Policy Brief

Electricity at Any Price?

The Real Cost of Wind Power

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Foreword

The Swedish electricity market is undergoing major changes. Expectations are being expressed from many quarters that demand for electricity will grow significantly in the coming decades. At the same time as demand is growing, the expansion of electricity from solar and wind power has increased in recent times and the electricity system is changing its composition with regard to different power sources. With this, the electricity system is also changing.

In recent years, electricity consumers have been faced with a more volatile price of electricity, which also varies in price per kilowatt-hour between electricity areas in the country. The variations are due to demand and supply in the power system in different electricity areas, and the issue of expanding electricity production therefore affects both businesses and households that are buyers of electricity.

Over the past two to three years, there have been a large number of analyses and forecasts regarding Sweden's future electricity needs from government agencies, interest organizations and think tanks. They all forecast a sharp increase in future electricity demand to meet the mandated green transition. In many cases, they also advocate a rapid expansion of weather-dependent power sources, both because it is considered to be faster and because it is considered to be economically advantageous. In particular, onshore wind power is highlighted as the best option. This conclusion is based on the assumption that the share of weather-dependent power generation can be allowed to increase from today's level without jeopardizing the functioning of the electricity system.

The authors of this Policy Brief question such a strategy, arguing that the functioning of the Swedish electricity system cannot be guaranteed if the share of weather-dependent power generation increases sharply from what they consider to be an already high level. Rather than reviewing each of the many analyses and forecasts advocating rapid expansion of wind power, the authors have chosen to examine in detail one of the reports, namely the SNS Economic Council's annual report, which this year analyzes the Swedish electricity market. The three authors chose to review this particular report for several reasons: it is written by highly qualified researchers, it is new, and the SNS Economic Council is held in high repute and thus has great influence on the public debate.

Given the purpose of this Policy Brief, it is not a crucial limitation that the review mainly concerns a single report. The criticisms the authors make of the SNS report typically also apply to other reports that argue for a strong and rapid expansion of wind power, resulting in an increasing share of weather-dependent power in the production mix.

The authors are responsible for the content, conclusions and recommendations.

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Electricity at Any Price? The Real Cost of Wind Power*

On April 28, almost the entire Iberian Peninsula was affected by a total shutdown of the electricity system. People were trapped in elevators, trains and subways and all electronic communications were rendered impossible. The system crash became inevitable after power equivalent to 60% of instantaneous demand suddenly disappeared. Although it is not yet clear what caused the shutdown, we can note that a very large share of Spain's electricity comes from weather-dependent power sources. Wind and solar power have roughly equal shares, together accounting for 43% of annual production, and on sunny days solar power alone can provide the lion's share of demand.[1]

There are many indications that the risk of system crashes increases as the share of weather-dependent electricity generation increases. This share is now also increasing rapidly in Sweden. Last year, a quarter of all electricity generated came from wind power and around 2.5% from solar power. Ten years earlier, weather-dependent power accounted for just over 7% and if we go back another ten years, there was no solar power at all, and wind power's share was less than 1%.[2] It is unclear what the system costs will be for these power systems to be as robust as the systems they are intended to replace. However, there is reason to believe that these systems could be costly.

In recent years, there have been a large number of forecasts and scenario analyses from government agencies, think tanks and interest groups. The most recent example is the Confederation of Swedish Enterprise's report *Power system: Robust for 300 TWh*, which was published in March. Like many others, the organization's baseline scenario estimates Sweden's electricity demand to be around 300 TWh in 2050. At the same time, it takes an optimistic view of the potential for increasing the share of intermittent power sources in electricity generation. They conclude that "a robust system needs at least 55–65% baseload power",[3] i.e., it would be possible to increase the share of weather-dependent power sources to up to 45% without jeopardizing stability. The report also underestimates the costs of wind power and does not address sustainability and land use issues. Hence, the often-expressed view that since onshore wind can be expanded most rapidly, it should be given high priority.

At the end of January, an analysis was published that was even more optimistic about the electricity market's ability to function well in the event of a sharp increase in the proportion of electricity from weather-dependent sources, namely the SNS Economic Council. Since 1974, the Center for Business and Policy Studies (SNS) annually appoints a group of researchers who, under the name of the SNS Economic Council, analyze how the economy functions over time with regard to various key issues. Based on their conclusions, the researchers make recommendations to politicians and other decision-makers. Through the Council, SNS aims to help ensure that the public debate is based on research of high scientific quality. The reports often have a major impact both on the public debate and on the economic policies pursued.

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* A note to the reader: Most of the sources and references are in Swedish and can be found by following the embedded links or by going to the Swedish version of this Policy Brief. However, to give the reader an idea of the content, all titles in Swedish were translated into English.

[1] https://ember-energy.org/countries-and-regions/spain/.

[2] https://www.energiforetagen.se/statistik/energiaret/.

[3] Jacke, Jan-Olof (2025). "New nuclear and wind power key to a competitive and robust electricity system". *Dagens Industri*, March 5.

This year's Economic Council – consisting of electricity market researchers Thomas Tangerås, Pär Holmberg and Chloé Le Coq – examines "the challenges of the energy transition for Sweden". In the introduction to the report, *Investing in Electricity Production for a Sustainable Energy Transition*, the researchers state that "a well-functioning electricity supply will become increasingly important for the country's economic prosperity and competitiveness" and "extensive electrification is the most realistic path to ... meet the goal of Sweden having no net greenhouse gas emissions by 2045."[4] As the main solution, the Council advocates a large-scale expansion of onshore wind power.

The purpose of this policy brief is to critically review the assumptions made and the conclusions drawn by the Council. In the review, we show that (1) the Council ignores key system functions, (2) their cost models underestimate real economic consequences, and (3) their conclusions are not supported by empirical evidence or theory.

We choose to review the SNS report precisely because it is written by highly qualified electricity market researchers, is one of the latest in a series of electricity market analyses and because the SNS Economic Council has a very high reputation and regularly has a major influence on the public debate. But our criticism of the SNS report typically also applies to other reports in recent years that have argued for a strong and rapid expansion of wind power because it is both said to be most cost efficient and allegedly can be done much faster than the expansion other low-carbon alternatives.

System functions

System function is primary for electricity supply. A functioning electricity system requires four things: delivery of sufficient energy, sufficient instantaneous power, high power quality, and robust security of supply. These requirements must be met in real time and in concert. In 2023, the Swedish National Audit Office delivered scathing criticism of the Swedish energy policy's lack of impact assessment for these basic needs.[5] Svenska kraftnät – the agency responsible for ensuring that Sweden's transmission system for electricity is safe, environmentally sound and cost-effective – has for many years warned of the rapidly increasing problems with the expansion of wind power. In 2023, the authority estimated that in the winter of 2025/26, there may be a lack of planned capacity equivalent to five nuclear power plants.[6] However, more wind power will not solve the problems, quite the opposite. The Economic Council also suggests a major expansion of the transmission grid, an extensive cost that will be necessary with more wind power. But the larger the transmission network and the more distributed electricity generation, the more difficult it will be to maintain the stability of the system. The more uneven production spread over larger areas requires not only longer but also transmission networks of higher capacity, which creates a high additional cost and is negative for the environment. To a large extent, these transmission costs are avoided with nuclear power.

Fuel-based power, such as nuclear power, can act as baseload, balancing and regulating power and the fuel itself functions as storage. It can also be located close to high-consumption areas, whereas wind power is generally built far from users and requires additional external systems in the form of balancing power/storage, transmission networks and grid stabilization systems.

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[4] Tangerås, Thomas, Pär Holmberg and Chloé Le Coq (2025) *Investments in Electricity Generation for a Sustainable Energy Transition*. Report of the SNS Economic Council 2025. Stockholm: SNS Förlag.

[5] National Audit Office (2023). *Government Measures for the Development of the Electricity System – Reactive and Insufficiently Substantiated*. RiR 2023:15. Stockholm: Swedish National Audit Office.

[6] Svenska kraftnät (2023). *The Power Balance on the Swedish Electricity Market. A Report to the Ministry of Climate and Enterprise*. Case no. 2023/1019. Sundbyberg: Svenska kraftnät.

Synchronous generators in hydro and nuclear power plants, due to their large rotating mass, are proactive, i.e., prevent disturbances from occurring. In contrast, "synthetic" inertia, which is often promoted as a solution for wind power,[7] is reactive and must constantly correct disturbances that have already occurred. This adds both complexity and cost to the system. To assist wind power, large rotary converters are also installed to stabilize the grid and manage reactive power.[8] They basically act as synchronous generators but without producing any electricity; instead, they consume electricity and incur an additional cost.

Countries with a high share of solar and wind power have major system problems and are partly forced to ensure the functioning of the system by means of fossil fuel power plants. To manage the intermittency of wind and solar power, there must be other power sources that can be switched on and off whenever needed to balance supply and demand. The more wind and solar power in the system, the more capacity must be available in balancing power plants to replace solar and wind power when the sun is not shining and/or there is insufficient or no wind. The capacity utilization of this balancing power will be lower the more wind and solar power is installed, which means that its revenue will be lower. To compensate for this fact, either the balancing power prices have to be higher, or the owners of the balancing power have to get paid for their availability. Therefore, even if intermittent power were cheaper than traditional baseload power, it will not only lead to more volatile prices but also to higher electricity prices overall. Average household electricity prices have therefore increased in countries with high shares of wind and solar power.[9]

The system-level economy

According to the Council, system-level externalities should be internalized (brought down to the power plant level), which would be excellent, but then these costs need to be calculated before advocating a particular power source. Cost calculations that do not take into account frequency control, reactive power, system inertia and regulating capacity give a misleading picture of the real social cost of electricity production.

The Council mainly uses the power plant cost LCOE (Levelized Cost of Electricity), but this measure excludes significant system costs. These costs consist mainly of profile costs (e.g. how production variability affects the capacity factor and pricing), balancing costs and grid costs. System costs are added to the LCOE in various studies using measures such as system LCOE, ACOE and LFSCOE. When analyzing system LCOE (LCOE plus all system costs), Ueckerdt et al. (2013) conclude that already at a market share of 20% for wind power, the integration cost to the system was significant and largely driven by the profile cost. The authors also found

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[7] This is also the case for the SNS Economic Council, which believes that inertia and other balancing services may fall by "80–90% in the coming years" (Tangerås et al., 2025, p. 107).

[8] Reactive power is the difference between active power—i.e., the useful power—and the total power consumed. In electric power systems with a high share of weather-dependent solar and wind generation, there are few synchronous generators, which traditionally provide intrinsic control of reactive power. As a result, active power may constitute only a fraction of the total system power unless additional, often costly, equipment is installed to manage reactive power. Excess reactive power reduces system efficiency, limits transmission capacity, and increases losses.

[9] See e.g. Hannesson, Rögnvaldur (2025). "An electricity market model with intermittent power". *Energies*, vol. 18, no. 6, p. 1435. Admittedly, it can sometimes be difficult to compare prices between countries as prices vary due to different forms of support. Despite these differences, the positive correlation is robust. Germany is an obvious case in point where the average electricity price for households was just over SEK 5 per kWh in 2024 despite extensive direct subsidies to producers (Karlsson, Svenolof (2025), "Enormous costs for renewables in Germany". *Second Opinion*, January 2. The installed capacity of solar power in Germany now exceeds the maximum power requirement by a wide margin.)

that at a share above 20%, the integration cost increases rapidly and at 40% the system level cost was doubled.[10] Similar results were also reported by the OECD-NEA (Nuclear Energy Agency).[11]

ACOE (*Actual Cost of Electricity*) gives the LCOE plus the profile cost, i.e., taking into account the decreasing electricity price and the decreasing capacity factor due to overcapacity resulting from an increasing share of weather-dependent power. Manzolini et al. (2024) report on the impact of the cost of the declining capacity factor with increasing wind power share. Based on real data for 2022, when the share of wind power increases from 0 to 50 percent, the cost of wind power per kWh increases in Denmark from SEK 0.9 to 1.1, in Germany from SEK 0.9 to 1.4 and in the Netherlands from SEK 1.2 to 1.4.[12]

LFSCOE (*Levelized Full System Costs of Electricity*) is a measure of the cost of a system with 100% of a given power type and gives, e.g., an indication of the cost of a 100% renewable system. Idel (2022) calculates values per kWh for Germany based on LFSCOE (when the entire demand is covered by one type of power source), which amount to SEK 1.11 for nuclear power, SEK 5.28 for wind power and SEK 16.21 for solar power.[13]

With continued expansion of wind power in Sweden, the country cannot rely on hydropower as balancing power; hydropower is already largely more or less fully booked as balancing and regulating power. From 2020 to 2022, balancing costs increased by more than SEK 5 billion as wind power increased by 4.6 billion kWh. Although not all of the increase is linked to wind power, it is the main cause, and it corresponds to a balancing cost on the margin that exceeds the value of the LCOE adopted by the Council.

The only system service wind power contributes is *not* to produce in excess and for that it may even get paid. Svenska kraftnät has pointed to the problems caused by the fact that so much wind power is sold under fixed PPA contracts. These contracts give the wind power companies a guaranteed price for the electricity they produce and as long as the negative price in absolute terms is lower than the guaranteed price, it will be profitable for these companies to continue producing. This electricity is not on the electricity exchange, does not react to the exchange's price signals and is not available to Swedish users, which is reflected in the fact that most wind power is exported.[14] Sandström (2025) also points to the clear correlation between increased wind power and increased exports and that the increase in the share of wind power has been associated with a decline in domestic electricity use for 20 years.[15] The decline in

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[10] Ueckerdt, Falko, Lion Hirth, Gunnar Luderer and Ottmar Edenhofer (2013). "System LCOE: What are the costs of variable renewables?". *Energy*, vol. 63, December, pp. 61–75.

[11] OECD-NEA (2012) "Nuclear energy and renewables: System effects in low-carbon electricity systems". NEA No. 7056. Paris: Nuclear Energy Agency, OECD.

[12] Manzolini, Giampaolo, Marco Binotti, Giancarlo Gentile, Giovanni Picotti, Lorenzo Pilotti, Michael E. Cholette (2024). "Actual cost of electricity: An economic index to overcome levelized cost of electricity limits". *iScience*, vol. 27, pp. 109897. They thus find that the production cost can increase by more than 50% when system costs are taken into account in the case of weather-dependent power sources.

[13] Idel, Robert (2022). "Levelized Full System Costs of Electricity". *Energy*, vol. 259, November, pp. 124905.

[14] One of the main reasons why wind companies have to be paid to close their plants despite negative prices is that PPAs give wind companies a guaranteed price for the electricity they produce and as long as the negative price is lower in absolute terms than the guaranteed price, it will still be profitable for these companies to continue producing.

[15] Sandström, Christian (2025). "More wind power is suicide – how does Vattenfall think?". *Affärsvärlden*, April 27.

electricity use is not due to reduced demand but to increased costs and the inability to connect new subscribers to the due to the lack of dispatchable capacity (following the premature closures of six nuclear power plants).[16]

The Council's baseline scenario, where 107.5 TWh is produced by wind power (see section "How much does electricity demand increase" below), requires a significant addition of balancing power to cope with periods of low wind. A frequently suggested balancing option is battery storage. It may be reasonable to allow for a week of no wind in the middle of winter and for up to half of the shortfall to be met by increased off-take from other sources. Since the electricity consumption in the Council's main scenario is about 4 TWh per week, this would require a battery storage capacity of one TWh, which corresponds more or less exactly to one third of the world's production of batteries in 2024.

Buying that much battery capacity at world market prices would cost about SEK 3.7 trillion.[17] If the batteries can be expected to last for 10 years, this means a depreciation cost of SEK 370 billion per year plus a financing cost of half the amount invested, on average, which at an interest rate of 4 percent amounts to SEK 74 billion per year. The cost corresponds to 7 percent of Sweden's GDP. At an estimated carbon footprint of 150 kg per kWh of storage capacity, this means that the manufacture of the batteries needed emits 150 million tons of carbon dioxide. Over 10 years, this amounts to 15 million tons per year, i.e., the required battery storage alone would be equivalent to one third of Sweden's current total carbon dioxide emissions! This approximate calculation is fully sufficient to dismiss massive battery storage as a balancing option (except for extremely short spells like a shortage of a few seconds).

A high share of wind power not only impairs the economics of wind power; it affects all types of power generation and in particular those sources necessary for system operation. According to the OECD-NEA, the loss of profitability can be 24% for nuclear power at a 10% wind power share and 55% at a 30% wind power share.[18] The corresponding values for gas power (OCGT), an important candidate for balancing power, are 54% and 87%, respectively. These calculations make it abundantly clear that the costs of ensuring that the necessary balancing and stabilizing power is available are very high. This aspect is almost completely ignored in the Council's analysis, even though the main scenario assumes a wind power share of over 50%.

The power-plant level economy

According to the Council, all benefits and costs should be addressed at the power plant level. This is an important principle that ties in with the European guidelines for connecting electricity generation to the grid. However, the cost measure used by the Council (LCOE) only covers the cost of the power plant, which the International Energy Agency (IEA) considers to be grossly inappropriate in systems with a high share of solar and wind power. The LCOE equals the price that just allows a plant to be built and operated without making a loss in systems with dispatchable capacity. But there is no allowance in that price for any profit or for overly optimistic assumptions regarding financing costs (interest rates), longevity, power factor and O&M costs.

[16] The two southernmost reactors in Barsebäck were closed in 1999 and 2005. Two out of three reactors in Oskarshamn were closed in 2015 and 2017, and two out of four reactors in Ringhals were closed in 2019 and 2020.

[17] The battery price as well as the estimate of the CO_2 footprint of battery production are taken from Ask, Per (2025). "The dark side of solar power". *Kvartal*, March 25.

[18] Keppler, J. H., et al. (2018). *The Full Costs of Electricity Provision*. NEA No. 7298. Paris: Nuclear Energy Agency, OECD.

The Council advocates onshore wind power and states low and falling production costs for this type of power (SEK 0.30–0.50/kWh); figures that, with knowledge of the development of Swedish wind power's profitability, are far too optimistic.[19] The production cost is already at power plant level probably twice as high as the Council's calculated values. A good indication can be obtained by looking at the guaranteed price wind developers ask for building onshore wind in the UK. That price was SEK 0.92 per kWh at today's exchange rate,[20] a level similar to Germany. The economic viability of Swedish wind power production has been financially unsustainable for several years. Wind power companies in Sweden lost an average of SEK 0.35 on each krona of electricity sold in 2017-2023,[21] which means that they would have had to receive an average of SEK 0.35 more per kWh sold in order not to make a loss. This simple observation is enough to refute the industry's claim of a production cost of around SEK 0.30.[22]

Monitoring thousands of wind turbines shows that new generations have become more expensive, with shorter lifetimes and higher operating costs than the previous ones.[23] This is reflected in the fact that major wind turbine manufacturers have incurred large losses due to the lack of durability of the turbines,[24] triggering large warranty obligations. In practice, the economic life expectancy has been found to be only 15 years for onshore and 12 years for offshore wind, while the economic calculations use 25-30 years.[25] In addition to this, Sandström and Steinbeck (2025) show how the increasing share of wind power weakens the

[19] The Council relies heavily on a background report by Sandén, Björn (2024). "The cost development of three types of electricity generation: Historical trends and thoughts on the future". Chalmers University of Technology. However, the report does not contain any information on how the calculations were made: assumptions about capacity factors, costs for operation, maintenance and decommissioning (e.g,. waste management), how efficiency and operation and maintenance costs change over time, what economic lifetime is assumed, etc. However, he sees these costs as so marginal that he believes it is reasonable to conclude (p. 22) that "[t]he cost estimates in the previous section indicate that solar and wind are likely to constitute the 'base power' of the future."

[20] The price reached SEK 0.66 per kWh (£50.9 per MWh) at the 2012 price level. Since then, inflation has been 39.3% (https://www.bankofengland.co.uk/monetary-policy/inflation/inflation-calculator), giving a 2024 price level of SEK 0.92 per kWh at the April 2025 exchange rate. See https://assets.publishing.service.gov.uk/media/66d6ad7c6eb664e57141db4b/Contracts_for_Difference_Allocation_Round_6_results.pdf.

[21] Sandström, Christian, and Christian Steinbeck (2025). "Green bubble in Swedish wind power?". *Ekonomisk Debatt*, vol. 53, no. 3, pp. 63–68. https://www.

[22] See, e.g., "Wind power cheapest to produce, new report shows".

[23] Hughes, Gordon (2021). "Costs, performance and investment returns for wind power". School of Economics, University of Edinburgh, and Renewable Energy Foundation

[24] Matthis, Simon (2023). "Why the wind industry is asking for more handouts". *Energinyheter.se*, March 15. Siemens Gamesa, one of the world's two largest wind power manufacturers, was particularly affected (but General Electric and Vestas were also affected). Siemens Gamesa ended up in an acute crisis in 2023. Salvaging the company required a €7.5 billion bailout by the German government and €1.3 billion in guarantee commitments from the Spanish government. Eidenmüller, Horst and Javier Paz Valbuena (2023). "Taxes blown in the wind? The Siemens Gamesa bailout". Working Paper 745/2023. Brussels: European Corporate Governance Institute.

[25] Hughes, Gordon (2021). "Costs, performance and investment returns for wind power". School of Economics, University of Edinburgh, and Renewable Energy Foundation

economy – a profile cost that is ignored by the Council but which contributes to the total wind power in Sweden losing about SEK 0.35 on every SEK of electricity sold.[26]

In the UK, a review of the costs of the country's wind energy production in 2020 was carried out.[27] The average cost of onshore wind power was SEK 1.18/kWh (GBP 0.091) and for offshore wind SEK 1.98/kWh (GBP 0.152), while its market value was only SEK 0.17/kWh (GBP 0.013). The costs are in line with guaranteed prices for German wind power and contract prices for wind power in the UK. Swedish municipalities, which have invested in wind power, have lost a lot of money and taxpayers have in several cases been forced to finance the rapid decommissioning of these plants.[28] However, the majority of plants in Sweden are foreign-owned,[29] to a great extent financed with publicly guaranteed loans from the European Union or national governments, and the electricity is often sold via PPAs directly to foreign customers at a higher price than the price on the electricity exchange (that wind power electricity is therefore not available to Swedish customers).

Cautionary examples can be found not least in Germany, Denmark, the UK, California and Finland, but increasingly also in Sweden. Germany has an installed capacity of solar and wind power that is more than twice the maximum power demand, yet more than half of its electricity is planned fuel-based electricity.[30] Finland has expanded its wind power at a record pace and is vying with Spain for being the country in Europe with highest number of hours with negative prices (8%).[31]

Systems with a large share of wind power have large excessive installed power (in some cases more than 300% of the maximum power needed at any point during a full year). As a result, operators have to be paid to reduce production when there is a lot of wind and/or too much sun. In Sweden, hydropower is paid to “spill” water and wind power to “spill” wind, which lowers their utilization rate and increases their environmental impact. At the same time, fossil balance power is paid to remain idle when the wind blows.

Social benefits and costs of externalities

The fact that wind power also has negative effects is often overlooked. It is exemplary that the Council points out that wind power has environmental costs, creates disturbances for local residents, can affect military defense capabilities and that compensation should be given to those affected. The Council estimates that “the cost [in southern Sweden] of compensating local residents for disturbances and the cost of the government’s contribution to the

[26] Sandström, Christian and Christian Steinbeck (2025). “Green bubble in Swedish wind power?”. *Ekonomisk Debatt*, vol. 53, no. 3, pp. 63–68.

[27] Hughes, Gordon (2021). ”Wind power economics – rhetoric and reality”. School of Economics, University of Edinburgh and Renewable Energy Foundation (REF).

[28] Fahlén, Per (2023). *Sweden’s Electricity Supply in 2050: 100% or 0% “Renewable”? – A Comparison of Four Scenarios Regarding Function, Cost and Environmental Impact*. EN-R2023:02. Resele: Entro Nova. Sandström, Christian (2025). “Northvolt owner Skellefteå Kraft writes down wind power by a quarter billion”. *Affärsvärlden*, March 14.

[29] At the end of 2022, 78% of wind power in Sweden was foreign-owned, and in 2018–2022, an average of 88.3% of newly built wind power was foreign-owned. *Source*: Sandström, Christian and Christian Steinbeck (2024). “Which country loses most from Swedish wind power – China or Luxembourg?”. *Affärsvärlden*, May 20.

[30] Karlsson, Svenolof (2025), "Huge costs for renewables in Germany”. *Second Opinion*, January 2. The installed capacity of solar power in Germany now exceeds by far the maximum power demand.

[31] Karlsson, Svenolof (2025), “Finnish wind power about to blow away”. *Second Opinion*, February 17. The installed capacity of wind power in Finland will soon be twice that of nuclear power.

municipalities [for not exercising their right to veto wind power establishments] totals SEK 0.02 per kWh of wind power produced" (p. 142).[32] But paying municipalities to take a different decision than they otherwise would is a violation of basic democratic rules. Any compensation should be in the form of direct compensation to affected citizens and should be paid for by the wind industry, not by taxpayers.

It is estimated that wind power's debt to property owners due to reduced property values exceeds SEK 100 billion,[33] which is about as much as the total wind power investments over the eight-year period 2017–2024 and about ten times more than the annual value of the generated wind power electricity. If this SEK 100 billion were to be applied to the total production of wind power electricity over the past ten years (230 TWh), it would mean a cost of SEK 0.43 per kWh in lost property values alone. Add to this the impact on rural industries such as agriculture, forestry, livestock farming and fishing, and the Council's proposed SEK 0.02 compensation does not go very far.

With regard to the cost of balancing power as a result of a sharp increase in wind power's share of electricity generation, the Council agrees with Pär Holmberg's assessment in a background report to the Ministry of Finance.[34] He estimates that if solar and wind power continue to expand strongly, so that the total annual renewable electricity production is up to 240 TWh, they should pay about SEK 0.01 per kWh produced as compensation for the disturbances that increase the need for balancing power. It is insufficient to address such a central system cost with such a limited analysis.[35] The system support for balancing power is already today of the same order of magnitude as the Council indicates for the production cost of wind power. Moreover, this marginal cost increases rapidly with the increasing share of wind power. In addition, as already mentioned, there are large profile and transmission costs.

Both the assessment of the cost of compensating local residents and the cost of the increased need for balancing power seem completely unrealistic and unrelated to existing experience.

How much will electricity demand increase?

The Council estimates that a transition of current industry, transport and other needs would result in an increase in electricity demand of 55–60%, but at the same time they flag that "a further expansion of the steel industry, battery factories and other industrial activities" would create an electricity demand exceeding 300 TWh. At the same time, the actual trend shows that electricity consumption is declining and in 2024 it was the second lowest since 1990 – in 2020 (when economic activity fell sharply due to the pandemic), consumption was 0.1 TWh (0.07%) lower.[36] Important explanations for the development going completely against the forecasts of a sharp increase are that the ongoing transition has resulted in a system that is partly unable to connect new subscribers due to power shortages, and partly has created great uncertainty about the future price of electricity.

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[32] The assessment is based on Lundin, Erik (2024). "Wind ower and the cost of local compensation schemes: A Swedish revenue sharing policy simulation". *Energy Economics*, vol.135, pp. 107632.

[33] Westlund, Hans, and Mats Wilhelmsson (2021). "The socio-economic cost of wind turbines: A Swedish case study". *Sustainability*, vol. 13, no. 12, p. 6892.

[34] Holmberg, Pär (2024). "The Swedish electricity market". Background report to the memorandum "Financing and risk sharing for investments in new nuclear power". Ministry of Finance.

[35] This estimate is at least two orders of magnitude less than the estimates we cited above.

[36] https://www.ekonomifakta.se/sakomraden/elfakta/energianvandning/elanvandning_1208519.html. In 2001, electricity consumption peaked at 150.5 TWh. Since then, the trend has been downward. In 2024, consumption was 134.8 TWh, a 10.4% decline from the 2001 peak.

The Council has great confidence in the market's ability to meet the challenges ahead. Despite the problems already identified, the Council's main track is a massive expansion of wind power and transmission networks. Their main scenario involves an increase in electricity consumption of 67 TWh (p. 103), and they argue that the most efficient way of meeting the entire increase in consumption would be to expand onshore wind power. In that case, 107.5 TWh – 55% of the total – would come from intermittent sources. This means that there would have to be balancing power for more than half of the annual demand through storage, dispatchable power or imports (even hydropower is weather dependent and there can be almost 30 TWh difference between wet and dry years). To our knowledge, there is also no example of a high-income country with such a high share of intermittent power in its electricity system.[37] Countries approaching such a high share of intermittent power generation – e.g., Spain and Germany – have major problems and high costs.

In the case of Germany, the very high and highly variable electricity prices have already led to a discussion regarding the impact of energy policy on the competitiveness of German industry. Swedish industry can be assumed to be considerably more sensitive to high electricity prices, as the industry that has evolved in Sweden has done so to no small extent as a result of access to cheap and stable electricity.

The concept of sustainability remains unclear

The concept of "sustainable development" had its international breakthrough when the United Nations World Commission on Environment and Development (the Brundtland Commission) launched the concept in its report *Our Common Future*.[38] It defined the concept as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Brundtland emphasized that sustainable development is based on three dimensions: social, environmental and economic.

However, in the public debate, sustainable development, renewability and environmental friendliness are often equated, but this is not necessarily correct. Account must also be taken of the fact that the measures advocated are socially and culturally acceptable (e.g., by providing people with a secure livelihood) and economically viable. Thus, neither inexpensive measures that destroy the environment nor extremely costly measures with little environmental impact per dollar invested are sustainable.

Given that the term "sustainable/sustainability" is central to the Council's report – it appears no fewer than 39 times – we would have expected a rigorous definition of the concept, preferably linked to the Brundtland Commission's definition. Since sustainable development is about making decisions on how to use society's resources in order to take account of three aspects at the same time – environmental, social and economic – as effectively as possible, three economists, who are also electricity market experts, would be ideal for carrying out such a socio-economic analysis. Against this background, it is surprising that it remains unclear what the Council means by "sustainable"; the Swedish Consumer Agency does not allow the marketing of electricity as "sustainable", "renewable", "climate smart" or the like.[39] They are undefined and unverified claims and thus misleading.

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[37] Except for small countries like Denmark, whose electricity system can be balanced by interconnection with neighboring countries and does not have a large electricity-intensive industrial sector.

[38] United Nations (1987). *Report of the World Commission on Environment and Development: Our Common Future*. New York, NY: United Nations.

[39] Edlund, Ulrika (2020). "Marketing of electricity contracts by virtue of environmental claims". Dnr 2020/1301, Karlstad: Swedish Consumer Agency.

What happened to the sustainability aspects?

The motive for a 'sustainable' transition has not been the cheapest possible electricity, yet it is almost exclusively the lowest cost that is discussed. But compared to nuclear power, wind power lacks several crucial system characteristics. It does not contribute to system function, produces higher carbon emissions ,[40] has a much worse energy sustainability,[41] increases the need for non-renewable resources tenfold (in particular the need for strategic metals)[42] and requires vast areas of land. The environmental consequences of wind power are great with problematic noise emissions,[43] negative impact on biodiversity as well as large amounts of environmentally hazardous waste and the spread of toxins and nanoparticles in the local environment.[44] The Swedish National Audit Office criticizes that there is still a lack of both planning and reserved funds for the management of environmentally hazardous waste from solar and wind power development.[45] Hence, industrial wind power conflicts with most Swedish environmental goals.

The Council should have asked itself whether it is reasonable to advocate a large-scale expansion of technology that contains environmental risks that are not yet fully clarified. Despite the fact that the precautionary principle of the Environmental Code regulates this matter and that the risks have been pointed out to agencies and environmental courts for more than a decade, they have largely ignored the problems.[46] It is hard not to wonder why the authorities seem to take the precautionary principle so lightly in this particular area compared to how it is applied in so many other areas. However, the agencies concerned have been instructed to promote an

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[40] Vattenfall (2018). "Life cycle assessment – Vattenfall's electricity generation in the Nordic region". Stockholm: Vattenfall. Ask, Per (2025). "The dark side of solar power". *Kvartal*, March 25.

[41] Weissbach, D., Ruprecht, G., Huke, A., Czerski, K., Gottlieb, S., and Hussein, A. (2013). "Energy intensities, EROIs (energy returned on invested), and energy payback times of electricity generating power plants". *Energy*, vol. 52, pp. 210–221.

[42] Department of Energy (2015). "Quadrennial Technology Review – An Assessment of Energy Technologies and Research Opportunities, Chapter 10: Concepts in Integrated Analysis". *Quadrennial Technology Review,* September Washington, DC: US Department of Energy. IEA (2021). *The Role of Critical Minerals in Clean Energy Transitions* . Paris: International Energy Agency.

[43] For an early study, see Kampanis, Nikolaos A. and John A Ekaterinaris (2001). "Numerical prediction of far-field wind turbine noise over a terrain of moderate complexity". *System Analysis Modelling Simulation*, Vol. 41, No. 1, pp. 107–121. For a recent high-quality study, see:

Garcia Forlim, Caroline, Leonie Ascone, Christian Koch and Simone Kühn (2024). "Resting state network changes induced by experimental inaudible infrasound exposure and associations with self-reported noise sensitivity and annoyance". *Scientific Reports*, vol. 14, no. 1, pp. 24555.

In Sweden, Uppsala professor Ken Mattsson has carried out measurements of noise at Swedish wind turbines. He reports on his research in this Youtube lecture in Swedish: https: "The dark secret of wind power – with Ken Mattsson". The main results of the research are reported in Mattsson, Ken, Christian Steinbeck and Hans Kindstrand (2025). "Wind power is noisier than you think". *Kvartal*, February 26. Mattsson's scientific report is currently undergoing *peer review*.

[44] Karlsson, Helen (2024). "Wind power and health problems: The state of research on the effects on humans and animals of exposure to noise pollution, chemicals and particles from wind turbines". In Magnus Henrekson (ed.), *De norrländska stålsatsningarna – frälsare eller gökunge?* Stockholm: Samhällsförlaget.

[45] Lindberg, Helena, and Fredrik Engström (2023). *End-of-Life Photovoltaic Panels and Wind Turbine Blades – Government Efforts for Effective Management*. RiR 2023:11. Stockholm: Swedish National Audit Office.

[46] From Chapter 2. Section 9 of the Environmental Code (our own translation): "An activity or measure may not be conducted or taken if it entails a risk that a large number of people will have their living conditions significantly impaired, or the environment significantly deteriorated."

increase in solar and wind power. Moreover, the environmental impact assessment, which forms the basis for the County Administrative Board's permit decision, is not based on its own disinterested assessment, but on the developer's submitted assessment.[47] It is thus *not* made by independent experts and not based on the best available knowledge. The licensing authority, the County Administrative Board, is tasked with promoting increased wind power and its interpretation of statutory consultation with those affected by a wind power industry does not imply the obligation to answer questions or respond to errors or alleged violations of the law.

The SNS Economic Council's recommendations are weakly substantiated

Further expansion of wind power must be considered in the light of its overall impact on system stability, costs and environmental objectives. The share of wind power is now 25%, which is already too high. The cost structure and external effects of wind power should be analyzed more comprehensively in order to determine its long-term socio-economic value. Instead, investment in nuclear power should be strengthened and diversified and, in the short term, supplemented with gas power in the south of Sweden. Gas power plants can then provide back-up power when nuclear power development has caught up

On a misleading basis, the Council advocates extensive expansion of wind power in Sweden. The analysis is based on a market model which in turn is based on assumptions of low costs, large-scale value creation and limited negative effects. Sweden's electricity market policy must be based on actual empirical experience, not on wishful thinking. Why invest more in a power source that, with its current market share, already causes significant system costs, is unable to create value that covers its costs, increases carbon emissions and the use of non-renewable resources, requires large areas of land and can impact significantly on local ecosystems, biodiversity and the habitat of animals and humans in the vicinity of the plants? The three authors comprising the Council have either no or unsatisfactory answers to these crucial questions.

The conclusions we have drawn regarding the SNS Economic Council's analyses and conclusions also apply to other reports that advocate a rapid expansion of weather-dependent power sources and thus a continued sharp increase in the share of intermittent electricity.

[47] According to the stipulations in Chapter 6 of the Environmental Code, an environmental impact assessment must be carried out by the operator, i.e., the person applying to construct a wind farm or to conduct any other environmentally hazardous activity. In Sweden, unlike many other countries, there are no independent government agencies or other bodies that carry out their own environmental impact assessment and make decisions based on it. Instead, the licensing authority (the County Administrative Board and the Environmental Court [*mark- och miljödomstolen*]) must decide whether the operator's environmental impact assessment meets the statutory requirements.