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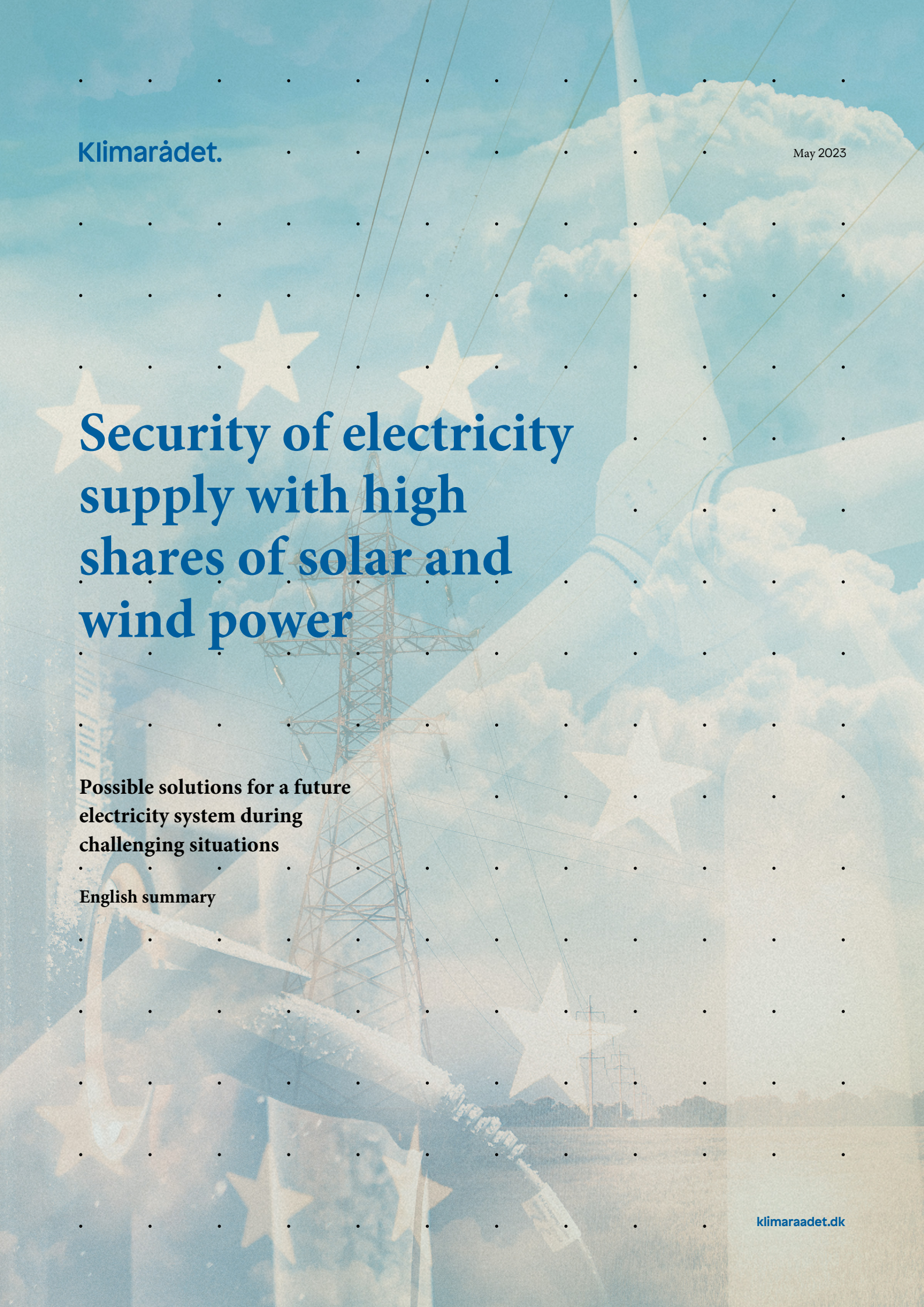
Security of electricity supply with high shares of solar and wind power

Possible solutions for a future electricity system during challenging situations

English summary



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Introducing the Danish Council on Climate Change

The Danish Council on Climate Change is an independent body of experts who advise the Danish government on how to transition to a climate-neutral society, thereby ensuring that, in the future, we can live in a country with very low emissions of greenhouse gases while retaining our level of welfare and development. Each year, the Danish Council on Climate Change assesses whether the government's climate efforts have demonstrated that Danish climate targets are likely to be met. The Council also contributes to the public debate and regularly prepares analyses and recommendations for climate efforts.

Security of electricity supply with high shares of solar and wind power

Possible solutions for a future electricity system during challenging situations

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1 Abstract

Denmark currently holds the highest share of solar and wind power in Europe, with solar and wind energy contributing nearly 50 pct. of the country's total electricity generation in 2021. This share is projected to surpass 100 pct. in the future, indicating that Denmark will generate more electricity from solar and wind power than it consumes domestically. In parallel, existing dispatchable generation capacity is expected to decrease over time while electricity consumption continues to grow due to widespread electrification of society. Consequently, the security of electricity supply in Denmark faces challenges, particularly during weather events with poor wind and solar resources across multiple countries. Although Denmark is well-connected to neighbouring countries by interconnectors, reliance on these connections may be limited during such events, since neighbouring countries might also face difficulties in generating adequate power.

This analysis investigates potential challenges in ensuring the security of supply in terms of power adequacy. The analysis finds that Denmark will be able to ensure security of supply with high shares of solar and wind power, even in situations with very challenging weather conditions. Apart from transmission capacity, this requires the implementation of various measures, such as dispatchable generation capacity, energy storage systems, and flexible consumption. Implementing these measures can address the challenges at a relatively low cost of approximately DKK 2-3 billion annually.

Failure to act may lead to extended power shortages, emphasizing the need for proactive measures. Implementation of the measures could be challenged by existing EU legislation. Therefore, the Danish Council on Climate Change encourages the Danish government and relevant energy authorities to increase focus on this task already now.

Relevant Danish Energy Authorities

- **The Danish Energy Agency** is part of the Ministry of Climate, Energy and Utilities and holds the responsibility for tasks related to energy production, supply and consumption. Furthermore, the agency is responsible for and monitors Denmark's effort to reduce carbon emissions.

- **Energinet** is the Danish TSO owned by the Ministry of Climate, Energy and Utilities. Energinet owns, operates and develops the transmission system of electricity and gas in Denmark as an independent public enterprise. Energinet thereby holds the overall responsibility for ensuring security of electricity supply.

Policy recommendations beyond Danish national policy

The main task of the Danish Council on Climate Change is to advice on how Denmark can undertake an effective transition towards a low-carbon economy by 2050 at the latest. However, the *analysis Security of electricity supply with high shares of solar and wind power* also contains policy recommendations beyond Danish national policy. These include:

- A recommendation on a potential adjustment of EU-legislation towards easier approval of capacity mechanisms.
- A recommendation on increased collaboration on electricity transmission in the Nordic region or active efforts to strengthen cross-border electricity transmission within the EU.

Further, the analysis contains recommendations, which could also be relevant for other countries. These include recommendations on:

- Ensuring adequate flexibility in the energy system;
- More analysis on the risk of extreme events in a future with low production from solar and wind power.
- More analysis on scenarios with large amounts of solar and wind power

The full list of recommendations can be found below.

2 The analysis summarized in 2 minutes

Is it possible to ensure security of electricity supply in a future where the majority of electricity comes from solar and wind energy, and where our electricity consumption is much higher than today? Fortunately, the short answer is yes, if we address the challenges in due time.

Both Denmark and the rest of Europe are facing a widespread electrification of society. Cars, industries, and many other parts of society will be powered by electricity which should come from renewable energy sources that do not emit greenhouse gasses. Therefore, in the future, Europe will be supplied with electricity from renewable energy sources while traditional fossil fuel power plants will be gradually phased out.

The Danish Council on Climate Change has examined whether Denmark will have sufficient electricity generation capacity, even in extreme situations when the wind does not blow, when the sun does not shine for extended periods, and when importing electricity is not possible due to neighbouring countries facing similar weather challenges. The analysis focuses on what is technically called 'power adequacy'.

If no political action is taken, significant and long power outages could occur in Denmark. These outages could become gradually more frequent and last longer, when looking further into the future. To investigate this challenge, the Council has examined a range of scenarios for the European electricity sector in the years 2030, 2035, and 2040.

The Council's analysis shows that security of electricity supply can be ensured with a range of different measures:

- Dispatchable generation capacity, such as gas turbines, which can generate electricity from green gasses such as hydrogen. The turbines provide power during the few hours per year when electricity generation from solar and wind is very low.
- Electricity storage, such as large-scale thermal energy storage.
- Flexible consumption, such as increased flexibility in electricity consumption in industries.

However, electricity storage and flexible consumption are not sufficient to prevent all potential power outages caused by power inadequacy. Preventing all potential outages would require investment in dispatchable generation capacity, such as gas turbines, while also ensuring that this capacity is ready for electricity generation during challenging situations – even if only for a few hours a year. This can be ensured by establishing capacity mechanisms. The term 'capacity mechanisms' describes a range of solutions aimed at ensuring adequate power capacity. In a capacity mechanism, authorities offer payments to actors who can deliver electricity or reduce their consumption when required during critical periods.

The investment costs of the necessary gas turbines or a similar generation capacity depends on the scenario. In one scenario, the costs amount to approximately DKK 3 billion annually, equivalent to DKK 100 annually for an average household.

However, EU legislation could limit the implementation of capacity mechanisms. According to EU legislation:

- the need for additional capacity must be documented by the country wishing to introduce capacity mechanisms. The methodology for documentation does currently not allow for sufficient inclusion of extreme weather events. Further, wind and solar power capacities often follow projections which tends to underestimate the actual buildout. These two examples could lead to an underestimation of future adequacy issues while also making it more difficult to get EU-approval of national capacity mechanisms.
- challenges in ensuring adequate capacity should first be addressed by market-based solutions.

Overall, this means that establishing capacity mechanisms under EU legislation can be a time-consuming process. Therefore, the Council encourages the government and relevant energy authorities to increase focus on this task already now.

The Danish Council on Climate Change's recommendations:

- **The expansion of solar and wind energy should not slow down due to concerns of the security of electricity supply, but challenges should be addressed in due time.**
  There are good opportunities for limiting power shortages in the future or even completely avoiding power shortages during challenging periods. Implementation of several solutions may take many years, and therefore the government and relevant energy authorities should address challenges of security of electricity supply in due time.

- **Danish energy authorities should examine and plan for measures to increase flexibility in the energy system beyond what is supplied by the electricity market.**
  To maintain a desired level of security of electricity supply, there may be a need for additional flexibility in the electricity system in the future, beyond what is supplied by the electricity market. Flexibility can be ensured through means such as interconnectors, energy storage, flexible electricity consumption, and dispatchable generation capacity, which can be provided through various measures, including capacity mechanisms. In this regard, energy authorities should clarify whether the generation capacity that is scheduled for decommissioning can and should be used in such mechanisms. The possibilities for establishing a capacity mechanism are strictly regulated by the EU, so energy authorities should examine and plan for possible measures that can be allowed under EU legislation or alternatively work towards adjusting these rules.

- **The Danish government should ensure incentives for energy storage and demand flexibility.**
  Energy storage and flexible electricity consumption can contribute to security of electricity supply in a climate-friendly and cost-effective manner. Therefore, the government should ensure that there are incentives for utilizing the potential of both storage and demand flexibility. Furthermore, the government should focus on supporting overall technological development in these areas.

- **The Danish government should work to reduce the risks associated with import of electricity.**
  Towards 2040, Denmark will increasingly depend on imported electricity during periods of low electricity generation from solar and wind sources. This development reflects a cost-effective integration of electricity markets, but it also makes Denmark more dependent on import of electricity. The government should therefore work to reduce the risks associated with import dependency. This could be achieved through increased collaboration on electricity transmission in the Nordic region or through active efforts to strengthen cross-border electricity transmission within the EU – also in situations where the energy system is under pressure and electricity prices are high.

- **Danish energy authorities should consider the risk of extreme events in the future.**
  Danish authorities are currently in the process of determining a socio-economically optimal level of security of electricity supply. When the Danish TSO Energinet assesses whether we meet this target, the authorities should, to a greater extent than today, consider the risk of extreme events, such as rare, but still possible extreme weather events and long-term disruptions of essential interconnectors.

- **Danish energy authorities should consider scenarios with large amounts of solar and wind energy.**
  The Danish authorities currently monitor the security of electricity supply by conducting analyses that include the risk of various technical failures and critical historical weather years. The Council recommends that these analyses also include scenarios with assumptions consistent with the Paris Agreement, with large amounts of solar and wind energy and high electricity consumption. These scenarios should be considered when the authorities assess whether we meet the target of security of electricity supply.

- **Electricity supply should be ensured without a high consumption of biomass.**
  To limit the consumption of biomass, any potential preservation of thermal electricity generation capacity under a capacity mechanism should only aim to ensure adequate capacity in challenging situations. Preservation of thermal capacity should not be used for general generation of electricity and heat and should not delay a reduction in biomass consumption. The Council has previously recommended the government to develop a comprehensive, long-term strategy on how Denmark's biomass consumption can be reduced to a globally sustainable level. In this context, the Council has also recommended the implementation of appropriate incentives to ensure that consumption of biomass is taxed according to its climate impact. These recommendations are valid, even if Denmark's security of electricity supply will be challenged in the future.

3 The analysis summarized in 15 minutes

Denmark has the highest share of solar and wind power in Europe

Danish electricity generation relies heavily on solar and wind power. As illustrated in figure 1, Denmark currently holds the highest share of solar and wind power in Europe, with solar and wind energy contributing to nearly 50 pct. of the country's total electricity generation in 2021. In 2021, the share amounted to almost 50 pct., while Ireland, which ranks second in Europa, was at 33 pct. In the future, the share in Denmark could exceed 100 pct. This means that solar and wind power will generate more electricity than what is consumed domestically in Denmark.

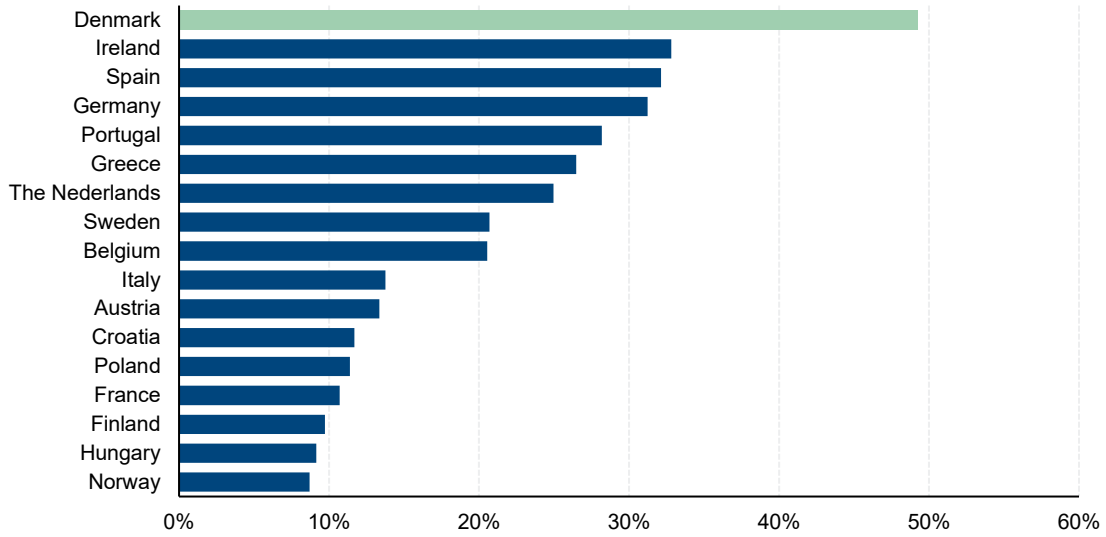

Figure 1 Electricity generation from solar and wind power in 2021 in various European countries.

Note: Only selected countries in Europa are included. Solar and wind power included.

Source: Eurostat.

The high level of security of electricity supply in Denmark may be challenged in the future

We rarely experience power outages in Denmark. Danish consumers have, on average, experienced power outages for about 20 minutes per year over the past many years. Power outages refer to situations where there is no electricity in the outlets at home or in industries. This is a low level compared to other European countries.

Climate change requires a transition of society to an electrified and climate-positive society. This involves a transformation of the energy system towards a system based increasingly on renewable energy sources such as solar and wind, and less on thermal power plants consuming fossil fuels or biomass. At the same time, electricity consumption will grow due to a widespread electrification of society. The same transition is happening across Europe.

The combined expansion of solar and wind power, the gradual phasing-out of existing thermal power plants and the increase in electricity consumption means that dispatchable electricity generation will be able to cover a decreasing share of the electricity consumption towards 2040. Figure 2 illustrates that dispatchable electricity generation today potentially is able to cover all electricity consumption. In 2030, dispatchable generation is only expected to cover 39 pct. of inflexible consumption. And in 2040, this share may decrease to 22 pct.

This development challenges the security of electricity supply in Denmark. Although Denmark is highly connected to its neighbouring countries via interconnectors, periods with poor wind and solar resources in large geographic areas across boarders can become challenging. The neighbouring countries will also increasingly rely on solar and wind power, and Denmark cannot expect full availability of interconnectors during these challenging periods. The aim of this analysis is to investigate these challenging situations. More specifically, the analysis addresses the following questions: Is it possible to

base our electricity supply on wind and solar power in a future that requires large amounts of electrical energy? And how do we handle situations where the sun is not shining and the wind is not blowing?

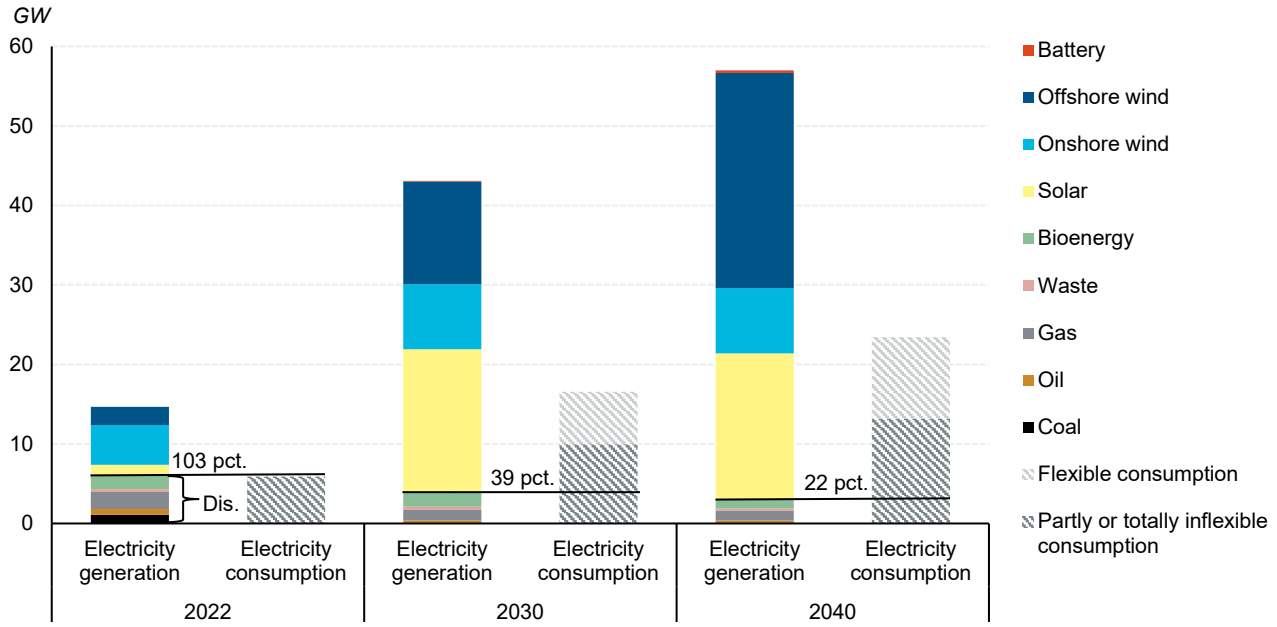

Figure 2 Expected electricity generation capacity and consumption in Denmark towards 2040.

Note 1: The percentage reflects the share of inflexible consumption potentially being covered by dispatchable generation (Dis.) Dispatchable includes power plants consuming bioenergy (biomass and biogas), waste, gas, oil and coal.

Note 2: Electricity consumption is divided in 'Partly or totally inflexible consumption' and denotes the consumption in hours of the year with highest consumption.

Source: The Danish Council on Climate Change

The analysis points towards solutions in a long-term perspective

The transition of the energy sector from thermal power plants to solar and wind energy is a major task. The transition was initiated many years ago and will continue over the next decades. Therefore, it is necessary to look far into the future when examining potential challenges to the security of electricity supply. This analysis examines the development towards 2040.

Although the transition to wind and solar energy will take place over many years, there are two main reasons to address the potential challenges to the security of electricity supply already now:

- **Certainty**. It is important to obtain certainty that the ongoing transition of the energy sector to wind and solar energy does not create problems of security of electricity supply that we are unable to handle.

- **Implementation in due time.** It takes time to plan and implement some of the initiatives and solutions necessary to address the challenges of future security of electricity supply.

The analysis focuses on electricity generation and not the electrical grid

This analysis does not address all the different factors that can lead to power outages. The analysis focuses on the part of security of electricity supply that concerns whether there will be enough power in a Danish energy system that is primarily based on wind and solar energy. This is also known as 'power adequacy'.

Power outages may also be caused by other factors, such as unforeseen and sudden breakdowns or inadequate grid capacity. However, the analysis does not address these factors.

Security of electricity supply will be challenged without new measures

To answer the questions stated above, it is important to distinguish between a situation where issues of security of electricity supply are not addressed in due time, and a situation where the market and authorities take sufficient action to address the issue. First, the analysis analyses a situation where no new solutions are implemented, beyond expanding the interconnector capacity.

Security of electricity supply is examined in four different scenarios described in Table 1. The scenarios are described in greater detail in the full report (only available in Danish).

Table 1 Review of scenarios

Scenario	Description
Normal weather year	This scenario reflects a year with normal wind and solar conditions and a normal amount of precipitation for hydropower in the Nordic region.
Challenging weather year	This scenario represents a weather year with poorer wind and solar conditions compared to a normal weather year, as well as low precipitation levels for hydropower in the Nordic region. Based on historical data, these conditions could represent a weather year that occurs approximately once every decade (thus classified as a 10-year event).
Weather shock	This scenario reflects a weather shock where the electricity system faces additional challenges due to reduced production from solar and wind. The weather shock can be considered as something similar to a 100-year event.
Weather and transmission shock	This scenario adds a transmission shock on top of the weather shock, corresponding to a situation where critical infrastructure is out of operation during critical periods. Specifically, the interconnectors to/from Sweden and Norway are shut down for two weeks with very low generation of wind and solar power.

Source: The Danish Council on Climate Change

Table 2 shows the expected power shortage in a challenging weather year and under different shocks in 2030 and 2040 without additional measures. The data presented are based on electricity system modelling simulating the European electricity system far into the future. The table shows that when simulating the electricity system under a challenging weather year in 2040, power inadequacy can reach up to 4.6 GW. This corresponds to a situation where approximately 50 pct. of the expected electricity consumption in the most challenging hours cannot be supplied. In simulations that include both weather shocks and transmission shocks, the power inadequacy increases up to 85 pct. of the expected consumption in the most challenging hours. Power inadequacy would also occur in 2030, however, to a lesser extent.

The table also presents the total number of hours with power shortage for each scenario. In the majority of hours, only a small share of consumers in Denmark would be affected by the power shortage and left without electricity in their outlets.

Table 2 Maximum power inadequacy and number of hours with power shortages in different scenarios without new additional measures

Scenario	2030		2040	
	Maximum power inadequacy	Number of hours with power shortages	Maximum power inadequacy	Number of hours with power shortage
Normal weather year	0 GW	0 hours	0 GW	0 hours
Challenging weather year	1.9 GW	59 hours	4,6 GW	83 hours
Weather shock	2.4 GW	76 hours	5,8 GW	130 hours
Weather and transmission shock	4.2 GW	99 hours	7,9 GW	194 hours

Note: The total number of hours with power shortage are not necessarily continuous.

Source: The Danish Council on Climate Change

The results indicate a significant decrease in security of supply compared to the present if these scenarios actually occur and no action is taken to address the challenges. For instance, data from simulations of a challenging weather year in 2040 show that there would be power shortages that last for 83 continuous hours. In comparison, Denmark has not experienced power shortages due to inadequacy of power generation for many years.

The challenges for security of electricity supply can be addressed with a range of different measures

High security of electricity supply in Denmark can be ensured through a range of technical solutions and measures that can contribute to flexibility in both electricity generation and electricity consumption.

The analysis has examined three solutions:

- Dispatchable generation capacity (e.g., gas turbines)
- Energy storage systems
- Flexible consumption

In addition, an expansion of interconnectors to other countries is assumed in all scenarios.

Dispatchable generation capacity can generate electricity during shortages

Currently, dispatchable thermal generation capacity contributes considerably to Danish electricity generation. However, in a future energy system with a large share of electricity generation from solar and wind energy, these dispatchable power plants will play a different role. Instead of providing electricity for many hours throughout the year, dedicated plants can contribute to maintaining security of electricity supply by supplying electricity during the few hours per year when the generation from solar and wind power is very low. This analysis examines how new dispatchable plants, fuelled by natural gas, hydrogen, or biogas, can contribute in this role.

Energy storage systems can store surplus electricity from periods with a high level of solar and wind energy

Energy storage systems are currently not widely deployed in the Danish energy system. However, this type of installation can play a much larger role in the future when new technologies are needed to balance the differences between electricity demand and non-dispatchable electricity generation from solar and wind. In this context, thermal storage is one possible storage technology, where large amounts of electricity can be stored at a relatively low cost. A thermal storage system works by heating a material, such as stones, to a high temperature using electricity. The heated storage can then later generate electricity.

More flexible consumption of electricity

Electricity consumers already exhibit some flexibility in the energy system today. Many consumers have apps that allow them to see when electricity prices are lowest. Both industries and private consumers have the option to reduce their energy costs by changing their consumption from hours with higher electricity prices to hours with lower prices. These opportunities will increase in the future.

This analysis examines the effect on security of electricity supply when certain types of industries reduce their electricity consumption by 20-25 pct. during peak periods, and when up to 25 pct. of all electric vehicles make their battery capacity available (also known as vehicle-to-grid) for discharging during the same periods.

Interconnectors are not always the solution to power shortages

The scenarios in the analysis show that Denmark will be dependent on imports to ensure power adequacy for a significant number of hours per year. This emphasizes the importance of interconnectors and their availability to contribute to security of supply when needed.

However, interconnectors to and from Denmark are not always the ideal instrument to ensure security of electricity supply during periods of low electricity generation from solar and wind. This is due to the fact that poor solar and wind conditions often affect multiple countries simultaneously. Therefore, power inadequacy may occur both in Denmark and several of Denmark's neighbouring countries.

The solutions can be implemented at a relatively low cost

The costs of the examined solutions are affordable compared to other expenses in the electricity system. The other expenses include costs for electricity production, transmission, and distribution. An estimate of costs for implementing the examined solutions are shown in figure 3 below.

Additional dispatchable generation capacity is estimated to an approximated cost of EUR 0.2 billion annually to establish adequate capacity that can cover all encountered outages during a challenging weather year. In this scenario, approximately 4.5 GW capacity is established, which is sufficient to handle the challenge in all simulated years until 2040. In comparison, current installed dispatchable capacity amounts to approximately 6 GW. In the scenario with weather and transmission shocks, the cost increases to EUR 0.4 billion annually covering the cost of nearly 8 GW capacity.

In the scenario with dispatchable generation capacity in combination with storage capacity, the costs are estimated to be between EUR 0.5-0.8 billion in a challenging weather year. This solution is therefore more expensive than when using dispatchable generation capacity only. However, there is a large uncertainty regarding the future costs of energy storage technologies at this scale.

In the scenario with dispatchable electricity generation capacity in combination with more flexible electricity consumption, the cost is estimated to be minimum EUR 0.2 billion for the challenging weather year and minimum EUR 0.5 billion for the scenario with weather and transmission shocks. The minimum cost solely reflects the cost related to dispatchable electricity generation capacity since there is a considerable uncertainty about the costs associated with additional flexible electricity consumption.

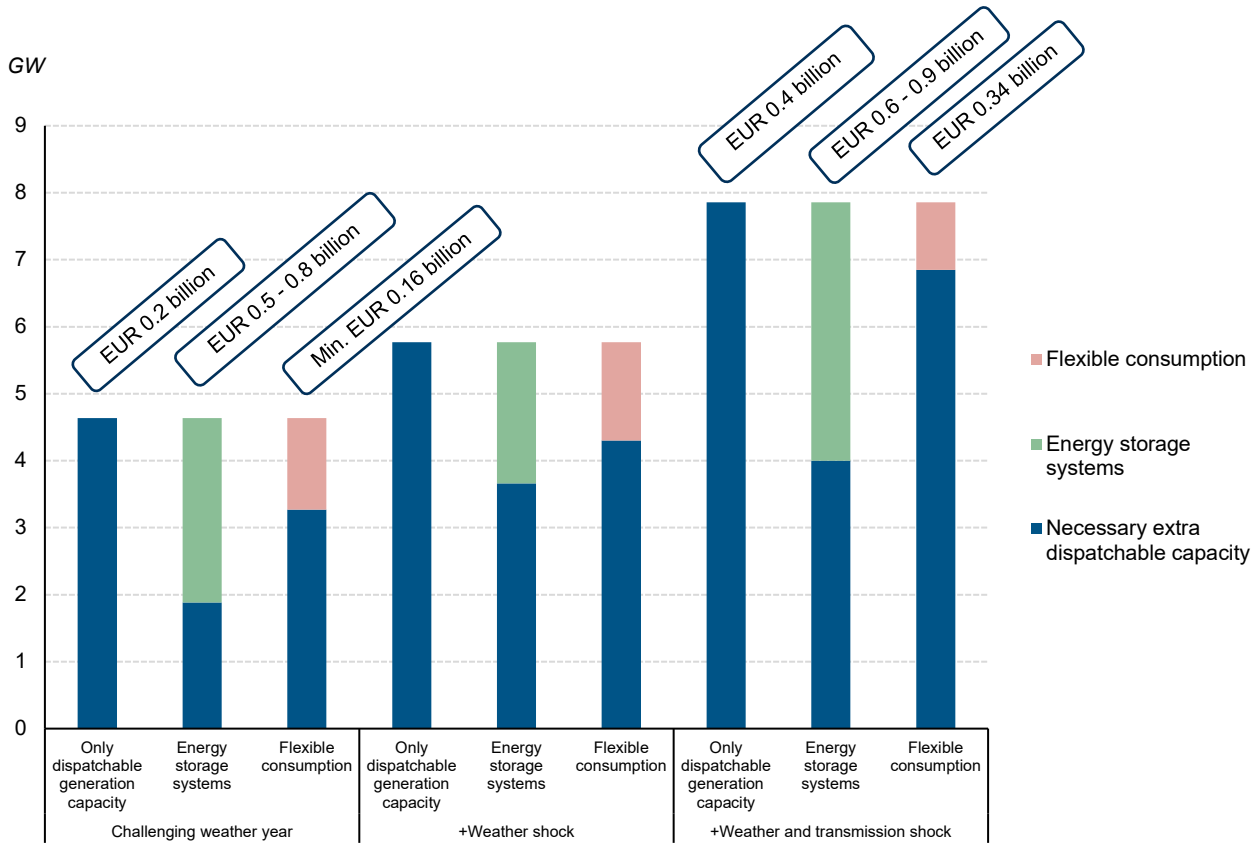

Figure 3 The required additional dispatchable capacity and annual cost to prevent power shortages

Note: The prices stated above the bars represent a rough cost estimate. Therefore, it is difficult to compare costs across scenarios. Note that the cost estimate is only provided for a 'Challenging weather year' and for a 'Weather and transmission shock'. All costs are stated in 2022 prices.

Source: The Danish Council on Climate Change.

It is difficult to determine the optimal solution. This is primarily due to uncertainties regarding costs and technological developments. However, it is likely that the most cost-efficient solution would be a combination of dispatchable electricity generation capacity, storage capacity, and flexible consumption.

This analysis focuses on *how* to ensure adequate electricity supply in extreme situations with different solutions, and not whether we *should* ensure adequate electricity supply in all these situations. From a socio-economic perspective, it is probably disproportionately expensive to operate an electricity system which is able to avoid power outages in all possible situations. Rather, it might be economically more viable to accept a certain risk of power outages, as we do today, rather than investing in technical solutions covering all possible situations.

Financing the solutions will increase the electricity bill of an average Danish household by approximately 13 Euro per year

The costs of ensuring the security of electricity supply are relatively limited compared to overall electricity system costs. For example, the costs of dispatchable generation capacity are estimated to be up to 0.4 billion EUR annually. If we compare this value to expected electricity consumption in 2040, it corresponds to approximately 4.0 EUR per MWh. In comparison, this amount is roughly half of the current system tariff paid to the Danish TSO Energinet to ensure system balance (9.0 EUR per MWh in 2023).

For an average household that paid 317 EUR per MWh for electricity in 2021 (including taxes, fees, and tariffs), the mentioned cost of 4.0 EUR per MWh would increase the total electricity price by approximately 1 pct. This translates to an increase in the electricity bill of approximately 13 EUR annually for an average Danish household of two adults and two children.

Power shortages lead to higher electricity prices

Electricity prices tend to increase during periods of power shortages. This analysis shows that, under the current electricity market legislation, the annual average price in a challenging weather year in 2030 would increase by 121 pct. compared to a normal weather year. A combined weather and transmission shock would result in a 162 pct. increase. In comparison, the actual average price level in 2022, with extraordinary high electricity prices, was 154 pct. above a normal weather year in 2030. It is worth noting that historical weather data indicate that the challenging weather year scenario will not be frequent, and the conditions in the combined weather and transmission shock are highly unlikely. However, years with periods of challenging weather will occur, posing a real challenge in transitioning to an energy system with a larger share of solar and wind energy.

The scenarios in this analysis illustrate that the average electricity bill can be expected to increase significantly in years experiencing periods of power shortages. It is therefore relevant to consider measures that can prevent significantly higher electricity bills for consumers. This can contribute to maintaining social cohesion and general support for the green transition. How and to what extent this issue should be addressed is a political question.

Establishing a capacity mechanism takes time

This analysis highlights dispatchable power capacity, such as gas turbines or other power plants, as a key solution for maintaining security of electricity supply in the future. Most of the time, these power plants would be on stand-by and activated only during the relatively few hours per year when solar and wind production is very low. However, planning needs to start well in advance to ensure that power plants are ready when needed.

Currently, there is sufficient dispatchable power capacity in the Danish electricity system to maintain a high level of security of electricity supply. However, it is expected that the existing dispatchable power plants will gradually be phased out over the coming decades. This is because the increasing amounts of solar and wind energy in the system reduce the profitability of dispatchable thermal power plants, making them economically unviable and leading to their closure, typically when they face potentially significant lifespan extensions.

If the security of electricity supply is to be supported by dispatchable generation capacity in the future, these facilities will need financial support beyond the regular electricity market. This would require the establishment of so-called capacity mechanisms that provide owners of dispatchable capacity with clarity regarding remuneration for power plant services. Specifically, this could be achieved by guaranteeing the owner of a power plant a fixed annual income for a period, in exchange for the plant being available and able to generate electricity when the electricity system is challenged.

In the EU, legislation dictates how and when member states can support security of electricity supply. This legislation provides a framework for when intervention in the electricity market with a capacity mechanism is allowed. According to legislation, challenges related to power adequacy should first be attempted to be resolved through market-based solutions. Additionally, the country seeking permission to establish a capacity mechanism must demonstrate that the socio-economically optimal level of security of electricity supply is expected to be exceeded in the future if the mechanism is not established. Currently, this assessment does not consider more extreme weather years than what is found in a historical reference period of 30 years, making it more challenging to obtain permission to establish a capacity mechanism.

Nuclear power is not necessary in Denmark to ensure a high level of security of electricity supply

This analysis shows that security of electricity supply in Denmark can be ensured through climate-friendly measures without the use of Danish nuclear power. This applies even in a future where electricity consumption and the share of solar and wind energy in the Danish and European energy systems increase significantly, while dispatchable capacity decreases significantly, especially in Denmark. Even in situations with very challenging weather conditions, there are several alternatives to nuclear power that can ensure high security of electricity supply in Denmark at a relatively low cost and without significant greenhouse gas emissions.

The latest analyses from, among others, the International Energy Agency (IEA) estimate that the future costs associated with electricity generation from newly built nuclear power plants in Europe are significantly higher than for other technologies, including solar and wind. Nuclear power plants are also less favourable in comparison to solar and wind, even when considering the system benefits of nuclear power plants being a dispatchable energy source. This is particularly true in Denmark, due to the strong wind resources and good interconnectors.

Finally, it is essential to note that the establishment of nuclear power in Denmark is likely to take a very long time as other recent European nuclear plants. Therefore, there is a significant risk that nuclear power may not contribute to security of electricity supply within the period leading up to 2040, even if the decision to establish nuclear power were made today.

Overall, the Council does not consider nuclear power as a necessary or economically attractive solution to ensure security of electricity supply in the transition of the Danish electricity system. New reactor technology such as small modular reactors may potentially change the situation, but this is still in the early stages of development and cannot be used as an argument for Danish investments in nuclear power today.