

# Summary

In the political debate, claims are often made that Sweden should limit its export of electricity. The stated reason has primarily been to keep electricity prices down in Sweden. Recently, security policy aspects of increasing foreign trade in electricity have also sometimes been put forward as arguments. The purpose of this report is to investigate the possibilities and effects of limiting the export of electricity from Sweden. With the help of new modelling, we have tried to estimate how large these effects can be.

Sweden has one of the highest rates of electricity consumption per capita in the world. We also have extensive foreign trade in electricity. The Swedish electricity system is strongly interconnected both with the other Nordic countries and with the European continent. During the last ten-year period, Sweden has had significant net exports of electricity, meaning that we have exported more electricity than we have imported, measured on an annual basis. In 2022, Sweden was the largest net exporter in all of Europe.

## **Net flows with Norway and Finland dominate**

International trade in electricity is still modest, compared to many other sectors. However, Sweden's foreign trade in electricity is significant in this context. Sweden's transmission grid is connected to six countries (Finland, Norway, Denmark, Poland, Germany and Lithuania) with high-voltage lines and cables with a combined trading capacity of just over 10,000 MW, which corresponds to about 25 percent of the installed power in the Swedish electricity production (i.e. its maximum production capacity).

The fact that Sweden has become a net exporter is due to several reasons. One explanation is that the total electricity production capacity in Sweden has increased mainly because wind power has been expanded at a rapid pace, while the total domestic demand for electricity has remained more or less constant for a long period. But it also has to do with how electricity is produced, i.e. the characteristics of the power flows. Unlike, for example, hydro-power, which can be regulated and saved in the water reservoirs, electricity from wind power cannot be stored but must be set aside somewhere. In this way, the surplus electricity has been exported.

In 2022, Sweden's net exports were just over 33 TWh, corresponding to about a fifth of the same year's electricity production. Sweden's geographical location in the middle of the Nordic electricity system means that the Swedish transmission network has come to be the backbone of the Nordic grid. However, trade flows between Sweden and neighbouring countries vary both between the years and over the year. Export and import of electricity can occur simultaneously. Net flows to other countries (Denmark, Germany, Poland and Lithuania) have been relatively modest in this context, with the exception of individual years. An important reason is that the physical transmission capacity between Sweden and these countries is limited. During the past two years, Sweden has only been a net importer of electricity for a few hours. However, the electricity system is currently undergoing rapid changes. We envision a rapidly growing need for electricity, an increased element of (weather-dependent) wind power and new electrical flows (partly due to the planned large industrial projects in the north). All in all, these developments are expected to lead to an increase in the number of hours during which Sweden needs net imports of electricity.

## Electricity pricing

The price of electricity is determined by the supply and demand of electricity, within Sweden and also in the countries that are connected to the Swedish electricity market. The price is also affected by the ability of electricity networks to transport electricity within Sweden (especially from north to south) and between countries.

The trade in electricity takes place mainly on the so-called day ahead-market and refers to deliveries during all 24 hours of the coming day. This trading takes place via the interconnected electricity exchanges in Europe. Based on buy and sell bids, the electricity price is set using a common calculation procedure (an auction procedure) that takes into account how much capacity is available for import or export in each bidding zone.

The division of countries into electricity bidding zones is one way of dealing with the physical constraints, known as bottlenecks, that exist in the national transmission networks and in the interconnections with other countries. Most bidding zones in Europe coincide with national borders, e.g. in Finland, Germany and France. But Sweden, Norway and Denmark, for example, are divided into several bidding zones.

All electricity producers and consumers in a bidding zone receive the same price for electricity. However, prices between bidding zones can differ significantly due to capacity constraints in the transmission networks. Without restrictions between bidding zones, area prices would be the same everywhere.

The free pricing in the electricity market contributes, among other things, to prioritizing the use of electricity generation facilities with the lowest variable costs (e.g. hydropower and wind power), while more expensive power sources enter the system only on the margin. This means that everyone has to pay the price for the most expensive form of power production required to cover demand. This practice (which is applied in most commodity markets) is referred to as market pricing or sometimes marginal cost pricing.

Electricity from Sweden will be exported if there is available capacity on the interconnections from Sweden while at the same time electricity prices being higher in our neighbouring countries. There is no trade between individual buyers and sellers (bilateral trade) that relates to the physical supply of electricity across bidding zone boundaries, but all foreign trade in electricity, as well as intra-country trade, takes place over the electricity exchange. The net flows that occur between the countries are determined as a result of the bids that sellers and buyers of electricity in the different countries submit to the electricity exchanges. Thus, individual power companies or power consumers cannot determine in advance whether they will "export" or "import" electricity.

There is a strong correlation between fossil fuel prices, in particular natural gas, and international electricity prices. The main reason is that electricity production on the continent largely takes place in natural gas-fired power plants, which thus determine the price of electricity. The international price of gas has been driven up mainly due to Russia's invasion of Ukraine, which has led to dramatic increases in the price of electricity all over the world. But the price of electricity in Sweden is also affected by the availability of other types of European electricity production, such as wind power and nuclear power.

## **A new situation**

Sweden, with its harsh climate and its large basic industry, is more dependent than many other countries on a secure and cost-effective electricity supply.

Russia's full-scale invasion of Ukraine in February 2022 has dramatically raised issues of energy prices, security of supply and import dependence. The ongoing climate transition means, among other things, increased electrification and that fossil-free electricity replaces fossil fuels (oil, coal and natural gas) for many different purposes. Available scenarios point to an extremely rapid increase in electricity use in Sweden over the next 10–20 years. According to some scenarios, Sweden's demand for electricity in 10–15 years could be more than twice as high as present. It is worth noting that developments in many other countries, including our neighbouring countries, also point towards rapid electrification.

The production of electricity in Sweden is also expected to increase. However, it is uncertain whether we will continue to have a surplus that we can export. Important uncertainties are, for example, the penetration of electricity-based hydrogen, the pace of transition and the transition to electric power in the transport and industrial sectors. The uncertainty is underlined by the fact that a few large industrial projects account for the predominant part of the predicted increase in demand for electricity. If any of the planned industrial projects, such as the production of fossil-free steel or electrofuels, do not happen, it would have a major effect on the demand for electricity.

The fact that the use of electricity has remained more or less constant for a long succession of years has also meant that the expansion of the transmission network within Sweden and to other countries has taken place at a relatively moderate pace. The new situation places new and great demands on the transmission networks, both within the country and to our neighbouring countries. For example, an increased element of weather-dependent electricity generation (wind and solar power) is expected to increase trade flows both domestically and across borders. The system operator Svenska kraftnät's scenarios show an increased need for electricity trading between bidding areas in the future. In order for the electricity system to function efficiently, there is a need both to strengthen the transmission network in Sweden and to increase transmission capacity between Sweden and our neighbouring countries.

For more than a hundred years, Sweden has been connected to the electricity systems of other Nordic countries. Through the Nordic electricity exchange, both Sweden's and the other Nordic countries' electricity supply has become less vulnerable by the fact that we have had the opportunity to utilize the most environmentally friendly electricity production and been able to avoid building power plants that are only used during the most loaded hours of the year. In recent years, Sweden's large electricity surplus has also generated significant export revenues.

But at the same time, our dependence on other countries carries risks and potential disadvantages. When electricity scarcity occurs (as a result of, for example, extreme cold, lack of wind, breakdowns, voluntary or involuntary reduction of power in power plants), we are forced to rely on imports from other countries. The interconnection of high-voltage networks means that we are periodically affected by a "contagion effect" of price increases on the continent. Security policy issues have increasingly characterized the energy policy discussion in recent times. It is against this background, together with the sharp rise in the price of energy, that the current political discussion about restricting foreign trade in electricity should be seen.

## Effects of restricting foreign trade in electricity

Foreign trade in electricity can be restricted in various ways. In principle, the government could order Svenska kraftnät not to lease capacity on foreign connections. Another way is to somehow regulate different prices for Swedish customers and foreign customers. Another possibility could be to restrict foreign trade by not giving permits to new interconnectors.

If restrictions were to be imposed on foreign trade in electricity, there would be effects on the supply of electricity, environmental effects and effects on the economy. And if Sweden – hypothetically – were to choose to become completely self-sufficient in electricity (i.e. not allow any exports or imports), it would mean that we ourselves would have to build up the domestic generation and transmission capacity required to establish the electricity supply during every hour of the year and during the day, which would require substantial investment in power plants and transmission lines.

Trade restrictions would probably also lead to increased emissions of greenhouse gases and other polluting emissions from power generation plants. One reason for this is that the countries which today benefit from Sweden's fossil-free electricity exports would be forced to use power generation plants with poorer environmental performance. However, this effect can be expected to decrease over time, as more and more countries get rid of fossil-based power generation to reach their climate goals.

Against these obvious additional costs, however, one must set the benefits that a higher degree of self-sufficiency would bring, mainly in the form of reduced dependence on imports from other countries and (periodically) lower electricity prices. At the end of the day, the balance between the benefits of free trade and the value of increased national self-sufficiency is a political issue.

We have had model calculations carried out on the quantitative effects of the introduction of restrictions on foreign trade. We then compare a reference case with various cases where foreign trade in electricity is restricted. According to these calculations, restrictions on foreign trade in electricity will lead in the short term to lower domestic electricity prices, expressed as an annual average. However, electricity prices may be higher during periods of high load. In the

longer term, trade restrictions are estimated to mean higher societal costs for electricity supply and higher carbon dioxide emissions (especially in the next few years). This would then lead to higher costs for consumers.

In our reference case, the model results point to a Swedish electricity price (expressed as an annual average) of around 50 öre/kWh during the period 2025–30. During the latter part of the analyzed period (2040–45), the price is estimated to be about 10 öre higher per kWh, i.e. around 60 öre/kWh. If no new foreign connections are allowed, the effect is expected to be moderate (1–2 öre/kWh lower electricity price compared to the reference case), while a halt to all foreign trade in electricity entails significantly lower prices (in the order of 10–15 öre/kWh lower electricity price compared to the reference case), expressed as an annual average.

However, the picture is more complex in terms of the price effect during certain periods within the year. During the winter or other periods of high load, according to the model calculations, electricity prices can be significantly higher, especially in a case completely without electricity trading with the outside world (compared to the reference case). In all the cases studied, the additional cost of electricity supply will be significantly higher than today, and carbon dioxide emissions from the European energy system will increase. Over the next few years, most indications are that we will have a surplus of electricity to export. But already in a few years the situation may be the reverse, that for long periods we need to import more electricity than we export. In that case, restrictions on trade could have significant negative effects on our electricity supply.

Our analyses lead us to the following conclusions:

- *Restrictions on foreign trade is an inappropriate method to keep Swedish electricity prices down*

Restrictions on foreign trade in electricity could, according to the reported model calculations, in the next few years result in lower average electricity prices in Sweden during certain periods. But it cannot be inferred, in our view, that such restrictions would be beneficial. Foreign trade in electricity fulfils several important functions. Free foreign trade means lower total costs for electricity supply, a higher degree of security of supply and lower emissions of

carbon dioxide. Well-functioning cross-border trade also makes it easier to introduce more and more renewable electricity generation (wind and solar power).

A restriction on foreign trade is therefore, in our opinion, an inappropriate method of keeping Swedish electricity prices down. According to the reported model calculations, a trade stoppage could certainly result in lower average electricity prices in Sweden over the next few years. But at the same time, electricity prices could be higher during strained periods if we placed restrictions on foreign trade in electricity. A limitation of the possibilities for exporting electricity would also weaken the incentives for building new power generation in Sweden, which could complicate the planned electrification.

- *Trade restrictions lead to higher system costs and reduced security of supply*

Sweden is a small and open economy, which is heavily dependent on foreign trade. Our analysis indicates that restrictions on foreign trade entail higher socio-economic costs (as each country is then forced to operate an excessive system) and higher emissions of carbon dioxide from European electricity production. Unilateral Swedish initiatives to restrict trade can also lead to political countermeasures and retaliation from other countries, which could lead to lower security of supply. This is especially true in a situation where we envision large amounts of weather-dependent electricity production such as wind and solar energy.

- *There are legal barriers to restricting foreign trade in electricity*

Part of our task has been to investigate the legality of a restriction on foreign trade in electricity. Our analysis shows that there are significant legal obstacles to imposing more lasting restrictions. Above all, it is the EU-wide competition rules and the rules on free movement (the single market) that set clear limits on what is allowed. Violation of competition rules may result in severe financial penalties.

However, there are opportunities for the government and parliament to condition or limit additional cables and wires to other countries (interconnectors). In our opinion, there may be a case for



reviewing the criteria to be applied when granting permission for new interconnectors.

- *New interconnectors are needed but on new terms*

One method of restricting foreign trade – which is often put forward in the debate – is to place restrictions on the addition of new interconnectors. Our review indicates that today we are faced with a new situation, in which new considerations must be taken into account in the further expansion of interconnectors. This also applies to the issue of renewal of existing interconnectors. As a result of the climate transition and the new security policy situation, there is much to suggest an increased interest from the countries in the world around us to connect with the Swedish and Nordic electricity systems. In our view, we should acknowledge this development; a powerful expansion of interconnectors is necessary for Sweden and the rest of Europe to be able to achieve their goals for both the climate and electricity supply. How much expansion will be needed depends on a number of factors, including how demand develops and how much new electricity production will be added in Sweden and in the world around us. Security policy considerations also need to be taken into account. This will place new demands both on politics and on transmission companies. What is an appropriate capacity for interconnectors with electricity is ultimately a political trade-off. This raises the question of what considerations should be made when authorizing new interconnectors.

## Proposals for further work

Sweden's electricity supply is in many respects in a new situation, both in terms of security policy and in terms of the climate. In addition, the high and highly fluctuating electricity prices of recent years have changed the economic conditions for both households and businesses. Both Sweden's and the EU's climate and energy strategy is based on rapid electrification and an expansion of fossil-free electricity production.

Most observers today envision a larger share of weather-dependent electricity production, new technology, new types of

electricity use and a new security policy situation. In the light of the new reality, we see before us a number of issues that need to be analyzed more closely.

- *Review the criteria for authorizing new interconnectors.* Presently, it is the government that, on the basis of, among other things, Svenska kraftnät's socio-economic analyses make decisions on permits for new interconnectors. In our opinion, this arrangement should be maintained, as the granting of permits has a significant political dimension. However, this does not prevent there from being a need to review the assessment criteria on which authorization decisions are based. These may include both the possibility of imposing requirements on the acceding country (e.g. in terms of sufficient reserves or division into bidding zones) and considerations of foreign and security policy. We therefore propose that the government appoint a committee with the task of analyzing the criteria that should apply when examining additional foreign relations.
- *Analyze the need for a goal for the degree of national self-sufficiency in electricity.* For a long succession of years, Sweden has been a net exporter of electricity. However, it is not obvious that this will continue to apply in the future. For example, Svenska kraftnät reports scenarios that mean that Sweden can already become a net importer of electricity within a few years. It raises questions about what degree of self-sufficiency is appropriate, not least from a security policy perspective. There is therefore, in our view, reason for the government and responsible authorities to analyze the issue of an appropriate degree of self-sufficiency without preconditions, taking into account various possible scenarios.
- *Investigate the ownership of interconnectors.* Current legislation implies that the State has a strong influence on the licensing of new interconnectors, but does not give Svenska kraftnät the exclusive right to own such connectors. In view of the new situation, the question arises as to whether there is a need to strengthen social control over ownership and whether, if so, Sweden has the freedom of action to do so with regard to EU law. At the same time, there may be a need for private actors

to be given the opportunity to invest in new foreign connections. In our opinion, this issue needs to be analyzed in more detail.

- *Explore new ways to deal with price variations.* In many countries, new systems for pricing electricity are being discussed, including different types of two-price systems. It has been beyond the scope of this study to analyze such proposals more closely. As far as we can see, the proposals that have been presented in the debate de facto mean that – in one way or another - foreign trade in electricity is restricted. As mentioned above, we believe that such restrictions are an inappropriate way to keep electricity prices down. However, there may be reason to investigate other ways of dealing with the undesirable effects of rapid price variations. This can involve both stimulating technical measures such as energy storage, user flexibility and energy efficiency, and analysing and designing effective schemes to financially compensate vulnerable consumers and businesses for high electricity costs.
- *Set long-term rules of the game.* Finally, we point out that major investments must be made in all parts of the electricity supply chain in order to meet new demands for security of supply, the environment and climate, as well as national security. We believe that the government should take the initiative for a broad review of the future electricity supply, with the aim of creating a long-term stable framework that also includes support to technical development and innovation as well as security policy considerations.