Integrating climate and energy policies

Points of inspiration from the energy transition in Denmark

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Integrating climate and energy policies

Points of inspiration from the energy transition in Denmark

When the oil crises hit in 1973 and 1979, Japan and Denmark were in the same situation. Both were fully dependent on fossil fuels, particularly oil from the Middle East, and both - like many other countries - experienced inadequate energy supply leading to deep economic crises. Since then, energy developments differ significantly for the two countries.

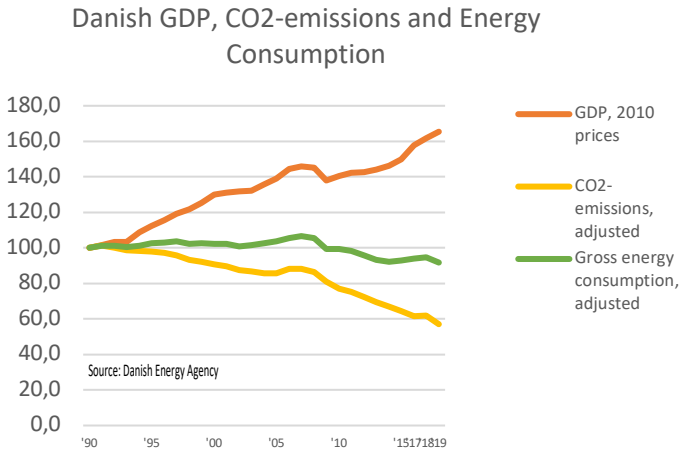
Denmark has evolved into a frontrunner in green transition, striving for GHG emission reductions of 70% by 2030 and climate neutrality by 2050. The key to the Danish development has been comprehensive energy policies to promote energy efficiency, energy savings and renewable energy sources which have been consistently implemented and continuously enhanced despite changing governments. Since 2020, the Danish Climate Act provides a systematic approach to ensuring that adequate policy measures are implemented in due time.

For Japan, the 2011 Great East Japan Earthquake and the subsequent accident at the Fukushima Daiichi Nuclear Power Plant led to a higher dependence on fossil fuels as nuclear energy was substituted by coal and natural gas. However, Japan recently adopted the targets of a 46% reduction in GHG emissions by 2030 and carbon neutrality by 2050.

This paper seeks to identify elements of the Danish energy transition that may be of interest to Japan when striving for the ambitious new climate targets. [1]

1. Danish energy developments since the 1970s

Denmark was fully dependent on fossil fuels when the two oil crises hit in the 1970s. The deep economic crisis led to a target of energy security through self-sufficiency and independence from the Middle East, substituting oil by coal in the power plants and taking advantage of domestic oil and gas supplies in the North Sea. The energy self-sufficiency ratio reached 100% in 1997. However, the domestic oil and gas was challenging to extract and limited in quantity. Therefore, the strategy was to increase energy efficiency and energy savings, while also exploring alternative energy sources.



Denmark has a long tradition of wind turbines, and wind energy has been promoted since the 1970s. While nuclear power was expected to be part of the energy strategy, public opinion against nuclear power grew in the late 1970s, and in 1985, the Danish Parliament decided not to include nuclear power in the Danish energy planning.

The need for a sustainable development became a political priority in Denmark following the so-called Brundtland report from 1987[2], and the attention to climate change intensified while preparing to host COP15 in 2009. The focus on renewable energy, energy

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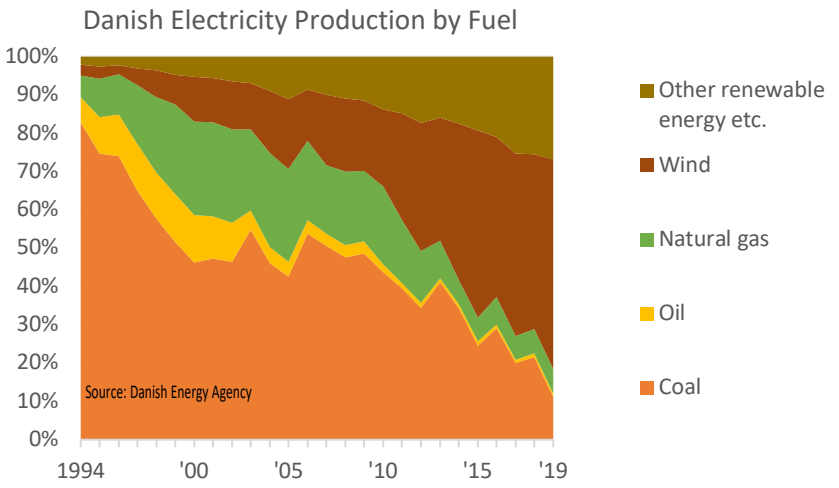
[1] The information on Danish climate and energy policies draws on the paper "Integrating climate and energy policies and promoting wind power - The case of Denmark", 28 October 2021, Gitte Wallin Pedersen, https://cigs.canon/en/uploads/2022/01/Integrating%20climate%20and%20energy%20policies%20and%20promoting%20wind%20power.pdf.

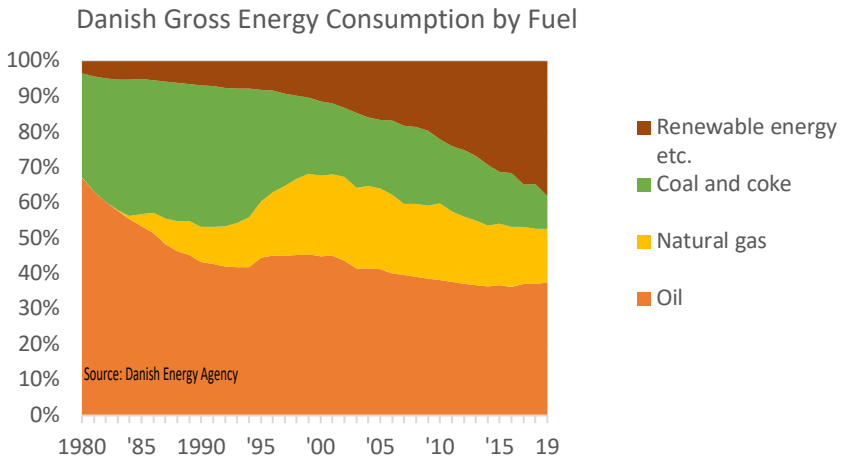
[2] The World Commission on Environment and Development, "Report of the World Commission on Environment and Development: Our Common Future", 20 March 1987, https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf.

efficiency, and energy savings implied a stable energy consumption and lower emissions even though GDP increased substantially. The CO2 emissions[3] were reduced by 43% from 1990 to 2019 while total GHG emissions were reduced by 40% in the same period.[4] The reduction mainly took place in the generation of electricity and district heating which accounted for 30-40% of the emissions until 2010 but only 11% in 2019. In 2019, emissions from agriculture, forestry, horticulture & fisheries made up 32% while the transport sector accounted for 29%.[5]

In particular, the generation of electricity has evolved towards renewable energy which accounted for 82% of the production in 2019 (wind, solar, biomass, and biogas).[4] Wind power is especially important as it accounted for 55% of the electricity production in 2019. When focusing on domestic power supply, renewable energy accounted for 67.5%, including a wind power share of 46.8%.[4] The promotion of wind power has spawned the world's largest manufacturer of wind turbines, Vestas, and the largest offshore wind energy developer, Ørsted. At the same time, Denmark has a security of supply of 99.99% and there have been no disruptions in electricity supply due to lack of production capacity.[6] The domestic electricity supply is supplemented by interconnectors to the neighboring countries.



The gross energy consumption since 1980 reflects the increasing importance of renewable energy, reaching a share of 38% in 2019, as well as the phasing-out of coal.[4] Since 1997, no new coal-fired power plants have been approved. Ørsted has announced the phase-out of coal in their plants by 2023.[7] The remaining 2 coal-fired plants (owned by municipalities) expect to abolish coal by 2023[8] and 2028[9]. However, the energy mix also indicates that further measures are necessary as oil and natural gas are still important energy sources with shares of 37.6% and 15.1%, respectively.



[3] Adjusted for fuel consumption for net import of electricity, as well as for temperature fluctuations.
[4] The Danish Energy Agency, website, "Månedlig og årlig energistatistik", https://ens.dk/service/statistik-data-noegletal-og-kort/maanedlig-og-aarlig-energistatistik.
[5] The Danish Energy Agency, "Klimastatus og –fremskrivning 2021", p. 13, April 2021, https://ens.dk/sites/ens.dk/files/Basisfremskrivning/kf21_hovedrapport.pdf.
[6] The Danish Energy Agency, website, "Electricity", https://ens.dk/en/our-responsibilities/electricity.
[7] Ørsted, Press Release, "DONG Energy to stop all use of coal by 2023", 2 February 2017, https://orsted.com/en/media/newsroom/news/2018/06/dong-energy-to-stop-all-use-of-coal-by-2023.
[8] Fjernvarme Fyn, website, "Fjernvarme Fyn udsætter kulstop tre måneder på grund af krigen i Ukraine", https://www.fjernvarmefyn.dk/nyheder/fjernvarme-fyn-udsaetter-kulstop-tre-maaneder-paa-grund-af-krigen-i-ukraine.
[9] Aalborg Forsyning, Press Release, "Det haster med en aftale om at fremskynde udfasning af kul på Nordjyllandsværket", 5 October 2021, https://aalborgforsyning.dk/privat/nyheder-og-presse/seneste-nyheder/5-oktober-2021-det-haster-med-en-aftale-om-at-fremskynde-udfasning-af-kul-pa-nordjyllandsvaerket/.

1.1 Organization of Danish climate and energy policies

In Denmark, climate and energy policies are integrated in the Danish Ministry of Climate, Energy and Utilities which is responsible for national and international policies to promote effective and stable solutions in the areas of climate, energy, and utilities. The Department has around 200 employees and it is organized in five centers: Center for Vision and Strategy; Center for Climate Neutrality in Denmark; Center for Green Transition; Center for Global Climate Action; and Center for Management and Implementation.[10][11]

As part of the Ministry of Energy, Utilities and Climate, the Danish Energy Agency (DEA) is responsible for tasks linked to energy production, supply, and consumption, as well as Danish efforts to reduce carbon emissions, and the DEA has around 750 employees. Three independent energy-related bodies are associated with the Ministry: 1) Energinet is the Transmission System Operator, an independent public enterprise which owns, operates, and develops the electricity and natural gas transmission systems; 2) the Danish Utility Regulator is the independent body which regulates the Danish markets for electricity, natural gas, and district heating; and 3) the Danish Council on Climate Change is the independent body of experts which provides recommendations on climate policies (see Section 1.2).

Climate and energy policies were unified in one Ministry in 2007. Before then, the Ministry of Environment (created in 1971) was responsible for climate policies. The Ministry of Energy was created in 1979 when energy policies were detached from the Ministry of Trade. However, the interconnection between climate and energy policies has been acknowledged for decades as illustrated by the world's first plan for CO2 reductions being presented by the Danish Minister for Energy in 1990. Energy and environmental policies (which included climate policies) were also unified in the Ministry of Environment and Energy from 1994 to 2005.

1.2 Current Danish climate and energy policies

In the run-up to the 2019 parliamentary election in Denmark, climate issues were high on the agenda, and the new 1-party minority Government pledged to propose a Climate Act with legally binding emission reduction targets. In June 2020, the Danish Climate Act[12] was adopted, supported by 8 out of 10 political parties of the Danish Parliament, and the Act includes the targets of climate neutrality by 2050 and 70% GHG emission reductions by 2030 as compared to 1990. The 70% target is ambitious since emissions are to be reduced by 20 million tonnes CO2e by 2030, and it is seen as an important milestone to reaching climate neutrality by 2050.

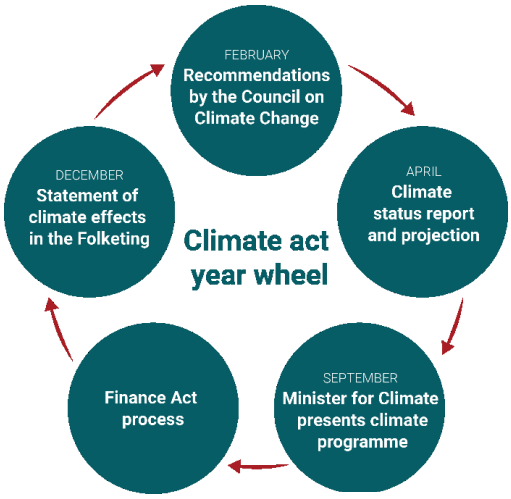
The Climate Act prescribes setting milestone targets, committing the Danish Government-in-office to present sub-targets with a ten-year perspective every 5 years. The first ten-year sub-target is the 70% reduction in emissions by 2030. The sub-target for 2035 is to be settled by 2025 and so forth. The updated climate target may never be less ambitious than the previous target, respecting the "no back-gliding" principle of the Paris Agreement.

The Danish Council on Climate Change (DCCC) plays a key role in the Danish Climate Act. Based on independent professional analyses, the DCCC advises the Danish Government how the transition into a climate-neutral society can take place cost-effectively while maintaining, e.g., welfare and business development. The DCCC also contributes to the public debate. The DCCC consists of 1 chair and 8 other members, mainly university professors, which have a broad

[10] The Danish Ministry of Climate, Energy and Utilities, website, "Organisation", https://en.kefm.dk/the-ministry/organisation.
[11] The Ministry consists of the Department, the Geological Survey of Denmark and Greenland, the Agency for Data Supply and Efficiency, the Danish Meteorological Institute, the Danish Geodata Agency, the Danish Energy Agency, and the associated independent bodies the Danish Utility Regulator, Energinet.dk, and the Danish Council on Climate Change.
[12] The Danish Ministry of Climate, Energy and Utilities, "Climate Act", 18 June 2020, https://en.kefm.dk/Media/1/B/Climate%20Act_Denmark%20-%20WEBTILGÆNGELIG-A.pdf.

expertise as well as a high level of climate-relevant academic knowledge relating to energy, buildings, transport, agriculture, environment, nature, economics, climate science research, and behavioral research. The members are appointed for a period of 4 years and may be reelected once.[13]

The systematic annual procedure of the Climate Act is illustrated by the Climate Act Year Wheel below which has been drawn up by the Danish Ministry of Climate, Energy and Utilities.[14]



Source: See footnote 14.

In the beginning of each calendar-year, the DCCC provides recommendations on the Danish climate efforts. The DCCC assesses whether the Government's climate efforts make it probable that the climate targets will be reached and prepares a catalogue of potential further measures.

The next step is the Climate Status Report and Projection prepared by the Danish Energy Agency: a technical projection of how Denmark's GHG emissions will evolve up to 2030 based on the assumption of a frozen-policy scenario, i.e., a scenario in which no new policies are introduced. This is followed by the Government's Climate Program, presented by the Minister for Climate, Energy and Utilities, which includes the envisaged policy measures, a state-of-play on reaching the climate targets, the Minister's view on the DCCC's recommendations, and information on the development of new climate measures world-wide. If the Danish climate targets are not projected to be within reach, the Minister must include new measures leading to the targets being met. Where appropriate, policy measures are included in the following year's Finance Act.

At the end of each year, the Danish Minister for Climate, Energy and Utilities presents a report to the Danish Parliament on the effects of the overall climate policies, and a majority of the Parliament may require additional efforts. In the last resort, a majority of the Danish Parliament may move to a vote of no-confidence to the Minister.

Since the adoption of the Climate Act in June 2020, the Danish Government has initiated a vast range of policy measures to reach the 2030 target, usually agreed with most political parties of the Danish Parliament to ensure long-term support and predictability.

- An earlier decision to construct 3 offshore wind farms was updated to include two energy islands serving as hubs for offshore wind turbines, and the capacity was expanded from 2.4 GW to at least 6 GW (which is a doubling of the wind power capacity in Denmark in 2019). The 3 wind farms are: 1) an energy island in the North Sea with a capacity of 3 GW, potentially expandable to 10 GW[15]; 2) the island of Bornholm will be an energy island with a capacity of 2 GW; and 3) an offshore wind farm off the island of Hesselø with a capacity of 1 GW.[16] Recently, it was decided to

[13] DCCC, website, https://www.klimaraadet.dk/en/about-danish-council-climate-change. The DCCC was established by the first Danish Climate Act in 2014 and its mandate was strengthened by the Climate Act of 2020. The DCCC is assisted by a secretariat of approximately 25 employees with expertise relating to the Council's areas of operations. The head of secretariat is appointed by the chair of the DCCC.
[14] The Danish Ministry of Climate, Energy and Utilities, "Climate Programme 2020", December 2020, p. 32, https://en.kefm.dk/Media/3/9/ClimateProgramme2020-Denmarks-LTS-under-the%20ParisAgreement_December2020_.pdf.
[15] The energy island in the North Sea will be artificially constructed 80 kilometers from the shore of the peninsula Jutland, and it will serve as a hub for offshore wind farms gathering green electricity from hundreds of wind turbines surrounding the island and distributing the electricity to consumers in countries surrounding the North Sea. The energy island will be a public-private partnership between the Danish State and private companies, and the tender is under preparation.
[16] The Danish Ministry of Climate, Energy and Utilities, "Danish Climate Agreement for Energy and Industry 2020 - Overview", 22 June 2020, https://en.kefm.dk/Media/C/B/faktaark-klimaaftale%20(English%20august%2014).pdf.

add 2 GW offshore wind energy which are to be constructed before end-2030. 2 GW corresponds to the electricity consumption of about 2 million Danish households.[17]

- The energy from the islands is planned to be utilized also for PtX technologies that can store or convert green electricity into green fuels. In addition, there will be a tender to support the establishment of PtX plants with a total capacity of 100 MW.
- Taxes on electricity for heating were reduced and taxes on fossil heating were increased.
- More funds were made available for industry contributing to a green transition through energy efficiency improvements, electrification, and more biogas and other green gases. Further support was also provided for energy efficiency measures in public buildings and phasing-out of oil and gas boilers in households.
- Financing was provided for carbon capture and storage, and work is ongoing to identify potential storage sites in the Danish subsoil, enable import and export of CO2, and ensure that CO2 storage will take place in a safe manner.[18] In 2022, two projects are initiated aimed at storing CO2 in the Danish oil fields in the North Sea.[19]
- The waste sector was targeted for climate neutrality by 2030. The plan for a green waste sector and circular economy includes, inter alia, strengthened waste sorting and waste management and further recycling of collected plastic waste. By 2030, waste for incineration is to be reduced by 30%, and 80% of the Danish plastic is to be sorted out from incineration. The restaurant industry is targeted for a reduction of plastic take-away packaging, while agriculture and construction are targeted for further sorting of plastic waste. The Danish incineration capacity is to be reduced accordingly, and investment in new recycling facilities is planned.[20] Further initiatives are envisaged.
- The road transport sector was targeted for a reduction of 2.1 million tonnes CO2e emissions by 2030 through, e.g., a reform of the registration tax on cars, based on the value of the car and its CO2 emissions; a lower electricity tax for charging zero- and low-emission cars; and a kilometer-based and CO2-differentiated toll on heavy traffic. At the EU level, Denmark is working for a phasing-out of new petrol and diesel cars.[21]
- A green tax reform was agreed, targeting a uniform CO2e tax by 2030.[22] The current tax on industries' consumption of fossil fuels will increase by 6 DKK per GJ, phased in 2023-2025. An expert group consisting primarily of university professors has been set up to prepare proposals for the design of uniform CO2e regulations and its report is to be finalized by the autumn of 2022.[23]
- The agriculture and forestry sector was targeted for a reduction of 8 million tonnes CO2e emissions by 2030 through removal and rewetting of climate-damaging lowland soils, investment in technologies such as pyrolysis, further development of manure handling and feed additives, as well as more support for development of plant-based

[17] The Danish Ministry of Finance, Press Release, "Grøn delaftale sikrer nye CO2-reduktioner og mere vedvarende energi", 4 December 2021, https://fm.dk/nyheder/nyhedsarkiv/2021/december/groen-delaftale-sikrer-nye-co2-reduktioner-og-mere-vedvarende-energi/.
[18] The Danish Ministry of Climate, Energy and Utilities, Press Release, "Bred politisk aftale om CO2-lagring", 30 June 2021, https://kefm.dk/aktuelt/nyheder/2021/jun/bred-politisk-aftale-om-co2-lagring.
[19] The Danish Ministry of Climate, Energy and Utilities, Press Release, "270 mio. kr. til CO2-lagring i Nordsøens oliefelter", 8 December 2021, https://kefm.dk/aktuelt/nyheder/2021/dec/270-mio-kr-til-co2-lagring-i-nordsoeens-oliefelter-.
[20] The Danish Ministry of Climate, Energy and Utilities, "Klimaplan for en grøn affaldssektor og cirkulær økonomi", 16 June 2020, https://kefm.dk/Media/4/3/aftaletekst%20Klimaplann%20for%20en%20grøn%20affaldssektor%20og%20cirkulær%20økonomi.pdf.
[21] The Danish Ministry of Finance, "Aftale om grøn omstilling af vejtransporten", 4 December 2020, https://fm.dk/media/18511/aftale-om-groen-omstilling-af-vejtransporten_a.pdf.
[22] An explicit CO2 tax was first introduced in Denmark in 1992. The CO2 tax has been amended several times, and it differs across sectors.
[23] The Danish Ministry of Finance, "Aftale om grøn skattereform", 8 December 2020, https://fm.dk/media/18317/aftale-om-groen-skattereform.pdf.

food and ecological land use. Initial policy measures only imply a reduction of 1.9 million tonnes CO2e by 2030, and the agreement is to be revisited by 2023/24.[24]

- It was decided to end the oil and gas extraction from Danish fields in the North Sea by 2050, and all future licensing rounds have been cancelled.[25]
- It was decided to target a GHG emission reduction of 50-54% by 2025 compared to 1990, following a recommendation by the DCCC.[26]

In February 2022, the DCCC projected that policy measures agreed since the adoption of the Climate Act in June 2020 reduce the gap in required GHG emission reductions from 20 to 10 million tonnes CO2e by 2030, implying emission reductions of 57.1% by 2030 compared to 1990. The DCCC also calculated that there is a gap of 1.1-4.2 million tonnes CO2e to meet the 50-54% emission reduction target by 2025. The DCCC emphasized the need for a high and uniform CO2e tax and called for further policy initiatives in the field of agriculture and food as well as advancement of wind and solar projects, also to enable green PtX.[27] The Danish Government has announced that all the necessary remaining political decisions must be taken by 2025 in order to reach the 2030 climate target of a 70% reduction.[28]

1.3 Key features of Danish climate and energy policies

Even before the Climate Act of 2020 and subsequent policy measures, Denmark achieved a 40% reduction in GHG emissions compared to 1990, as mentioned in Section 1. The past four decades have illustrated how focusing energy policies on energy efficiency, energy savings, and renewable energy may lead to reduced energy consumption and GHG emissions without jeopardizing economic development and even spawning a competitive global wind industry.

Summing up Danish climate and energy policies over the years, 4 key features deserve particular mentioning:

1. Political framework Integrating climate and energy policies and applying strong coordination between the Danish Ministry of Climate, Energy and Utilities and other relevant Ministries. Setting ambitious climate targets, including 5- and 10-year targets, since a stand-alone 2050 target precludes reliable projections and risks postponing the necessary measures. Establishing broad political support for forward-looking energy policies to ensure regulatory stability and predictability, facilitating the long-term private investments necessary. Establishing a systematic approach through the Danish Climate Act, imposing a duty-to-act upon the Danish Minister for Climate, Energy and Utilities, annual evaluations by the independent experts of the DCCC, and involvement of the Danish Parliament.

2. Whole-of-society approach Engaging in public-private partnerships to promote a green transition, including agreements with the energy sector and energy-intensive industry to increase energy efficiency and expand renewable energy. Establishing climate partnerships with all the different sectors of the Danish economy to engage the individual sectors in limiting GHG emissions. Involving universities and other experts, including the DCCC. Involving municipalities as responsible for identifying suitable areas for sustainable onshore energy

[24] The Danish Ministry of Finance, "Aftale om grøn omstilling af dansk landbrug", 4 October 2021, https://fm.dk/media/25215/aftale-om-groen-omstilling-af-dansk-landbrug.pdf.
[25] The Danish Ministry of Climate, Energy and Utilities, Press Release, "Denmark introduces cutoff date of 2050 for oil and gas extraction in the North Sea, cancels all future licensing rounds", 4 December 2020, https://en.kefm.dk/news/news-archive/2020/dec/denmark-introduces-cutoff-date-of-2050-for-oil-and-gas-extraction-in-the-north-sea-cancels-all-future-licensing-rounds.
[26] The Danish Ministry of Finance, "Aftale om et indikativt drivhusgasreduktionsmål for 2025", 7 May 2021, https://fm.dk/media/18803/aftale-om-et-indikativt-drivhusgasreduktionsmaal-for-2025.pdf.
[27] DCCC, "Statusrapport 2022", 25 February 2022, https://klimaraadet.dk/da/rapporter/statusrapport-2022.
[28] The Danish Ministry of Climate, Energy and Utilities, "Key facts about the 2030 green roadmap and Danish Climate Program", 29 September 2021, https://en.kefm.dk/Media/637685164704392354/One-pager%202030%20roadmap.pdf.

projects. Raising awareness in the public, e.g., through energy labeling of electrical appliances and houses, and through the establishment of a Citizens' Assembly and a Youth Climate Council. Reaching out internationally to learn from others and share Danish experiences which includes partnerships with 19 countries spread over 4 continents.

3. Holistic approach Addressing both supply and demand through expansion of renewable energy sources on one side and increased energy efficiency and energy savings on the other side. Applying both regulatory requirements and economic incentives to promote renewable energy, energy efficiency and savings, and to reduce GHG emissions. Internalizing the external environmental costs of emissions via direct CO2e taxation and participation in the EU emissions trading system. Applying policy measures across different sectors (electricity generation, heating, transport, buildings etc.). Utilizing renewable energy and electrification to facilitate a green transition in sectors other than the energy sector.

4. Energy policy strategy *Promoting energy efficiency and savings*: building requirements for existing/new houses; energy-saving requirements for public buildings; economic incentives, including taxation, subsidies, and grants; publicly funded R&D resources; energy efficiency agreements with large energy-intensive businesses, powerplants, and power distributers; and competitive energy markets.

Promoting renewable energy, in particular wind power: economic incentives, including subsidies and grants; publicly funded R&D resources; public planning requirements for sustainable energy projects; tenders to establish offshore wind farms; and agreements with the electricity generators to include wind power and with the transmission grid operators to develop the grid and ensure that renewable energy sources can always be connected. While Government support has been instrumental to wind energy, a milestone was reached in December 2021 as the tender for the 1 GW Danish offshore wind farm Thor to be built by 2027 resulted in a winning bid guaranteeing an income to the Danish State of 2,800 million DKK or app. 427 million USD. The construction of the wind farm as well as the landing cables connecting to the Danish transmission grid will be paid by the winning bidder, Thor Wind Farm I/S (RWE AG, RWE Renewables GmbH, RWE Renewables Management UK Limited).[29]

The energy sector has been, and continues to be, key to the green transition in Denmark. The energy sector is no longer the largest emitter and expects to reach 95% emission reductions by 2030 compared to 1990. Heating and electricity generation has been integrated; district heating has been developed; and renewable energy is promoted while energy security and flexibility in the energy system is ensured by continuously developing the transmission grid and ensuring interconnectors to neighboring countries. The energy sector will facilitate the green transition in other sectors, e.g., by supplying electricity to produce hydrogen (PtX).

1.4 Conclusion

The key to reaching the Danish 70% climate target is electrification based on renewable energy, and adequate and timely development of the energy infrastructure, underpinning a green transition in all of society. The transition will be expensive; Copenhagen Economics has estimated that up to 600 billion DKK are required to realize the 70% target.[30] However, private funding is available. As part of the Danish Government's climate partnership with the financial sector, the Danish pension funds have announced that they will invest 350 billion DKK globally

[29] Danish Ministry of Climate, Energy and Utilities, Press Release, "Thor Wind Farm I/S skal bygge Danmarks største havvindmøllepark til rekord god pris", 1 December 2021, https://kefm.dk/aktuelt/nyheder/2021/dec/thor-wind-farm-is-skal-bygge-danmarks-stoerste-havvindmoellepark-til-rekord-god-pris.

[30] The Danish Ministry of Industry, Business and Financial Affairs, "Klimapartnerskab for finanssektoren", p. 8, October 2021, https://em.dk/media/14287/sektorkoereplan-for-klimapartnerskab-for-finanssektoren.pdf.

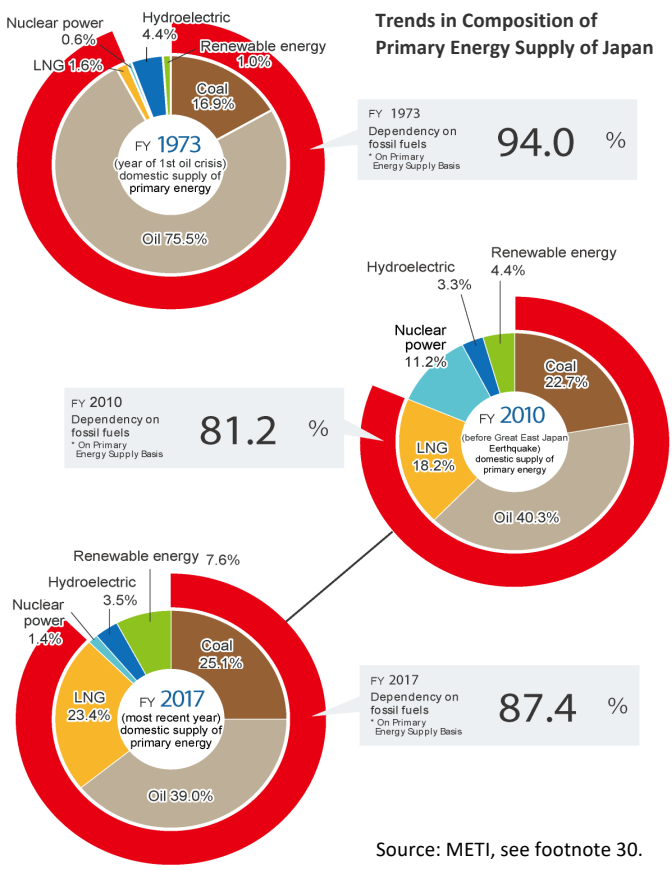
in green transition up to 2030. Additionally, the Danish banks and mortgage credit institutions aim to increase their green lending to 700 billion DKK by 2030.

The main challenge will be whether all the regulatory framework is in place in due time to allow for the long-term planning required for the execution of such large investments. The Danish 2030 target is challenging but further policy measures are underway, and the systematic approach of the Danish Climate Act applies constant pressure on the Government-in-office to act with due diligence.

2. Japanese energy developments since the 1970s

The two oil crises in the 1970s and the consequent economic crisis led to an energy transition in Japan. Japan was highly dependent on oil from the Middle East and the need for energy security became the focal point. The Japanese response was to reduce the dependence on oil, to diversify the energy sources and imports, and to increase energy efficiency.

Over the following decades, the dependency on oil in the energy supply was reduced from 75.5% in 1973 to 40.3% in 2010, as illustrated by METI's chart below.[31] The diversification of energy sources was to a large extent focused on fossil fuels, substituting oil with gas and coal.



Source: METI, see footnote 30.

However, alternative energy sources were also targeted, and the share of nuclear energy in primary energy supply rose significantly from 0.6% to 11.2% in the period 1973-2010. The share of renewable energy also increased from 1.0% to 4.4%.

The 2011 Great East Japan Earthquake and the subsequent accident at the Fukushima Daiichi Nuclear Power Plant led to a higher dependence on fossil fuels as nuclear energy was substituted mainly by coal and gas. The fall in domestic energy production led to a higher import dependency and the energy self-sufficiency ratio fell from 20.3% in 2010 to a low of 6.4% in 2014. In 2019, the ratio was 12%[32], and Japan is still in a recovery process from the Fukushima accident.

Imports of natural gas are well-diversified while coal is mainly imported from Australia. The dependency on oil from the Middle East has continued and 88% of oil imports still came from the Middle East in 2018.[33] Japan has one of the largest oil stockholdings globally, which acts as an insurance against geopolitical risks and large global shocks.[34]

[31] METI, website, "2019 – Understanding the current energy situation in Japan (Part 1)", November 2019, https://www.enecho.meti.go.jp/en/category/special/article/energyissue2019_01.html.
[32] IEA, "Japan 2021 Energy Policy Review", p. 24, May 2021, https://iea.blob.core.windows.net/assets/3470b395-cfdd-44a9-9184-0537cf069c3d/Japan2021_EnergyPolicyReview.pdf.
[33] METI, website, "2019 – Understanding the current energy situation in Japan (Part 1)", November 2019, https://www.enecho.meti.go.jp/en/category/special/article/energyissue2019_01.html.
[34] IEA, "Japan 2021 Energy Policy Review", p. 17, May 2021, https://iea.blob.core.windows.net/assets/3470b395-cfdd-44a9-9184-0537cf069c3d/Japan2021_EnergyPolicyReview.pdf.

Japan's total GHG emissions were at the same level in 2018 as in 1990, around 1,200 million tonnes CO2e. Following the Great East Japan Earthquake and consequent substitution in favor of fossil fuels, the emissions topped 1,400 million tonnes CO2e in 2013 but they have been declining since then. In 2018, Japan was among the world's 10 largest emitters, according to WRI data.[35]

According to the IEA, energy-related emissions peaked at 1,234 Mt CO2 in 2013 due to the shift from nuclear to natural gas, coal, and oil for power generation. Emissions have since decreased thanks to the gradual expansion of renewable power generation, energy efficiency improvements, and the restart of some nuclear power plants. The energy intensity of the economy measured as total primary energy supply/gross domestic product (TPES/GDP) has improved by 30% since 2000. However, the benefits of higher energy efficiency in terms of CO2e emissions were largely offset by the increase in the carbon intensity of energy supply (+20% in 2010-12), following the shift from nuclear to fossil fuels in power generation.[36]

2.1 Key elements of Japanese energy policies

The Ministry of Economy, Trade and Industry (METI) has the primary responsibility for energy policies in Japan, including climate change mitigation policies in the energy sector. METI also determines overall national targets for renewable energy. Within METI, the Agency for Natural Resources and Energy (ANRE) is responsible for ensuring strategic energy security, ensuring an efficient energy supply, promoting environmentally friendly energy policies and energy efficiency, and implementing renewable energy policies.[37]

As mentioned, the oil crisis implied focus on reduced dependence on oil, diversification of energy sources and imports, and enhanced energy efficiency. Natural gas and nuclear energy were advanced and oil stockpiling established, while energy savings and research and development were promoted. The ANRE was established in 1973 and numerous energy-related laws were launched.

The Three Power Source Development Laws[38] (1974) included grants to promote power plants through funding of development of public facilities and infrastructure where the power plants were located, including nuclear power plants. The Petroleum Supply and Demand Adjustment Act (1973) aimed to optimize the supply and demand of oil by taking measures to secure proper oil supply and reduce oil use in case of a significant shortage in supply of oil to Japan.[39] The Oil Stockpiling Act (1975) was adopted to ensure a stable supply of oil by taking measures to stockpile and appropriately distribute such oil in case of a shortage in Japan, and it requires METI to set five-year targets for oil stocks.[40][41] The Energy Efficiency Act (1979) continues to be the foundation of Japan's energy efficiency and conservation policy aimed at factories, transport, buildings, and machinery. The Act has been updated many times and includes the

[35] WRI, website, "2018 Total Greenhouse Gas Emissions by Country", https://resourcewatch.org/data/explore/cli008-Greenhouse-Gas-Emissions-by-Country-and-Sector-Full-Longform?section=All+data&selectedCollection=&zoom=0.3353902413267229&lat=7.35344242354365e-12&lng=69.65183271731748&pitch=0&bearing=0&basemap=dark&labels=light&aoi=&page=1&sort=most-viewed&sortDirection=-1&topics=%255B%2522climate%2522%255D.

[36] IEA, "Japan 2021 Energy Policy Review", p. 43 and 45, May 2021, https://iea.blob.core.windows.net/assets/3470b395-cfdd-44a9-9184-0537cf069c3d/Japan2021_EnergyPolicyReview.pdf.

[37] Ibid, p. 227.

[38] 1) Power Development Promotion Tax Law, 2) Power Development Promotion Measures Special Account Law, and 3) Power Generation Facility Peripheral Area Development Law.

[39] Japanese Law Translation, website, "Petroleum Supply and Demand Adjustment Act", 22 December 1973, https://www.japaneselawtranslation.go.jp/en/laws/view/3001.

[40] Japanese Law Translation, website, "Oil Stockpiling Act", 27 December 1975, https://www.japaneselawtranslation.go.jp/en/laws/view/3000.

[41] For 2017-21, the target is 90 days of imports for government stocks and 70 days of domestic demand for industry stocks, according to IEA, "Japan 2021 Energy Policy Review", p. 188, May 2021, https://iea.blob.core.windows.net/assets/3470b395-cfdd-44a9-9184-0537cf069c3d/Japan2021_EnergyPolicyReview.pdf.

"Top Runner Program".[42] The Law Concerning the Promotion of the Development and Introduction of Alternative Energy (1980) aimed at development and introduction of alternatives to oil.[43] In the year of the Kyoto Protocol, the New Energy Law (1997) was adopted to accelerate the utilization of non-oil energy sources.[44]

Energy research and development was, and still is, central to Japanese energy policies. The Sunshine Project (1974) was a long-term comprehensive plan for the research and development of new energy technologies. The Moonlight Project (1978) was established to advance energy conservation technologies. An RD&D system (1989) was established to focus on global environment technologies. The three projects were merged in the New Sunshine Program (1993) aimed at sustainable growth and the resolution of energy and environmental problems.[45] Among renewable energy resources, solar PV has played a particularly important role and Japan had the second-highest share of solar power in the IEA in 2019.[46]

One of the largest public research and development institutions in Japan is the New Energy and Industrial Technology Development Organization (NEDO) which was established in 1980 under The Law Concerning the Promotion of the Development and Introduction of Alternative Energy.[47] NEDO plays an important role in distributing funding for energy-related research, development, and innovation, and in fostering collaboration among industry, academia, and the Government. It supports activities ranging from basic research to pre-commercial demonstration and deployment.[48]

Japan is one of the largest investors in energy-related RD&D among IEA members. In 2019, public spending on energy-related RD&D was 314 billion JPY. Nuclear energy continues to be the largest funded sector at 36% of the total in 2019 while energy efficiency was the second-largest sector at 25% of the total. Renewable energy sources accounted for 11% of the 2019 budget, with almost half of the budget targeting wind. Hydrogen and fuel cells accounted for 10%, while other power and storage technologies, cross-cutting research, and fossil fuels received the rest with around 6% each.[49]

Renewable energy accelerated with the introduction of the feed-in tariff (FIT) scheme in 2012. Through the FIT scheme, electricity generated by renewables was purchased at a fixed rate and part of the cost was paid by consumers through an electricity surcharge. The surcharge has been raised over the years which is one of the reasons for increasing electricity rates.[50] The FIT scheme is in the process of being changed to market-based feed-in premiums to reduce costs and improve the integration of renewables into the power market.

2.2 Current Japanese energy policies

The Basic Act on Energy Policy from June 2002 establishes the basic energy policy of Japan. The Basic Act delineates responsibilities of the national and local governments and promotes

[42] IEA, website, "Act on the rational use of energy (Energy Efficiency Act)", https://www.iea.org/policies/573-act-on-the-rational-use-of-energy-energy-efficiency-act.
[43] IEA, website, "Law on Establishment of NEDO", https://www.iea.org/policies/4091-law-on-establishment-of-nedo?country=Japan&page=5&qs=japan.
[44] IEA, website, "Special Measures Law for Promoting the Use of New Energy", https://www.iea.org/policies/4451-special-measures-law-for-promoting-the-use-of-new-energy?country=Japan&page=4&qs=japan.
[45] IEA, website, "New Sunshine Programme", https://www.iea.org/policies/3497-new-sunshine-programme?country=Japan&page=4&qs=japan.
[46] IEA, "Japan 2021 Energy Policy Review", p.134, May 2021, https://iea.blob.core.windows.net/assets/3470b395-cfdd-44a9-9184-0537cf069c3d/Japan2021_EnergyPolicyReview.pdf.
[47] NEDO, website, https://www.nedo.go.jp/english/introducing/introducing_message_c.html
[48] IEA, "Japan 2021 Energy Policy Review", p.114, May 2021, https://iea.blob.core.windows.net/assets/3470b395-cfdd-44a9-9184-0537cf069c3d/Japan2021_EnergyPolicyReview.pdf.
[49] Ibid, p. 111-112.
[50] METI, website, "2019 – Understanding the current energy situation in Japan (Part 1)", November 2019, https://www.enecho.meti.go.jp/en/category/special/article/energyissue2019_01.html.

long-term, comprehensive policymaking on energy supply and demand which contributes to preserving the environment and ensuring a sustainable development in Japan and globally.[51]

Under the Basic Act, the Strategic Energy Plan is to be formulated and, subsequently, reviewed at least once every 3 years. The Strategic Energy Plan prescribes energy policy measures and technologies requiring research and development measures which are to be implemented comprehensively and strategically in the long term. The Strategic Energy Plan is prepared by ANRE, and the Advisory Committee for Natural Resources and Energy is consulted. The Minister for Economy, Trade and Industry submits the plan to the Cabinet for approval.

Japan's energy policy is guided by "3Es+S": with the underlying premise that Safety is always the primary concern, programs are being carried out to simultaneously achieve improvement in Energy Security, Economic Efficiency, and Environmental Sustainability.[52] The 5th Strategic Energy Plan (2018) targeted a 26% reduction in GHG emissions by 2030 and 80% by 2050 as compared to 2013.

In October 2020, the former Japanese Prime Minister Suga declared the target of carbon neutrality by 2050. In April 2021, the target was supplemented by the pledge of a 46% reduction in GHG emissions by 2030 as compared to 2013.

Consequently, the 6th Strategic Energy Plan was adopted on 22 October 2021 which targets GHG emission reductions of 46% by 2030 as compared to 2013, and Japan submitted its updated Nationally Determined Contribution (NDC) to the UNFCCC.[53] The target is to be reached by further strengthening energy conservation, expanding renewable energy sources, and introducing hydrogen, while reducing the consumption of coal, LNG, and petroleum, cf. the box below.[54] The target share of nuclear energy is unchanged.

	FY2019	5th Strategic Energy Plan FY2030	6th Strategic Energy Plan FY2030
GHG reduction rate	14%	26%	46% (Aiming for 50%)
Energy efficiency improvement	16.55 million kl	50.3 million kl	62 million kl
Final energy consumption	350 million kl	377 million kl	350 million kl
Power generation by source			
Renewable energy	18%	22-24%	36-38%
- *Solar*	*6.7%*	*7.0%*	*14-16%*
- *Wind power*	*0.7%*	*1.7%*	*5%*
- *Geothermal*	*0.3%*	*1.0-1.1%*	*1%*
- *Hydro*	*7.8%*	*8.8-9.2%*	*11%*
- *Biomass*	*2.6%*	*3.7-4.6%*	*5%*
Hydrogen/ammonia	0%	0%	1%
Nuclear	6%	20-22%	20-22%
LNG	37%	27%	20%
Coal	32%	26%	19%
Petroleum etc.	7%	3%	2%

Source: METI, see footnote 53.

[51] Japanese Law Translation, website, "Basic Act on Energy Policy", 14 June 2002, https://www.japaneselawtranslation.go.jp/en/laws/view/3818.
[52] METI, "Japan's Energy 2019 - 10 questions for understanding the current energy situation", p. 9, March 2020, https://www.enecho.meti.go.jp/en/category/brochures/pdf/japan_energy_2019.pdf.
[53] UNFCCC, website, NDC Registry, "Japan", https://www4.unfccc.int/sites/NDCStaging/pages/Party.aspx?party=JPN.
[54] METI, Agency for Natural Resources and Energy, "Outline of Strategic Energy Plan", p. 12, October 2021, https://www.enecho.meti.go.jp/en/category/others/basic_plan/pdf/6th_outline.pdf.

Thermal power generation is to be lowered and inefficient thermal plants are to be phased out. Japan aims to increase decarbonized power supply and to decarbonize thermal plants by introducing innovative technologies such as hydrogen/ammonia-fired power generation and CCUS. Japan will not provide new direct government support for unabated international thermal coal power generation projects after end-2021.[55] According to the IEA, Japanese coal-fired plants are among the most efficient and clean globally, and Japan is investing heavily in the development of high-efficiency new generation coal technology. However, the IEA also notes that adding new coal capacity risks locking in carbon-intensive infrastructure since the design lifetime of a coal plant is typically 40-50 years, making it more challenging and costly to meet Japan's climate mitigation goals, while also creating stranded assets.[56]

The 6th Strategic Energy Plan was praised for being ambitious, while some experts questioned whether accompanying policy measures were sufficient to reach the 46% target and whether the foreseen 2030 energy mix was attainable.[57] The unchanged target for nuclear energy requires that around 30 reactors are in operation by 2030[58] - a tripling of the reactors currently in operation - which is challenging due to comprehensive safety requirements as well as limited public acceptance. Even if the significant increase in renewable resources is achieved, the targeted reduction in coal and LNG is considered challenging to reach.

In May 2021, the IEA's recommendations to the Japanese Government included[59]:

- Continue Japan's leadership role in enhancing global energy security, and in innovative technology development in key sectors such as energy efficiency and hydrogen.
- Deepen Japan's electricity market reform, ensuring that the wholesale electricity market encourages the participation of all generation sources, and stimulates investments in zero-emission electricity while ensuring electricity security and affordability. Provide additional regulatory powers and independence to the EGC, the electricity and gas regulator.
- Encourage investments in zero-emission electricity generation, transmission, and distribution infrastructure, and improve electricity system operations, thereby reducing grid constraints across the country that, in turn, should enable larger penetration of variable renewable electricity sources.
- Accelerate the Nuclear Regulatory Agency (NRA) safety reviews to facilitate prompt return to operation of Japan's nuclear reactors, thereby ensuring that the 2030 climate goals are achieved, while meeting high safety standards and public acceptance.
- Evaluate the need for future coal-fired power generation capacity in Japan, taking into account both GHG emission goals and the decreasing costs of alternatives such as renewables and LNG.
- Assign higher priority to the deployment of CCUS on coal- and gas-fired power stations and create a requirement that any new coal and gas plants are built "CCUS-ready".
- Map out energy scenarios, including road maps that are compatible with the vision for a decarbonized society by 2050. Consider strengthening price signals to encourage investments across the economy in low- and zero-emission technologies.

[55] METI, Agency for Natural Resources and Energy, "Outline of Strategic Energy Plan", p. 9, October 2021, https://www.enecho.meti.go.jp/en/category/others/basic_plan/pdf/6th_outline.pdf.
[56] IEA, "Japan 2021 Energy Policy Review", p. 195 and 201, May 2021, https://iea.blob.core.windows.net/assets/3470b395-cfdd-44a9-9184-0537cf069c3d/Japan2021_EnergyPolicyReview.pdf.
[57] See, e.g., KIKKAWA Takeo, "The Road to Carbon Neutrality and the Issues of the 6th Strategic Energy Plan", 30 August 2021, Discuss Japan, Japan Foreign Policy Forum, website, https://www.japanpolicyforum.jp/economy/pt20210830135642114 29.html.
[58] IEA, "Japan 2021 Energy Policy Review", p. 28, May 2021, https://iea.blob.core.windows.net/assets/3470b395-cfdd-44a9-9184-0537cf069c3d/Japan2021_EnergyPolicyReview.pdf.
[59] Ibid, p. 37.

- Deepen engagement with civil society in energy policy making to gain greater social acceptance for infrastructure developments needed to meet Japan's energy and climate policy goals.

3. Points of inspiration for a green transition in Japan

Both Japan and Denmark have ambitious climate targets for 2030 and strive for neutrality by 2050. So far, Denmark has been more successful in reducing GHG emissions. Part of the reason is the set-back in Japan caused by the Fukushima accident in 2011 leading to the shutdown of nuclear power plants and higher reliance on fossil fuels.

Nevertheless, it might be useful to go through the 4 key features of the Danish energy policies set out in Section 1.3 to identify specific elements that might serve as an inspiration for Japan: the political framework, the whole-of-society approach, the holistic approach, and the energy policy strategy.

3.1 Political framework

The political framework is crucial to reaching climate targets as predictability and regulatory stability is key to facilitating the long-term private investments in fossil-free energy and infrastructure necessary for a green transition. If uncertainty prevails, the investor will choose the current most inexpensive investment which may result in higher carbon emissions as well as wasted financial resources if the framework conditions change at a later stage.

In Japan, climate policies are not institutionally integrated into energy policies and climate policies have not been high on the political agenda over the years. However, Japan's ambitious pledges of carbon neutrality by 2050 and 46% emission reductions by 2030 provide momentum. The 10-year target is key to urging the decisive action necessary in the shorter run since the 2050 target does not allow for reliable projections and risks postponing the necessary measures.

In Denmark, the stability and continuity of climate and energy policies over the years have been vital to fostering the necessary investments and achieving the energy transition so far.

Points of inspiration from the political framework in Denmark could be the following:

- Exercising strong political engagement, preparing detailed road maps and coherent scenarios to reaching ambitious 5- and 10-year targets, thereby facilitating the long-term private investments necessary.
- Establishing a systematic approach, for instance through a Climate Act, imposing a duty-to-act upon the responsible Minister, annual evaluations and recommendations by independent experts, and regular follow-up in the Parliament on the implementation of policy measures and whether milestones are achievable. The Danish Climate Act enhances transparency, policy implementation, and accountability.
- Establishing broad political support - within and across political parties - for forward-looking climate and energy policies reducing fossil fuels in order to ensure regulatory stability and continuity and establish wider public support and confidence in the green transition. In Denmark, support across political parties is a crucial element since the Government often constitutes a minority of the Danish Parliament.
- Fully integrating climate policies into overall energy policies, acknowledging that energy is key to emission reductions, and exercising strong coordination between all relevant Ministries and Ministers to ensure cross-sector policy implementation. As

mentioned, energy and climate policies are united in one Ministry in Denmark and all sectors of the economy are targeted for emission reduction.

3.2 Whole-of-society approach

The green transition of any country will be easier if all of society is engaged in decarbonization. This involves inducing climate priorities and cooperation across relevant Ministries, from the Government level down to municipalities, and across all sectors of the economy. It also involves engaging the different sectors of the economy in emission reductions and mobilizing the wider public to save energy and accept the necessary infrastructure development accommodating a fossil-free future as well as benefitting from the knowledge of universities and other experts. In Denmark, the whole-of-society approach is considered to foster both ownership and innovation.

In Japan, climate discussions have been revitalized following the pledge of carbon neutrality by 2050. But so far, the discussions do not appear to be coordinated and utilized to advance the green transition. In the 2021 parliamentary election, the need for a green transition was not a major topic. The IEA has encouraged Japan to deepen the engagement with civil society in energy policy making to gain greater social acceptance for infrastructure developments needed to meet Japan's energy and climate policy goals, as mentioned in Section 2.2. And, a survey from Pew Research Center might suggest that there is basis for further inclusiveness of society as 80% of the Japanese adults inquired responded that they saw climate change as a major threat to Japan even during the challenging times of COVID-19.[60] In the private sector, the Japanese business association, the Keidanren, has set out a new "Carbon Neutrality Action Plan" in November 2021 with a private sector vision for carbon neutrality by 2050, and many Japanese companies have decided to join RE100, the global corporate renewable energy initiative bringing together large businesses committed to 100% renewable electricity.

Points of inspiration from the whole-of-society approach in Denmark could be the following:

- Establishing climate partnerships with the different sectors of the economy, inducing ownership and innovative thinking. In Denmark, 14 sectors of the Danish economy – from the key energy sector over the transport sector to the financial sector - were asked how they could contribute to reaching the 2030 targets. This has fostered ambitious sector plans for investments and GHG emission reductions, and they are followed up in the Green Business Forum which includes 10 Danish Ministers as well as chairpersons and CEOs from leading Danish companies and trade unions.[61][62] Subsequently, sector roadmaps are developed where the individual sector describes its objectives and efforts, and the Government outlines policy measures to support the sector's green transition.

  For example, the climate partnership with the financial sector is crucial since the ambitious climate targets cannot be met relying on public funds alone. As mentioned in Section 1.4, the Danish pension funds have vowed to invest 350 billion DKK in green transition globally up to 2030 while the Danish banks and mortgage credit institutions aim to increase their green lending to 700 billion DKK by 2030. The partnership on finance is chaired by Torben Möger Pedersen, the CEO of PensionDanmark, which pioneered to invest in renewable energy in Denmark already in 2010. PensionDanmark

[60] Pew Research Center, website, "Many globally are as concerned about climate change as about the spread of infectious diseases", October 2020, https://www.pewresearch.org/fact-tank/2020/10/16/many-globally-are-as-concerned-about-climate-change-as-about-the-spread-of-infectious-diseases/.

[61] The Danish Ministry of Climate, Energy and Utilities, website, "Regeringens klimapartnerskaber", https://kefm.dk/klima-og-vejr/regeringens-klimapartnerskaber-og-groent-erhvervsforum.

[62] The Danish Ministry of Industry, Business and Financial Affairs, "Kommissorium for Grønt Erhvervsforum", 12 November 2019, https://em.dk/media/13419/kommissorium-for-groent-erhvervsforum_121119.pdf.

notes that the investments in infrastructure and renewable energy are characterized by a non-cyclical revenue uncorrelated to economic cycles with expected investment returns substantially higher than the bond interest rate.[63] PensionDanmark has a close collaboration with Copenhagen Infrastructure Partners (CIP) which is among the largest fund managers globally within renewables. At end-2021, PensionDanmark's investments in CIP managed funds amounted to 1.1 out of 15 billion EUR currently under CIP's management.[64]

- Entering into agreements with energy-intensive industry to increase energy efficiency, reduce energy consumption and carbon emissions, and advance the use of renewable energy. In Denmark, voluntary agreements with energy-intensive industry, offering tax relief in return, have reduced energy consumption significantly. Reduced energy intensity and costs have contributed to the industries' global competitiveness.
- Requiring electricity generators to include renewable energy and transmission grid operators to ensure that renewable energy can always be connected to the grid.
- Involving universities and other experts. In Denmark the outreach includes:
    - The DCCC, the key player in the Danish Climate Act, advises the Danish Government on climate policies, assesses the adequacy of policy measures to reach climate targets, and raises awareness on the need to meet the challenges of climate change.
    - Demonstration facilities for wind turbines have been established at the Danish universities in cooperation with the authorities and the wind energy sector, providing key facilities to wind turbine manufacturers.
- Requiring municipalities to identify suitable areas for sustainable onshore energy projects while taking into account the opinions of citizens and organizations. In Denmark, the municipalities are key to locating areas for energy projects and obtaining public acceptance of infrastructure development. The Danish municipalities play an increasing role in advancing the green transition, and 95 of the 98 municipalities have signed up to develop climate action plans, supported by Realdania (a philanthropic association), the Local Government Association, and Concito (a green thinktank).[65]
- Creating ownership and raising awareness in the public, including through economic incentives, energy-saving campaigns, energy labeling of electrical appliances and houses, and ownership in renewable energy assets (e.g., community-owned wind farms). In Denmark, the public is also engaged in the Citizens' Assembly and Youth Climate Council, enhancing public attention to the need for climate-friendly policies, c.f. the box below.
- Engaging in international cooperation, learning from others and sharing experiences, to enhance knowledge of energy transition and R&D. Denmark has 19 partner countries, representing more than 60% of global emissions.[66] In March 2022, Denmark and Japan signed a Memorandum of Cooperation which focuses on sharing

[63] See PensionDanmark, website, "Investments - Infrastructure and renewable energy", https://www.pensiondanmark.com/en/investments/infrastructure-and-renewable-energy/ and "Nysted offshore wind farm" https://www.pensiondanmark.com/en/investments/infrastructure-and-renewable-energy/nysted/.
[64] PensionDanmark, website, "Copenhagen Infrastructure Partners", https://www.pensiondanmark.com/en/investments/copenhagen-infrastructure-partners/.
[65] Realdania, website, "DK2020", https://realdania.dk/projekter/dk2020.
[66] China, Egypt, Ethiopia, France, Germany, India, Indonesia, Japan, Kenya, Mexico, the Netherlands, South Africa, South Korea, Poland, Turkey, the USA, Vietnam, Ukraine, and the United Kingdom. See the website of the Danish Energy Agency, "Global Cooperation", https://ens.dk/en/our-responsibilities/global-cooperation.

experiences on regulatory issues regarding offshore wind energy, transmission planning, and integration of variable renewable energy.[67]

The Citizens' Assembly was established in 2019 and consists of 99 members randomly selected by Statistics Denmark to represent the Danish population. The Assembly discusses dilemmas facing the Danish society in view of the climate crisis, based on presentations by climate experts. The Ministry of Climate, Energy and Utilities finances the citizens' participation and serves as secretariat for the Assembly, while the Danish Board of Technology (a non-profit corporate foundation) facilitates the meetings of the Assembly and appoints relevant experts from the universities. The Assembly reports to the Minister for Climate, Energy and Utilities as well as the Danish Parliament's Committee on Climate, Energy and Utilities, and its recommendations are wide-ranging, for instance teaching about the climate crisis in elementary schools, introducing climate taxes, and encouraging climate-friendly eating habits.[68] The Minister for Climate, Energy and Utilities has stated that the recommendations will be considered for inclusion where relevant in the continuous development of climate policy initiatives.[69]

The Youth Climate Council was also established in 2019, and its members between 18 and 29 years of age come from all over Denmark. The members have different educational backgrounds and represent different approaches to climate challenges. The first voluntary members were appointed by the Minister for Climate, Energy and Utilities while the Council appointed new members for a 2-year period in 2021 following an application process. The Council aims to infuse innovative thinking into climate policy and provides recommendations for the Minister for Climate, Energy and Utilities. The work of the Council can be followed on social media, which includes streaming when the Council presents recommendations to the Minister. The Council's recommendations are wide-ranging and include the establishment of more wild nature to promote biodiversity, more focus on climate and sustainability at all levels of education from elementary school up to the universities, and recommendations on the structure and content of Danish climate policies to further encourage the green transition.[70]

3.3 Holistic approach

A holistic approach to climate and energy policies, focusing on broader interactions and systems, will enable a faster green transition as a wide range of policy instruments are used to target both the demand and supply side of energy as well as different sectors of the economy with a view to reducing GHG emissions. Economic incentives are crucial and strong price signals may direct the behavior of consumers and encourage investments in low- and zero-emission technologies.

The IEA generally encourages a holistic view, for instance on taxation, and emphasizes that behavior can be affected through carbon taxation without increasing the overall tax bill, e.g., by lowering registration taxes on cars while increasing the fuel tax. In connection with the Japanese shortages in gas supply in January 2021, the IEA called for a holistic approach to ensuring electricity security since other energy sources and market frameworks than gas supply and storage could be considered to mitigate the effects of gas shortages on the electricity and gas markets.[71]

Points of inspiration from the holistic approach in Denmark could be the following:

- Targeting different sectors: electricity generation, heating, transport, buildings, agriculture etc.
- Targeting supply by promoting renewable energy: economic incentives such as subsidies and grants; public funding of R&D in renewable energy, agreements with electricity generators to include renewable energy etc.
- Targeting demand by promoting energy efficiency and savings: rules & regulations; Government agreements with energy and energy-intensive companies; raising

[67] Royal Danish Embassy in Japan, Press Release, "Signing of energy cooperation agreement between Japan and Denmark", 16 March 2022, https://japan.um.dk/en/news/signing-of-energy-cooperation-agreement-between-japan-and-denmark.
[68] The Danish Ministry of Climate, Energy and Utilities, website, "Borgerting på klimaområdet", https://kefm.dk/klima-og-vejr/borgertinget-
[69] The Danish Ministry of Climate, Energy and Utilities, "Tilbagemelding på behandling af anbefalinger", 25 June 2021, https://kefm.dk/Media/637602274652417628/Ministerbrev%20til%20Borgertinget.pdf.
[70] The Danish Ministry of Climate, Energy and Utilities, website, "Ungeklimarådet", https://kefm.dk/klima-og-vejr/ungeklimaraadet and "Ungeklimarådet søger nye stemmer i klimakampen", https://kefm.dk/aktuelt/nyheder/2021/feb/ungeklimaraadet-soeger-nye-stemmer-i-klimakampen.
[71] IEA, "Japan 2021 Energy Policy Review", p. 16 and 36, May 2021, https://iea.blob.core.windows.net/assets/3470b395-cfdd-44a9-9184-0537cf069c3d/Japan2021_EnergyPolicyReview.pdf.

awareness among citizens and companies; taxing energy consumption etc. In Denmark, taxes on electricity and oil were introduced in the 1970s to reduce energy consumption and energy imports, and the taxation of electricity supplied to households is particularly high. For a typical Danish household, the raw electricity price is only 17% of the total electricity costs, according to the Danish Energy Agency's estimates.[72]

- Directly targeting CO2e emissions through a CO2 tax in order to internalize the external environmental costs and affect the behavior of industry. The Danish CO2 tax is under review with a view to strengthening. Another way to target CO2 emissions directly is CO2 emissions trading systems.
- The Danish energy sector is taking the holistic approach further by estimating how other sectors - mainly transport and industry - may achieve the necessary emission reduction towards 2030 through energy efficiency and new technologies as well as change in fuels, since the energy sector needs to prepare in due time for the future increased demand for infrastructure and renewable energy, including PtX.

3.4 Energy policy strategy

For both Japan and Denmark, the two oil crises in the 1970s resulted in focus on energy efficiency and energy savings. Both countries also continued to rely on fossil fuels to a large extent while exploring alternative energy sources - for Japan mainly nuclear energy and for Denmark renewable energy sources, in particular biomass and wind energy.

Over the past decades, Denmark's long-term investment in renewable energy has significantly reduced the reliance on fossil fuels, leading to lower carbon emissions. Meanwhile, Japan was severely challenged by the Fukushima accident in 2011 leading to the shutdown of all nuclear reactors and higher reliance on fossil fuels. Among the renewable energy sources, Japan has focused primarily on solar energy and the share of solar energy in the power mix is targeted for a doubling from 6.9% to 14-16% by 2030.

At the same time, energy security has been a driver for both Japan and Denmark since the two oil crises in the 1970s. Japan lacks natural resources such as oil and natural gas and has focused on diversification of energy sources and imports, stockpiling of oil, and nuclear energy. The self-sufficiency rate was 12% in 2019. Denmark initially targeted self-sufficiency which was reached in 1997 by exploiting domestic oil and natural gas resources. Today, renewable energy sources play a major role and energy security is also ensured by interconnections to neighboring countries. For Denmark, focus on the development of the energy sector has been key to energy security as well as to reduced GHG emissions.

3.4.1 Energy efficiency

Japan has been successful in increasing energy efficiency and reducing energy consumption. Japan improved its energy intensity in terms of TFC per unit of GDP by 27% between 2000 and 2018 which ranked Japan at the 11th-lowest energy intensity among IEA countries and 14% below the IEA median in 2018. Nevertheless, there is room for improvement and the IEA points to expanding the benchmarking system to more industry and commercial sectors, enhancing the non-binding target in industry to improve energy efficiency by 1% per year, investigating the effect of the targeted increased share of pure electric and plug-in hybrid vehicles (20-30% of new sales in 2030) on electricity demand and grid integration, expanding

[72] The Danish Energy Agency, "Liberalisation of the Danish power sector 1995-2020, An international perspective on lessons learned", p. 29, September 2020, https://ens.dk/sites/ens.dk/files/Globalcooperation/liberalisation_of_the_danish_power_sector_-_report_final.pdf.

the highly successful Top Runner Program to cover more products, and designing a policy to accelerate the renovation rate of existing buildings.[73]

Denmark was ranked as having the 5th-lowest energy intensity among IEA countries in 2018.[74] When comparing Japan and Denmark, the manufacturing energy intensity per value added is significantly higher in Japan, at 3.9 MJ/USD PPP versus 2.2 MJ/USD PPP in 2018.[75] In addition, energy efficiency of Danish buildings has been targeted, leading to energy consumption in buildings being reduced by 45% in the period 1975-2015.[76]

Points of inspiration from the Danish energy efficiency measures could be the following:

- One of the main measures in Denmark has been the Energy Efficiency Obligation Scheme for grid and distribution companies in the electricity, natural gas, district heating and oil sectors. The scheme was market-oriented, allowing companies to choose the most cost-efficient measures to achieve savings. The costs of the efficiency obligation could be included in the grid tariff, i.e., passed on to the consumer.
- Another cost-effective measure has been voluntary agreements with energy-intensive companies improving energy efficiency in exchange for a tax relief.
- The Danish Energy Agency is responsible for a website offering advice on energy savings and possible subsidies to households, businesses as well as the public sector.[77]
- Rules and regulations have been key to improving energy efficiency of buildings. The building code includes minimum energy performance requirements for new buildings and rules for upgrading energy efficiency when renovating existing buildings. For public buildings, energy-saving requirements are in place.
- Economic incentives are applied in a new tender-based scheme providing support for energy efficiency improvements in businesses and buildings (instead of the Energy Efficiency Obligation Scheme mentioned above). Other incentives include grants for the replacement of oil-fired boilers with heat pumps, and loans for energy renovation of municipal and regional buildings.[78]

3.4.2 Renewable energy

Japan has experienced an expansion of renewable energy in the electricity sector, mainly due to the FIT scheme. From 2012 to 2018, renewable electricity capacity almost doubled, with solar PV representing 94% of this expansion. However, the Japanese contract prices for solar PV and onshore wind are significantly higher than in many other OECD countries and the IEA's recommendations include improving the renewable electricity auction system to increase competition and accelerate cost reductions. The IEA also recommends ensuring a smooth transition to the envisaged feed-in premium scheme that should strike a balance between providing long-term revenue stability to developers and exposing variable renewables to electricity market price signals, while reducing the cost of subsidies.[79]

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[73] IEA, "Japan 2021 Energy Policy Review", p. 86 and 88, May 2021, https://iea.blob.core.windows.net/assets/3470b395-cfdd-44a9-9184-0537cf069c3d/Japan2021_EnergyPolicyReview.pdf.
[74] Ibid, p. 70.
[75] IEA, website, "Energy Efficiency Data", Japan; https://www.iea.org/data-and-statistics/data-browser/?country=JAPAN&fuel=Efficiency%20indicators&indicator=EEIManufacturing and Denmark; https://www.iea.org/data-and-statistics/data-browser?country=DENMARK&fuel=Efficiency%20indicators&indicator=EEIManufacturing.
[76] The Danish Energy Agency, "The Danish Energy Model", p. 6, https://ens.dk/sites/ens.dk/files/contents/material/file/the_danish_energy_model.pdf.
[77] The Danish Energy Agency, website, "Sparenergi.dk", https://sparenergi.dk/erhverv.
[78] The Danish Ministry of Climate, Energy and Utilities, "Energy Agreement of 29 June 2018", 29 June 2018, https://en.kefm.dk/Media/C/5/Energy%20Agreement%202018%20a-webtilgængelig.pdf.
[79] IEA, "Japan 2021 Energy Policy Review", p. 91, 99 and 107, May 2021, https://iea.blob.core.windows.net/assets/3470b395-cfdd-44a9-9184-0537cf069c3d/Japan2021_EnergyPolicyReview.pdf.

When comparing to Denmark, renewable energy plays a modest role in Japan. In Denmark, biomass has been used in combined heating and power (CHP) plants since the early 1990s. Wind power has been promoted since the late 1970s and accounts for almost half of the electricity consumption today. A study of the socioeconomic impact of offshore wind suggests that for each new GW offshore wind, around 4,900 jobs are generated directly within the Danish offshore companies. Adding labor inputs from subcontractors and spending of wages and salaries implies that the labor input on a 1 GW Danish offshore wind farm is estimated at a total of 14,600 jobs.[80]

Points of inspiration from the promotion of wind power in Denmark could be the following:

- Publicly funded resources for R&D have been available since 1976 and the authorities, universities and private companies have successfully collaborated, including on test and demonstration facilities for wind turbines.
- The Danish Government has required the electricity generators to include wind power and the transmission grid operators to develop the grid and ensure that new wind turbines can always be connected.
- Public planning requirements are in place for onshore as well as offshore wind, and tenders are offered to establish offshore wind farms. While the municipalities are responsible for identifying suitable locations for sustainable onshore energy projects, the Danish Energy Agency is responsible for the planning of offshore wind farms and provides a "one-stop-shop". If a company wants to set up an offshore wind farm, the Danish Energy Agency will manage the necessary permissions, involve the relevant authorities, and hear the interested parties. In 2021, the Danish Maritime Authority published Denmark's first maritime spatial plan which establishes which sea areas in Danish waters can be used for, inter alia, offshore energy extraction towards 2030.[81]
- Wind power has been efficiently promoted by grants, subsidies, and tax-exemptions over the years but is now turning competitive and subsidies are decreasing. Today, onshore wind is the cheapest power generation technology when adding new capacity in Denmark.[82] However, as mentioned earlier, the 2021 tender for the 1 GW Danish offshore wind farm Thor resulted in a winning bid even guaranteeing an income to the Danish State of 2,800 million DKK or app. 427 million USD.

3.4.3 The energy sector

In Japan, energy-related emissions amounted to 1,066 million tonnes CO2 in 2019, only slightly below the level in the year 2000, according to the IEA. The power sector was the largest CO2 emitter, representing 49% of emissions, followed by transport (19%) and industry (18%). Energy-related emissions have decreased in all sub-sectors since 2000, but this was offset by increasing emissions from power generation, which grew by 24%.[83] Work is ongoing to reform the electricity and gas markets with a view to enhancing security of supply, increasing competition, and reducing end-user prices.[84] The transmission network is fragmented into ten regional grids and divided into two frequency levels: eastern Japan operates at 50 Hz and western Japan at 60 Hz. Transmission capacity between the two regions remains limited and

[80] QBIS, "Socioeconomic impacts of offshore wind", 1 July 2020, available at https://www.danishshipping.dk/presse/nyheder/ny-rapport-havvind-sikrer-tusindvis-af-arbejdspladser.
[81] The Danish Maritime Authority, website, "The Maritime Spatial Plan", 2021, https://havplan.dk/en/about.
[82] The Danish Energy Agency, "The Danish Energy Model", p. 9, https://ens.dk/sites/ens.dk/files/contents/material/file/the_danish_energy_model.pdf.
[83] IEA, "Japan 2021 Energy Policy Review", p. 43, May 2021, https://iea.blob.core.windows.net/assets/3470b395-cfdd-44a9-9184-0537cf069c3d/Japan2021_EnergyPolicyReview.pdf.
[84] Ibid, p. 16.

available wind (in the north-west) and solar resources (in the south-east) are far from major demand centers.[85] A well-functioning integrated domestic grid could facilitate an increase in renewable resources in Japan, implying lower energy import dependency and enhanced energy security.

In Denmark, the energy sector has been key to the energy transition. Carbon emissions in the energy sector have been cut by 58% 1990-2019 and it is no longer the largest emitter.[86] The generation of electricity and district heating accounted for 30-40% of Denmark's GHG emissions up until 2010 but only 11% of the emissions in 2019, as mentioned in Section 1. Liberalization of the electricity market was decided in 1999, following up on EU regulation to create an internal market for energy, and the energy sector was restructured by 2004. The companies generating electricity would have to be price competitive, and they were no longer allowed to be responsible for the transmission grid. Since 2005, the electricity and natural gas transmission systems are owned, operated, and developed by Energinet which is responsible for security of supply. The fully independent Danish Utility Regulator administers the regulation and supervision of the utility sectors in accordance with sectoral law and analyzes and monitors the utility sectors in order to create transparency.[87] The Danish Energy Agency assesses that the wholesale electricity market today is very dynamic, liquid and has a high degree of competition.[88]

Points of inspiration from the energy sector in Denmark could be the following:

- Close cooperation between the Government and the energy sector, including the current climate partnership. The energy sector presented its strategy in 2020 which outlined a 95% reduction in carbon emissions by 2030 as compared to 1990, accompanied by a set of comprehensive requests to the Government. Since then, political agreements have accommodated many of the sector's requests. In 2020, the sector emitted 10.8 million tonnes CO2 and the agreements combined with the sector's own initiatives are now estimated to leave a gap of only 2.5 million tonnes CO2 to reach the target of 1 million tonnes CO2 emissions in 2030.[89]
- Ensuring competition and efficiency through liberalization of the electricity and gas markets and well-functioning exchanges. Providing the necessary regulatory powers and independence to the electricity and gas regulator.
- Rebuilding the power plants to generate both heating and electricity (CHP) which drastically increase energy efficiency as heat is recovered while generating electricity. At the same time, providing district heating, to a large extent generated by CHP plants, and shifting from fossil fuels to biofuels. District heating has been a key driver in reducing energy consumption and CO2 emissions from the energy sector. District heating supplies more than 60% of households in Denmark with heat and hot water.[90]
- Expanding renewable energy resources, such as biomass, wind, and solar PV.

[85] IEA, "Japan 2021 Energy Policy Review", p. 102, May 2021, https://iea.blob.core.windows.net/assets/3470b395-cfdd-44a9-9184-0537cf069c3d/Japan2021_EnergyPolicyReview.pdf.
[86] Danish Energy, "Powering Denmark's Green Transition", May 2020, p. 5, https://www.danskenergi.dk/sites/danskenergi.dk/files/media/dokumenter/2020-07/Powering_Denmarks_Green_Transition_Climatepartnership.pdf.
[87] The Danish Utility Regulator, website, https://forsyningstilsynet.dk/about-us.
[88] The Danish Energy Agency, "Liberalisation of the Danish power sector 1995-2020, An international perspective on lessons learned", p. 7, September 2020, https://ens.dk/sites/ens.dk/files/Globalcooperation/liberalisation_of_the_danish_power_sector_-_report_final.pdf.
[89] The Danish Ministry of Climate, Energy and Utilities, "Klimapartnerskab for energi og forsyning - Sektorkøreplan", p. 4, March 2021, https://kefm.dk/Media/637522788959292805/Sektorkøreplan_Energi-%20og%20forsyningssektor.pdf.
[90] The Danish Energy Agency, "The Danish Energy Model", p.13, https://ens.dk/sites/ens.dk/files/contents/material/file/the_danish_energy_model.pdf.

- Continuously developing the transmission and distribution grid to ensure flexibility and energy security. The increasing share of renewable energy has not affected the level of security of supply in Denmark.[91] The Danish consumers were without electricity supply for only about 20 minutes per year on average during the last five years.[92] Measures to strengthen energy security include:
    - Substituting overhead power lines for underground cables in the distribution grid.
    - Requiring the transmission grid operators to ensure that renewable resources can always be connected to the transmission grid.
    - Ensuring effective operation of an electricity system relying to a large extent on the variable generation of power from energy sources such as wind and solar which requires determining and forecasting capacity adequacy and balancing the use of renewables with conventional sources.
    - Establishing interconnections to neighboring countries, enabling export when domestic supply is abundant and import when domestic supply is insufficient. This also increases efficiency and competition in the electricity market. The natural gas transmission system is connected to Germany and Sweden while the electricity transmission net is connected to Germany, the Netherlands, Norway, and Sweden. The Baltic Pipe, under construction, is a gas pipeline that will provide Denmark and Poland with a direct access to Norway's gas fields by October 2022. Other plans include the Viking Link, a 760 km long electricity interconnector between Denmark and the UK.[93]

The energy sector continues to be key to the Danish energy transition. In the future, energy islands connected to offshore wind farms will play a major role, including an energy island in the North Sea with a capacity of 3 GW and a potential of expanding the capacity to 10 GW. The energy sector will continue the expansion of renewable energy and expects to facilitate the green transition in other sectors, e.g., by supplying electricity to produce hydrogen and other renewable-based fuels (PtX).

4. Conclusion

While Denmark and Japan were both highly dependent on fossil fuels in the 1970s, energy developments have differed sharply since then. Japan continues to be heavily dependent on fossil fuels, not least because of the Fukushima accident, and GHG emissions are at the same level as in 1990. Denmark has reduced GHG emissions by 40% since 1990 and is already undergoing a green transition, increasingly relying on renewable energy, which implies that the challenges are more manageable.

Nevertheless, policy decisions are urgent for both countries in order to reach the 2030 climate targets since energy measures often take considerable time to implement, for instance the construction of offshore wind farms and CCUS facilities. The international attention to climate issues has accelerated since the Paris Agreement in 2015 and after COP 26 in Glasgow there is no doubt that the pressure to reduce GHG emissions decisively will continue to build up.

Japan is facing a major challenge living up to the climate targets of carbon neutrality by 2050 and a 46% reduction in GHG emissions by 2030 as compared to 2013. As outlined in the 6th

[91] The Danish Energy Agency, "Security of Electricity Supply in Denmark", p.3, 2016, https://ens.dk/sites/ens.dk/files/Globalcooperation/security_of_electricity_supply_in_denmark.pdf
[92] The Danish Energy Agency, website, "Electricity", https://ens.dk/en/our-responsibilities/electricity.
[93] Energinet, website, "International infrastructure projects", https://en.energinet.dk/Infrastructure-Projects.

Strategic Energy Plan, the targeted decline in fossil fuels requires comprehensive measures regarding energy efficiency, renewable energy, hydrogen and CCUS, as well as nuclear energy. The latter is particularly challenging due to safety measures and limited public support. Hence, further specific policy measures will probably be necessary.

As Denmark is experiencing declining GHG emissions without jeopardizing economic growth, elements from the Danish energy transition could support Japan's transformation to a decarbonized society.

A fundamental characteristic of the Danish energy model is to engage with others to develop efficient and innovative measures. Internationally, Denmark cooperates with 19 countries, including Japan, exchanging experiences on green transitioning, inter alia, on offshore wind energy. Internally in Denmark, all parts of society are involved, inducing ownership, innovation, and confidence in the green transition.

The independent experts of the DCCC have been mandated to advise how the transition to a climate-neutral society can take place in a cost-effective way, based on professional analyses. The municipalities are responsible for identifying suitable sites for sustainable energy projects. The public is engaged in promoting green solutions, inter alia, through the Citizens' Assembly and the Youth Climate Council.

The different sectors of the Danish economy have been requested to prepare sector road maps to reach the 2030 climate target. The key energy sector has provided an ambitious plan which paves the way for a green transition also in other sectors. But all sectors are engaging, and the financial sector has developed plans for financing investments in green transitioning. A holistic approach implies measures across different sectors, promotion of renewable energy, and regulation and taxation affecting behavior to reduce emissions. A higher CO2 tax is underway. Energy and climate policies are fully integrated and there is close cooperation between relevant Ministries.

Politically, the Danish Climate Act implies a systematic approach, supported by the DCCC, ensuring that adequate policy measures are implemented in due time, and the Act provides transparency and predictability, facilitating the crucial long-term investments. In Denmark - as well as in Japan - strong and consistent political engagement will be key to enacting the required changes of all parts of society and fulfilling the ambitious 2030 climate targets.

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