NorthSEE project
WP 5 – Energy Infrastructure in MSP

Status quo report on offshore energy planning provisions in the North Sea Region

Report annexes

Annex 3: National Energy profiles

April 2018

Project information

Funding programme:	INTERREG VB: North Sea Region Programme 2014 - 2020
Project Name:	NorthSEE: A North Sea Perspective on Shipping, Energy and Environment Aspects in MSP
Project Agreement number:	38-2-2-15
Project implementation period:	May 2016 and July 2019
Lead Partner:	German Federal Maritime and Hydrographic Agency (BSH)
Work Package	WP5 – Offshore Energy
Links to Task(s):	Task 5.1 – Status quo of energy infrastructure provisions in national MSPs Task 5.2 Analysis of national and transnational energy policies by country in the NSR

Document information

Document Title:	Status quo report on offshore energy planning provisions in the North Sea Region
Author(s):	Andronikos Kafas, Malena Ripken, Kirsty Wright, Mailys Billet, Stephen Sangiuliano, Erik Ooms, Ulrich Scheffler Country contributions by: Jeroen van Overloop and Diederik Moerman (Belgium), Lise Schrøder and Suzanne Dael (Denmark), Ulrich Scheffler (Germany), Xander Keijser (Netherlands), Anne Langaas Gossé and Hanne-Grete Nilsen (Norway), Linus Hammar and Jonas Pålsson (Sweden), and Andronikos Kafas, Kirsty Wright, Ian Davies, Peter Hayes, Matt Gubbins, and David Pratt (Scotland). GIS figures by Christian Aden
Version history:	01/03/2017 – Version 1; Partners Review 26/04/2017 – Version 2; Internal review comments addressed 12/06/2017 – Version 3; Restructured report; shared with partners 09/10/2017 – Version 4; North Sea level summaries added; National information moved to annexes and new figures added; shared with partners 18/11/2017 – Version 5; Final draft shared with Political Declaration – Support Group 1, Internal Scottish Government and Energy Working Group 12/04/2018 – Version 6; Shared with European Project Coordination Office (EPCO) for publication on the project website
Publication Date	12/04/2018

Proprietary Rights statement

This document contains information which is proprietary to the "NorthSEE" Consortium. Neither this document nor the information contained herein shall be used, duplicated or communicated by any means to any third party, in whole or in parts, except with prior written consent of the "NorthSEE" consortium.

Disclaimer

NorthSEE is an EU funded project - INTERREG VB: North Sea Region Programme 2014-2020 – and runs from May 2016 and July 2019. Project partners include all of the countries that border the North Sea (Belgium, Denmark, Germany, Netherlands, Norway, Sweden, and the United Kingdom (partner representation only from Scotland) with the exception of France as it is not eligible under the North Sea Region Programme. The sole responsibility for the content of this publication lies with the authors. It does not necessarily reflect the opinion of the European Union or partner organisations. National information included in the report is indicative, as provided by respective project partners. In many cases, there are formal systems through which Member States/Competent Authorities report to the European Commission. The information provided here is not intended to replace the original formal systems. The data contained in this report have been collected from a variety of online sources (e.g. 4C Global Offshore Wind Farms Database, Wind Europe) and have been verified by the relevant project partners for each country as of early 2017. Information has been collected over the course of 2 years (2016 and early 2017), hence information which became available in late 2017 and early 2018 has not been included in the report. Neither the NorthSEE Consortium nor the European Commission are responsible for any use that may be made of the information contained in this publication.

Acknowledgements

All icons used in the figures included in this report have been designed by Freepik (www.freepik.com) accessed through free icons search engine "Flaticon" and used under Flaticon's Basic Free License (www.flaticon.com , Graphic Resources S.L, Commercial Registry of Málaga, volume 4994, sheet 217, page number MA-113059, with Tax Number B-93183366 and registered office at 13 Molina Lario Street, 5th floor, 29015 Málaga, Spain).

Cover photo

Robin Rigg offshore wind farm in Scotland. Photo by Fiona Thomson, Marine Scotland. Crown copyright 2017.

Please cite this document as:

Kafas, A., Ripken, M., Wright, K., Billet, M., Sangiuliano, S., Ooms, E., Scheffler, U. et al. (2017) Status quo report on offshore energy planning provisions in the North Sea Region, NorthSEE project, INTERREG North Sea Region Programme, Grant agreement 38-2-2-15.

Annex 3: National Energy profiles

1.12. Belgium

Quick summary

There is no national energy policy in place in Belgium, but each of the three regions in Belgium has high authority in terms of energy policy. Energy security is a challenge for the near future, since the country opts to phase out nuclear energy by 2025. In 2016, half of Belgium's energy generation was produced nuclear.

Renewable energy production has increased substantively from 7.8% in 2009 to 19% in 2014. However, changing support systems considering renewable energies affect the processes of developing renewable energy capacity in Belgium and there is a need for a stable support system.

Country's energy system

In 2015, Belgium had a TPES of 52.9 million tons of oil equivalent (Mtoe) and a TFC of 35.8 Mtoe. Meanwhile, Belgium imported 81.5 Mtoe and exported 30.9 Mtoe in this same year. In total, Belgium produced 10.4 Mtoe of energy, of which on- and offshore wind energy accounted for 0.5 Mtoe.

Half of Belgium's energy generation consists of nuclear energy. In 2011, it was determined that nuclear energy would be phased out, starting with shutting down the first 30% of the total production in 2015. Approaching 2015 however, it became clear that the security of the energy supply in Belgium could not be guaranteed without the nuclear plants, and the phase out was delayed until 2025. Under current policy all nuclear plants will be shut down by 2025.

In 2014, Belgium's fossil fuel share was at a medium level compared to other North Sea Region countries. Belgium relies on energy imports (primarily fossil fuels), since domestic production only accounts for 23.6% of TPES. Both, the import of oil and natural gas have declined over the period 2004-2014 by 9.8% and 7.5% respectively. In 2010, the share of energy imported by Belgium is 77% of the total energy use. The share of energy imports is expected to remain a challenge for Belgium in the coming decades, increasing to 86% in 2050.

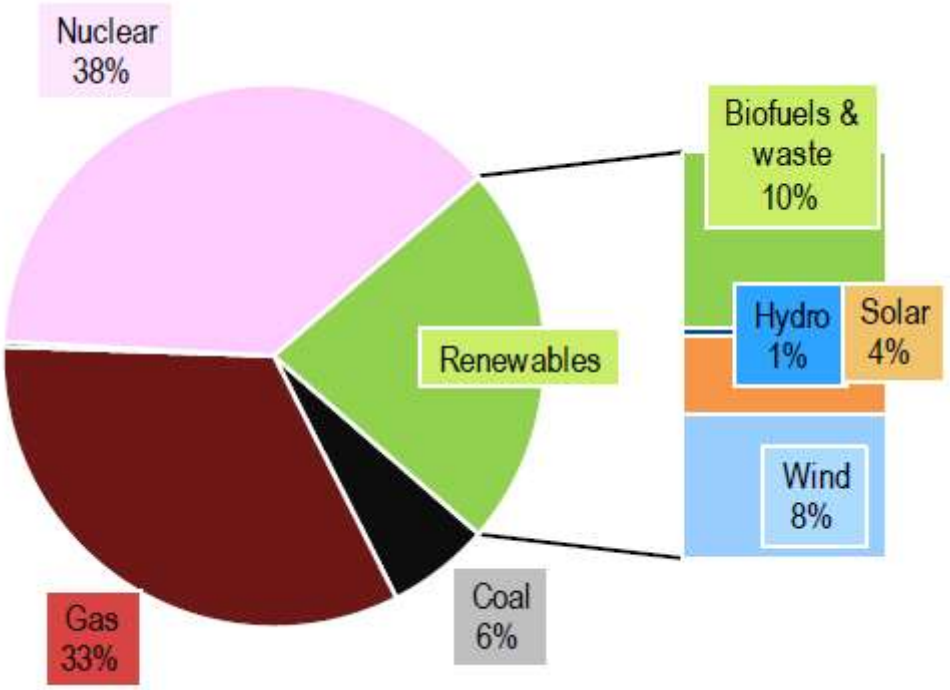

Figure 18: Percentage composition of Belgium's electricity generation (69.5 TWh) with 23% renewable energy generation in 2015 (Source: IEA).

Energy policies

Belgium does not have a national energy strategy. However, various efforts are being taken to alter the status quo. The three regions of Belgium have a broad legal authority in energy policy. Each of them adopted various measures and policies. These include regional climate policy plans; strategies for low-carbon energy supply; and legislation implementing EU Electricity and Natural Gas Market Directives.

However, the Belgium government has been encouraged to develop a long-term energy technology strategy (e.g. by the IEA). The need for this strategy is stressed by concerns over the security of electricity supply and the need of de-carbonization of the economy.

Currently, Belgium depends for half of its electricity production on nuclear energy. This type of electricity generation, however, is opted to be phased out by 2025. To avoid electricity security challenges by this time, clarity over power supply options is needed. The IEA suggested to keep the plants running, as long they are safe, to make sure a good low-carbon alternative is found for the electricity generation.

Belgium’s power generation and heavy industry are subject to the EU-ETS, therefore limiting emissions in these sectors is not the federal or regional governments' responsibility. Beside the EU-ETS, most gains are to be made in the transport and building sectors.

Energy targets

Belgium has set an indicative ceiling of 43.7 Mtoe primary energy demand for 2020. This efficiency objective however, is only expected to be met in 2025. Furthermore, there is a renewable energy goal of 13% in Belgium's final energy consumption.

The Belgium government has used subsidizing methods to promote renewable energies and meet the binding national targets set for 2020. These helped to increase the share of renewable electricity from 7.8% in 2009 to 19% in 2014. These subsidies however, have grown faster than expected and were very costly, causing politicians to change the compensation rules abruptly. This changing support system affects the capital financing costs and the costs of project development, thereby affecting the processes of developing renewable energy capacity. There is currently a need for a stable and predictable support system.

Oil is the largest energy source in Belgium. While the security of energy has proven to be a challenge for Belgium, the security of oil and gas supplies is more successful.

Offshore Energy Developments

Wind

At the end of 2016, Belgium had 6 fully commissioned offshore wind farms operating in their waters with 182 turbines connected to the grid and an installed capacity of 712 MW in total. All 6 of these wind farms are within the North Sea. Belgium's first offshore wind farm was Phase 1 of the Thornton Bank offshore wind farm which was commissioned in June 2009. Phase 1 consisted of 6 turbines with a capacity of 30 MW. Phase 2 and 3 of the Thornton Bank wind farm project are also now fully commissioned with a total capacity of 325.2 MW.

Tidal

There are currently two Belgium tidal developers; FlanSea and Laminaria. Flan Sea launched their wave device in 2013 and Laminaria tested their wave device at the European Marine Energy Centre (EMEC) in Orkney, Scotland[79].

[79] The European Marine Energy Centre Ltd (EMEC). (2017). Wave Developers. Available: http://www.emec.org.uk/marine-energy/wave-developers/ Tidal Developers. Available: http://www.emec.org.uk/marine-energy/tidal-developers/

1.13. Denmark

Quick summary

In 2011, Denmark presented the Energy Strategy 2050, a general strategic framework to reach fossil fuel independence by 2050. This has led to the Energy Agreement for 2012-2050, including policies to support energy projects and a strategy to reach a low-carbon society with an affordable and stable energy supply. Main principles of this strategy are cost-effectiveness, minimal impact on public finances, retaining competitiveness, utilization of international frameworks and care for the environment.

Renewable energies are central within the Danish energy outlook. Already in 2010, biomass and wind represented 17.1 and 3.4% of TPES. By 2020 they aim for 30% of renewable energies in their final energy consumption.

Country's energy system

Denmark's TPES was 16 Mtoe with an energy production amounting to 15.7 Mtoe in 2015. Denmark is a net exporter for oil and gas and is also expected to remain so, until at least 2018 (for oil) and 2020 (for gas). Energy exports sum up to 16.3 Mtoe in 2015, while imports were 18.6 Mtoe. Denmark is not producing any nuclear energy.

Electricity is mostly exported to Germany and is also imported from Sweden and Norway. The share of renewable energy in TPES is already high, with about 20.7% in 2016 mostly due to wind and biomass. Energy production peaked around 2005 with over 30 Mtoe, the major source being oil, followed by natural gas. The energy production decreased since then. In 2015, oil and gas accounted for respectively 7.7 Mtoe and 4.1 Mtoe of the total energy production. The share in of wind energy (on- and offshore) was 1.2 Mtoe. Denmark's TFC of energy was 13.9 Mtoe in 2015 with an energy mix that remained relatively stable over the last years.

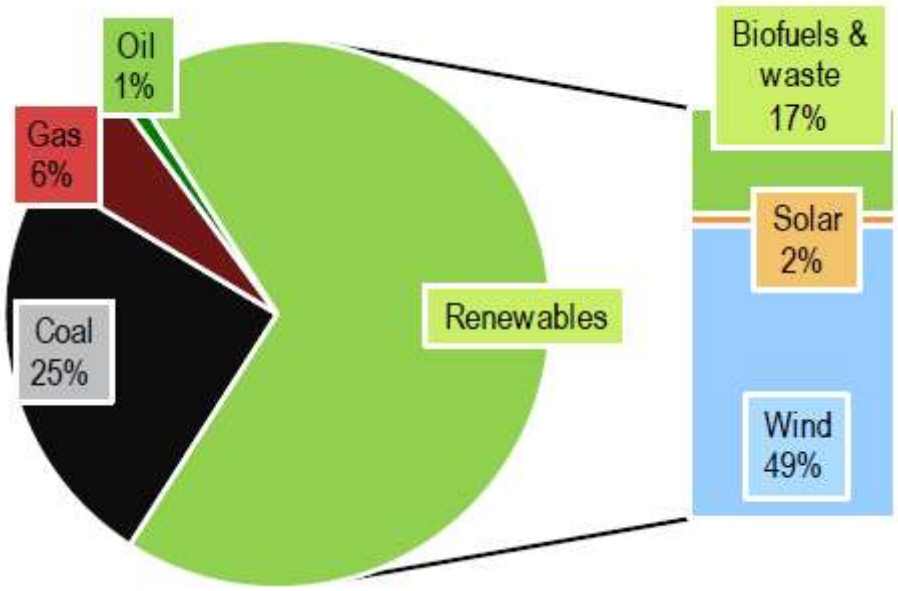

Figure 19: Percentage composition of Denmark's electricity generation (28.9 TWh) with 68% renewable energy generation in 2015 (Source: IEA).

Energy policies

The overarching long-term goal of Denmark is to become completely independent of fossil fuels by 2050. In 2011, the Danish government published a general strategic framework for the development of sectoral energy plans, called "Energy Strategy 2050: from coal, oil and gas to green energy". The Strategy sets out different principles for the transition to fossil fuel independence:

- Cost effectiveness – the transition must be cost-effective, with a focus on initiatives that provide maximum security of supply and the greatest reduction of fossil fuel use;
- Minimal impact on public finances – The distribution of costs and benefits must not create a burden on public finances. Energy consumers will finance the transition;
- Retaining competiveness – The competitiveness of Danish business will have to be considered; therefore, energy costs should not increase significantly;
- Full utilization of international frameworks – The transition must make full use of global opportunities and take advantage of participating international markets, and
- Care must be also taken to the environment.

The goal is to support a sustainable economic growth and create employment through an effective transition from fossil fuels to green energy. The energy plan will be less supported by subsidies, and mainly financed by electricity bills

Energy targets

The Energy Strategy led to a political agreement between various parties (Energy Agreement for 2012-2020), published by the Danish Ministry of 'Climate, Energy and Building' in March 2012. The agreement includes a range of new policies to support the energy projects and aims to transform Denmark into a low-carbon society with an affordable and stable energy supply. An overview of goals and actions is provided in Table 1. The strategy builds upon previous policies and work by a Climate Commission, which investigated and identified long-term climate and energy policies that will be needed to achieve independence from fossil fuels. A secondary goal of the Strategy is to secure the Danish's industry position as world leader in energy, climate and environmental technology. Implementing the strategy will also help to meet other goals and obligations, such as EU agreements. Denmark also aims to be in the top three countries in terms of renewable energy generation by 2020 and to be amongst the most energy-efficient EU members by 2020.

The strategy covers three main tracks and three phases: The phases comprise the transition phase, the preparation and planning of the next phase, and the technology development phase. It is a series of short-term initiatives, including strengthening and expansion of existing energy policies and an overall reduction of fossil fuel dependency, as well as long-term goals, which include green infrastructure and smart grid solutions.

The renewable energy sector will form the cornerstone of the new Danish energy economy. The sector has been increasing year after year. Biomass is by far the largest renewable energy source, representing 17.1% of TPES in 2010, followed by wind, which represents 3.4%. By 2020, the government aims for a 12% reduction of the gross energy consumption compared to 2006, 35% of energy produced by renewable sources, and 50% of electricity produced by wind energy (on land and offshore). Until 2030, it is estimated that renewable energies will contribute at least 30% of the total primary energy supply.

Table 1: Danish Government goals and relevant energy strategy actions.

Government Goals	Energy Strategy 2050 Actions
Fossil fuels independency by 2050.	Initiatives for increased use of renewable energy and energy efficiency improvements will reduce fossil fuel use in the energy sector by 33% by 2020, compared with 2009.
The share of renewable energy must increase to 30% of final energy consumption by 2020, as part of an overall EU target of 20% renewable energy by 2020.	Government initiatives for increased use of biomass. Wind and biomass will ensure a renewable energy share of 30% by 2020, and thus exceed compliance with the EU target.
The share of renewable energy in the transport sector must be 10% by 2020.	The government indicatives for 10% biofuels by 2020, in addition to the government´s initiatives to promote electricity cars, will ensure compliance with the EU target by 2020.

In 2020, primary energy consumption must be 4% less than in 2006.	Government initiatives for energy efficiency improvements in private homes, businesses, the state and municipalities will ensure a reduction of 6% by 2020 compared with 2006.
Emissions in the non-ETS sectors must be reduced gradually in 2013-2020 and by 20% by 2020 relative to 2005.	Government initiatives to reduce fossil fuels will also reduce non-ETS emission by 4-5 million tons CO_2.

Offshore Energy Developments

Wind

At the end of 2016, Denmark had 13 fully commissioned offshore wind farms operating in their waters with 517 turbines connected to the grid and an installed capacity of 1,271 MW. Two of these wind farms are within the North Sea, with 171 turbines and 369.3 MW capacity installed. Denmark hosted the World's first offshore wind farm, Vindeby, which was fully commissioned in 1991 and decommissioned in March 2017.

The Danish government has agreed on the construction of three offshore wind farms, one of them will have a capacity of 600 MW and will be developed in cooperation with Germany and possibly Sweden. The other project of offshore wind farm they agreed on will have a capacity of 400 MW, and an additional 500 MW capacity wind farm will be constructed nearer the coast. They should be operational by 2020. There are also 23 designated development zones for future offshore wind installations.

Wave

Conditions for wave energy are ideal in Denmark and over the last decades the Danish have been among the top international developers in the advancement of wave technologies. There are currently 11 wave projects.

1.14. Germany

Quick summary

In 2007, Germany adopted the Integrated Energy and Climate Program (IECP), including the goal to produce 30% of the generated energy using renewable sources. The IECP was followed by the German Energy Concept in 2010, setting out more long term goals, which was shortly followed by the decision to phase out all nuclear energy by 2022 and make renewable energies the cornerstone of the German energy production. The set of policies designed to realize this is called the Energiewende, including legislative measures to support renewable energy, promote energy efficiency, improve the grid, fund the reforms and phase out nuclear power. In 2030, 50% of all energy is opted to be produced by renewable sources.

Country's energy system

Germanys TPES was 311.8 Mtoe in 2015. A downward trend over the last three decades is notable. It is expected that this trend will continue until 2030, when about 216.7 Mtoe are reached.

The total energy production of Germany in 2015 was 119.8 Mtoe, of which 3.6 Mtoe were oil and 6.3 Mtoe were natural gas, while the largest share represents brown coal (38,4 Mtoe). Wind energy accounted for 6.8 Mtoe. The country exported 59.8 Mtoes of energy, and energy imports summed up to 255.8 Mtoes. In 2015, Germany's TFC was 212.1 Mtoes. By 2022, nuclear energy will be phased out.

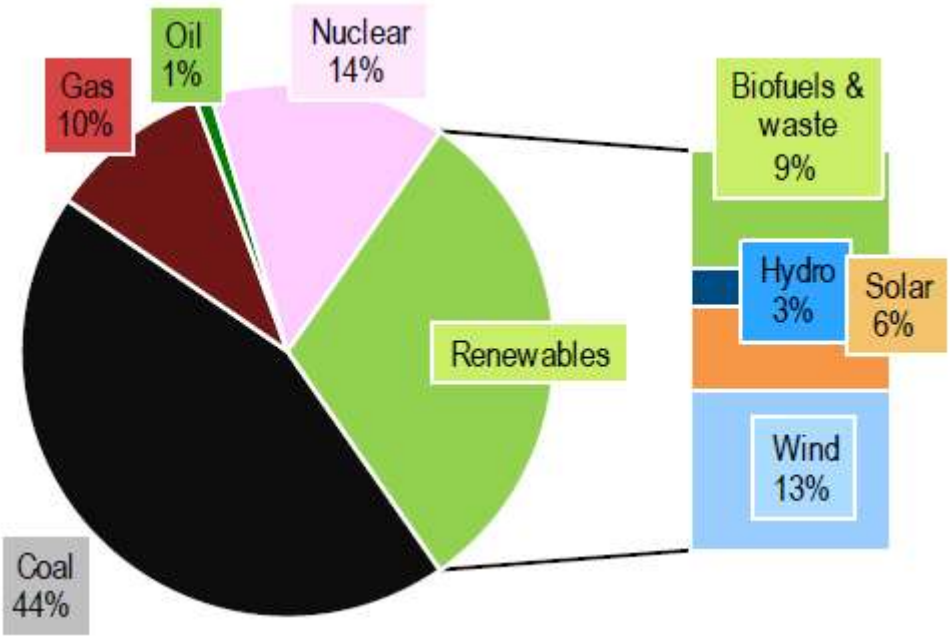

Figure 20: Percentage composition of Germany's electricity generation (641 TWh) with 31% renewable energy generation in 2015 (Source: IEA).

Energy policies

In 2007, the federal government of Germany adopted the Integrated Energy and Climate Program (IEKP) with 29 separate measures in the field of climate and energy. IEKP included the goal of an increase to at least 30% renewable electricity generation by 2020. The fundamental decision that has been taken by the German government was to obtain a greater part of its energy supply from renewable energy sources over the long term.

Likewise, in 2010, the German Energy Concept had been adopted; however the new goals were more ambitious. The concept is a comprehensive strategy for a long-term integrated energy pathway to 2050. It has been shortly followed by the decision to accelerate the phase-out of nuclear power by 2022 by closing the eight oldest plants. Renewable energy has subsequently been determined as the cornerstone of future energy supply. The set of policy instruments is known as the 'Energiewende'. The 'Energiewende' contains seven legislative measures to support renewable energy and grid expansion, while also promoting energy efficiency, fund the reforms, and reverse a previous decision to extend the lifetime of nuclear plants.

Energy targets

The aims formulated in the Energy Concept are broader and deeper compared to the Integrated Energy and Climate Program. Aims are the increase in energy efficiency, the expansion of renewable energy sources and the reduction of GHGs. This also includes the phasing out of nuclear energy by 2022. The general energy policy goals are: securing supply and protecting the climate while at the same time promoting growth and competitiveness of German industry. Germany wants to become a world leader in the fields of energy efficiency and environmental protection, while simultaneously maintaining competitive energy prices and high level prosperity. However, the core aim is to achieve a 40% cut in GHGs by 2020, 70% by 2040 and between 80 and 95% in 2050, compared to 1990 levels.

Actions focus on the expansion of offshore wind power and the expansion of power grids. There will be a monitoring process every three years. New gas pipelines are also expected to be installed in German waters and the Marine Spatial Plan foresees coordinated uses of the marine space between offshore wind energy, oil and gas, shipping, and other uses. Targets contained in the Energy Concept (Table 2):

Table 2: German targets contained in the Energy Concept

Target description	2012	2020	2030	2040	2050
Reduction in GHGs (base year 1990)	-27%	-40%	-55%	-70%	< -80%
Share of renewable energies in TFC	10%	18%	30%	45%	60%
Share of renewable energies in electricity consumption	20%	35%	50%	65%	80%
Reduction of primary energy consumption	-5%	-20%	/	/	-50%

(base year 2008)					
Reduction of electricity consumption (base year 2008)	-1%	-10%	/	/	-25%
Reduction of final energy consumption in the transport sector (base year 2008)	/	-10%	/	/	-40%

Germany aims to develop cost-effective market-based approaches for the renewable energy sector. The goal is to use renewable energies in electricity consumption to produce about half of all energy by 2030. Additionally, the cost and benefits will be transparent among all participants, especially households. It is stated that future renewable energy capacity must expand in parallel with the development of distribution and transmission networks. Close monitoring of Germany´s ability to meet electricity demands at peak times should continue.

In July 2016, the Federal Parliament amended the law on renewable energy (called EEG 2017) to introduce the new auction system for electricity produced by offshore wind sources. The law has set a target of achieving 15,000 MW of offshore wind capacity by 2030, less ambitious than the original Energy Programme (IEKP). The Offshore Wind Act was also created to support the implementation of the new law. The Act presents the new planning and licensing process which will be implemented in January 2017. The auction system will be fully implemented from 2026. BSH will undertake environmental and socio-economic assessments to identify suitable areas to develop offshore wind farms in the EEZ and will be carried out from 2026. Developers will have to receive permits to develop offshore wind farms in such sites, and successful bidders will receive subsidies for their project.

Offshore Energy Developments

Wind

At the end of 2016, Germany currently had 18 fully commissioned offshore wind farms operating in their waters with 947 turbines connected to the grid and an installed capacity of 4,108 MW. Twelve of these wind farms are within the North Sea, with 785 turbines and 3,657.8 MW installed.

Wave and Tidal

There are currently 4 wave projects in German waters and there are currently 4 tidal projects in German waters.

1.15. The Netherlands

Quick summary

The Dutch climate policies were presented in the Energy Report 2011, expressing the aim for a low-carbon economy by 2050. The 2013 Energy Agreement provided an action plan for 2020. The Dutch strategy focusses on providing reliable energy supply at competitive prices and has green growth as its economic objective. The Energy Agreement is based on the EU framework, implementing the EU targets into national policy. By 2020 the Netherlands aims to have a 14% share of renewable energies in the TFC. Currently, however the Netherlands are not on track to reach this goal. In 2015, only 5.8% of the TFC was produced by renewable sources.

Country's energy system

The Netherlands TPES was 71 Mtoe in 2015. An energy peak of 83.4 Mtoe was reached in 2010 and has declined the following years. The total energy production in 2015 was 47.6 Mtoe. The energy production is dominated by natural gas, which accounted for 39 Mtoe in 2015. Only 2 Mtoe of oil was produced and 0.7 Mtoe of wind energy. However, during the last years, there has been a shift towards renewable energies, nevertheless fossil fuels remain strong. About 4% of the country's electricity is produced by a nuclear power plant.

The country produces a large amount of natural gas – twice as much as the Netherlands consume. The gas, as well as oil is traded with other countries. The total energy imports in 2015 were 220.3 Mtoe and the export accounted for 173.7 Mtoe. In 2015, the TFC of the Netherlands was 48.5 Mtoe.

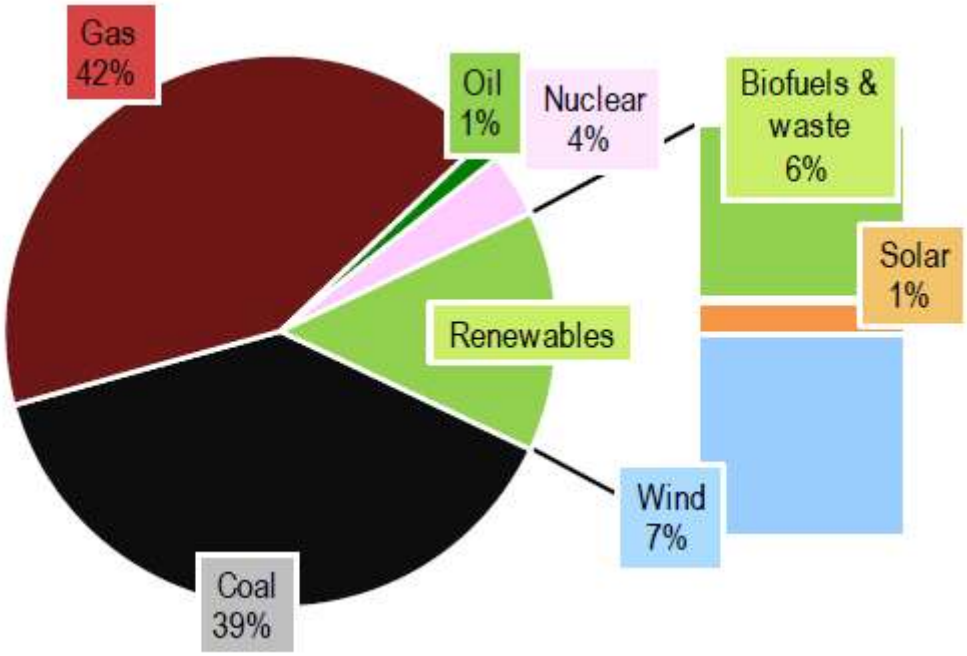

Figure 21: Percentage composition of Netherlands' electricity generation (110.1 TWh) with 14% renewable energy generation in 2015 (Source: IEA).

Energy policies

The Netherlands is a major producer of natural gas and leveraged investment in energy infrastructure facilities, such as ports, modern power plants and efficient industrial processes. Combined, this makes the Netherlands one of Europe´s largest energy trade hubs and therefore they strongly support energy security.

In 2011, the Energy Report 2011 was presented, which sets the energy and climate polices. It is written that the overall aim is to become more sustainable in energy terms of, less dependent on fossil fuels, in the transition to a low-carbon economy by 2050. In late 2013, the 'Energy Agreement' laid out the actions needed for the 2020 horizon. The model is a consensus-driven and bottom-up decision making process. It aims to align the interests of industry, civil society and government, towards the key objectives of sustainable and secure energy supply, industrial competiveness and affordability for the consumers. Finally in 2016 a new version of the Energy Report (Energy Report 2016) has been published that provides a long term and comprehensive vision of the energy system of the Netherlands

This includes the goal of an increased energy production share of renewable energies of 14% by 2020 and 16% by 2023. This Energy Report focusses on the phase after the Energy Agreement, beyond 2023. In Netherlands' energy policy, three main principles are highlighted 1) focus on CO_2 reduction; 2) make the most of the economic opportunities that the energy transition offers, and 3) integrate energy in spatial planning policy.

The pillars of the strategy are: ensuring reliable energy supply at competitive prices and green growth as primary economic objectives, while also maintaining an international approach in the long-term transition to a sustainable energy supply. The key policy objectives are:

- A modern industrial policy to strengthen the competitiveness of the Dutch energy sector through public support to businesses and knowledge institutions to work together in the development of energy technologies
- Expand the share of renewable energies to meet EU targets through the Sustainable Energy Incentive Scheme (SDE+)
- Encouraging energy conservation and decentralized sustainable energy generation
- Providing scope for all energy options for a reliable energy supply to ensure a balanced mix of green and conventional energy
- Investing in a sound European energy market with a good infrastructure by ensuring careful spatial planning, including the connection to future offshore wind and cross-border co-operation of transmission system operators

Energy targets

The country is on track to meet its targets under the Kyoto Protocol. As an example, the GHG emission in 2012 were 8.8% lower compared to 1990, while the gross domestic product had increased by about 50% in the same period. However, the European goal of 14% renewable energy share increase by 2020 is not expected to be met[80] (Netherlands in 2015: 5,8%, expected for 2020: 11,9%).

The National Energy Agreement of 2011 is a long-term vision and more consistency in policy making. It contains the goal of 14% renewable energy by 2020, and made energy efficiency a key priority. A new Energy Agreement for Sustainable Growth was adopted in 2013. This energy agreement is expected to deliver 13 to 18 billion Euros of extra investments and approximately 15,000 extra jobs between 2013 and 2020. The energy agreement presents a ten-point action plan for 2020. Key is to balance between sustainability and competitiveness, enhancing energy efficiency and stimulating new investments in the sector, while reducing the financial burden for citizens and companies.

The Netherlands is ambitious to reduce CO_2 emissions in the transport sector by 60% by 2050. It supports the reduction of GHG emission of at least 40% by 2030 and further reductions of 80–95% by 2050 in line with international commitments. So far, the Netherlands is lacking behind its target for renewable energies, especially compared to Germany or the Denmark.

The Dutch government is committed to an international climate policy. The Climate Letter 2050 (Klimaatbrief 2050) of 2011 has four core elements to achieve a climate neutral economy by 2050: CO_2-free electricity supply, sustainable use of biomass, energy savings and CCS. This was reaffirmed in 2013 to achieve a CO_2 reduction of 80-95% in 2050 compared to 1990.

The Energy Agreement for Sustainable Growth, signed by the cabinet in 2013, sets a goal for producing 14% of the energy from renewable sources by 2020 and up to 16% by 2023. The Water Policy within the National Water Plan will contribute to achieve these objectives particularly in the areas of energy production, energy storage and transport. The activities of interest for energy production are offshore wind energy, minerals, oil and gas extraction, sand extraction and CO2 storage.

Moreover, the Agreement aims towards deploying more renewable energy. It also promotes sustainable energy at local level, network investments and a strong EU Emission Trading Scheme. Furthermore, the transition to clean coal and carbon capture and storage technologies, energy savings and emission reductions in transport, and the commercialization of clean technologies are promoted.

[80] Planbureau voor de Leefomgeving. (2016, September 9). Balans van de leefomgeving 2016. Opgeroepen op Januari 30, 2017, van Planbureau voor de leefomgeving: http://themasites.pbl.nl/balansvandeleefomgeving/jaargang-2016/themas/energie-en-klimaat/hernieuwbare-energie

Offshore Energy Developments

Wind

At the end of 2016, The Netherlands had 6 fully commissioned offshore wind farms operating in their waters with 365 turbines connected to the grid in 2016 and an installed capacity of 1,118 MW. Four of these wind farms are within the North Sea, with 289 turbines and 957 MW capacity installed. The Dutch government is aiming at implementing 4,450 MW of offshore wind energy by 2023. It has been agreed in the Energy Agreement that the government will provide a robust framework to achieve the offshore wind energy production target. In this purpose, consultation has been undertaken with the wind energy sector.

Eleven areas have been designated by the government to develop wind farms in the Dutch sea waters. Within each area, several wind farm sites will be developed and seven of them will have a capacity of 1,000 MW. The indicators that have been use to designate the areas were the transport routes, distance to mining sites and other uses of the area, hydrology, sediment type and wind speeds. The government will provide the permit and subsidies to the company that has the best and least expensive plan for offshore wind energy production on these sites.

Tidal

The Netherlands currently have 5 tidal projects. The Netherlands produced its first commercial tidal energy in 2015 by placing five turbines between the pillars of the Oosterschelde storm barrier in Zeeland.

1.16. Norway

Summary

Norway's energy policy is focusing on creating long-term management and assuring value-creation within an environmentally acceptable framework for their petroleum sector. In doing so, Norway aims to reduce CO2 reduction from fossil fuels and they have voluntary strengthened their Kyoto commitment. A key element in their policy is also to limit the growth in energy consumption and increase energy use efficiency. The renewable energy sector is still relatively limited in Norway, but efforts are made to investigate off-shore wind possibilities.

Country's energy system

Norway's energy production amounted to 207.8 Mtoe in 2015 and only varied slightly within the last decades. Oil and natural gas accounted both for almost half of Norways energy production (respectively 91.4 Mtoe, 102.1 Mtoe) of Norway's energy production in 2015. The remaining production came mainly from hydropower, while coal, biomass and wind power contributes only minor to the energy production.

The country exports most of its oil and gas with net exports of about 185.2 Mtoe and imports of only 8.1 Mtoe in 2015. In this same year the TPES was 30.2 Mtoe, this has increased since the 1990s. The TFC of energy was 18.6 Mtoe in 2015.

The future oil production is expected to decline, while the total natural gas production is likely to increase in the next years. The demand for natural gas is calculated to be significant higher in the coming decades. Currently, there is no nuclear power plant in Norway.

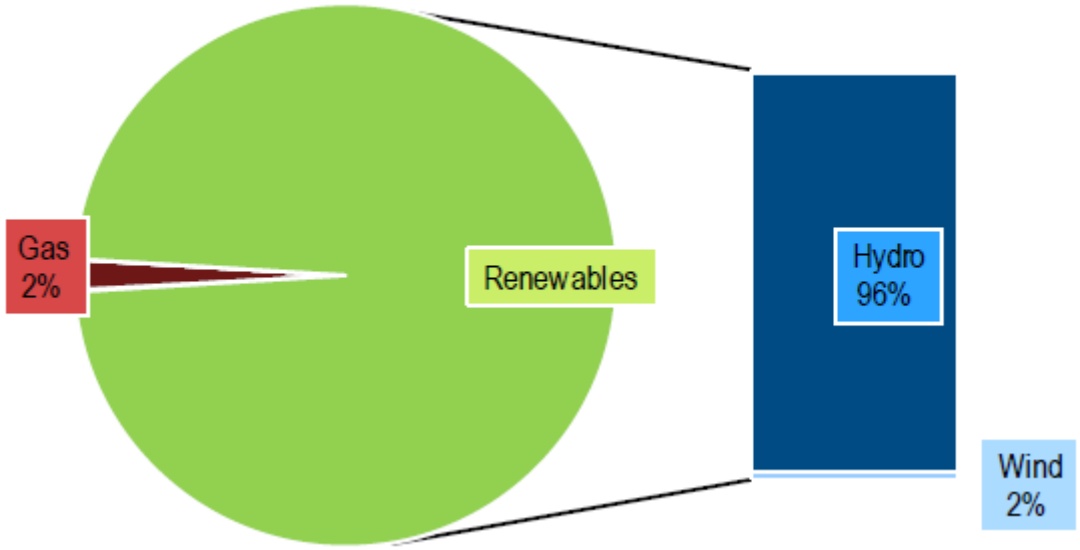

Figure 22: Percentage composition of Norway's electricity generation (143.9 TWh) with 98% renewable energy generation in 2015 (Source: IEA).

Energy policies

Norway is a major oil and gas producer but also a strong advocate of climate change mitigation, while being one of the largest energy exporter in the world.

The main objective of the Norwegian government for the petroleum sector is to assure long-term management and value creation within an environmental acceptable framework, and in coexistence with other users of Norway's waters. High employment and creating wealth in Norway is an important part of it. The petroleum sector has contributed to the state´s strong financial position and welfare society. Oil and gas in Norway are produced in an environmentally-friendly manner with low GHG emissions. Through various policies, the country aims to remain the world leader in this field and to contribute to a sustainable energy future.

The government's priorities for Norway's domestic energy supply sector, which excludes the export-oriented oil and gas production, are outlined in the April 2016 White Paper Power for Change – an energy policy towards 2030.

Norway is frontrunner in cross-border integration and electricity market liberalization. The government emphasizes the construction of new connections and the upgrading of existing ones, also across borders. Furthermore, an increased access to renewable energies is promoted. A central element to the countries energy policy is to limit the growth in energy consumption and to make energy use more efficient. Moreover, research and development are perceived as crucial for increasing value creation.

The Ministry of Petroleum and Energy is the authority responsible for oil and gas and renewable energy developments in Norway. The management plan for the North Sea provides a framework for oil and gas activities in the North Sea area of the Norwegian waters.

Energy targets

The government envisions itself as a leader in the development of environment-friendly energy. To this end, they want to implement new technologies, amongst others to reduce CO2 emission from fossil fuel production. A comprehensive set of policy instruments has therefore been developed. By 2020, Norway aims to cut emissions of GHGs equivalent to 30% of the country's emissions in 1990, while also aiming to be carbon neutral by 2030.

The Norwegian government has developed policies to achieve a low-carbon emissions economy by 2050. Currently, the offshore wind sector in Norway is limited to one floating wind turbine in operation. The cost of renewable energy development prevents Norway from going ahead in this sector, making further developments uncertain.

In 2010, a working group for Offshore Wind Power formed by the Norwegian Water Resources and the Energy Directorate, a governmental agency, identified suitable areas for developing offshore wind. Fifteen areas were identified and five of them were located within the management plan area. In 2011 and 2012 a strategic impact assessment was conducted, taking account of the important areas for oil and gas exploitation in Norwegian waters. The impacts of offshore wind power development on the oil and gas sector have been evaluated as moderate, minor or insignificant depending on areas. It has been considered that, as areas are large, it would be very likely that solutions could be found to make activities coexist. Therefore, when offshore wind farms will be integrated in the marine management plans, any conflict with other sectors will be resolved and a compromise should be found before starting any development. The working group identified 4 priority areas in the North Sea for developing offshore wind, representing from 58 to 2591 km^2. These four sites would produce 1.6 to 3.7 GW of electricity together.

Offshore Energy Developments

Wind

At the end of 2016, Norway had 1 fully commissioned wind turbine, with 1 turbine connected to the grid and an installed capacity of 2 MW. This is Statoil's Hywind Floating Wind Demo project within the North Sea. This technology has now lead to a full-scale commercial floating wind farm in Scotland, also called Hywind. However in Norway, the consent of 5 offshore wind farms has been authorised each with a capacity of 10 MW.

Wave

There are currently 12 wave projects in Norway. The developer, Waves4Power have a demonstration site in Runde Norway where they are carrying out field trials of WECs[81]. Waves4Power has also developed a 100 kW power plant which has been delivering electricity to the Norwegian power grid since 2nd June 2017.

Tidal

There are currently 6 tidal projects in Norway, with 1 project, TideTec Test being fully commissioned with a capacity of 0.1 MW. There are also 4 projects that have their consent authorised. Two tidal projects have already been decommissioned.

[81] https://oceanenergy-sweden.se/projects/

1.17. Sweden

Summary

In 2009, Sweden presented the Integrated Climate and Energy Policy, implementing the European 20/20/20 goals, but also raising the bar beyond these. Different action plans lay out the strategy to reach the targets set. For 2045 Sweden aims to reach 100% renewable electricity production. The three main pillars of the Swedish energy policy are (1) ecological sustainability, (2) competitiveness and (3) security of supply. In 2013, only 0.4% of the total energy production was produced through offshore wind.

Country's energy system

Sweden´s TPES was 50 Mtoe in 2015 with a stable level over the last decades (only interrupted by a drop in 2009 due to the financial and economic crises). TFC was 31.8 Mtoe in 2015. According to the Swedish Energy Agency, the countries total final consumption (TFC) is expected to grow until 2020, while remaining stable between 2020 and 2030. Numbers, such as a 10.4% increase in the TFC until 2020, are predicted mostly due to the industry sector. They also project that the energy supply from biofuels and waste will increase until 2020. Afterwards, most renewable energy will come from wind power, which will grow the strongest from 2020–2030. The long-term forecast of the Swedish Energy Agency is expecting a total energy production from wind power of about 175 Twh in 2030.

In 2015, Sweden produced 33.6 Mtoe of energy, with no oil or gas production. Wind energy made up for 1.4 Mtoe in this same year. Sweden imported 32.6 Mtoe and exported 18.31 Mtoe of energy.

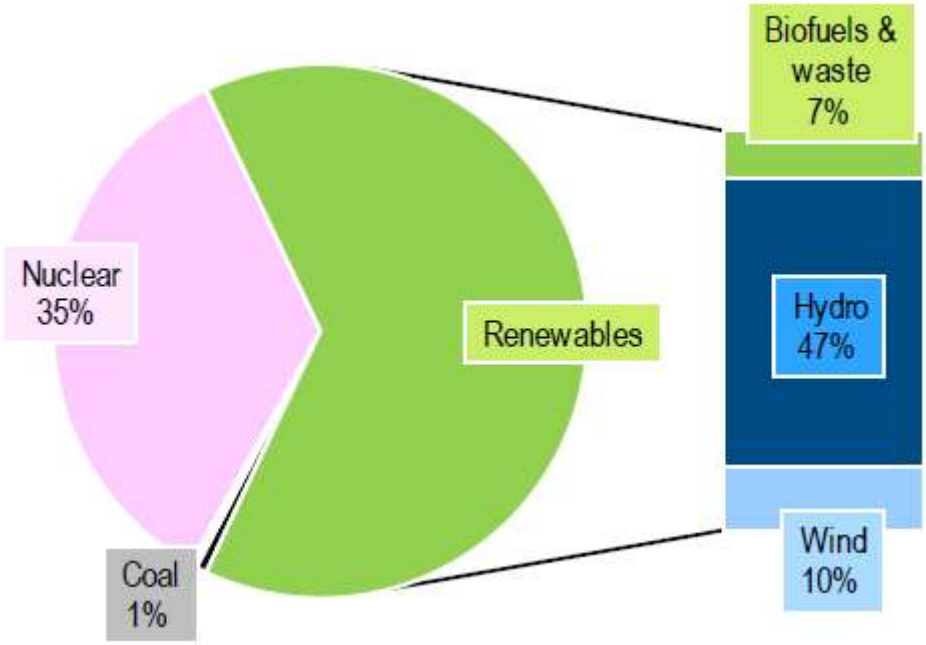

Figure 23: Percentage composition of Sweden's electricity generation (161.9 TWh) with 64% renewable energy generation in 2015 (Source: IEA).

Energy policies

Sweden's long-term goal is described as an economy based on sustainable energy with low-carbon intensity and high share of renewable energy in the total energy supply, with strong growth coming from solid biofuels and onshore wind. The Swedish Government approved a major bill in 2009 called the "Integrated Climate and Energy Policy". It sets out ambitious targets in support of and beyond the 20/20/20 objectives of the EU, especially regarding sustainable policy for the environment, competitiveness and long-stability. For the long-term, two priorities are set: a fossil-independent vehicle fleet by 2030; and a zero net GHG emission by 2045.

The Climate Roadmap 2050 developed by the Swedish Environmental Protection Agency in collaboration with the Swedish Energy Agency points out how to achieve the 2050 vision of zero net GHG emissions in a cost-efficient way based on different emissions trajectories in different sectors. The Climate Roadmap 2050 also describes the three main elements of a successful transition: cost-effective market based measures, consumer benefits and technological innovation.

Sweden is regarded to be the leader in smart grid technologies and it is well integrated into the Nordic electricity market. Furthermore, the government is strongly committed to reduce oil use in heating and the transport sector by increasing the share of renewable energies. In 2013, all natural gas consumed in Sweden was imported via a single pipeline from Denmark.

As part of the Integrated Climate and Energy Policy, an action plan for renewable energy has been set in motion. This includes a higher ambition for the electricity certificate system with an increase of 25 TWh by 2020 compared to 2002 (with 10 TWH offshore) to provide orientation to municipal spatial planning procedures. In addition, an action plan for energy efficiency has been adopted.

Impacts of climate change adaptation have been fully integrated in the Climate and Energy Policy Framework by Sweden. Regional responsible is given to co-ordinate activities in the area. The fundamental basis for the integrated policy is energy markets with effective competition, efficient use of resources and effective pricing.

Energy targets

At the latest in the year 2045, Sweden aims to have no net emissions of greenhouse gases to the atmosphere, and will thereafter achieve negative emission. Furthermore, the goal in 2040 is 100% renewable electricity production.

Within the "Integrated Climate and Energy Policy" both short and long term targets were included.

Short term targets until 2020 are:

- 40% reduction of GHGs (about 20 million tons of carbon dioxide equivalent (MT Co2-e compared to 1990);
- At least 50% share of renewable energy in the gross final energy consumption;
- At least 10% share of renewable energy in the transport sector; and
- 20% more efficient use of energy compared to 2008.

Long-term targets are:

- By 2030, Sweden aims to phase out fossil fuels in heating.
- By 2030, have a vehicle stock that is independent from fossil fuels.
- Be committed to develop a third pillar of electricity supply, next to hydro and nuclear power, with increased co-generation, wind and other renewable power production to reduce vulnerability and increase security of electricity supply.
- By 2050, the vision to have sustainable and resource-efficient energy supply with zero net emission of GHGs.

Besides this, Sweden joins the overall effort of the EU to achieve the Union-wide target of reducing CO2 emissions by 21% relative 2005 until 2020.

Offshore wind is the main source of offshore energy in Sweden, which presents good conditions for wind energy production regarding wind speed, depth and size of the potential sites. In 2013, the production of electricity from offshore wind sources accounted for only 0.4% of the total electricity.

Swedish nuclear power is facing major investment needs to meet future safety requirements. The Swedish Radiation Safety Authority has decided that these new requirements need to be met by 2020, otherwise the reactors may not continue operation. It has already been decided that four reactors will be decommissioned before 2020. Nuclear power must bear its own costs, and the principle that nuclear power should not be subsidized remains.

Offshore Energy Developments

Wind

At the end of 2016, Sweden had 5 fully commissioned offshore wind farms operating in their waters with 86 turbines connected to the grid and an installed capacity of 202 MW. However, none of these projects are within the North Sea Region. A further 8 projects have their consent authorised and are expected to be constructed within the near future. A National interest area of wind farm development has been designated with a planned capacity of 20,430 MW.

Wave

There are currently 10 wave projects in Sweden. Some Swedish developers are Ocean Harvesting, Waves4Power and Corpower. CorPower is currently in a

Stage 3 pilot together with Iberdrola Engineering, WavEC Offshore Renewables, EMEC and University of Edinburgh. In this program a 25kW WEC undergone ocean testing at EMECs Scapa Flow nursery site on Orkney during the first half of 2017.

Tidal

There are currently 2 tidal projects in Sweden, Current Power AB which is a horizontal axis turbine and Minesto (Deep Green) which is a Tidal Kite.

1.18. UK

Quick Summary

The UK has set out targets to reduce GHG emissions with 50% until 2027 and 80% until 2050. To reach these targets three technological pathways are laid out: renewable sources, nuclear power and carbon capture and storage (CCS). Currently 21% of the UK's energy production is provided by nuclear power, and they aim to increase this in the coming years. To decrease their already relatively low energy use per unit GDP, the UK has introduced the Green Deal. A focal point in their policy is also the security and supply of energy in a qualitative and reliable way. In 2015, renewable energies electricity generation made up for 26% of the UK's total energy requirements.

The Scottish government has set out more ambitious goals for 2020. They aim to generate 100% of the gross annual consumption and 11% of the heat consumption using renewable sources. The large wave and tidal energy resources in Scotland have the potential to produce more than needed for Scottish consumption. Moreover, Scotland has 25% of Europe's off-shore wind potential.

Scotland has large wave and tidal energy resources and the potential to generate more electricity than currently needed around the Scottish coast. Furthermore, Scotland boasts 25% of Europe´s offshore wind resources.

Country's energy system

The UK´s TPES was 180 Mtoes in 2015 and its TFC 130.3 Mtoe. TPES is on a decreasing trend with a slight average decline each year. It is expected that this trend continues until 2020 and reduce TPES supply by 13% compared to 2010. Natural gas dominates the energy supply and plays an increasingly important role as a fuel for electricity generation and space heating.

The UK produced 118.3 Mtoe of energy in 2015, of which 46.5 Mtoe oil, 35.7 Mtoe natural gas, and 3.5 Mtoe wind energy (both off- and onshore).

The government expects renewable energy supply to grow strongly to 2020 with up to 22% per year for wind power as the UK still imported around 30% in 2010 of its energy supply. The total import of energy in 2015 was 143.2 Mtoe and the export 71 Mtoe.

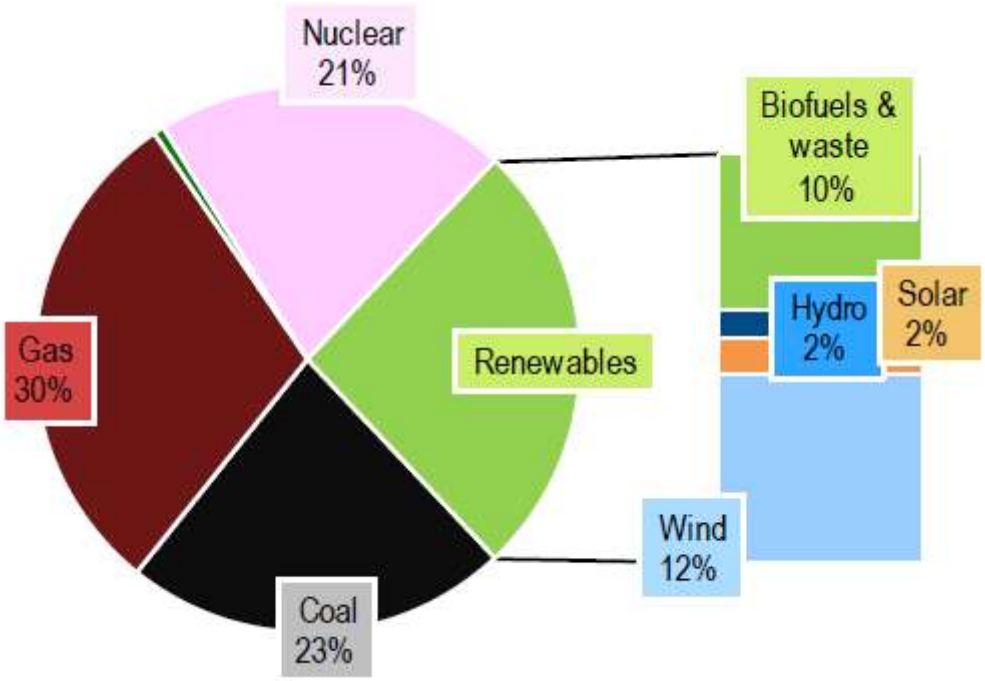

Figure 24: Percentage composition of United Kingdom's electricity generation (336.4 TWh) with 26% renewable energy generation in 2015 (Source: IEA).

Scotland accounts for 10% of UK energy consumption and like the rest of the UK, 93% of Scotland's TPES in 2016 came from oil and gas. Scotland's energy balance in 2016 shows that 102.478 Mtoe of energy was produced and imported and out of this, 13.736 Mtoe of energy was consumed and the remaining 88.742 Mtoe of energy was exported or reported as a loss.

In terms of Scotland's electricity generation mix in 2016, in descending order of percentage: 19,676 GWh (42.9%) from renewables, 19,630 GWh (42.8%) from nuclear, 3,130 GWh (6.8%) from gas, 2,238 GWh (4.9%) from coal and 1,839 GWh (1.5%) from oil. Scotland is a net exporter of electricity to the UK exporting 20% of total generation in 2016.

Energy policies

The following section focuses on energy polices in the UK (England, Wales, Scotland, and Northern Ireland), while also highlighting the Scottish ambitions due to Scotland's neighbouring of the North Sea as well as partners composition.

In the past, the UK has heavily relied on fossil fuels as energy supply. Political parties have agreed on the need to decarbonize the energy system and laid out targets to reduce carbon emissions up to the year 2050. Greening the economy is perceived as an opportunity for creating future jobs and growth. Climate change has therefore become a priority in the energy policy.

The UK has set binding targets to reduce GHG emissions by 50% by 2027 and 80% by 2050 from 1990 levels. To that end, the electricity sector is in the focus of the carbon reduction efforts of the UK. Three low-carbon technology pathways are indicated: renewable sources, nuclear power and carbon capture and storage (CCS).

Since 2013, the UK is world leader in installed offshore wind power capacity. Yet, several thousand wind turbines (on- and offshore) need to be installed, while also adding the necessary network connections.

Furthermore, plans are made to invest in more nuclear energy in the UK. Currently, about 21% of electricity is provided by nuclear energy. Besides nuclear energy, the UK is among the most committed supporters of CCS worldwide and does significant research in this field. Different coal and oil-fired capacities are scheduled to close within the next years.

The political parties agreed that the energy system needs to be transformed to become more secure and low-carbon. The government aims to catalyse private sector investments in new infrastructure and energy efficiency by developing a clear, transparent and long-term policy framework. Therefore, the UK's energy policy focuses on four key areas:

- Saving energy through the Green Deal and supporting vulnerable consumers.
- Delivering secure energy on the way to a low-carbon energy future.
- Managing the countries energy legacy responsibly and cost-effectively.
- Driving ambitious action on climate change at home and abroad.

Key is also the security and supply of energy. The UK wants to ensure that energy supplies are of right quality, reliable, secure and can provide for future demand. Policies encourages open, transparent energy markets, both domestically and internationally; diverse energy sources; international energy dialogue; and timely and accurate information of market.

Energy targets

Related to the above-mentioned key policies, the Climate Change Act 2008 is the approach to avoid the risk of dangerous climate change by cutting GHG emissions by 34% by 2020 and 80% by 2050 below the 1990 levels and setting and meeting five-year carbon budgets for the UK during that period.

The UK transition comes with the need for sufficient infrastructure planning to ensure costumer protection while maintaining energy affordability, ensure public acceptance, minimize effects of new infrastructure on the population, ensure environmental protection, ensure the transport and infrastructure planning framework and finally, ensure infrastructure deployment in a timely manner. The 2008 Planning Act is the tool to secure that these targets are met in England and Wales. Scotland has developed the Electricity Act.

The largest renewable energy sector in 2015 in Scotland is onshore wind, followed by solar. Renewable electricity generation made up to about 26% of the total UK energy requirements in late 2015. Renewable energies are also the single largest contributor to electricity generation in Scotland (compared to nuclear generation and fossil fuels). The Scottish Government has the overall renewable

energy target to generate the equivalent of 100% of gross annual electricity consumption and 11% of heat consumption by 2020. Scotland has large wave and tidal energy resources and the potential to generate more electricity than currently needed around the Scottish coast. Furthermore, Scotland boasts 25% of Europe´s offshore wind resources.

Moreover, Scotland is estimated to have the largest oil reserves in the EU, accounting for about 60% of total EU reserves.

Scotland is developing sectoral plans for offshore wind, tidal and wave energy to meet the targets that Scotland has set:

- 100% electricity demand generated by renewable energy sources in 2020,
- 42% greenhouse gas emissions cut by 2020 (compared to 1990 levels) and at least 80% by 2050,
- Achieve the contribution to a low carbon economy.

A strong political aspiration drives the development of offshore energy planning to find an alternative to finite fossil fuels and promote sustainable growth. The Low Carbon Economic Strategy and Climate Change (Scotland) Act 2009 provides a framework for Scotland's actions to adapt to climate change and develop low carbon economy. Scotland has an estimated potential of offshore resource of 206 GW. The main energy sectors are offshore wind, tidal and wave power, and oil and gas.

Scotland's wind energy target is to install 5 GW from Offshore wind energy territorial waters and 4.8 GW of electricity for two Round 3 sites in Scottish Offshore Waters, before 2020. Its potential is about 25% of the whole European offshore wind resource. The Offshore wind energy plan for Scotland, called Blue Seas Green Energy, was published in March 2011 and adopted in 2013.

The Scottish Government aims at installing a tidal capacity of 398MW by the early 2020s. In this purpose, the Scottish Government has developed a Marine Plan for Tidal Energy in Scottish Waters for the development of tidal renewable energy in Scottish Waters (0–200 nautical miles).

Offshore Energy Developments

UK

At the end of 2016, the UK had 28 fully commissioned offshore wind farms operating in their waters with 1,472 turbines connected to the grid and an installed capacity of 5,156 MW.

Scotland

Wind

Currently Scotland has two offshore wind developments that are fully commissioned with 63 turbines connected to the grid and generating at capacity of 204 MW. There are 4 upcoming projects that are in the process of being constructed with the Beatrice offshore wind farm in the Outer Moray Firth expected to become fully operational in 2019 with 84 turbines and a generating capacity of 588 MW. The North Sea wind farms: Inch Cape, Neart na Gaoithe and Seagreen Alpha and Bravo totalling 2,282 MW also have their consent authorised and are beginning preparations.

Wave

There are currently no fully commissioned wave projects in Scotland. However, testing of wave devices is progressing at the test facility at EMEC.

Tidal

There are currently 3 tidal projects fully commissioned in Scotland. The MeyGen Tidal Energy Project is split into several phases with Phase 1 implementing a generating capacity of up to 86 MW. MeyGen have currently installed Phase 1A which includes 4 turbines with a generating capacity of 6 MW and have consent authorised for Phase 1B which will introduce a further 6 MW. There is also progression with tidal devices being tested at the test facility at EMEC where they have development zone for wave and tidal energy developments.

Sources

EU Commission (2010) National Action Plan Belgium
EU Commission (2010) National Action Plan Denmark
EU Commission (2010) National Action Plan Sweden
EU Commission (2012) National Action Plan Norway
EU Commission (2012) National Action Plan UK
EU Commission (2014) National Action Plan the Netherlands
Eurostat (2015) Energy balances 2015. ec.europa.eu/eurostat/documents/38154/4956218/Energy-Balances-January-2017-edition.zip/3f9e5208-67cc-4dfd-8bdf-e260d9983641
EWEA (2014) Wind energy Scenarios 2030. https://www.ewea.org/fileadmin/files/library/ publications/reports/EWEA-Wind-energy-scenarios-2030.pdf
IEA (2007) International Energy Agency: Energy policies of the IEA countries Belgium. http://www.iea.org/publications/freepublications/
IEA (2009) International Energy Agency: Energy policies of the IEA countries Norway http://www.iea.org/publications/freepublications/
IEA (2010) International Energy Agency: Energy policies of the IEA countries Denmark http://www.iea.org/publications/freepublications/
IEA (2011) International Energy Agency: Energy policies of the IEA countries Germany. http://www.iea.org/publications/freepublications/
IEA (2011) International Energy Agency: Energy policies of the IEA countries Sweden http://www.iea.org/publications/freepublications/
IEA (2011) International Energy Agency: Energy policies of the IEA countries UK http://www.iea.org/publications/freepublications/
IEA (2012) International Energy Agency: Energy policies of the IEA countries Netherlands http://www.iea.org/publications/freepublications/
OECD (2015) Country statistical profiles: Key tables from OECD. http://www.oecd-ilibrary.org/ economics /country-statistical-profiles-key-tables-from-oecd_ 20752288;jsessionid=tqwo12m58ez.x-oecd-live-02
Windeurope (2015) Annual Statistics 2015 https://windeurope.org/wp-content/uploads/files/about-wind/statistics/EWEA-Annual-Statistics-2015.pdf
Windeurope (2016) Annual Offshore Statistics https://windeurope.org/wp-content/uploads/files/about-wind/statistics/WindEurope-Annual-Offshore-Statistics-2016.pdf