early stages of research and development and the possibilities of sectoral coupling in energy generation by increasing the share of renewable energies should be explored. If Poland continues relying on CCS, the support and financing of research in this field must be further developed.

Transport sector

Germany

The final energy consumption in the transport sector in Germany amounted to a total of 2,612 PJ in 2013 and corresponds to a share of 28.2 % of total final energy consumption of the country (BMWi 2015, Table sheet 6a). The most important energy sources in the transport sector are diesel (50.2 %) and petrol (28.4 %), followed by jet fuel (kerosene) (14.4 %), while biofuels (4.2 %), electricity (1.7 %), and (liquefied) gases (1.3 %) play a minor role (BMWi 2015, Table sheet 6a). Two different scenarios, the UBA study "A greenhouse gas-neutral Germany in 2050" (THGND) and the climate protection scenario (KS 90, 1st modelling round) by the Öko-Institut/Fraunhofer ISI, were considered for German decarbonisation pathway. The THGND scenario assumes that 100% of electricity is generat-

ed from renewable energy sources and that energy carriers for passenger and freight transport (excluding maritime transport) are supplied by electricity from renewable sources (about 20 %) and liquid fuels from renewable sources (about 80 %), On the other hand, the KS90 scenario considers fossil fuels (34 %) as well as biofuels (44 %), electricity (20 %) and hydrogen (2 %), as energy carries for the transport sector. The scenarios also differ with respect to final energy consumption in 2050. The KS 90 calculates a final energy consumption (excluding freight shipping) of 1,347 PJ, while the final energy consumption (excluding freight shipping) in the THGND is 20 % higher with 1,623 PJ (UBA 2014a, Öko-Institut 2013, Öko-Institut et al., 2014a).

In the determination of energy efficiency potentials, an absolute reduction potential of around 789 PJ (compared to a trend review[1]) is expected under the THGND scenario by 2050, which corresponds to a relative reduction of 32.7 %. The KS 90 scenario shows an absolute reduction potential of 622 PJ (compared to a trend scenario), corresponding to a relative reduction of 31.6 %.

While the absolute reduction potential in the THGND is roughly the same for passenger and freight transport, a significantly greater reduction potential is found for passenger transport compared to freight transport in the KS 90 (-435 PJ to -187 PJ, respectively) (Öko-Institut 2013, pp. 70 ff., Öko-Institut et al., 2014a, pp. 174ff.).

At all levels of efficiency levels (system, travel or transport and vehicle efficiency) there are currently barriers which impede the realisation of these potentials. At system level there is a lack of a mandatory master plan for an integrated transport policy. This can be seen in an absence of integration at the spatial, modal, and sectoral levels, which is reflected in a number of partially conflicting and uncoordinated plans. A shift to more energy-efficient and sustainable transport modes is countered by a number of financial obstacles, such as insufficient internalisation of external costs and competition-relevant differences in taxes, duties and subsidies, resulting in an insufficient steering effect in energy efficiency and climate compatibility of transport choices (UBA 2014 b, p. 17). In addition, a limited cost awareness when choosing a transport mode and high symbolic importance of the car contribute to the widespread use and ownership of cars. An increase in vehicle efficiency is confronted primarily with the higher costs of vehicles with alternative drives and continuing scepticism about these new alternative drives and technologies.

Germany has set the goal of reducing the final energy consumption in transport by 10 % by 2020 and by 40 % by 2050 compared to 2005. To achieve these targets and to raise energy efficiency potentials and overcoming the existing barriers in the transport sector, a large number of (types of) policy instruments have been employed. The focus of the existing instruments is essentially on increasing vehicle efficiency, but areas such as system, trip, and transport efficiency are hardly addressed by the existing policy package. All in all, the majority of the existing instruments have a minor effect on the achievement of the energy and climate change targets for the transport sector. As such, the strengthening of these instruments would not be enough to achieve the proposed targets. A general transition in transport is necessary in order to achieve a drastic reduction of the energy demand and an extensive decarbonisation of the sector. A necessary paradigm shift that not only addresses an increase in vehicle efficiency but also a shift to more efficient transport modes, as well as the avoidance or optimisation of traffic, is required. This shift requires an overall concept for an integrated, energy-efficient and climate-neutral transport policy at the national level. Further economic incentives and/or better financial resources are necessary to provide high-quality, comprehensive eco-modes of transport and thereby a competitive alternative to motorised individual transport. At the regulatory

[1] Not only the two scenarios THGND and KS 90 differ in the final energy consumption in traffic in the year 2050, but also the trend considerations for the scenarios. While the THGND assumes 2,412 PJ of final energy consumption in the trend view, the KS 90 assumes only 1,969 PJ

level, it is important to further develop and expand existing EU instruments (for example, fleet targets) but also to strengthen the use of restrictive measures against motorized individual traffic (e.g. speed limits at national level). The taxation of cars should be based on their CO_2 emissions and specific energy consumption. The acquisition and operating costs of private used company cars should only be deductible to a limited extent and with an environmentally-oriented differentiation of tax. This mix of instruments should be supplemented by informative tools that influence the mobility behaviour and the choice of transport modes towards an environment-friendly transport sector.

Italy

The final energy consumption in the transport sector in Italy was 1,494 PJ in 2013. As a result, around 29.5 % of total final energy consumption in Italy came from the transport sector in 2013. Within the transport sector, motorized road transport was the main consumer in 2013 with 1,375 PJ (equivalent to 92 %). 91 % of final energy consumption related to transport stems from petroleum products, 2.9 % natural gas, biofuels and waste 3.5 % and electricity 2.6 % (OECD/IEA 2016).

In 2013, Italy adopted its National Energy Strategy (NES), which focuses on targets up to 2020. For the target year 2050, NES calls for a "flexible and efficient long-term strategy", emphasizes the importance of research and development, and explicitly opposes the establishment of specific technology pathways (MiSe, 2013, p. 118). For the year 2050, the NES outlines necessary targets for primary energy consumption, the expansion of renewable energies, and the electrification to achieve a 75 % reduction of GHG emissions compared to 1990, but does so without taking a closer look at the underlying scenarios. Background information on the NES scenarios for 2050 has not yet been published.

For this reason, the country study reverts to the current scenario calculations by ENEA for 2050, which were created within the framework of the Deep Decarbonation Pathways Project (DDPP) (Virdis et al., 2015). In this study, three scenarios were developed and compared with a reference scenario. The Demand Reduction scenario (DMD_RED) is the focus of this study. It is the scenario with the highest efficiency increase, the lowest share of CCS, the highest assumed modal shift, and the lowest final energy consumption in 2050 (both in the transport sector and in total) (Virdis et al., 2015, pp. 22 and 60ff).

The DMD_RED scenario, which is based on the use of renewable energies and biomass, shows that by 2050 there is an additional mitigation potential of almost 40 % of the primary energy, compared to the reference scenario in which around two thirds of the primary energy supply in 2050 comes from fossil fuels coal, oil and gas (Virdis et al., 2015, p. 25). For the transport sector, the DMD_RED scenario assumes investment in the expansion of public transport infrastructure and freight transport by rail and water. 15 % of private car traffic is shifted to public transport. Compared to the reference scenario, which shows an increase in traffic volume of 10.7 % for passenger traffic by 2050 compared to 2010 values, the DMD_RED scenario shows a decrease of 11.7 % over the same period. The traffic volume increases by more than 38 % in the reference scenario, while the DMD_RED scenario shows a considerably lower increase of 3.4 %. In addition, the DMD_RED scenario is based on a comprehensive market penetration of alternative driving concepts for passenger cars. In 2050, according to the DMD_RED scenario, about 90 % of private car travel will occur with electric cars and plug-in hybrid vehicles.

Overall, the DMD_RED scenario shows a drop in the final energy demand in transport from around 1,770 PJ in 2010 to around 913 PJ in 2050. The total CO_2 emissions caused by the transport sector amount to 31.6 Mt in 2050. This corresponds to 76 Mt CO_2 less than the reference scenario by 2050 or 73 % less compared to 2010.

However, obstacles at all efficiency levels (system, travel, transport and vehicle efficiency) have so far prevented these potentials from being tapped. In regards to system efficiency, the lack of integration of transport and settlement development is the main issue. In the past, this has led to car-

oriented urban development in Italy, associated with an increase of the travel distance due to the suburbanization. Overall, there is a lack of a national strategy for the promotion of sustainable mobility, in particular a strategy for the nationwide promotion of cycling and pedestrian mobility. National requirements for the promotion of a traffic-saving settlement development are also missing. At the level of travel and transport efficiency, the deficits concerning public transport are particularly noteworthy. For example, the infrastructure for public transport in parts of the country is only insufficiently developed. There is also a lack of viable financing for a high-quality offer to develop public transport. In terms of increasing vehicle efficiency, the currently incomplete infrastructure for alternative drives is notable. This contributes to the fact that a stronger market penetration of these alternative motors, which is associated with the substitution of conventional vehicles, has hitherto been very difficult. There is also a lack of tax incentives for potential users to buy vehicles with alternative as opposed to conventional drives. A further obstacle to vehicles with alternative drive systems are the higher purchase costs compared to conventional vehicles.

It is the goal of Italy to reduce CO_2 emissions 21 % by 2020 against 1990. The share of renewable energies should be increased from ten to 19 % - 20 % over the same period. To reach the target of the National Energy Strategy by 2020, the largest savings are expected to come from the transport sector(MiSe, 2013, p. 48). The National Energy Efficiency Action Plan (NEEAP) also expects the largest contribution from the transport sector (MiSe, 2015b, Table ES.1). To achieve these targets, increase the energy efficiency potentials in the sector even further, and overcome the existing barriers, a considerable number of policy instruments have already been implemented. These include planning, regulatory, economic and informational tools, as well as instruments promoting research and development. The primary objective of these instruments is to increase vehicle efficiency, and to a lesser extent, address an increase in system, travel and transport efficiency. However, the majority of the existing instruments, have only a small or selective impact on sustainable mobility. Therefore, the expansion and modification of existing instruments and the implementation of additional ones are the priorities.

One approach at the regulatory level is the further development of existing instruments at European level, such as the CO_2 fleet limits for passenger cars and light commercial vehicles. It is also necessary to implement restrictive measures for passenger car transport to a further extent than was previously the case. The existing economic instruments should, for example, be further developed in such a way that the level of the registration and car tax are related to the CO_2 emissions of the vehicle this should also be the case for tolls on motorways. Overall, the economic instruments should internalise many more of the externalised costs caused by the transport sector than is currently the case.

It can be assumed that an expansion and/or modification of the existing instruments alone will not be sufficient to reduce the energy demand of the transport sector and lead to the sector's decarbonisation. On the contrary, a fundamental modal shift is also necessary in Italy. Without alternative drives on the basis of low-carbon and carbon-free energy sources, this goal cannot be achieved. A paradigm shift is needed in Italy's transport policy such that the focus is not only on the search for technical solutions, but also on the promotion of low transport settlement structures and economic structures, as well as the promotion of low-carbon and carbon-free transport modes. This requires an overarching national transport concept to promote energy-efficient, climate-friendly, and socially acceptable mobility. The building blocks of such a concept should, for example, include the long-term provision of public transport, cycling and pedestrian traffic with the financial resources needed to ensure high-quality offerings around the country that would allow such transportation modes to become real alternatives to the passenger car in the future.

Further development options of European energy efficiency policies

Finally, recommendations for possible further development options for European efficiency policies were developed. The findings from the analysis of the best practice examples and country studies were also taken into account. Country studies, for example, show that key levers for increasing energy efficiency in the various sectors are particularly regulatory instruments, sectoral efficiency targets and strategies, financing and energy and CO_2-based taxation of fossil fuels. These require numerous regulations at EU level, either directly or as a prerequisite for the implementation in the Member States. A more ambitious implementation of existing instruments as well as further instruments are necessary for all countries under investigation in order to achieve the country-specific target scenarios.

Identification of prototypical policy packages

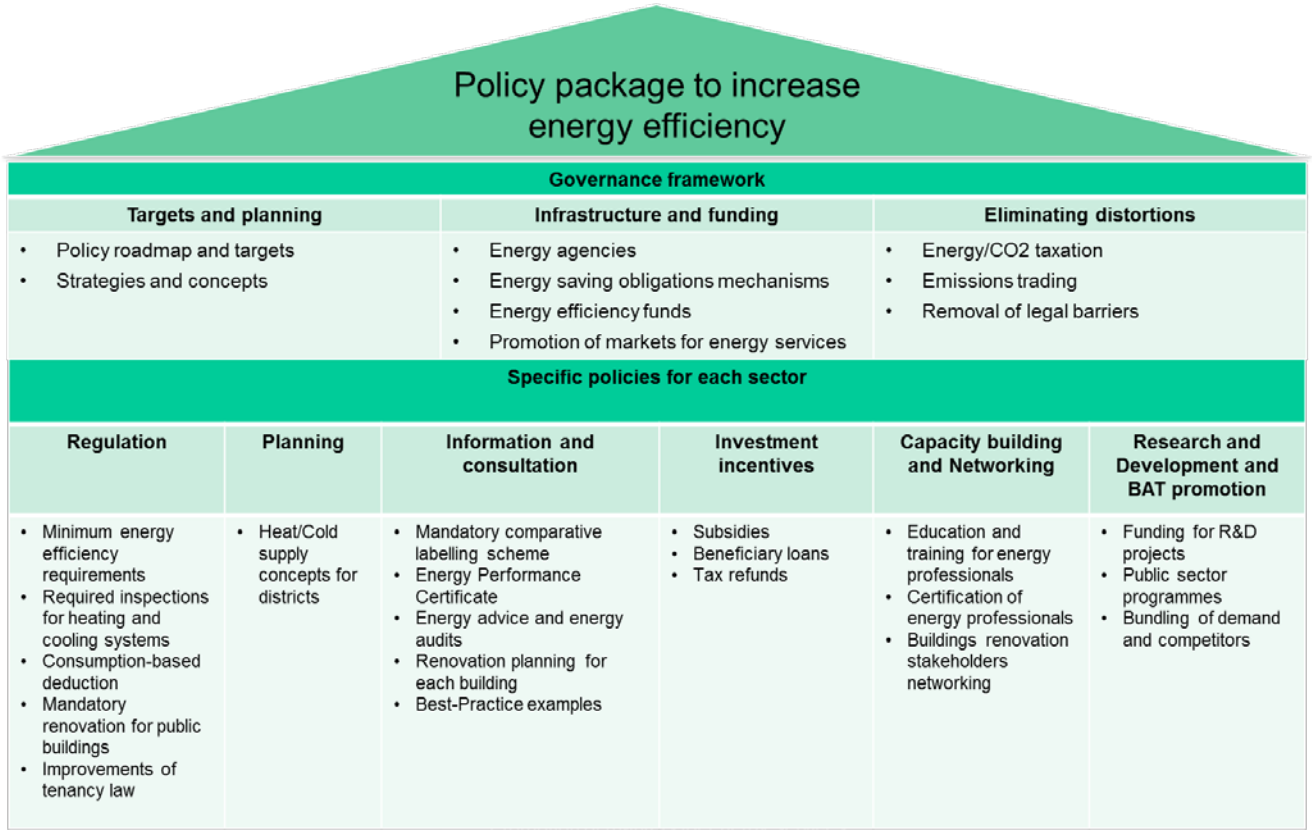
For the individual sectors and for the overall supporting framework, prototypical policy packages are elaborated in Work Package 3 that are identified as valuable and essential in the scientific literature on energy efficiency policies (eg. Thomas et al. 2015; Thomas et al. 2016; ifeu 2012). The favorable framework includes, in particular, overarching instruments that must be in place to successfully implement sector-specific policy instruments aimed at specific energy efficiency improvements in certain sectors/technologies, etc. In addition to the policy package for the favorable framework, the following figure shows an example of the policy package in the private household sector.

The conducive framework includes clearly defined, ambitious and long-term targets and strategies for energy consumption or energy savings compared to a base year or reference scenario. An important requirement for the implementation of this objective is the existence of qualified actors with clear responsibilities (for example energy agencies) and sufficient financing for the implementation of the sectoral policy instruments. To provide an attractive incentive, save energy, and reduce market distortions, the implementation of a functioning price or quantity control mechanisms through policies is essential.

In addition to this overall part of instruments, it is necessary to implement specific policy packages for each sector. Even if the mix of policy instruments differs slightly from one sector to another, it can generally be said that for successful policy-making it is necessary to establish (“promote, demand and inform”) planning, regulatory, informational, and financial instruments.

These policy packages can achieve both push and pull effects in conjunction with accompanying instruments for training, networking, research and development, and the use of public procurement. The instruments should not simply stand side by side, but they should mutually reinforce one another by, for example, addressing different target groups and obstacles in a targeted manner, or by harmonizing energy efficiency requirements and calculation procedures. These policy packages serve as a basis for the subsequent deficit analysis.

Figure 2: Policy package for the private households sector



Source: own illustration

Deficit Analysis

On the basis of the prototypical policy packages, it was analysed whether and how effectively the implementation of the essential instruments of each policy package has taken place in the European Union. The principal and current instruments are identified and analysed on the basis of their effectiveness via a literature review. It was determined in which areas the policy package had gaps or whether existing instruments had deficits and therefore should be further developed. Due to the numerous instruments that are implemented in the EU and their many of its shortcomings, only a few examples can be given here.

Overall, it has been found that the policy packages in various sectors, combined with the supportive EU-level framework, to a lesser extent in the industry sector, only have a few gaps. The most important instruments identified in the prototypical of policy packages have already been implemented; however, a variety of shortcomings in the existing instruments were identified. It is therefore of utmost importance to make the existing instruments more effective in achieving the EU's energy efficiency and climate protection targets and to exploit their economic potential.

One example of deficits in existing instruments is that of the derogations in Article 7 of the Energy Efficiency Directive (EED). They lead to the fact that the potential is far from being exhausted. It is possible to, among other things, disregard the transport sector and to account for realised measures already made since 2009. In addition, exceptions in the emissions trading scheme can be made for companies subject to it and the savings target of 1.5 % can be introduced in a step-wise manner. The energy tax directive, which covers all sectors, also has deficits. The minimum rates are too low and show no steering effect. There are also a number of derogations that ensure that in some cases only very low energy taxes must be paid.

Apart from the inefficiencies of existing instruments, there are only a few major gaps that should be filled with new instruments at EU level. Particularly in the industry sector in the area of planning (for example, the lack of concepts of heat/cooling/power supply or plans for commercial areas), and information and consultation, there are gaps that should be filled with new policy instruments.

Details on the sample deficits mentioned and the numerous other shortcomings can be found in the report in chapter 4.

Further development options

The following table summarizes recommendations for the further development of EU energy efficiency policies. They were ranked according to the descending priorities determined as a result of the study. The priority was established based on the assumed level of potential savings and time sensitivity, in particular with regard to the ongoing revisions to the Energy Efficiency Directive, the Energy Efficiency of Buildings Directive, and the Eco-design and Energy Labelling Guidelines.

Sector	Further development options of existing EU energy efficiency policies, sorted by descending order of priority
Financing Framework	Highest priority ▸ Binding target of 40 % primary and final energy saving until 2030 in comparison to the 2007 reference scenario; differentiated, binding targets for the Member States, which totals 40 % of the EU as a whole.The validity of Article 7 of the EED must be unlimited and adapted: an annual saving of 2 % in Art. 7 EED for each Member State, annulment of exceptions, inclusion of the transport sector and a more precise calculation method savings; sector-specific targets ▸ European Commission and Member States: Increase and ensure the budget and personal capacity for energy efficiency policy (where necessary) (in ministries, authorities, agencies) ▸ Redesign energy taxes and increase minimum rates, use some of the revenues for energy efficiency policy, including from EU ETS ▸ Strengthen monitoring activities for all described measures, including sector-specific measures, strengthening controls, execution (including networking of implementation authorities) and sanctioning opportunities ▸ Compulsory implementation of mandatory systems without exceptions under Article 7 in all Member States, but wide freedom in the share of the Article 7 targets achieved through this mechanism (specifying a minimum and a maximum) ▸ Mandatory national energy efficiency funds under Art. 20 EED for all Member States (specifying a minimum and a maximum) ▸ Goals for the Member States regarding the development of energy service markets and more precise definitions. ▸ Obligation for Member States to create national and support local/regional energy agencies Lowest priority
Private Households	Highest priority ▸ Development of a building strategy by 2050 with concrete (interim) targets and sub-targets for the MS to achieve a climate-neutral building stock. The building strategy should incorporate housing development and the monitoring of the building stock with the help of national databases that include building energy performance indicators. ▸ Development of ambitious minimum standards through the Eco-design Directive

	and an accelerated regulatory process, greater consideration of resources; ▸ Development of a top runner roadmaps for each category of energy-consuming products ▸ Homogeneous and ambitious definition of low-energy buildings throughout Europe; a time-tiered, development of minimum requirements for nearly zero energy buildings or plus energy buildings. ▸ Creation of standardized and quality-assured energy consulting services and educational training and certification of professionals in the energy efficiency field; linked to: ▸ Effective funding programmes for 'deep' renovation ▸ Evaluation of buildings through an improved energy certificate: create comprehensive, separate energy rating classes,; measure recommendations that encourage deep renovation and the development of a public database with the parameters for each building ▸ building-specific renovation plans as result of the consultations to standardise nearly zero energy buildings whenever buildings need to be completely or partial renovated. ▸ Further development of the cooling and heating strategy with concrete goals and transformation pathways ▸ Requirements for Member States: Promotion and comprehensive implementation of local/regional stakeholder networks for stakeholders in housing renovation Lowest priority
Industry	Highest priority ▸ Strengthen the requirements for energy audits of non-SMEs (EED) with an obligation to implement recommended measures that fulfil certain requirements (for example, on cost-effectiveness); also applies to measures regarding energy management systems ▸ Further develop the requirement of energy audits for all non-SMEs companies that consume more energy than a threshold (to be determined) to use energy management systems ▸ Obligation for Member States to support energy audits and energy management systems among the remaining companies that consume less energy than the threshold that is to be defined ▸ Development of an European strategy for the industry sector towards a climate-neutral and energy efficient economic system, including a strategy for the promotion of key technologies ▸ Mandatory for Member States: Support energy efficiency networks ▸ Commitment to report data and the creation of a database for the determination of benchmarks (consequently: elaboration of standards, norms and benchmarks) ▸ Specify the objectives and targets for information programs, consulting and investment support ▸ Minimum standards and obligations for Member States for training energy professionals and the certification of energy consultants ▸ Industrial Emission Directive: Article 9 (2) should be removed, so the EU-wide requirements for energy efficiency also apply to installations under the EU ETS; the requirements concerning energy efficiency listed in the BAT-information

	sheets should be concretised ▸ Expand the promotion of research and development activities under Horizon 2020 regarding energy-efficient technologies and innovations in the industry sector ▸ Introduction of a quota for demonstration projects on low-carbon and energy-efficient processes in the industry sector through Innovation Funds in the framework of NER 300 program Lowest priority
Transport	Highest priority ▸ Mandatory inclusion of the transport sector in Article 7 of the EED for the determination of energy saving targets and measurements ▸ Modification of the basis of assessment for the fleet target values and the energy labelling: Vehicle base ▸ Harmonise taxation of fuels throughout Europe, based on the CO2 emissions and energy intensity (energy tax) ▸ Harmonise taxation of motor vehicles throughout Europe, based on the CO2 emissions and energy intensity (car tax) ▸ Development of new and realistic test procedures to determine fuel consumption and CO2 emissions ▸ Europe-wide standardization of road-use charges for lorries and introduction of coaches: depending on the driving performance, including GHG emissions and no external costs ▸ Relocation of funding (within framework of the TEN Finance Regulation) from road to rail; the revitalization of the European night train transport ▸ Introduction of fleet targets for heavy commercial vehicles ▸ Europe-wide standardization in the taxation for company cars: incentives for more economical and environment-friendly vehicles ▸ Air-conditioning systems in vehicles should be addressed by an implementing regulation according to the Eco-design Directive ▸ Mandatory, pan-European introduction of SUMP ▸ Development of a public product database on energy efficiency for vehicles and vehicle accessories Lowest priority