DOKUMENTATIONEN
06/2016

Proceedings of the Workshop „Decarbonisation – 100 % Renewable Energy and more“ 9 November 2015 in Berlin

A report to document the presentations and discussions during the course of the event

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Umwelt Bundesamt

DOKUMENTATIONEN 06/2016

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

Project No. (FKZ) 58573
Report No. (UBA-FB) 002328/ENG

Proceedings of the Workshop „Decarbonisation – 100 % Renewable Energy and more“ 9 November 2015 in Berlin

by

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Imprint

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Study performed by:
Ecologic Insitut
Pflazburger Str. 43-44
D-10717 Berlin

Study completed in:
[Datum]

Edited by:
Section I 2.2 Energy strategies and scenarios
Oliver Seel

Publication as pdf:
http://www.umweltbundesamt.de/publikationen/proceedings-of-the-workshop-decarbonisation-100

ISSN 2199-6571

Dessau-Roßlau, April 2016

The Project underlying this report was supported with funding from the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear safety under project number 58573.

ABOUT THIS REPORT

The workshop “Decarbonisation – 100% Renewable Energy and more”, was held on 9 November 2015 in Berlin, hosted by the German Environment Agency and organised by Ecologic Institute. It offered a valuable opportunity for decision-makers, academia, business and civil society from EU Member States, to exchange ideas and lessons learned on the design and implementation of long-term decarbonisation strategies and discuss how industrialised nations, regions and cities can mitigate greenhouse gas emissions in various economic sectors.

Workshop participants, Source: Ecologic Institute.

The workshop generated important momentum for raising awareness on the topic and advancing the debate at EU level.

This report gives an overview of the key presentations of the workshop and outcomes of the debate, clustered along the following topics:

- Introduction: the case for action
- National long-term strategies
- Experience with implementation of national strategies
- Local and regional examples

The report’s structure follows the internal logic and outline of the workshop agenda. Substituting for the presentations made on the day, it is made up of articles written by the original presenters, which contain the main facts and summarise their key messages. These are complemented by background and conclusions prepared by researchers from Ecologic Institute, the organisation that implemented the workshop on behalf of the German Environment Agency.

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FOREWORD

Introduction by the President of the German Environment Agency, Maria Krautzberger, to the conference proceedings for the workshop "Decarbonisation – 100% Renewable Energy and more"

Maria Krautzberger, President of the German Environment Agency

In 2015, the international community has taken a huge step forward in terms of climate protection. In June, the G7 heads of state came together in Elmau, Bavaria, and agreed to try and create economies that are long-term low-carbon. Based on this, they also decided to transform the energy sector by 2050. In December, at COP21 in Paris, 196 countries concluded a new agreement under the United Nations Framework Convention on Climate Change, which once again underlined the importance of a decarbonisation of the world economy. The decarbonisation of national economies beyond the energy sector was discussed from a variety of different angles in the workshop "Decarbonisation – 100 % Renewable Energy and more" hosted by the German Environment Agency.

President Maria Krautzberger. Source: German Environment Agency

A positive atmosphere was already palpable in the run-up to COP21, spreading confidence that a worldwide climate agreement could be reached. This positive mood was amplified by the voluntary climate protection pledges (Intended Nationally Determined Contributions - INDCs) given by a majority of the countries involved.

During the negotiations in Paris, the European Union took on a leading role alongside a number of other countries. This resulted in a highly ambitious climate agreement. The EU aims to cut greenhouse gas emissions by at least 80 to 95 % by 2050 compared to 1990, which is deemed to be a reasonable contribution to limiting global warming to a maximum of 2°C. All this is in accordance with the recommendations issued in the Fourth Assessment Report by the United Nations Intergovernmental Panel on Climate Change (IPCC) in 2007 for industrial countries.

The decisions made at the Paris Climate Change Conference give a new, very powerful impulse to debates on the decarbonisation of all economies. It is in particular a matter of limiting global warming to no more than 2°C and aiming for a rise in temperature of just 1.5°C. Which concrete effects these resolutions will have on future climate protection policies of the European Union and its Member States is currently not foreseeable. All countries, the European Union included, are facing a great challenge: the climate protection goals and the implementation of measures in accordance with the Framework Convention on Climate Change will be reviewed every five years.

At a European level, decarbonisation is being addressed as part of several concepts. E.g., the “Energy Roadmap 2050”, which also has an influence on the “roadmap towards a low carbon economy in 2050”, shows what the transformation of the European energy system could look like. However, experts are arguing that a revision of the roadmaps is necessary, because the hypotheses are no longer up to date.

Several EU Member States have developed their own decarbonisation strategies in addition to those prescribed by the European Commission. The varied economic framework conditions as well as country-specific infrastructures and economic sectors make the decarbonisation a different challenge for each Member State.

The time has come to develop a joint strategy that meets the highly ambitious climate protection requirements of the European Union and takes the different conditions in the individual member states into account.

To this end, the German Environment Agency is focussing on an exchange of experiences between the EU Member States and on developing and implementing such strategies. While looking at different sectors within the European Union, we can identify decarbonisation approaches that could potentially be translated to other regions.

The German Environment Agency is keen to shape such a collaboration and, with these conference proceedings, offers a first overview of what has been discussed at the workshop “Decarbonisation – 100% Renewable Energy and more”, namely the strategies currently employed in the European Union. It goes on to explore possible synergies and challenges.

Maria Krautzberger

President of the German Environment Agency

EXECUTIVE SUMMARY

In order to keep global warming below 2°C, greenhouse gas emissions will need to be reduced drastically in all economic sectors, moving towards **decarbonisation**. To achieve the necessary transformation of the economy which entails, that all levels of governance – international, European, national and sub-national – need to take ambitious action in all economic sectors and design long-term visions of their mitigation pathways. Governments at all levels need to give clear and reliable long-term signals to the many actors involved, to induce lasting change and provide security for investment in low carbon technologies.

Across the globe, countries are starting to take climate action more seriously and are developing strategies to limit or reduce emissions. Also at the sub-national level, many regions or cities are designing or already implementing decarbonisation strategies. Presenters and participants highlighted the challenges of designing and implementing decarbonisation strategies and addressed possible solutions and key measures, distinguishing measures to be taken at the international, European, national and sub-national level.

The **European Union** has long been acting as a climate frontrunner and could lead by example on organising the long-term response by adopting a coordinated European approach. In that respect, workshop participants highlighted key measures such as an improvement of existing policies, notably through reforms the EU emissions trading scheme to establish a credible carbon price. Furthermore, participants noted that the EU could revise its roadmaps on climate and energy towards decarbonisation and work towards a common climate strategy that offers a credible pathway towards decarbonisation.

Regarding the **national level** it became clear that although national circumstances may require differentiated strategies, many Member States face similar opportunities and challenges. Several national studies have shown that moving towards an energy system that uses 100% renewable sources is technically and economically feasible. However, effective decarbonisation strategies also need to address energy demand and tackle other economic sectors and find integrated solutions. Successful strategies will also need support across political parties as well as from the public, which should be involved when designing climate policies. In addition, long-term strategies with targets for 2050 should, ideally, be enshrined in national law and be accompanied by pathways and interim targets that are consistent with the long-term objective.

At the **sub-national level**, hundreds of local communities across the world have committed to becoming 100% renewable. Regions, cities and communities can serve as role models, showcase the positive co-benefits of the transition to a low-carbon economy – this is crucial for building public acceptance on a wider scale. At the local level it also might be easier to develop targeted solutions that provide visible co-benefits for society and might thus prove more acceptable. However, some structural issues may not be easily addressed at local level. For example, decisions on the promotion of renewable energy are often taken at a higher level. Thus, it is key to consider how local action can connect back to the national level.

Overall, the biggest challenge is to create the political will to meet visionary goals and build acceptance for decarbonisation strategies at every governance level, and across the population. Also the integration of the different governance levels constitutes a crucial challenge that requires a

multi-level dialogue, also inside the EU, to provide the possibility to learn from each other and lead to better solutions and increased acceptance. The German Environment Agency remains committed to fostering this dialogue, also in the future.

Workshop participants, Source: Ecologic Institute.

Opening Statement

Why we must plan ahead to achieve our long-term targets

Maria Krautzberger, President of the German Environment Agency

Dear Professor Edenhofer,

Ladies and Gentlemen,

It is my pleasure to welcome you today in Berlin – only days ahead of the Paris Climate Conference.

We do not know yet whether Paris will be a success. However, what we do know is that we do not have a choice. It is literally vital to limit global warming to about two degrees Celsius above the pre-industrial level. And to halt global warming, we have to decarbonise our economies.

G7 leaders responded to this urgent need in a historic announcement earlier this year. In fact, G7 leaders effectively signalled the end of the fossil fuel era. This is – or should I say, this would be – a seismic political shift. In concrete terms, emissions are to be cut globally by 40 – 70% by 2050 compared with 2010.

Also, the newly adopted Global Goals and the latest IPCC results have further strengthened the political momentum for decarbonisation.

Maria Krautzberger, Source: Ecologic Institute.

Ladies and Gentlemen,

Why did we invite you to join us today: we want to take the chance to focus during this workshop on approaches and strategies for making the decarbonisation of our economies a reality. We are deeply convinced that highly industrialized regions — such as Europe — must take the lead in climate mitigation action. We bear a historic responsibility and should have the necessary capabilities.

The German Environment Agency has been working on climate change issues and their implications for many years. An important result of our work was the feasibility study "Germany in 2050 – a greenhouse gas-neutral country". It shows that it is technically feasible for Germany to become greenhouse gas neutral by 2050. Based on our work, we are firmly convinced that there is no other way than to nearly completely decarbonise the power sector as well as the other relevant sectors.

However, this tremendous challenge cannot be tackled by any one country alone. We need our international partners and friends to join us, or maybe even drive us to new initiatives. In order to realize ambitious domestic goals, we need first of all ambitious European policies. Policies which push for very high greenhouse gas reduction targets. Those targets have to refer to the upper bound of the 80-95% reduction corridor we envisage for Europe until 2050. European policies have to support national policies on greenhouse gas neutrality. Apart from focusing on national scenarios, we also need to explore how a greenhouse gas-neutral Europe as a whole can be achieved.

On the European level, different roadmaps supporting decarbonisation have already been developed. This includes roadmaps for a low carbon economy; for energy as well as for a resource efficient transport system. These roadmaps are important and in line with the greenhouse gas mitigation goal set for 2050. The energy roadmap for example shows cost efficient ways to decarbonise the European energy sector. It further highlights that the decarbonisation scenario is more cost effective than the business as usual scenario.

However, there is a debate about whether the existing EU roadmaps are still politically and technically up to date and feasible. In this discussion, it is also crucial to address the global perspective. We have to carefully take into account the risk of emissions being simply transferred to other regions. In this context, a reform of the EU emissions trading scheme (EU ETS) is essential. We still do not have sufficient economic incentives for the private sector to invest in climate action. One of the reasons is the existing excess liquidity in EU emissions trading. On a global level the development of a general carbon pricing system could provide necessary incentive for the necessary scaling up of our investments in climate action.

In addition to regional policy frameworks, enabling synergies and joint action is one of the keys. Throughout Europe, a range of very promising initiatives and concepts have been developed at national and regional levels. But also local actors are playing a vital role in decarbonisation of our economies. A new Europe-wide dialogue on decarbonisation strategies therefore offers as-yet-untapped potential for creating synergies and launching joint actions. Countries with broadly comparable approaches to energy and climate issues can jointly advance more cost effective solutions.

A range of national decarbonisation scenarios have already been developed for different EU Member States. However, we have to ask ourselves: “Are our scenarios ambitious enough to achieve the 2050 target? And are the measures we are proposing also appropriate from a larger environmental perspective?”

Ladies and Gentlemen,

The title of today’s workshop is “Decarbonisation – 100% renewable energy and more”. You might have wondered what exactly “and more” refers to. It simply hints at the fact that we not only need to decarbonise the energy sector. But that all sectors need to be nearly completely decarbonised. This means that we also have to address the issue of sustainable supply and protection of natural resources. We have to sustain high environmental standards when transitioning to decarbonised economies. Last but not least, we need to develop and implement this change process with meaningful stakeholder participation and cross border cooperation.

At the German Environment Agency, we are now focusing our research efforts on broader environmental issues that come into play in efforts to decarbonise Germany by 2050. We are currently developing a pathway for transformation to a greenhouse gas neutral Germany, which also envisages a minimization of per capita resource consumption and environmental trade- offs seeks to enable a sustainable use of natural resources. We carefully consider possible environmental trade-offs. For example, we believe that growing biomass crops for energy production is not an acceptable measure to achieve decarbonisation by 2050. The reasons are the heavy competition for arable land, as well as expected negative impacts on water, soil, biodiversity and wildlife.

Ladies and Gentlemen,

All the concepts, strategies and approaches will not make a real difference if we don´t walk the talk. An important instrument in Germany to drive decarbonisation is the Climate Action Programme 2020, which was adopted in 2014. It includes a number of concrete measures to reduce greenhouse gas emissions in all economic sectors. The programme aims at a 40% reduction of greenhouse gas emissions by 2020 compared to 1990 levels.

(The biggest contribution – at 25 to 30 million tonnes – is achieved with energy efficiency measures. On top of this, measures in the field of climate-friendly building and housing will be implemented. In the electricity sector, the Federal Minister for Economic Affairs will draw up a concept for distributing 22 million tonnes as a mitigation commitment across the entire fleet of power plants in Germany. The transport sector contributes 7 to 10 million tonnes to the action programme. Moreover actions also target non-energy-related emissions in industry, commerce, trade, services and waste management as well as in agriculture).

Maria Krautzberger and workshop participants, Source: Ecologic Institute.

Moreover, the Environment Ministry plans to launch the 2050 Climate Action Plan next year. The Climate Action Plan will put forward concrete measures for achieving a greenhouse gas emission reduction of 80 to 95 % by 2050 compared to 1990.

The German Environment Agency also supports municipalities in transitioning to 100% renewable energy supply. As part of this support, we are co-hosting a side event tomorrow to the 100% Renewable Energy Regions Congress in Kassel.

At the German Environment Agency, we are very interested to learn about your approaches and lessons learned. And we are looking forward to discussing with you how to put decarbonisation into practice in Europe – on European, national, regional and local levels. On this note, I wish you interesting discussions and a successful workshop.

Thank you for your attention.

Background

Decarbonisation – The case for action

Lena Donat & Matthias Duwe, Ecologic Institute

Climate change is one of the greatest challenges our world is facing today. Global anthropogenic greenhouse gas emissions have increased considerably over the last decades, already causing widespread alterations of the climate system. Our scientific understanding of the underlying processes is continuously improving and points to the likely consequences. The 5th Assessment Report (AR5) of the International Panel on Climate Change (IPCC) indicates that, compared to pre-industrial levels, the global mean temperature will increase by 4°C by 2100 under business as usual projections. This would increase the likelihood of severe, pervasive and irreversible impacts for people and ecosystems.

The global community agreed in 2010 to limit global temperature increase to 2°C, to prevent the most severe impacts from occurring. In order to have a likely chance[1] of staying within this limit, global emissions of all greenhouse gases must be net zero by 2100 (IPCC 2014 and 2014a). Industrialised countries need to take the lead in this task due to their stronger historical responsibility and relative economic strength. As a group, the IPCC suggests that these countries should reduce their emissions 80-95% below 1990 levels by 2050 (AR4).

Mitigation pathways consistent with such deep emission cuts require a deep transformation of the economy and especially of the energy system. They pose substantial technological, economic, social and institutional challenges but also provide opportunities and co-benefits. These include, for example, a better quality of life and health as well as increased access to energy or local employment.

The science is clear; action cannot be further delayed. Since global warming is tied to the cumulative amount of emissions in the atmosphere, delaying action today means that in the future emissions need to be cut even more drastically.

Against this background it is necessary to clarify what contribution European countries can make towards achieving decarbonisation by 2050, what decarbonisation strategies they pursue and how these are being designed and implemented. It is essential that governments send a clear signal to investors and stakeholders on the direction of development, providing clear targets and pathways that allow for the predictability of policies.

International Context

More than 25 years ago, the United Nations General Assembly declared in Resolution 43/53 that climate change is a “common concern of mankind,” and that “timely action should be taken to deal with climate change within a global framework” (UN General Assembly 1988). Only four years later,

[1] The IPCC defines the assessed likelihood of an outcome or a result as follows: “virtually certain 99–100% probability, very likely 90–100%, likely 66–100%, about as likely as not 33–66%, unlikely 0–33%, very unlikely 0–10%, exceptionally unlikely 0–1%.” (IPCC 2014).

the international community adopted the 1992 United Nations Framework Convention on Climate Change (UNFCCC). It provides a framework for action aimed at stabilising atmospheric concentrations of greenhouse gases to avoid “dangerous anthropogenic interference” (Article 2 UNFCCC) with the climate system. However, negotiations under the UNFCCC have not yet been successful in setting the world on the track to achieve this objective. The 1997 Kyoto Protocol, adopted under the UNFCCC, established binding mitigation targets at the international level, but these were not ambitious enough, covered only short time periods or commitment periods and pertained to only a few countries.

In December 2015, the UNFCCC convened its 21st Conference of the Parties (COP21) in Paris with the aim of forging a truly global climate agreement. After difficult negotiations on the specific details, the Paris Agreement was adopted to standing ovations. The document specifies as one of its key goals, to hold “the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels“. (UNFCCC 2015)

In preparation for the Paris Agreement, almost all countries handed in intended nationally determined contributions (INDCs), which set out the mitigation (and sometimes also adaptation) effort each country is willing to undertake. The INDC preparation process has triggered unprecedented planning processes for climate mitigation in many nations.

While these INDCs mainly cover the period 2020-2025/2030, some also provide a long-term perspective with indicative mitigation objectives for the year 2050. A few countries have even announced goals of carbon neutrality by 2050 (e.g. Liberia, Marshall Islands, Sierra Leone).

The new Paris Agreement foresees that country shall review their INDCs every five years starting i2018, to make sure that the long-term goal is being met.

Article 4.19 of the Agreement furthermore establishes that all Parties should strive to prepare “low greenhouse gas emission development strategies”. The accompanying Paris COP decision specifies that these strategies should have a perspective towards the middle of the century (2050) and invites all countries to communicate these by 2020. The concept of long-term strategies had already been in existence in the UNFCCC negotiations since 2008, under the terms Low Carbon Development Strategies (LCDS) and Low Emission Development Strategies (LEDS). At the sixteenth Conference of the Parties (COP16) in Cancun in 2010, countries agreed that all developed countries should prepare LCDS—and developing countries were encouraged to develop LEDS. However, following COPs only reiterated this call but had not provided any additional guidance or created a specific follow-up process. Article 4.19 of the Paris Agreement now brings back the concept of long-term strategies.

EU Targets and Roadmaps

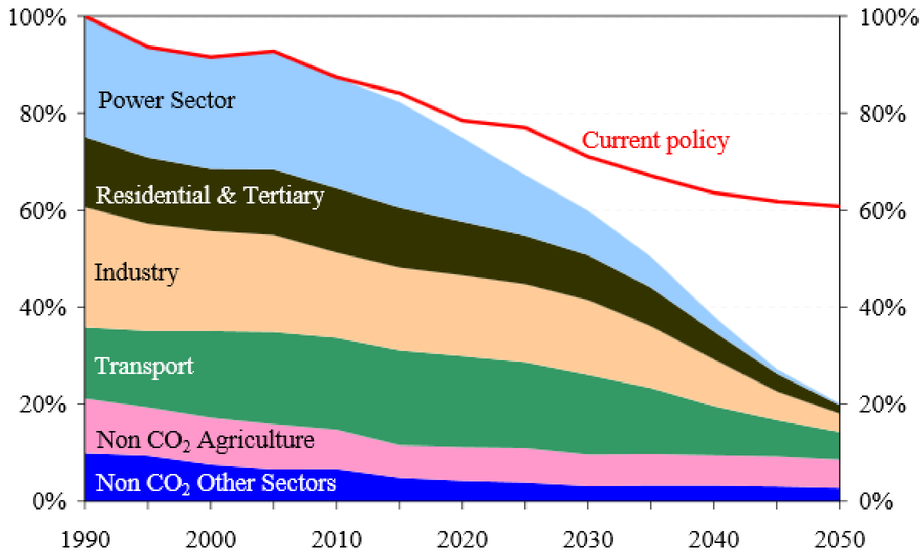
At the EU level, the European Council adopted a clear quantitative long-term objective in October 2009, in the run-up to the Copenhagen climate summit (European Council 2009).[2] In the context of

[2] Therein, the European Council “calls upon all Parties to embrace the 2°C objective and to agree to global emission reductions of at least 50%, and aggregate developed country emission reductions of at least 80-95%, as part of such global emission reductions, by 2050 compared to 1990 levels; such objectives should provide both the aspiration and the yardstick to establish mid-term goals, subject to regular scientific review. It supports an EU objective, in the context

necessary reductions by developed countries as a group (according to the IPCC), EU heads of State and Government additionally committed to reducing emissions 80-95% by 2050 compared to 1990 levels (European Council 2009). This commitment has since been reiterated and alluded to on several occasions (e.g. Council of the European Union 2014).

The European Commission published a Roadmap for “moving to a low carbon economy” in 2011, which looked at reducing domestic GHG emissions by 80% by 2050 compared to 1990 levels and set out milestones for the decades in between. All key sectors of a low carbon economy must contribute to progressive reductions in GHG emissions, but to different degrees and at different speeds. The greatest and earliest emissions reductions are projected for the power sector whereas the most moderate reductions will come from the agricultural sector (European Commission 2011; see Figure 1 below).

Figure 1: EU GHG emissions towards an 80% domestic reduction (1990 = 100%)



Source: European Commission (2011).

The European Commission’s 2050 Energy Roadmap, communicated in December 2011, analysed different emissions scenarios, indicating that the decarbonisation of the energy system is not only possible but could even be cheaper than a business-as-usual scenario (European Commission 2011a).

However, both the Energy Roadmap 2050 and the Low-Carbon Roadmap for 2050 have yet to be properly adopted by the European Council even though the former was passed as a resolution by the European Parliament in March 2013 (European Parliament 2013). The inability of the Council to adopt the Commission’s 2050 low-carbon objectives was largely due to opposition from Poland. On multiple occasions, Poland essentially vetoed proceedings, disagreeing both with the intermediate

of necessary reductions according to the IPCC by developed countries as a group, to reduce emissions by 80-95% by 2050 compared to 1990 levels.” (European Council 2009).

emissions reduction goals and arguing that the EU should wait to set targets until other developed countries show matching ambition in the context of international negotiations (Skjærseth 2014). Now, over half a decade later, some of the assumptions underlying the Roadmap, e.g. on costs for photovoltaic energy technologies, are outdated. There has been no direct follow-up process on developing a 2050 vision — as the focus then shifted towards adopting a framework for 2030 first.

The European Union communicated a 2030 mitigation target in its INDC but has not provided an indication for a 2050 objective. As part of the INDC, the European Union and its Member States commit to a binding target of reducing domestic GHG emissions by at least 40% by 2030 in comparison to 1990 levels. To meet this target, the European Commission will further submit legislative proposals to the Council and European Parliament in 2016 (as a first one of the essential pieces of legislation, a proposal for a revision of the EU Emissions Trading System was published in July 2015[3]). These proposals will detail how to implement the 2030 climate and energy framework, taking into account both its non-traded and emissions trading sectors (Latvian Presidency of the Council of the European Union 2015).

Against this background, and with the new impetus resulting from the adoption of the Paris Agreement, a process for developing a long-term vision for GHG reductions in the EU is both required and more likely to be initiated in the near future.

EU Member States – Decarbonisation Strategies

While the process at EU level itself has moved away from a long-term strategy to zoom in on the specifics for 2030, several individual EU Member States have already developed or are currently developing climate strategies towards 2050.

Some countries have enshrined 2050 mitigation targets in legally-binding climate acts; the United Kingdom and Finland both adopted an 80% reduction target for 2050 from 1990 levels (2008 UK Climate Change Act (UK 2008) and 2015 Finnish Climate Change Act (Finland 2015)). France aims at reducing its emissions 75% by 2050 according to its 2015 Energy Transition Act (France 2015). While some additional countries have published climate plans with targets for 2050 – Ireland and Germany are currently developing such plans – other countries have established long-term renewable energy targets only.

The climate acts and plans of EU Member States show differences with respect to the following features:

- Ambition: Few Member States establish 2050 GHG reduction targets beyond 80%.
- Scope: For example, many plans only cover emissions from energy but exclude land use, land use change and forestry.
- Level of detail: Some plans only establish a 2050 target, sometimes as a single number, sometimes as a target range. Others also provide pathways or interim targets. Some plans additionally set out targets for emissions from individual economic sectors, or for energy efficiency or renewable energy.

[3] Proposal for a directive of the European Parliament and of the Council amending Directive 2003/87/EC to enhance cost-effective emission reductions and low-carbon investments, COM/2015/0337 final/2 - 2015/0148 (COD).

- Institutional set-up: Some establish advisory or monitoring committees

For most EU Member States (even those without an adopted plan), some form of national mitigation scenario has been drawn up, either by the government, NGOs or academia[4] - even if their insights have not been taken up as adopted government strategies.

The 2013 Monitoring Mechanism Regulation (MMR) of the European Council and European Parliament translated the international commitment from Cancun to prepare low-carbon development strategies (LCDS) into an obligation for EU Member States, and required them also toreport on their implementation and updates and to make these public. The first deadline for reporting on the implementation of LCDS was 9.01.2015, which implies that LCDS should have been developed by that date. All Member States have—although some with delay—submitted reports on LCDS. Several Member States have indicated in their 2015 report that their LCDS is still under development, making the different situations between Member States on national decarbonisation strategies apparent.

Another related process is ongoing in relation the process of implementing the EU's 2030 climate and energy target infrastructure. The European Commission has made a proposal to streamline existing planning and reporting obligations into a new process, which would build on integrated "National Energy and Climate Plans (NECPs)" (European Commission 2014). The general concept has been embraced by Heads of State and Government (European Council 2014) and in further development by the Commission the scope for these plans is currently meant to include a long-term perspective towards 2050 (European Commission 2015). This hints at the possibility that a more standardised planning process with a long-term focus could be established. These NECPs could in principle take up the functions of long-term strategies such as those referred to in the Paris Agreement (or previously the LCDSs). It certainly has the potential to bring about some greater standardisation to national decarbonisation strategies.

Sub-national level

At the sub-national level governments are also working on strategies towards cutting GHG emissions. Regions like Scotland, Wales, Wallonia or Baden-Württemberg have declared their intention to reduce emissions by 80% by 2050. The city of Stockholm even aims to completely phase-out emissions by 2025 (Carbon Disclosure Project (CDP) 2014; Stockholms Stad 2014; Roadmap for a Fossil Fuel-Free Stockholm 2050, 2014).

Almost a hundred cities and regions have adopted long-term mitigation targets or renewable energy targets, many of them in the run-up to COP21 in Paris (Track 0 2015). Cities are at the centre of economic activity and a key source of emissions. At the same time, they offer many opportunities to mitigate GHG emissions while improving the quality of living.

Activities at the sub-national level can become key drivers for action at the national or international levels. First, they may function as a testing ground for policies and approaches. Secondly, they can make the benefits of climate policies visible to the broader public.

[4] For more information on nationally adopted strategies, see for example the country reports elaborated for DG CLIMA at the European Commission, available at http://www.ecologic.eu/11022. A more in-depth analysis of national decarbonisation studies is being undertaken by the German Environment Agency in the context of the research project "Support in the development of ambitious climate scenarios in Europe" (FKZ 3715 41 113 0).

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Keynote speech

Global Decarbonisation – What role should Europe play?

Professor Ottmar Edenhofer, Director of the Mercator Research Institute on Global Commons and Climate Change (MCC), Chief Economist of the Potsdam Institute for Climate Impact Research (PIK)

Christoph von Stechow, doctoral researcher, MCC and guest scientist, PIK

In the run-up to the 21st Conference of the Parties (COP) to the UNFCCC in Paris, there are good reasons for both pessimism and optimism about the prospect of an international treaty to effectively combat climate change. This talk will describe worrying trends and developments but will end with a glimpse of hope.

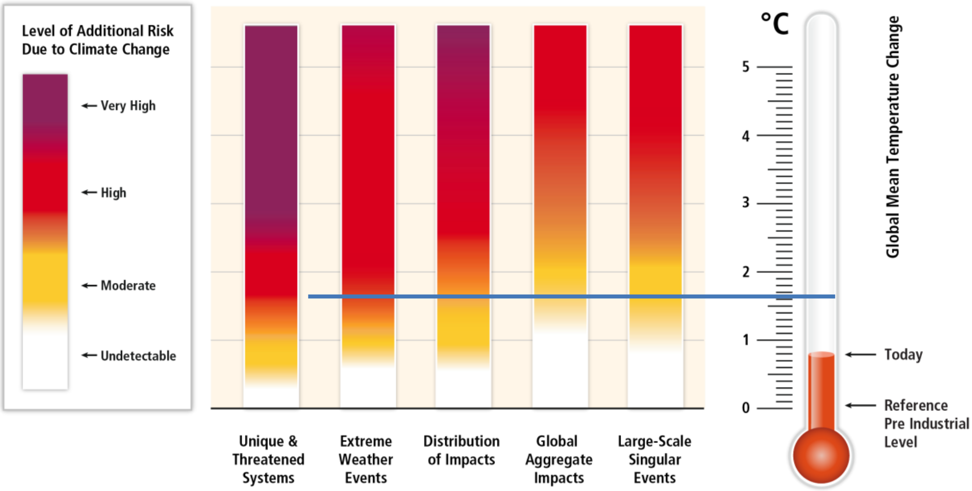
Professor Ottmar Edenhofer. Source: Ecologic Institute.

The aim of staying below 2°C global mean temperature rise has been a major focal point of climate policy debates since its recognition by the UNFCCC during the 16th COP in Cancún. As confirmed by the IPCC AR5 (see green line in Figure 1), limiting global warming to 2°C is still associated with some risks from climate damages, and is a huge economic, technological and institutional challenge (Edenhofer et al. 2014). Given that 2100 business-as-usual (BAU) temperature projections reaching about 4°C (3.7-4.8°C based on the median climate response) significantly increase the likelihood of severe, pervasive and irreversible impacts for people and ecosystems, the 2°C target appears to be a pragmatic compromise in line with the precautionary principle (Edenhofer, Kadner, et al. 2015).

More recent studies, however, paint an even bleaker picture. A recent letter from Nature, Burke et al. (2015) analyse global non-linear effects of temperature changes on economic production with a focus on labour and agricultural productivity. Based on past observations of declining gross domestic product (GDP) that accompany higher-than-average temperatures in most countries, they project a steep decline in GDP with BAU temperature increases (RCP 8.5 scenario) – up to 75% GDP decline in those countries already among the poorest today.

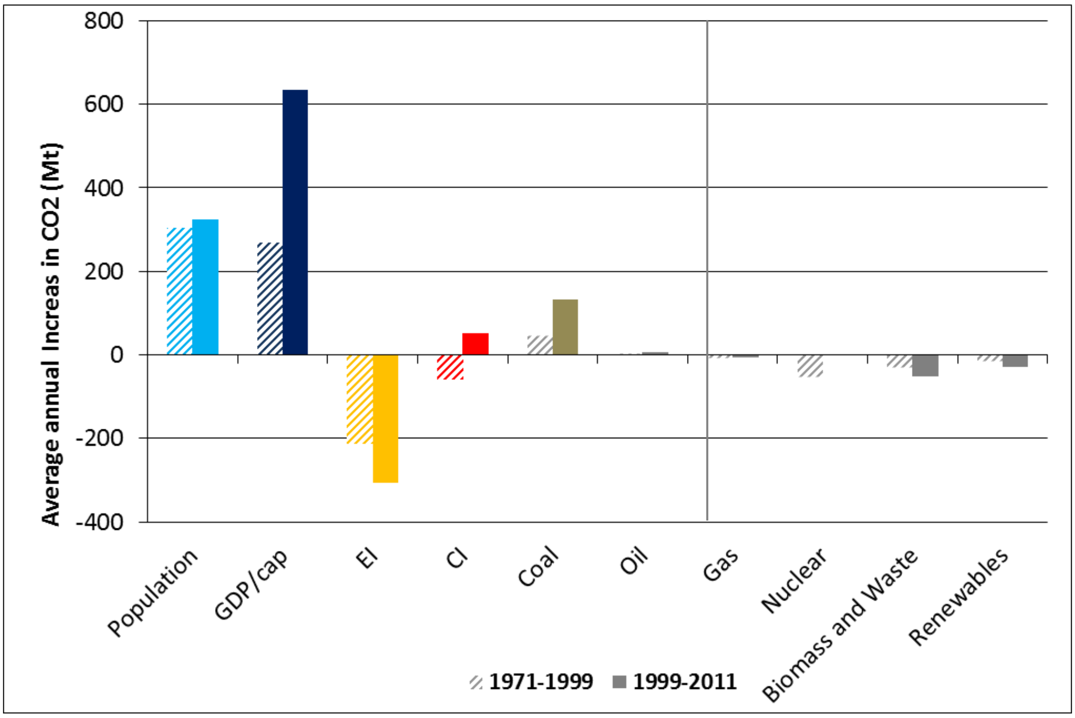
Despite significant efforts around the world to pursue climate policies, the world is not on a promising decarbonisation pathway. Instead, it is getting increasingly carbonised. Between 2000 and 2010, greenhouse gas (GHG) emissions grew at 2.2 %/year on average – an increasing growth relative to what was seen in previous decades: Between 1970 and 2000 GHG emissions only increased by 1.3 %/year (Edenhofer et al. 2014). This carbonisation of the world economy between 1999 and 2011 was driven in part by global growth in population and GDP per capita, only partially offset by substantial energy intensity reductions. Due to its low price and high availability, coal has experienced a renaissance and has caused an increasing global carbon intensity of energy, even despite significant investments in renewable energy (Figure 2). This rising importance of coal in the energy mix is particularly pronounced in poor but fast-growing countries and happens even faster than foreseen in baseline projections from the IPCC Working Group III scenarios database (https://secure.iiasa.ac.at/web-apps/ene/AR5DB).

Figure 1: Risks from climate damages at a global scale. The colour indicates the additional risk due to climate change at a specific level of temperature change, based on the degree to which impacts are detectable and attributable and the level of confidence among experts.



Source: For details, see IPCC (2014).

Figure 2: Decomposition of average annual increases in CO_2 emissions into standard Kaya factors and primary energy sources, explaining changes in carbon intensity.

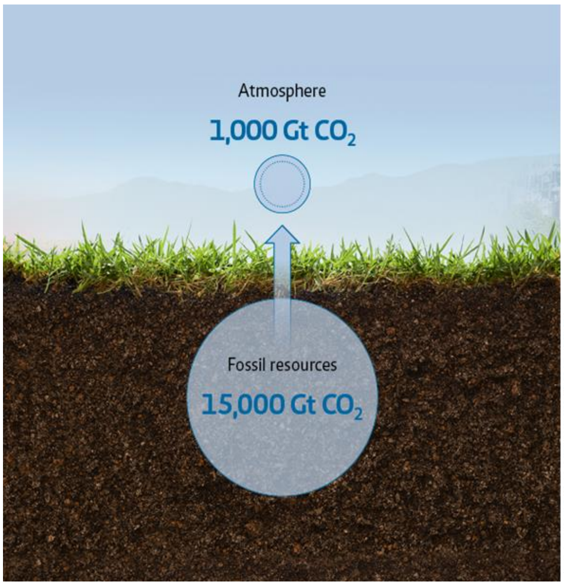


Source: For details, see Steckel, Edenhofer, and Jakob (2015).

In the past decade, nearly 800 GW of coal power plant capacity was added, another 275 GW is under construction and more than 1,000 GW are in the pipeline. Even if only a third of the proposed coal power plants eventually come online, future CO2 emissions emitted over the lifetime of those, plus the currently existing global infrastructure, could increase to nearly 850 Gt (Shearer et al. 2015). In such a case, most of the global carbon budget that would theoretically be available over the entire century to meet the 2°C goal (with a 66% likelihood) could be used up within a couple of decades – even without taking into account the GHG emissions from land use and land use change (see Edenhofer et al. 2014 and Figure 3).

It is a major challenge for climate policy that many of the fossil fuel resources and reserves, also beyond coal, would have to remain underground to stay within the remaining carbon budget of roughly 1,000 Gt CO2. Relative to BAU scenarios in the WGIII AR5 scenario database, the emissions from 70% of coal, 35% of oil and 32% of gas reserves and resources would need to be kept out of the atmosphere (Figure 3). To some extent, the deployment of negative emission technologies (such as bioenergy coupled with carbon capture and storage (CCS)) can reduce this pressure due to their potential to remove CO2 emissions from the atmosphere. Without CCS technologies, this flexibility to compensate is lost and mitigation would need to start immediately to stay below the 2°C goal with a high likelihood (Edenhofer et al. 2014). This would increase the shares of fossil fuel reserves and resources that would need to remain underground to 89%, 63% and 64%, respectively (Bauer et al. 2013; Jakob and Hilaire 2015).

Figure 3: Challenge for climate policy - fossil fuel supply is not a limiting factor. It is the disposal space for waste GHGs in the atmosphere that is limited. Fossil resources include conventional and unconventional reserves and resources. Median values in the table are relative to BAU scenarios in the WGIII AR5 scenario database.



Resources/reserves to remain underground until 2100 (median values relative to BAU)		
Until 2100	With CCS [%]	No CCS [%]
Coal	70	89
Oil	35	63
Gas	32	64

Source: For details, see Bauer et al. (2013) and Jakob and Hilaire (2015).

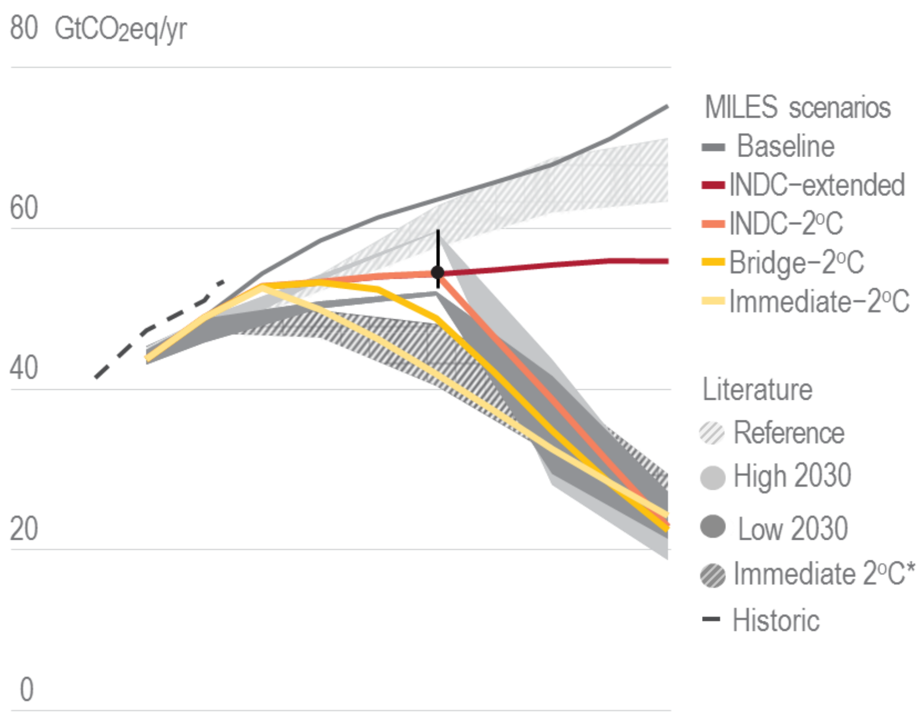
Thus far international climate negotiations are not on track to limit the atmospheric disposal space for waste GHG emissions to the extent necessary to reach the 2°C goal. It may be a political achievement that 188 countries—both industrialized and developing—have submitted Intended Nationally Determined Contributions (INDCs) to the UNFCCC Bureau, covering over 90% of global GHG emissions (excluding emissions from land use and land-use change, see climateactiontracker.org). However, there are no pledges for after 2030, making any assessment of long-term climate effects challenging. Analysis with an integrated assessment model (IAM) indicates that the mitigation efforts implied by the INDCs are not nearly enough to approach a 2°C pathway (Figure 4). Instead, these limited efforts would result in substantial lock-in to carbon-intensive infrastructure, making any ambitious transformation to a low-carbon energy system in the future all the more challenging (Bertram et al. 2015).

For GHG emissions to stabilize (red line in Figure 4) the model already needs global carbon prices to increase annually by 1.5% after 2030. Carbon prices across regions would also need to converge, which would imply stronger growth rates in regions with low prices in 2030. Achieving GHG emissions reductions compatible with the 2°C goal (albeit with higher likelihood of exceeding it relative to immediate 2°C scenarios, see orange line in Figure 4) would imply much more rapid increases in carbon prices after 2030 (US$150 until 2050 instead of US$125 in immediate 2°C scenarios, see light yellow line in Figure 4). Such a lock-in effect could be reduced to some extent by policies that lead market actors after 2020 to anticipate optimal carbon pricing from 2035 onwards (see warm yellow line in Figure 4).

The most important message emerging from any of these scenarios is that clear carbon price signals are needed, at least after 2030, to drive economies to a 2°C pathway. Climate policies currently on the table may be a first step in the right direction, but they certainly fall short of reaching the 2°C goal. Carbon price levels may diverge across the globe for a limited amount of time to reflect the different priorities and political economy, but globally efficient GHG emissions reductions in the medium term rely on a credible commitment by countries to make the disposal of GHGs in the atmosphere more expensive in the future.

Rather than pricing carbon, many countries subsidize fossil fuels. In 2013, pre-tax subsidies were as high as about 550 billion US$ worldwide, according to the IEA (2014). Contrary to stated goals, these subsidies are apparently not well spent for poverty alleviation because richer households profit from them the most (Arze del Granado, Coady, and Gillingham 2012). If non-pricing of negative external effects (such as air pollution and road congestion) is also taken into account, post-tax subsidies are much higher, amounting to 4.9 billion US$ in 2013, according to the IMF (Coady et al. 2015). This is an average of more than $150 per ton of 32 GtCO2 emitted by the global energy sector in 2013 (Edenhofer 2015). Approximately 60% of post-tax subsidies can be allocated to coal, thanks to the high social costs resulting from mining, transport and combustion.

Figure 4: GHG emissions trajectories based on REMIND calculations, historical emissions from EDGAR (JRC/PBL), calculations with the PBL INDC Tool (www.pbl.nl/indc: INDC range and best estimate represented by vertical black line and circle) and the WGIII AR5 scenario database.



Source: For details, see IDDRI (2015, Figure D).

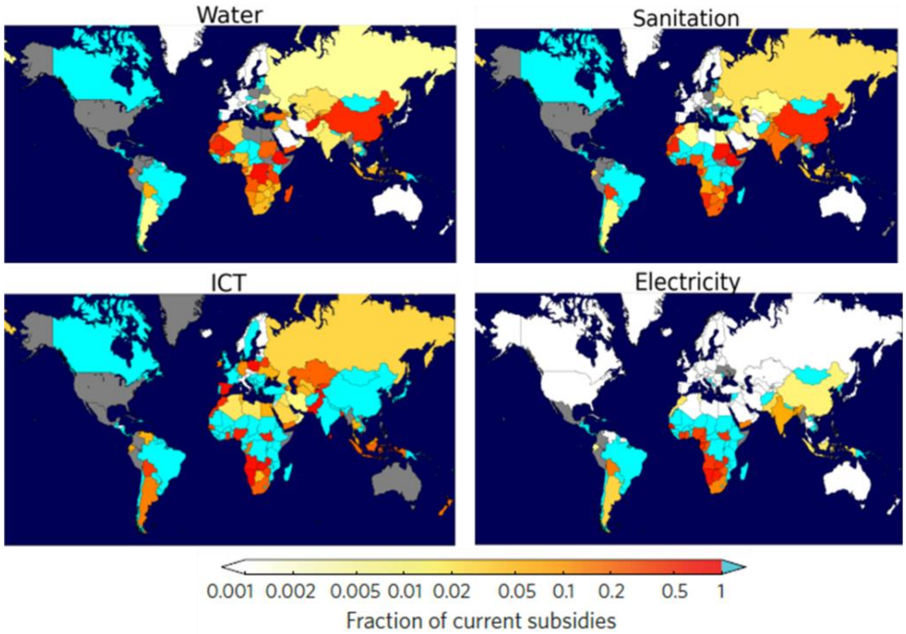
Removing fossil fuel subsidies would reduce many social and environmental problems related to fossil fuels and make low-carbon alternatives more competitive. Such a step could also free up financial resources that could be spent to close basic infrastructure gaps, such as for clean water and electricity access, improved sanitation and telecommunications infrastructure (see Figure 5 from Jakob et al. 2015). If combined with revenues from carbon pricing consistent with 2°C scenarios, many poor economies could significantly improve their long-term growth prospects. The window of opportunity for combining carbon pricing with low-carbon infrastructure investment is rapidly closing, however. To prevent a lock-in into carbon-intensive infrastructure, effective carbon pricing is essential (Edenhofer 2015).

There is a glimpse of hope: the idea of pricing carbon is back on the political agenda and has even gained momentum by the G7 pledge to phase out fossil fuels completely by the end of the century. Ever more countries are experimenting with emissions trading schemes at domestic or regional levels and there is a growing awareness of the multiple benefits of phasing out fossil fuel subsidies for both climate and health. There is also a growing awareness of carbon pricing as an appropriate climate policy instrument (e.g. in documents and speeches by officials of the International Monetary Fund, the Organisation of Economic Co-operation and Development, and the Bank of England).

The pressing question is how to discipline free riders throughout the world in their use of the atmosphere as free disposal space of waste GHG emissions, while others are trying to introduce ambitious climate policies. Why should any country invest in climate change mitigation if the potential gains from reduced climate impacts are only worth a fraction of the benefits of those efforts?

One reason for hope is that there are several rationales for introducing carbon prices unilaterally (Edenhofer, Jakob, et al. 2015) such as co-benefits for other sustainability goals (von Stechow et al. 2015), optimal taxation rationales (Franks, Edenhofer, and Lessmann 2015) and investment of revenues (see above).

Figure 5: Potential to achieve universal access to key infrastructure by 2030 through removing fossil fuel subsidies, measured by the share of fossil-fuel subsidies required to finance access to water, sanitation, telecommunication and electricity. Grey areas indicated missing data.



Source: For details, see Jakob et al. (2015).

A second reason for hope lies in behavioural economics: Based on field and laboratory studies, reciprocity is seen to be the cornerstone for stable cooperation among a diverse set of actors (Cramton, Ockenfels, and Stoft 2015). In the context of climate change mitigation, reciprocity would necessitate a shared commitment to climate policy, i.e., a common understanding of what efforts can be expected from one another, creation of incentives for cooperation and, eventually, mutual trust. While negotiation of global emissions targets and distribution of the overall budget has thus far been unsuccessful, an internationally agreed minimum carbon price would carry less financial risk related to uncertain BAU emissions and mitigation costs. Such a price instrument would also allow for a comparison of mitigation efforts across countries. Such a benchmark system could ensure that free-riders are disciplined and compliance with shared commitments is rewarded.

In order to build on the momentum, Europe could lead by example and consider further climate policy reforms to improve its emissions trading scheme. While recent reforms may have reduced the oversupply of emission allowances (EUAs) to some extent, they are currently priced around 10 € per ton of CO2. Market actors are apparently sceptical of European Commission announcements that it would continue lowering the upper ceiling after 2020, with the consequence that EUA prices on future markets have collapsed as well (Koch et al. 2014). Introducing a minimum EUA price seems to be a way forward for evoking trust in Europe’s climate policy and the negotiations more broadly and for creating a reliable environment for investment decisions. Such a step would increase the chances that some of the unilateral benefits of carbon pricing are reaped.

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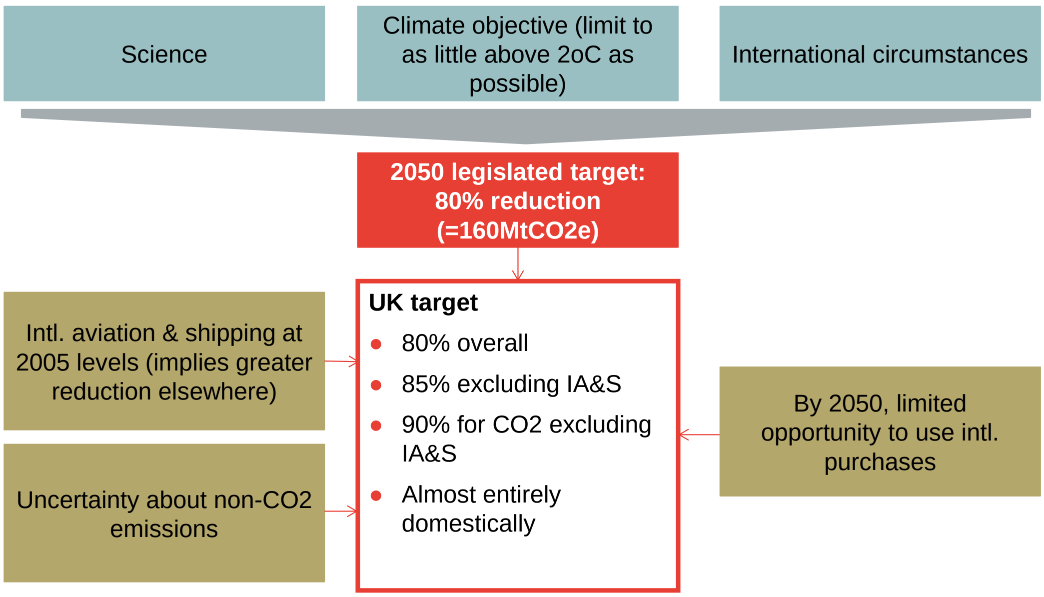
Session I: Long-term decarbonisation strategies in EU Member States

The UK's low carbon strategy: the Carbon Plan

Dan Roberts, Director, Frontier Economics

The UK has established a clear legal framework to provide a framework in which to achieve material emissions reduction goals. The Climate Change Act (CCA) sets a target for emissions reduction across the economy in 2050 of 80% relative to 1990 levels. This implies emissions of 160MtCO2e.

Figure 1: Diagram shows breakdown of the UK Climate Change Act (CCA) as a legal framework for 2050 emissions reduction objectives.



Source: Frontier Economics (contact author for details)

This 80% overall target can be subdivided further. It is expected that international aviation and shipping will abate proportionately less than other sectors. Similarly, there is uncertainty around non-CO2 greenhouse gas emissions. This implies that for other sectors, CO2 emission reductions have to be greater than 80% (around 90%) by 2050. Finally, it is expected that there will be little potential to purchase emissions reductions internationally, so the majority of this CO2 abatement is expected to be achieved domestically.

The CCA establishes an institution to support the achievement of this target. The Climate Change Committee (CCC) is an independent body established under the legislation. Its role is to act as an advisor to the government in relation to emissions reduction and climate change more generally. The Act requires the CCC to:

- Advise the government on any amendments to the 2050 target required;
- Advise the government on the level of carbon budget for each “budget period” on the way to 2050 (budget periods are 5 years in duration);
- Review on behalf of the government previous decisions on carbon budgets to ensure they reflect the latest information;
- Advise the government on the split of carbon abatement between:
    - National and international;
    - Traded and non-traded sectors;
- Advise the government on specific sectoral opportunities; and
- Reports on progress towards targets and budgets.

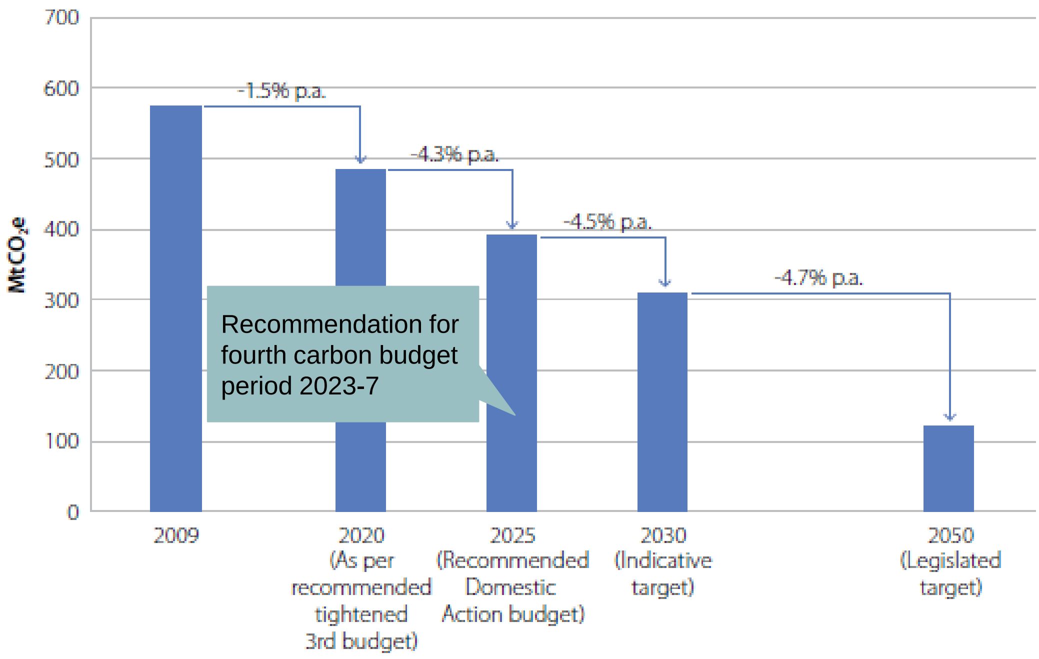
The CCC is required to do this on the basis of a balanced view across objectives, rather than just being focused on climate science. In reviewing the 2050 target and in setting carbon budgets on the way to 2050, the CCC must take into account:

- climate science;
- technology developments;
- the impact of climate change and emissions abatement on the economy and competitiveness of specific sectors;
- the fiscal circumstances of the country;
- the social circumstances of the country (and particularly the situation in relation to fuel poverty);
- the impact of policies on energy supplies; and
- circumstances at European and international level.

The CCC has previously set out views on its assumptions as to how the competitiveness of some industrial sectors will be affected by the achievement of carbon budgets, and implied levels of appropriate compensation.

The CCC has set out a long term profile for emission reductions to 2050, along with an overall strategy for the economy to achieve the 2050 target.

Figure 2: Long-term profile for emissions reductions to 2050.



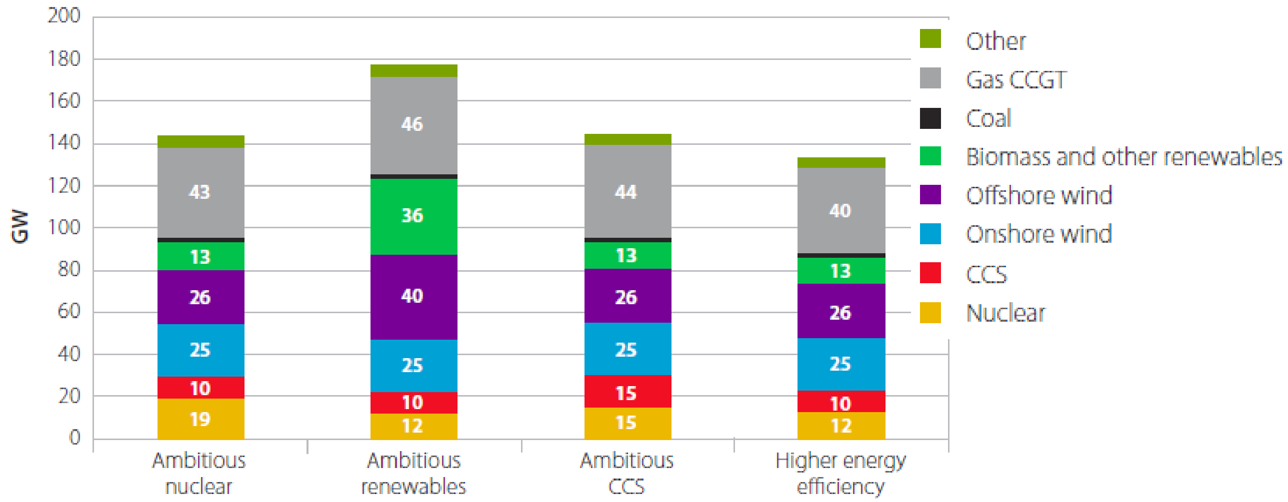
Source: Committee on Climate Change (2013).

The CCC foresees emissions reductions at around the same annual rate between 2020 and 2050, with this representing an increase in the rate envisaged to be achieved between 2009 and 2020. Underpinning this profile is a recognition that emissions reductions in some sectors are significantly harder to achieve than in others. The overall plan is therefore to decarbonize the electricity sector (on the grounds that significant progress can be made here quickly and cheaply) and then to use low or no-carbon electricity to decarbonize the heat and transport sectors. On this basis, the CCC advises that electricity production in 2030 should involve no more than 50gCO2/kWh, compared to around 500g today.

However, under the legal framework established in the UK, none of these intermediate budgets is legally binding. The government must determine whether to accept the CCC’s advice on a carbon budget for each period and if not, to set an alternative budget and legislate to achieve it. It is only the 2050 final target which is legally binding and set down in the Act.

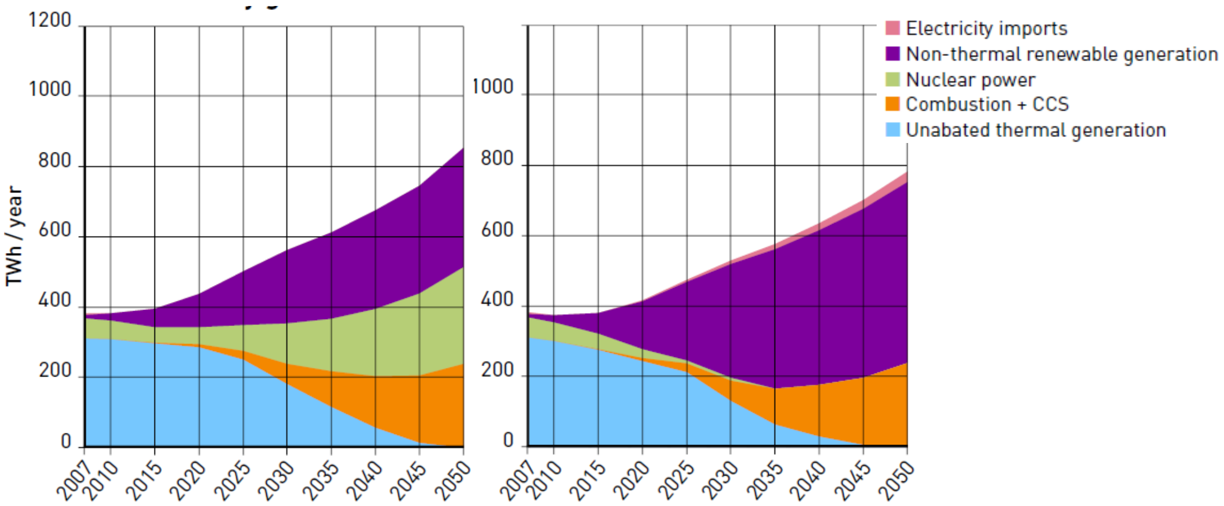
The electricity sector is clearly key to the CCC’s overall strategy. However, beyond the EU-wide 2020 targets for the sector, there are no clear targets established. There are lots of power sector “scenarios” for 2030, which vary according to the source of medium term low carbon electricity.

Figure 3: Electricity sector scenarios



Source: Committee on Climate Change (2013).

Figure 4: ‘Pathways’ for the electricity sector up until 2050



Source: Department of Energy and Climate Change (DECC) (2010).

There are also numerous “pathways” for the electricity sector to 2050. All of these 2050 scenarios basically envisage electricity production based on one of nuclear, RES, CCS and imports.

To implement the early carbon budgets set by the CCC and confirmed by the government, a programme of work in the electricity sector called “Electricity Market Reform (EMR)” was launched. This aimed to encourage the growth of renewables on the electricity system at a low cost while maintaining system security. There were four key pillars to the EMR programme:

- CfDs for low carbon generation which guaranteed developers a certain revenue stream from their installations;
- An emissions performance standard which effectively prohibits the construction of new coal fired generation capacity without CCS;

- A capacity auction to ensure that system security standards are maintained; and
- A carbon price support, to ensure that if the ETS price for carbon is lower than the government view of a “social cost of carbon”, generation in the UK faces a higher carbon cost.

The EMR programme was incorporated into legislation by the government and all elements of it are now in place. However, experience to date in each area has been mixed.

In relation to the **implementation of CfDs for low carbon generation:**

- A significant volume of wind power secured CfDs in the first competitive auction for renewables plants at a lower price than was awarded for previous contracts where the price had been administratively determined – this was a significant win for the customer and society, since it secured low carbon generation at a lower price; Wind cleared in first auctions at lower price than previous contracts;
- However, a significant volume of solar plants also secured CfDs in the first auction, only then to conclude that they had bid too low, and their projects were not economic at the winning price. The developers walked away from these plants – a lesson to the government in the design of tenders for support arrangements;
- Following the first auction and reductions in fossil fuel prices (implying the need for greater subsidies to achieve the same level of revenue), the government stated that they had spent up to the cap on total subsidy levels agreed with the Treasury. Hence, they cancelled the next round of CfD auctions;
- At about the same time they also:
  - removed subsidies for onshore wind, as a result of a manifesto commitment by the Conservative Party, who saw subsidies for onshore wind as jeopardising success with voters in rural communities where issues around visual amenity are important;
  - reduced subsidies for solar PV, on the grounds that solar PV costs are currently high relative to alternative renewable technologies;
  - reduced subsidies for small scale renewables plant, on grounds of cost efficiency;
  - removed a tax support on renewables, on grounds of cost, and the fact that significant amounts of the subsidy “leaked” to existing overseas power stations;
  - ended a programme to support energy efficiency in households, on grounds of both cost and the historically low effectiveness of the programme;
  - removed a target around the number of Zero Carbon Homes to be built, on grounds of the shortage of housing in the UK, and the desire to reduce regulation on housing developers.
- Discussions are now commencing with the Treasury on a new subsidy “envelope” post 2020.

In relation to the **Emissions Performance Standard (EPS):**

- Despite prohibiting new coal under the EPS, existing coal plants have seen running increased hours as a result of
  - A switch between coal and gas as a result of relative prices;
  - The risk of higher carbon price support reducing future coal plant profitability, and incentivising them to run in the short term (particularly if other environmental legislation implies they have a limited number of running hours);

- As a result there have been persistent government rumours that additional regulation beyond the EPS will be implemented. The government has now confirmed that coal will be “regulated off” the system by 2025 (provided enough gas plant is built).

In relation to the **capacity auction**:

- The first capacity purchased enough capacity to secure the system in 2018 at a price far below expectations – a win for the customer
- However, in this auction around 1GW of the capacity purchased was in small “diesel farms” – c. 20 MW diesel power stations that are not expected to run frequently. More diesel capacity has pre-qualified in the second auction (still to be held);
- A further 1.8GW was in a new CCGT plant, which few in the industry expected to be economic given the price levels and which the promoter has subsequently said will not be built (they prefer to pay the c. £8m penalty for walking away rather than risk greater losses through build at this price): again a lesson in tender design.

In relation to the **carbon price support**:

- The initial plan was for the price support to escalate steadily to a “target consistent” carbon price (c. £70/tonne). However, this escalation was abandoned amid political worries about energy prices and the fact it creates a windfall for existing nuclear and imported energy by raising wholesale price;
- The effect of the price support on delivering any low carbon generation has been minimal:
    - It is a tax – and so it is not considered as bankable by any potential investors; and
    - All low carbon is procured through separate support regimes (i.e. CfDs).
- All that said, it is likely to be retained as a policy, as it brings in c. £2bn of tax revenue for the government.

So while the UK has a clear framework for the definition of a long term carbon abatement pathway, the legislative measures undertaken by the government to implement this pathway in the short term have not been without their issues. The tensions between two objectives in the energy trilemma – affordability and sustainability – remain at the forefront of the debate on energy policy in the UK.

Figure 5: Energy trilemma – security, affordability and sustainability

Press websites: Financial Times (2015), Financial Times (2015a), Climate Home (2014).

It has been suggested by some that the current government has placed more emphasis on security (particularly given the UK's very tight plant margin) and affordability than on sustainability. Many commentators are noting that this is hurting renewables investment and potentially jeopardising the UK's ability to meet cheaply its long term carbon goals. Resolution of these policy conflicts in the light of evolving costs and technologies will be critical to meeting the UK's long term pathway.

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100% Renewables – a scenario for France

Dr. Christopher Andrey, Project Manager, Energy Division, Artelys France[5]

Introduction

Over the last few years, significant technological progress relative to renewable energy has occurred. There is consensus among numerous studies that renewable energy costs will fall sharply by 2050. In this context, it is perfectly legitimate to wonder not only about the feasibility but also about the economic impact of an electricity mix with a high level of renewable energy generation.

Answering this question requires precise and innovative modelling to take into account the demand-supply equilibrium on short time-scales (typically using an hourly resolution, over the course of one year, and for several climate scenarios), the way electricity generation and consumption will be managed (e.g. demand-response, electric vehicles charging, warm water heating, etc.), and the spatial distribution of renewable energy systems (RES) amongst the regions and the circulation of electricity flows.

This study aims at answering the following questions:

- What kind of challenges emerge if the share of renewable energy in the electricity mix in France is substantially increased?
- What are the optimal electricity mixes to suit various sets of assumptions concerning technological developments, consumption, public acceptance, etc.?
- How are the different renewable energy generation assets distributed on the French territory?
- What are the economic impacts of electricity mixes with a high level of renewable energy penetration?

The study has been commissioned by ADEME, the French Environment and Energy Management Agency and undertaken by Artelys, with contributions from Energies Demain (hourly demand scenarios) and Armines-Persée (RES generation potentials and profiles for solar and wind).

Methodology and main assumptions

This study is based on the use of Artelys Crystal Super Grid, a model of the electricity system which optimises both the power generation mix - i.e. the electricity generation capacities and storage portfolio per region, and the interregional exchange capacities - and simulates the optimal management of this power generation mix over a period of one year with an hourly time resolution (8,760 chronological time-steps).

In order to take into account regional differences in renewable energy potential (capacity factors and technology generation profiles differ from region to region), France has been broken down into the 21 administrative regions existing in 2015. Capacities (renewable technologies, storage) are

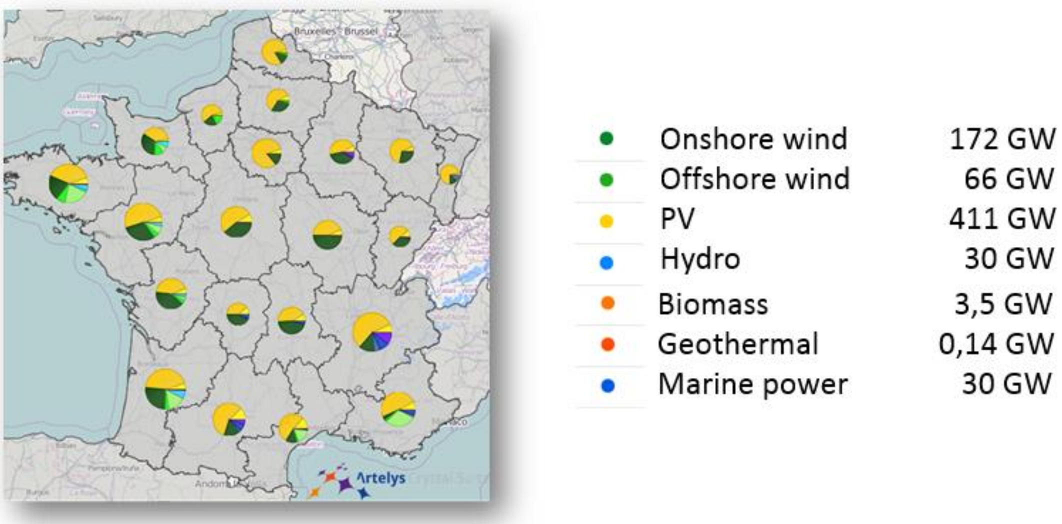
[5] This article and the included figures are based on the final report: Agence de l’Environnement et de la Maîtrise de l’Énergie (ADEME) (2015): Un mix électrique 100% renouvelable? Analyses et optimizations. Un travail d’exploration des limites du développement des energies renouvelables dans le mix électrique métropolitain à un horizon 2050, Rapport final, Octobre 2015.

optimised for each region, as are inter-regional exchange capacities, allowing network development requirements to be estimated. An optimal management of generation portfolios in France’s neighbouring countries is simulated with hourly time-steps. International exchange capacities and the installed electricity mixes of the other European countries are exogenously set by an ambitious European scenario in terms of the share of renewable energy generation (Roadmap 2050, 80% renewable energy).

The 2050 demand level has been assumed to be 422 TWh (466 TWh in 2013), peak demand to be 96 GW (100 GW in 2013) and thermal sensitivity to be 1,500 MW/°C (2,300 MW/°C in 2013). The demand is assumed to be able to react to appropriately designed signals: heating (including warm water), white devices and electric mobility are providing the system with flexibility options.

The potential for all renewable power generation technologies have been evaluated at the regional level, as illustrated below. Up to 1,250 TWh could be generated if one were to exploit the entirety of the potential.

Figure 1: Regional RES generation capacities



Source: ADEME 2015.

In order to guarantee the robustness of the optimised electricity mix, several climate scenarios are used. Each of these scenarios corresponds to a historical year, including records for temperature, consumption, and wind and solar production profiles for each French region and each neighbouring country. Capacities have been optimised for the most demanding of these scenarios (2012, which includes a two-week period of very cold weather). The resulting mix has then been simulated on six other climate scenarios and for a year of drought (resulting in less hydro production) to ensure the electricity generation mix is robust to climate variations.

Moreover, given the wide variety of technical, political and social developments which may have occurred by 2050, different assumptions were fed to the model resulting in different electricity mixes. The scenarios are listed below:

Baseline scenario, based on which variation assumptions have been made

- Variations simulating various levels of social acceptance:
  - moderate demand-side management[6],
  - low acceptance of network reinforcement,
  - two variations respectively corresponding to moderate and very limited public acceptance of onshore solar and wind energy farms
- Variations simulating different technical and economic developments:
  - two variations for different levels of technological progress: a first scenario with more progress for technologies which are currently less mature, and a second one with less progress (and higher costs for all technologies),
  - access to cheap capital for renewable energy
- “Unfavourable” case with both very limited acceptance and a low level of technological progress
- Four "contrasting" variations exploited to analyse the sensitivity of the resulting mix to a specific parameter (particularly dry year, absence of the photovoltaic sector, second-generation wind energy sector not taken into account, no dynamic demand management)
- A case taking into account sub-transmission level network modelling.

The capacities of the different technologies listed in Figure 1 are optimised based on assumptions on annualised investment costs and on annualised maintenance costs extrapolated for 2050 from in-depth bibliographic research[7]. The average levelised costs of energy (LCOE) are given in the table below. Note that since the various French regions may be characterised by different load factors the LCOE differ from region to region.

Table 1: LCOE for RES-e generation technologies

Ground PV	60 €/MWh
Onshore Wind	65 €/MWh
Offshore Wind	80 €/MWh
Rooftop PV	85 €/MWh
Offshore Wind (floating)	107 €/MWh
Wave Power	110 €/MWh
Tidal Power	110 €/MWh

[6] The moderate demand scenario is based on an extrapolation to 2050 of the annual volume assumptions from the RTE New Mix scenario.

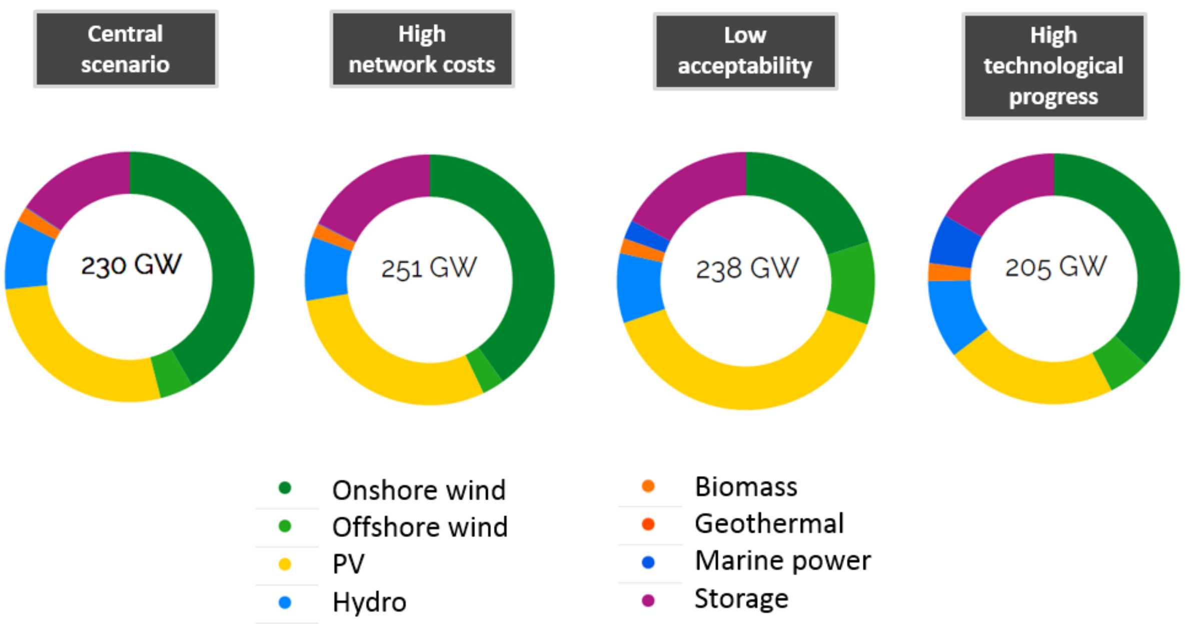
[7] The main sources studied are as follows: Appendix 8 of the court of auditors report into renewable energy, "Energy technology Perspectives 2014" by the IEA, the IEA ETSAP programme, "Levelized cost of electricity renewable energy technologies – 2013" report by the Fraunhofer ISE, NERL "Transparent cost database", and SRU study "Pathways towards a 100 % renewable electricity system".

Key lessons

Lesson #1 - Several 100% renewable power generation mixes can balance supply and demand on an hourly basis, including in unfavourable weather conditions. In all cases, wind and PV energy provide most of the power.

The various possible constraints have a significant impact on how the associated optimal electricity mixes are structured. Depending on the acceptance constraints, the rooftop PV and offshore wind capacities increase while ground-mounted farms and onshore wind capacities decrease. Moreover, when severe network development limitations are introduced, local power generation will often be preferred, even if it results in exploiting potentials with lower levels of full load hours. Scenarios with an 80% share of renewable energy generally require a lower level of network reinforcement and fewer storage assets.

Figure 2: 100% renewable power mixes for various scenarios



Source: ADEME 2015.

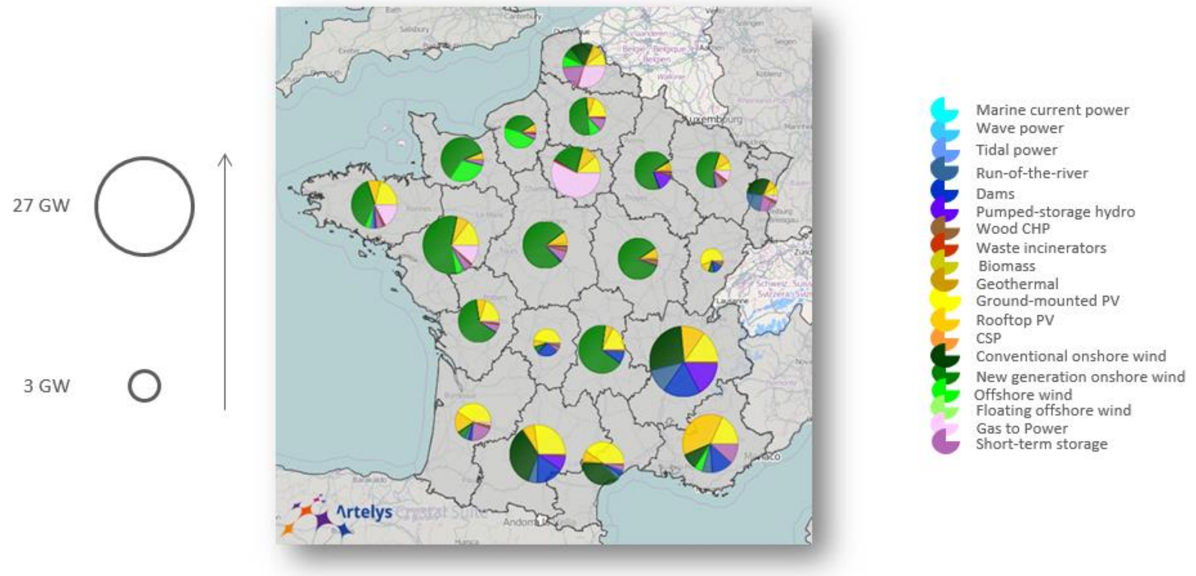
Lesson #2 - According to the assumptions, overall electricity costs vary from €103 to €138/MWh. The parameters which stand out as the most significant for electricity costs are social acceptance, the evolution of technological costs and demand-side management. Keeping a non-renewable energy fraction in the generation portfolio reduces the degree to which costs are affected by these factors and provides a certain resilience with regard to economic and social constraints.

Lesson #3 - A mix with a high penetration of renewables requires demand flexibility and the development of storage solutions. The study highlights how the need for storage solutions varies with the targeted level of renewable generation. To increase the share of renewable power from 80% to

95%, the flexibility introduced by thermal generation is replaced by inter-seasonal storage so that the system can handle even the most challenging weather conditions. Inter-seasonal storage is shown not to be necessary to balance the electricity system below an 80% share of renewable power. Short-term storage represents around 20% of the PV installed capacity from an 80% renewable energy share upwards.

Lesson #4 - Complementarity between technologies is key. The economic optimum depends not only on the energy cost but also on the services provided to the system. Indeed, the analyses conducted during the study confirm that energy costs are not the only criteria to be taken into account when selecting which technologies to include in the optimised generation portfolio. The service provided to the system by the different technologies, i.e. the way the generation profiles correspond to non-dispatchable demand at hourly, daily or monthly levels, and the flexibility of dispatchable technologies, is also a key criterion. Moreover, the study demonstrates the value of next-generation wind turbines, which enable output from lower-wind sites with less fluctuating generation profiles. Some technologies with a flat profile - such as geothermal energy - or dispatchable technologies - such as wood-fired co-generation - see their extra cost compensated by the benefit they provide to the system.

Figure 3: Regional technology portfolios of a 100% renewable power mix



Source: ADEME 2015.

Lesson #5 - The transmission network must be reinforced to pool the regional potentials. In a 100% renewable electricity mix, inter-regional exchange capacities should be increased by 36% with respect to the current situation. Note that the reinforcement of cross-border interconnections is also planned (these were established upstream based on assumptions from the RTE New Mix scenario), from 14 to 23 GW for export and 11 to 16 GW for import. These interconnection capacities allow the system to exploit the differences in dynamics of renewable energy generation and demand between

France and its neighbours. The study has demonstrated that a 100% renewable electricity mix in France could be integrated into an 80% European power mix, and neutral import-export annual balance.

Conclusions and outlook

This study has demonstrated that power generation mix with high shares of renewable power in France (up to 100%) are not only feasible but also economically viable. The Artelys Crystal Super Grid software has allowed for a thorough investigation of the ability of the system to robustly balance the supply and demand with an hourly time resolution over several years of climate data.

Further analysis is now needed to assess whether a 100% renewable electricity mix can cope with sub-hourly perturbations, and if a more detailed assessment of the distribution-level costs due to the integration of distributed generation can influence some of the above conclusions. Externalities such as the impact on employment, and on GHG emissions also have to be estimated.

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Greenhouse gas neutral Germany – Main parameters and findings

Benno Hain, Katja Purr, Mark Nowakowski

The latest report by the United Nations Environment Programme (UNEP) on greenhouse gas emissions makes clear that the 2°C limit can still be observed (UNEP 2015). The so-called Emissions Gap Report 2015 states that the intended national contributions of the UN member states to mitigate the emissions are an important step but have to be raised in their ambition to really get on track towards a safe climate. This will only be possible, however, with highly ambitious climate protection measures that are implemented quickly. All levels of authority are called upon to act, from national governments to local administrations.

National Goals and Perspectives

Concrete national policy decisions on climate protection in Germany also specify the action pathway for all stakeholders and decision makers. This includes the ambitious reduction of greenhouse gas emissions in this country by 40% by 2020 (Fig. 1).

Figure 1: Energy and climate protection targets of Germany

	Climate	Renewable Energy		Efficiency		
	GHG (vs. 1990)	Electric power	Total share	Primary energy	Energy productivity	Modernising buildings
2020	– 40 %	35%	18%	– 20%	increase to 2,1% p.a.	double rate 1% → 2%
2030	– 55 %	50%	30%			
2040	– 70 %	65%	45%			
2050	– 80-95 %	80%	60%	– 50%		

Source: Federal Ministry of Economic Affairs and Energy (BMWi) 2014.

In December 2014, the German Cabinet adopted the Climate Action Programme 2020. The German government presented a comprehensive package of measures to combat climate change. With its action programme the German government aims to ensure that it will achieve the goal it set in 2007 to cut greenhouse gas emissions by 40% by 2020 compared with 1990 (German Ministry for the Environment 2014). According to the latest projections, without the new programme Germany would fall short of its goal by 5 to 8 percentage points. The action programme contains measures for an additional reduction of 62 to 78 million tonnes CO_2-equivalent compared to the current projections for 2020. This range is a result of different assumptions on the impact of the individual measures. All sectors contribute to the programme. The largest share (25 to 30 million tonnes) is achieved through energy efficiency measures under the National Action Plan on Energy Efficiency (NAPE). Measures in the field of climate-friendly building and housing will yield further emissions reductions amounting to 1.5 to 4.7 million tonnes. Additional measures in the electricity sector contribute 22 million tonnes. The Federal Ministry for Economic Affairs and Energy (BMWi) has drawn up a concept for distributing these 22 million tonnes as a mitigation commitment across the fleet of fossil fuelled power plants in Germany. Specifically, the new Act on the Further Development of the Electricity Market is setting up an arrangement whereby older, high-emission lignite power plants are gradually put on "security stand-by" for four years and will then be decommissioned. From the time they are put on security stand-by, they are not allowed to participate in the electricity market anymore and therefore will no longer emit carbon dioxide in normal operation mode, thus ensuring that the national 2020 climate target can be met. In this context, a swift reform of the European Emission Trading System is essential as the current excess liquidity in this scheme interferes with investments in climate action due to a lack of sufficient economic incentives.

The transport sector contributes a reduction of 7 to 10 million tonnes to the action programme. Moreover, measures to reduce non-energy-related emissions in industry, commerce, trade, services, and waste management will yield reductions of 3 to 7.7 million tonnes and approximately 3.6 million tonnes in the agriculture sector. The Climate Action Programme 2020 also contains a range of measures that are difficult to quantify. These include advice and information, and the effects of training and further education. These measures further contribute to reducing greenhouse gas emissions. Research and development are also crucial for achieving the necessary gradual decarbonisation of the economy. Moreover, the role model function of the state is particularly important, e.g. with regard to public procurement and improvements in the energy efficiency of public premises. On the whole, these measures can contribute reductions of at least 3 to 4 million tonnes by 2020. Combined with the programme's overall volume of 78 million tonnes this means a total reduction of 82 million tonnes could be achieved by 2020. To implement the programme the German government will carry out regular monitoring with an annual climate action report which was first published in November 2015. It will also involve all stakeholders: the federal states, local authorities, major groups and associations.

In order to achieve the long-term goal of an 80–95% greenhouse gas reduction by 2050, the so-called Climate Action Plan 2050 which is currently under progress will be adopted by summer 2016 (German Ministry for the Environment 2015). It follows the rationale that climate protection needs a long-term framework.

The German Government stated in the Coalition Agreement of 2013: "In Germany, we want to commit to an emissions reduction pathway [...] with a final target of 80 to 95% lower greenhouse gas emissions compared to 1990 by 2050. We will augment this target with concrete measures, drawn up through a broad participatory process (Climate Action Plan)." See Fig 2 (German Federal Government 2015, p. 37).

For this reason the Federal Government has mandated the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) to develop the climate action plan and to coordinate the consultation and consolidation process with stakeholders and other governmental departments so that it can be passed by the Federal Cabinet in 2016. The guiding principle and benchmark for climate policy is the internationally adopted goal to limit global warming to 2°C above pre-industrial levels which has to be lowered to 1.5°C following the Paris Agreement of December 2015. This limit is necessary if the worst effects of climate change are to be avoided and effective adaptation is to remain feasible. This 1,5 to 2,0°C target is the benchmark for both the European Union's and Germany's climate protection efforts in the long term.

After having discussed robust strategies and transformative pathways in summer 2015, the federal states, municipalities, associations, and individuals are called upon to actively participate in the development of the Climate Action Plan 2050 by suggesting potential measures. Fig. 2 illustrates the issues addressed as well as the participants being involved in the dialogue process.

Figure 2: Dialogue process for the Climate Action Plan 2050

Source: German Ministry for the Environment 2015.

The Federal Government initiated this innovative and broad participatory process to ensure societal support for the programme and its measures which will surely affect the whole country. The Federal Government regularly informs on the status quo of emissions reduction and the current participatory process. Discussions between different stakeholder groups ensure that experiences in the area of climate change are shared and ideas for implementing measures exchanged.

So far, stakeholders have suggested nearly 400 measures, which have been consolidated into currently 77 measures by the concomitant scientific institutions. The Committee of Delegates, which consists of representatives from all stakeholder groups, is monitoring the overall process so that the outcome still reflect the intentions of those involved. All groups will vote on the final measures suggested so that the Federal Government receives not only suggestions but also an idea of who is supportive of which recommendations. In return, the Federal Government will give feedback to those involved in the final recommendations. After multiple discussions it was concluded that broad participation and dialogue with all stakeholders and citizens is vital for the achievement of ambitious climate goals.

Indeed, it needs cross-linking at all political levels in order to shape climate protection in an ambitious way and bring about a greenhouse gas neutral society in the long run. The main objective of the German *Energiewende* (energy transition) is the sustainable transformation of the energy supply system in terms of economy, security of supply, and environmental impacts.

Greenhouse Gas Neutral Germany

A study by the German Environment Agency (UBA) entitled "Greenhouse Gas Neutral Germany 2050" (German Environment Agency 2014) illustrates by which means a 95% reduction of greenhouse gas emissions by 2050 across the nation could work, and demonstrates the technical feasibility thereof. The study is neither exclusively focused on the reduction of greenhouse gas emissions nor on the energy sector. Rather, all relevant emitting sectors are taken into account, and technological solutions are highlighted. It becomes obvious that along with the electricity sector, particularly the heat and transport sectors must become completely CO_2 neutral given that other sectors such as agriculture and certain industrial processes cannot eliminate all their emissions. The integration of renewable energy into and the interlinking of existing systems as well as technological innovations play a key role. Criteria for a long-lasting, environmentally friendly, and socially equitable development of the energy supply help to prevent conflicts with other sectors of society and facilitate the implementation and dialogue. Thus, all aspects of the energy supply should be compatible with environmental, climate, and health issues. If the energy supply is to become greenhouse gas neutral by 2050, it must be based entirely on renewable energy sources.

In earlier studies, the German Environment Agency demonstrated that an electricity supply based entirely on renewable energy is feasible. In Germany, the electricity sector accounts for around 40% of energy-related greenhouse gas emissions. The conversion of the power supply from fossil energy carriers to renewable sources is therefore an important building block towards achieving national and global climate protection targets. As stated above, the electricity sector must become fully carbon neutral by 2050 in order to reduce greenhouse gas emissions in Germany by 80 to 95% against 1990 figures. For the purpose of quantifying the potential for reductions in the electricity sector more accurately, the German Environment Agency has set out three different scenarios. The feasibility of supplying Germany solely with renewable forms of electricity generation by 2050 is investigated from varying technological and environmental angles in three archetypal scenarios: Regions Network, Local Self-Sufficiency, and International Large-Scale Technology (German Environment Agency 2010). These approaches are fundamentally different in their underlying electricity generation structures, the degree of cross-sector interlinking, and the flexibility options such as storage systems they require. In particular, the results of the Regions Network scenario demonstrate that an electricity supply based solely on renewable forms of energy will be feasible in technological and environmental terms by 2050.

These three archetypal scenarios represent different points within a solution space for a renewable electricity supply in Germany by 2050. This approach was chosen to demonstrate that there is not one technically and ecologically feasible path towards attaining this goal but a whole range of viable alternatives. A real-life future energy supply system for Germany will most likely include characteristics of all three scenarios, however, depending on political and social preferences, the development of electricity production costs and so on. Thus, the benefits of all variants may be combined in an efficient way. In a follow-up study, the results of the first three scenarios are used to simulate a set of optimised power scenarios involving a 100% renewable electricity supply system. The focus is now on the optimal spatial allocation of generation facilities, the power exchange between the regions and between Germany and its neighbours, and the deliberate over-production of renewable electricity in order to substitute fossil fuels in other sectors, too, especially in heating, hot water, and transport. Hence, the share of renewable energy in the gross energy consumption could be increased. The results of this study are expected to be published in 2016.

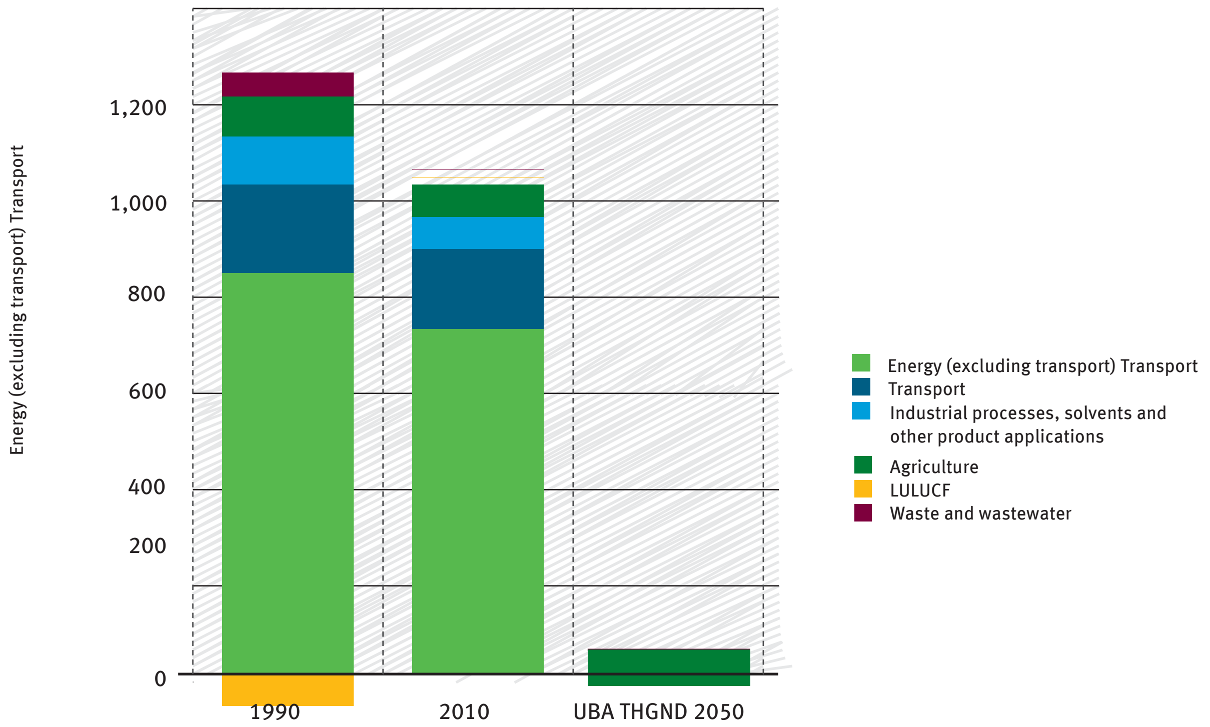
In 2011, a new study was launched with the scope of analysing a target scenario for a greenhouse gas neutral Germany by 2050 going beyond the electricity sector. The results were published in 2014. It could be shown that carbon neutrality even for an industrialised country like Germany can be reached by 2050 through substantial contributions from all relevant sectors. The scenario describes one of several possible ways to realise a greenhouse gas neutral Germany. The study covers neither the thinkable pathways towards this transformation, however, nor associated economic assessments, nor the suggestion of suitable policy instruments. The findings show that by 2050 Germany could cut its greenhouse gas emissions by 95% compared to the level of 1990. It is assumed that in 2050 Germany will still be a highly-developed industrialised country that has maintained its standard of living, with close-to-current consumption and behaviour patterns.

The scenario assumes significant technological progress especially with regard to energy efficiency and greenhouse gas mitigation and a broad penetration with these technologies. Still, the analysis is based only on the best technology currently available or in late development stage. In this rather conservative approach, no major new inventions are expected, which would, however, make it easier to reach the target.

The study does not assume any significant changes in consumers' behaviour such as the development and proliferation of different lifestyles or changes in consumer patterns (except for traffic avoidance and modal shift and meat consumption) although the German Environment Agency might consider such changes desirable and indeed necessary from a sustainability point of view. The focus of this study has been deliberately chosen to cover technical solutions that would allow climate targets to be met while also considering the limits imposed by environmental and health aspects. However, where there is a close link between technical solutions and the reduction of greenhouse gas emissions through behavioural changes, this is discussed – for example in the chapters on transport, agriculture and waste disposal. We assumed that in 2050 Germany will be a net exporter, an industrial nation with continued average annual economic growth running at 0.7% of gross domestic product. The study is also based on the assumption that Germany's population of 82.5 million in 2005 drops by approximately 12.5% by 2050.

In the study we broaden the definition of *greenhouse gas neutrality* to include very low, basically climate-compatible emissions. Accordingly, we set an emissions budget for a greenhouse gas neutral Germany to approximately 60 million tonnes of CO_{2e}, which is equivalent to a reduction of 95% compared to 1990 levels (cf. Fig. 3). The present level of annual per capita greenhouse gas emissions in Germany would be reduced from roughly 11 tonnes to approximately 1 tonne. These figures only include greenhouse gas emissions generated in Germany and recorded in the National Emissions Inventory. Indirect emissions arising in other countries, associated with imported goods, are not included.

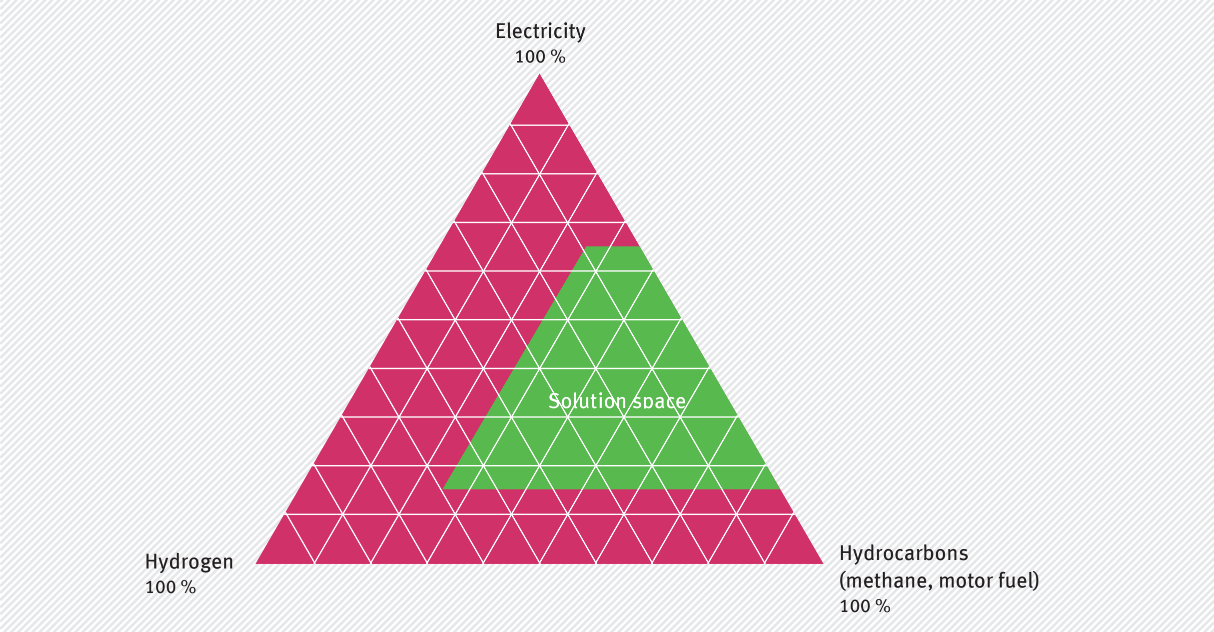
Figure 3: Greenhouse gas emissions in 2050 according the UBA scenarios. 1990 and 2010. Options for greenhouse gas reductions across all source categories were considered



Source: German Environment Agency 2014.

In addition to the above-mentioned electricity supply studies, we show that the complete energy demand for heating and transport can be met by a system based on renewable energy sources. The resulting energy system in our scenario is based largely on direct use of renewable electricity, renewably sourced hydrogen produced by electrolysis of water, and renewably sourced hydrocarbon compounds (i.e. methane and fuels). Due to technological restrictions it is not possible to base the entire energy supply on one of these components alone. The share of each of the three energy carriers in the final mix is limited by technical reasons. Fig. 4 gives a qualitative representation of the resulting solution space and its composition for the energy mix in our scenario. Depending on the available technology in the different sectors, the actual components of the final energy carrier mix may vary.

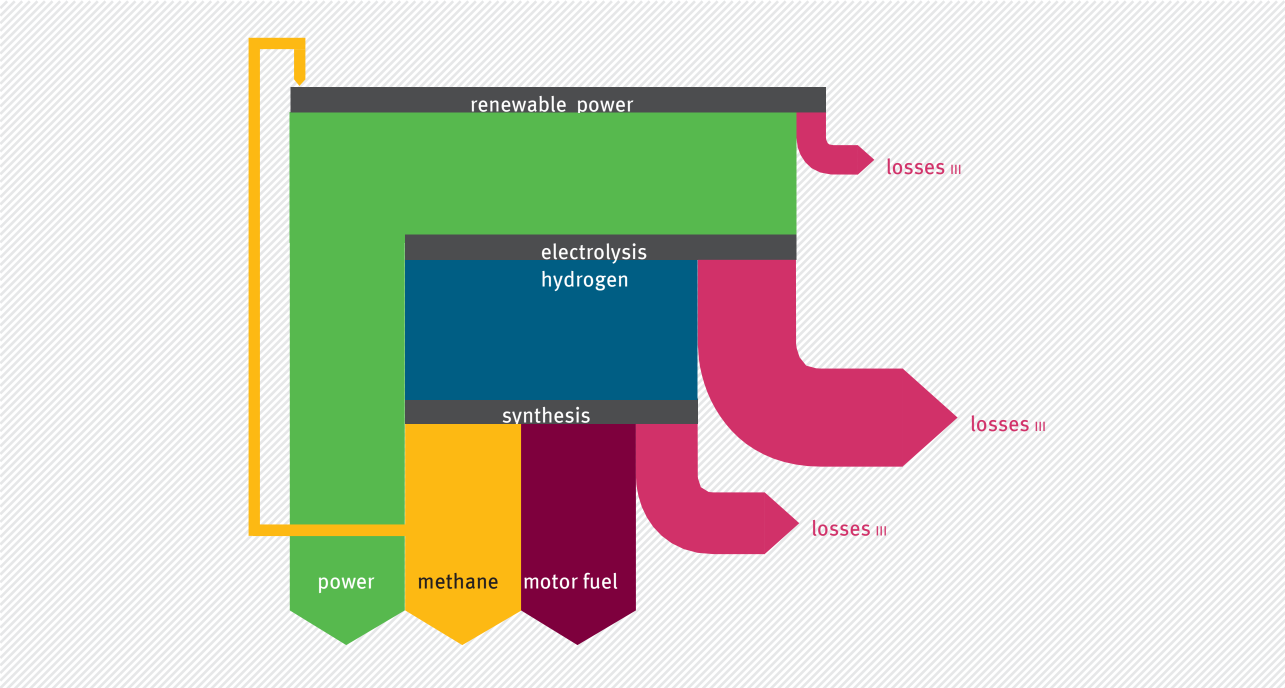
Figure 4: Qualitative representation of final energy carrier mix in the UBA scenario for 2050



Source: German Environment Agency 2014.

Fig. 5 shows a schematic of the energy flow in our scenario. Herein, final energy is predominantly provided by renewable power. The figure neglects further transport losses during of imported renewable gas and fuel. Hydrogen does not figure as a final energy carrier in our scenario which would open up further options, though.

Figure 5: Qualitative representation of the energy flow in the UBA scenario for 2050



I Including demand for renewable inputs for the chemical industry.
II Representations of energy flows are proportional to the energy flows required.
III Including line losses, losses from reconverting methane into power and losses from converting biomass into power

Source: German Environment Agency 2014.

Conclusions from the UBA 2050 scenario and outlook

The UBA study shows that a greenhouse gas neutral energy supply is technically feasible. Due to the integration of different sectors, in the long run the final energy demand for electricity cannot be lowered substantially but will settle around today’s level. If saving potentials are consistently exploited and efficiency increased across all sectors, final energy consumption could be halved. Sector integration facilitates a substitution strategy for fossil energy carriers in all sectors in the long term. Conversion of renewable electricity into chemical energy carriers (power to gas/liquid/fuel/chemicals) is the key technology for sector coupling in the long run – not just to ensure a stable supply of electricity through reconversion on demand, but mainly to supply industry with heat, fuels, and chemicals and the transport sector with fuel. So produced hydrogen, methane or higher hydrocarbons could play the key role as final energy carriers in a future energy system.

In an ongoing research project (to be published in 2017) UBA explores the link between greenhouse gas neutrality and resource demand. With the 2050 target scenario at hand, we now look at viable transformation paths towards a carbon neutral (-95% emissions) and resource efficient (-80% raw material consumption) future for Germany. The scope comprises the deduction of possible transformation steps for 2030 and 2040 to reach the 2050 targets. The study should give answers to the questions which key measures, technologies, societal developments are necessary at different points in time and what are their economic and ecological impacts. Conflicts between emission reduction targets and resource protection are to be highlighted while scenarios and approaches will be optimised.

Final Remark: A greenhouse gas neutral society in 2050 means a lot more than 100% renewable energy. It means a tremendous change and challenge. Therefore we need to foster public acceptance and a conjoint, well-coordinated collaboration throughout Europe and beyond.

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The three studies on the archetypes (Regions Network, Local Self-Sufficiency, and International Large-Scale Technology) can be downloaded free of charge from www.uba.de .

Session I: Summary and discussion

Panelists in Session I – “Long-term decarbonisation strategies in EU Member States”, Source: Ecologic Institute.

In most EU Member States, state or non-state institutions have developed long-term low-carbon **scenarios** for 2050. They use very different parameters and make different assumptions about what technologies to include and what they are likely to cost. These different choices can lead to a great divergence in outcomes. National preferences are, therefore, worth exploring and discussing.

Based on national low-carbon scenarios a number of EU MS have adopted long-term emission reduction goals and developed national 2050 **strategies**. However, progress and level of ambition and stringency varies significantly. Some are mere indications, others even legally binding and backed up by policies.

Dan Roberts, Director of Frontier Economics, presented the climate policy framework of the **United Kingdom** - the first country to adopt a legally binding Climate Change Act (2008). The Act obliges the government to reduce emissions by 80% by 2050 and to establish five-yearly carbon budgets as milestones towards the 2050 objective. However, many different scenarios have been developed for 2030 and 2050 and there is still no clear view on the role of different technologies in the energy mix. Currently, the government does not clearly communicate climate protection as a priority, keeping investors from putting more on low-carbon investment. The UK has established a quite comprehensive set of policy measures but, according to Dan Roberts, implementation of these faced many unexpected difficulties.

Dr. Christopher Andrey, Artelys France, presented a 100% renewable electricity generation scenario for **France**, financed by the French Energy Agency ADEME. The study, published in autumn 2015, is a snapshot of the optimal power production mix at the 2050 horizon with high shares of renewable power. It shows that 100% renewable electricity is feasible and only very slightly more costly than a scenario with only 40% renewable in the electricity mix. A diversified technology mix, management of storage and demand response are key factors for such a scenario.

Klaus Müschen, Source: Ecologic Institute.

Benno Hain, German Environment Agency, provided insights on the UBA study “Greenhouse gas neutral **Germany** “. As a first step, the UBA analysed the possibility of moving to a 100% renewable electricity – which proved feasible under three different scenarios (regional network, local autarky, international network). Starting from these findings, the UBA decided to look at the economy as a whole and to check the technical feasibility of reducing GHG emissions by up to 95%. Key parameters were set at the outset: no nuclear energy, no use of CCS nor energy crops. The study shows that all sectors need to contribute to decarbonisation. In 2050, final energy can be halved and only three sectors (industry, agriculture and land use) would contribute to GHG emissions. Hain highlighted that such a transformation of the economy would be a tremendous change, requiring much work on fostering public acceptance and a conjoint, well coordinated collaboration throughout Europe.

Tetsunari Iida, *Institute for Sustainable Energy Policies (ISEP)* in **Japan**, was brought in to join the panel with an extra-EU perspective, to broaden the scope of the conversation. Reflecting on the presentations made on the three EU Member States, he contrasted the European situation with that in Japan. Energy issues (security of supply, savings) are a more pressing concern following the Fukushima crisis, with climate change featuring less prominently. And so there is not a clear decarbonisation pathway at present. A majority of the population is now in favour of phasing out the use of nuclear power. The current government in return uses climate change concerns as a pro-nuclear argument, creating a complex field of debate. Even positions that question the science of climate change still exist, even among anti-nuclear groups.

However, at the same time, interest in renewable energy has been constantly increasing in Japan, including with the general public, who see the appeal of generating their own energy. A feed-in tariff system was passed into law, by coincidence on the same day as the earthquake, which led to the

Fukushima incident. It has led to a growing renewables market in Japan. This may lead to a structural change that is created from the bottom up, not through top-down regimes such as the climate conferences in Paris or Copenhagen.

With a view to European climate policy, he highlighted that many in Japan envied the EU for its potential to experiment with policies. For instance, small Member States, like Denmark, could start a social experiment on ambitious climate action. If successful, big Member States could follow. Due to the high level of centralisation, such experiments were hardly possible in Japan.

The subsequent **discussion** highlighted the feasibility of 100% renewable energy scenarios but also the need to foster public acceptance and to coordinate policies among EU Member States. The political will for a substantial climate change policy is a main requirement for a decarbonisation in EU Member States. An essential insight from the discussion was also that agriculture remains a particularly challenging sector for almost all Member States. There are few obvious means currently available to reduce emissions from this sector. Many scenarios thus calculate that in 2050 there will still be considerable GHG emissions from agriculture. Climate policies in many Member States tend to focus on the energy sector and leave agriculture aside.

Tweet by Matthias Duwe (Matthias_Duwe), Source: Twitter

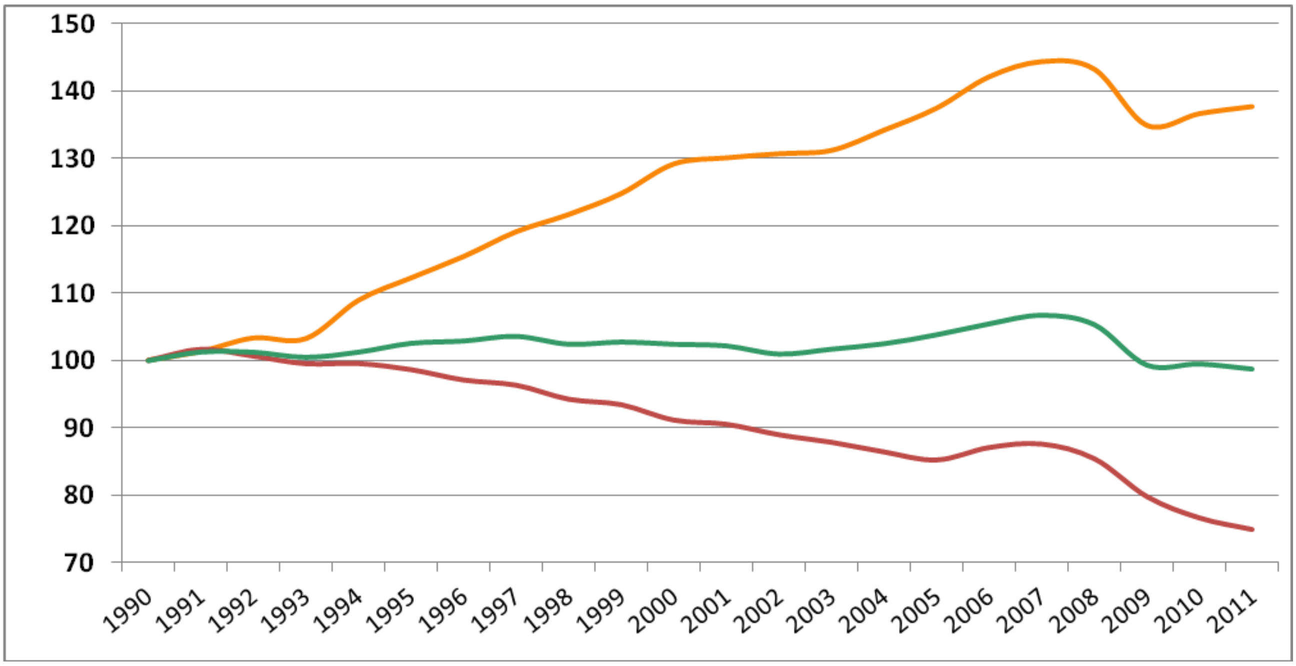
Session II: National implementation of strategies towards decarbonisation

Long-term climate policy in Denmark

Jacob Møller, Head of Division, Centre for Climate and Energy Economics, Danish Energy Agency

The figure below illustrates the Danish de-coupling of carbon emissions, energy consumption and economic growth.

Figure 1: De-linking Economic Growth from Energy Consumption and GHG Emission: 1990-2011



Source: Danish Energy Agency (2012).

Our effort has been motivated by three separate concerns:

1. The concern for security of supply
2. The concern for our economy’s viability
3. The concern for our impact on the global climate

This graph tells us that all three concerns can be addressed and are not mutually exclusive.

Our gross energy consumptions have been stabilized by energy efficiency and energy savings. Combined with a growing share of renewable energy sources, our climate impact has been reduced, and along with this, our dependency on foreign fossil fuel. All the while our economic growth has continued.

This development has been made possible through broad political consensus on the direction of the Danish energy policy. A consensus that has existed since the 1980s. In 2008, the end target was formulated: Independence from fossil fuels by 2050. A target which also can be said to encapsulate the three separate concerns behind the Danish efforts. It is not just a climate target or some sort of self-sufficiency with any sort of energy. All major political parties are behind the 2050 target.

The policies

To set in motion our path towards independence from fossil fuels, all the main parties negotiated an energy agreement in 2012. The agreement is the roadmap for development of energy supply and demand for the period 2012-2020.

Some of the concrete policies entailed in the agreement are:

- Tendering of two large off shore wind mill parks and a number of smaller off shore parks
- A halt to installation of oil-fired and gas-fired boilers in new buildings
- A halt to installation of oil-fired boilers in existing buildings in areas with district heating or natural gas
- Conversion from coal to biomass at large-scale CHP plants was made more attractive by allowing producers and consumers to make price agreements
- Energy companies were obliged to realise energy savings in enterprises and households by offering subsidies or consultancy, for example. The initiatives will target industry and household

All in all through expanded offshore wind production and use of biomass, renewables are expected to cover more than 70% of Danish electricity production by 2020.

What works and where is there work to be done?

The single most important part of the results of Danish energy and climate policy is our tradition for long-term energy agreements, based on broad political consensus. Our broad political consensus makes for a good investment climate. Investors are assured that their investments will not suddenly become unprofitable following a change in government. This security is reducing the costs of the transition.

Monitoring of the long-term vision

Lastly, I have been asked to touch upon how we monitor our progress towards our goal.

Firstly, we make yearly statistics and forecasts and if things are not developing as expected the parties behind the energy agreement are informed and if necessary suggested actions are taken.

Moreover, our energy agreement contains a large amount of mandatory analysis to prepare for the next agreement. This gives us the knowledge we need to make the necessary corrections to the course.

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Dutch climate policy: experience with planning

Jan Jaap van Halem, Policy coordinator National Climate Strategy, Ministry of Infrastructure and The Environment, Netherlands

An introduction to Dutch Climate Policies

In the Netherlands we work on climate change mitigation (reducing greenhouse gas emissions) as well as adaptation (increasing our resilience in the face of the expected consequences of climate change). The main measures are highlighted below.

Climate Agenda

The national climate agenda outlines how the Dutch government intends to deal with climate change. The agenda contains ambitions, goals and actions to prevent and adapt to climate change. The main purpose of the agenda is to:

- prevent further climate change as much as possible;
- nationally and internationally adapt to the expected consequences of climate change (such as extreme heat or increased rainfall).

At the same time, the climate agenda aims to reach out to businesses, civil society organizations and citizens to work together on a sustainable society. To achieve this, consistence is required in policy, implementation and adjustments.

The climate agenda outlines a climate approach that focuses on creating a broad coalition for climate action and a combined approach to climate change adaptation and mitigation.

Premise of the climate agenda is that the relevant ministries are jointly responsible for the end goal, but themselves remain responsible for their own policy fields.

SER Energy Agreement

Over 40 organizations, including the national government, employers, trade unions, environmental organizations, other civil society organizations and financial institutions are, since September 2013, committed to the Dutch Energy Agreement for sustainable growth.

In this agreement, parties have laid the foundation for a broad-based, robust and future-proof energy and climate policy. The agreement provides a long-term perspective with arrangements for the short and medium term, creates trust and reduces hence investment uncertainty for citizens and businesses.

The essence of this energy agreement is: a package of arrangements to get started now, as energetically as possible, each with its own responsibilities. Gradually, additions and revisions can be made in order to achieve the above mentioned objectives as effectively as possible.

The Incentive Regulation for Sustainable Energy (SDE+)

The SDE+ stimulates the production of sustainable energy and focuses on companies and (non-profit) institutions.

A budget is available every year to support projects. For 2014, this is a budget of 3.5 billion euros.

It is possible to apply for grants for the production of the following forms of renewable energy:

- Durable electricity;
- Durable heat or the combined generation of durable heat and power;
- Green gas.

An entrepreneur only receives subsidies, for a maximum period of 15 years, for the renewable energy he actually produces. The amount of the subsidy varies with the amount of the energy price. If the energy price is rising, fewer subsidies are needed (because a company has more revenues). And conversely, when the energy price is decreasing, the subsidy amount increases.

The SDE+ is paid through an increase (storage) of energy bills for citizens and businesses (and not from tax revenues).

Delta Program

The Netherlands needs to prepare for the impacts of climate change, and specifically water-related consequences such as rising sea levels and increasing rainfall. Plans for the future are and should be made. These plans are included in the Delta Program.

The Delta Program is a national program in which the government, provinces, water boards and municipalities work together. Social organizations, businesses and organizations with extensive knowledge in the field of water are involved as well. The main objectives of the Delta program are to protect the Netherlands, now and in the future, from flooding and to ensure sufficient freshwater.

Green Deals

If companies, community organizations or local authorities would like to implement a sustainable measure, the Dutch government can assist them through a Green Deal [hyperlink to English document].

In a Green Deal, the Dutch government attempts to remove bottlenecks within plans for sustainability. The government can, for example, change laws and rules or find partners for cooperation. This way, the Green Deal can help to implement plans for sustainability which are related to e.g. energy, climate, water, raw materials, mobility, bio-based economy, construction and food.

As of September 2014, the Netherlands has closed more than 160 Green Deals with companies and many other organizations. Examples of Green Deals are:

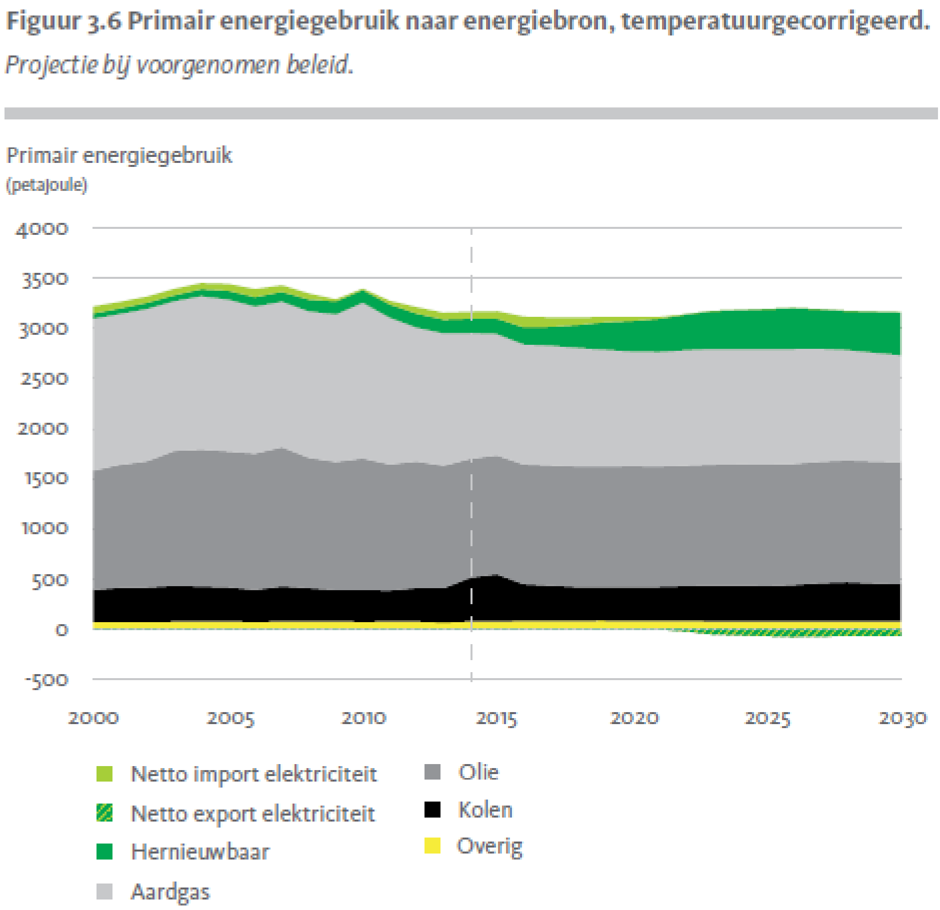
- Green Deal on zero-emission city distribution. Here, the Dutch government is working with municipalities and businesses, among others by taking measures to promote electric vehicles.

- Green Deal on Smart Energy Cities: focuses on the scaling up of new smart energy concepts, with demand and supply of energy to be aligned to each other as much as possible. The aim is to further develop these new concepts towards large-scale and financial applications. By scaling up these energy concepts, companies get opportunities in sales and thus it gives an extra boost to the innovation-motivation.

From: https://www.government.nl/topics/climate-change/contents/national-measures

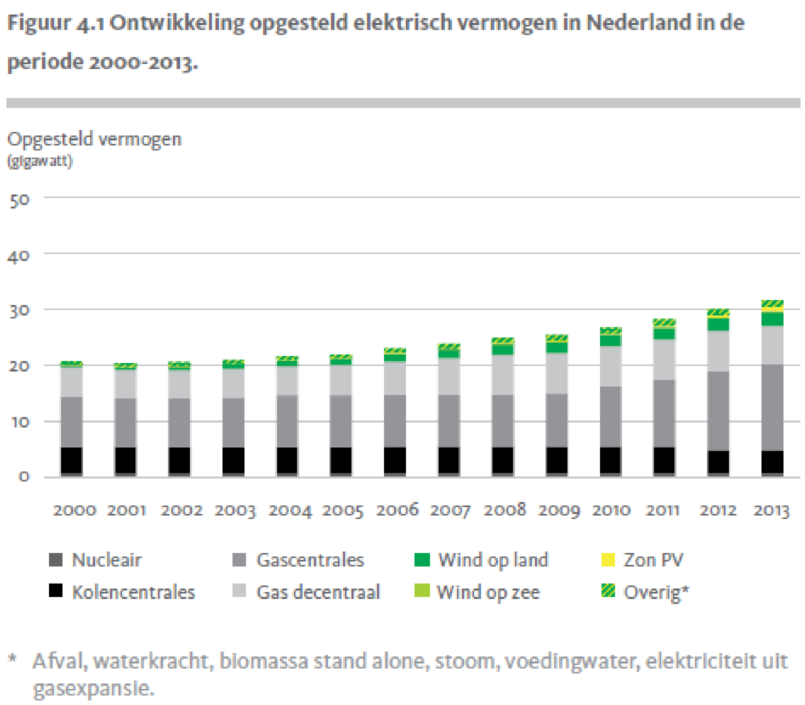
See below for a summary of the National Energy Report (NEV 2015).

Figure 1: Primary energy consumption



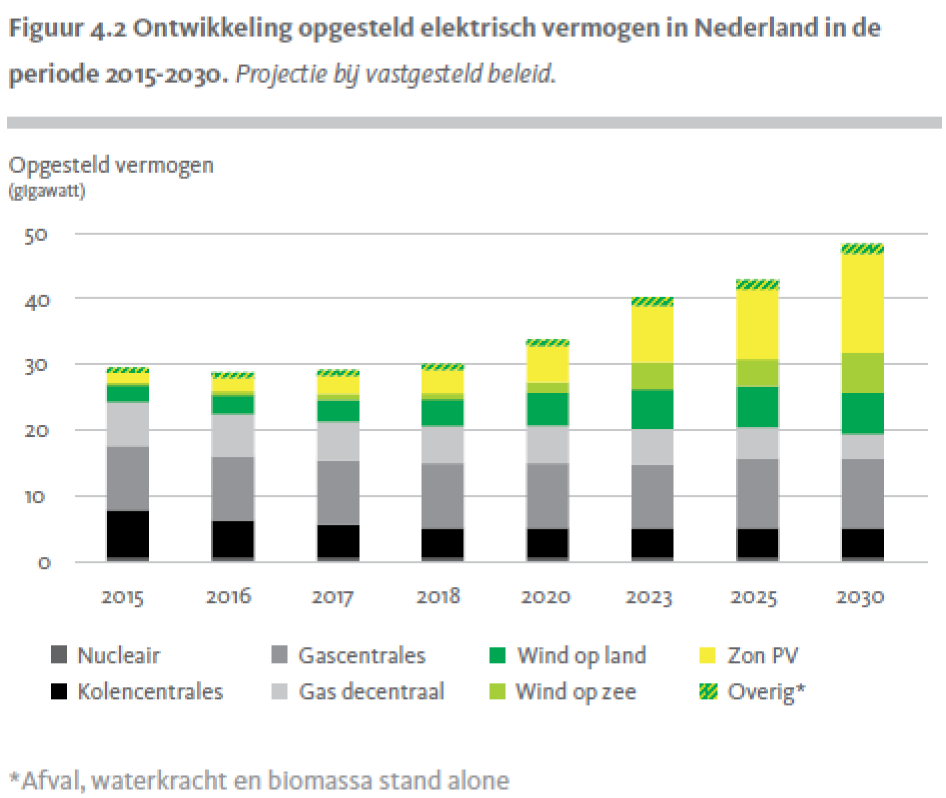
Source: National Energy Report 2015.

Figure 2: Development of power generation capacity



Source: National Energy Report 2015.

Figure 3: Future development of power generation capacity



Source: National Energy Report 2015.

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Session II: Summary and discussion

Panellists in Session II – “National Implementation of strategies towards decarbonisation”, Source: Ecologic Institute.

Several EU Member States have started designing national long-term climate strategies. They use different approaches to ensuring a successful implementation, e.g. using specific policies, building new institutions or fora for dialogue.

Denmark adopted an energy and climate strategy, called the Energy Agreement 2012-2020, in 2012. The Agreement aims to cover 100% of energy and transport from renewable sources in 2050. *Jacob Møller, Danish Energy Agency*, explained that the Agreement was based on three rationales - security of supply, healthy economy, climate concerns – and enjoyed support from all political parties. Denmark had a tradition of long-term agreements for the energy sector, always building them on broad political consensus, he said. This approach fosters long-term investment security and thus reduces the costs of transition. An independent Climate Council was established to advise the government on climate policy.

Janusz Michalski, Economic Ministry of Poland,[8] underlined that for **Poland** energy demand was expected to increase and that the way forward was a combination of more efficient coal use, more renewable energy and nuclear power and the use of cogeneration. He stressed that the Fukushima disaster had not changed the public opinion with respect to nuclear energy, but that costs could turn into an issue. To facilitate implementation, in Poland all policies need to be accompanied by a 4-year action plan. Also, there are several expert bodies that advise the Ministry on design and implementation of policies.

Ursula Fuentes Hutfilter, German Environment Ministry (BMUB), highlighted that also the **German** Energiewende and the targets of the 2010 Energy Concept were built on broad political consensus. However, current policies would not suffice to fulfil the domestic 2020 targets. A programme with around 100 measures was adopted in 2014 to fill the gap, and a strategy for 2050 is under way. Germany has established an independent external Monitoring Commission, which accompanies the government’s assessment process and provides recommendations on the implementation of the Energiewende. To foster dialogue and public acceptance amongst civil society, a climate action alliance, bringing together stakeholders from all governance levels and different stakeholder groups

[8] Due to the recent political changes in Poland, the Ministry was not in a position to contribute an article to the conference proceeds.

including science and research, meets twice a year to discuss the implementation of measures but also possible new measures.

Jan Jaap van Halem, Ministry of Infrastructure and The Environment, Netherlands, explained that adaptation policy was well advanced in the **Netherlands**, but that mitigation policy faced significant hurdles. The “not in my backyard” effect was quite strong in such a small country and had blocked the implementation of many policies – be it on gas, nuclear, shale gas, CCS, wind on land, or wind on sea. He highlighted that it was very helpful to have independent expert bodies that could make recommendations on their own initiative. Like this, topics could come to the agenda that the government itself might not want to raise due to political sensitivities.

The panellists agreed that putting a climate objective into law was not necessarily a guarantee against changes in political priorities – but did certainly provide a harder stick. However, it is often difficult to get political agreement on this.

The panel discussion also revealed that creating public acceptance for climate policies remains a hurdle across Member States. A first step is to assess, what policies could prove acceptable. The German Ministry for Environment asked for policy proposals from stakeholders, which gave a good indication of what seems political acceptable. Denmark has traditionally focused on gathering support across political parties. Since 2014, the Danish government has started to also use conferences and workshops to approach the wider public, noticing that climate policy will increasingly impact the life of individuals. However, it was mostly the same people participating in such dialogues – real participation would need to look different, said *Jacob Møller*. *Jan Jaap van Halem* underlined that it was helpful to create space for stakeholder dialogues because those actors could raise questions that the government itself might be hesitant to ask. *Janusz Michalski* noted in this context, that it was key for the government to provide information and promote an honest discussion.

Session III: Decarbonisation strategies at the local level

The necessity of local decarbonisation strategies

Stefan Schurig, Director Climate, Energy and Cities, World Future Council

Over the last decade, demand for renewable energy has seen a steady increase, surpassing all expectations. Primary energy supply from renewables has experienced an overall increase of 30%, from 57.7 EJ in 2004 to 76 EJ in 2013, as highlighted by REN21. This shows that the world is already shifting away from fossil fuels and towards renewable energy, adding more capacity for renewable power each year than coal, natural gas, and oil combined. Renewable energy technologies have passed a turning point, providing about 19% of global final energy consumption in 2013 (REN21, Global Status Report 2015).

The question therefore is no longer whether the world will transition away from an energy system powered by increasingly expensive and unsustainable fossil fuel resources towards one powered fully by abundant, local, and affordable renewable energy sources, but how long the transition to 100% RE will take and whether we will make it on our own terms in ways that maximize the benefits to us today as well as for the future generations. In fact, the increasing economic, health-related, and environmental costs of burning fossil fuels, combined with the accelerating impacts of climate change are introducing a new urgency into global efforts to rapidly diversify away from fossil fuels and shift from a high-carbon economic growth model to a low-carbon model. With an increasing share of renewable energy technologies, the way energy is produced, distributed and consumed in our societies is undergoing significant fundamental changes.

Thesis #1: Energy markets need to be transformed from a vertical structure into a horizontal structure.

Energy markets need to adapt to these changes. We are not only substituting oil, gas, coal and nuclear with wind and sun. We are in fact creating a new energy architecture with a totally different physical system of energy sources, carriers and demand sectors shaped by different businesses, governments and citizens. The paradigm shift we are observing is the transition from a centralized, hierarchical, supplier-centric energy infrastructure to decentralized, vertical, customer-centric and participatory energy models. Or in other words as Tony Seba describes it in his book *Clean Disruption of Energy and Transportation*: “The conventional energy model is about Big Banks financing Big Energy to build Big Power Plants or refineries in a few selected places. The new architecture is about everyone financing energy to build smaller, distributed power plants everywhere” (Seba, 2014).

Similar to the information industry, people do not only want to consume electricity, heat and fuel but actually want to produce and share it. Especially solar and wind technologies do not only allow but in fact require such a paradigm shift as conventional actors in the energy market – meaning utilities – do not have a business model for abundant, cheap and distributed energy.

Business models for oil, gas, coal and nuclear energy are based on decreasing returns as they increase production. When demand increases, deposits are being extracted and prices increase. This changes fundamentally with renewable energy, which is why fossil resources will never be able to compete with renewables. With solar and wind, prices for everyone drop when demand rises. As we have seen over the past years, the learning curve of the technologies reduces costs dramatically and people across the world could benefit. With renewables taking over the energy systems, we are building an infrastructure that is paid for by upfront investment and the fuel is free with almost no running costs occurring. The new energy architecture is therefore about energy services rather than consumption. In the new energy architecture, energy can be understood as an investment not a running cost. While the existing energy business model is based on scarcity, depletion, command-and-control monopolies, the new energy architecture is about abundant, participatory and essentially free energy. Therefore, energy markets urgently need to adapt to this new reality and be transformed from a vertical structure into a horizontal structure.

Thesis #2: Political 100% RE targets are needed to facilitate the transformation

Given the fact that this fundamental transformation is necessary to ensure today’s and future generations a liveable planet, we need ambitious political targets to facilitate this shift. Setting an ambitious and long-term renewable energy target like 100% RE, demonstrates political will, commitment and leadership. A clear vision provides both stakeholders and the population with a clearer view for the jurisdiction’s strategic decarbonisation and their role to achieve it. Likewise, it catalyses change by streamlining and providing an official mandate for action to the different stakeholders. It can help ensure a more efficient utilisation and channelling of technical, administrative, as well as financial resources; and it can create the investment security required to make large investments, such as in transmission and distribution grids.

Fortunately, many jurisdictions around the world, from communities, to cities and regions have embarked on the pathway toward 100% renewable energy and are becoming incubators of appropriate best practices and policies. This is visualized on the Global 100% RE online map, shown in Figure 1.

Figure 1: Global 100% RE online map

Source: 100% renewables, www.go100re.net/map.

The City of Frankfurt is one example that shows how local economies can be strengthened by transitioning to 100% RE. By 2050, the City will produce 100% of its energy consumption with local and regional renewable sources. Hereby, the German city brings down its current energy import costs of €2 billion a year to zero. Thanks to its public local utility which drives this transition, the city of Frankfurt not only benefits from these savings but also generates additional income in the form of revenues and tax incomes. By prioritizing energy production from within the city and the surrounding region – while still being connected to the larger national grid – the money will stay in the region. Energy efficiency measures have saved Frankfurt €100 million in energy costs, a number that is projected to rise. Finally, the city has reduced emissions by 15% since 1990, while its economy has grown by 50%, benefiting its approximately 715.000 inhabitants. And Frankfurt is not alone. In Germany, a network consisting of about 140 100% RE regions already includes more than 80 regions and municipalities that have already reached their 100% renewable energy targets.

In Spain, the island of El Hierro, with a long tradition of environmental leadership has already transformed its entire electricity and transport system to 100% renewable energy. The island benefits from stable and relatively strong winds throughout the year, and has appropriate island topography for the development of a pumped hydro storage system. As such, the majority of its 100% target is now being met by an 11.5 MW wind farm, whose output is coupled with the functioning of a pumped hydro facility situated in a volcanic crater. When the winds are strong and the output from the farm exceeds the island’s demand (whose peak is approximately 7.5 MW), the excess electricity is used to pump water into the upper reservoir constructed in an empty crater for storage purposes. When the winds are weak, or absent, the water stored in the upper reservoir is released and runs through hydro turbines (four units with a combined capacity of 11.3 MW) to produce electricity and storage in the lower reservoir. In this way, the pumped hydro system acts as a battery bank for the whole island. Another component of the system are the desalination plants that produce water for the islands’ residents – the plants are operated in an integrated manner with the wind farm, ensuring that the water supply for the island is also generated in a clean and sustainable way. Looking at the impacts on the economy, one can see that 100% RE makes economic sense on the island. The island's oil use is currently approximately 40,000 barrels per year, totalling approximately USD $4 million in annual fuel import costs. Estimates suggest that the project will save the island approximately $2.5 million in diesel costs every year. The remainder is currently used in the island's transportation system. However, once the vehicle fleet is transitioned to rely on domestically produced electricity, this will effectively eliminate the island's reliance on diesel power. This will not only save the island millions of dollars per year in imported fuels; it will also reduce its exposure to fossil fuel price volatility, making it more resilient to external shocks and strengthening the local economy by keeping more of its income in the region.

As another European champion, Austria is building on a bottom-up approach to reach the Government's target of becoming energy self-sufficient by 2050. In 2007, the Austrian Federal Government founded the Climate and Energy Fund to develop new, innovative ways of climate protection and sustainable development. Today, 104 regions have become independent from fossil resources by drawing on the regions' own natural resources and meeting their energy demand with a smart mix of renewable energy generation, enhanced energy efficiency and smart controls. Since its foundation, a total funding volume of € 930 million has been made available for the Fund's activities. Part of this budget is spent to employ energy managers in each region. Each energy manager is in charge of implementing the roadmap, coordinating projects and initiatives and hereby ensures coordination and commitment from the local government. This is one of the key elements, which has made this national initiative so successful.

Looking at North America, one city that leads this movement is Vancouver. Widely recognized as the most liveable city in the world, its environmental footprint is currently three times larger than it can sustain. Mayor Robertson and his team are committed to changing this by putting the city on track to meet all its energy needs via 100% renewable sources as part of a grand plan to make Vancouver the greenest city in the world. By 2050, Vancouver will obtain 100% of the energy it uses in all sectors from renewable sources and emit 80% fewer GHGs than in 2007. One of the key components of this strategy is to reduce the energy use and increase energy efficiency, especially in buildings. But it is not only the climate and environment that motivates the government to take this action: The city of Vancouver is a great example for how climate and environmental protection on the one hand and economic growth on the other hand can complement each other. A study by Brand Finance estimates that Vancouver's brand is valued at $31 billion due to its reputation as a “green, clean and sustainable” city. Additionally, by steering the city towards 100% renewable energy and focusing on local sustainability, the City has helped create more than 3,000 new local green jobs in only 5 years.

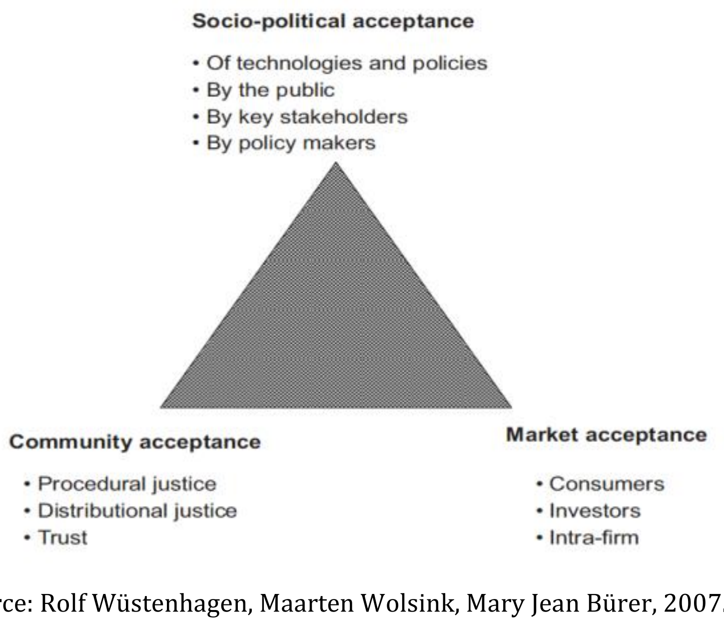
But the change is not only taking place in big cities or islands: The Town of East Hampton is the first municipal government on the east coast of the United States to set such a bold 100% renewable electricity goal by 2020 in 2014. The Town board took the decision inspired by the major blackouts caused by storm Sandy. The main driver was to “keep the money in the community”. These days the utility company charges customers $26 million annually. The energy efficiency measures taken as part of the 100% RE strategy have saved local residents and businesses $26 million annually.

Challenges across the world are diverse. Looking at African communities, the key challenge is first and foremost to provide people with access to energy in order to sustain their daily living. The District of Kasese in Uganda (affecting approximately 130,000 households) is radically transforming itself by supplying the energy needs of its population only via renewable energy sources by 2020. This ambitious target will be achieved by adopting a people-centered approach with a wide variety of renewable sources such as biomass, solar, geothermal and mini hydroelectric technologies. This will help the region overcoming issues related to local deforestation, land degradation as well as health issues which are strongly connected to the uncontrolled use of charcoal, firewood and kerosene, the main energy sources used in the region for cooking and for domestic electricity production. In facts, only 7% of the households in Kasese have access to the electricity grid while 97% of the people use firewood and charcoal for cooking and 85% of households use kerosene for lighting. By implementing a decentralized renewable energy system in the region of Kasese, new jobs are created for locals as several clean energy businesses have been started since 2012. They sell solar equipment, construct solar hubs, build biogas systems, improve cook stoves and deliver mini hydro projects. The number of businesses in the local green economy has increased from 5 to 55 since 2012 and at least 1,650 people have been trained in the process. Finally, the tourist industry sees greater development as camps and lodges have now access to electricity and are able to attract more visitors

Thesis #3: Only a people-centered approach will help to overcome barriers and increase acceptance

As the case studies show, decentralized renewable energy technologies unfold their impacts mainly locally and regionally. By engaging citizens and adopting a people-centered approach, barriers and resistance can be overcome. The following graph gives an overview of the different dimensions of the acceptance that can be increased by adopting a participatory and people-centered approach, as depicted in Figure 2.

Figure 2: Different dimensions of acceptance of renewables



Source: Rolf Wüstenhagen, Maarten Wolsink, Mary Jean Bürer, 2007.

Investing in a 100% renewable and people-centered energy future can be a tool for wealth redistribution and the creation of social well-being.

However, the benefits of involving citizens and communities go much beyond ensuring acceptance and avoid nimbyism (N.I.M.B.Y. = not in my backyard). In fact, the case studies prove that adopting a people-centered approach and empowering citizens, farmers and small businesses to invest in renewable energy projects is a tool for socio-economic development and wealth distribution.

To harness these benefits, governments must incorporate the following principles when formulating decarbonisation strategies - as listed in Figure 3.

Figure 3: Principles to incorporate when formulating decarbonisation strategies

- #1 Make energy efficiency a top priority
- #2 Electrify the heating/cooling and transport sectors
- #3 Maximize opportunities for citizen participation and the development of new business models
- #4 Educate and inform citizens and businesses
- #5 Adopt an integrated approach to fiscal, economic & energy policy

Policy Recommendations for achieving 100% RE

Source: World Future Council 2016.

Building on this, there is the urgent need for standards and indicators that allow measuring and assessing policies and implementation and hereby provide some guidance on what a sustainable transition to 100% RE entails.

Therefore members of the Global 100% RE campaign have initiated a consultation process to develop criteria and indicators that guide policy makers on how to reach a sustainable 100% RE vision. The overall goal is to define sustainability criteria for 100% RE in local governments and hereby creating the first label for local government’s action in this field. This will help to monitor and assess implementation toward 100% RE. A discussion paper that outlines some first proposals and thinking will be published in the coming weeks. A global 100% RE Cities and Regions network has been established that brings those local governments together who commit to these criteria and hereby inspire by example.

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Low carbon Vitoria Gasteiz

Jose Ignacio Arriba, Head of Energy Agency, City of Vitoria-Gasteiz

Vitoria-Gasteiz, capital of the Basque Country, is a medium-sized city with a population of 245,000 inhabitants. The municipality (276.8 km^2) is composed of the main city, 64 small villages, rural and green areas and forests. As a result of over 20 years of promotion of green policies, practice and commitment between the city council, citizens and all the social stakeholders, Vitoria-Gasteiz has a high environmental quality, which has been recognized with the European Green Capital 2012 Award, booming an example city for Europe (European Commission 2012).

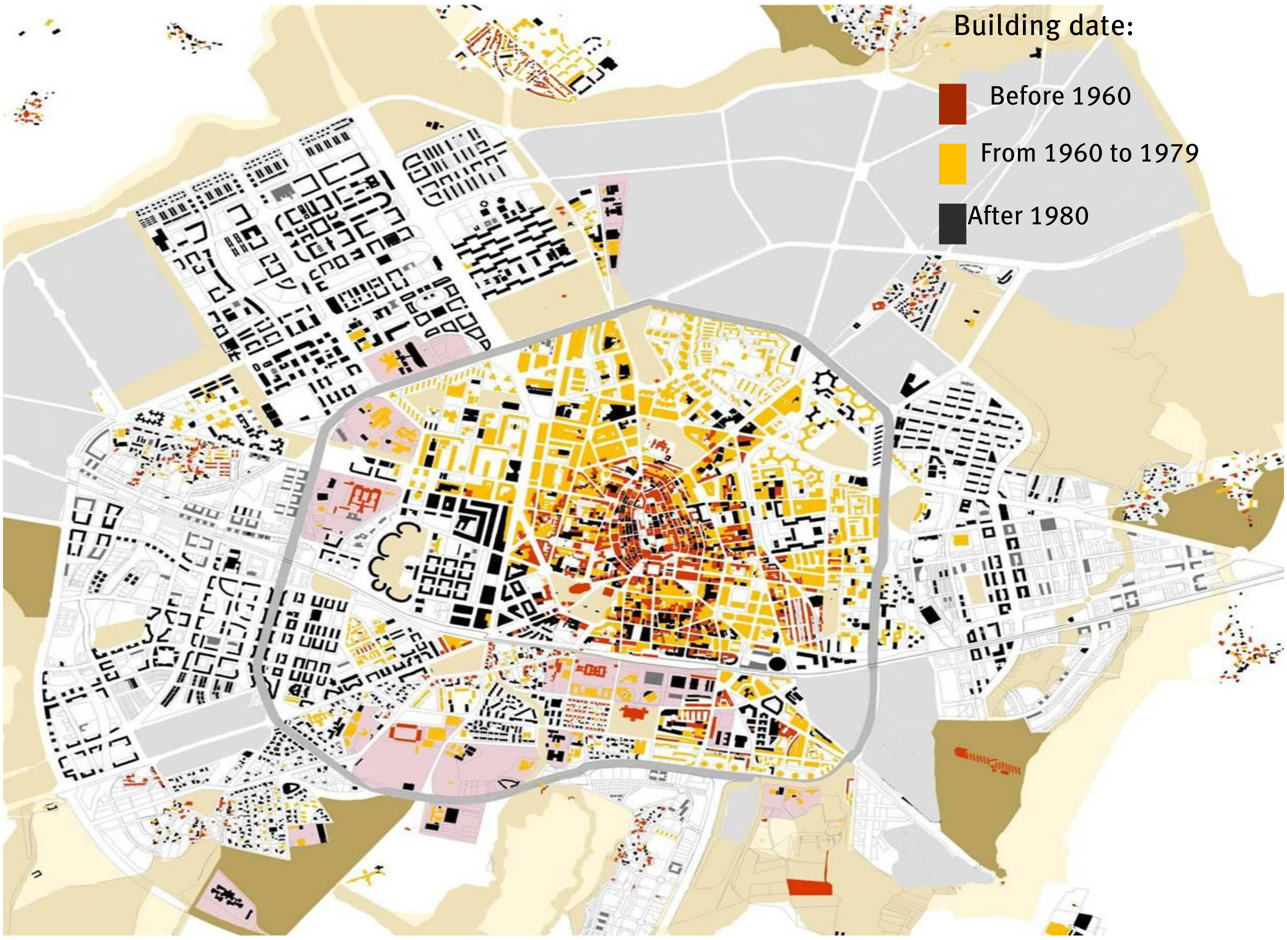
Some data supports our environment planning tradition: 1/3 of the surface area of the municipality are forested area (479 m2/person) and another 1/3 extensive rural area of high agricultural value, 4 Natura 2000 network spaces, 600 ha of Green Belt, 45 m^2 of public green areas/person, 130,000 trees in city streets, 210 organic farming plots, 284 days of good air quality each year and low levels of resident exposure to noise. The city is reasonably compact (around 46 homes per hectare) in a pedestrian scale (97% of the population lives within 3 km of the city centre), 95% of the population have access to all kinds of basic services (educational, health, sports, cultural, etc.) within 500 m of their home and 100% of the population lives less than 300 m from green spaces.

Given that over half of the total greenhouse gas emissions (GHG) are created in and by cities, local authorities have a key role in mitigating climate change. In this sense, mayors often have more control than national governments over issues that directly have an impact on climate change. In line with this principle, in February 2009, Vitoria-Gasteiz was one of the first EU municipalities that signed up to the Covenant of Mayors, voluntarily committing to increasing energy efficiency and the use of renewable energy sources to meet and exceed the European Union targets.

The implementation of the Plan Against Climate Change 2010-2020 will achieve a 26% GHG emissions reduction, over the base year (2006), through 79 energy reduction actions such as, for instance, renovating 20,000 building facades or 10,000 windows, transforming the previous transport modal split thanks to the Sustainable Mobility and Urban Space Plan, reducing the city water demand, increasing the reuse, recycling and collection of organic waste. Meanwhile, 21 actions for energy production have been taken in the areas photovoltaic, small wind, geothermal, biomass and biogas. Besides, sinks within the municipality (i.e. forests, crops, pastures, urban green parks and green roofs) will increase the CO_2 sequestration by 2,558 tonnes by 2020, achieving a storage of 163,104 t CO_2. Total diffuse sector (residential, services, mobility and primary) emissions per capita will reduce from 3.65 in 2006 to 2.44 t CO_2/habitant by 2020. If we focus on the municipal competence areas (hydrologic cycle, waste management and urban cleaning, public transport, public and traffic lighting, municipal buildings and facilities), the reduction and production measures will mitigate up to 56% of CO_2 emissions by 2020 (see BCN 2010a)

In the building sector, there are 60,000 flats built before 1980 out of a total of 110,000, 43,000 of which were built between 1960 and 1980. In Spain, the first regulation for energy conservation in buildings was approved in 1979, so buildings built before that date were not subject to an obligation to use insulation. Therefore it is very uncommon to find insulated residential buildings built before 1979.

Figure 1: Map of the buildings date of Vitoria-Gasteiz



Source: Vitoria-Gasteiz City Council (2014).

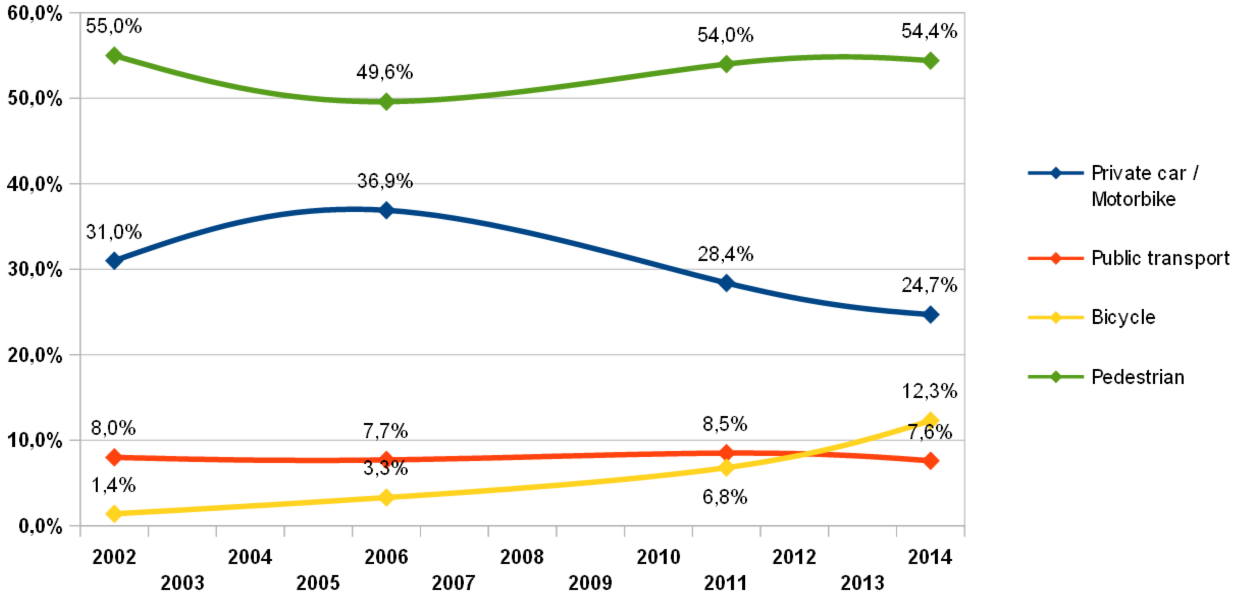
The city has selected the district of “Coronación” as the potential lighthouse project that will guide to potential future replication projects. The district is located at the heart of the city, connected to the well-known medieval quarter. It is a portion of urban consolidated ground from the 50s that was quickly populated and built, becoming a highly dense and complex urban district. It features a complex mix of buildings, mainly residential and built in the 50s, 60s and 70s. While the buildings do not have structural problems due to the typical concrete structures from the 50s, they clearly have a strong improvement potential in terms of energy efficiency and thermal comfort. This district gathers the major challenges in terms of retrofitting and implementation of smart city concepts: very high density, low-medium income and relevant social dimension.

The overall target for the retrofitting action in the Vitoria-Gasteiz demo is to build the foundations for a Zero Carbon district through the optimal investment on energy reduction measures and complementing the heating supply with a biomass-based efficient heating network. Around 750 dwellings are expected to be retrofitted and an estimated number of 113 buildings will be ready to be connected to the district heating system. Average savings of 135 kWh/m^{2}y are expected.

In the mobility sector, over 80% of the city’s inhabitants are employed within the municipal boundaries and walking is the most popular means of travel. There is ongoing investment in the provision and maintenance of sidewalks, boulevards and cycle zones. Over 25% of the public space is reserved for pedestrian access only and there are 33km of pedestrian pathways inside the urban area and 91km across the Green Belt.

In 2007, and supported by the consensus of all political parties in the municipality, the Vitoria-Gasteiz City Council set up a Sustainable Mobility and Public Space Plan that has been developed in the last years and is now starting to pay off: reducing private car use, raising the pedestrian share to 2002 levels and dramatically increasing the use of bicycles, without decreasing the public transport share.

Figure 2: General modal share (percentages) 2014, results from the Vitoria-Gasteiz Mobility Survey



Source: CEA, Transyt (2014).

The city's aim is to become carbon-neutral by 2050, through wide-ranging actions in different sectors:

- Rethinking the current mobility system within the city, drastically reducing travel by private vehicle (over 70%) and strengthening more efficient and environmentally friendly modes of transport (more public transport, encouraging the use of bicycles, transition to electric and hybrid vehicles, etc.). This can reduce the consumption within this sector by 82%.

- Reducing the energy demand of existing buildings: firstly, rehabilitating the housing and secondly, reducing consumption by replacing other appliances, lighting, boilers by more efficient systems. This can achieve an average consumption per dwelling lower than 7,000 kWh/year (i.e. a reduction of more than 40% in comparison to the current value).

- Designing and constructing new buildings with criteria for maximum efficiency (proper orientation, passive solar systems, capturing natural light, underfloor heating, high efficiency equipment etc.). These criteria can achieve a consumption lower than 5,000 kWh / year per household.

- Reducing energy consumption of public space, mainly by replacing the lighting and traffic lights with more efficient systems, achieving a reduction in energy consumption over 40%.

- Minimizing waste generation and implementing a management model that fosters, firstly, material recovery and, secondly, its energy recovery. This action allows achieving an energy production of 88.4 GWh per year.

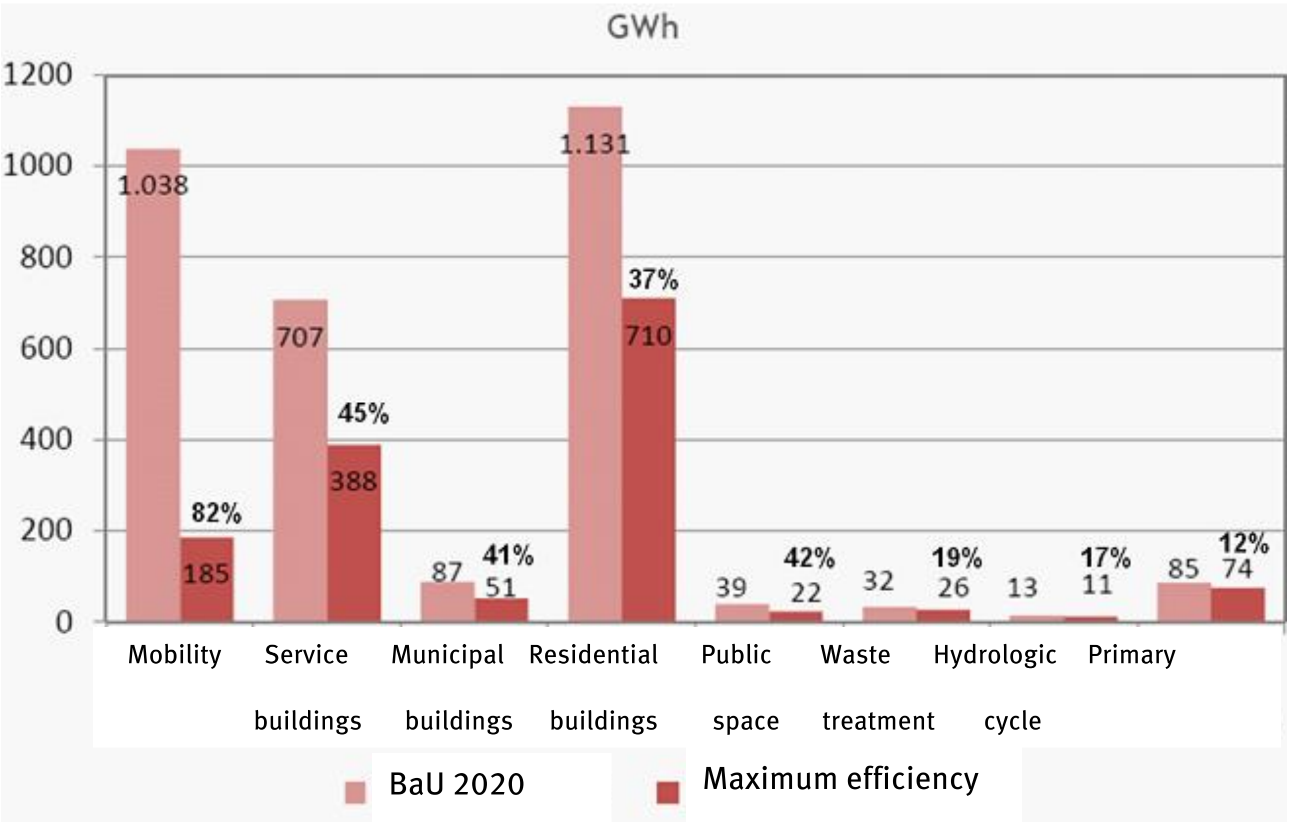
- Reducing water consumption by improving the efficiency of the network, the change in consumer habits, the installation of saving systems for and boosting the use of non-conventional water sources (rainwater, greywater etc). These actions allow achieving energy savings of 17% over the current value.

- Reducing emissions of the primary sector and achieving self-sufficiency in food. This can be achieved through sustainable production of local products and promoting the consumption of these products in the municipality. This model has advantages because it promotes local trade by establishing a network of local food producers of high quality.

- Achieving the potential of energy production from renewable sources within the municipality. It is estimated that the production ceiling is around 460 GWh/year, resulting mainly from solar energy (thermal and photovoltaic). Furthermore, the contribution of small wind energy and the use of municipal solid waste is also noteworthy.

- Increasing the CO_2 uptake capacity of urban green (+4 ha) and surrounding forests (+2,500 ha), achieving a total yearly sink of 209,186 t CO_2

Figure 3: Comparison of the BaU 2020 and the maximum efficiency scenarios.



Source: See BCN 2010b (Spanish only).

Finally, the City Council has conducted a vulnerability analysis, which has concluded that the most vulnerable municipal sectors are: citizens’ health, water resources, natural and rural environment, specially wetlands, and economic activities. The former analysis is part of the current draft of the Vitoria-Gasteiz Adaptation Strategy to Climate Change 2014-2020.

The success of sustainable development initiatives depends, amongst other factors, on sound management by public authorities and their partners. There is a need for coherent and cohesive actions undertaken towards common goals that address specific local challenges. In this sense, the City of Vitoria-Gasteiz is working on integrating the fight against climate change into the whole management system and all levels of decision-making in the Council. We must highlight the support of the government teams and the consensus position among all political groups in spite of the political changes occurred in the city after the elections in 2007, 2011 and 2015.

The Vitoria-Gasteiz Plan Against Climate Change 2010-2020 contributes to the Basque Climate Strategy 2050 and EU28 INDC goals (at least 40% of domestic reduction in greenhouse gas emissions by 2030) and to the Spanish Government’s subscribed commitment to limit emissions growth by 15% by the end of the current Kyoto Protocol period (2020).

Even though the Vitoria-Gasteiz diffuse sector emissions only represent a 0.18‰ contribution to the total emissions of the EU28, we believe in the necessity to contribute to the international transition towards a low-carbon economy and adapt to the climate.

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100% renewable energy for the City of Rheine

Barbara Fricke, Researcher, Solar Institute Jülich of FH Aachen University of Applied Sciences[9]

As part of the ongoing project, "The Municipal Efficiency Revolution for Climate Protection in German Cities (KomRev)," two target concepts were developed for energy supply in the sectors electricity, heat and traffic. The concepts rely entirely on renewable energy (RE). The goal was to reach a complete reduction of harmful direct emissions through an optimised and decentralised energy supply by 2050.

Description of the two alternative concepts

In order to evaluate in a differentiated manner the future possibilities and challenges German cities face when it comes to sustainable energy supply, two exemplary target concepts were developed for the city of Rheine: Maximum-Decentralisation (MaxDec) and Moderate-Decentralisation (ModDec). The general requirement was to reach a high share of energy generated from decentralised sources with high consumption and energy efficiency to allow keeping the amount of energy imported from outside sources at a low level.

Commonalities of both concepts

Both concepts are based on the same assumptions with respect to the future development of energy demand. The general assumption was that by 2050 a significant reduction in consumer and end energy demand will have been reached through the renovation of buildings, the use of efficient appliances, the adoption of efficient processes and a pronounced shift in both the composition of the urban transport mix and the types of vehicles used.

In both concepts the same assumptions were made with regard to standards for energy renovation of all buildings (heating and water needs) and the reduction of the process energy demand of businesses, commerce, services and industry. With respect to energy supply, both concepts rely on the same assumptions regarding wind energy, hydroelectric power and waste incineration.

Differences between both concepts

The most significant conceptual differences concern the provision of warm water and energy for heating, the proportion of roof space that can be utilised for photovoltaic systems, the utilisation of biomass as well as the determination and covering of mobility needs.

Covering mobility needs

- In MaxDec it was assumed that by 2050, the modal split will have changed significantly, shifting in favour of public transport, bicycles and walking as well as "car pooling". The remaining fleet of private motor vehicles (roughly 7,000 in total) will consist of electro-vehicles only.
- In ModDec, only a slight modal shift was assumed in comparison with today. Furthermore, it was assumed that there will still be many different propulsion technologies in use. As a result, 16,000 private motor vehicles will be on the roads, which will operate using (hybrid) electric

[9] This article and the included figures and tables are based on the following report: Fricke et al. (2015): 100% renewable municipal energy supply: Chances and restrictions of solar thermal district heating.

technology, bio-fuels produced from regional biomass and power-to-liquid fuels. Vehicles powered by fuel cells will constitute the largest percentage.

Energy imports "from outside"

- In MaxDec, it was assumed that electricity will be the only form in which energy is imported or exported beyond the boundaries of the municipality.
- In ModDec, in contrast, also the import of renewable power-to-x fuels was allowed, both for transport and to provide process energy that cannot be made available in the form of electricity.

Biomass utilisation

- In MaxDec, the biomass available within the municipality is exclusively used to cover the need for process energy that cannot be provided in the form of electricity (bio-methane, biochar). This is partly done via CHP generating stations.
- In ModDec, the biomass available in the municipality primarily serves to cover the demand for fuels (Fischer-Tropsch diesel, bioethanol, biomethane). The remaining biomass is – just as in the case of MaxDec – used in CHP generating stations to cover the demand for process heat.

Heat supply

- In MaxDec, the heat for warm water and space heating is mainly provided by solar-thermal collectors; the heat is stored in seasonal pit storages for winter periods and distributed by district-heating networks. In order to ensure the supply of heat during periods of shortage, it was possible to expand the storage capacity through heating pumps. Buildings outside of settlement areas are supplied with heat through individual heating pumps along with borehole heat exchangers while buffer tanks were used for heat storage purposes.
- In the ModDec concept, all buildings are supplied with heat through individual heat pumps and borehole heat exchangers in the same way as has been described for peripheral buildings in the MaxDec concept.

Models and simulation

In the simulation environment SimREN, an overall model was created to calculate the interconnected supply of the sectors heat, transport and electricity. In the model, the energy demand and the amount of energy generated over the course of the year was calculated with an hourly resolution. The goal was to illustrate the mutual influences, dependencies and synergy effects of an interconnected energy supply of the sectors electricity, heat and transport through the development and connection of corresponding model components.

The simulation model is divided into three fundamental areas:

- A demand model representing the energy demand,
- A climate model providing meteorological data (calculation of energy generation through solar and wind energy),
- A supply model representing electricity and heat generators, as well as heat storage systems.

Simulation results

On the whole, modelling results for both concepts showed that in all sectors a large proportion of the municipality's energy demand could be covered with the locally available generation potential.

For the MaxDec concept, the simulation of annual electricity generation and demand resulted in an electricity surplus of 45 GWh_{el}, corresponding to 10% of the municipality's gross annual electricity production (cf. Table 1). In contrast, modelling results for the ModDec concept showed an annual shortfall of around 3 GWh_{el} (cf.

Table 2).

Table 1: Simulation results for annual amounts of electricity generation and demand in the MaxDec concept

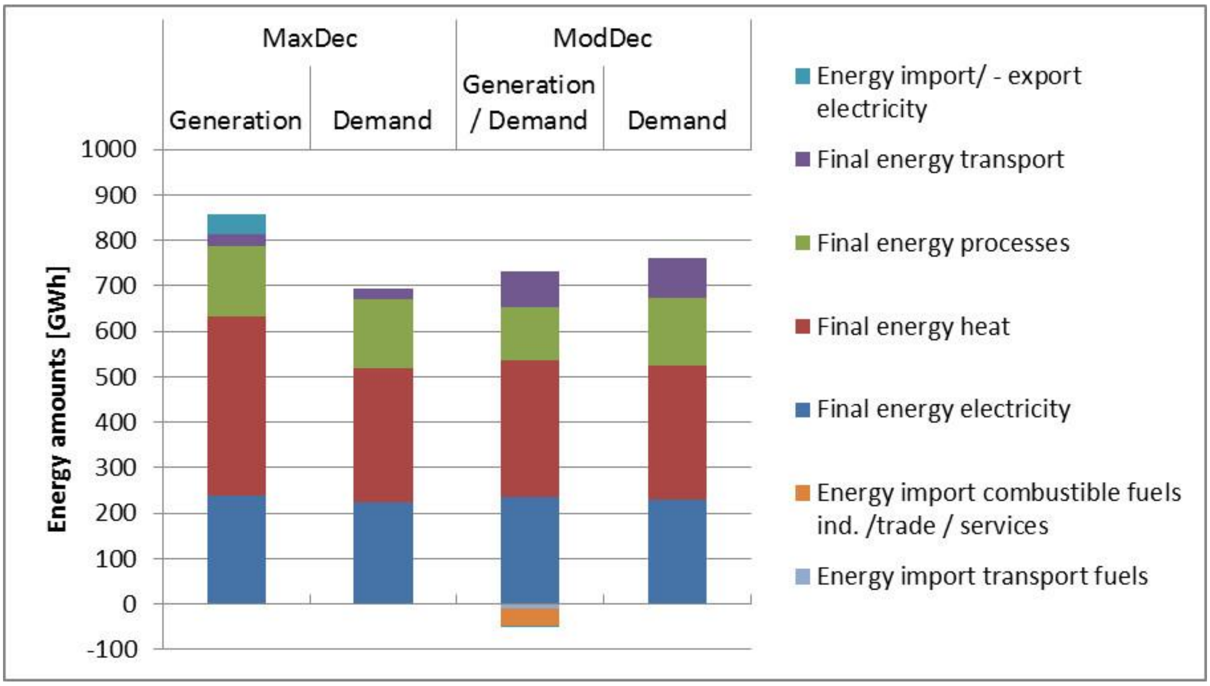
MaxDec Concept MustRun	MW_{el}	GWh_{el}/
Electricity Generation		**net**
Wind	148	352
Hydroelectric		1
Photovoltaic (36.8% Roof Surfaces)	66	55
Biomass Electricity HotModule (Fuel Cell)		10
Biomass Electricity Wood Gas CHP		4
Biomass Electricity Waste Incinerator		6
Total Annual Electricity Generation		**428**
Electricity Demand		**gross**
Industrial Electricity		195
Processing Heat Electricity		101
Household Electricity		37
Transport Electricity		24
Heat Pump Electricity Solar Distr. Heating Supplement		17
Heat Pump Electricity Peripheral Buildings		3
Total Annual Electricity Demand		**383**
Total Annual Electricity Balance		**45**

Table 2: Simulation results for annual amounts of electricity generation and demand in the ModDec concept

ModDec Concept MustRun	MW_{el}	GWh_{el}/a
Electricity Generation		**net**
Wind	148	352
Hydroelectric		1
Photovoltaic (100% roof surfaces)	177	147
Biomass Electricity HotModule (Fuel Cell)		11
Biomass Electricity Waste Incinerator		6
Electricity feed-in from Fischer-Tropsch diesel production		0.1
Total Annual Electricity Generation		**517**
Electricity Demand		**gross**
Industrial Electricity		195
Processing Heat Electricity		101
Household Electricity		42
Transport Electricity		20
Heat Pump Electricity Industry + Residential Buildings		102
Biogas Plants (own electricity demand)		1
Biogas Methanation (own electricity demand)		2
Hydrogen Fuel Production		57
Total Annual Electricity Demand		**520**
Total Annual Electricity Balance		**-3**

Figure 1 shows the annual energy amounts for generation and demand for both concepts in comparison. In the concept ModDec, the demand for transport and process energy is higher than the generation from municipal sources. This gap is offset through an import of combustible and engine fuels.

Figure 1: Simulation results for energy generation and demand for both concepts in comparison



Source: Fricke et al. (2015).

On the supply side, the total amount of energy provided by end and secondary energy carriers is 122 GWh higher in the MaxDec model than in ModDec. This illustrates the efficiency differences of the selected supply options. In the MaxDec model, 17% more energy is provided despite the same potential of surfaces, wind, solar radiation, exhaust heat, biomass, geo-thermal technologies and residual materials.

The reduction in consumption in MaxDec is also slightly higher than in ModDec; this mainly results from significantly lower energy consumption levels in the transport sector as well as from a slightly lower household electricity demand. As a result, total energy demand in MaxDec is around 10% (slightly less than 70 GWh) lower than in ModDec.

In the ModDec concept, approximately 3 GWh of electricity needs to be imported into the territory of the municipality. Furthermore, around 48 GWh_{LHV} of combustible and engine fuels has to be provided by external sources.

Regarding the exergy-related efficiency of overall electricity-heat supply, modelling results showed an overall exergetic level of effectiveness of 73% for MaxDec and 67% for ModDec. This difference is mainly due to the higher exergetic level of effectiveness of solar-thermal installations compared to heat pumps.

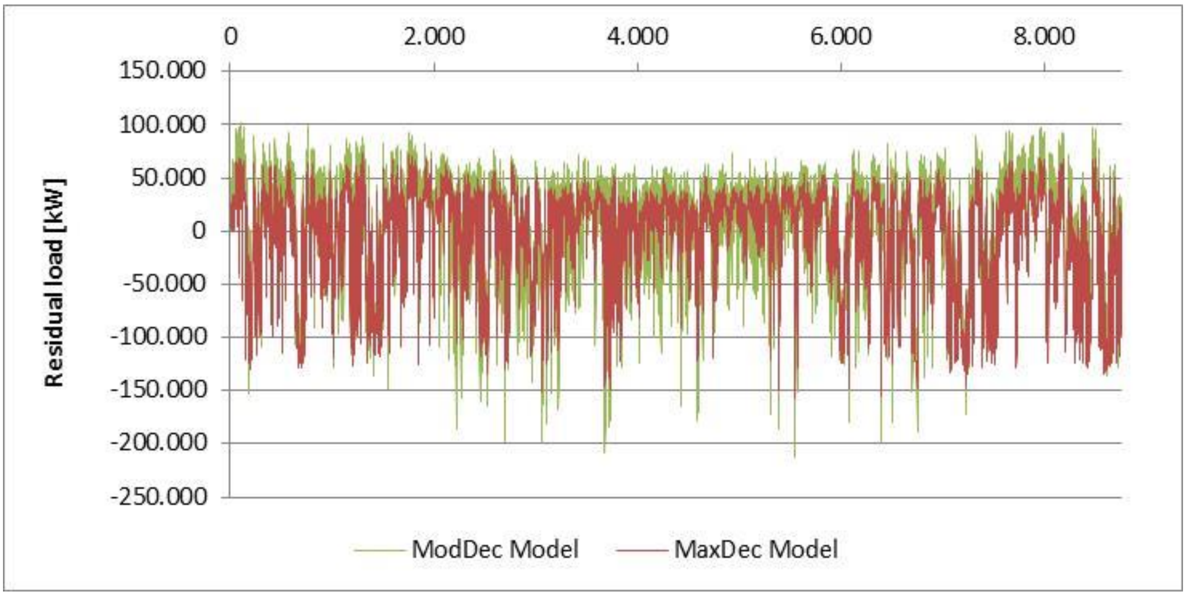
Simulation results for residual load sequences

The models used in the project neither considered distribution grids nor upstream power networks. The results of the simulations show which effective power per hour would have to be delivered by the municipal system, or imported (residual load). It has to be taken into account that so far these residual loads have been calculated without considering any equalisation options through demand-side management or electricity storage. Thus, they correspond to worst-case scenarios. A detailed simulation of equalisation options will be carried out during the final phase of the KomRev project.

For both concepts, the positive (importing of electricity) and negative (electricity feeding-in) extreme values of the residual load lie significantly above the current maximum value of electricity imports of up to 70 mega volt ampere (MVA). In the MaxDec concept, the residual load values range between -157 and 73 MW_{el}; in the ModDec concept, they are between -213 and 102 MW_{el}.

Figure 2 shows both residual load curves for the entire course of the year 2050.

Figure 2: Residual load curves for both concepts for the year 2050



Hour 0 = 1.1.2050, 1:00h

Source: Fricke et al. (2015).

The time segments with particularly high amounts of electricity imports demonstrate that the significantly higher heat pump performances in ModDec contribute substantially to higher needs for electricity imports. Periods with particularly high electricity feed-in levels, in turn, are driven by solar energy generation to a considerable extent.

Discussion and Conclusion

The overall assessment of energy supply showed that a sustainable decentralised energy supply in Rheine is possible when the generation and efficiency potentials are utilised.

Modelling results show that high peaks of electricity (and possibly also solar-thermal energy) generation occur throughout the course of the year.

In ModDec, due to the heat supply concept (i.e. a combination of photovoltaic and heat pump systems as main sources), the residual load extremes are particularly pronounced. In consequence, fluctuations would need to be compensated to a significantly higher degree by means of electricity storage, as well as through a regulation of consumption through demand-side management.

In the MaxDec concept on the other hand, feed-in as well as load peaks can be reduced significantly in comparison to ModDec through solar-thermal provision of off-peak time heat in conjunction with seasonal heat storage and heat networks.

Acknowledgements

The authors would like to thank the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety for supporting the Project “KomRev" (FKZ 03KSE043A) within the framework of the National Climate Protection Initiative.

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Main study: Fricke et al. (2015): 100% renewable municipal energy supply: Chances and restrictions of solar thermal district heating.

Session III: Summary and discussion

Panelists in Session III – "Decarbonisation strategies at the local level", Source: Ecologic Institute.

All levels of government need to play a role in the ambitious task of addressing climate change. A great number of activities on municipal climate action have been planned and implemented since the late 1980s.

Stefan Schurig, World Future Council, called for a fundamental transformation of energy markets, from vertical to horizontal structures. He emphasized that 100% renewable energy targets are already reality in a number of **cities**. Setting targets has a power in its own because targets demonstrate political will, mobilise stakeholders, catalyse resources and provide investment security. Successful strategies would need to focus on benefits for people, e.g. keeping the money in the communities, in order to create the necessary public acceptance. Schurig also pointed to the crucial role of public procurement in promoting climate action.

Barbara Fricke, Solar Institute Jülich, presented a 100% renewable scenario for the city of **Rheine**. The case study shows that an energy supply system without fossil fuels with high share of local energy sources is feasible, considering a reduction of energy demand by 20% to 90%. The study examined two scenarios: a maximum decentralized and a moderate decentralized scenario. According to the findings, the maximum decentralized model would be able to even create an electricity surplus of 45 GWh. This is despite the fact that the study also covers the industrial sector, including some heavy industry.

Jose Ignacio Arriba, City of Vitoria-Gasteiz, provided insights into how the city of **Vitoria-Gasteiz** designed and implements its low-carbon vision. The city first evaluated the current and predicted levels of GHG emissions and energy consumption before developing a long-term scenario for a carbon neutral city. For the scenario, they started off from the questions which basic human services should exist in the future. The government found the biggest potential for energy savings in mobility, and energy demand of residential buildings and service buildings. He specifically highlighted the example of redesigning public spaces: reducing space for cars but increasing space for sustainable mobility created space for greening spaces, which in turn had positive effects for air quality, water quality, and city life more general. Ignacio Arriba underlined that pilot projects and information offices in certain city districts had been crucial for increasing public acceptance. The city decided, however, to exclude industry from its plan because companies were difficult to address, especially if decisions were taken in the parent company located elsewhere.

Tweet by Stefan Schurig (sschurig), Source: Twitter

The following **discussion** addressed the benefits of having ambitious CO_2 and renewables targets, which, according to the panellists, can serve an important function as an expression of leadership and a driving force for a transformation process. In that regard, targets and incentives can stem from the international UNFCCC arena as well as the national level. Nonetheless it was noted during the debate that even a lack of such targets cannot serve as an excuse for low ambition at the regional or local level. Regions can do a lot on their own behalf, even without national strategies to guide them – especially now that renewable energy technologies have become affordable. Against that background, Stefan Schurig highlighted the various different actions regions can take, including adopting measures to promote the local renewables production, improving heating systems and buildings energy performance, and through public procurement.

Throughout the discussion, participants also highlighted the importance of addressing and considering local circumstances, including existing industry sectors and structures. Jose Ignacio Arriba noted how important yet challenging it can be to gain public acceptance. To this end, starting off with pilot projects and triggering transformation with the help of subsidies – for example for refurbishment investments to foster energy efficiency – has proven to be a feasible approach. Generally it was emphasized that the private sector should be involved in a dialogue with policy makers, also to trigger investments in renewables.

Conclusions and outlook

The scientific basis is clear: GHG emissions across all economic sectors need to be drastically reduced to keep global warming below 2°C. Delaying the necessary steps will only increase the costs. To bring about the necessary transformation of the economy, all levels of governance need to take ambitious action and design long-term visions of their mitigation pathways.

Across the globe, countries are starting to take climate action more serious and are developing strategies to limit or reduce emissions – but these still lack ambition and rarely provide a long-term vision towards 2050 and beyond. While the EU has set itself the target to reduce, in the context of necessary reductions according to the IPCC by developed countries as a group, emissions by 80-95% by 2050 compared to 1990, a common strategy of how to get to that target is still missing.

Many EU Member States have already developed or are currently developing climate mitigation strategies towards 2050. Also at sub-national level, many regions or cities are designing or already implementing decarbonisation strategies. These are often more ambitious than those at the national level.

The Workshop "Decarbonisation – 100% Renewables and more" provided a forum for dialogue among European and international actors on the challenges of designing and implementing decarbonisation strategies, and possible solutions.

This summary brings together insights from all the levels of governance touched upon in the course of the workshop's presentations and discussions.

International level

In the run-up to the Paris climate summit there has been growing momentum towards global action on climate change. As of December 2015, 158 so-called INDCs (intended nationally determined contributions) representing 186 countries had been submitted, signalling their intent to contribute to the global effort. The Paris Agreement now foresees that these national contributions should be updated every five years to ensure continuous progress towards the long-term objective.

However, emissions are still rising, and the estimated aggregated effect of INDCs is still nowhere near a pathway that would bring us on track for staying below the 2°C limit. The main drivers for emissions are population growth and increasing GDP per capita – but also misleading policies. Governments are still heavily subsidising the use of fossil fuels, and around the globe new coal power plants are in planning. There are concerns that the world is rather on a carbonisation pathway than on the much proclaimed pathway towards decarbonisation. To turn this around, key decisions are needed at the international level. Key insights from the workshop include:

- A realistic **carbon pricing strategy** is needed to stop the coal renaissance.
- For this to be acceptable also to those poor countries whose emissions are expected to increase in the future, governments could create a **transfer mechanism** from North to South.
- Climate change and mitigation should also be framed as a **social justice issue**. Many mitigation policies have positive co-benefits for health, quality of living etc. Redirecting subsidies from fossil fuels to much needed infrastructure could close essential development

gaps (water, clean energy, telecommunications) – even more so with the revenues from carbon pricing.

- Most countries will experience a significant **decline in GDP with increasing temperatures**. This could be up to a 75% reduction of GDP. Focusing the debate on these economic arguments could help forge public acceptance for climate policies.

European level

More than ever, the world needs frontrunners on climate policies. Now that there is a momentum at the international level, the EU could showcase successful policies and lead by example. The EU could also follow the example of other countries that have included in their INDC a long-term objective and elaborate on its long-term pathway. Key insights from the workshop include:

- **Improving existing policies** could prevent other countries from walking into the same trap. Most importantly, the EU needs to reform the Emissions Trading Scheme to establish a credible carbon price.
- This is also the right moment for **revising the EU's roadmaps** towards decarbonisation, taking into account the recent developments in climate science, technology etc. and scenarios to match the common 2050 climate goal.
- The EU should work towards a common European long-term climate strategy that offers a credible pathway towards decarbonisation. While one should welcome the advances of some more ambitious Member States, national strategies will soon hit limits. A **coordinated European approach** is needed to create synergies and avoid conflicts between strategies of different Member States.

National level

A number of EU Member States have adopted long-term emission reduction goals and developed national **2050 climate strategies.** These Member States have approached the design of climate strategies coming from very different starting points. Next to environmental concerns, energy security, energy poverty or economic considerations might bring the decisive momentum. Also, the structure of the economy and the energy sector vary widely across Member States and bring with them distinct challenges. Such different national **circumstances require different strategies** to get to the same long-term goal. For example, carbon pricing might be a good approach for the UK but prove less effective to move away from nuclear energy in France. However, the different Member States also face some similar opportunities and challenges:

- Studies across EU Member States have shown that moving towards an energy system with **100% from renewable sources is technically and economically feasible**. Since the energy sector accounts for more than 80% of GHG emissions in the EU, this is an important message for policy makers. Turning such scenarios into reality would bring EU Member States a long way towards a GHG neutral economy – but not all the way.

- To get towards the required emission reduction trajectory, strategies need to address energy demand as well, and also tackle other economic sectors. Ambitious **climate strategies should be comprehensive**.
- A first step are sectoral studies, e.g. for agriculture or waste. These can help identify sector-specific technologies and paint a picture of a possible future. But effective decarbonisation strategies need to tackle all economic sectors and find **integrated solutions**, also taking into account interactions and synergies between sectors, but also with other policy areas. For example, resource use and land use will be closely linked to sustainable mitigation policies.

In designing climate strategies, generating **political support** is key – but also very challenging.

- A successful strategy needs support **across political parties**. This helps making long-term strategies **durable** across legislative periods.
- Transformative policies will increasingly impact the life of **individuals**. It is crucial to create awareness and **acceptance from the public** about the future transformation. EU Member States have started to pay more attention to public involvement in designing climate policies. Some have established alliances between different government levels and civil society (e.g. German Climate Alliance), organised dialogs and workshops, or called for public inputs via online platforms. Using such approaches, governments can test what objectives and measures could be politically feasible but also can raise awareness for the necessity of climate policies. It also helps to better align climate objectives and policies with the needs of people. There is, however, room for improvement given that these public participation processes often do not reach the wider public but only interested individuals or organisations.
- Creating **independent advisory bodies** may also help governments to gain public support. A policy proposal might be perceived as more credible if supported by independent analysis from renowned individuals. Furthermore, such bodies can bring issues to the public agenda that might be too “hot” for the government to pick up.
- Successful policy experiments at **sub-national level** can be an important means to **showcase** climate policies that increase quality of life and are beneficial to the economy (see also below). Governments could better align their national strategies with and build on existing climate action at local level.

Progress in **implementing** long-term strategies differs widely across Member States.

- Enshrining strategies in **national** law guarantees more durability but it is often difficult to find public support for such a step.
- Often it has been possible to agree on targets for 2050. But agreeing on **pathways and interim targets** that would be consistent with the long-term objective has been challenging. However, such pathways are necessary for starting the transformation process.
- Some Member States have established **monitoring systems** that regularly assess the progress of implementation. Such systems can help to address gaps at an early stage and identify new opportunities.

Sub-national level

Sub-national governments are key players in tackling climate change. They are often – depending on the attribution of powers in the respective country – responsible for the regulation of areas that are key to reducing GHG emissions, such as transport or land use management. Also, they are often better placed to identify the real needs of their societies, and mitigation opportunities that bring co-benefits. Many sub-national governments have taken up this challenge. For example, **hundreds of local communities** across the world have committed to becoming **100% renewable energy.** Regions, cities and communities can serve as role models, showcase the positive co-benefits of the transition to a low-carbon economy – this is crucial for building public acceptance at a wider scale.

Like governments at the national level, local governments need to base their strategies on sound analysis, gather political support and find adequate ways to involve the public in design and implementation. However, at local level it might be easier to develop **targeted solutions that provide visible co-benefits** for the society and might thus prove more acceptable. For example, changing to alternative modes of transport and greening public spaces can improve air and water quality or reduced traffic (and stress) during rush hours. The local level can also involve and inform the public in a more targeted way.

Public procurement could play an important role in local decarbonisation strategies to facilitate more acceptance for climate neutral measures on local level. Targeting public investment in line with decarbonisation strategies could be an important leverage for local governments.

However, some structural issues may not be easily addressed at local level. For example, decisions on the promotion of renewable energy are often taken at a higher level. Also, it might prove difficult to involve companies if key business decisions are taken by a parent company that is located elsewhere.

It is also key to consider how local action can connect back to the national level. For example, how can the national policy trigger and support sub-national action? Or how can GHG reductions at the local level be reflected at the national level and not offset elsewhere?

Conclusion

Even though we have 35 years of experience in discussing scenarios for modelling an Energiewende in Germany, we are only at the “mid-way point”. While realising that many changes can occur in such a period of time, we need to face the challenges ahead. Thanks to technological advances and enhanced understanding there is now a general consensus that decarbonising the economies of EU Member States is possible. The fastest way to decarbonisation is increasing the use of renewable energy. Today we have the technologies available to make the energy future we want to have become a reality by developing integrated energy approaches to reach our climate and energy goals. Following the adoption of the Paris Agreement, it is clear that these integrated energy approaches have to reflect the ambitious long-term objective agreed upon in Paris.

Governments at all levels need to give clear and **reliable long-term directions** for the next decades. Only if the path towards decarbonising the economy is clear, investment will be steered towards sustainable low carbon technologies. With the adoption of the Paris agreement an important step has been taken to provide such direction towards a long-term decarbonisation. To encourage investment in sustainable low carbon technologies it is important to strengthen investment security. In the EU, Member States face different circumstances, which makes coming to a joint vision and a common strategy an extremely complex endeavour. The biggest challenge is to create the **political will** to fulfil such visionary targets. Building acceptance for decarbonisation strategies at every governance level, and across the population, will be hard work.

A fundamental challenge is the integration of these different political levels – local, regional, national and for the EU also European. To facilitate this cross-sectoral and multi-level integration, **dialogue is needed, at all political levels**. These dialogues need to provide the possibility to learn from one another, from the inevitable errors that will be made. This learning from other experiences can bring better solutions and increase acceptance.

The **German Environment Agency remains committed to fostering this dialogue**, also in the future.

Harry Lehmann and workshop participants, Source: Ecologic Institute.

ANNEX

Annex A: Conference Agenda

Programme

Workshop "Decarbonisation - 100 % Renewable Energy and more"

WHEN? Monday, 09 November 2015, 09:00 – 17:30

WHERE? Tagungswerk Jerusalemkirche, Lindenstraße 85, 10969 Berlin

09:00 – 09:30	Registration
09:30 – 10:00	Opening and welcome “Why to plan ahead to achieve our long-term targets” Maria Krautzberger, President of the German Federal Environment Agency (Umweltbundesamt (UBA))
10:00 – 10:30	Key note “Global Decarbonisation – What role should Europe play?“ Prof. Dr. Ottmar Edenhofer, Potsdam Institute for Climate Impact Research (PIK), Director of the Mercator Research Institute on Global Commons and Climate Change (MCC), Former Co-Chair of IPCC's WG III
10:30 – 11:00	Coffee Break
11:00 – 12:30	Session I: “Long-term decarbonisation scenarios in EU Member States” Moderator: Dr. Klaus Müschen, UBA

	“The UK’s low carbon strategy: the Carbon Plan” Dan Roberts, Director, Frontier Economics “100% Renewables – a scenario for France” Dr. Christopher Andrey, Project Manager, Energy Division, Artelys France “Greenhouse gas neutral Germany – Main parameters and findings” Dr. Benno Hain, UBA followed by comments from international experts and discussion with the audience - Statement by Tetsunari Iida, ISEP, Japan
12:30 – 13:30	Lunch Break
13:30 –15:15	Session 2: “National implementation of strategies towards decarbonisation” Moderator: Dr. Benno Hain, UBA Panel discussion with inputs from Jacob Møller, Head of Division, Centre for Climate and Energy Economics, Danish Energy Agency Janusz Michalski, Head of the Energy Policy Unit, Economic Ministry of Poland Ursula Fuentes Hutfilter, Head of the National Climate Policy Division, German Environment Ministry (BMUB) Jan Jaap van Halem, Policy coordinator National Climate Strategy, Ministry of Infrastructure and The Environment, Netherlands followed by comments from international experts and discussion with the audience
15:15 – 15:45	Coffee Break
15:45 – 17:15	Session 3: “Decarbonisation strategies at the local level” Moderator: Dr. Camilla Bausch, Ecologic Institute

	“The necessity of local decarbonisation strategies” Stefan Schurig, Director Climate, Energy and Cities, World Future Council “Low carbon Vitoria Gasteiz” Jose Ignacio Arriba, Head of Energy Agency, City of Vitoria-Gasteiz “100% renewable energy for the City of Rheine“ Barbara Fricke, Researcher, Solar Institute Jülich followed by comments from international experts and discussion with the audience
17:15 – 17:30	Summary of results and closing remarks Dr. Harry Lehmann, UBA

Annex B: List of participants

Workshop
"Decarbonisation - 100 % Renewable Energy and more"

Monday, 09 November 2015, 09:00 – 17:30
Tagungswerk Jerusalemkirche, Lindenstraße 85, 10969 Berlin

List of Participants

First Name	Surname	Organisation	Country
Leszek	Adamczyk	ATMOTERM	Poland
Afrodit	Adsal	Nordic Folkecenter for Renewable Energy	Denmark
Mark	Agana	University of Arkansas	United States
Shaima	Alhabsi	Embassy of the United Arab Emirates	Germany
Christopher	Andrey	Artelys	France
José Ignacio	Arriba	City of Vitoria-Gasteiz	Spain
Albert Hans	Baur	E3G - Third Generation Environmentalism	Germany
Camilla	Bausch	Ecologic Institute	Germany
Eva-Maria	Baxmann-Krafft	SynergieKomm	Germany
Andreas	Bertram	German Federal Environment Agency	Germany
Wolfgang	Brückner	Carbonbay GmbH & Co.KG	Germany
Peter	Busch	Energie Forum Potsdam, Klimarat Potsdam	Germany
Galina	Churkina	Institute for Advanced Sustainability Studies	Germany
Gunnar	Demuth	Freelance Agrar Journalist	Germany
Christopher	Doll	United Nations University Institute for the Advanced Study of Sustainability	Japan
Lena	Donat	Ecologic Institute	Germany
Matilde	Doni	Berlin School of Economics and Law	Germany
Matthias	Duwe	Ecologic Institute	Germany

First Name	Surname	Organisation	Country
Ottmar	Edenhofer	Potsdam Institute for Climate Impact Research, Co-Chair of IPCC's WG III	Germany
Jean-François	Fauconnier	Climate Action Network Europe	Belgium
Hannah	Förster	Öko-Institut	Germany
Doerte	Fouquet	Becker Büttner Held	Belgium
Marta Maria	Fracas	Italian Embassy Berlin	Germany
Barbara	Fricke	Solar Institute Jülich	Germany
Uwe	Fritsche	International Institute for Sustainability Analysis and Strategy	Germany
Ursula	Fuentes Hutfilter	Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety	Germany
Benjamin	Görlach	Ecologic Institute	Germany
Leire	Gorroño	Nordic Folkecenter for Renewable Energy	Denmark
Molina	Gosch	Fossil Free Berlin	Germany
Stefanie	Groll	Heinrich Boell Foundation	Germany
Benno	Hain	German Federal Environment Agency	Germany
Jonathon	Hartman	Renewable Energies Agency	Germany
Wolfgang	Hein	Ministry for Transport, Innovation and Technology	Austria
Joachim	Hein	Federation of German Industries	Germany
Christian	Hey	German Advisory Council on the Environment	Germany
Holger	Hofmann	Hofmann Gebäudeenergieberatung	Germany
Tetsunari	Iida	Institute for Sustainable Energy Policies	Japan
Winfried	Jäger	Beckmann-Kommission	Germany
Nikita	Kabanov	Ministry of Economic Development	Russian Federation
Tobias	Kampet	Consultant	Germany
Ludger	Kemper	LuKe	Germany

First Name	Surname	Organisation	Country
Hans Peter	Klein	Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety	Germany
Malte	Kock	German Federal Environment Agency	Germany
Harald	Kohl	Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety	Germany
Jan	Kolar	Czech Environmental Information Agency	Czech Republic
Natalia	Kostus	International Alliance of Women	United States
Maria	Krautzberger	German Federal Environment Agency	Germany
Cornelia	Langer	com4europe	Germany
Karl	Lehmann	Ecologic Institute	Germany
Harry	Lehmann	German Federal Environment Agency	Germany
Bianka	Liebscher	University of Potsdam	Germany
Wolf-Jürgen	Lindlahr	ENGINKO	Germany
Joachim	Lund	Wachstums-Förderung-Strategie	Germany
Andrew	Lundquist	German Renewable Energy Federation	Germany
Adela	Marian	Institute for Advanced Sustainability Studies	Germany
Ana	Marques	ICLEI - Local Governments for Sustainability	Germany
Niklas	Martin	The German Renewable Energy Research Association	Germany
Hironao	Matsubara	Institute for Sustainable Energy Policies	Japan
Janusz	Michalski	Economic Ministry of Poland	Poland
Jacob	Møller	Danish Energy Agency	Denmark
Klaus	Müschen	German Federal Environment Agency	Germany
Celine	Najdawi	eclareon GmbH	Germany
Nives	Nared	Ministry of Environment and Spatial Planning	Slovenia
Rostislav	Neveceral	The Czech Hydrometeorological Institute	Czech Republic

First Name	Surname	Organisation	Country
Joachim	Nick-Leptin	Federal Ministry for Economic Affairs and Energy	Germany
Anika	Nicolaas Ponder	Institute for Climate Protection, Energy and Mobility	Germany
Lenka	Nová	Ministry of the Environment	Czech Republic
Mark	Nowakowski	German Federal Environment Agency	Germany
Kirsten	op de Hipt	German Federal Environment Agency	Germany
Josep	Puig	Eurosolar	Spain
Mohammed	Qader	Institute for Advanced Sustainability Studies	Germany
Gordian	Raacke	Renewable Energy Long Island	United States
Jennifer	Reck	Ecologic Institute	Germany
Susan	Roaf	Heriot Watt University	United Kingdom
Dan	Roberts	Frontier Economics	United Kingdom
Patrycja	Rogalska	WFOŚiGW Szczecin	Poland
Erika	Romberg	Federal Office for Building and Regional Planning	Germany
Anna-Helene	Römer	Ecologic Institute	
Stefan	Rother	German Federal Environment Agency	Germany
Dieter	Rütten	Wingas GmbH	Germany
Kai	Schätzl	Berlin School of Economics and Law	Germany
Florian	Schmidt	German Energy Agency	Germany
Fabian	Schroth	Technical University of Berlin	Germany
Sabrina	Schulz	E3G - Third Generation Environmentalism	Germany
Stefan	Schurig	World Future Council Foundation	Germany
Oliver	Seel	German Federal Environment Agency	Germany
Wolfgang	Seidel	German Federal Environment Agency	Germany
Ahmed	Shalaby	Consultant	Germany

First Name	Surname	Organisation	Country
Ulla	Strenge	German Federal Environment Agency	Germany
Stefan	Stückrad	Institute for Advanced Sustainability Studies	Germany
Jurga	Tallat-Kelpsaite	eclareon GmbH	Germany
Heiko	Thomas	Institute for Advanced Sustainability Studies	Germany
Jan Jaap	van Halem	Ministry of Infrastructure and the Environment	The Netherlands
Alberto	Varone	Institute for Advanced Sustainability Studies	Germany
Manfred	Volksdorf		Germany
Judith	Voß-Stemping	German Federal Environment Agency	Germany
Jakob	Wachsmuth	Fraunhofer Institute for Systems and Innovation Research	Germany
Sieghard	Weck	Umwelt- und Abfallberatung	Germany
Isabel	Weininger	Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety	Germany
Simone	Wissowski	German Federal Environment Agency	Germany
Christine	Wistuba	Permanent Representation of Germany to the EU	Belgium

Annex C: Feedback of the Participants

According to the evaluation of 26 feedbacks concerning the workshop organisation and covered contents, the following results were condensed:

1. Are you satisfied with the workshop, in general?

completely	1	2	3	4	5	6	not at all
	8	13	2	2	-	-	

2. Are you satisfied with the contents of the workshop?

completely	1	2	3	4	5	6	not at all
	8	10	5	1	-	-	

3. Are you satisfied with the results of the workshop?

completely	1	2	3	4	5	6	not at all
	5	10	5	2	-	-	

4. Are you satisfied with organisation of the workshop?

completely	1	2	3	4	5	6	not at all
	18	5	1	0	0	1	

5. Are you interested in participating at the next workshop concerning decarbonisation strategies?

   Yes: 23 No: 1

Comments

Which topics would you recommend for the next workshop?

- Decarbonisation strategies in different sectors – energy, industry, mobility, heating, waste, LULUCF
- Outcome of the COP21 concerning decarbonisation
- Policy and regulation for decarbonisation
- The possibilities of the digitalisation for the development of renewable energies in the future (soft- and hardware)
- Broad look on decarbonisation measures in i.e. China, India, US, etc.
- Future of agriculture

- Implementation of 100 % decarbonisation in the energy sector
- More case studies of communities, cities and regions, regional cooperation on energy policy
- Multi stakeholder issues, social agreement, finance approach, economy effects of RE, co-benefits
- Innovative financing mechanisms, new business models not connected to state aid
- Valuable and useful cooperation between national and subnational levels
- Discussion about what if coal plants close down? Lessons learned on structural change process
- Case studies about how to solve challenges in the transformation pathways