



Roadmap 2040

Wind power: combating
climate change
and improving
competitiveness



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1. Letter from the CEO

The direction of the world is clear: Green and sustainable energy solutions are in demand by both industry and households. Wind power is in the midst of a fantastic journey and as the newly appointed CEO of the Swedish Wind Energy Association, I am really looking forward to contributing to the continued development of this industry of the future.

There is no doubt that the demand for electricity will increase due to a rapid electrification of both transport and industry. The overall assessment is that electricity use in 2040 will be around 140 percent of today's level. This is a large increase, but I believe that this transformation will be both faster and more revolutionary than we can imagine today.

For Sweden, it is important that we take advantage of our great conditions for renewable electricity production. If we do, we can lay the foundation for a competitive Sweden with continued large exports of products and services with the lowest possible carbon footprint. Solutions that are in demand in global markets. At the same time, competitive electricity prices and a minimal carbon footprint creates an attractive environment for investments and new establishments. This shows that deployment of renewable electricity is not just an energy policy issue – it is also a cornerstone of industry and innovation policy.

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"As the newly appointed CEO of the Swedish Wind Energy Association, I look forward to further broadening the collaborations needed to fully harness the enormous potential of a transition renewable, low-carbon society"
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Land-based wind power in Sweden will from now on be built without financial support. The production cost has more than halved in the last ten years and at less than 3,5 Eurocent/kWh, wind energy is by far the cheapest type of power.

As wind power grows, it is important that our industry actively contributes to the development of the whole energy system. We get the best outcome when wind power and other renewable electricity production interact with the development of storage, flexible use and a strong electricity grid. When we transform the energy system, we create

exciting new business models and fundamentally change the dynamics of the electricity market. I hope that the government's electrification strategy will focus on this.

To continue the expansion of wind power, access to locations with good wind conditions is not enough. It is also necessary to modernize the grid infrastructure. This is an issue that has been neglected. On the positive side, there is a broad consensus among politicians on the challenges we face. Now it is time to move from words to action.

Another challenge is the permitting processes. They must become more predictable and the climate benefits of operations need to be considered to a greater extent. A recent survey shows that just over half of all wind turbines are rejected or revoked and that permit applications have decreased by as much as 70 percent in recent years ([Nätverket Vindkraftens Klimatnytta 2020](#)). This is not good enough.

The EU is now sharpening its climate targets substantially and wind power both on land and at sea is an important part of the solution. The EU Commission's new strategy for offshore wind power makes the high ambitions and expectations from Brussels very clear. The strategy announces a 25-fold increase in offshore wind power by 2050 in Europe. There is no doubt that wind power is very high on the political agenda both in Sweden and internationally.

It is certainly a very exciting time to take the step into the wind power industry. As the newly appointed CEO of the Swedish Wind Energy Association, with a background from energy intensive industry and ministries, I look forward to

further broadening the collaborations needed to fully harness the enormous potential of a transition to a renewable, low-carbon society.



Stockholm January 2021,
Daniel Badman, CEO,
Swedish Wind Energy Association



2. Summary

The climate crisis is an urgent threat. The doubling of wind power output that is taking place 2019–2022 can reduce emissions equivalent to almost one quarter of Sweden's total emissions. The expansion is also economically profitable, and Sweden can benefit greatly from the ongoing electrification. However, despite these obvious benefits, the expansion of renewables still faces many obstacles.

Sweden's ambitious climate and energy policy goals from 2016 led to an investment boom for wind power. According to agreements already signed, more than SEK 100 billion will be invested between the years 2017–2023.

Wind power creates immediate climate benefits and brings down electricity prices, which improves the competitiveness of Swedish industry and benefits all electricity consumers. The expansion is driven by the market and contributes to growth and jobs, primarily in the countryside.

Studies show that every €1 invested in renewable energy returns €4 in socioeconomic benefits (BCG 2018). Assessments of future electricity demand points to around 200 TWh in 2040. We believe wind power can deliver at least 120 TWh, but we also note that the potential for both demand and production is far higher. Electrification implies

a much more efficient use of energy and the possibilities of future technologies, such as electric fuels, can be assumed to be grossly underestimated.

Electric fuels like hydrogen and e-methanol, can enable a flexible power system adapted to the increasingly variable power production.

Sweden is in a uniquely good position to meet these demands due to the properties of hydro and wind power, which allow the power generation to interact and shift. Water can be stored when the wind is strong and be released to increase electricity output when the wind calms.

At the same time, technological advancements enable wind power to increase the delivery of both energy and capacity, even at lower wind speeds. When the expansion



of offshore wind power is given the political prerequisites needed to be implemented, it will contribute with significant system benefits given its large scale and more level output.

In theory, wind and hydro in combination with maximized electricity import, cogeneration, and gas turbines could cover the highest plausible power demand. But there are however limitations in the grid, and sufficient margins are needed. This can be created through storage solutions or services that increase flexibility of consumption. It is also essential to increase the transmission capacity of the power grid, both in Sweden and to our neighbouring countries to better face variability in production and consumption.

There is wide political and popular support for the transition to renewables, and it is regarded as both necessary and desirable. Wind power, in combination with hydro power, can provide a solid basis for a fully renewable electricity system.

There are four areas that the government needs to prioritize:

- **Take action for electrification.** Set an expansive planning goal for power supply, with a view to green growth and to phase out of fossil fuels completely. Provide a planning framework for authorities and enterprises and work strategically with electricity exports, electricity taxes and the electricity market.
- **Strengthen and expand the electricity grid.** The electricity system must be modernized and adapted to a higher share of renewables, among other things through continued development of markets for ancillary services. Abolish the connection costs for offshore wind power and see proactive grid investments as an enabler for transition.
- **Facilitate the permitting processes.** Simplify in accordance with the requirements of the EU's revised Renewability Directive. Give municipalities a direct economic advantage of wind power by awarding them the property tax and adjust the municipal veto for increased legal certainty.
- **Integrate climate thinking into all decision-making.** Update instructions to authorities to make balancing interests easier, include climate benefits in the Environmental Code's portal section and plan for taking advantage of the climate benefits of wind power.

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"Technological advancements enable wind power to increase the delivery of both energy and capacity, even at lower wind speeds."

The Swedish Wind Energy Association projects that wind power generation will increase from today's roughly 30 TWh to *at least* 120 TWh in 2040. The potential is however far greater.

The output from wind power is increasing, but the number of turbines is not increasing significantly – they may even become fewer. This is due to the rapid technology development, which increases the generation of each turbine.

Out of the total wind power output 2040, offshore wind power is expected to make up around 45 TWh annually. Given the right circumstances, unlocking the full potential of offshore wind power, the production could increase several times over.

Expected development of wind power in Sweden until 2040

2020

Generation 30 TWh
4 500 wind turbines
Installed capacity:
10 600 MW

2030

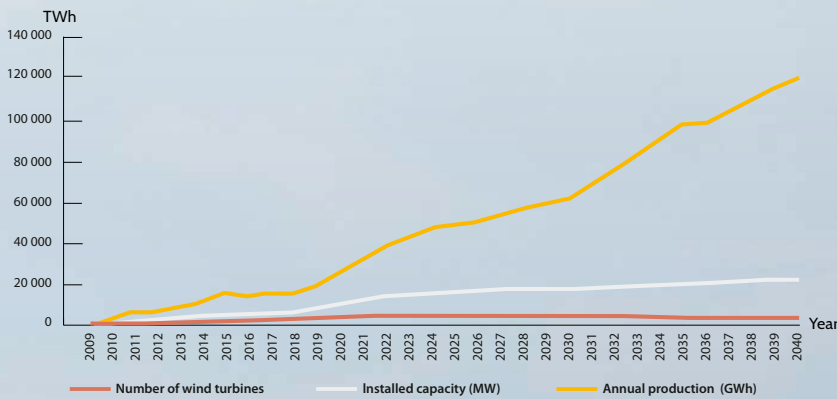
Generation 60 TWh
5 300 wind turbines
Installed capacity:
18 500 MW

2040

Generation 120 TWh
4 000–5 000
wind turbines
Installed capacity:
33 300 MW

Annual wind power generation in Sweden (TWh)

Source: Swedish Wind Energy Association



The potential of wind power

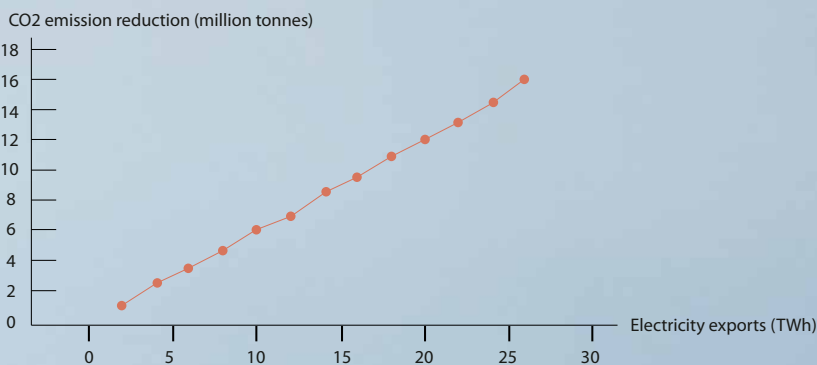
The Swedish Energy Agency is planning for 100 TWh wind power in 2040.

The actual potential from onshore and off-shore wind power is, however, much larger. Technology development has in 10 years led to a 50 percent decrease in cost for onshore wind power and it can now be built without support.

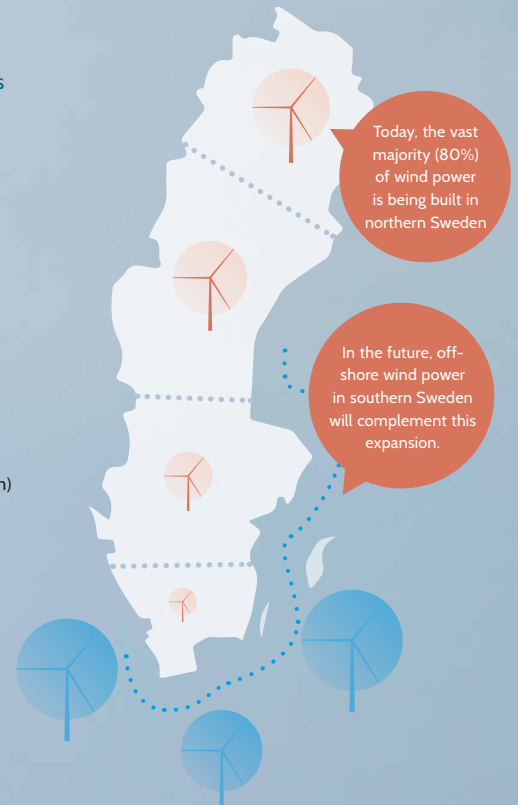
Production costs for offshore wind power are also falling quickly. Our neighbouring countries invest heavily in the development while Sweden is lagging behind. But if the need for electricity from wind power within the EU is broken down per member country, it will be as much as 80 TWh of offshore wind in Sweden by 2050. This corresponds to more than half of all the electricity we use today, annually. (*WindEurope 2020*).

Combating climate change with electricity exports

The great wind conditions in Sweden set the scene for a new green export industry. The 25 TWh exported last year give security of supply at home, while at the same time reducing emissions by more than a quarter. An absolutely fantastic figure. (*Nätverket för vindkraftens klimatnytta 2019*).

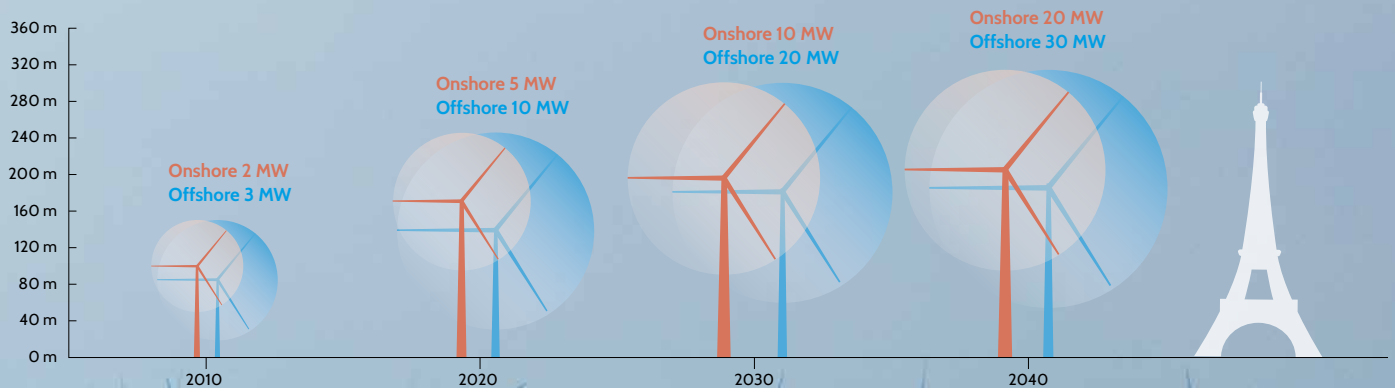


Geographical distribution



Technology development 2010–2040 (height and installed capacity)

At sea, winds are steady and strong. Offshore turbine blades are generally longer in relation to the tower and the swept area is larger, hence more energy per turbine can be extracted.



3. Sweden's large-scale green industry

Globally, within the EU and in Sweden, several initiatives are being taken to address the climate crisis and transition to a renewable world. Sweden's conditions for wind power are among the best in Europe and can quickly reduce emissions, while increasing our industry's competitiveness and building a new large-scale industry.

3.1 Long-term framework promote investments

The UN Sustainable Development Goals, the Paris Agreement, the revised EU Renewable Energy Directive, Sweden's National Energy and Climate Plan, the Swedish Climate Act, and the Swedish Energy Policy Agreement. The list of frameworks within areas of climate and energy is long. In the coming decade we will decide how to overcome the climate crisis, and a clear path forward is needed for the transition.

Increasing the share of renewables is a central part of addressing climate change. Fossil fuels still make up almost 80 percent of global energy input. There is a clear connection between ambitious and long-term climate and energy politics, with clear targets for shares of renewables, and rapid emission reductions. Through the joint targets of the EU, Europe has taken the helm and we now see declining emissions from electricity generation. Since a few years back, as much as 95 per- cent of all investments in new capacity within the EU are going to renewables ([BNEF, NEO 2019](#)).

In our neighbouring countries to which our electricity system is directly connected, coal, oil, and gas still represent almost half of the electricity generation ([Sandbag 2019](#)). Swedish electricity generation has historically been reliant on nuclear and hydro power and produces very little emissions. However, Swedish nuclear power is being phased out, for financial reasons, and even if nuclear power owners state that the technical lifespan of a nuclear power plant is 60 years, it is uncertain how many reactors will be operational by 2040. The energy source that has the best conditions to replace nuclear power is wind power, on- and offshore.

Sweden's conditions for wind power are among the best in Europe. Politics and frameworks need to ensure that the advantages of good wind conditions and low production



Photo: Ørsted

Sweden's National Energy and Climate Plan

EU member states have developed National Energy and Climate Plans to live up to the Union's common 2030 target. However, in the plan Sweden sets a very low target for renewables, in comparison with the national targets ([SWEA 2019](#)). Since the plans were drawn up, the EU has also increased its target from 32% renewable energy to 55% by 2030, which implies that the Swedish government has every reason to upgrade its ambition. The Commission also recommends Sweden to strengthen measures for electrification of the transport sector and the abolition of fossil subsidies.

costs are harnessed. Wind power, Sweden's new large-scale green industry, is ready to grow and contribute to the target of an all renewable electricity system.

Deliver on political promises

The market-based electricity certificate system that supported the early deployment of renewable energy in Sweden during its early phases has meant an economic jackpot for the electricity consumer. The large amount of additional electricity production has lowered the price of electricity considerably more than consumers have paid in electricity certificate fees. Meanwhile, technological development has advanced, resulting in a source of power that is far cheaper, and more sustainable, than previous alternatives.

However, electricity producers have paid a high price. The energy agreement's promise to close the certificate system in balance has not been fulfilled and the expected value of the certificates has not materialized. This is not only a betrayal of early investors, but it also threatens future investments. More than SEK 100 billion

of mainly foreign capital has already been invested in wind power during 2017–2023. Money that, in addition to enabling Sweden to meet its climate goals, creates Swedish jobs and growth in areas where the need is great. But without a level playing field and stable market conditions, such future investments are at risk.

Now it's time to deliver promptly on remaining promises. The cost of grid connection to offshore parks must be eliminated as soon as possible, so that offshore wind power is given the same conditions as all other types of power have received over the years, both renewable and non-renewable. Offshore wind power would also meet the urgent power demand in southern Sweden and contribute to increased security of supply and stability in the electricity system.

3.2 Electrification – electricity in new areas of use

There is a broad consensus among Swedish political parties about the importance of electrification of society. The process will greatly increase energy efficiency which is good both for the climate and for the national economy.

Sweden still uses just over 120 TWh of fossil energy, as well as a large amount of other fuels and fossil raw materials in the manufacturing industry, which need to be replaced with renewable alternatives. In November 2020 LKAB announced its transition to fossil-free production, predicting a need of 55 TWh electricity annually to make the shift, investing SEK 400 billion over a 20-year period.

Just imagine when the big shift comes and ...

- ... the shipping industry uses e-methanol produced by wind power in Sweden?
- ... aviation, heavy vehicles and industry have switched to green hydrogen?
- ... the chemical industry wants renewable raw materials, instead of fossil products?
- ... data centers in Sweden perform calculations for Europe's self-driving cars and other advanced applications?

Add to that a steady increase in population and maintaining a strong position as an electricity exporter. All in all, the need for electricity is expected to increase very sharply in the coming years. Today's highest assessments ([eg the Confederation of Swedish Enterprise 2020](#)) point to over 200 TWh and we believe that even that figure is greatly underestimated.

Wind power has shown that with today's established supply chains it can be deployed on land with 2 GW per year; corresponding to just over 8 TWh annually or 160 TWh in 20 years. In addition, there is great potential for offshore wind power. Deployment is not limited by wind power's own potential, but rather on technological development in other areas of the power sector and society's demand for electricity, as well as on the possibility to effectively replace older turbines with new ones (so-called repowering). In the short term, SWEA:s forecast shows that wind power production will increase from the current 20 TWh to around 40 TWh already in 2022, corresponding to almost 30 percent of electricity use in Sweden ([SWEA 2020](#)).

To create this new sustainable economy, work must begin now. The forthcoming electrification strategy to be developed by the government should therefore:

- 1. Dare to be visionary:** Set an expansive goal for electricity supply, with a view to phase out of fossil fuels completely, and commission authorities to increase the capacity of the electricity system by 300 TWh in 30 years.
- 2. Act quickly and forcefully:** Take rapid measures to eliminate the electricity grid's lack of capacity and obstacles to new electricity production, such as defense policy interests and long permit processes.
- 3. Be clear that jobs and competitiveness is on the line:** Analyze and take advantage of the overall business policy opportunities that an expansive goal for electrification creates. It is about creating wealth.



Photo: ENERCON

3.3 Environmental industry benefits

The wind power sector is attractive to long-term investors. The interest is expected to increase as the demand for renewable energy rises – if Sweden continues to offer low risks for investors.

Wind power and renewable energy are a rapidly expanding part of Swedish industry. Where wind power is built, primarily in rural areas, job opportunities and investments in the local community and infrastructure follow.

Sweden already has ample supply of cheap and clean electricity, and this has encouraged many energy-intensive companies to establish themselves here. Other companies are also likely to locate in Sweden attracted by the renewable energy mix and low electricity prices. Environmentally conscious companies that work towards climate

neutrality and promote sustainability are on the rise. It is essential that Sweden demonstrates a clear commitment to development of the electricity system and wind power for this trend to continue.

Swedish wind power developers are at the forefront in attracting investors – often foreign investment funds and insurance companies – through initiatives such as long-term power purchase agreements (PPA). Today, most new investments are realized through PPAs or other price hedging. Potential future buyers are government agencies and municipalities as well as heavy industry. To continue attracting capital, the market needs to be predictable and offer low risks for investors, with stable long-term policy conditions and high ambitions for power production in Sweden.

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”Sweden is positively distinguishing itself in many ways, with one of the strongest wind resources in Europe.”

Fredrik Norell, Vice President BlackRock Alternative Investors – Renewable Power

Combating the climate crisis

When Sweden exports electricity it primarily offsets electricity generation from coal-fired power plants, since those have the highest operational costs. The carbon emissions from coal-fired power plants are around 780–1000 grams per kWh, depending on type of plant. Limits to transmission capacity and other dynamic effects implies that all Swedish electricity exports cannot be assumed to reduce the use of coal, but a reasonable estimation is that emissions are reduced by around 600 grams per kWh, or 600 000 tonnes per TWh ([Vindkraftens klimatnytta 2019](#)).

EU Emission Trading Scheme

The climate benefits of electricity exports have become even clearer since the reform of the EU Emission Trading Scheme (EU-ETS). The surplus of allowances are now successively transferred to a reserve and cancelled. Replacing electricity from coal-fired power plants thereby creates direct and substantial climate benefits, while increasing the competitiveness of renewable energy. The reform has already led to heavily increased prices of allowances, and this is expected to continue since the EU commission have stated that additional far-reaching reforms are necessary to meet the Union's stricter climate targets.

3.4 Increased export of renewables

Sweden has a large and growing surplus of electricity. Even though nuclear power generation is reduced by 13 TWh, the Swedish Energy Agency is expecting electricity exports to reach a record-high 29 TWh by 2022. The benefits of a more integrated European electricity market with Sweden as a net exporter are obvious.

The EU imports over 50 percent of all energy used in the union. At the same time, the target of the EU Energy Union is to create a safe, competitive, and sustainable energy transition – at a reasonable price. According to a report to the European Commission, European businesses and consumers could save up to €40 billion with a more integrated electricity market and an additional €30 billion if renewables are deployed where it is the most cost efficient to do so ([Booz & Company](#)).

For Sweden, whose conditions for renewable electricity generation are uniquely good, a more integrated electricity market would mean increased profits through electricity exports. At the same time, Swedish consumers and Swedish industries would enjoy long-term lower electricity prices than the countries we export to. This strengthens competitiveness and attracts new business.

3.4.1 Interconnectors are cost-effective

A continued increase in electricity exports requires improved transmission capacity within Sweden as well as with other countries, but the expansion is slow and investments inadequate. A typical interconnector of 0.7 GW costs about 3.6 billion. As a reference, it can be noted that Sweden's imports of coal annually amount to 6 billion and that annual electricity exports are worth 12 billion. In addition to the benefits of electricity export, an increased level of physical market integration also increases the security of supply. Electricity exports furthermore supports the development of storage solutions, user flexibility, sector integration and other solutions which underpin the renewable society of the future.

The Swedish Wind Energy Association proposes that the government:

- Ensures that bottlenecks throughout the country are reduced, and that additional interconnectors are built to other countries.
- Implements a strategy for electricity exports and for Sweden to contribute towards the EU sustainability targets in a cost-efficient way.
- Urges to further develop cooperation in the EU Energy Union in line with the implementation of all parts of the Clean Energy package, by supporting that renewables are deployed in areas with the best conditions.

Photo: Susanne Tellström



4. What is needed to enable green investments?



4.1 Update the Swedish Environmental Code and the agencies' instructions

If Sweden's climate and energy targets are to be met in the most cost-efficient way possible, efficient regulation and cooperation between our government agencies is needed. The government should update the agencies' instructions and supplement the Environmental Code so that climate benefits is weighed in in the environmental assessment.

Despite a broad agreement on the urgency to reduce emissions, the climate benefits of renewable energy sources are given low priority when compared to other interests. A simple first measure is to update the instructions to government agencies to include climate aspects in all decision making. Conflicts of interests could thereby be easier to handle, for instance with regards to the Armed Forces' restricted areas, species protection and reindeer herding. Furthermore, the Environmental Code needs to be adjusted so that climate benefits can be weighed in permit processes and courts.

To reach the common goal, increased cooperation is needed. County Administrative Boards, the Environmental Protection Agency, the Energy Markets Inspectorate, the Swedish Agency for Marine and Water Management, and the Swedish Armed Forces, among others, are all involved in scrutinizing wind power. Good initiatives have already been launched and we look forward to more, in close dialogue with the industry. All with the purpose of meeting Sweden's ambitious targets in the most cost-effective way possible.

The Swedish Wind Energy Association proposes that the government:

- Amends the instructions of all relevant agencies to ensure that focus on achieving the climate and energy targets approved by the Swedish Parliament.
- Adjusts the Environmental Code so that climate benefits are weighed when prioritizing among interests.
- Clarifies the division of responsibilities among the authorities and agencies involved in energy and climate change issues, and takes measures for increased collaboration.
- Acts to increase cooperation between agencies.
- Instructs the authorities to report annually on measures taken that contribute to achieving Sweden's climate and energy policy goals.



4.2 Simplify permitting processes for grid and environment

Today, several obstacles in the permitting process threaten to delay the deployment of renewable energy.

Every new wind power project is subject to two separate permitting processes: one for building the wind farm (environmental permit), and one for connecting it to the grid (concession). The relevant authorities examining the application are the environmental delegations of County Administrative Boards, the Swedish Energy Markets Inspectorate, and the Swedish Mapping, Cadastral and Land Registration Authority. In addition, several review bodies also scrutinise the project.

4.2.1. Drawn-out and complicated permitting processes

Few projects are as carefully reviewed as wind power. What makes it unique, however, is that the municipality explicitly need to approve all wind power projects. A new compilation confirms the findings of legal firm Fröberg & Lundholm, that more than half of all wind power plants are rejected or revoked ([The Network for climate benefits of wind power 2020](#)).

In total, the time taken from initial consultation to environmental permit can exceed 10 years. Meanwhile, technological progress is fast, and the terms of the permit seldom leave scope to use the best possible technology, as the Environmental Code instructs that it should.

Access to good wind conditions is crucial for building efficient wind farms. When wind power is relegated to non-ideal conditions more turbines are required, which leads both to greater impact on the landscape and increased costs to achieve the same output. Since winds strengthen with height, it is important that wind turbines can be as high as the technology allows.

If the average wind speed is reduced by an average of 0.5 metres per second, the output of a wind farm decreases by 20 percent. This implies that an increase of the total wind power generation from 30 TWh today, to at least 120 TWh by 2040, would require 25 percent more wind turbines. Consequently, the effect on the local environment and the cost of production will increase by the same amount.

Common challenges for the environmental permit and the concession

By 2021 at the latest, the revised Renewable Energy Directed is to be implemented in Sweden. The directive can solve several of the common challenges facing the environmental permit and the concession.

Obstacles	Environmental permit	Grid concession	Possible actions
Increased resources to agencies	✓		A centralised and more effective process, extended time limits for the realisation of permits
Long appeals period:	✓	✓	Property tax should go to the municipality in order to increase local acceptance
Lack of flexibility in regard to technological advancements:	✓	✓	Enable box permits, simplify the permit process for repowering
Difficult to adjust a given permit:	✓	✓	Change the Swedish Environmental Code
Individually dependent administration of permits:	✓		Centralise the process, make a manual for administrators with unified routines.
Non-complete permit applications:	✓	✓	(See above). Make a manual for project developers.
More investigations because of stricter environmental regulations:	✓	✓	Change the Swedish Environmental Code, and take the climate benefits of wind power into account when considering local effects.

4.2.2. Grid connections – a limiting factor

At present, there are major challenges in connecting wind power to the grid. It is difficult for a developer to, within a reasonable timeframe, get information on availability of connections and the cost of connecting the wind farm.

There is uncertainty about which power lines require concession, and concessions tend to become more expensive and more drawn out. Requirements for technical details are high and often difficult to predict before the environmental permit has been passed. The speed of technological progress means that the technology approved in a permit rapidly becomes obsolete and it is difficult to have the conditions changed. The Concession Investigation presents some suggestions on how these challenges can be met, which should be implemented quickly (SOU 2019:30).

As wind farms become larger, connections are increasingly being made directly or indirectly to the national power grid. The connection process to the national grid is regarded as one of the major obstacles to connection. It can take over two years to be notified whether it is possible to establish a connection, either directly or indirectly, to the national grid. This process is inflexible and doesn't follow neither the

environmental permit process nor the process of investing in new wind power.

All things considered, connecting to the grid is one of the most problematic parts of a new wind power project. An additional complicating circumstance is that the grid in general has started to suffer from capacity limitations, which means that capacity raising measures have become the rule rather than the exception when connecting wind power to the grid, especially in northern Sweden.

The Swedish Wind Energy Association proposes that the government acts to simplify grid connections through:

- Freedom of concession in the entire area covered by the wind farm project plan and the possibility to make it easier to change existing concessions in accordance with the recommendations of the Concession Investigation.
- Letting the Swedish Energy Agency investigate how the amount of appeals and time for appeals can be reduced for concessions.
- Instructing TSO Svenska kraftnät to change their connection policy, so that the connection process is more rapid and better aligned with the permit process and the investment process for wind power developments.



4.2.3. How can the permit process become more efficient?

To reach our national climate and energy policy goals, many new permits for wind farms are needed. The drawn-out processing times for environmental permits and concessions need to be shortened to avoid cost increases.

Many of today's problems and challenges are relevant for both kinds of permitting processes, environmental and grid. Examples are a lack of flexibility, drawn-out processes, and poor coordination between public authorities and agencies. Also, permissions in general are appealed with increased lead times as consequence.

The revised Renewable Energy Directive requires that permitting processes for renewable energy are simplified and shortened. The directive will be implemented in Swedish law by June 2021 at the latest. Among other things, it contains a requirement for a single contact point, which will enable the permitting processes for a wind farm and concession to run parallel. Today, two main factors make parallel permitting processes difficult: not knowing the levels of connected power for the concession until the environmental permit has been granted, and the large economic risks to apply for concession before acquiring the environmental permit.

To enable wind power being expanded in the most environmental and efficient way possible, increased flexibility

is needed, e.g. regarding turbine heights, rotor blade width, and the placing of wind turbines within the area. This is needed to fully take advantage of new technology and harness the potential of increased generation. Technological advancements result in more efficient wind turbines and more electricity for the same cost, but drawn-out permitting processes in combination with lacking flexibility, makes it impossible to use the best available technology.

The Swedish Wind Energy Association proposes that the government:

- Instructs the Swedish Energy Agency and the Environmental Protection Agency to investigate how permitting processes can be made more flexible in respect to technological advancement.
- Increases funding for review agencies and courts in order to shorten lead times in the permitting process.
- Investigates how the permitting process could develop within the framework of the revised EU Renewable Energy Directive (RED II), by, for example, creating better conditions for allowing the environmental and grid permitting processes to run in parallel.

4.2.4 Repowering with simplified permitting processes

By 2040, most of all wind power developed before 2015 will have reached its technical life spans. Through so called repowering, where old turbines are replaced by new,

modern and more efficient turbines, there is potential to massively increase today's generation.

The oldest wind turbines in Sweden are in the south, in the counties of Skåne, Halland, Västergötland, and Gotland. Considering the power system, the best solution would be to increase production in these areas, and there is great potential for this.

An example is the modernizing of the wind farm Näsudden on Gotland. There, 58 old wind turbines were replaced with 27 new ones, the production increased four-fold, while the local intrusion was reduced.

To fully realise the potential of repowering, there is a need for a simplified permitting process that enables continued or increased generation in areas where wind power installations are already located.

The Swedish Wind Energy Association proposes that the government:

- Instructs the Energy Markets Inspectorate and the Environmental Protection Agency to create a special permitting process for repowering by 2021, in accordance with the revised Renewable Energy Directive.

Environmental impacts of wind power

Compared to other power sources, wind power has a low climate impact from a life cycle perspective, and progress forward is rapid. Studies from Vattenfall show that compared to older turbines, modern wind turbines have only half the climate impact from mining for raw materials to disassembly. This is partly because better production processes and lighter steel which reduces transport emissions. Turbines are also much bigger and more efficient, generating more electricity during the lifespan of the turbine.

Modern life cycle analyses show that carbon emissions from modern wind power are around 6 grams per kWh (Vattenfall 2019). For comparison, coal emits around 780–1000 grams per kWh (depending on the plant) and natural gas emits just over 500 grams per kWh (Vattenfall 2012).

Photo: Ørsted





Photo: Svevind AB 2018

4.3 Adjust the provisions on the municipal veto

Since 2009, the municipalities have had a sole right of decision over new wind projects being adjudicated under the Swedish Environmental Code, i.e. the municipal veto.

The municipal veto was intended to simplify and shorten the permitting process and was implemented to promote the expansion of wind power in Sweden. The intended simplification did not happen. It has, in practice, complicated the permit process and prolonged the timespan, completely against its first intentions.

Municipalities should of course have a say in where wind power is being developed. But even without a veto, the municipalities can control the location of wind power through the spatial planning and as a central reviewing body during the permit application process.

The municipal veto completely goes against the demands for simplified and shortened permits processes, as per the revised Renewable Energy Directive. The use of the veto is not compatible with the principles of impartiality and objectivity which are central to decision making in the public sector.

The Swedish Energy Agency and the Environmental Protection Agency state that establishing wind power would be easier and more coherent with the law if the municipal veto is removed ([Swedish Energy Agency 2017](#)) and the government has appointed an inquiry to investigate how this could be done.

The Swedish Wind Energy Association proposes that the government

- Adjusts the municipal approval in 16 ch. 4 § of the Environmental Code so that the municipality's decision
 - applies to the location (appropriate use of the land and water area, not number of plants, height or MW),
 - is given early and is not allowed to change during the process.

4.3.1. Property taxes to the municipality

Wind power is one of the most popular energy sources in Sweden, according to the SOM-institute's yearly study of the public opinion on energy ([SOM-institutet 2020](#)). 65 percent answer that Sweden should develop wind power even more, while an additional 20 percent answer that we should keep going at the same pace as today. By letting the property tax for wind power go directly to the municipalities, there will also be an economic benefit to those who live where wind power is built.

For a continued expansion of wind power, those most closely affected must also reap the benefits of wind power. This is achieved through information on how wind power benefits the local community through job opportunities, growth, and investments. In addition, we should revise the compensatory system to municipalities whose citizens are directly affected by developments.

A concrete suggestion is to let the property tax of the wind farm go to the municipalities instead of the state. This would ensure a meaningful addition to the municipalities' economy. The property tax amounts to around €1000 per MW per year, which means that a project involving 20 modern wind turbines would result in €100,000 per year. This guarantees the local community part of the value of wind power, without compromising the financial conditions for wind power.

If the property tax goes to the municipality, the central government can still receive increased revenue from wind power. Both electricity production and consumption in Sweden is assumed to increase drastically in the coming years, meaning that the state revenue from energy taxes and VAT will far outweigh the lost revenue from property taxes.

The Swedish Wind Energy Association proposes that

- The parliament allocates the property tax from wind power to the municipalities.
- The government initiates an information campaign to make the expansion of wind power easier.

4.4 Promote co-existence with other interests

4.4.1 The Armed Forces' restricted areas

The direction towards renewables is clear, and not only within energy policy. The Government's total defense bill 2021–2025 emphasizes that the transition towards renewables is beneficial from a total defense perspective. Increased decentralized generation means more resilience compared to the centralized production of today.

Despite the insight on the pros of a decentralized electricity generation, and the climate targets we have committed to, restrictions set up by The Armed Forces' has long been one of the main obstacles to deployment of renewable energy. Previously, half of the south of Sweden was affected. At the end of 2017, they decided to expand the restrictions even further and in the suggestion to the Swedish Marine Spatial Planning, the restrictions are so extensive that off-shore wind power is threatened to be completely excluded. In other countries wind power and defense interests manage to coexist without in any way risking national security and we are convinced that solutions can be found in Sweden as well.

The Swedish Wind Energy Association proposes that the government:

- Changes the instructions to the Armed Forces and yearly tasks them with contributing to creating the necessary conditions for developing wind power in line with 100 percent renewable electricity generation by 2040.
- Introduce a rule of "conditional yes", meaning that the Armed Forces - in cases where they assess that a wind farm affects the defense capability - must give suggestions on how this can be overcome, for example by letting the wind power developer pay for technical solutions to mitigate the impact.

4.4.2 Strong species protection – on a population level

It has become more difficult to obtain permits for wind farms under the Environmental Code in areas with significant bird life. This is even though the Swedish Environmental Protection Agency has stated that wind power poses no

Fair property tax

In a deregulated market it is important to strive for similar regulations for different power sources. In a Supreme Administrative Court case, it was judged that the tax rate of 0.2 percent of the assess value is a non-allowed state support for wind farms.

The court wants to see an increase to 0.5 percent, the same as other power sources (case 3873–18). However, because the assess value model is different for different power sources, the property tax for a given tax rate expressed in €/MWh means that that wind power would pay three times more than other power sources at a rate of 0.5 percent. This would unfairly reduce the competitiveness of wind power and distort competition in the market. Therefore, it should be ensured that the property taxes of wind power remain at 0.2 percent of the assess value.

threat to the population of any bird species at a national level (EPA 2017).

Research shows that the number of birds dying from wind turbines is many times lower than the number of birds killed in other ways (Compare about 34,000 deaths caused by wind power with about 17 million deaths caused by traffic, windows and cats). Global warming poses a huge threat to biodiversity while wind power is one of the most effective ways to prevent it. Nevertheless, wind farms can be rejected to protect individuals of bird species that are otherwise hunted.

The application of the Swedish Species Protection Act needs to be revised so that it is the protection of species – not individuals – that is weighed against other environmental benefits.

The application of the Swedish Species Protection Act needs to be revised so that it is the protection of species – not individuals – that is weighed against other environmental benefits.

The Swedish Wind Energy Association proposes that the government:

- Clarifies the application of the Swedish Species Protection Act to comply with the EU Birds Directive, so that § 4 of the Swedish Species Protection Act correctly adheres to the equivalent decision in the EU Directive (2009/147/EG) on the conservation of wild birds, and so that § 4 of the Swedish Species Protection Act can help ensure that the scrutiny process is reliable and predictable.

4.4.3 Wind power in reindeer pastures

The past few years courts have increasingly been favouring reindeer herding when balancing the national interest of wind power against the national interest of reindeer herding. It has become common that areas that are important for reindeer herding are exempted from wind power, even if the reindeer herding has not been deemed a national interest in the spatial planning.

National interest in reindeer herding relates to the important issue of indigenous peoples' rights, at the same time as climate change is an acute threat to Sami culture as well. The continued expansion of wind power is crucial to succeed in combating global warming, and the two interests must find ways to coexist. There are several cases where early dialogue between the projector and the affected Sami village resulted in a design of the wind farm that both parties accepted. With strong measures to remove the obstacles that exist for deployment of wind power in southern Sweden, such as connection costs for offshore parks and the military's low-flying areas, the expansion could also be more evenly distributed across the country.

The Swedish Wind Energy Association proposes that the government:

- Takes strong action to remove the obstacles that exist for the deployment of wind power in southern Sweden
- Instructs the Swedish Energy Agency to suggest how the agencies involved in the permitting process can revise the conditions which, in practice, excludes the urgent interest of increasing the production of renewable electricity.

4.5 Enable job opportunities across the whole country

As a rule, wind power is built in rural areas, and gives people the opportunity to live close to nature and make a living off the new green technology. Big expansions in the north and along the coasts creates long-term job opportunities and bring tax revenue to rural towns. Over 37.5 million work hours, corresponding to 18 000 fulltime jobs, will be created between 2017-2021 in building and operating wind power.

Glötesvålen wind farm is situated in the county of Jämtland, about 40 kilometers northwest of Sveg. The farm is owned by IKEA who thus achieved 100 percent renewable electricity use in the Nordic countries.

Glötesvålen has created 78 regional full-time jobs during construction and another 7 local full-time jobs for the operational period of 25 years. Additional jobs are also created for accommodation and service. For example, the construction of the wind farm resulted in nearly 12 000 guest nights in hotels. During 5 years of construction, salaries worth over €830 000 were paid and the local society saw reduced costs for unemployment by over € 2,5 million (given €32 000 per person per year).

The total addition to the local society from regional work during the building phase is estimated to just under € 3,4 million. Around 40 companies have provided services, products and working hours to the project. After an investment of over €92 million, 30 wind turbines are now in place that are calculated to produce 220 million kWh per year. That means electricity to 44 000 households per year.

"Around € 6 billion will be invested in Markbygden, which means a lot for the local businesses in our county. With the expansion of wind power, the access to renewable energy also increases. Over time, that is equally important as it attracts establishments of new industries"

Anders Lundkvist, Municipal Councillor in Piteå. (Svevind).

4.5.1 Wind power technicians

At least 170 new wind power technicians are needed every year to meet current demand.

In the coming four years wind power production will double, but there is already a shortage of wind power technicians.

To ensure quality, safety and economic sustainability for future operation, well-trained personnel is needed in order not to become reliable on short term employees from other industries and countries. Currently, specific wind power technician education is only offered in Varberg and Strömsund but the total of 55 students per year is far from enough.

The Swedish Wind Energy Association proposes that the government:

- Instructs the Swedish National Agency for Higher Vocational Education to quickly act to make space for larger numbers of wind power technician students.
- Instructs the Ministry of Employment and the Swedish Energy Agency to spread information of the demand.



Photo: Ørsted

4.6 Set off offshore wind power

Offshore wind power has several advantages: The winds are strong and stable, the capacity factor is high and the powerful turbines mean that a wind farm can produce as much electricity as a nuclear power plant.

The expansion and planning for offshore wind power is in full swing in the world around us. The EU is raising its climate goals sharply and the EU Commission has recently presented a strategy for offshore wind power that points out the need for a 25-fold increase in offshore wind power in Europe by 2050. However, despite our long coast and shallow waters, Sweden is far behind pioneering countries such as the United Kingdom, Germany, the Netherlands and Poland.

Sweden needs more renewable electricity production, located close to energy consumption centers, to cope with increased electrification while at the same time establishing new electricity-intensive industry. The offshore wind farms that are being planned by developers are mainly situated around the central and southern half of the country, where the need for electricity is the greatest.

But there is still a lack of strong political initiatives to expand offshore wind power. It has now been over four years since the energy agreement was confirmed by the parliament. The agreement states that connection costs for offshore wind power should be abolished, but the industry is still waiting for a final proposal.

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”Sweden has great potential for offshore wind, which could not only contribute significantly to Sweden’s targets of carbon neutrality by 2045 and Europe’s net-zero target by 2050, but also ensure sufficient long-term power supply to the southern part of Sweden.”

Rasmus Errboe, Senior Vice President and Head of Continental Europe, Offshore, Ørsted

Promotion of technology that is necessary to renew the electricity system and meet new needs is nothing new - it has been the case for all types of power - and support can be temporary. The electricity certificate system, which was the main driver behind the expansion of onshore wind power, has played out its role nine years ahead of schedule and onshore wind power is now being built without support. The long lead times for realizing offshore wind power mean that a decision from the government on abolished connection costs creates predictability for the market today, while new large-scale electricity production from offshore facilities will not be in place until the end of the 2020s.

Sweden needs similar conditions to other countries around the Baltic Sea in order to be able to compete. Other countries have auction systems and parts of the cost of development and grid connection are financed by the government. In contrast, in Sweden all risks and costs are placed on the developer. This is why it is so important that connection costs are eliminated, so that the pent-up interest can get an outlet and existing projects can be realized.

The lack of planning for the expansion of offshore wind power is also illustrated in national marine spatial plans, where it is clear that wind power has been de-prioritized in favor of other interests - in particular those of the Armed Forces. If there is a will, the areas designated for wind power in the plans can be expanded. As an example, new technology enable wind power in deeper waters.

Project developers are hiring new employees and investor interest in offshore is growing in Sweden. TSO Svenska

kraftnät has granted 9000 MW of offshore connection to the grid in southern Sweden (electricity areas SE3 and SE4), which is on a par with all wind power in operation today. Today, Sweden has 0.6 TWh of offshore wind power, and by 2040, offshore can contribute at least 45 TWh annually. The potential beyond this is enormous given the right conditions.

The Swedish Wind Energy Association proposes that the government:

- Ensures that the connection cost for offshore wind power is immediately abolished and that areas for offshore wind power in the marine spatial plans are increased.
- Decides on the expansion of the Ekhyddan-Nybro transmission line, which is crucial for offshore connections in southern Sweden.
- Clarifies in regulatory letters to relevant authorities that they should contribute to an energy transition that includes offshore wind power.
- Takes action to ensure "equal conditions around the Baltic Sea" in accordance with the Energy Commission's report.
- Ensures adequate resources for ministries and authorities for planning and management of offshore wind power.
- Sets clear targets for offshore wind power in Sweden - at least 45 TWh by 2040, in line with the European Commission's strategy for offshore wind power
- Assigns TSO Svenska kraftnät to continuously analyze planned offshore production, large electricity consumers around connection points and develop a strategy for connection.



37 Mkr

regional yearly
employments have been
created to build
Glötesvålen
wind park

78

€ 3,7 million in total
contributions to our society
from regional work
performed during the
construction phase.

40

companies have provided
services or products to
the project

Windpower in Sweden



During the service period of a wind farm (25 years) **one person per four wind turbines** is required for operation and maintenance.



By 2022, energy exports are predicted to reach a record high of 29 TWh, even while nuclear power generation is decreasing. This is due to the increased production of wind power.



Wind power contributes to a thriving countryside through increased employments as a result of wind farm establishments.



A modern on-shore wind turbine reduces yearly emissions by an equivalent to 5000 cars each driving 120 000 km per year (calculated at 2 tonnes of co2 per car).



Swedish electricity consumption was ca. 140 TWh in 2019. However, it is expected to increase greatly the coming decades due to the electrification process.



A modern offshore 8MW-turbine provides electricity to around 7000 households – three times more than a new onshore wind.



On-shore wind power can today be built completely without subsidies. **The costs of offshore wind power are continuing to go down dramatically**, and it is likely that offshore will also be able to expand without subsidies during the 2020s.

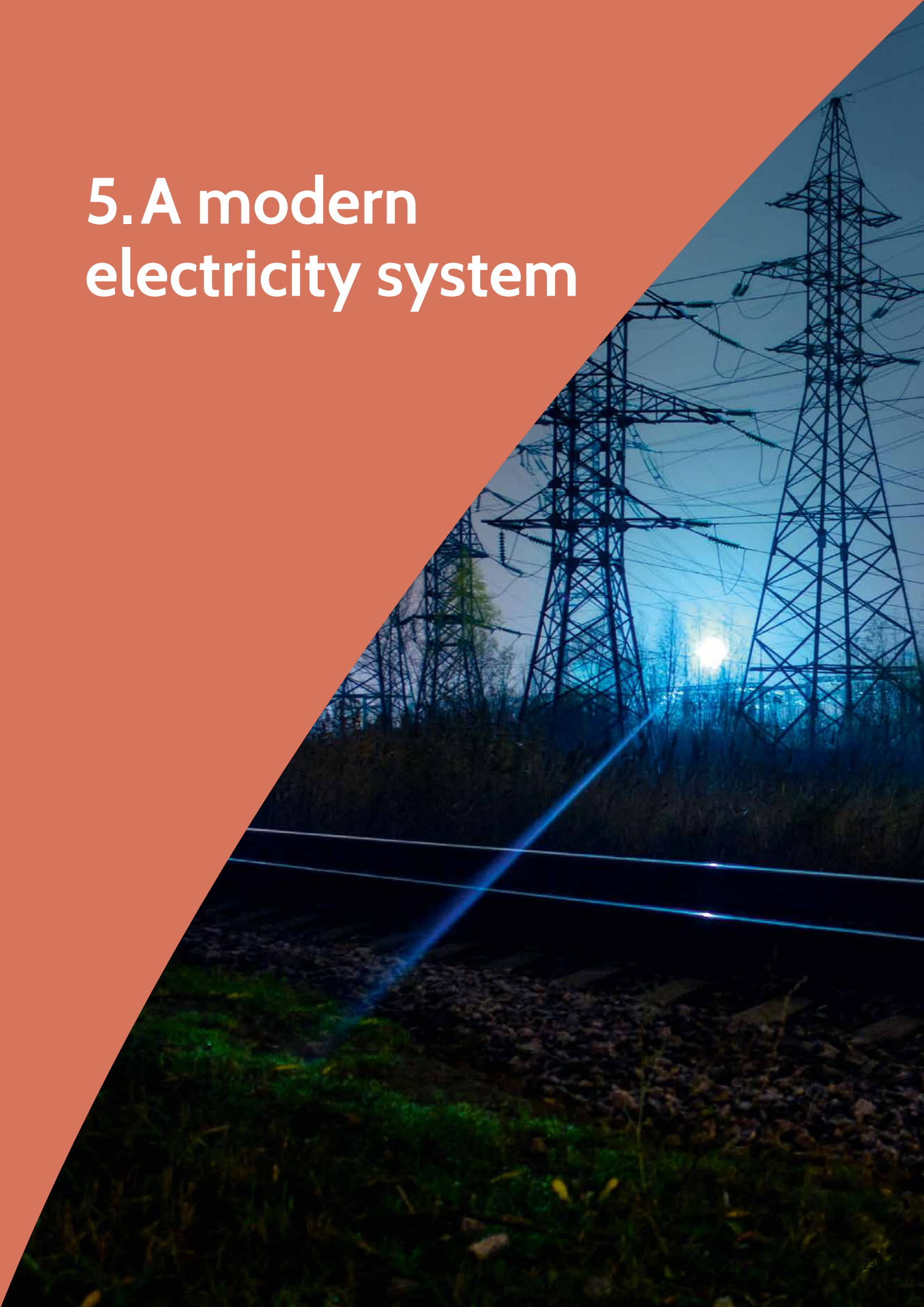
164 TWh/year

Swedish electricity production in 2019.

What are TWh, GWh, MWh, and kWh?

1 TWh =
1000 GWh =
1 000 000 MWh =
1 000 000 000 kWh

5. A modern electricity system



5.1 How wind power contributes to a stable electricity system

Swedish hydro power and trading with our neighbouring countries provides Sweden with an excellent foundation for a 100 percent renewable energy system. At the same time, the transition presents challenges in establishing a secure supply of electricity in all conceivable situations, since wind power is weather dependent by its nature.

Nuclear power generally produces electricity evenly, while wind and solar power generation varies depending on the weather. The transition to a renewable electricity system needs enough power to cover all conditions, and a built-in resilience against operational disturbances affecting both voltage and frequency.

Below, the main challenges to the system are described, along with the available solutions.

Power adequacy:

the ability of the electricity system to cover the demand for power and energy in any situation.

Frequency stability:

the ability to handle larger deviations in the prognosis for production and consumption.

Security of electricity supply

Voltage stability:

the ability of the power system to uphold stable voltage levels and return to a new equilibrium after a disturbance.

5.1.1 Power adequacy: Power surplus gives great opportunities

Power adequacy implies the ability of the electricity system to cover the demand for power and energy in any situation.

Historically, the price of electricity has been driven by demand, and the price has for instance been higher in winter than in summer. With a larger share of wind power in the electricity system, the price becomes more dependent on the wind conditions. On the night of February 10th 2020, Sweden had negative electricity prices for the first time and in November 2020 it happened again.

There is now a virtually untapped opportunity for companies and households to save money through automatic control of charging, heating or production of electric fuels at these times (DNV-GL 2020).

To supplement the renewable electricity production, so-called flexible resources are needed. Today, flexible resources of around 28 GW are available in the forms of hydro power production, import, CHP, and gas turbines, which combined are equivalent to the highest plausible power demand. Given a very sharp increase in future electricity demand, new technical capacity may be built in

a way that benefits from the variability of wind and solar power. It will also become increasingly important to eliminate bottlenecks in transmission lines, as the wind is almost certain to blow in either the northern or southern parts of the Nordic region.

5.1.2 Electrification and e-fuels as a way to meet the challenges

Increased transmission capacity within Sweden and to our neighbouring countries, as well as increased power outputs from hydro power, are easy technical solutions, even if the permitting processes are slow.

Moreover, the contribution of wind power increases as wind turbines with a higher capacity factor is being introduced to the system. Offshore wind power delivers a more even generation and can be deployed in Sweden if the economic conditions are improved. The capacity factor for wind power has improved from 24 percent in 2014, to 37 percent today. In the long run, the capacity factor is calculated to reach almost 50 percent, even for onshore wind power.

Electricity areas SE1 and SE2 have perhaps the best conditions in world for establishing electricity-intensive opera-

tions, and production of electrical fuels such as hydrogen or methanol is an untapped source for increased flexibility and electrification. At sufficiently high prices electric fuels can also be used to produce electricity.

Replacing fossil fuels with electric fuels would both help balancing the electricity grid and create conditions for a zero-carbon society. But if electricity use is to become more flexible, the price signal must be clearer. Today, the energy tax is fixed, regardless of the price of electricity. A tax that reflects the price would provide increased incentives for users.

5.1.3. Frequency stability: can be kept through synthetic inertia, batteries and inertia from other countries

For the energy system to work, it is not only important that enough planned resources are available to balance the system, but it also needs to be able to handle larger deviations in the projections for production and consumption. If production exceeds consumption, the frequency rises and vice versa. If the frequency falls outside of the allowed interval, it may result in a power outage.

Today, nuclear power contributes with inertia to the system which reduces the effect of a sudden drop in production since the generators keep rotating for a while thanks to the stored kinetic energy. Wind turbines often lack this ability, but with power inverters that connect the wind farms to the grid, the rotational energy in the wind turbine can be temporarily increased or decreased. This is usually called synthetic inertia.

So far, the incentive for wind power owners to contribute with synthetic inertia is lacking, since the ancillary services purchased by TSO Svenska kraftnät are not adapted to the conditions of wind power. In countries like Canada or Ireland, however, these services are used quite extensively. There are several other ancillary services that wind power can contribute with if the right conditions are given. Beyond synthetic inertia in wind turbines, there is potential to solve the challenges described above with batteries and by using system inertia in other countries through direct current links.

5.1.4 Voltage stability: wind power is already contributing today, but economic compensation should be given

Voltage stability concerns the ability of the power system to uphold stable voltage levels and return to a new equilibrium after a disturbance. For a system to have voltage stability, the need for reactive power needs to be met in

Power Circle has put together examples of solutions that help meet power demands when the share of renewables is very high. The numbers below come from TSO Svenska kraftnät, the Swedish Energy Agency, the Swedish Energy Markets Inspectorate, energy companies and Power Circle's own research.

Resources available today:

- Import/export (around 10 GW)
- Hydro power (13 GW currently, potentially 15 GW in the future)
- Gas turbines (1–2 GW)
- Combined heat and power (CHP) (3–4 GW)

Future resources:

- Electric cars with vehicle-to-grid (V2G) technology (between 14–114 GW)
- Batteries (up to 30 GW)
- Flexible demand (5–7 GW)
- Energy effectivization (around 3 GW)
- Energy storage (yet unknown potential)

each separate part of the grid. If this is not met, a voltage collapse can occur, which can result in a power outage for parts of, or the entire system.

Today, wind farms contribute with reactive effect through terms in the connection contract. Using reactive effect always means a decrease in generation, which needs compensation. Maximum use of the capacity for reactive effect can mean a 5 percent loss of total yearly production, which is a lot of money for the owner.

With additional equipment, wind power can deliver reactive effect even when the turbines are not active. This is of interest for the grid owners, since it can replace capacitors and reactors which otherwise need to be purchased for stabilising voltage. Thus, it can be socioeconomically beneficial to get help from wind power.

The Swedish Wind Energy Association proposes that:

- TSO Svenska kraftnät continues to develop ancillary services in cooperation with the wind power industry, to make them better suited to the technical capabilities of wind power.
- The Energy Markets Inspectorate regulates network tariffs so that they steer toward increased user flexibility.
- The Energy Markets Inspectorate reviews the revenue regulations to incentivize the power companies to buy additional energy storages services.
- The Swedish Energy Agency evaluates the system margins which offshore wind power and developing wind power technology can help increase.

Frequently asked questions on a 100 percent renewable electricity system:

Where will the electricity come from when the wind is not blowing?

Sweden is well suited for a completely renewable energy system, not least thanks to hydro power and our possibilities for importing when the wind is not blowing. There is also an enormous potential in flexible electricity usage and energy storage, which together with today's solutions will be able to meet the challenges. Moreover, wind power production becomes more stable in line with technological development.

Will Sweden become dependent on importing fossil energy when the electricity system is 100 percent renewable?

Sweden already has continuous trade with our neighbouring countries, where we sometimes import energy primarily from Norway, and sometimes export. Over a year, Sweden has a large net export, and this is expected to increase in the coming years. In the future, we will sometimes have to import electricity, but by expanding our renewable electricity production, Sweden can keep its large surplus and keep exporting more than what we import.

Will disturbances become more common in a renewable electricity system?

Wind power does not contribute with natural inertia like nuclear power does. However, it can support the system with so called synthetic inertia, down-regulation, and voltage regulation. For wind power to contribute with these actions, the incentives need to become more clear and ancillary services become more adapted to the conditions of wind power.

5.2 Reinforce the grid's capacity

According to TSO Svenska kraftnät, the permitting processes for building new overhead lines is probably the largest bottleneck limiting the speed of expansion of wind power ([Svenska kraftnät 2015](#)). Politicians have an important responsibility to ensure that laws and regulations are able to weigh different societal interests against each other in an effective way.

In September 2020, TSO Svenska kraftnät decided on its largest investment package ever, NordSyd, with the aim of renewing and strengthening large parts of the transmission

grid in central Sweden over the next twenty years ([Svenska kraftnät 2020](#)). This is welcome, but unfortunately it is not enough, neither in time nor scope. The investment rate in the Swedish electricity grid is approximately SEK 6 billion per year, in comparison with close to SEK 20 billion that is invested in wind power.

The Swedish Wind Energy Association estimates that until 2023, 80 percent of all new wind power will be built in the north, which means that power will continue to be transmitted over long distances. Parts of the grid have already



Photo: Anna-Karin Drugge

reached the limit for how much power that can be received and bottlenecks between north and south lead to power shortages and higher electricity prices in the south. Hydro-power's potential to balance cannot be fully utilized, conditions for private customers and industries south of Gävle are deteriorating, and the profitability of power plants in northern Sweden is declining.

Increased interconnectors are crucial when the share of intermittent power increases; partly to balance the power system, and partly to ensure that fossil-free power can be exported and contribute to green growth and emission reductions in our neighboring countries. Since 2010, when the wind power expansion took off, Sweden's electricity exports have increased and today correspond to about 15 percent of electricity production, at a value of over SEK 10 billion. But the potential is far greater than that, and in order to maintain investor confidence and not hamper development, the lack of transmission capacity needs to be dealt with urgently.

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"The current grid plans create a catch-22 situation: no new grid without wind power, but no new wind power without the grid."

Daniel Kulin, Head of Grid and Markets, SWEA

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TSO Svenska kraftnät does not want to expand the grid based on speculation, even though studies show that it is socio-economically preferable to expand when the future need is known ([Sweco 2018](#)). Thus, many challenges appear when wind power develops faster than any predictions: calculations for future investments are underestimated leading to undervaluing the need for future grid expansion, and long lead times for grid expansion result in solutions not arriving until it's too late and wind power investments have already been inhibited.

The Swedish Wind Energy Association proposes that the government

- Instructs the TSO Svenska kraftnät to develop an action plan that shows how the power grid can be a driving force instead of a brake in the transition to a low-carbon, electrified society
- Provides additional assignments to the ongoing Environmental Code Inquiry (2020: 86) to also focus on how processes related to the expansion of the electricity grid can be accelerated and simplified.



Photo: WPS Sweden AB

5.2.1 Alternatives to grid expansion

Enabling increased capacity in the existing grid is an important success factor for electrification of the society in a cost-effective way. The transmission capacity of the grid is often limited due to overheating in the cables or a drop-in voltage. Through better measurement and control based on actual weather conditions, transmission capacity can be increased without having to building new power lines.

In what is often called the NorthSouth project, TSO Svenska kraftnät are installing features in main grid stations to regulate the reactive effect thus enabling a higher transmission capacity, which is something grid-connected wind farms also can do. This is a fast and cost-effective approach to somewhat increase the transmission capacity without building new power lines.

Another way of enabling more wind power in existing grids is to connect an energy storage facility between the wind

farm and the power grid. This may become feasible if the costs of storage solutions continue to fall at a rapid rate.

The energy storage unit can be charged during high winds and transmit electricity to the grid when the wind farm is not producing. Through a hybrid system which combines wind, hydro, solar, and storage, the peak load can be reduced, which enables the grid to be optimized and dimensioned more efficiently. This also enables wind power to be connected to power lines which would otherwise be considered “full”.

The need for grid reinforcements can also be limited through placement of new large electricity consumers, such as the Northvolt factory outside of Skellefteå, new data centers or the Hybrit-project in the north. Therefore, it is important to hold a dialogue and cooperate between producers, power companies, and consumers around the plans for the grid.

6. Final words

Wind power is a growing green industry, and through electricity exports it can replace electricity generated from coal in Europe. Wind power enables the electrification of industry and transportation, increases security of supply, and creates jobs in rural areas. This roadmap outlines the fantastic opportunities that a transition to renewable energy entails. It is not only necessary for the climate – it is also profitable.

Today, wind power is the cheapest power source that is also capable of large-scale expansion in Sweden. Our favourable wind conditions give us a big competitive advantage and the industry is ready to meet the increased demand for electricity. The need to combat climate change is critical, but with the help of wind power, we can drastically decrease carbon emissions.

Technological progress is fast, and we now see a huge amount of ways to face the challenges of a renewable electricity system. Wind turbines are developing and can now deliver energy and power even during weaker winds, while new solutions are developed for energy storage and flexible consumption are emerging. Together with the strengthening and modernization of the power grid this contributes to securing the supply of electricity in the future.

To replace fossil energy in Sweden, we need to undergo extensive electrification. This means that access to good wind conditions, efficient permitting processes, and modern grid infrastructures are critical. This requires a number of policy

measures already within the current governments' term of office.

A good start would be to update all climate related instructions to government agencies and authorities to make it easier to balance different interests. Furthermore, we need to take advantage of the opportunities that electricity exports offer and abolish the connection cost for offshore wind power. An additional key measure is to create incentives for municipalities to contribute to the transition to renewables, for example by redirecting the property tax from wind power. Finally, Sweden needs to set an expansive planning goal for power supply, with a view to green growth and a total phase out of fossil fuels.

When these obstacles are overcome, the full potential of wind power can be realised. It creates climate benefits and competitiveness. It provides job opportunities and growth. It promotes Swedish industry and builds a modern and sustainable society.

Photo: Ørsted



"This roadmap outlines the fantastic opportunities that a transition to renewable energy entails. It is not only necessary for the climate – it is also profitable."

Daniel Badman, CEO, Swedish Wind Energy Association

swedish wind 
energy association