Launch: Nordic Clean Energy Scenarios

07.09.21

Audience questions via Slido (1-36)

Questions for Nordic Energy Research

1. *Is there a link to view the results / figures online?*

- Yes, you can review the entire report via NERs project page: https://www.nordicenergy.org/project/nordic-clean-energy-scenarios-solutions-for-carbon-neutrality/

  // Nordic Energy Research

2. *Will the presentations be distributed after the seminar? Will it be possible to download the report in pdf-version?*

- Presentations shown at the launch event at the project webpage: https://www.nordicenergy.org/project/nordic-clean-energy-scenarios-solutions-for-carbon-neutrality/.
- Report in pdf-version: https://pub.norden.org/nordicenergyresearch2021-01/nordicenergyresearch2021-01.pdf

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Questions addressed to panellists

3. *All: What do you think are the main barriers to reach carbon-neutrality in the Nordic region, in each of the three scenarios?*

- Infrastructure related to direct electrification (grids, charging, wind power) and acceptance for that infrastructure (in particular, if we go for high use of PtX) are key questions in all scenarios. Stimulating and planning for changed behaviour is politically difficult but has great potential and carries many benefits besides climate change.
  // Markus Wråke

4. *All: What clean energy resources have significant potential to play a part of the global energy mix and how feasible is it that they'd reach their potential?*

- The NCES project is, of course, focused on the Nordic system, and here hydro, bioenergy and wind will play the biggest parts in terms of total energy supply. All three of those have higher technical potentials than what is used in the NCES scenarios. Partly this is because we do not need more, but here are also other factors like public acceptance and local environmental impacts that are likely to limit their deployment.
  // All

5. *Markus: I believe that one important factor to take into consideration is the carbon budget. Is the transition fast enough to stay within the limits?*

- In fact, we decided against defining a fixed carbon budget for the Nordic region, and instead use the country targets as the boundary conditions for the analysis. As the report shows, these targets are indeed possible to meet, which in turn would make the Nordic region carbon neutral by 2040. There is an extensive discussion around why we decided against a carbon budget in the report. Depending on how you choose to set key parameters, to include moral and political considerations, you get different carbon budgets. Thus, even though a carbon budget is relevant at the global level, it is harder to define at the regional level. However, if you wish to explore how a Nordic carbon budget can be set, there is a calculator on the project page that you can use to try different assumptions and their effects on a Nordic carbon budget. https://www.nordicenergy.org/project/nordic-clean-energy-scenarios-solutions-for-carbon-neutrality/
  // Markus Wråke

6. *Markus: Study of L. Catalist showed that H-production by nuclear is cost-effective. Why your electrification scenarios foresee very low share of nuclear?*

- This is primarily driven by our cost assumptions – it is cheaper to produce electricity from new wind than from new nuclear. However, in most of our scenarios it seems cost effective to extend the lifetimes of several of the existing reactor fleets, and in a very high electricity demand scenario it may even be interesting to invest in new reactors. Should the expansion of wind power be limited, for instance by higher costs than expected or public resistance, things could change. The report contains a focus section on Swedish nuclear (Annex B), that quantifies the effects of limiting or expanding nuclear beyond the base scenarios.
  // Markus Wråke

7. *Markus: In the high PtX scenario, the share of plannable production is very small. This will lead to a very unstable energy system. PtXtP is very inefficient!*

- We have tried to capture this in our modelling, and the analysis shows that the combination of flexible hydro and electricity trade, and to a lesser extent flexible demand and coupling of the heat and electricity systems goes a long way to handle this. We do not rely on using hydrogen to produce electricity as a big flexibility resource. There are detailed aspects that we have not analysed, such as frequency stability, but it seems unlikely they would make showstoppers in the scenarios.
  // Markus Wråke

8. *Markus: What is the share of blue and green hydrogen in the Nordic hydrogen production in 2050?*

- Steam reforming and blue hydrogen are included in ON-TIMES, but we do not see it coming in, as it still has some emissions and, therefore, makes it harder to reach GHG neutrality. In chapter 8, we discuss the business case for exporting both green and blue hydrogen from the Nordic countries to continental Europe. Specifically, we look at a case where the Nordics export about 200 TWh of green hydrogen and 100 TWh of blue hydrogen, so 2:1 in that case.
  //Markus Wråke and Kenneth Karlsson

9. *Markus: Have you looked into land use requirements for the massive build out of on-shore and off-shore wind towards 2050?*

- No, not explicitly. However, the assumptions on wind potentials implicitly include these factors. It should be noted that in most of the scenarios in the report, the density of Nordic wind power, in terms of MW/km2, is lower than what is *currently* the case in Germany.
  // Markus Wråke

10. *Markus: Battery technology has come a long way in terms of energy density, but end-of-life remains a question mark. Are the Nordics advancing on this front?*

- This is not my expertise, but I know that there is activity in this area. From a general standpoint I think it is likely that as volumes of batteries increase, so do the business opportunities to reuse the materials.
  // Markus Wråke

11. *Markus: Does electricity demand in heavy industry include increased demand for hydrogen?*

- No. Electricity for hydrogen and other PtX fuels is included in the "Upstream" or PtX categories in our graphs.
  // Markus Wråke

12. *Markus: What are the associated energy prices especially electricity prices to consumers in the scenarios.*

- We have assessed the impact on wholesale electricity prices and the short story is that we see low or no increase in Nordic prices, and the same seems likely also at the level of individual price areas. There will be times of the year and in some price areas where price variations will increase, and we have not analysed that in detail. Average prices for consumers are unlikely to be a dealbreaker.
  // Markus Wråke

13. *Markus: Should the Nordic Countries jointly design and perhaps even publicly construct CO_2 transport and storage infrastructure?*

- Yes, good point. In fact, we see this as one of the great opportunities for Nordic collaboration and synergies. As the economies of scale and potential benefits of common strategies and shared infrastructure are large, this should be a priority for Nordic co-operation.
  // Markus Wråke

14. *Markus: Shall we use ccs as an alibi for continuous use of fossil fuels?*

- No. In fact, 90% of carbon captured in the NCES scenarios come from bioenergy sources.
  // All

15. *Markus: What about the reuse of the energy loss (heat) from hydrogen production?*

- Our scenarios contain significant use of that heat, for instance for space heating. The location of electrolysers will be important, as using district heating networks is a very efficient way to distribute heat.
  // Markus Wråke

16. *Kenneth: Why exactly do we need negative emissions from 2026 and accelerating to 2035, is it so much cheaper? Is that for all Nordic countries?*

- The situation is different from country to country. Iceland and Denmark have a need for negative emissions to reach GHG neutrality as both countries have large emissions from land-use, which can only be counter-balanced by negative emissions. In Norway, Sweden and Finland, negative emissions are mainly used for compensating heavy industry. This is because the BECCS option is cheaper than using green fuels in these heavy industries.
  // Kenneth Karlsson

Other questions

17. *Results from this year's study noticeably differ from a similar project 5 years ago. Can we draw any common conclusions to make the energy transition coherent?*

- Fair question, and yes, I think we can. The core messages, e.g., about the feasibility of the transition, the importance of electrification and infrastructure related to that, and the benefits of energy efficiency, are very robust. This report, compared to e.g., NETP 2016, explicitly recognises the importance of non-economic factors in which pathways are attractive, which can help illustrate to decision-makers the impact of different choices.
  // All

18. *Which life cycle perspective is applied to efficiency improvements of transport? From oil well to km of transport? Or from produced electricity to kms?*

- As we include the upstream sector in ON-TIMES, energy consumption and emissions linked to the production of fossil and green fuels are also included. However, upstream impacts from imported fuels to the Nordics are not included.
  // Kenneth Karlsson

19. *Would like to ECO to energy efficiency and energy management question below. How do we increase the knowledge and monitoring of actual energy consumption?*

- Large energy users already pay a lot of attention to energy consumption and energy efficiency, as that is a considerable cost in their operations. However, energy might amount to a much smaller cost for most users, and there are several reasons blocking energy efficiency investments, e.g., different payers of the investment and the energy bill, which is the case of all rental apartments and commercial buildings. In addition, many consumers have flat monthly rates, which do not benefit from real time monitoring. A few measures to increase the awareness in residential sector are apartment specific measurements of energy consumption, distribution of free consumption meters – as some utility companies do – and many more listed in national energy efficiency strategies.
  // All

20. *Electrification and decarbonisation Nordic region is less challenging with hydro, wind resources, biomass (plenty land), summer sun, nuclear friendly Finland.*

- Yes. The Nordic region is in a good position to reach carbon neutrality. As our NPH scenario and the cases with high demand for PtX-fuels in Europe show, there are also tremendous business opportunities in this area.
  // Markus Wråke

21. *Do you consider only batteries or also contact wire solutions when talking about the electrification of trucks?*

- We have included electric roads in our analysis. We believe it is likely that a combination of battery technologies and electric roads will be the way to directly electrify heavy trucks.
  // Anders Kofoed-Wiuff and Kenneth Karlsson

22. *Finland and another country had a much lower baseline for transportation than Denmark and the higher countries – how come?*

- We have relied on the official transport demand forecasts from each country's transport agency. Only in the Climate Neutral Behaviour scenario did we alter these assumptions to reflect a different pathway. The reason for the differences is found in how each transport agency has done their forecasts. There is a lively discussion about the importance of these forecasts, for instance in planning of infrastructure. As we show and discuss in the report, there would be large benefits from a more limited transport demand than what our base scenarios contain.
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23. *Hydrogen economics- what about the other benefits such as system integration, social and energy security etc.*

- This is one reason why we analysed scenarios with higher use of hydrogen than what our least cost scenario (CNN) indicates would be cost effective. Some of these benefits can be quantified and modelled, such as making use of waste heat from hydrogen production, while others, such as energy security or strategic business decisions in multinational companies, are harder to capture explicitly. Although we focus on climate and economic benefits, we have taken other potential advantages into account to the best of our ability.
  // Markus Wråke

24. *What is driving the Very high PtX-scenario? For what is the PtX produced used mainly?*

- In the Nordic countries, shipping is where PtX-fuels are most critical, followed by aviation. In some scenarios, we have also included substantial demand for hydrogen in the iron and steel sector, motivated by ongoing plans for that technology in Sweden, although this is not obviously the cheapest solution to decarbonise that sector, as CCS looks competitive. We also see significant potential in using green hydrogen to replace fossil hydrogen as a feedstock in the chemical industry.
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25. *How do you see the competition situation between synthetic fuels (maybe manufactured with BECCU) and biofuels?*

    This is a close race in our modelling, with both synthetic fuels and biofuels being present in substantial amounts in all scenarios. In general, biofuels are likely to have a minor cost advantage, but the potential is limited by biomass supply and competition for biomass from other uses. Hence, there is a need for both solutions. It should be noted that the current EU policy signals may change this, as there is a strong push for the hydrogen pathway while restrictions to Nordic forestry may imply higher biomass costs and/or lower biomass supply.
    // Torjus Folsand Bolkesjø

26. *How did you define sustainable biomass?*

We used the potentials reported in Pöyry and Nordic Energy Research. (2019). Potential for Bioenergy in the Nordics. Available at: https://www.nordicenergy.org/publications/potential-for-bioenergy-in-the-nordics/ These potentials consist mainly of residues from forest industries, in addition to some agricultural biomass and waste. In the scenarios, the modelled bioenergy production is lower than these defined potentials. As such, economic competitiveness limits the use of biomass for energy. In the analysis of the role of bioenergy, it is important to remember that biomass is far from limited in its potential, and the use of biomass for energy may conflict with other eco-system services, as well as competition with other industrial uses of wood. For these reasons, we limited forest biomass potential to residues.
// Torjus Folsand Bolkesjø

27. *PtX scenarios fig 4.1 estimates cost of el. at 30 EUR/MWh in 2030. Why such a low cost? A Thema Consulting report expects offshore wind at 40-60 EUR/MWh 2050.*

In our standard assumptions, we are more optimistic with respect to the cost development of offshore wind. We arrive at a levelized cost of electricity for a typical site of about 35 €/MWh by 2050. Moreover, the PtX scenarios explore two cases with even more favourable conditions for renewable energy generation in the Nordic countries. The High and Very High PtX cases include more favourable conditions for siting onshore wind in the Nordic countries, lower cost of offshore wind everywhere, and allows for trading of PtX fuels between countries. The lower cost of offshore wind in the scenarios could result from either technological improvements or support from governments that favour RE deployment to take place offshore (for example, by having the TSO or government pay for the grid connection).
// Anders Kofoed-Wiuff

28. *Everyone is obsessed with zero or neutral carbon emission, but the question is how do we monitor going to zero carbon emission?*

- The official energy balances that are reported to Eurostat and the International Energy Agency, combined with other national statistics, give a robust picture of national carbon dioxide emissions. Also, there is an internationally agreed standard on how to report greenhouse gas emissions to the UNFCCC that the Nordic countries have signed up to. We do not cover monitoring, reporting and verification directly in the report, but one of the deliverables of the project was a database of Nordic energy indicators, that can also be used to track emissions. The database can be accessed through the project webpage: https://www.nordicenergy.org/project/nordic-clean-energy-scenarios-solutions-for-carbon-neutrality/
// All

29. *There is a lot of discussion on sustainability of biomass, but what about a subsequent discussion on ensuring the sustainability of batteries/electrification?*

- Indeed, there are concerns over how materials for batteries are extracted, and the resource efficiency of infrastructure development more broadly. The sustainability of the lifecycle of a battery, including both sourcing and recycling of materials is a critical part of the pathway to carbon neutrality. However, the NCES project has not addressed these aspects, and worked off the assumptions that materials can be sourced and recycled in a sustainable manner.
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30. *How robust is the finding about electric solutions being most cost-effective also for trucks? What is needed for other solutions to be more cost-effective?*

- It seems robust, particularly for lighter trucks, but still less certain than the development for cars and light duty vehicles. Direct electrification of heavy trucks relies on continued improvement and cost reduction of battery technologies (see the NCES technology catalogue for the assumptions used), as well as the roll out of charging infrastructure and associated electricity grid strengthening. If these developments proceed slower that we anticipate, biofuels are the most likely alternative. Biofuels are already used extensively in Nordic trucks and will likely play an important role over the coming 10-20 years, to phase out fossil fuels. Hydrogen fuel cells could also be an option, if the rest of the EU spends significant resources expanding distribution and other infrastructure to enable hydrogen for transport. To some extent, there could be parallel systems for direct electrification, biofuels and hydrogen, but at some point, it is likely that one of the three solutions will dominate. The NCES analysis indicates that direct electrification is the most likely of these three.
  // Markus Wråke and Anders Kofoed-Wiuff

31. *Any report on the carbon footprint of CCS solutions against CCS benefits?*

- CCS technologies are a known solution that can be scaled up, with a focus on storing CO_2 instead of using it in industrial processes. There will be a GHG footprint from construction of facilities and transporting the CO_2 around – but this will likely be minor compared to potential stored amounts. However, we have not found any report analysing this.
  // Kenneth Karlsson

32. *Have you considered (and if yes, how?) spatial constraints for the development of the energy infrastructure (RES and grids), which would influence social acceptance?*

- Not explicitly. However, the assumptions on technology potentials implicitly include these factors. For instance, the modelling constrains how quickly and to what level the electricity grid, including international interconnectors, can be expanded, based in part on factors such as permitting time and social acceptance.
  // All

33. *Can new transmission lines (maybe not accepted by public) be substituted by smart grid connected energy storage?*

- Yes, to some extent. More generally, a higher degree of integration of the energy system, including storage but also demand side flexibility and sector coupling between heat and electricity can decrease the need for both supply-side flexibility and new transmission lines. In NCES, we have made general assumptions on these factors, but not modelled it in detail.
  // All

34. *By what factor do we need to increase our total renewable energy production by 2030 and then by 2050 (2019 baseline)?*

    If we look at total primary energy consumption, the renewable energy share increases by a factor 1.5 in energy units, but this might not give the right picture, as wind and solar have an almost 100% conversion efficiency. If we look at the energy delivered from renewables, biofuels increase by a factor of 1.1 from 2020 to 2050, hydropower by 1.07, solar PV by 42 and wind by 4.8. If we look at installed capacity for wind and solar in particular, the factors are respectively 15.7 and 19.2.

// Anders Kofoed-Wiuff

35. *What shares of the electricity demand from hydrogen do you forecast to be flexible (PEM) and inflexible (alkaline)?*

    In the modelling, we have not distinguished between PEM and alkaline electrolysers. Moreover, the most refined time resolution we apply in the modelling is hourly time-steps and at scale, PEM can be considered highly flexible. There is a description of regulatory factors regarding different types of electrolysers in the Danish Energy Agency's technology catalogue for renewable fuels, see p. 99
    https://ens.dk/sites/ens.dk/files/Analyser/technology_data_for_renewable_fuels.pdf
    // Markus Wråke

36. *I would support the question in relation to monitoring and reporting on energy consumption. How can we better define the role that smart grids can play?*

- Smart grids promise advanced metering, improved load control, better integration of variable production, and better efficiency in general. Smart grids are actively researched in Nordic countries, see e.g. Norwegian and Swedish smart grid centres (https://smartgrids.no/, https://www.kth.se/swegrids), Finnish real life test environments (https://www.businessfinland.fi/en/do-business-with-finland/explore-key-industries/energy/smart-grids), and Danish smart grid strategy (https://ens.dk/sites/ens.dk/files/Globalcooperation/smart_grid_strategy_eng.pdf). Each has defined their approach and next steps differently.
  // All