PBL Netherlands Environmental Assessment Agency

LOW-CARBON ENERGY SCENARIOS IN NORTH-WEST EUROPEAN COUNTRIES

Report of the PBL round-table of June 10th, 2016

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Low-carbon energy scenarios in north-west European countries

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PBL Netherlands Environmental Assessment Agency is the national institute for strategic policy analysis in the field of environment, nature and spatial planning. We contribute to improving the quality of political and administrative decision-making by conducting outlook studies, analyses and evaluations in which an integrated approach is considered paramount. Policy relevance is the prime concern in all our studies. We conduct solicited and unsolicited research that is both independent and scientifically sound.

Preface

This report is written based on the workshop hosted by PBL Netherlands Environmental Assessment Agency on "Low-carbon energy scenarios in north-west European countries" on June 10th, 2016. We would like to express our gratitude to all the participating members in this workshop and their contributions to the workshop and the discussions.

Summary

Discussing low-carbon energy scenarios with six north-western European countries

For the purpose of the Energy Union, European Member States are obliged to compose a long-term strategy for energy and climate policy that covers the period from 2021 to 2030 and includes a perspective up to 2050. However, in the absence of clear governance of the processes, it seemed useful to discuss the differences in progress, approaches and uses of national energy and climate perspectives in policy. With this in mind, a round-table meeting was organised by PBL Netherlands Environmental Assessment Agency, inviting modelling and policy representatives from France, the United Kingdom, Germany, Denmark, Belgium, the Netherlands and the European Commission to take part in the discussion.

Different methods yet similarities in low-carbon perspectives

The PBL round-table discussions, generally, revealed large differences among a relatively homogenous group of countries, with respect to the various approaches and low-carbon energy scenarios in policy. Overall, these differences concerned:

- Scenario designs;
- The modelling landscape of assessing national low-carbon scenarios;
- Long-term ambitions;
- Governance approach.

However, the presented trajectories all underlined a similar narrative for achieving the EU 2050 target of reducing greenhouse gas emissions by 80% to 95%, compared to 1990 levels. Decarbonising power supply and improving energy efficiency were considered key strategies by all countries, although uncertainties in trans-border developments, public engagement and lack of long-term visions may prevent them from aligning with the long-term low-carbon ambitions.

Moving forward in ambition and collaboration

Participants, overall, agreed that ambitions in the national low-carbon energy scenarios would need to be increased by aiming for the upper range of the 80% to 95% EU greenhouse gas emission reduction target for 2050. This would help to flesh out the challenges in the medium term and steer the debate towards more critical factors in the energy transition. Participants also encouraged Member States to take initiative and collaborate to create an environment in which ambitions and knowledge can move forward.

Contents

1 Introduction

By 2019 EU Member States will have to prepare for the first time national energy and climate plans that cover the period from 2021 to 2030. In addition, these plans should also include a perspective until 2050 to ensure consistency with long-term EU and national policy objections. These national energy and climate plans provide the basis for monitoring progress toward the Energy Union, and drafts are expected to be completed by early 2017[1]. From the European Commission's perspective, plans are meant to assess the extent to which 2030 EU targets for renewable energy and energy efficiency will be met. Another reason for the plans is to stimulate Member States to think about the long-term as currently only a third of Member States has a 2030 climate and energy strategy. A third reason is to stimulate thinking about regional issues hence the plans will have to contain an overview of key issues of trans-border relevance.

Recent developments in the climate and energy debates, like the outcome of COP21 in Paris and the developments under the EU Energy Union, are an incentive for the scientific community to intensify their support with further analysis on long-term low-carbon scenarios for energy and non-energy systems. Such analysis has to be done at all levels from global to sub-national levels. The EC provides some requirements to which national climate and energy plans need to comply (European Commission, 2015) but it does not prescribe how to compose such a plan in terms of design or how to provide quantification of the plan. In that sense it is of particular interest to discuss the differences in progress, approaches and utilisations of national energy and climate perspectives across several homogenous countries in the EU.

In order to discuss the country-specific national low-carbon scenarios and to learn from each other a round-table was organised in June 2016 by PBL Netherlands Environmental Assessment Agency. The objective of the workshop has been to gain insights into the differences in national low-carbon scenarios in terms of their progress, approach and utilisation in the science-policy interface. The round-table included delegates of France, United Kingdom, Germany, Denmark, Belgium and The Netherlands. The round-table was set up in such a way that each participating country had a national scenario expert present, describing the policy context and low-carbon scenario landscape in their country. Where possible, a country reflection on the national scenarios was provided by a second national scenario expert. Representatives of a number of national and European governments were present to follow the scientific debate, search for relevant information for their policy making processes and provide feedback from a policy perspective.

[1] Progress of Member State country reports are to be found here: https://ec.europa.eu/priorities/publications/national-factsheets-state-energy-union_en

2 Country characterisations

This chapter shortly summarises the country scenario landscapes presented during the PBL round-table meeting, describing the processes of creating medium to long-term visions in their respective countries.

2.1 France (Patrick Criqui, GAEL-edden)

The French national low-carbon strategy is established in the *Energy Transition for Green Growth* Act since 2015, which adopts three carbon budgets periods that need to be maintained in three subsequent periods before 2030. The *Energy Transition for Green Growth Act* also contains long-term greenhouse gas emission reduction targets, including the EU 40% greenhouse gas (GHG) emission reduction target in 2030 and 75% by 2050 compared to 1990 levels ("Factor 4"). The *Factor 4* emission reduction target, established in 2005, is now associated with an energy consumption reduction of 50% in 2050, a share of nuclear down to 50% in 2025 and several sector specific targets.

The establishment of the *National Energy Council for Energy Transition* in 2012 allowed for a new and innovative approach to develop representative national energy scenarios. Based on multiple pre-existing French national energy scenarios, four characteristic "future trajectories" have been identified then have been subjected to scrutiny in a "multi-criteria" analysis by participating stakeholder groups. Stakeholder groups included environmental NGOs, consumer associations, trade-unions, industry, local authorities, members of parliament and of administration. The procedure also involved an expert and a citizen group.

Patrick Criqui (*GAEL-edden*) highlighted two of four trajectories during his presentation, explaining that the *Energy Transition for Green Growth* Act focuses on ambitious energy demand reductions (*EFFiciency* is thus considered as the "first-best scenario"). However, given the uncertainties in efficiency policies Criqui also stressed that "second-best perspectives" need to be taken into consideration, such as demand reduction and a more decarbonised supply (*DIVersity* and *DECarbonization*). Based on the analysis it was found that retrofit in buildings is the most urgent policy problem. Also the degree of renovation of nuclear reactors after 2022 and the corresponding share of nuclear in power generation remains a major uncertainty in French energy policy.

The four trajectories are intended for the French authorities to stimulate a clear vision and different economic actions – however Criqui recommended that continuous monitoring of policy implementation may help to identify complications. It was also concluded that an adaptive strategy is needed, urging a fixed long-term goal but keeping operational targets flexible. Most uncertainties will be solved during the implementation process of attaining the aim of the *Act*.

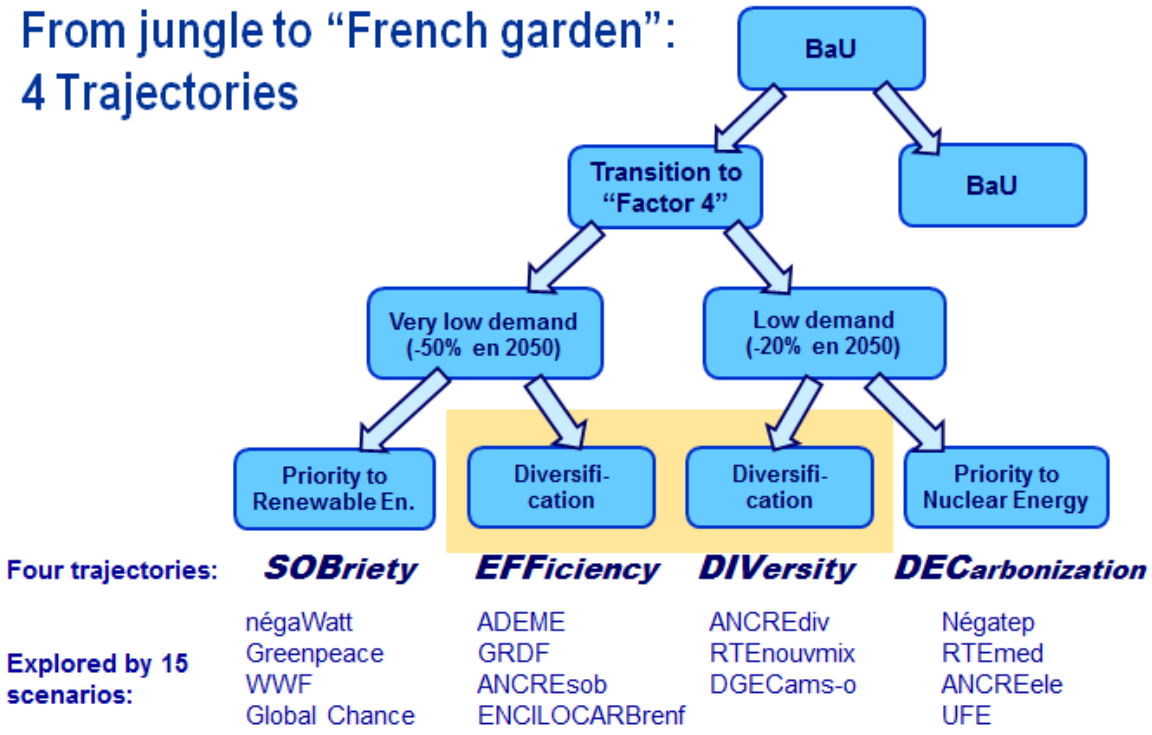

Figure 1 - Overview of "Factor 4" national energy scenarios in France

2.2 Denmark (Sigurd Lauge Pedersen, DEA)

In the Danish context there has been a recent shift in politics, changing the long-term vision for decarbonisation in Denmark from fossil-free to fossil-independent. Even though the current administration still explicitly embraces a fossil-free power supply by 2050, milestones toward 2050 for 2030 and 2035 have come to disappear (heat sector ambitions, ban on coal). These milestones offered stability for investors and were widely accepted.

Denmark has been developing national energy scenarios and models in both research institutions and governmental agencies. The different scenario analyses resulting from these bodies show an overall agreement in long-term trajectories for a low-carbon Denmark. This consensus transcends the parliament as these low-carbon perspectives are supported by the breadth of Danish society which is also focused on achieving a 100% renewable energy supply in the Danish energy system.

Sigurd Lauge Pedersen (Danish Energy Agency) explained that 100% renewable energy scenarios have been designed in Denmark already for quite some time. However, only recently the government started adopting such scenarios as well. In the five different scenarios that were presented by the Danish Energy Agency it becomes clear that the main focus is using "known" technologies and predominantly wind energy (see Figure 2). Furthermore, electrification, energy efficiency and energy savings (domestic energy reductions of 40%) are considered as "no regret" options in all considered scenarios, leading to 5%-23% additional costs under stringent mitigation as compared to remaining a fossil-based system.

Part of these additional costs are allocated to the expansion of interconnecting systems. However, one major caveat in the modelling of such interconnection and grid expansion is that the models do not take any (renewable) developments of adjacent countries into account. Some Danish perspectives exists that take developments in north-western Europe into consideration, but projections up to 2050 remain uncertain on this topic. Another pressing policy and modelling problem is, as addressed by Poul Erik Morthorst (Danish

Technical University), the transport sector. He also added that the estimation of additional costs of a renewable energy system strongly depends on the assumptions of oil and gas prices.

A possible weaknesses of the Danish back-casting approach is the focus on the long-term (2050), excluding the medium 2030 term. To provide more guidance for investors, Danish policy should include the medium term and the actual transition. Especially the absence of milestone development for 2030 / 2035 may create uncertainty for investors.

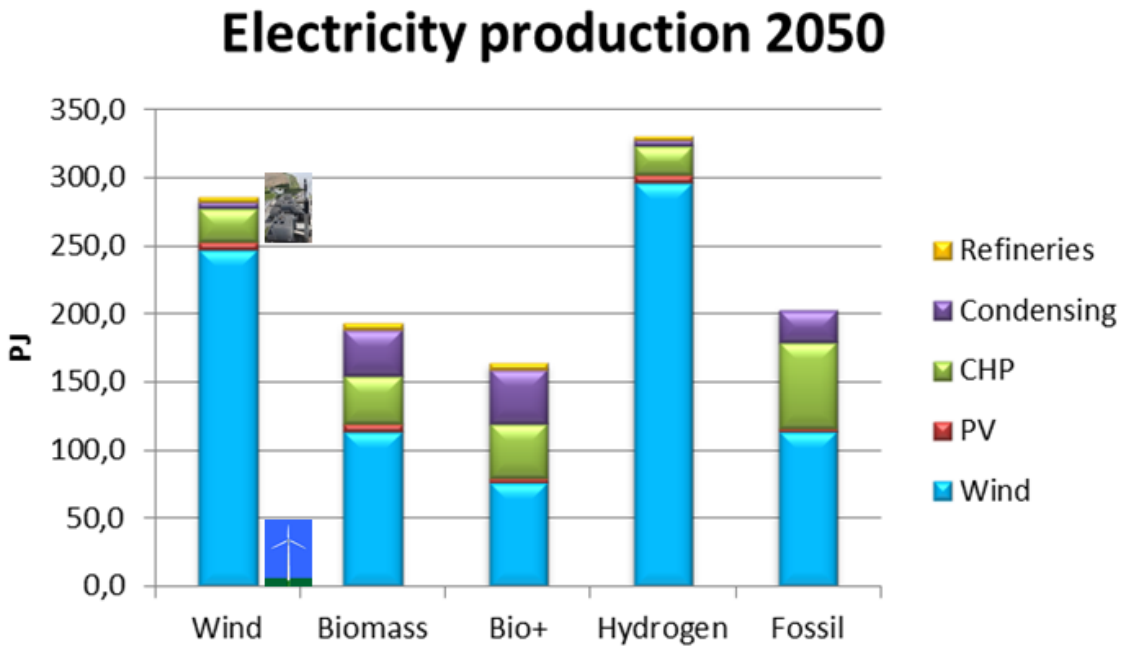

Figure 2 - Depiction of the 5 considered scenarios of the Danish Energy Agency

2.3 Belgium (Danielle Devogelaer, FPB)

The Federal Planning Bureau elaborates on possible long-term energy perspectives for Belgium, based on the PRIMES model results. The *Reference* scenario accounts for the national 2020 targets: including 13% renewables target and 15% non-ETS target. However, in the absence of a long-term Belgian vision, alternative policy scenarios are adopting European visions after 2020, such as the EU2030 Climate/energy framework and the low-carbon economy by 2050 EU perspectives. As the PRIMES model is a model covering all EU regions, it allows to allocate the GHG reduction target on EU level among Member States for any considered year. For the EU 2050 target (80%-95% less GHG emissions compared to 1990 levels) this thus results in a 65% reduction target for Belgium under cost-efficient allocation criteria.

The context to which these Belgian scenarios are used in policy making is not yet clear given the fact that Belgium still needs to develop a long-term energy and climate plan.

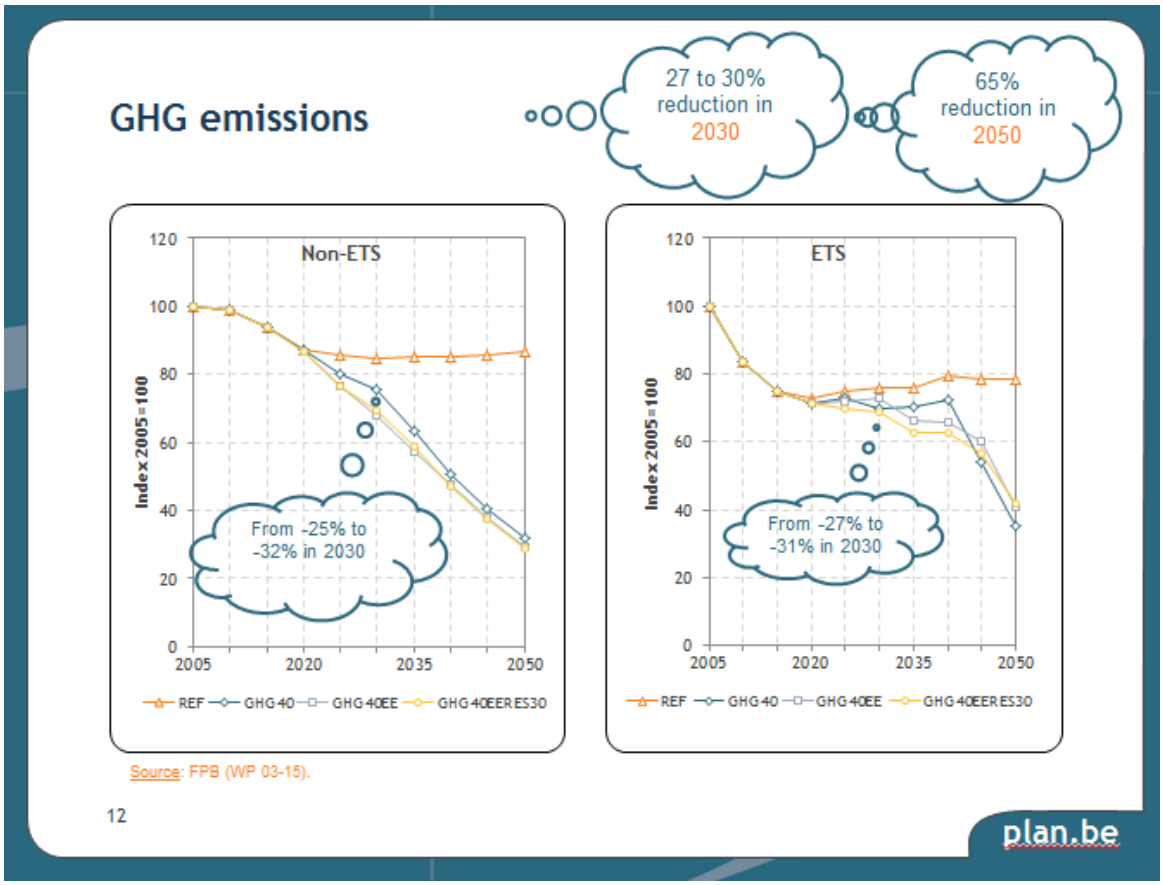

Figure 3 - Divide for ETS and non-ETS emission reductions for Belgian scenarios

2.4 United Kingdom (Jim Watson, UKERC)

Several policy changes have been enforced by the UK government recently. In the recent 'policy reset', the government placed a particular emphasis on closing unabated coal-fired power stations, striving to close coal by 2025 and restricting its use from 2023 onwards. Offshore wind has also been strongly supported, as has nuclear power and heat networks. However, on the other side, policies to support solar PV, energy efficiency, (deep) retrofits and CCS have been abandoned or downgraded by the government over the past year.

In June 2016, the Department of Energy and Climate Change (DECC), in agreement with the advice of the Committee on Climate Change (CCC), have accepted an ambitious new fifth carbon budget (for the 2028 – 2032 period), broadly accepting 57% reduction from 1990 by early 2030. However, with the start of the Theresa May administration in July 2016 DECC has been merged with the Department of Business to form a new ministry – the Department for Business, Energy and Industrial Strategy (BEIS). It is yet unclear what implications this has for the UK long-term energy and climate vision.

Since the early 2000s scenarios have been routinely used in the UK to underpin strategic energy and climate policy statements and documents. A wide range of scenarios have been developed by multiple actors in the UK; many of the scenarios are academic scenarios, while other long-term scenarios come from the *Energy Technologies Institute* (a public-private innovation organisation), the National Grid and the government itself. In the past, some stakeholder engagement has occurred, but it is unclear how far government will engage with stakeholders for meeting the new fifth carbon budget. The government has to develop a new 'Carbon Plan' by the end of 2016 that sets out how the new carbon budget, and other previous budgets, will be met.

Jim Watson (UKERC) explained that UKERC scenarios have been used in discussions with several UK government departments at a senior level to help them consider their response to the Committee on Climate Change recommendations. The former lead department (the Department of Energy and Climate Change) has now adopted the same model that UKERC utilises (the TIMES model), and they have been running large numbers of their own scenarios, though these are not yet published.

Overall goals for emissions reduction are the main driver of scenarios that comply with official UK carbon budgets and targets. But since UKERC is an independent research centre, it is also able to explore non-compliant scenarios in which other energy policy drivers could compromise or over-rule emissions reduction. This is why UKERC scenarios include futures in which emissions reductions are more modest, the growth of low carbon energy is much slower and so on.

The scenarios presented by Jim Watson (UKERC) focus on the so called 'trilemma' of energy policy goals: affordability, security and sustainability. In general, they show a crucial deep decarbonisation in the power sector in the first decades and a fundamental transformation of the heat and transport sectors between 2030 and 2050. Systemic uncertainties lead to scepticism about transformations to whole new systems, underlining the importance of using existing systems with more smart and hybrid solutions for the UK (hybrid heat pumps, hybrid vehicles). The actual power market model has established itself in such a way that no investments are being made without governmental support, leading to question current market structures and corresponding business models. Local decision making factors are also only relatively weakly represented in UK energy system models that tend to be used for such scenarios.

2.5 Germany (Felix Matthes, Öko-Institute)

German energy policy is well known for generating a strong increase in renewable energy capacity with a simultaneous decrease in nuclear power. The explosion of wind and solar energy capacity, in combination with overcapacity of fossil fuels, led to falling energy prices, the export of electricity and a stagnation of greenhouse gas emission reduction.

A broad range of modelling projects on climate policy have been taken place in Germany since the 1990s, consisting mainly of bottom-up and partial equilibrium models. The German energy policy discussion frameworks are relatively normative and costs play only a secondary role. The first 2050 model was developed by WWF. Since 2014 a complex modelling framework reports on an annual basis, making projections up to 2050. The modelling framework respects several restrictions given by the ministries, for example, by not allowing new nuclear power plants, allowing CCS only for process industry and limiting the potential of sustainable biomass via the "access rights concept". The German government takes note of all scenarios but does not commit to any of the trajectories.

One advantage of reporting annually is that the process can include real world fluctuations in the environment, creating an impression of the sensitivities in political environments. However it also leads to accounting difficulties as European institutes do not report on the desired level of detail on an annual basis (e.g. IEA reports fuel prices on a biannual basis) creating dependencies on US-based organisations that do report annually (EIA).

Felix Matthes (Öko-Institut) elaborated that the modelling of electricity import and export is very uncertain. Currently ENTSO-E is the leading institute to provide scenarios of electricity

grid developments by 2030[2], but these have been developed with a different purpose in mind than considering different long-term low-carbon pathways. Developing more credible long-term visions on grid expansion is considered very important as it is a very inert factor in the energy system (capital stock, infrastructure). The timing matters and scenarios may help in having an informed public debate. The total macro costs of well-planned low-carbon pathways could be limited, but distributional issues have to be kept in mind. Furthermore, as decentralised options are becoming more and more important, public backing of the relevant issues is becoming more important – such as the choice for high voltage grids or cables.

Wolfgang Eichhammer (Fraunhofer-ISI) responded that strategies to meet the lower end of the 80%-95% GHG emission reduction range for 2050 are fundamentally different than meeting the upper range. A 95% reduction pathway is not just a slightly more ambitious 80% GHG reduction pathway, it would instead demand a whole different approach that fully exploits the available technical potential in any supply or demand sector. One way to move beyond the floor value of GHG mitigation is by generating societal support and acceptance for more radical energy system transformations. This also requires a more harmonised European approach. From a technical point of view, society would benefit from a clearer vision of the role of power-to-gas / power-to-liquids and CCS in the (national) energy system. Transformation signals to industry in an early stage are also important.

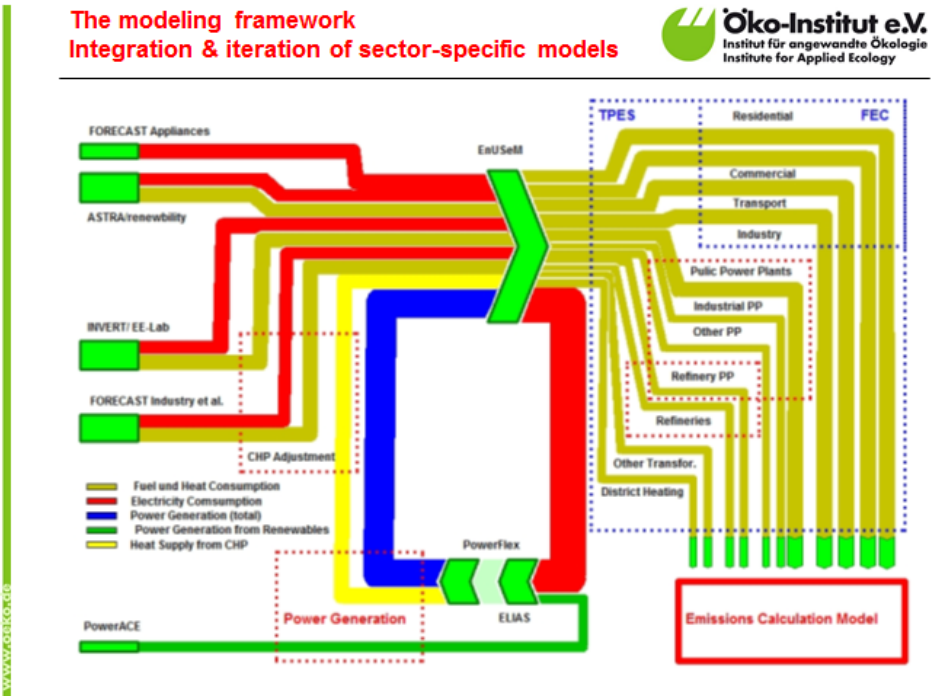

Figure 4 - German modelling framework to calculate system-wide emissions

2.6 The Netherlands (Robert Koelemeijer, PBL)

The current Dutch energy policy debate has been affected by two influential occurrences. The first one has been the *National Energy Agreement* which has been enforced since 2013, and the second has been the '*Urgenda'* court case that resulted in a verdict obligating the Dutch government to increase its GHG reduction efforts by 2020. To current knowledge, complying with the verdict would imply the closing down of all coal-fired power plants in the Netherlands before 2020. In 2016, stakeholders and civil society have been included in the

[2] See for example the Ten Year Network Development Plan 2016 by ENTSO-E: https://www.entsoe.eu/Documents/TYNDP%20documents/TYNDP%202016/rgips/TYNDP2016%20Scenario%20Development%20Report%20-%20Final.pdf

national energy policy process via extensive energy dialogues. The government expects to draw conclusions from this by the end of 2016.

Robert Koelemeijer (PBL Netherlands Environmental Assessment Agency) describes that only a limited number of national decarbonisation studies exist for the Netherlands that cover the energy system in its entirety, which are mostly written by PBL in collaboration with ECN. Sector specific decarbonisation studies for built environment, road transport, or power-to-gas are more abundant. The Dutch decarbonisation scenarios do not have a formal role in policy and the political debate is limited, as the Netherlands is more focused on meeting short-term goals (up till 2023) as described in the Dutch *Energy Agreement*. PBL publishes annually the "*Nationale Energieverkenning*"-report that quantifies the implications of current or proposed policies up to 2030. However, projections that go beyond 2030 underline a misalignment between the set course in the Netherlands and the needed course for deep decarbonisation consistent with EU 2050 targets. Discussions on such deep decarbonisation have hardly ever played a role in the Dutch climate and energy discourse up to now.

The most recent Dutch long-term climate and energy scenarios have been compiled by the Dutch 'planning bureaus" (such as *PBL Netherlands Environmental Assessment Agency* and *CPB Netherlands Bureau for Economic Policy Analysis)*, as part of a broader study looking at long-term developments in the Netherlands. This study is the basis for national cost-benefit analyses. It distinguishes a low and a high economic growth scenario that lead to 45% and 65% GHG emission reduction by 2050. In addition, for the high economic growth scenario, two variants have been designed that both aim to meet the 80%-95% GHG emission reduction target by 2050. The decarbonisation scenarios pose a central role for the electricity producing sector which can provide both low-carbon electricity supply as well as mitigate end-use sectors as the residential sector and transport via electrification. The Dutch national scenarios also include the use of CCS in the long-term (with restrictions in available storage capacity), though over the past years there has been hardly any progress in the development of CCS demonstration projects.

3 Overview of national approaches

The presented long-term scenarios of the six north-western European countries show a diversity in terms of approaches towards designing national scenarios and the usage in policy processes. Table 1 shows an overview of a limited number of scenario characteristics per country.

Table 1 - overview table of presented country scenarios and key characteristics. Table compiled based on background material and personal communications.

	NL[*1]	GER[*2]	FRA[*3]	DK[*4]	UK[*5]	Be[*6]
Contributing Institute(s)	PBL / ECN / CPB	Öko-Institute Fraunhofer-ISI	Expert Group of National Council on Energy Transition	Danish Energy Agency	UKERC	FPB
Mitigation scenarios	2 (simulation scenarios 2030) 4 (back casting scenarios)	7	4 ”trajectories” (from an initial set of 16 scenarios)	5	6	3 (mitigation 2030-2050)
2030: Modelled GHG emission reductions compared to 1990	-21% GHG (simulation scenario)	-52%-72% GHG			-36% to -54% GHG	-27-30% GHG
2050: Modelled GHG emission reductions compared to 1990	- 45% - 80% (back casting scenarios)	-80% -95% GHG	Factor 4 (i.e. -75% GHG)	-80% -95% GHG	-34% to -80% GHG	-65% GHG
Used for policy design?	Simulations 2020/2030: Yes. Decarbonisation scenarios: strategic thinking	Indirectly (for 2030 time horizon)	Yes (Energy Transition for Green Growth Act)	Strategic thinking	Strategic thinking	Strategic thinking
Stakeholder involvement?	No	Yes (public survey)	Yes	Yes	Not currently	No
Non-technology options included?	No	Implicit	Carbon pricing, Lifestyle and urban planning policies	No	Implicit	Implicit

* See References for the background materials

Overall, several differences are observed in (1) how scenarios have been designed, (2) the modelling landscape of assessing national low-carbon scenarios, (3) long-term ambitions and (4) the governance approaches per country. In the following paragraphs we will elaborate on these differences.

3.1 Scenario set-ups

A striking difference between the countries is found in the design of the process, resulting in varying numbers of scenarios that are being used in the process. Several approaches are adopted across of the presented countries:

- **Preference hierarchy:** France displays a ranking of various potential futures that each are in line with the national 2050 ambitions but vary in how the target is met (e.g. behavioural or via more technology oriented solutions and portfolios). This leads to a hierarchy of "first-best" to "second-best" scenarios.

- **Technology favouring**: The Danish example showed scenarios that revolve around a technology taking the lead. For example, the wind scenarios favour the wind technology in power production whereas the hydrogen scenario promotes the production of hydrogen.

- **Range of trajectories:** Another approach is found for Germany, Belgium and the UK, utilising a multiplicity of scenarios looking into different future narratives and ambition levels. This method provides the strategic underpinning of all possible policy decisions. Moreover, in an engaged stakeholder setting, it will also allow for a better and more informed dialogue.

- **Drawing out extremes**: An alternative method has been to outline the full range of options by exploring a high and low scenario (and "central" or "decentral" scenario) as presented by the Netherlands. By drawing out the extremes it will provide the most contrasting images with business-as-usual trajectories.

This has raised the question as to what is considered the most optimal number of future trajectories to be taken into consideration (or the type of approach), as well as the need or use of a "representative" scenario. Aiming on a single trajectory might not be desirable.

3.2 Modelling landscapes

Simultaneously, striking differences arose in the complexity of the exercises presented, being characterised by the number of people and models involved:

- **Stakeholder involvement:** The degree of stakeholder cooperation varied across the countries. For example, to find support from society for future pathways, several dialogues and national surveys have been undertaken in the UK and Germany. In France, stakeholders have been an integral part in the process of shaping the "Factor 4" scenarios. By involving stakeholders into the process of shaping long-term energy and climate visions it also inherently makes the quantification of its implications more complex.

- **Modelling landscapes:** The countries display varying landscapes in terms of how the long-term national low-carbon scenarios are assessed. For example, in both Germany and the Netherlands multiple bodies have been working in tandem in a so-called "modelling framework" to produce the best possible quantitative results. Other countries like France, Denmark and the UK have a multitude of agencies producing their own scenarios. In Belgium, scenarios are made simply as part of the work of a single agency.

- **Frequency of production:** The national scenarios are found to be produced at varying frequencies. The German scenarios are republished periodically (annually) to incorporate changes in the environment (e.g. fuel price, policies), which is similar for the <2030 scenarios in the Netherlands. Belgian scenarios are published every three years. For the other countries the national scenarios are not formally (re)published at set intervals of time.

3.3 Focus of long-term trajectories

EU policy describes a long term policy vision of reducing GHG emissions by 80%-95% in 2050 compared to the 1990 levels. Yet as also shown in Table 1, different GHG emission

reduction ranges are presented across the countries for both 2030 as well as 2050. We therefore observe the following differences:

- **Different mitigation ambitions:** In some countries a specific GHG emission reduction target may be the leading figure which deviates from the EU 2050 target of 80%-95% GHG emission reductions compared to 1990 levels – for example France aims at a 75% GHG emission reduction in 2050 compared to 1990 levels.

- **Allocation of mitigation efforts:** Some studies include assumptions on European burden sharing. For instance, because calculations are done using a European (optimisation) model, Belgian mitigation scenarios show a 60% GHG emission reduction target in 2050, compared to 1990 levels, which is the result of a cost-efficient allocation of the 80% GHG emission target in Europe. It should be noted, however, that alternative burden sharing assumptions can be used.

Scenarios that translate the 80%-95% EU target to a less ambitious national GHG reduction target seem to reflect an "other countries will balance out my deficits" rhetoric. GHG emission reduction targets are policy decisions, but the robustness of outcomes in the science-policy interface may be helped more by developing scenarios that are relatively difficult to implement. It was therefore commented that modellers should prevent this type "wishful thinking mechanism" into their scenarios by creating scenarios that aim for at least 95% GHG emission reductions compared to 1990 levels on the national level.

3.4 Governance approaches

The responsibility of quantifying the contributions and implications of possible future national policies has been distributed differently, distinguishing three approaches:

- **Modelling as part of the government:** In some administrations the responsibility of quantifying the contributions and implications of national plans has been internalised. Within the UK, government has started to pick up on the use of the TIMES model to create and research various futures. Practically this may result into outsourcing the production of research tools to an external agency (e.g. the TIMES model has been extensively supported by an energy systems modelling team at University College London) but the government may keep an "intellectual property" on the tool itself.

- **Separated from policy design**: As is the case for Germany, a multitude of research institutes have been responsible for the quantification of contributions and implications. The government has completely outsourced the quantification work to external bodies and have invested substantially to maintain the construct. An advantage of outsourcing is that it creates continuity in the research discipline. Secondly, the credibility of the scenarios has incidentally been improved as well due to the extensive documentation of the process.

- **Hybrid construction**: In the case of the Netherlands, national modelling is being done in a semi-governmental way. The 'planning bureaus" in the Netherlands (such as *PBL Netherlands Environmental Assessment Agency* and *CPB Netherlands Bureau for Economic Policy Analysis)* are fully independent, but administratively part of the government. The Belgian situation is comparable.

Most of the scenario work that has been done on a national level is used for the strategic planning of national energy and climate policy. No government has adopted a single trajectory as leading for the design of policy – and for some other instances, such as in the Netherlands and Belgium, it is still unclear to what extent policy will be shaped based on scenario work.

4 Main findings and recommendations

4.1 Robust messages in national low-carbon scenarios

The workshop has provided insights in the common features of the national low-carbon energy scenarios. Overall the national scenarios found agreement on the following measures:

- **Increased efficiency:** Greater energy efficiency is considered as a key element of decarbonisation policies and, to a certain level, identified as a "no-regret" option.

- **Increased electrification:** In general the country a presentation depicted a large role for increased electrification throughout the energy system, placing much weight on acquiring a low-carbon power supply and a roll out of new energy infrastructure and processes that can facilitate this. This is accompanied with a strong diffusion of renewable energy sources and transformations in existing systems for the transport and building sectors.

The low-carbon energy scenarios all depicted that, in order to achieve a low-carbon power supply, the developments need to be much quicker than currently set out in current and proposed policies. The workshop thus addressed inertia as a common factor, which is caused by the following issues:

- **Trans-border issues:** National scenarios have rarely included detailed assumptions about future developments of neighbouring countries and how global markets will evolve. For example, given the overall agreement of the significant production of intermittent electricity, it shows that import or export of electricity will become more important. Yet, scenarios only marginally account for developments in improved interconnection and (European) trade. Similar for biomass imports, for which varying assumptions about biomass availability have been used in the different country models. The workshop thus called for a greater inclusion of trans-border regional developments in national scenario analyses. For example, neighbouring countries could design a set of plausible storylines for electricity infrastructure transformations and trans-border effects together.

- **Public engagement:** Countries experience a varying degree of understanding by the general public on the level of current and required change. Involving the public in scenario design could educate people about the urgency of change, involve them in the development of plans, and help to gain acceptance for controversial technologies. Moreover, modelling efforts could also include 'opportunity costs' into the scenario which reflect the costs needed to overcome (public) resistance.

- **Lack of long-term vision**: Carbon capture and storage and "negative emissions" have been shown to be an integral part of some of the national decarbonisation scenarios. However, demonstration projects are currently still postponed (Netherlands) or cancelled (UK), either due to the estimated costs or acceptance issues, where the lack of long-term vision make stakeholders less inclined to embark on demonstration projects. A joint approach by knowledge institutes could investigate these issues more thoroughly and could assist policy in these issues in an interactive way.

- **Reservations for radical change:** As illustrated by the differences in ambition of decarbonisation strategies in the building sector, ranging from deep retrofits in France to hybrid solutions in the UK, a preference for making incremental changes in existing systems is perceived in the national low-carbon energy scenarios. This

inhibits any further going debates about possible alternative response strategies, such as the role of power-to-gas, power-to-liquid, district heat and small scale heat networks.

4.2 Future challenges

4.2.1 Increasing ambition

The workshop yielded an overall agreement that national low-carbon energy scenarios should include a higher ambition level than currently presented. The Paris agreement sets out an ambition of limiting temperature increase to 2 degrees Celsius or well below, and the current focus on meeting the lower end of the 80%-95% range in GHG reductions is not up to par with this ambition. Designing national low-carbon energy scenarios that aim for the 95% GHG emission reduction target would help in fleshing out the challenges in the medium term. Not only would it facilitate a better suited pathway that is in line with long-term climate and energy ambitions, it would also allow to shift the dialogue to more critical factors (like, amongst others, acceptance issues, negative emissions, agriculture emissions, rigidness of the transport sector, interconnection, decentral options). It would also allow for better consideration of the options that are needed and the options that are beyond reach.

4.2.2 Improved governance

The European Commission facilitates a framework towards improved energy governance and does not strictly mandate a specific trajectory after the formally agreed upon short-term targets. Various suggestions were articulated during the workshop to progress into improved energy governance:

- **First movers:** The 2030 EU emission reduction target (40%) is acknowledged as not consistent with the 2 degree ambition and awaiting a reformulation of this target in 2023 may close up various opportunities. National strategies that come forward with increased efforts may subsequently also create an environment in which ambitions can move forward.

- **Establish coalition groups:** The national energy scenarios are not intended as a private national exercise independent of the EU. If European Member States benefit from a cooperative approach then they are free to collaborate and create "coalition groups" amongst themselves. An example could be the recent establishment of the "Political declaration on energy cooperation between the North Seas Countries" (European Union, 2016) – which facilitates the cooperation of nine countries in the North Sea region to better utilise the potential of the North Sea as an area for offshore wind farms. Another example is found in the *Pentalateral Energy Forum*, in which governments from north-west Europe, together with TSO's and other stakeholders moved forward in their joint interest, but with the European Commission as a keen observer.

By improving both the initiative taking and the cooperative effort of Member States it would create a bridge between the nations and Europe, leading to adaptive strategy designs rather than one shot policies being imposed at a time.

4.2.3 Improved reporting

The round-table exposed that, among six (rather homogeneous) European countries, a large diversity exists in national low-carbon scenario design processes and institutional embedding of scenarios in policy design. Based on the experiences from the workshop several areas for improvement could be articulated:

- **Data collection:** National scenarios are relying on large quantities of empirical data sourced from various EU and non-EU databases. Moreover as the frequency of production varies, there could be an high-frequent demand for data. The workshop addressed that standardising data collection and facilitating national cooperation could help to progress the design of national scenarios.

- **Improving joint understanding:** Deviating assumptions on, amongst others, fuel price, biomass availability, technology diffusion and GDP are employed to design the national futures. There might be some merit to align various assumptions across the national models, or to create more transparency or joint understanding for these assumptions. Simple tools or devices (like templates with indicators) have been proposed to compare national results and scenarios.

- **Conveying information:** With the wide diversity in processes, assumptions and trajectories across the countries, the core messages of these countries and what they expect from other Member States or the EU should be communicated more clearly. Simultaneously, next to conveying national strategies to transform the energy system and infrastructure, national low-carbon scenarios should also consider to address a wider scope of impacts and co-benefits (such as public health, employment, etc.).

4.3 A way forward

The scenario design approaches differed in the six countries attending the Utrecht workshop. Countries with a relatively clear long-term policy orientation have a broader and deeper experience in scenario building and using these scenarios in the policy context as well. However, the workshop also noted several issues in which the knowledge institutes could learn more actively from each other. Especially the trans-border issues, public engagement challenges and designing more relevant long-term visions seemed potential priorities in the science-policy interface for the participating north-western European countries.

5 References

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*3 FRA: ADEME (2014) "ADEME energy transition scenarios 2030/2050"

*4 DK: Danish Energy Agency (2014) "Energy scenarios for 2020, 2035 and 2050" http://www.ens.dk/sites/ens.dk/files/energistyrelsen/Nyheder/2014/energiscenarier_uk.pdf

*5 UK: UKERC (2013) "The UK energy system in 2050:Comparing Low-Carbon, Resilient Scenarios". [In this overview we focused on the set of scenarios meeting at least 80% GHG reductions in 2050]

*6 Be: Devogelaer and Gusbin (2015) "2030 Climate and Energy Framework for Belgium - Impact assessment of a selection of policy scenarios up to 2050" Working Paper 3-15, Federal Planning Bureau

ANNEX I: List of participants

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