General Perspectives on the Law of Energy Transition in Denmark

Bent Ole Gram Mortensen

The green transition is characterized as the development which the energy supply in many western countries is currently undergoing. Primarily, the transition includes a reduction in the use of fossil fuels. This chapter is about the transition in Denmark, a country with approximately 6.0 mill. citizens.[1]

A. More Recent Historical Overview

Denmark has gone through a number of energy transitions. Wood was originally the common Danish resource for energy as well as for other purposes such as buildings and ships.[2] In resent historical times in Denmark, the extent of the forest has until recently had a significant correlation with the size of the population. The ravages of the Black Death in the 14th century and several centuries later, wars and other misfortunes and the resulting population reduction in the next few centuries gave way to the forest. Around the year 1600, 20–25 % of Denmark was covered with forest. But

1 The Kingdom of Denmark includes Denmark, Greenland, and the Faroe Islands. This chapter only discusses the legislation in Denmark.

2 On the topic of wood see Bent Ole Gram Mortensen, 'Fredskov – mere skov end fredning [Protected Forest – More Forest Than Protected]' in Nis Jul Clausen/Annette Kronborg/Nina Dietz Legind/Bent Ole Gram Mortensen (eds), *Festskrift til Hans Viggo Godsk Pedersen* (Liber Amicorum to Hans Viggo Godsk Pedersen, DJØF Publishing 2017) 389–408. See in general M. Rüdiger/A. Åberg, 'Energy in the Nordic World' (Aarhus Universitetsforlag. The Nordic World, 2024); Kirsten Gram-Hanssen, 'Energy Consumption in Homes – An historical approach to understanding new routines' in Mogens Rüdiger (ed), *The culture of Energy*, (New Castle 2008); K. Hvidtfelt Nielsen, 'Danish Wind Power Policies from 1976 to 2000: A Survey of Policy Making and Techno-Economic Innovation' in Volkmar Lauber (ed): *Switching to Renewable Power: A Framework for the 21st* Century (London 2005); Birgitte Wistofte/Harriet M Hansen/Flemming Petersen (eds), *Elektricitetens Aarhundrede* [The Century of Electricity](vol. 1, Copenhagen 1991); Birgitte Wistofte/Jytte Thorndahl/Flemming Petersen (eds), *Elektricitetens Aarhundrede* (vol. 2, Copenhagen 1992).

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the population increased again, and slowly the pressure on the forest grew. In the middle of the 18th century, the forest's share was reduced to 8–10 %, and around 1800 it was down to 2–3 %. It was widely feared that society would come to a standstill as a result of a lack of wood.[3]

Over time, wood was partially replaced by the import of English and Scottish coal. From the middle of the 18th century, coal was increasingly used as an energy source in industry. Denmark became more and more dependent on imported energy. This was the first energy transition – fossil fuel. However, it came under pressure when Denmark was on the losing side of the Napoleonic wars.

Local hydropower and peat played a role until oil replaced it as the primary energy source, both in power plants, domestic heating and in the transport sector. However, the Yom Kippur War in 1973 and the Iranian revolution in 1979 gave rise to oil import problems and a jump in prices. At that time, Danish power plants were primarily oil-based but were now rebuilt for coal, the extraction of hydrocarbons from the Danish part of the North Sea was started, and a series of other energy policy measures was initiated.

It was not until the aftermath of the oil crisis of the 1970s that Denmark got laws on energy supply, first regarding electricity supply[4], then regarding heat supply including gas.[5] In the same period, Denmark got its first overall energy policy[6] and a construction law on natural gas supply.[7]

Since then, a number of energy plans have shifted Denmark towards a more diversified energy supply.

Until around 1990, energy plans and political agreements were focussed on making Denmark independent from imported oil. Hereafter, following inspiration from the UN Brundtland report- *Our Common Future*[8], the emission of greenhouse gases was also put into focus.

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3 Thorkild Kjærgaard, *Den danske Revolution 1500–1800. En økohistorisk tolkning [The Danish Revolution 1500–1800. An ecohistorical interpretation]* (Gyldendal 1991) 23.

4 Act no. 54 of 25 February 1976 on electricity supply.

5 Act no. 258 of 8 June 1979 on heat supply.

6 Handelsministeriet [Ministry of Commerce], *Dansk Energipolitik 1976 [Danish Energy Policy 1976]* (Copenhagen 1976), Expansion of district heating and natural gas for residential heating based on municipal heating planning. Tightened energy standards for buildings and subsidies for e.g. re-insulation of homes, energy inspection, etc.

7 Act no. 232 of 8 June 1979 regarding natural gas supply.

8 Available at https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf accessed 17 June 2025.

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Currently, Denmark's two largest energy resources are fossil and renewable energy. Biomass makes up the main part of renewable energy. A large part of this is imported.[9]

As elsewhere, the energy supply is being electrified. Solar and wind energy are growing steadily. Solar parks and wind turbines on land can now be built without government subsidies, though recently the lack in growth in demand for electricity in the hours where solar and wind power produces most drives the prices down and weakening the business case for new solar and wind power. The same might also apply for offshore wind, but rising cost has recently made this unrealistic. Please see chapter C5: The Law of Renewable Energies in Denmark.

B. The Current Energy Supply and Policy

The energy sector in Denmark is generally characterized by broad political agreements. Traditionally, a political agreement is concluded by a majority of the parties of the Danish Parliament, after which the settlement is implemented through one or more (amending) laws. This was the case with Act no. 1392 of 27 December 2008, the Law of Expansion of Renewable Energy, where existing provisions regarding renewable energy electricity were combined into one law. The purpose of the law was to make the rules on installation and production of renewable energy plants as clear as possible for the interested parties.

In 1985, Denmark decided not to use nuclear power for its production of electricity. This policy continues to be supported by a majority in the Danish parliament. Among the population, the press reports on increasing support for nuclear power, although there does not seem to be a majority for this. Two Danish companies are currently developing smaller modularized reactor solutions. For decades, Denmark has imported electricity from Sweden and Germany, which have/had nuclear power in their production portfolio. It is uncertain whether or not the political ban on nuclear power will be lifted. However, it is less likely that nuclear power plants will be established in Denmark, except maybe for smaller test plants.

Because of the country's topography, hydropower is of no importance in Denmark except as imported energy. Electricity is primarily produced

9 Energistyrelsen [Danish Energy Agency], 'Energistatistik 2021' [Energy Statistics 2021] <https://ens.dk/sites/ens.dk/files/Statistik/energistatistik2021.pdf> accessed 17 June 2025.

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via renewable energy and natural gas. There will within a few years be no coal-fired power plants left. Combined heat and power (CHP) play a large role in the energy supply, which ties electricity production together with space heating. Around 69 % of Danish homes are heated by district heating, a number which is increasing. District heating uses biomass, waste, and natural gas. Electric heat pumps are becoming increasingly important. Waste incineration has made a certain contribution, while geothermal energy has so far had close to no effect on the energy supply. However, this may change, as new projects are in the pipeline. Also the utilization of waste heat from industry may in the future contribute more to the district heating systems.

The transport sector is still dependent on oil, but electric cars are gaining ground. Hydrogen is of little significance for the Danish transport sector, and there is no publicly available network of hydrogen filling stations.

Denmark extracts oil and especially natural gas from the North Sea. It has been politically decided that this production must cease in 2050. In the period from 1997 to 2012, Denmark was a net energy exporter, but traditionally, the country has been dependent on the import of energy. In 2023, the degree of self-sufficiency was 59 %. For a short time, Denmark must once again will be a net gas exporter from 2024 onwards. It is uncertain to what extent, in particular, plans for offshore wind turbines will increase the country's degree of self-sufficiency.

The power transmission grid is owned by the state company Energinet (the TSO- Transmission System operator), while the distribution is owned by various private companies with a particular consumer-owned background. The natural gas transmission grid in Denmark is also owned by Energinet. The natural gas distribution network is also owned by the state.[10] In 2019, all Danish distribution of natural gas was brought together in Energinet's subsidiary company, Evida. In 2021, this company was purchased by the Ministry of Finance. Natural gas is in the process to be phased out or at least reduced as a source of domestic heating.

At the time of writing, no hydrogen network has been established. Nevertheless, in May 2023, a political agreement has been made concerning who will, if necessary, own and operate a hydrogen infrastructure in Den-

10 Originally, the natural gas distribution network was operated by regional companies owned by the local municipalities.

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mark.[11] Evida will be responsible for a possible domestic hydrogen network (connection of domestic hydrogen producers and consumers), while Energinet will be system operators and will partially own the cross-border piped hydrogen infrastructure to a Danish receiving point, including cross-border hydrogen pipes across the country to hydrogen storage facilities, and offshore hydrogen pipes. On 4 April 2024, a majority in the Danish Parliament entered into a political agreement on the economic framework conditions for establishing a hydrogen transmission network in the western part of Denmark (Jutland) and down to Germany.[12]

In October 2023, state aid of 1.25 billion DKK was distributed to a total of 6 electrolysis projects of between 9 and 150 MW. It is uncertain whether Denmark can manage to establish a larger hydrogen industry or create a further use for it, e.g., for the production of methanol. It will demand an expansion of the production of renewable electricity in Denmark. Other projects without state aid are being planned or established. At Kassø in the southwest of Denmark, a plant with an expected annual e-methanol production of 32.000 tons has been established.

C. Fossil Fuels

The Danish gross share of fossil fuels in 2023 was registered by Eurostat[13] at 55.40 %. Among the EU countries, a lower share of fossil fuels was only found among four other countries all with a large share of nuclear power and hydropower respectively: Finland with 35.67 %, France 47.89 %, Latvia 53.77 % and Sweden 30.37 % fossil fuels. In 2013, Denmark's share was 75.91 %. There has thus been a significant reduction in the share of fossil fuels over recent years.

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11 See Klima-, Energi- og Forsyningsministeriet [Danish Ministry for Climate, Energy and Utilities], Political agreement of 22 May 2023, 'Mulighed for etablering af brintinfrastruktur' [Possibility of establishing hydrogen infrastructure] <https://www.kefm.dk/Media/638204311368810699/Aftaletekst%20-%20mulighed%20for%20etablering%20af%20brintinfrastruktur.pdf > accessed 17 June 2025.

12 See Klima-, Energi- og Forsyningsministeriet [Danish Ministry for Climate, Energy and Utilities], Political agreement of 4 April 2024, 'Økonomiske rammevilkår for brintinfrastruktur' [Economic framework conditions for hydrogen infrastructure] <https://www.kefm.dk/Media/638478420542283365/%C3%98konomiske%20rammevilk%C3%A5r%20for%20brintinfrastruktur%20-2.%20delaftale%20om%20r%C3%B8rbunden%20brintinfrastruktur_april%202024.pdf> accessed 15 July 2024.

13 See Eurostat, 'Share of fossil fuels in gross available energy' <https://ec.europa.eu/eurostat/databrowser/view/nrg_ind_ffgae/default/table?lang=en> accessed 14 June 2025.

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Natural gas consumption in Denmark has been declining over a number of years. In Denmark, around 40 % of the gas supply comes from biogas (2023). Lately the figure has been increasing sharply. Around 380,000 households corresponding to about 800,000 people have a gas boiler. The numbers are declining, and the political aim is phasing out natural gas for space heating in favour of district heating and electrically powered heat pumps. Different kinds of support schemes have been introduced in order to promote district heating and heat pumps.

Biogas is seen by many as an opportunity to get rid of fossil fuels in industries involving high process temperatures. Denmark is characterized by relatively large biogas plants that mainly operate on market terms. Manure is the largest energy source for biogas in Denmark. A previous consumption of energy crops is to be phased out.

1. Production

Since 1972, oil and natural gas have been extracted in Denmark. Production takes place in the Danish exclusive economic zone (EEZ) in the North Sea. The Danish Energy Agency estimated in August 2023 that the total reserves at the beginning of 2023 amounted to 139 million m^3 of oil and 77 billion Nm^3 gas. Daily production for 2023 is expected to be 3.4 million m^3 (approx. 58,000 barrels) of oil and 0.9 billion Nm^3 of gas (approx. 16,000 barrels of oil equivalent). Production is expected to increase in the coming years as a result of the completion of the renovation of the important Tyra gas field, but by 2030 at the latest, production will fall again as a result of the Danish North Sea fields being 'mature' and therefore production-wise in natural decline.

There are currently 21 oil and gas fields in operation. French Total has been the operator of the majority of the fields (16) since the purchase of Danish Mærsk Oil in 2017. There are a total of 55 platforms located in the Danish part of the North Sea, as well as a number of oil and gas pipelines between different platforms. In addition, there are two gas pipelines and one oil pipeline to the Danish west coast of Jutland as well as a gas pipeline to the Dutch NOGAT pipe system.[14]

14 The Danish offshore natural gas pipeline system is connected to the NOGAT system through the Tyra West – F3 pipeline.

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In a political agreement of 3 December 2020,[15] it has been agreed by a majority in the Danish Parliament that oil and gas shall not be extracted in the Danish part of the North Sea after 2050, and that no new tender rounds shall be launched. There was no change to the possibility of applying for new exploration and production permits on the basis of mini-tender rounds[16] and neighbouring block procedures[17] towards 2050.

The production of oil and natural gas in Denmark will thus continue for many years independently of the green transition.

2. Consumption

The total energy consumption in Denmark has been relatively constant over the past 10 years at between 1,100 and 1,300 petajoules.

In 2024, Denmark's actual oil consumption accounted for 37.5 % of the total energy consumption (252 PJ out of 672 PJ). For natural gas, the proportion is 8.3 % and for coal and coke 2.8 %. By comparison, renewable energy accounted for 46.7 %.[18]

The last 20 years have been characterized by a significant drop in the consumption of fossil fuels, while the consumption of renewable energy has increased. However, a large part of the renewable energy consisted of solid biomass, which includes, inter alia, wood pellets and wood chips (24.9 % in 2024 of the total energy consumption). A large part of this was imported. It remains to be seen whether such a large consumption of solid biomass for energy purposes is sustainable.

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15 See Klima-, Energi- og Forsyningsministeriet [Danish Ministry for Climate, Energy and Utilities], 'Aftale mellem regeringen (Socialdemokratiet), Venstre, Dansk Folkeparti, Radikale Venstre, Socialistisk Folkeparti og Det Konservative Folkeparti om fremtiden for olie- og gasindvinding iNordsøen af 3. december 2020' [Political agreement of 3 December 2020 on the future of oil and gas extraction in the North Sea] <https://kefm.dk/Media/0/3/Nords%C3%B8aftale%20(2).pdf> accessed8 June 2025.

16 At a mini-tender round, interested companies can apply for permission for an area, without a prior tender notice. A notice of the application is then published in the Official Gazette and in the Official Gazette of the European Union, after which other interested parties have the opportunity, within a period of 90 days, to submit their application.

17 If there are geological or production reasons for this, the holder of an existing permit can apply for a permit for an adjacent area (a neighboring block).

18 Key Figures from the Energistyrelsen [Danish Energy Agency], 'Preliminary Energy Statistics 2024' <https://ens.dk/service/statistik-data-noegletal-og-kort/maanedlig-og-aarlig-energistatistik> accessed 14 June 2025.

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D. Electrification

As in many other countries, Denmark's energy consumption is at present in a process of significant electrification.

Electrification in Denmark is most pronounced among passenger cars. Electric cars account for 51 % of new cars in 2024. Electric cars and plug-in hybrids make up a total of 16.5 % of today's stock of 2.86 million passenger cars.[19]

The AFI Act (Alternative Fuels Infrastructure)[20] supports the spread of public charging stations for electric vehicles. The law also includes filling stations and LNG filling stations[21] as well as facilities for power supply from shore to vessels. Municipalities, regions, and joint municipal companies are given the opportunity to pay for a private operator to ensure the spread of charging stations.

E. Heating of Buildings

Heating of buildings is a traditional obligation of landowners. But as a result of the energy crises in the 1970s, updated legislation was introduced,[22] the purpose of which was to reduce the energy supply's dependency on oil. The municipalities were given a planning obligation, and it was hereby determined whether areas were to be supplied with district heating or natural gas, or whether it should be left to the choice of individuals, which at the time would often be an oil burner.

When it comes to domestic space heating, district heating is currently the most widespread technology. Approximately 69 % of Danish homes are heated with district heating.

In Denmark, a home needs heating and supply with hot domestic water. Originally, this was solely the responsibility of the owner. In light of the

19 Statistics Denmark, < https://www.dst.dk/da/Statistik/nyheder-analyser-publ/nyt/NytHtml?cid=48639#:~:text=Nyregistrerede%20motork%C3%B8ret%C3%B8jer%20december%202024,af%20elbiler%20med%2072%20pct.> accessed 14 June 2025.

20 Consolidated Act no. 1043 of 17 September 2024on infrastructure for alternative fuels for transport. Original Law no. 1537 of 19 December 2017. Implements AFI Directive 2014/94/EU. In the 'Fit for 55' legal package, the AFI Directive is proposed to be replaced with a Regulation. The AFI directive is now replaced by Regulation (EU) 2023/1804 on the deployment of alternative fuels infrastructure.

21 However, filling stations and LNG filling stations seems not to have any role in the electrification.

22 Act no. 258 of 8 June 1979 regarding the Heat Supply Act.

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1970s oil crisis, a political desire for increased control over the energy supply arose. This desire first led to the adoption of the Electricity Supply Act and later, in 1979, the Heat Supply Act, which regulated collective heat supply in the form of district heating supply and natural gas supply. The latter has later been separated in Gas Supply Act.

Individual heat supply is not regulated in a particular supply act. There are relevant provisions in various other pieces of legislation. This concerns a ban on the use of certain technologies. Thus, it has been prohibited to install oil burners in new buildings from 2013, and from 2016 in existing buildings in areas with district heating or individual natural gas supply.[23] The Wood-Burning Stove Executive Order,[24] which entered into force on 1 August 2021, mandates the scrapping of wood-burning stoves from before 2003 in connection with a change of ownership within 12 months after the sale. The motive is health-related, as the large-scale emission of particles from old wood-burning stoves is assumed to cause both respiratory ailment and deaths. The provision is assumed to cover approximately 260,000 of Denmark's approximately 700,000 wood-burning stoves. Many of these wood-burning stoves only function as a supplementary energy source. However, there are approximately 100,000 houses that are primarily heated by a wood pellet stove. In the winter of 2022–23, these homeowners experienced increasing prices and feared an impending supply crisis.

Government support is currently provided for homeowners to phase out natural gas boilers faster than normal market conditions dictate.

Many Danish district heating installations have a solar heating system among their production facilities. There are currently (2023) more than 1.1 GW (thermal effect) of solar heating associated with Danish district heating installations.[25]

Although a solar heating system visually looks a lot like a solar park, a solar heating system is not subject to the special schemes in the Expansion of Renewable Energy Act, including the value loss scheme. Only three minor geothermal plants are in operation in Denmark. Licences by the municipalities to drill wells of a depth of less than 250 metres. If wells for geothermal plants are to go deeper than 250 metres, the Danish Energy Agency must be contacted in advance.

23 Act No. 577 of 18 June 2012.

24 Executive Order no. 1449 of 17 June 2021.

25 An overview of solar heating systems can be found at Solvarmedata, <https://solvarmedata.dk/> accessed 8 June 2025.

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F. Biomass

In 2022, renewable energy accounted for 45.6 % of the total energy consumption in Denmark. Biomass made up the majority of the renewable energy with a share of 68 %. The remaining part came from solar, wind, water, geothermal energy, and heat pumps.[26]

Around 30 % of Denmark's consumption of biomass is covered via imports. Wood pellets constituted a total of 68 % of Denmark's import of biomass in 2022, while whole-tree chips constituted 19 %. Furthermore, there were imports of biodegradable waste, firewood, biodiesel, bioethanol, and biooil.[27]

However, the Danish production of biomass, especially in the form of biogas, has increased sharply since 2018. Biogas is promoted through public subsidies.

A significant part of Danish gas production consists of biogas. There are currently around 150 biogas plants in operation in Denmark. A significant expansion of biogas production capacity is excepted, in the form of both new plants and the expansion of existing plants.

A significant part of Danish production of biogas is based on waste products from agricultural animal production. Manure represents more than threequarters of the total feedstock input on agricultural biogas plants. However, energy crops such as corn and beets can be used in biogas. If animal production is reduced, the Danish production of biogas will be dependent on new sources.

A part of the biogas is upgraded to the calorific value equivalent of the North Sea's natural gas. This happens by removing CO2 from the biogas at an upgrading plant. By upgrading the calorific value of biogas, it can be introduced to and distributed via the natural gas distribution network. Over 30 % of gas consumption in Denmark is based on biogas. The number is increasing. In August 2023, Evida stated that 57th biogas plant had been connected to the natural gas grid.[28] It is a political ambition that Danish gas

26 See Statistics Denmark, 'Danmarks forbrug af biomasse til energi holder historisk højt niveau' [Denmark's consumption of biomass for energy remains at a historically high level] <https://www.dst.dk/da/Statistik/nyheder-analyser-publ/bagtal/2023/2023-08-23-Danmarks-forbrug-af-biomasse> accessed 7 June 2025.

27 See Danmark Statistics (n 27).

28 See Energistyrelsen [Danish Energy Agency], 'Evida tilkobler biogasanlæg nr. 57' [Evida connects biogas plant no. 57] <https://evida.dk/nyheder/evida-tilkobler-biogasanlaeg-nr-57/> accessed 8 June 2025.

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customers in 2030 can be supplied exclusively with biogas. The fulfilment of this ambition is eased through the falling consumption of natural gas.

So far, the CO_2 (carbon dioxide) released has mostly been emitted to the atmosphere, but in the future, it can be a source for CCS (Carbon Capture and Storage) or PtX (Power-to-X-covers processes for converting renewably sourced electricity (power) to a substance or energy carrier). Tenders for CCS have been issued.

G. Development of Solar and Wind

1. Offshore

In 1991, Denmark established the world's first offshore wind farm – Vindeby – close to the island Lolland with a capacity of 5 MW. With the climate agreement on green power and heat from 25 June 2022,[29] there was a political majority in favour of tendering at least four gigawatts of offshore wind for realization by 2030 at the latest. Political agreements had already been made on offshore wind farms of a little over 16 gigawatts, of which two are energy islands (in the North Sea and around Bornholm). These political commitments have even been confirmed by international agreements in the form of The Esbjerg Declaration[30] and The Marienborg Declaration.[31]

Production of energy offshore requires state approval, cf. the Renewable Energy Act art. 22–29a. The approval authority has been delegated to the Danish Energy Agency. The Danish municipalities do not have authority when it comes to offshore plants, regardless of whether they are energy plants or other plants (e.g., sea farming).

On 1 February 2023, the case administration of 33 open-door offshore wind turbine projects was put on hold. The reason was uncertainty regarding the compliance of the open-door procedure with EU law.

29 Klima-, Energi- og Forsyningsministeriet, [Danish Ministry of Climate, Energy and Utilities], Delaftale om mere grøn strøm 2022 [Partial Agreement on More Green Electricity 2022] dated 25 June 2022 <https://www.kefm.dk/Media/637920977082432693/Klimaaftale%20om%20gr%C3%B8n%20str%C3%B8m%20og%20varme%202022.pdf> accessed 20 June 2025.

30 'The Esbjerg Declaration' <https://www.regeringen.dk/aktuelt/tidligere-publikationer/the-esbjerg-declaration/> accessed 20 June 2025.

31 'The Marienborg Declaration' <https://www.regeringen.dk/aktuelt/tidligere-publikationer/the-marienborg-declaration/> accessed 20 June 2025.

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However, in March 2023, the case administration of 4 projects could be resumed. Common to the projects was the fact that they had received preliminary research permits in the period of 2014–2019. The market situation in 2023 was so different compared to this earlier period that were no longer any conflicts with EU law.

Two additional projects, which received establishing permits in the autumn of 2022, were assessed not to be in conflict with EU law. The projects in question received preliminary research permits in 2019 and 2018, respectively. All the remaining open-door projects was refused, primarily on the grounds that they are not in accordance with the marine plan. Several of the refusals were brought before the Energy Board of Appeal, which has turned them back to the Danish Energy Agency due to deficiencies in the reasoning. When the manuscript was submitted in June 2025, the Danish Energy Agency had not yet made any new decisions.

At the same time, the establishment of energy islands is already delayed and there is a real possibility that especially the North Sea energy island will not be economically feasible to establish. The energy island Bornholm in the Baltic Sea seems to be more realistically to establish.

2. Onshore

Danish onshore wind turbines have a capacity of 2.7 GW. For some time, wind turbines have had the reputation of being the most 'fertile crop on the field'. While it has proven attractive to the owners, the neighbours of the up to 180-meter-tall wind turbines have often been less enthusiastic.

In recent years, the expansion with solar cell plants has mainly taken place as field installations. The currently largest field installation is 340 hectares (340,000,000 m^2). The disadvantage of field installations is precisely the use of land space, which competes with other uses, including use for nature and the production of food. Mark installations currently seem to be the commercially most attractive form of solar cell plants. This is presumably due to economies of scale in the possibility of large plants and lower installation costs in fields than on buildings.

Solar cells on buildings have the advantage that the electricity produced can often be consumed closer to the solar cell plant, which reduces network costs. Furthermore, the utilization of buildings has the advantage that no other areas (e.g., agricultural land or nature) is included in the production of energy. It is to be expected that going forward, the technology on solar

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cells will make it more commercially relevant to utilize existing buildings and spaces for the production of electricity. So far, only a limited amount of commercial solar cells have been constructed on Danish roofs. Solar cells on the roof of ordinary households have formerly been popular due to the possibility of saving electricity tax. When this possibility was degraded, this extension came to a standstill.

The localization of wind turbines and solar parks is typically done by an installer of wind turbines or solar cells (often referred to as a developer) who has entered into an agreement with one or more owners of land (typically farmers) regarding the installation of the plants in question. However, before this happens, the installation is dependent on whether or not the municipality will grant planning permission for this. An overall national plan has been lacking.

However, with the 'Partial Agreement on More Green Electricity 2022',[32] a number of political parties representing a majority in the Danish parliament have agreed to ensure framework conditions that can enable a quadrupling of total electricity production from solar energy and onshore wind towards 2030.

Further, in October 2023, the government (which has a majority in Parliament) came up with a plan based on 32 state-designated areas[33] with a total potential for 127,000 GWh of production. However, at the time of submission of the manuscript, none of the designated areas have transformed into concrete projects.

H. The Dilemma of Conflicting Interests

One of the challenges of switching to renewable energy production is the many other considerations that also must be taken care of in a society: nature protection, appropriate waste management, food production, and groundwater protection.

32 Delaftale om mere grøn strøm 2022 [Partial Agreement on More Green Electricity 2022] dated 25 June 2022 <https://www.kefm.dk/Media/637920977082432693/Klimaaftale%20om%20gr%C3%B8n%20str%C3%B8m%20og%20varme%202022.pdf> accessed 20 June 2025.

33 Klima-, Energi- og Forsyningsministeriet [Danish Ministry of Climate, Energy and Utilities], 'Climate Action Plan' (October 2023) <https://kefm.dk/Media/638324394100598678/Udspil%20-%20Mere%20gr%C3%B8n%20energi%20fra%20sol%20og%20vind%20p%C3%A5%20land.pdf> accessed 20 June 2025.

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1. Nature Protection

Denmark is a country with a limited amount of nature. The Danish Biodiversity Council pointed out in November 2023 in its annual report that there is worryingly little protected nature in Denmark.[34] Despite this, there seems to be acceptance by the Danish government that facilities for the production of renewable energy can be established in a protected manner.

Nature protection considerations represent a common area of conflict in connection with the establishment of large plants, including renewable energy plants. E.g., in connection with offshore wind turbines, offshore wind turbines can conflict with forage areas of sea birds and migration routes of migratory birds and bats.

A special scenario is the establishment of offshore wind power in the Wadden Sea, which is on the UNESCO World Heritage List. The three Wadden Sea countries – Denmark, Holland and Germany – confirmed at the latest in 2023 with the so-called Wilhelmshaven declaration not to build e.g. wind turbines within the relevant world heritage area: 'Reconfirming the existing trilateral agreement that prohibits the construction of wind turbines, oil and gas exploration, and exploitation and construction of new installations for oil and gas within the boundaries of the Wadden Sea World Heritage Site'.[35]

2. CCU or CCS

With the political agreement[36] of 20 September 2023 between 10 of the Danish Parliament's parties, which represents the vast majority of the members of Parliament, the future framework for CCS was determined.

34 Biodiversity Council, 'Mod robuste økosystemer – Årsrapport 2023' [Towards resilient ecosystems – Annual Report 2023] <https://www.biodiversitetsraadet.dk/viden/aarsrapport-2023> accessed 20 June 2025.

35 See point 28 i of Common Wadden Sea Secretariat, 'Wilhelmshaven Declaration. Ministerial Council, Declaration of the 14th Trilateral Governmental Conference on the Protection of the Wadden Sea' *(2023)* <https://www.waddensea-worldheritage.org/sites/default/files/2023_Wilhelmshaven%20Declaration_signed.pdf> accessed 20 June 2025.

36 Klima-, Energi- og Forsyningsministeriet, [Danish Ministry of Climate, Energy and Utilities] 'Aftale om styrkede rammevilkår for CCS i Danmark. Klimahandling – Vejen til fuld fangst og lagring af CO_2 i 2030' [Agreement on Strengthened Framework Conditions for CCS in Denmark. Climate Action – The Path to Full Capture and Storage of CO_2 in 2030] <https://kefm.dk/Media/638307862071081909/Aftale%2

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The agreement is based on the premise that Denmark's 70 % reduction target in 2023 only can be achieved if CCS is included as a means of action. At the same time, it is assumed by the Geological Survey of Denmark and Greenland (GEUS) that Denmark's underground has room for a total of 12–22 billion tons of CO_2, which corresponds to up to 500 years of emissions from Denmark.

The agreement builds on other agreements that since 2020 have allocated up to a total of 38 billion DKK to CCS. It is therefore also a premise that CCS needs public aid. Thus, it is explicitly stated in the agreement that CCS 'in the years to come is expected to continue to be dependent on public aid.' In the long term, it is the idea that CCS is to be operated on marked terms, e.g., via financial incentives such as taxes, quotas on CO_2 from fossil sources, and possibly certificate sales.

In February 2023, the Danish Energy Agency announced the first three permissions for full scale CO_2 storage projects in the Danish Part of the North Sea. In March 2023, the first CO_2 was stored in the North Sea. In May, the Danish semi-state energy company Ørsted won a tendered establishment of the first full scale CCS project in Denmark. It is unknown whether there will be as great a demand for domestic CO_2 for PtX as, for example, methanol, that future CCS in the Danish underground must rely on imported CO_2. The Danish Energy Agency has issued a tender for Contract on subsidy for carbon capture, transport and storage. In May 2025 the Danish Energy Agency has selected 10 companies from a pool of 16 applicants to compete for DKK 28.7 billion in funding for Carbon Capture and Storage projects.[37]

In 2022, Denmark signed an agreement on cross-border transport of CO_2 with Belgium concerning geological storage under the seabed.

Rules on the transport of CO_2 are gathered in a special law on transport of CO_2. It is the intention that both private and state companies should be able to own, establish and operate infrastructure for the transport of CO_2. However, third-party access to all pipelines must be ensured.

The State's owner share via Nordsøfonden in storage licenses is set at 20 % going forward. This corresponds to what has been agreed upon for the three licenses issued in February 2023.

0om%20styrkede%20rammevilk%C3%A5r%20for%20CCS%20i%20Danmark%20af%2020.%20september%202023.pdf> accessed 20 June 2025.

37 See <https://ens.dk/en/press/10-companies-selected-compete-denmarks-ccs-fund-dkk-287-billion-carbon-capture-and-storage> accessed 20 June 2025.

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3. Local Communities

The majority of wind turbine capacity and solar cell capacity have been established as parks by commercial developers. Household installations have a very limited contribution to the production capacity.

In some cases, an energy park is established by a community of citizens. Ownership of local energy parks could otherwise be one of the ways to achieve greater local acceptance of these plants. The lack of enthusiasm about becoming a neighbour to a large energy plant has often been characterised as an expression of NIMBYism, and the law also prescribes compensation for loss of value of a property. However, this does not change the fact that an outside developer typically makes money from establishing the facility, while the local residents have to live with the disadvantages such as impaired views and noise.

I. Conclusion

Denmark has gone through a number of energy transitions which, in varying degrees, have concerned wood, coal, oil, natural gas and, most recently, wind and solar power.

Security of supply has previously been an important element in Danish energy supply policy. Most recently, it was most strongly expressed in the oil crises of the 1970s, when oil was phased out in electricity production. However, other major considerations now also apply. First environmental and then climate consideration was included from the 1970s onwards.

However, the short-term gas supply crisis in connection with the war between Ukraine and Russia has also led to an increased political focus on phasing out gas for domestic heating.

With increasing geopolitical challenges, security of supply has again become relevant. And the green transition implies increasing use of domestic energy sources – solar and wind – which contribute to reducing the need to import energy resources.

However, there seems to be a conflict between these three considerations. Nature conservation can stand in the way of rapid expansion with solar and wind. There have been several cases where environmental permits have been rejected in the appeals body. Projects have been delayed with heavy losses. In the worst case, the basis for the business case in question

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disappears as a result of changes in market conditions during the appeal process.

Characteristic of the current green transition is that the political visions also include expansion with a larger export in mind, whether it is electricity produced from offshore wind, hydrogen, or methanol via PtX.

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