From black to green – a Danish sustainable energy growth story

A case study of how an energy utility can transition from fossil fuels to renewable energy and the enabling regulatory framework that made it possible

FROM BLACK TO GREEN: A DANISH SUSTAINABLE ENERGY GROWTH STORY
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LIST OF ABBREVIATIONS USED IN THIS REPORT

CfD	Contract for Difference
CHP	Combined Heat and Power plants
DEA	The Danish Energy Agency
DONG	Danish Oil and Natural Gas A/S
DSO	Distribution System Operator
EBITDA	Earnings Before Interest, Taxes, Depreciation and Amortisation
ESG	Environmental, Social and Governance
ETS	Emissions Trading System
FiT	Feed-in tariff
FTE	Full-time equivalent
GFC	Global Financial Crisis of 2008/2009
GHG	Greenhouse gas
GW	Gigawatts
IEA	The International Energy Agency
IPO	Initial Public Offering
kW	Kilowatt
LCoE	Levelised Cost of Energy
m	Metres
Mt	Megatonne
MW	Megawatt
OPEC	Organization of the Petroleum Exporting Countries
PSO	Public Service Obligation
PV	Photovoltaic
RE	Renewable energy
TSO	Transmission System Operator

Executive Summary

About this report

Across the globe, policy makers and commercial entities are grappling with the challenge of how to transition from a power system based on fossil fuels to a renewable based one. In doing so, regulators and policymakers have to tackle numerous issues along the way, such as how can ambitious targets be met in an economical way and secure sufficient job creation? How can markets attract investment in new technologies, without triggering high risk premiums? How can support schemes incentivise competition in new technologies, without placing heavy economic burdens upon the state?

For energy companies willing to make the transition to clean energy, the challenges in a radical reorientation of their business are equally many and complex. How does a new technology challenge the workforce? How can the companies adapt to changes in their risk profile brought about by the adoption of new assets? How should they account for existing assets?

This report aims to tackle both these sets of challenges, by describing in detail the green transition underway in Denmark, and including lessons learned along the way – both positive and negative. Despite having no nuclear or hydroelectric energy, Denmark consistently ranks in the top 3 of the World Energy Council's Energy Trilemma Index, which assesses countries based on their performance in three key dimensions: energy equity, environmental sustainability and energy security (Wyman, 2020). It is also ranked as the country most advanced in terms of system integration of variable renewable energy by the IEA, and is leading the world in terms of the share of variable renewable energy in the grid, with the equivalent of 50 per cent of the gross electricity consumption supplied by wind and solar in 2020. The transition in Denmark has so far led to not only cleaner energy, but also fostered a focus on renewable energy as a growth sector.

Gross Electricity Production in Denmark

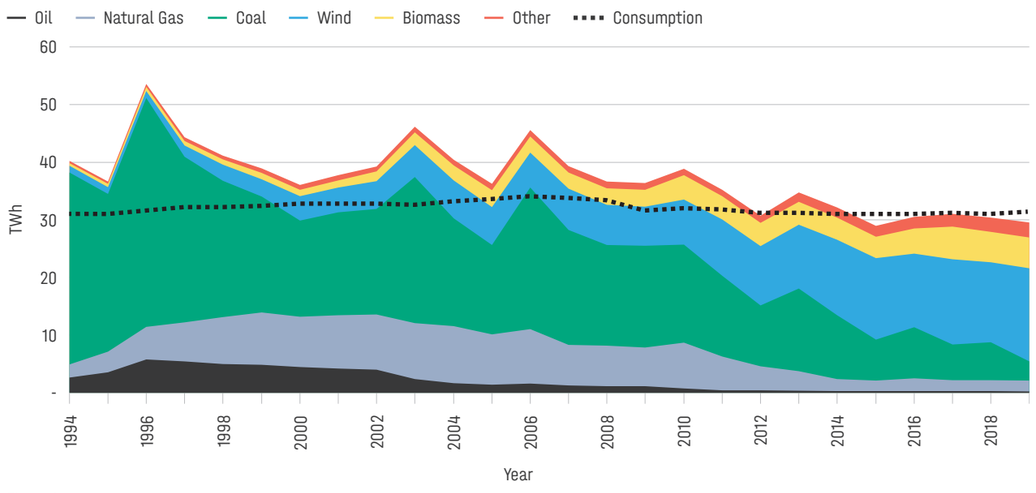

Figure 1:
Electricity production and consumption in Denmark. "Other" includes (listed in descending order by size): solar, non-renewable waste, biogas, biomethane, hydro and surplus heat. Source: Danish Energy Agency, 2019.

Enter Ørsted – an energy company that has undergone a radical transition throughout the last decade, transitioning from a business based almost entirely on conventional fossil fuels to a financially successful company based almost entirely on renewable energy. In 2006, the company was 81 per cent owned by the Danish state and had a portfolio 85 per cent based on fossil fuels, making it one of the most coal-intensive companies in Europe, and responsible for around one third of Danish emissions. By 2019, the company had changed name, implemented a new business model, was owned 50.1 per cent by the state and had a portfolio that comprised of 90 per cent renewable energy. Many energy companies have embarked upon a green transition in Denmark. However, as Ørsted is the largest electricity generating company in the country and has undergone a significant "green transition", it is the prime choice for a case study to analyse *how did Ørsted transtition from black to green energy whilst remaining profitable?*

The purpose of this report is twofold. Firstly, it aims to provide an overview of the policy/regulatory aspects which helped accelerate the decarbonisation of Denmark. Secondly, based on a case study of the transition of the energy company Ørsted, the report aims to provide learnings and recommendations for other utilities which are about to follow a similar path. Written with contributions from the Danish Energy Agency (hereafter referred to as the DEA), including information from interviews with senior experts from government, academia and Ørsted, the report commences with a detailed timeline of events from Denmark's energy policy landscape and Ørsted's evolution. The report concludes by presenting a catalogue of learnings and recommendations which can be useful for regulators, policy makers and energy companies located across the globe in achieving a just, sustainable transition to renewable energy.

State-owned energy companies in many countries willing to make the transition from conventional, fossil-fuel based thermal generation to renewable energy generation may not have that same opportunity to be global first movers that Denmark has had. However, the global situation surrounding climate change and rapid growth in renewable energy means that the timing of this report is highly relevant, and if there is one clear outcome from this report, it is that the transition to green energy must be made to stay competitive, relevant and profitable.

"IT'S NOT JUST GOVERNMENTS THAT CHANGE THE WORLD AND IT'S NOT JUST BUSINESSES. IT HAS TO BE GOVERNMENTS AND BUSINESS WORKING TOGETHER. BUSINESSES CAN BE QUITE GOOD AT GETTING THINGS DONE. GOVERNMENTS HAVE A KEY ROLE TO DO IN SETTING THE AGENDA, DESCRIBING A VISION, SETTING SOME TARGETS." DUNCAN CLARK, HEAD OF REGION, ØRSTED UK

This report demonstrates how energy planning and policy has created the framework conditions necessary to incentivise a large shift from fossil fuels to renewable energy (primarily wind and biomass energy in Denmark's case). The learnings as presented in this report are that energy planning and policy should be long-term, transparent, stable and supported by the legislation through concrete reforms. From a regulator and policy perspective, some of the instruments that led to a successful transition in Denmark include:

- Economic incentives such as subsidies and taxes
- Competition-based reforms of the electricity sector
- Demonstration projects and test facilities through public-private partnerships or joint ventures
- De-risking and reforms to permitting procedures
- Investment in research and development
- Local ownership of renewable energy

Key recommendations for energy companies include:

- Devise an entry strategy into new renewable energy markets, as that is where the future growth is. Implement the strategy by making the corresponding investments and developing the skill base
- Commit seriously to renewable energy to steer strategic development and help attract financing for new projects
- Devise a strategy in collaboration with government agencies for the reduction of coal consumption and divestment of fossil fuel assets. This could include the conversion of coal to sustainably sourced bioenergy or a complete overhaul of sites to renewable energy and using fossil plants as a backup

Minister foreword

BY DAN JØRGENSEN, DANISH MINISTER FOR CLIMATE, ENERGY AND UTILITIES

The Paris Agreement requires a significant transformation in the way we produce and consume energy. Denmark has enacted ambitious policies and legislation to achieve this goal, and aspires to lead the way in the global transition to a more sustainable future.

We have set a target of a 70 per cent reduction in greenhouse gases by 2030 compared to 1990. According to the latest projections, renewable energy will cover 100 percent of our electricity consumption in 2028 and 58 percent of our overall energy consumption in 2030. With wind and solar providing 50 percent of our electricity consumption, and coal supplying less than 3 percent of the national gross energy consumption in 2020, we are well on the way to an energy system that is virtually fossil free.

Denmark has accumulated valuable experience in navigating the challenges of simultaneously achieving continuous economic growth, a high security of supply, affordable electricity prices and an increasing share of renewable energy – all while fostering a world leading renewable energy sector that is key to the Danish economy today.

By sharing the story of how an entirely state-owned energy company succeeded in transitioning from black to green, we hope to inspire not only policy makers and regulators, but also other energy companies around the world to do the same and embark on a path towards greener energy.

For Denmark to reach the position we hold today has required bold decisions, a pioneering spirit and broad cooperation between the government, industry and citizens. The policies and business models of yesterday will not work for the governments and energy companies of tomorrow. Governments need to set ambitious goals that are supported by sound regulatory frameworks which will aid in the fulfilment of the targets, thus incentivising and enabling companies to embark upon this transition and securing the confidence of investors, industry and civil society.

We hope you feel inspired, and we hope the learnings presented in this report are useful in your country's green transition.

Dan Jørgensen
Danish Minister for Climate, Energy and Utilities

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TIMELINE

The Danish renewable energy journey

Key milestones in Denmark and Ørsted's transition to green energy

Danish energy policy landscape

Danish state-owned generation company

1972 – State announces establishment of commercial natural gas, oil extraction and transmission company, DONG

1973 – First major wind turbine (2 MW) in Denmark starts generating electricity

1973 – Oil crisis in Denmark

1978 – Elkraft (a predecessor to DONG) establishes Europe's largest wind farm, with capacity of 3.75 MW

1985 – Parliament decision on energy planning without nuclear

1987 – "Energi 2000" energy plan announced.

1990 – Deal for increasing use of biomass energy is published

1991 – A fixed feed-in tariff is put in place for onshore wind

1991 – Elkraft installs the first offshore wind farm, Vindeby

1993 – Ministry orders electricity companies to expand onshore wind

1995 – Environment and Energy ministers' council on offshore wind turbines publish assessment of 5 areas for offshore wind

1995 – Elsam (predecessor to DONG) and Midtkraft install Tunø Knob wind farm

1996 – No new coal plants can be built in Denmark

1997 – Horns Rev 1 wind farm installed by Elsam and Eltras

1999 – The electricity reform bill is implemented, liberalising the electricity sector

2002 – Revised subsidies for RE including market premium

2003 – Nysted (AKA Rødsand) offshore wind farm installed

2004 – First tender for offshore (HR2) is done – 4 applications received

2005 – DONG begins construction on Barrow wind farm in the UK
Energi E2 wins HR2 tender

2006 – Merger of 6 power companies into DONG Energy A/S

2007 – Sold transmission and gas storage to TSO

2008 – Energy agreement to increase share of renewable energy

2008 – January: announcement of ambition to switch to 85% renewables by 2040

2009 – Announcement of 400 MW offshore wind tender, Anholt

2009 – Decision to close two coal-fired power stations, Asnæs and Studstrup

2009 – Agreement with Siemens for 500 3.6MW wind turbines

2010 – DONG wins Anholt tender

2012 – 6 areas are reserved for future offshore wind farm auctions

2012 – Credit rating downgraded

2014 – Financial restructuring of company

2015 – Takeover of US offshore wind development project

2016 – Investment decision on Hornsea 1, largest wind farm in the world at 1.2 GW

2017 – Invests in Taiwan offshore project. Awarded three new projects in Germany, including without subsidy

2017 – Changes name to Ørsted, divests oil & gas business

2018 – Acquires Deepwater Wind and Lincoln Clean Energy in US

2019 – DSO sold

2020 – Thor and Hesselø tenders announced (800-1000 MW offshore wind)

2020 – Energy agreement announced, 70% reduction in CO2 by 2030

2021 – Energy island plan announced

TIMELINE

1970s and 1980s

The oil crises call for new energy policies and technologies

In 1972, oil accounted for 92 per cent of gross energy consumption in Denmark. Thus, when the OPEC oil crisis quadrupled the price of oil in 1973, Denmark's economy and energy supplies were severely affected. While some short-term measures such as the introduction of car-free Sundays in Denmark during the 1973/74 winter were launched, the event was the catalyst for long-term energy planning.

This culminated in the establishment of the DEA and the government's "Danish Energy Policy 1976". Short-term aims ranged from reducing the country's dependence on oil, increasing diversity of supply, reducing energy consumption to increasing energy-related research and development. The long-term aims of the agreement were to slow the depletion of natural resources and develop stable, long-term solutions to energy demand by utilising renewable energy sources. However, the initial measure enacted as part of the policy was the rapid conversion of power stations from oil to coal.

Locally extracted natural gas was initially seen as a solution to the country's energy woes and the Danish state-owned natural gas company, Dansk Naturgas, was merged with the Danish state-owned oil company to create Danish Oil and Natural Gas A/S (DONG A/S) in 1974, which later evolved into Ørsted. DONG was largely a gas wholesaler, distributing gas to regional natural gas companies. At the same time, there were 7 power companies in the power group Elsam in Western Denmark and 3 power companies in the power group Elkraft in Eastern Denmark. These two companies were responsible for planning for new power capacity and coal imports, and were also in charge of the overall transmission system and system operation.

Energy Agreements or Climate Agreements are politically agreed documents that bind the government based on a political majority in the parliament, before going through a formal process of changing or introducing new legislation. For example, the Climate Act of 2020 was initially agreed to by 8 out of the 10 parties in the Danish Parliament on December 6, 2019, before going through three parliamentary proceedings and a committee hearing to be adopted as the legally binding Law on Climate on June 26, 2020. Most major energy policies are decided in this way and ensure continuity and stability in Denmark's energy planning, regardless of whether there is a change in government.

Although Danish scientists had experimented with wind as a form of energy since the late 1890s with varying degrees of success, the energy crises of the 1970s meant that wind energy attracted renewed interest. The Danish government increased funding for research and development in the technology and subsidies for electricity generated by wind were thus introduced in 1976. Two years later in Jutland, in the north western part of Denmark, the world's first large turbine (2 MW) was erected by a high school and began generating electricity from the grid. The turbine is still operational to this day. The Danish parliament passed the Natural Gas Supply Act and the Heat Planning Act in 1979 that started the process of further utilising surplus heat from power plants and natural gas.

From 1984, feed-in premiums equivalent to the tax on electricity were passed by Parliament, which led to the creation of a market for small, 25-55 kW wind turbines. Growing domestic demand for wind turbines spurred a number of small engineering companies to develop industrial mass production of increasingly large wind turbines. The agreement included further ambitions such as to increase the recovery rate of hydrocarbons, tighten energy requirements for new construction projects, and to assess the need for nuclear power, and if so, put it to a referendum. The 1980s were also the decade where quotas for SO_2 and NO_x were introduced in Denmark.

While neighbouring Sweden developed nuclear energy, Denmark said "Nej Tak" (No Thanks) to nuclear power as a source of electricity, motivated by strong public opposition. A parliamentary decision on public energy planning without nuclear energy was passed in Denmark under the auspices of the Energy Agreement of March 1985 (Danish Energy Agency, 1985). With imported oil and nuclear now excluded from Denmark's energy mix, the quest for local, secure and environmentally friendly sources of energy continued, until two energy agreements laid the foundation for the primary energy sources that have featured in the Danish energy transition – wind energy, natural gas and biomass-based, Combined Heat and Power plants (CHP).

Another Energy Agreement was made nine months later, between the Ministry of Energy and state-owned energy companies to increase electricity generation from wind turbines in pilot projects. The agreement arose as an initiative on behalf of the utilities, so that the grid connection of wind turbines could be included in their planning, and the companies were tasked with implementing a program that would install 100 MW over the period of 1986-1990 (a doubling of installed capacity compared to the previous five years). The Electricity Supply Act allowed for the cost of development to be included in the electricity price, while the energy companies made large developments in terms of professionalising the wind energy industry.

A year later, a new Energy Agreement in 1986 mandated that the energy companies should carry out a demonstration program to develop 450 MW of decentralised CHP plants, which should be based on domestic fuels such as natural gas, straw, wood-based biomass, waste and biogas. These decentralised CHPs based on biomass were a new technology, and as such, the agreement mandated a demonstration program to gain the technical and economic experience necessary for wider expansion.

These government initiatives set the wheels of Denmark's wind energy adventure in motion. 1987 saw Europe's largest onshore wind farm to date inaugurated by Elkraft on the island of Masnedø in south-eastern Denmark. The wind farm with a capacity of 3.75 MW consisted of five 750kW wind turbines. The following year, the record was beaten by a 4.68 MW wind farm called Nørrekær Enge, which consisted of 36 turbines with a rated individual capacity of 130 kW.

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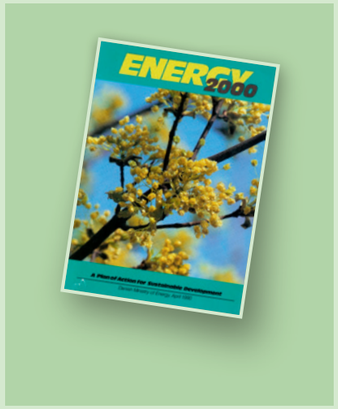
Elkraft (a predecessor to DONG) establishes Europe's largest wind farm, with capacity of 3.75 MW

TIMELINE

1990 to 1995

Sowing the seeds of sustainable growth



In March 1990, an Energy Agreement mandated the increased target for the installation of onshore wind, with another 100 MW before 1994, and increased utilisation of CHPs, natural gas, and other "environmentally-friendly fuels". This was the Danish government's response to the recommendations set out in the report by the World Commission on Environment and Development, the Brundtland Report, and the 2000 United Nations' Environmental Perspective. This entailed a goal of converting coal-fired district heating plants to gas-fired decentralised CHPs before 1996. The participation of energy companies in the development of wind power was planned in conjunction with the Ministry of Energy, and the energy companies subsequently released a joint report on wind power development. This is another example of the close stakeholder engagement in policy development between the Ministry of Energy and the energy companies, with the political goal of increased socio-economic welfare and environmental benefits. The immediate impacts of this policy were seen, with an application to construct a new 350 MW coal unit at the Skærbæk power station in Jutland refused, as it did not meet the agreement's criteria of sourcing supply from decentralised CHPs with environmentally-friendly fuels.

Following the Energy Agreement, an Energy Action Plan in April 1990 named "Energy 2000 – A plan of action for sustainable development", was sent to parliament with a target of a 15 per cent reduction in energy consumption and at least a 20 per cent reduction in CO_2 emissions by 2005. This was a milestone in energy policy, as climate and energy policies were integrated, and can be considered the first governmental plan in the world to reduce CO_2 emissions. The report proposed the implementation of environmental taxes on CO_2 and SO_2, which were subsequently realised via the introduction of taxes on CO_2, SO_2 and NO_x in 1992 (the first country to do so), 1995 and 2008 respectively. Further extensive initiatives in energy efficiency were also introduced.

The latter half of 1990 was characterised by cross-border collaboration in setting CO_2 emission reduction targets. Danish domestic efforts were followed by a joint European Communities Council meeting in Luxembourg in October 1990 to agree on a target for stabilising CO_2 emissions. Two weeks later in Oslo, Nordic energy ministers announced common initiatives designed to tackle greenhouse gases.

In 1992, subsidies for electricity production from wind turbines were introduced, as well as state support for the completion of the district heating network and to promote the decentralised cogeneration and utilisation of bioenergy. The support for wind turbines was in the form of a Fixed Feed-in-Tariff (FiT), as at the time there was not an electricity market and generators received a constant price for generation.
In June 1993, the Energy Agreement to promote biomass was made. This included a requirement to use surplus straw and wood chips for fuel. The main thrust of the agreement was a focus on converting large, central CHPs to biomass, starting by co-firing coal thermal plants. Then, newer plants would be installed with the aim of being solely biomass-fired, while simultaneously starting a large research program in order to bring down costs. At the same time, burning biomass on the land was banned.

This early 1990s momentum in the policy space was followed by concrete projects from the energy companies. In 1991, Elkraft installed a historic demonstration project called Vindeby. The world's first offshore wind farm, Vindeby arose as a response to the 1985 agreement and due to the fact that it was becoming difficult to find space onshore. The project consisted of 11 wind turbines of 450 kW each, totalling just under 5 MW. The project essentially used onshore turbines and at a sea depth of only 2-7 m. Despite initial challenges with the turbine performance (the turbines had to be shipped back to land to be repaired before being re-installed), the project effectively proved the concept of offshore wind as being both technically and commercially viable. Valuable lessons were learned, such as the need for a sophisticated Operations and Maintenance (O&M) Plan, and the requirement of specially made vessels for installation and O&M. Powering approximately 2,200 homes, Vindeby laid the foundations for the vast offshore windfarms that exist today. In 2017, Vindeby was decommissioned due to the age of the turbines. In 1995, Midtkraft and ELSAM joined forces to install another demonstration project, the world's second offshore wind farm, called Tunø Knob.

The ability to harness wind resources more effectively offshore and avoid the land use constraints of onshore wind meant offshore projects gained in popularity. However, the access of multiple stakeholders to maritime spaces was emerging as an issue. The Ministry of Environment and Energy's committee on offshore wind turbines reported its mapping of the regulatory interests in Danish waters in 1995, including environmental protection, navigation, the military, fisheries and visual consequences, etc. The report pointed to five major areas as suitable locations for future offshore wind farms.

1990
"Energi 2000" energy plan announced.

1991
Elkraft installs the first offshore wind farm, Vindeby

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A fixed feed-in tariff is put in place for onshore wind

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Deal for increasing use of biomass energy is published

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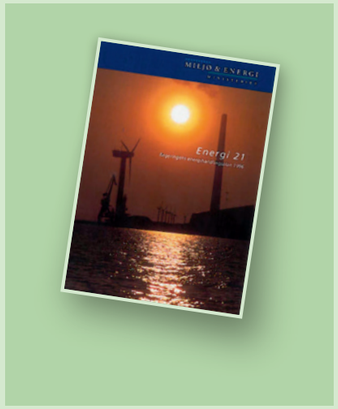
1995
Elsam (predecssor to DONG) and Midtkraft install Tunø Knob wind farm

TIMELINE

1996 to 2000

Denmark at the forefront of change and the first EU provisions for a liberal internal market



In the latter half of the 1990s, the EU Commission issued a number of directives aimed at gradually opening up the European power systems to market competition and to be part of the EU's internal market. The First Energy Package for electricity was adopted in 1996 and set the stage for the liberalisation of European electricity markets, including Denmark's.

A Ministry of Environment and Energy initiative in 1996 mandated the electricity companies to expand onshore wind by 200 MW by 1999 and 900 MW by 2005, accelerating the pace of onshore wind growth in Denmark. A year later in 1997, an Action Plan published by the ministry and the electricity companies revealed that offshore wind could be far cheaper than expected. The Public Service Obligation (PSO) tariff was introduced in 1996, which from 1999 was used to finance renewable energy subsidies, as well as R&D for environmentally-friendly energy technologies and subsidies for decentralised cogeneration (small-scale CHP). The PSO tariff was financed by consumers via their electricity bills. In 2016, it was decided by Parliament to gradually phase out the PSO from 2017-2022, as it was deemed in breach of EU competition laws, as subsidies were not given to foreign renewable energy producers selling electricity to Denmark. From 2022 onwards, renewable energy subsidies will be financed by the national budget.

In the same year (1997), the government began to deny approval to new power stations partly or wholly based on coal as a fuel, starting with an application by Midtkraft to install a partly coal-fired CHP in Aarhus. The Minister for Environment and Energy from 1994 - 2001, Svend Auken, was instrumental in much of the progress towards sustainable energy in this period. He was highly supportive of offshore wind and the fight against climate change, pledging 750 MW of offshore wind farms as a "Gift to the Earth" at a World Wide Fund for Nature (WWF) event in Washington as part of the WWF's Living Planet Campaign. 1997 was also notable in that it was the year Denmark achieved its long-held goal of energy independence, insomuch as the energy production overtook energy consumption in the country. Following this, in 1998 the Ministry issued an order to the electricity companies to develop five 150 MW offshore wind farms, to act as demonstration projects.

Following the "Gift to the Earth", a political agreement was made with the energy companies to establish the first major offshore wind farms in the world (200 MW each) at Horns Rev (Elsam in West Denmark) and Nysted (Energi E2, DONG A/S and Sydkraft in East Denmark). These projects were highly significant, early steps on the way to large projects with competitive prices.

It was also in this period that liberalisation of the electricity sector in Denmark took place (Danish Energy Agency, 2020b). Motivated by two parallel movements, the development of the electricity market in Norway and Sweden, and the EU's focus on the European internal market, where electricity was also seen as a commodity that should be traded freely across borders, the electricity reform in 1999 set the scene for the liberalisation of the electricity sector and the establishment of the electricity market. Liberalisation aimed to enhance consumer protection, environmental protection and security of supply. Shortly after the reform, it was necessary to pay a support package of 8 billion Danish kroner (approximately EUR 1.1 billion) to the six power plant companies in the Elsam area and the two in the Elkraft area. This was done in order to secure the generation companies' survival in a liberalised market, and that they trade on the Nord Pool power exchange to ensure the lowest possible prices for consumers.

By the turn of the century, offshore wind was continuing to grow in Denmark, characterised by several notable events; the Middelgrunden offshore wind farm which was owned by local utility Copenhagen Energy and a cooperative of wind turbine enthusiasts, and can be seen from the shores of Copenhagen was constructed, and the DEA granting permission for feasibility studies for two smaller offshore wind farms – near Samsø (Samsø wind farm is notable in that it is jointly owned by Samsø municipality and the residents of Samsø) and the Port of Grenå.

Concurrently, onshore wind was experiencing rapid growth due to improving technologies and subsidies to incentivise generation. In the year 2000, wind turbines produced the equivalent of 13 per cent of electricity consumption in Denmark.

Cumulative Installed Capacity of Wind Power in Denmark

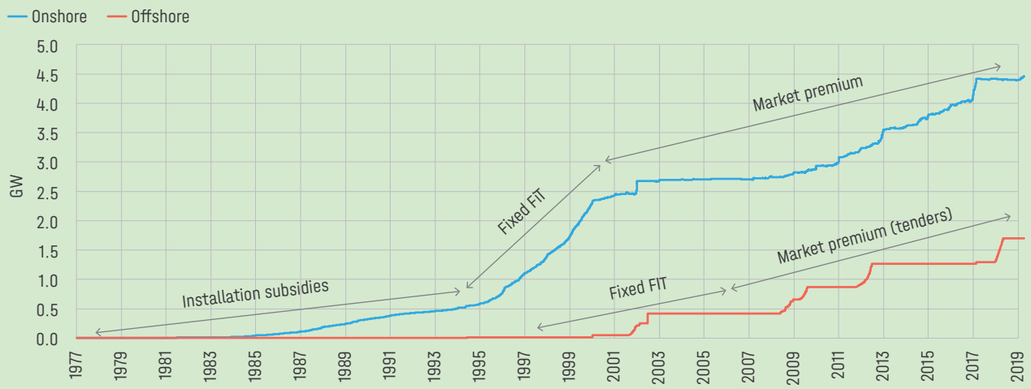


Figure 2:
Onshore wind grew rapidly in the 1990s in Denmark until the year 2000 saw market liberalisation, combined with reduced subsidies and low electricity prices. Since then, the growth has resumed mainly due to replacing older turbines with newer, larger turbines. Offshore wind turbines installed since 2004 have been through a competitive tendering procedure, whereas projects before this were demonstration projects through public-private partnerships with a Fixed FiT. Note, the data does not include recently connected 600 MW offshore wind farm Kriegers Flak

1996
Ministry orders electricity companies to expand onshore wind

1997
No new coal plants can be built in Denmark

1999
The electricity reform bill is implemented, liberalising the electricity sector

TIMELINE

2001 to 2006

A new era for the supply of electricity

Figure 3:
The integration of day-ahead markets started with the liberalisation in 1999 and by 2021, 25 countries have fully integrated day-ahead markets, and an electricity demand of around 3,000 TWh/year (ENTSO-E). More information can be found at (ENTSO-E, 2021)

The new millennium was greeted by a new electricity sector in Denmark. The liberalisation and reform, after being mandated from the EU, was successfully implemented in Denmark. Essentially overnight, the ownership of power production was changed from a monopoly-based system to a market-based, competitive system. Reimbursements went from long-term physical contracts to short-term liquid markets combined with forward markets with instruments (such as the Electricity Price Area Differentials which were introduced in 2000). After debts were paid out to the power plants, they were empowered to trade on the newly created day-ahead market, Nord Pool's Elspot. As east and west Denmark are part of the Nordic and European continental synchronous areas respectively and were not connected across the Great Belt until 2010, it was logical to have two price zones. The socio-economic benefit of being able to trade electricity between bidding zones was that generators could sell for higher prices in neighbouring regions and consumers could access a larger pool of generators, thus lower prices.

A CO_2 quota was introduced, which set an annual quota for the period 2000-2003, reducing by 1 Megatonne (Mt) per year from 23 Mt in 2000 to 20 Mt in 2003. Producers that surpassed their quota would pay a fee of 40 DKK/tonne CO_2 (approximately 5.38 EUR/tonne CO_2) to the state.

At the start of the new millennium, onshore wind development slowed considerably as compared to the impressive momentum witnessed in the 1990s. This can be attributed to two factors:

1. Firstly, with the newly established electricity market, support for wind energy was revised, and the FiT established in 1993 was replaced with a market premium, which meant that renewable generators were exposed to market prices but received a premium on top. This scheme, with the uncertainty of the electricity price as it was a new system at the time, created uncertainty and risk for project developers. The electricity prices were very low in the Nordics due to overcapacity, causing the business case for onshore wind to be less attractive in the new scheme. This risk was perhaps not taken into account in the development of the new support scheme.

2. Secondly, the European market conditions were characterised at the time as being "sellers' markets", and in particular, the UK and Germany provided more attractive markets for developers of onshore wind projects.

On the other hand, offshore wind continued from the previous years' developments. In 2004, a new Energy Agreement was reached in Parliament, introducing the concept of an offshore wind tender – the first offshore wind tender system in the world. The tender would be an auction, where developers would enter a bid for the amount of support they would need from the state to develop the project. Thus, the auctions incentivised cost-effectiveness from the developer. Two offshore wind auctions of 200 MW each were announced – Horns Rev II and Rødsand II. Energi E2 won the Horns Rev II tender, and a consortium of Energi E2, E.ON Sweden, and DONG wind A/S won the Rødsand II tender.

As these were the first two offshore wind tenders, lessons were learned about the design of an auction. For Rødsand II, the initial winner of the auction refused to continue with the project after learning the price of the wind turbines had increased, making it necessary to conduct the tender again. This time E.ON Sweden won the tender.

DONG Energy was awarded a lease to develop an offshore wind farm in the United Kingdom called Barrow. This was the first offshore wind farm a Danish company was involved in abroad.

The EU introduced its Emissions Trading System (ETS) in 2005 to combat climate change. The system worked according to the "cap and trade" principle, where a cap is set and reduced over time, and companies could trade from a finite number of emissions allowances. It remains the world's largest carbon market but was an ineffective driver in the green transformation from 2008 until 2018. Now prices have risen again, and businesses must strongly consider this aspect in business decisions.

In 2005, the national, state-owned Transmission System Operator (TSO) Energinet.dk was created. In 2006, a merger of six power companies: DONG, Elsam, Energi E2, Nesa, Copenhagen Energy and Frederiksberg Utility, resulted in the formation of the company DONG Energy A/S. This was a major merger, meaning that one company generated around 60 per cent of the power of Denmark at that time, and had the capital necessary to invest further in offshore wind. The company was 81 per cent owned by the Danish state and had a portfolio where 85 per cent was based on fossil fuels, making it one of the most coal-intensive companies in Europe, and responsible for around one third of Danish emissions. The business areas included:

- North Sea oil and gas production and exploration
- Power and heat production (coal, gas and biomass) – 5,682 MW of thermal capacity
- Gas wholesale business
- Retail
- Small renewable energy business (including Vindeby, Horns Rev I and Rødsand I) – in total 828 MW renewable capacity

After the merger was approved by the EU, the Danish government announced that the company should be listed on the stock exchange. Plans to list DONG Energy were put in place and essentially finalised, however, the global financial crisis (GFC) of 2008/2009 meant that it was not an opportune time for the listing.

2002
Revised subsidies for RE including market premium

2002
Horns Rev 1 wind farm installed by Elsam and Eltras

2003
Nysted (AKA Rødsand) offshore wind farm installed

2004
First tender for offshore (HR2) is done – 4 applications received

2005
DONG begins construction on Barrow wind farm in the UK
Energi E2 wins HR2 tender

2006
Merger of 6 power companies into DONG Energy A/S

TIMELINE

2007 to 2010

DONG Energy pioneers the green transition in response to new, long-term political targets

In March 2007, leaders across the EU established targets for an integrated approach to climate and energy policy that would tackle climate change, while increasing the EU's energy security and strengthening its competitiveness. This resulted in what is commonly known as the "20-20-20" targets, where a series of targets to be met by 2020 were agreed to by EU heads of state and governments. These included:

- 20 per cent cut in greenhouse gas emissions (from 1990 levels)
- 20 per cent of EU energy to be sourced from renewables
- 20 per cent improvement in energy efficiency

Crucially, the targets were enacted in legislation in 2009, making them legally binding. The targets were 20 per cent on average for the EU and distributed among countries depending on their starting point – meaning Denmark therefore had to meet an even higher target. Following this, the 2008 Danish Energy Agreement strengthened the country's renewable energy ambitions, setting a target of sourcing 20 per cent of energy consumption from renewables by 2011 and 30 per cent by 2025. The medium-term goal of the agreement was to reduce consumption of fossil fuels by at least 15 per cent by 2025, with the long-term goal of the agreement to make Denmark completely free of fossil fuels. The agreement also included new additions such as: a revised subsidy scheme to improve the conditions for wind turbines (onshore), biomass and biogas and the announcement of a 400 MW offshore wind tender. For example, a subsidy of 15 øre/kWh (0.02 EUR/kWh) was added to biomass and wind energy market prices in 2008.

These firm commitments by the Danish government appear to have sparked radical change in DONG Energy. A few months later, DONG Energy announced its intention to shift from a portfolio consisting of 85 per cent fossil fuels to 85 per cent renewables by 2040. This decision is all the more significant, given it was made in the midst of the GFC, where other energy companies were scaling back their renewable developments and sticking to known technologies. The annual report of DONG Energy in 2009 is notable for being the first annual report with a mention of the carbon intensity of electricity production (grams of CO_2 emitted per kWh generated). This metric was to be a focus of the annual report from 2009 onwards. In the same year, the company decided to close coal-fired power units Asnæs 5 and Studstrup 4, and scrapped plans for its 1600 MW Griefswald coal-fired power station in Germany due to public opposition. This was despite the fact that the Griefswald power station had been under planning for over six years and was supported by the German federal government at the time. The cancellation was an indicator of the changing direction of the energy world.

Realising that infrastructure and economies of scale were important to reduce the cost of offshore wind, DONG Energy placed an order for 500 3.6 MW wind turbines from Siemens in 2009 - equivalent to more wind turbines than were in operation offshore at that point in time in the world. This was necessary for industrialisation of the offshore wind turbine industry.

Offshore wind was also gaining the support of institutional investors, which helped to finance the capital-intensive offshore wind projects and spread the risk of equity investments. In 2010, the Danish pension fund, Pension Denmark, invested in the Rødsand wind farm - a significant injection of capital. Following Denmark's lead, the UK and Germany also announced long-term financial support to offshore wind farms, increasing their attraction to DONG Energy as potential new markets. In 2011, DONG Energy was able to make an investment decision on Borkum Riffgrund 1, the first offshore wind project in Germany.

The tender for the largest offshore wind farm in the world to date, the 400 MW Anholt project, was launched in 2009. Lessons from the previous tender dictated that penalties were applied in the tender process so that the winning bidder would have to pay penalties if they withdrew their bid. Furthermore, the tender specified that if the winning bidder withdrew within the first half year, the second placed bidder would have to take over the project. Additionally, it was decided that Anholt had to be established in a record-breaking four years. At the time, the wind turbine market was overheated due to the many projects being developed as a result of the UK 's first round of tenders, meaning wind turbines and components came at a higher cost than the previous Horns Rev II tender. A combination of these factors, alongside the context of the GFC, meant that in the end, only one company submitted a bid. DONG Energy won the tender, with a higher price than had been seen at the previous two tenders. The government decided nonetheless to accept the offer to remain on schedule with targets.

One of the most important overriding lessons from this tender was to systematically de-risk the process. A method to achieve this was to include industry in a market dialogue prior to the tender. This allowed industry and government to discuss all matters relating to the tender, which resulted in an adjustment to penalties and greater flexibility in the different milestones in the timeline for the next tender, and ultimately, a lower price. More information on the Danish offshore wind tender model can be found in the Danish Offshore Wind Tender Model (Danish Energy Agency, 2020d).

Offshore wind auctions in Denmark

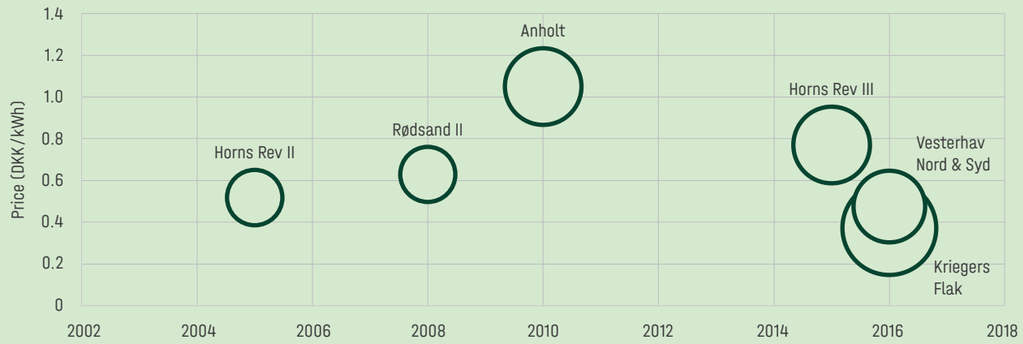


Figure 4:
Offshore wind auctions by prices and years in Denmark. The size of the bubble is in relation to the capacity of the project. Note 1 DKK ≈ 0.13 EUR as of 2021.

2007
Sold transmission and gas storage to TSO

2008
Energy agreement to increase share of renewable energy

2009
January: announcement of ambition to switch to 85% renewables by 2040

2009
Announcement of 400 MW offshore wind tender, Anholt

2009
Agreement with Siemens for 500 3.6MW wind turbines

2009
Decision to close two coal-fired power stations, Asnæs and Studstrup

2010
DONG wins Anholt tender

TIMELINE

2011 to 2016

Denmark waves goodbye to coal and DONG Energy expands overseas

In 2011, the Danish government published the Energy Strategy agreement, "Energistrategi 2050", with ambitions to become free of fossil fuels by 2050. This led to the energy agreement "Our Energy", which was published in late 2011. The agreement aimed to expand the development of renewable energy, especially as regards to wind, biomass and biogas, and was designed to replace coal and natural gas with biomass in CHPs, with a focus on greenhouse gas reductions (GHGs); specifically, a reduction of 40 per cent by 2020 compared to 1990 levels, and targets that wind should generate 50 per cent of Denmark's electricity by 2020 and that by 2035, the heating and electricity sectors should be supplied by renewable energy only. Denmark also announced it would completely phase out coal by 2030. This landmark goal was subsequently adopted by several European countries, such as the UK deciding in 2015 that coal should be phased out by 2025, France in 2016 to stop using coal by 2023, as well as Portugal and Finland by 2030.

Eager to expand on the success of the development of offshore wind, the Danish government reserved six areas for large-scale offshore wind farm development in 2012. The areas chosen were those deemed most suitable based on socio-economic assessments. The six areas were only to be developed via a government tender round. In the same year, feasibility studies were initiated by Energinet, the Danish TSO, for two offshore wind farms: Horns Rev III (400 MW) and Kriegers Flak (600 MW).

In 2012, DONG Energy's financial outlook was downgraded to "negative" according to Fitch ratings, and the S&P credit rating downgraded from A- to BBB+. One of the reasons for this was the company's dependence on gas prices for gas sales, which took a downwards turn in 2012, as well as gas contracts that ended in 2012. In August 2012, Henrik Poulsen was appointed as CEO, and one of his first steps was to draft an action plan to restore a healthy financial foundation. The Ministry of Finance carried out a process to find a capital injection for DONG Energy and agreed to a plan of around 13 billion Danish kroner (approximately EUR 1.75 billion) in 2013 and 2014, and selling shares to Goldman Sachs (19 per cent) and Danish pension funds ATP and PFA (7 per cent combined), while the state maintained majority ownership. The process was politically sensitive with government consequences. By 2014, the financial outlook of DONG Energy had been adjusted to "stable" again.

From 2012, power producers and consumers have been able to share the saved tax on the fuel in CHPs for heat production with the heat customer. In 2014, an industry agreement was reached on the sustainability criteria for biomass, ensuring strict sustainability documentation requirements in line with internationally recognised sustainability standards for biomass procurement. In 2014, following the Danish government's incentives for the conversion of CHPs to biomass, DONG Energy decided to convert the Studstrup and Skærbæk power plants to biomass.

DONG expanded further into international offshore markets, taking over a US offshore wind development project in 2015, which marked its first venture outside of Europe. Concurrently, DONG Energy become a majority investor in the largest offshore wind farms in the world, the Walney Extension in 2015 (659 MW), and Hornsea 1 in 2016 (1.2 GW), both of which are located in the UK. Hornsea 1 was by far the largest wind farm in the world, being the first time an offshore wind farm broke the "Gigawatt barrier". DONG also won a tender in the Netherlands for the project Borssele 1 & 2. These ventures into international markets further cemented DONG Energy as the offshore wind market leader.

Denmark's total annual GHG emissions have been reduced by approximately 25 million tonnes from 2006 to 2016, and as of 2016, DONG Energy's share of the reductions amounted to approximately 53 per cent.

2012
6 areas are reserved for future offshore wind farm auctions

2012
Credit rating downgraded

2014
Financial restructuring of company

2015
Takeover of US offshore wind development project

2016
Investment decision on Hornsea 1, largest wind farm in the world at 1.2 GW

TIMELINE

2017 to 2021

Heightened ambitions for Denmark's green transition

In 2019, solar PV and wind energy generated the equivalent of 50 per cent of Denmark's electricity consumption. In December 2019, the Danish government announced a legally binding Climate Act, which stipulated a 70 per cent reduction in CO_2 emissions by 2030, with 1990 being the baseline year, and Denmark to achieve climate neutrality by 2050. The Act was passed by a broad majority of the Danish parliament and includes the following key initiatives:

1 **A new era: the world's first energy islands (with a capacity up to 10 GW) and more renewable energy.**
   a. One energy island on Bornholm with a capacity of 2 GW by 2030.
   b. One purpose-built energy island in the North Sea with a capacity of 3 GW by 2030.
   c. Hesselø offshore wind farm (800-1200 MW), with the tender to be finalised in 2023/2024.
   d. Thor offshore wind farm (800-100 MW), with the tender to be finalised in 2021 (announced prior to the Climate agreement).

2. **Investment in the green technologies of tomorrow – carbon capture and Power-to-X.**
   a. 800 million DKK (approximately EUR 108 million) to be set aside annually from 2024 for carbon capture and storage.
   b. Tender to support the establishment of large-scale Power-to-X plants with a capacity of 100 MW. The Netherlands has decided to invest approximately DKK 1 billion (approximately EUR 134 million) in this project.

3. **Green transition of industry**
   a. 2.5 billion DKK (approximately EUR 336 million) in subsidies in the period 2020 to 2030 for electrification and energy efficiency improvements.
   b. 2.9 billion DKK (approximately EUR 390 million) in the same timeframe for biogas and other green gases.

4. **Efficient use of energy and renovations.**

5. **Green heating for Denmark, including support for surplus heat, district heating and electric heat pumps, as well as requirements for biomass' sustainability.**

6. **Green transport.**

7. **Green tax reform.**

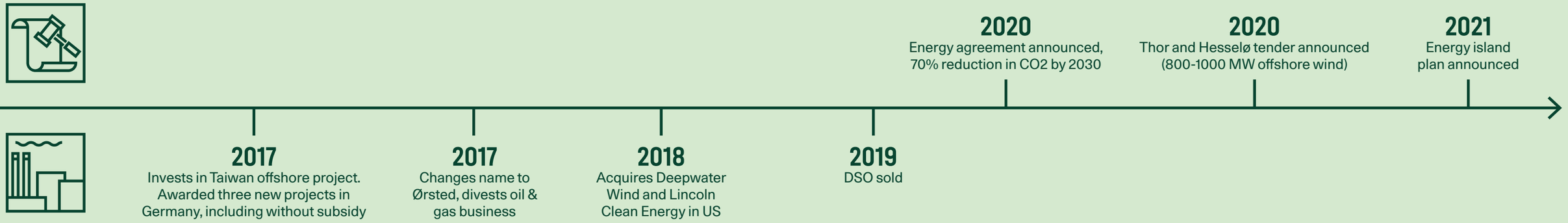
With the increased capacity of offshore wind, PtX offers a way to decarbonise heavy transport by using the excess electricity from offshore wind through electrolysers to produce hydrogen. This can be used in industry, up to a certain limit in the natural gas grid, and as an intermediary to produce Ammonia (NH3) or Methanol (CH3OH) which can be used as green biofuels for heavy transport.

The green transition of the company DONG Energy continued and its financial health continued to improve. 2017 was another pivotal year for the company, as DONG Energy divested its oil and gas business and changed its name to Ørsted. The name change was in honour of the Danish scientist, Hans Christian Ørsted, who discovered electromagnetism, and to reflect its new, green direction, where the portfolio would be reweighted towards green energy. Ørsted was listed on the stock exchange, with the world's second-largest Initial Public Offering (IPO) at USD 15 billion.

The year included a decision to invest in the offshore wind farm Formosa 1, the first project in Taiwan, and three new offshore wind farm projects in Germany, including the first without a subsidy. According to then Executive Vice President and CEO of Wind Power at DONG Energy, Samuel Leopold, "The zero-subsidy bid is a breakthrough for the cost competitiveness of offshore wind, and it demonstrates the technology's massive global growth potential as a cornerstone in the economically viable shift to green energy systems. Cheaper clean energy will benefit governments and consumers – and not least help meet the Paris COP21 targets to fight climate change. Still, it's important to note that the zero bid is enabled by a number of circumstances in this auction. Most notably, the realisation window is extended to 2024. This allows developers to apply the next generation turbine technology, which will support a major step down in costs. Also, the bid reflects the fact that grid connection is not included."

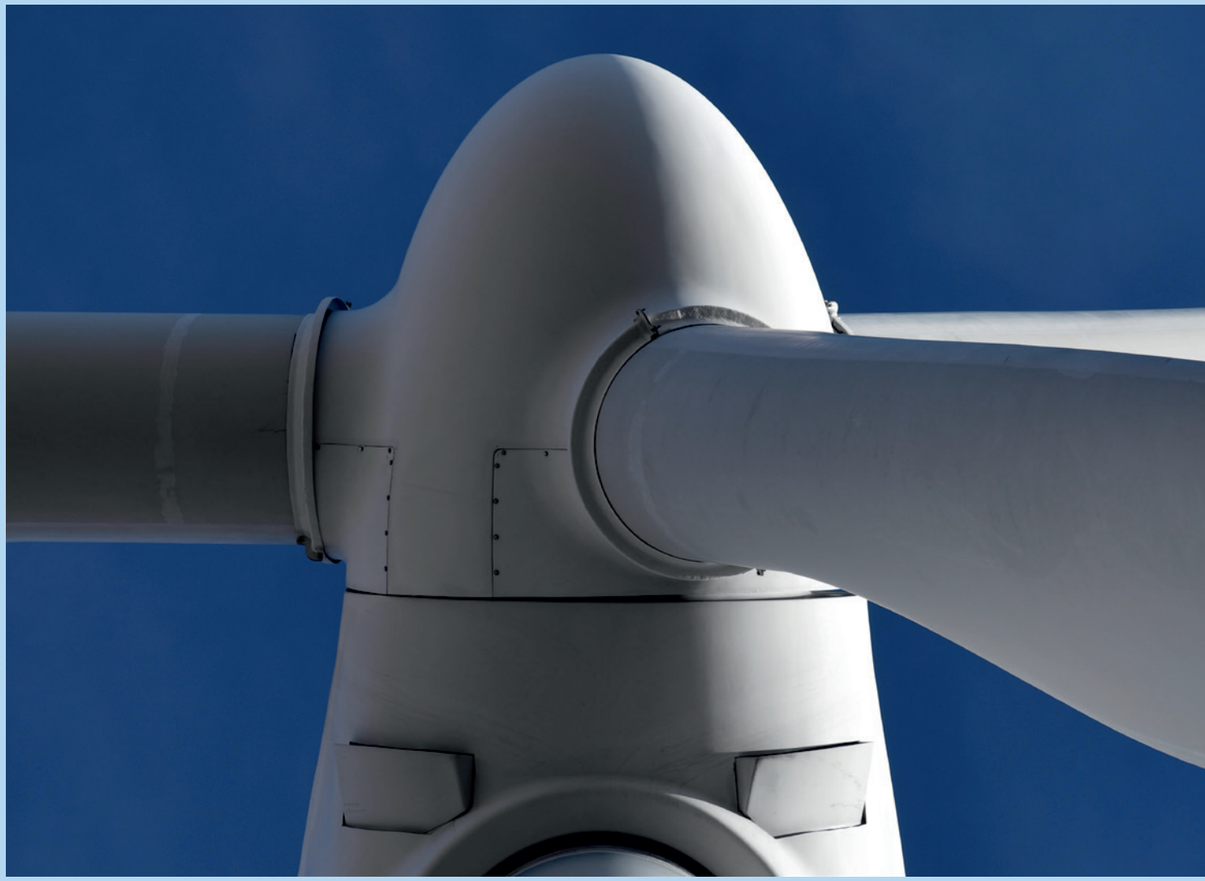
Around this time, Swedish state-owned company Vattenfall, sold its large-scale CHPs (Amagerværk, Fynsværket, and Nordjyllandsværket) to three city utilities (Copenhagen, Odense and Aalborg), all of which had plans to phase out coal. Vattenfall did not find it attractive to have coal-fired power plants in Denmark. Since then, both the Amagerværket and Fynsværket plants have been converted to biomass, and Nordjyllandsværket plans to do the same before 2028.

The following year, Ørsted decided to invest 200 billion Danish kroner in green energy by 2025. It also acquired Deepwater Wind and Lincoln Clean Energy, two US wind developers, marking a venture into onshore wind, solar and storage in the US market. In December 2019, the decision was made to sell the natural gas business, and a month later, Ørsted was ranked #1 by Corporate Knights' 2020 index of the Global 100 most sustainable corporations in the world (Corporate Knights, 2021).



Policy-side learnings

This section aims to outline the main learnings from the policy makers' and developers' sides, clarifying the changes in the business model of the largest Danish energy company, Ørsted[1] , which is majority-owned by the Danish state. It must be said that the Danish model was made for Denmark. Many learnings can be used in other countries, but the timing and initiatives must be adapted to local circumstances



First of all, the role of stability in long-term policy decisions cannot be overstated. While not everything has been perfect, Denmark has a long history of broad political agreements with a long-term time horizon. This has helped secure robust and continuous political commitment toward the green transition despite changes in government over time. This framework allows policy makers to devise clear, transparent and stable policy signals with regards to the future development of electricity markets, grid investments and environmental policies. Furthermore, politicians across different parties in the Danish parliament have broadly supported the transition; as a means to reach energy independence from imported fuels, local job creation, as well as a transition to a low-carbon energy system, thus limiting climate change. In other words, the transition helps fulfil multiple political goals, further promoting an environment of financial stability that has been key for the success of the transition.

Stability and transparency in long-term policy decisions are key to the development of renewables, guaranteeing subsidies and CO_2 taxes (which might otherwise be modified or removed retroactively), reducing the risk for developers and investors, and so further promoting investments in technologies that are in line with long-term policy goals.

When long-term policy goals are set, the regulatory framework needs to reflect this. The regulatory framework should be designed to de-risk projects in order to achieve policy goals and can include elements as listed in the below table, and further elaborated in the following section.

Planning – setting ambitious and reliable targets	Long-term, stable, inclusive and transparent energy planning procedures, supported by legislation, concrete reforms, and dialogue with the industry and with the public, are an essential part of the green transition
Demonstration projects	Demonstration projects provide invaluable regulatory, technical and engineering learning and boost investors' confidence, proving the scalability of the technology.
Economic incentives	Subsidies, taxes and CO_2 prices have proved instrumental, when designed in a transparent manner to reduce regulatory risk
Competition	An electricity sector built on the fundamental concept of competition creates incentives to innovate and lowers prices
Permitting and de-risking	Appropriate allocation of risk and the streamlining of permitting procedures reduce regulatory risk and potential delays

[1] While we have referred to Ørsted's previous incarnations in the historical timeline section (i.e. DONG, DONG Energy), we will refer solely to the company as Ørsted, its current name, in this section, in order to avoid confusion.

POLICY-SIDE LEARNINGS

Planning: setting ambitious but reliable targets

In order to achieve a clear, stable and transparent policy framework, energy planning should meet the following conditions:

1. Be long-term. Energy plans are typically made to meet targets decades in the future. By being designed with a long-term mindset, such plans provide a stable framework and the long-term horizon that industry requires to join the transition. As no transition can ever happen overnight, long-term planning shall reflect that in order to gain investor confidence. Tangible commitments for long-term planning, such as target years for phasing out fossil fuels, will also send a strong signal to the industry that changes are about to happen, and thus risks in committing to renewable energy are mitigated.

2. Reflect transparency and stability. In order to attract investments, there must be transparency and reliability in regard to decisions taken. If political decisions that significantly affect the business case for large investments are reversed, it will severely damage the government's credibility with investors. If subsidies are retroactively changed for a renewable energy technology, this will create high levels of uncertainty and risk for developers, and thus increase the price of the investment, lose market attractiveness and consequently slow the green transition down.

3. Include dialogue with the future players at the early stages: a transparent dialogue between government and industry can give the necessary inputs for designing the rules from parties involved. Denmark has used industry dialogue as a methodology for collecting input e.g., for designing auctions or for collecting technology data to use in long-term analyses (technology catalogue). The constructive engagement between government and industry has led to numerous benefits for both sides, e.g., by defining the criteria for the auctions, this easing the bidding process for companies, but also ensuring that projects are not overcompensated. Engagement with local communities is also paramount, as a lack of public support throughout the process can pose project development risks. As hosts of potential projects, local communities should be engaged in the process, including in the design of compensation schemes.

4. Be supported by the legislation through concrete reforms. The first step requires the development of a reliable plan with calculations of when and how to achieve the targets in accordance with socio-economic priorities. This will then be implemented by government institutions. An example is the EU 20/20/20 targets, set in 2007 and followed by targets that were enacted in legislation in 2009. Examples of specific regulatory reforms and tools are listed in the following sections.

In the development of national energy plans, international agreements and collaborations were also included, typically as a minimum target for the political agreements in Denmark.

POLICY-SIDE LEARNINGS

Demonstration projects

Demonstration projects have been a key factor in the genesis of renewable energy technologies. This is particularly evident in the offshore wind industry in Denmark, building on years of research, innovation and development in the country, where the National Laboratory of Sustainable Energy at Risø (which became a department of the Danish Technical University in 2008) has played a key role (Danish Energy Agency, 2015).

Although initial projects using new technologies are more expensive, they are essential to kickstart an industry. In Denmark, the demonstration projects have been a policy tool which served as a proof of concept for offshore wind. Key learnings can be divided into the following categories:

- Myriad of technical and engineering learnings to develop the supply chain and reduce costs
- Environmental impact assessments – learnings from the offshore projects have helped shape the regulations around environmental impact assessments
- Investor confidence, as the projects showed that the technology was possible at scale
- Has underpinned the Danish wind industry as a first mover on offshore wind

The first smaller wind farms Vindeby in 1991 and Tunø Knob in 1995 proved it was technically possible to install wind turbines at sea, but it needed to be done at a larger scale to reduce costs. The Offshore Wind Action Plan of 1997 was a key turning point, establishing public-private partnerships between the DEA and the energy companies. The plan involved a screening process and identified key areas for offshore wind development (maritime spatial planning). The exercise was a success and was repeated several more times. As a planning exercise, maritime spatial planning is used to:

- Reduce conflicts between sectors and create synergies between different activities
- Encourage investment – by creating predictability, transparency and clearer rules, it gives developers a clear idea of when, where and how large the offshore wind farms will be in the future, so they can begin planning and development for the coming pipeline
- Increase cross-border cooperation between EU countries to develop energy grids, shipping lanes, coherent networks of protected areas, etc

The first two projects from the plan were constructed (Horns Rev I and Nysted). Doing so instilled confidence among industry and regulators that offshore wind farms could be installed efficiently at large scale and survive alongside the harsh marine climate. A large part of the demonstration element was the environmental studies that the DEA was responsible for.

POLICY-SIDE LEARNINGS

Economic incentives

Economic incentives have long been used as a tool to achieve political targets in the energy sector and now, renewable energy is cost competitive to fossil fuels without the need for subsidies.

If the political target is to increase share of renewable energy, then the first step should be to redesign subsidies so that they do not incentivise fossil fuels. Economic incentives for renewable energy in the form of subsidies or tax incentives can be seen as an investment in the future and have helped develop solar and wind at scale, so that it can compete, subsidy-free, against fossil fuels. In Denmark, economic incentives have been effective at providing an entry path for domestic, sustainable sources such as wind, and an exit path for polluting and imported fossil fuels such as coal. Tax incentives and subsidies for renewable energy were introduced in 1976. Subsidies were tweaked over time to further incentivise wind energy, and it is now at a point where subsidy-free offshore wind projects have been tendered in Germany and the Netherlands. Onshore wind is also being constructed with zero subsidies in Denmark. The huge reductions in costs and therefore gradual removal of subsidies are due to technological and business model developments as well as learnings on the regulatory and planning side.

Prior to the liberalisation of the electricity sector in Denmark, a fixed FiT was set to incentivise renewables, which resulted in the rapid growth of onshore wind in Denmark in the 1990s (Danish Energy Agency, 2020b). Then, after liberalisation, the electricity price was very low, and the revised subsidy of a market premium for onshore wind turbines proved less attractive in the 2000s, compared to other markets such as Germany and the UK. The world's first tenders for offshore wind were run in Denmark in the 2000s, and the coming tenders such as the Thor and Hesselø offshore wind farms will utilise a two-way Contracts for Difference (CfD) with caps on both the Danish state's payment to the concession owner and the concession owner's payment to the Danish state. The CfD model provides the concession owner with long-term investment certainty but places more short-term risk on the concession owner by exposing the concession owner to market signals. This is done to provide a stronger incentive to enhance the socio-economic value of the electricity production. That is to say, that Denmark has experience with a number of different subsidy mechanisms for renewable energy. Subsidies can be an effective tool, but only when they complement the other aspects named here, such as competition, transparency and stability of the renewable energy policy of the country.

Subsidies can be attractive for a business case, but for a whole company to rely on a single government's subsidies it can actually be the source of risk – regulatory risk. Developers may want to follow the incentives but need certainty that the subsidies will not be retroactively changed, reduced or removed. The developer may also perceive higher risks due to political risk, so a way to counteract this is a contract between the developer and the government. A legally binding contract such as a concession agreement protects the developer against this regulatory risk. The rapid growth of the offshore wind industry in northern Europe has been notable in that there are no examples of major offshore parks where governments have retroactively changed subsidies or regulatory frameworks, and it is important it remains this way to maintain the industry's growth rate. The CfD scheme in itself is designed in a way to reduce regulatory risk and has proven successful in reducing risk in markets such as Denmark, the Netherlands and UK.

As previously mentioned, it is important to have transparency, and this is also important when designing economic incentives. For Denmark, it has been advantageous to engage the industry with inputs to planning. The practice nowadays happens for example during the market dialogue for offshore wind tenders, where the DEA and Energinet publish information and invite industry to a dialogue in order to collect viewpoints from potential investors to optimise tender conditions, with the ultimate goal of obtaining the lowest possible bid prices. Another example of transparency in planning is the technology catalogues, which include a list of agreed technological, economic and environmental data, which are published by the DEA after getting input from industry. The technology catalogues are thus a transparent way to communicate data, and are used in energy modelling and planning by government, industry and academia (Danish Energy Agency, 2021b).

Conversion to biomass: regulatory and sustainability aspects

The EU Renewable Energy Directive II (2018) includes minimum requirements for the sustainability of biomass fuels from forestry, and will be implemented into Danish law no later than 30 June 2021. This directive defines a methodology for estimating production chain emissions from the use of biomass fuels – considering the sum of net emissions of greenhouse gases from cultivation, processing, transport and non-CO_2 emissions from biomass cobustion.

Biomass can only be regarded as "renewable energy" if these emissions are be below a certain level and the GHG saving compared to fossil fuels is at least 70 per cent from 2021 and 80 per cent from 2026.

Until the directive is in force, nearly all the forest biomass used for district heating and electricity is covered by a voluntary Danish industry agreement that was concluded in 2014 to ensure that the biomass used in Denmark fulfills internationally recognised sustainability criteria. The sustainability of the biomass used has to be documented in annual reports verified by a third party. More information can be found in the "Biomass Analysis", from the DEA (Danish Energy Agency, 2020a).

Projections in the Danish national energy and climate plan from 2019 show biomass for energy consumption is projected to decrease by 12 per cent from 2017 to 2040. Biomass can be said to have played a role as a "transition fuel" in Denmark, in that it has played an important role in converting coal-fired CHPs, but its use is not expected to continue to grow. Nor has it experienced significant cost reductions as wind and solar have. An analysis of different options and consequences of reducing bioenergy consumption further is currently taking place.

From a technological perspective, the conversion of coal CHPs to woody biomass is not extremely challenging, given that proper framework conditions are there to incentivise the transition. The framework conditions in Denmark have led to considerable consumption of biomass for CHP and district heating production. Conversion of large-scale CHP plants from fossil fuels to biomass has been promoted through a combination of different schemes: 1) incentives, such as state aid for electricity production based on biomass (the 15-øren scheme - DKK 0.15), 2) tax exemptions for biomass as opposed to electricity and fossil fuels, and 3) the possibility to use tax benefits to reduce electricity production costs (the net benefit model). The latter was introduced with the 2012 Energy Agreement (Danish Energy Agency, 2020a). State aid for electricity production is closed for new plants and is being phased out for existing plants.

In Denmark, biomass used for heat production is not subject to tax; in contrast, fossil fuels are subject to energy and CO_2 taxes, and so is electricity production, which is subject to an electricity tax. Fossil fuels used at large plants are also subject to the EU ETS, which means these plants must buy emissions allowances corresponding to the plant's CO_2 emissions that arise from burning fossil fuels for electricity as well as heat production.

Up to 2012, a portion of the tax advantage of CHP plants linked to heat production (i.e. the majority of the tax advantage) went to district heating end users, which meant there was no incentive for CHP plants themselves to convert their production from coal to biomass. The 2012 Energy Agreement gave large-scale power plants the possibility to divide their tax advantage, so that some of the advantage went to electricity production. This change proved significant for the conversion of large-scale power plants to biomass, as it made it advantageous for the plants to use biomass instead of coal. Consumption of solid biomass for electricity and heat production in Denmark has subsequently increased, from around 58 PJ in 2012 to an expected 105 PJ in 2020.

POLICY-SIDE LEARNINGS

Competition

Competition is at the centre of the Danish power sector; motivated by the EU's focus on the European internal market, where electricity is also seen as a commodity that should be traded freely across borders.

"THE PURPOSE OF THE LIBERALISATION WAS TO CREATE BETTER CONDITIONS FOR COMPETITION, AND THUS TO IMPROVE THE UTILISATION OF PRODUCTION RESOURCES AS WELL AS TO PROVIDE GAINS FROM IMPROVED EFFICIENCY IN THE OPERATION OF NETWORKS." (NORDIC ENERGY REGULATORS, 2006)

Until 2000, power companies operated according to a non-profit principle. They were a monopoly, so they could recover all costs from consumers. Costs were controlled before liberalisation, but there was an increased focus on cost reductions after the transition to competition (legislation in parliament in 1999 that allowed external income to power companies). To do this, it was necessary that there was a separation between market-based generation activities and the natural monopoly of the transmission and distribution activities. While the idea was to pass savings on to consumers, it also stimulated a competitive electricity sector, and the cost of renewables plummeted. The creation of a competitive electricity sector opens up new business opportunities such as, for example, demand response using EVs and heat pumps, due to transparency and the accessibility of large amounts of data. The overall Danish experiences from the liberalisation of the electricity market are captured in detail in a report from the DEA, "Liberalization of the Danish Power Sector 1995-2020 - An International Perspective on lessons learned" (Danish Energy Agency, 2020c). This involved the creation of the national state-owned TSO (Energinet), as well as an independent energy regulator (Danish Utility Regulator). Transmission was open to be accessed by everybody, and generators were exposed to the electricity market and dynamic pricing.

The new competitive sector meant that all generating companies, including those with majority state ownership, were motivated to reduce their energy production costs if they wanted to remain in the domestic market. Cost reductions provided an opportunity to expand to and compete in international markets. Without the incentive to reduce costs in the first place, this opportunity would not have arose.

The state ownership of Ørsted was organised as 'arm's length' in terms of decision-making, meaning that the company acted as a private company, i.e., it could make its own decisions without the interference of the state. This was essential so that Ørsted could not influence Denmark's energy policies more than other companies and vice versa, which is important if a fair, transparent and competitive market for renewable energy developers is to exist. One implicit benefit of state ownership was that Ørsted could look to the long-term view when transitioning to renewable energy.

The development of a new offshore wind industry and attractive tenders has also spurred competition within the industry. An example is the upcoming Thor offshore wind tender, where three of the six pre-qualified consortia are at least partially Danish owned, whereas 10 years ago there was only one offshore wind developer in Denmark. This shows that the sector has become more competitive over time.

One key event in the unbundling was the "power plant package" (kraftværkspakke). The power plants' economic situation was not favourable; partly because of the low market prices in the Nordic market in 1999, and partly because the companies had almost zero equity due to previous regulations that were in place which did not allow for this. For these reasons, many companies would not be able to bear the stranded costs. Political agreements were made to give the companies 8 billion Danish Kroner in aid (approximately EUR 1.1 billion), on the condition that they had to merge the energy companies into one company in the east and one in the west. While not all countries may have the financial capacity for such a buyout, capital can be raised in addition to any available funds, and cost benefit analyses can reveal where buyouts can make the most impact.

The package also included subsidies for biomass, wind power and payment for readiness in order to ensure security of supply. It also came with the condition that the companies in the east and west (Elsam and Elkraft) should not be economically harmed by the offshore wind demonstration projects – the previously mentioned Horns Rev I and Nysted wind farms. The future path was clearly set already in 1999: offshore wind was a technology that would play a key role in the new millennium.

The electricity market also opens op opportunities for incentivising system services. Having a dynamic price signal that shows the value of electricity production to the system is a way to incentivise thermal power plants to be flexible, in terms of ramping up or down to meet the demand, which will give best returns. Balancing the power system has been done in Denmark by imposing balance responsibility on generators as well as supply companies. This has been marketised to provide the opportunity for fast-moving generators to make returns on their investment by providing system-balancing services. The market integration with neighbouring countries ensures that interconnector capacity is utilised optimally, and social welfare is optimised, i.e., consumers can obtain the cheapest possible energy and producers can sell at the optimal price. For example, if the price was higher in Germany or Norway, a wind farm in Denmark could sell power across borders.

Denmark has experienced untold benefits by having such a thorough sector coupling of the heat and power sectors. Most central CHPs now are making the bulk of their returns on the heat market, and supplementing this by ramping up production at times of high electricity prices and by producing ancillary services. A deeper look at the flexibility solutions in the Danish power sector to integrate variable renewable energy can be obtained from the DEA (Danish Energy Agency, 2021a).

POLICY-SIDE LEARNINGS

Permitting and de-risking

The regulatory framework for offshore wind (for example) should be designed in a way so as to properly allocate risk, with the goal of attracting competition in projects to achieve the best price.

It is not to overburden either the developer or the government with all the risk, but so that, depending on the competences and roles of each stakeholder, the risks should be allocated accordingly. One parameter could be where the risk is handled at the lowest socio-economic cost.

Along with the appropriate allocation of risk, streamlining the consenting process is an important regulatory step to facilitate large offshore wind projects. In Denmark, a streamlined and transparent process contributes to reducing uncertainties and delays, which can otherwise be major disincentives in the development of renewable energy projects. The concept of a single point of access – known as a "one stop shop" - is an important organisational setup mitigating this regulatory risk.

A one stop shop ensures a smooth and administratively lean process in approving the development of offshore wind farms, including their decommissioning. The approval process takes into account a multitude of interests related to e.g., the economic attractiveness of the wind farm, the local community, protection of the natural environment, marine cultural heritage, safety at sea, resource extraction, defence issues, visual impact, etc. The coordination and communication with a large number of authorities is often a challenging part of approving an offshore wind farm and grid connection. When an offshore wind farm passes through the approval process in Denmark, the licenses and permits required for the development of the wind farm will be prepared and granted by the DEA through an iterative process involving contributions from the relevant authorities. Once the concession has been given, the DEA continues to operate as a single point of contact for the owner of the project, which receives the needed assistance on issues related to the granted licences and procedures, etc. This reduces the risk of unforeseen regulatory barriers in the project's development phases.

De-risking offshore wind

Type of Risk	Owner	Examples
Policy commitment	Government (policy makers, government agencies)	• Credible and realistic political agreements • Certainty of targets • Sanctity of contracts
Adequate project planning and permitting risk	Developer Government agencies	• Capability of developer to plan and time the project adequately • One stop shop licensing • Environmental studies carried out at the requisite level
Construction challenges	Developer Investors	• Technical and financial capability of project owner • Competitive selection of suppliers and sub-suppliers • HSE regulation
Operational risk	Investors Insurance companies	• Cost/quality balance to be struck in desired lifetime • Adequate insurance
Offtake security and revenue support	Policy makers System operator Off-taker	• Priority access to the grid and transparent rules for curtailment • Security of income by sale of energy (market, PPA) • Revenue support
Financial and currency risk	Investors Insurance companies Government guarantees	• Asset should be tradable and transferable • Cost of the financial loan package depends on the perceived risk of the project • Capital expenditure guarantee e.g., government backed loan

Learnings from the energy company's business transformation

The policies and business models of yesterday will not work for the governments and energy companies of tomorrow. What may have seemed impossible 10 years ago is now happening. Countries as diverse as China, South Korea and the European Union have pledged to achieve carbon neutrality by the middle of the century (Bazilian & Gielen, 2020; International Energy Agency, 2020; Ritchie & Roser, 2020). In 2019, the cost of renewable energies such as solar and wind energy had the lowest Levelised Cost of Electricity (LCoE) in the USA, EU, China and India. Energy companies who have invested significantly in renewable energy are overtaking oil majors in market capitalisation. For example, in 2020, Florida-based NextEra Energy Inc. briefly surpassed Exxon Mobil Corp in market capitalisation. Ørsted also overtook BP in terms of market capitalisation in 2020. Renewable energy companies are riding the wave of plummeting costs of renewable energy and supportive renewable energy policies by national governments to reap the rewards and overtake their oil rivals.

At the same time, major oil & gas companies are entering massively into the renewable energy space, with European oil majors such as Eni (with a goal of 25 GW by 2035), Equinor (with a goal of 16 GW by 2035), Total (with a goal of 35 GW by 2025) and BP (with a goal of 50 GW by 2030) announcing ambitious renewable energy targets. Investors are also requiring stricter Environmental, Social and Governance (ESG) standards and influencing companies through shareholder power towards sustainable energy. Coal investments are seeing a general decline globally, with financing becoming more of a challenge, as large institutional investors increasingly divest from these assets. Globally, over 100 financial institutions and more than 20 large insurance companies have divested from coal projects and are now operating with restrictions on financing new coal projects. This trend includes large government and international organisations such as the World Bank, the Norwegian Sovereign Wealth Fund, the Asian Infrastructure Investment Bank and private corporations such as AXA and ING, who began restricting investments into coal-related projects and planning a total phase out of these assets in the coming years.

The business model transformation of the energy company Ørsted, which is majority owned by the Danish state, has been an interesting case study which may provide some inspiration and learnings that are relevant for other energy companies around the world. The learnings from the business model transformation include creating a sustainable vision, which then leads to making an exit strategy for unsustainable energy and an entry strategy for sustainable energy.

Market capitalisation - selected companies

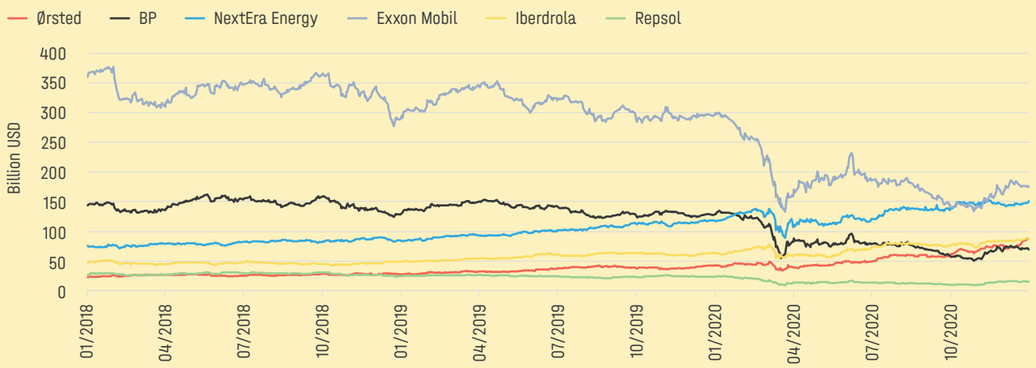


Figure 5:
Renewables overtaking their regional oil majors. Inspired by Bloomberg article, "New Energy giants are renewable companies" (Bloomberg, 2020).

LEARNINGS FROM THE ENERGY COMPANY'S BUSINESS TRANSFORMATION

Creating a sustainable vision

In the race towards zero emissions, European and Danish energy policies have shifted incentives away from fossil fuels towards renewable energy.

Given that fossil fuels were not environmentally or financially sustainable in the long term, companies reliant on fossil fuels such as Ørsted were now faced with an existential threat and needed to identify a way to remain relevant and to grow. The company had to answer the question: did it want to join in the green transition or be left behind?

Energy companies in Europe compete in a liberalised market and investors are undertaking profit-based decision making. This requires cost-benefit analyses of proposed projects using some key parameters (shown below), and as a result, across most of Europe investments in thermal power plants have come to a halt:

- Electricity prices
- Fuel prices
- CO_2 emission prices
- Heat offtake prices
- Ancillary services and reserve markets
- Subsidies
- Taxes & costs related to other emissions
- CAPEX and O&M

According to a former head of division in the DEA, Flemming G Nielsen, if Ørsted did not transition to green energy, "they probably would have gone out of business" (G Nielsen et al., 2021). The transition was a necessity and proved to be lucrative.

The Danish state and the other owners of Ørsted wanted to make an IPO listing to create a more flexible ownership structure and direct access to the global capital markets. As can be seen in the figure, wind has accounted for above 95 per cent of EBITDA (Earnings Before Interest, Taxes, Depreciation and Amortisation) for Ørsted since 2017 (Ørsted, 2020). A focus on the company's CO_2 footprint has been included in annual reports since 2009 to reflect the company's new vision. The greener and simpler the company's message, the better the value proposition to investors, as shareholders are increasingly concerned with ESG matters.

Annual Profit of Ørsted

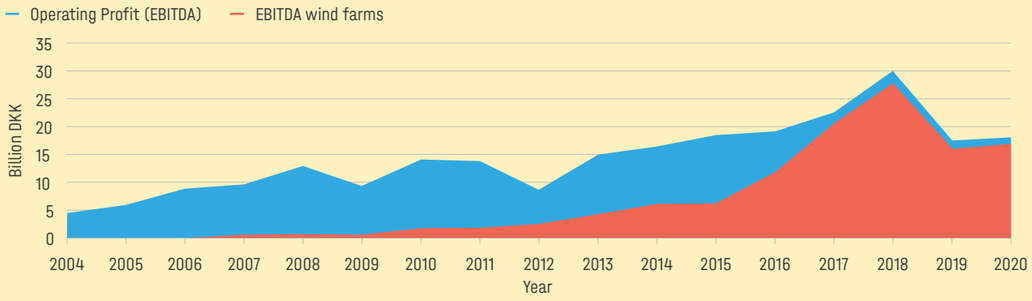


Figure 6:
Annual Operating Profit of DONG Energy / Ørsted over the years, and the share of profits from wind as a share of the total. The drop in 2019 was due to divestment.

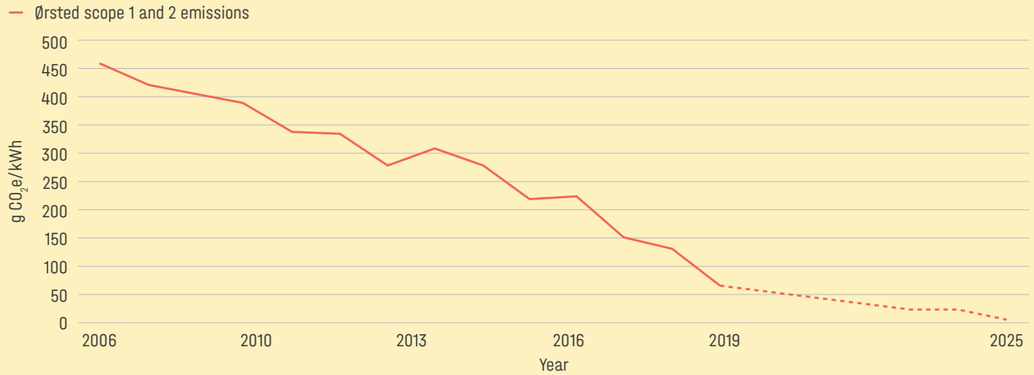


Figure 7.
Specific CO_2 emissions. Actual and prognosis. Source: Ørsted.

LEARNINGS FROM THE ENERGY COMPANY'S BUSINESS TRANSFORMATION

Exit strategy for fossil fuels

The exit strategy for fossil fuels at Ørsted has taken place through a number of different steps:

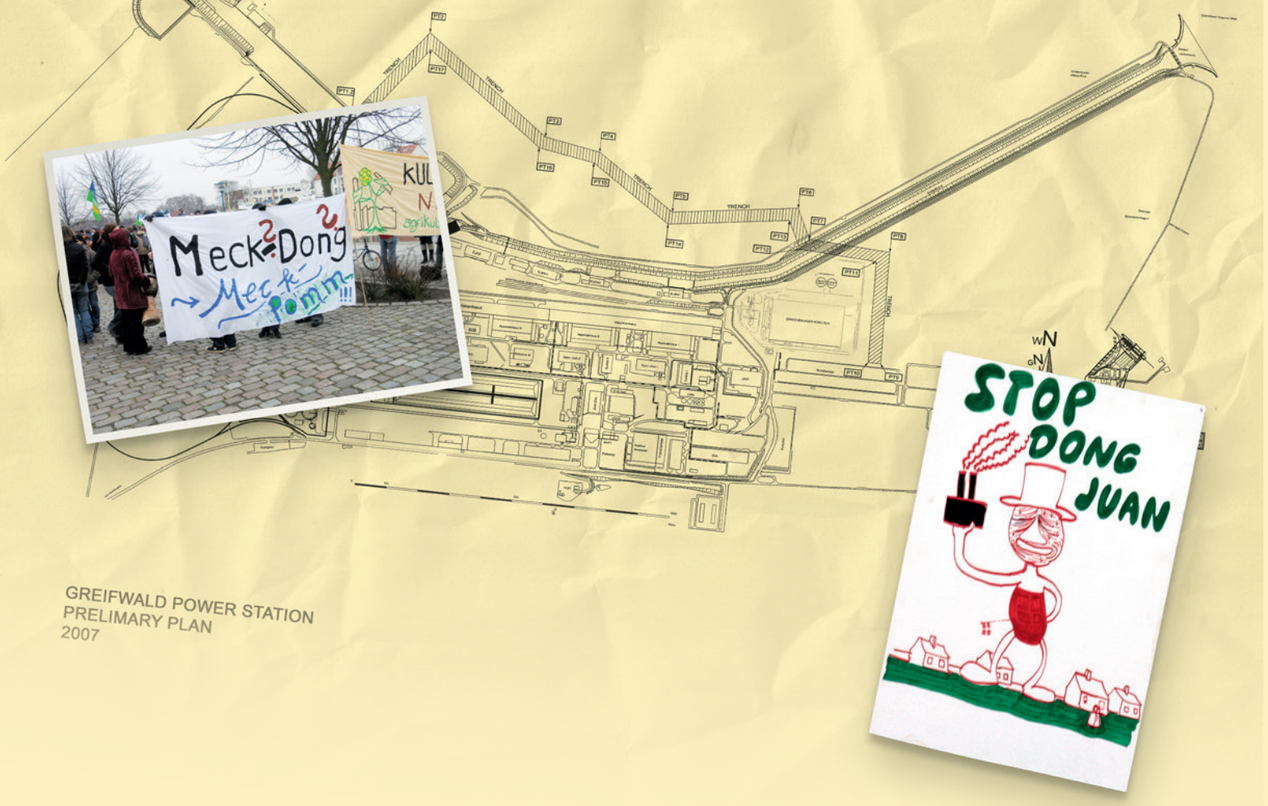
- Closure of around 40 per cent of the company's CHPs,
- A conversion to biomass with a favourable regulatory framework,
- Divestment of assets and businesses that do not align with the green vision, or
- If all else fails, abandoned investments.

The transition to a competitive electricity sector included the "power plant package" which ensured the companies did not go bankrupt during the transition, and in return, built offshore wind farms. This was part of negotiations with the energy companies and the government.

For the existing coal-fired CHP plants in Denmark, as previously mentioned, some economic incentives made the conversion to biomass attractive, such as biomass subsidies and tax incentives for the use of biomass as a fuel for heating.

Danish engineers were skilled in designing and constructing efficient coal-fired power plants. However, after Ørsted announced a strategy to phase out coal, these engineers were either transferred internally to focus on offshore wind (re-training), or transferred externally to consulting companies e.g. Rambøll Engineering (re-allocation). Similarly, when it became clear that oil and gas was not going to be a part of the company's future vision, the oil & gas division was sold off to INEOS. A short overview of the development of some of the key areas of Ørsted's business is shown below, from 2008, before the 85/15 goal was set, to 2019, when the goal was achieved earlier than expected.

DONG energy		Ørsted
Oil & gas exploration and production comprises roughly 40 per cent EBITDA		Divested to Ineos in 2017
Coal-fired thermal generation accounts for approx. 75 per cent of electricity generation & 25 per cent of EBITDA		Most coal-fired power plants have converted to biomass and plan to be completely coal-free by 2023. Engineers were either transferred internally to focus on offshore wind, or transferred to consulting firm Rambøll Engineering.
Sells the equivalent of approx. 20 per cent of Danish electricity demand of to end consumers		Divested to SEAS-NVE (now Andel) due to Ørsted's strategic focus on renewable energy
Accounts for less than 10 per cent of EBITDA and around 14 per cent of generation		Accounts for over 90 per cent of EBITDA and around 90 per cent of generation.
The Danish state owns 73 per cent		**The Danish state owns 50.1 per cent**



GREIFWALD POWER STATION
PRELIMARY PLAN
2007

Abandoned project:
Greifswald coal-fired power plant in Germany

After the merger in 2006, Ørsted acquired one project in Germany – a major coal-fired power plant development project called Greifswald. From a technical perspective, the plant was not technologically risky, as the company had many experienced and competent engineers. From a financial perspective, the business case was perhaps viable for the next 3-5 years, but was suboptimal for the future 20-30 years. The plant also faced significant local opposition due to environmental concerns. The project investment cost about 20 billion Danish kroner in total (approximately EUR 2.7 billion) but was abandoned after already 1 billion Danish kroner (approximately EUR 134 million) had been spent in project development costs.
This was a learning for the company and contributed to the strategic target of completely phasing out coal by 2023. Other decisions related to this target include:

- In Denmark, the CHP plants Avedøre, Studstrup, Skærbæk, Asnæs and Herning were converted from coal and natural gas to biomass. The economy of these CHP plants is increasingly dependent on the income from the heat market.

- Decommissioning of condensing coal-fired units at Asnæs (unit 3 in 2010, unit 2 and unit 5 in 2020), Stigsnæs (unit 1 and 2) in 2010 and Ensted in 2010. Ørsted has closed down almost 50 per cent of their power plant capacity in Denmark, as the large power plants have become increasingly challenged by wind power in particular.

The trend in Europe has for many years been away from coal, as the price of competing alternatives has fallen, and environmental standards and requirements have gone up. This has led to the divestment of efficient and modern coal-fired power plants, cancellations of plans to build new power plants and even to the complete abandonment of a new and efficient power plant by Swedish-owned Vattenfall in Germany over lack of profitability due to falling electricity prices and increasing CO_2 prices, leading to a billion-dollar write down and the abandonment of the power plant for the company. Several concurrent factors led to this decommissioning, such as the economic slump and lockdowns from COVID-19, which have led to a reduced demand for power; the wholesale electricity prices have reduced in part due to the large availability of renewable energy in the power mix; and carbon credit prices have been increasing. Vattenfall has decided to opt into a decommissioning auction facilitated by the German government to phase out coal from the country's electricity supply.

What is a decommissioning auction?

A decommissioning auction is a financial tool employed by some EU member countries to phase out coal from the national electricity mix.

The local government organises an auction to compensate for the decommissioning of the black asset for companies owning and operating coal power plants. This type of auction has been introduced both for tackling the impact of coal on climate change targets, but also to meet halfway with existing large coal plant operators, which are currently struggling in the increasingly difficult market situation.

The auction is structured to award bids based on the ratio between the asked compensation price and the resulting reduction in CO_2 emissions. In special cases, the transmission grid operators can ask to spare some of the plants to be used as backup capacity reserve in "critical situations". Nonetheless, the plants will not be allowed to participate in the electricity market remuneration mechanisms.

The decommissioning auctions have been both praised and criticised by local institutions. On one hand, the resulting benefits include:

- The auction demonstrates that the operation of many hard coal plants is apparently economically unviable, suggesting that coal plants are going to be decommissioned eventually for financial reasons due to the technology's difficult market situation

- The auction process showed how a competitive situation can reduce compensation claims, hence reducing the economic burden

- The auction's oversubscription is an "encouraging" sign that demonstrated there is "true competition" among operators.

On the other hand, the auctioning process was subject to the following criticisms:

- Some environmental actors highlighted that the results of the auctions granted coal companies substantial compensation for plants that might have turned into liabilities for operating companies, given the increasing market pressure on coal power.

- Similarly, some parties added that the decommissioning could have taken place more cheaply, as most plants will receive compensation for shutting down although they had already plans to drop out of the market due to low demand for coal power. Installations that had been written off already have now been turned into positive assets again.

- Lastly, some also argued that the outcomes are "good for the climate but a bad for taxpayers", as the funds supporting the decommissioning of coal plants are based on public contributions.

The auctions for hard coal plant decommissioning are expected to continue until 2026. Afterwards, in line with plans from the EU Commission, the decommissioning will happen by law and without compensation (for the period 2027-2038) (Wehrmann, 2020).

LEARNINGS FROM THE ENERGY COMPANY'S BUSINESS TRANSFORMATION

Entry strategy for renewable energy

Before investing into a new technology, Ørsted needed to decide which technology to base the business strategy on – a decision which was far from straightforward.

Several technologies were assessed and analysed. Key decision-making parameters were how the technology performed, and the competences and skills which could be combined to build a competitive advantage. In the end, the answer was offshore wind, which revealed to be a very attractive option for long-term growth and international expansion (The Economist, 2019).

The merger of the six energy companies in 2006 intended to centralise ownership of power plants in one company to withstand foreign competition (the acquisitions almost ended with Swedish-owned Vattenfall), but also resulted in that one company owning three offshore wind farms, including the two first major demonstration projects. This meant Ørsted had a stronghold and was a first mover in the offshore wind market at that time. Ørsted was searching for new areas of growth where it could leverage existing strengths. This highlights the importance of the regulatory framework, both before the merger, to develop the demonstration projects, and looking forward, to offer economic incentives and reduce the regulatory risk. As Anders Eldrup, former CEO of Ørsted, states: “The reason that the majority of investment went to offshore wind was the favourable regulatory framework, as was in the case in Denmark and the UK” (G Nielsen et al., 2021).

The risk of wind projects was actually perceived by the company to be much less than that for fossil fuels. Fossil fuels were subject to price volatility, which could seriously jeopardise the project. Ørsted had experienced the negative consequences of this price volatility in 2012, when the credit rating of the company had to be downgraded due to reduced gas prices. On the other hand, wind provided certainty for the investor as the regulatory framework promised a consistent, long-term return on investment.

An example of this increased comfort was that one of the institutional investors, Pension Denmark, invested in one of these demonstration projects – Nysted. The investors saw the project as low-risk and offering stable, long-term returns. This was a successful investment and meant the investors also wanted to participate in the next park, Anholt. The demonstration projects also resulted in a lot of technical and engineering knowledge gained by the industry, meaning that Ørsted could assume the construction risk. Ørsted constructed the Anholt park, taking 100 per cent of the construction risk, before selling 50 per cent of the project to Pension Denmark. These were the first examples of what is known today as the “farm down” model, which was a way to free up capital, which could then be used for the next project. This is a sustainable financing model which is widely replicated in the offshore wind industry today. The model can be found in various forms, including collaborating with local institutional investors in other countries. The farm down model entails the developer selling equity stakes pre-construction to outside investors in order to free up its own capital for further projects.

The most relevant learnings in entering a new renewable energy market, which could serve as a toolkit for similar companies facing a similar query, are hereby presented, ranging from management learnings to technical and logistic learnings (Muzondo et al., 2021).

Cultural shifts within the company, use of internal talent and competencies:

- The decision to move to the offshore business was initially met by some resistance within the company. Many were doubting the new mission and not understanding the strategy behind venturing into a new sector, when the core competences within the company and the employees were highly based on fossil fuels and coal-fired power plants.

  An internal shift in mindset was paramount, as by securing strong internal support and motivated employees, it was easier to face the risks, as there was a cohesive agreement not only among employees, but also with joint venture partners in the projects. The 85/15 strategy still meant that Ørsted would, over time, transition out of fossil fuels.

- One of the keys to Ørsted's transition was the conscious decision to create a separate organisation in the renewable business, a unit called Wind Power, where Ørsted would bundle all the competences in terms of onshore and offshore wind. A majority of the internal talents were offered the chance to contribute to making a move into the new direction, thus allowing the company to employ the internal competences and employees. The unit grew from 50 to 1000 employees in just two years. The many employees that joined brought along relevant competences, particularly on the engineering side. Although many of the engineers came from the fossil fuel side of the business, their competences were highly valuable for the new one: “if you have run and operated a 2 GW coal fired power plant, rest assured - you can transfer a lot of the competencies and a lot of the skills you require to operate a couple of hundred megawatts project, an offshore wind project” (Martin Neubert, Chief Commercial Officer and Deputy Group CEO, Ørsted) (G Nielsen et al., 2021).

  Furthermore, the benefit of recruiting internals was to have employees who knew the system, who fit into the culture and who understood the spirit of an organisation, which is always something which takes time for new hires. At the same time, by using internal employees, retraining when necessary, Ørsted mitigated job losses as much as possible.

Supply chain as a key factor to reduce costs

- At the time the 85/15 strategy was announced, offshore wind was expensive at around 160-290 €/MWh. Ørsted announced the target for price reductions: offshore wind should reach 100 €/MWh by 2020.

- One of the challenges as a first mover in the market was the lack of a supply chain for materials and for the transportation and maintenance of the offshore turbines. After the first initial small-scale projects, offshore wind was moving out of the proof of concept phase and venturing into the technical concept phase. It was difficult to find supply chain partners that could deliver at large scale and large volumes of major components, turbines, foundations or cables. Ørsted had to find potential partners that could deliver hundreds of components at an industrial scale which had not been seen before, over a 5–6-year timeframe. The company started to think how to move away from engineering, planning and constructing each of these projects as standalone projects (which required reinventing the wheel every two or three years), and think at a large and modular scale. By planning larger wind turbines and wind farms, Ørsted heightened the need for the mass production of turbines, foundations, cables and, consequently, the need for greater manufacturing capacity on the part of the suppliers and the number of players in the supply chain. The scaling up of the production and supply chain was considered as the only way to make offshore wind technology economically viable. The initial projects provided valuable learnings for the next phases from both a technical and a logistical perspective, due to expensive and challenging learning curves. Supply chain actors also took a significant share of the risk in developing the technology and the same was for the wind turbine manufacturers. By making tailored contracts and hedging against potential financial risks on the supply, Ørsted managed to re-distribute the risks, assessing the risk allocation of the full landscape of the players. By entering into mass agreements with turbine developers, e.g., the order for 500 turbines with Siemens in 2009, Ørsted sent a signal (a financial commitment) to the industry and the suppliers that the risks were worth taking, thus creating the framework for the development and construction of large-scale projects.

- In addition to the challenge of producing cost-effective components, there was also the issue of assembling all components and constructing the wind farms offshore. It became clear that one of the key bottlenecks in the supply chain were installation companies, as at the time there were no installation vessels that were built for the installing foundations, cables and turbines, but rather modified vessels coming from the oil and gas industry. Due to the tight availability, the company had to evaluate whether it was worthwhile relying on a small player to realise the project, which could fall apart if that player was e.g., going bankrupt. The decision that followed was to overcome that bottleneck by investing in offshore installation vessels. Although that was not in line with the core business of the company, the decision was evaluated as fundamental for the realisation of the long-term plans.

Joint ventures and investor engagement:

- From a technical perspective, the mechanism that led to the success of Ørsted in offshore wind was through joint venture projects, where an energy company teams up with other international companies with experience in the sector, and helps develop their own experience in the industry. Ørsted was already a market leader in the offshore wind industry, but the large-scale approach and the diversified tasks involved for the offshore plan required many other competences, such as local market and supply chain knowledge. Joint ventures allow for a combination of technical and commercial competences, and Ørsted has undertaken joint ventures recently, such as Bay State Wind with Eversource in the US, Choshi with TEPCO in Japan, and Baltica 2 and 3 with PGE in Poland. These projects are mutually beneficial, as the unique strength from both companies can be leveraged.

- From a financial perspective, the initial task was for Ørsted to convince investors that offshore wind projects were technically and financially sound. To secure the right partners on the institutional investor side, Ørsted did not go out approaching banks for each of the needed assets, as it was not quite in line with their funding strategy at corporate level. Instead, they looked for institutional equity partners, which would be willing to invest into a completely new technology. The target was initially national pension funds, although later on they expanded to international pension funds (Dutch, Canadian) as well as infrastructure investors, convincing them to co-invest in these new offshore wind projects. To overcome the concerns related with the risks (e.g., development, construction, long term operation), Ørsted developed an innovative concept to make the investment attractive: the farm down model. Furthermore, Ørsted discovered an important requirement to ensure investors were both comfortable and confident in the project: investors needed to be educated and brought closer to the technology. The task was particularly challenging given the novelty and the young stage of the technology. The solution was to create competences in-house, by building an engineering, procurement and construction department. While mastering the knowhow, Ørsted was educating the investors. Starting with onboarding workshops with the investors and their technical advisors. By working on an open book basis, investors became comfortable with Ørsted's capabilities required to developing, constructing and operating offshore wind farms.

  The key learning from the process was to make the investor acquainted with the technology, the challenges and the timings required to transform the sector. It was particularly difficult to support similar projects in times where all stakeholders or capital markets were measuring progress in quarters. As a new market, the offshore wind industry was not going to show results “tomorrow or the day after”, and thus was hardly measurable in quarters. The work performed to educate the investors and involve them in the growth process allowed Ørsted to obtain the necessary co-investments in the new asset.

Nowadays, wind and solar are both competitive with fossil fuels in terms of LCoE in many places around the world, thus making them technically and financially sound investments, where short, medium and long-term benefits can be gained.

The transition has also created many jobs, rejuvenating old fishing and oil & gas harbours such as the Port of Esbjerg in Denmark to become major offshore wind hubs. IRENA reported that 11.5 million jobs were reached in the renewable energy sector worldwide in 2019. An input-output analysis has shown that there are around three times as many jobs per MW installed capacity for renewable energy technologies as there are for fossil fuels. A study by the Danish Maritime Fund states that for each 1 GW of offshore wind in Denmark, 14,600 full-time equivalents (FTEs) jobs are created. In addition, the shift towards renewables has proved to be a source of employer branding, attracting many national and international talents from various sectors to Ørsted/Denmark: many moved due to their interest in a growing renewable sector, and many were motivated by ideals of contributing to mitigating climate change. Among those, young people are even more in favour of renewable energy, meaning that the best emerging talent are more likely to be attracted to renewable energy companies than fossil fuel ones.

	Entry strategy for renewable energy	Exit strategy for fossil fuels
Human resources	Cultural shift within the company. Build up human resources: harvest internal resources, retrain personnel, create synergies with existing base and attract new talents, increasing sustainable job opportunities.	Divest businesses that do not align with the new green vision
Technology strategy	Develop and test proof of concept projects, devise long term strategies with ambitious targets and scale up large-scale renewable projects. Then choose technologies based on their return and risk profile in a given regulatory framework, investigating the impact on players in the supply chain. Bring the technology to cost-competitive levels with the existing products, assessing the role of the new product in existing and new markets.	Convert directly, e.g., coal to biomass The same could be done with existing coal power plants, by using the land for hybrid solar and wind projects and re-using the existing transmission infrastructure.
Market forces & project choices	Invest in new projects. Joint ventures can be a good way to gain technical experience and knowledge, filling the gap with the missing technical competences to reach the objective. Institutional, national and international investors can be attracted to green projects with long-term returns and low risk. Investors and technical advisors which have been educated about the new technology and the mission are more likely to feel confident in approving co-investments.	Abandon projects Several coal-fired power plants have been abandoned in northern Europe as they are no longer profitable and attract public opposition.

Table 1

Examples of entry and exit strategies for energy companies, as experienced in Denmark over the last 10-15 years in particular

Recommendations

Stable, transparent, inclusive, long-term policy and planning provide confidence to developers and investors when followed by concrete reforms

Governments need to make energy planning and policy a priority to support the development of energy companies towards renewable energy. They can do this by ensuring energy plans are:

- Long term. Energy plans decades into the future give confidence to investors and companies that a market is worth investing in.
- Transparent in terms of the data, assumptions and scenarios used in energy plans. This gives confidence that all companies are provided with the same information and are competing on a level playing field.
- Stable in their nature. Adjustments may be necessary over time, but large, retroactive changes to subsidies or taxes can have long-lasting negative consequences on the certainty of renewable energy markets. Stability can also be shown through reliable and realistic targets, which are then followed by documentation of progress and fulfilment of stated policies. A proven track record helps negate the perception of risk from investors and increases confidence in future plans.
- Inclusive: a transparent and inclusive dialogue between government and industry will also ensure the necessary inputs from the involved parties are received, thus considering the needs of the players when designing the rules. Positive engagement between government and industry can lead to benefits for both sides, e.g., for defining auction criteria or to propose realistic data for analyses. Government support and engagement is also important, as local communities hosting potential projects should also be involved in the process, as their (rightful) opposition can pose project development risks for the realisation of renewable projects.

Energy plans should be supported by the legislation through concrete reforms to achieve the targets. These can be regulatory tools, such as:

- Economic incentives to achieve the policy goals such as reform to subsidies and taxes. These incentives need to be paired with the following regulatory tools to reduce the risk of a resulting larger price for the consumer (cost pass through).
- Reforms to ensure an electricity sector based on competition. Wind and solar have achieved record low prices in recent years and to harvest the benefits of these low prices, reforms of the electricity sector may be necessary to ensure the generation side of the sector can focus on producing energy at low prices, which can then be transferred on to consumers.
- Demonstration projects are an effective tool to gain technical, commercial and regulatory experience with new technologies.
- Permitting and de-risking. A proper allocation of risk and streamlining of the application process can lead to large reductions in prices. Local ownership can be an effective tool to increase local acceptance.

Energy companies need to devise a strategy for the new situation and follow through with investments

Energy companies should develop a tailored vision and strategies that are anchored in current government actions and policies in order to transition from fossil fuels to the renewable business and sector. The core recommendations, inspired by the Danish transition, are:

Create a sustainable vision

Make good use of the long-term planning policies in place

Similar to energy planning from a government perspective, energy companies need to create a long-term sustainable vision with concrete and tangible actions. Ambitious and achievable targets (backed up by relevant indicators) are paramount to keep the company focused while entering the dynamic energy sector, where renewable energy is set to be the key and major player for the future growth.

Contextualise the strategy

The regulatory framework developed by governments is largely expected to determine the path that energy companies will follow, as they look for the optimal business case. Therefore, an assessment of the regulatory framework and the future demand of various technologies should shape the business strategy going forward. Each approach will likely differ based on current conditions, e.g., whether or not a liberalised electricity market exists.

Develop a holistic vision within the dynamic landscape

The resulting sustainable, purpose driven vision should not only be about what the company can become, but how the company can contribute to the sustainable development of the sector. At the same time, the vision should time express company strategy and guide it (Ørsted, 2021).

Develop an exit strategy for fossil fuels

Engage actors and government agencies in the divestment plans

In the transition period, the strategy for the existing assets must be devised in dialogue between the actors involved and government agencies in order to ensure a smooth transition. Instruments such as aid packages or decommissioning auctions, in combination with conditions to incentivise investment in new renewable technologies with the new capital, can be a way to break the deadlock of stranded assets. The approach can create a positive direction, while at the same prioritising "fossil fuel free" technologies, supporting the reduction of operational costs and ensuring a healthier and less risky economy for the company in the long run.

Re-evaluate the asset to fit the future of the sector

If conversion to more sustainable options is incentivised, it is important to ensure that such solutions will still be sustainable in the long run (e.g., establish sustainability standard requirements for biomass from the start and perform independent and contextualised assessments of biomass sustainability).

Abandon investments when regulations and public opposition hinder future opportunities

Discontinue further investments in fossil fuel-based projects when future regulations and support will likely hit the financial sustainability and realisation of the project. Ørsted, like many European energy companies, discontinued investments, even during the realisation phase, as it became clear that no future opportunities were available for the continuation of such projects.

Develop an entry strategy for renewable energy

Attract finance to new renewable energy projects validating the proof of concept

Attracting finance to new renewable energy projects has proven to be an effective business model to incentivise future development, financial sustainability and profitability while accelerating the development of new projects. The farm down model, which was employed to finance the early projects, proved to be a successful approach; by withholding the majority of the risks throughout construction and operations of the assets, the offshore wind developer partially shields the investors from risk, thus making them comfortable to invest at an early stage. To do this, a proven track record needs to be shown, from "proof of concept" to "small and large scale" projects, pushing the ambitions further and further, and creating a collaborative framework where all the players in the industry are involved, from co-investors to supply chain actors.

Engage, align and educate stakeholders

The institutional investors and equity partners will not necessarily invest in the first project, but will after expertise is demonstrated, as witnessed in the offshore wind sector in northern Europe. Similarly, if a company wishes to make an IPO listing, financing will be more readily obtained if the company has a serious vision for renewable energy. Ørsted's strategy of educating investors and opening up the black box of offshore technology proved to be fundamental in providing certainty and confidence for joining and investing in the project. Furthermore, by mastering the knowhow with deepening in-house knowledge and by subsequently using the knowledge to educate investors, Ørsted achieved dual benefits: they got investors on board and re-trained internal staff, thus providing new opportunities for job creation.

Be a first mover: enjoy the benefits and be ready for the challenges

From a technological, logistical and financial perspective, being a first mover comes with perks and pitfalls. The example of Ørsted, which ventured in the offshore wind industry at the early stages, pursuing technical, financial and operational sustainability, revealed valuable learnings in terms of challenges, risk aversion and benefits. The cultural shift within the company, the use of internal talents, the re-training of competences to achieve the 85/15 vision with the full support of internal employees emerged as crucial pieces of the puzzle, culminating in Ørsted being ranked the world's most sustainable energy company in 2019, 2020 and 2021.

Value joint ventures: share the skills

The restructuring of strategic partnerships among old and new players in the supply chain is another key success that led to the flourishing of the offshore concept by reinventing the role of turnkey providers: teaming up with other international companies with experience in the sector, through joint venture projects, helped Ørsted develop their own experience in the new industry. Finally, the scaling-up process proved to be a strong signal for the industry, which reacted positively to the considerable commitment (e.g., 500 turbines from Siemens) and adapted to the new demand, thus leading to lower costs in future projects.

Build up human resources: harvest internally, retrain personnel, create synergies with existing base and attract new talents

Human resources for a new technology can be developed through retraining, learning by doing or by attracting new talent. Demonstration projects executed by public-private partnerships can be a good way to kickstart the industry and gain valuable in-house experience in a technology, while at the same time enhancing human resources competences in the field and expertise. In addition, new talents can be attracted by the green agenda, as the enthusiasm related to the novelty of an unexplored field often appeals to the brightest minds, thus leading to high quality job creation. Finally, for those in the upstream side of the fossil fuel chain, targeted labour market policies should be deployed to assist in reeducation and employment, thus securing a just transition.

Conclusion

This report details key events in the evolution of Danish energy policy. It uses Ørsted as a case study to demonstrate how an energy company has made a successful transition from black to green energy, while maintaining financial sustainability and profitability.

The international community has acknowledged the need to change with the Paris Agreement, and there is a noticeable shift in the attitude of institutional investors away from polluting energy sources, leaving conventional energy companies with an existential threat. Governments have the responsibility to plan long-term energy systems in a way to reduce emissions for the benefit of future generations and design the regulatory framework to support energy companies in contributing to the transition. Companies which acknowledge the changing landscape and make the necessary strategic decisions and investments to contribute to a sustainable transition can reap the potentially lucrative benefits of the green transition. While every country and company are context specific, the main learnings presented in this report should be useful as a guide for governments and energy companies ready to transition to green energy. Ørsted's successful green transition focuses mainly on offshore wind, although the technology choice is not necessarily the most important lesson presented here. The hope is that the same critical thinking, the decision process, the risks and the results presented in the report can provide valuable learnings for other situations with e.g., alternative technologies and context. Fifty years ago, Denmark started the process of venturing into the unexplored field of wind energy, and the green transition continues to this day. Perhaps not all first mover ventures will lead to the same Danish success, but one thing is certain: those that move earlier will fare better in the green transition.

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