

Norway's Role in the European Energy Transition

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Abstract

The EU has high ambitions for its clean energy transition. Reducing yearly CO₂ emissions by 80% until 2050 requires large-scale implementation of renewable energy technologies and likely a large-scale electrification of non-energy sectors such as transportation. A major challenge imposed by renewable energy supply is the uncontrollable and intermittent nature of generation. Large flexibility volumes and capacities are needed to manage an energy system with high shares of renewables. Norway, with a large hydropower base and flexibility potential in its offshore natural gas transmission grid, can support the EU clean energy transition by providing much needed flexibility and controllability. This will require expansion of hydropower production and transmission capacity as well as altered management of gas export pipelines. To make these flexibility options available, market participants must be incentivized by new market designs and instruments that place higher value on flexibility and controllability.

Keywords

energy transition; renewable intermittency; Norway-EU relations; hydropower; natural gas line-pack

Introduction

Norway is well positioned to facilitate and support Europe's transition to a sustainable energy future. In contrast to most other countries in Europe, Norway is a net exporter of energy and its domestic electric power system is largely based in renewables. The characteristics of Norway's energy supply system allow it to be a valuable and reliable partner in meeting the EU's long-term energy and climate goals, specifically in development of a clean, secure, and efficient energy system.

Norway's special situation is due to its abundant energy resources in hydropower and petroleum, and its excellent conditions for wind energy. In an average year, over 99% of Norwegian electricity production is renewable. The renewable supply share in Norway is close to 67.5% of gross final energy consumption, which meets Norway's 2020 target according to the RES directive.

Seemingly well positioned to adhere to climate and emission reduction commitments, Norway faces challenges and opportunities as part of the global transition to a low carbon future.

- Gas production after 2050 will depend on Carbon Capture and Storage (CCS) becoming a success.
- Until 2050, gas may have a role regardless of CCS, because it provides flexibility to the system.
- Average electricity prices in Europe have been low as a consequence of RES subsidies and low EU-Emission Trading System (ETS) prices. This has reduced incentives to invest in new (renewable) generation capacity and has deterred investment in CCS technology and pilot projects.
- Most of Norwegian hydropower and natural gas exports are sold in *energy only* markets, while the supply chains of both energy carriers have great intrinsic *flexibility*, which could be of much higher value both to the European energy system and to Norwegian market participants.

In the upcoming sections, we provide a context for Norway's role in the European energy transition by discussing main drivers of the transition, we then suggest potential roles for Norway in this transition and provide recommendations on how these roles could be facilitated.

Drivers in the European clean energy transition

The electricity sector plays a major role in the transition of the European energy system. A key factor in this transition is the substitution of polluting fuels in industry, transport, power production, and heating sectors with carbon-free electricity. Electrification of all these sectors puts upward pressure on the total demand for electricity, while at the same time, emissions linked to its generation should be reduced to virtually zero over the period until 2050. Although challenging, this transition is likely to succeed because of:

- The increasing RES share, providing clean energy at a very low marginal cost (albeit wind and solar have low controllability of generation in contrast to hydropower, fossil, and nuclear generation).
- Energy efficiency improvements, zero emission neighborhoods, and zero energy buildings, all of which drive towards lower energy needs to provide the same level of services to households and other sectors. Therefore, both total energy demand and peak demand levels will be reduced, which in turn decreases the need for capacity in the power transmission grids. Future electricity systems will tend more towards distributed generation and usage rather than the traditional large-scale centralized generation and transmission grids.
- Renewed focus on the customer. As a direct consequence of the high penetration of uncontrollable RES, a renewed focus has been put on consumer flexibility and measures to allow consumers to actively participate in the market and balancing of resources (c.f., the EU winter package of Nov 2016). Again, less centralization and more distributed control is in focus. Still, current policy and market structures focusing on *energy only* pricing and centralized systems (e.g., capacity payments; TSO-managed primary, secondary, and tertiary reserves) do not adequately incentivize prosumers, active consumers who self-generate and/or store, and deliver local flexibility.
- The phase out of fossil fuels, which is a direct consequence of the EU-ETS quotas and subsidies for renewables. Low average electricity prices combined with a moderate CO₂ price has partially crowded out fossil fuel-based electricity. As CO₂ prices rise - which must occur in a cost-efficient policy environment - this crowding-out effect will continue. A critical question however, is whether active consumers and (local) storage alone can substitute the positive features of coal and gas-based electricity generation. These types of power generation can be planned and controlled, and in particular, gas-fired generation can be up or down regulated very rapidly, providing great flexibility to the electricity system at large.
- More dynamic and integrated management of energy carriers, and substitution between them, to provide flexibility. This is a distribution aspect, since heat is produced and managed locally, but it is often linked to natural gas and electricity infrastructure with both central and local relevance.
- Heating based on hydrogen, possibly mixed with natural gas. This also links the local and central energy systems and makes energy system integration more important.
- Low / zero emission transport. The non-quota sectors (sectors not included in the ETS) have to reduce emissions by 30% by 2030 according to EU policy. The transport sector is likely to account for a major part of that reduction. It is expected that a mixture of hydrogen, electricity, and biofuels will enable this. For personal cars, electrification is promising (although not the only option); whereas, for large commercial vehicles, ships, and aircraft, a major role for hydrogen and biofuels is very likely. (This connects several sectors and options as hydrogen can be produced via electrolysis with (clean) electricity but also with biofuels or natural gas with CCS).
- Carbon capture and storage. In the future energy system, CCS can have a large role. If successful, in terms of acceptance, costs, and commercializing infrastructure, it will enable centralized generation infrastructure to continue to play a role in an electricity system with a more distributed nature, providing flexibility and controllability. In some industry sectors (such as metal smelting

and cement production) CCS is the only option for preventing CO₂ emissions, which increases the likelihood that CCS technology will be developed.

- The Paris Agreement. Signed and ratified by a large majority of the countries in the world underpinning the international commitment to reduce Greenhouse Gas emissions.

Norway's possible role in the European energy transition

Norway's hydropower reservoirs are very flexible and clean energy resources that can facilitate both the transition to and the operation of a European-wide clean energy system. The same is true for Norwegian natural gas resources and its offshore transmission grid, which, when combined with CCS, can continue providing clean base-load energy supply while a modified operation of the offshore gas grid would open up a large controllable flexibility source.

Considering hydropower: Yearly average Norwegian hydropower generation of about 135 TWh is larger than average domestic electricity consumption. Although future generation surpluses (from hydro and new wind power generation) will allow for significant exports, the transmission cables will be used to exploit price differences in the energy markets *in both directions*; major imports will occur frequently. This is mostly due to the main strength of the Norwegian power system: its flexibility. In contrast to most other power generation technologies, hydropower generators can be rapidly up and down regulated at a low cost. For example, in low demand periods consisting of a few hours, Sweden may prefer not to turn off thermal or nuclear production, but rather export its surplus to Norway. Similarly, in periods of high wind-power generation, Denmark can export its surplus to Norway. In opposite situations they can both import from Norway to cost-efficiently balance their domestic markets.

In today's power markets, most of such international exchange is based on hourly price differences only. This does not reflect the inherent value of the flexibility provided in periods with low power generation in Europe. Going forward, the Norwegian Water Resources and Energy Directorate has estimated that Norway has the potential to provide additional balancing capacity of 20 GW by 2030. (Which is in the order of 10% of the EU-wide needs *by 2050*.) The needed increase in Norwegian production capacity is about 65%, which will cover a significant part the EU's balancing needs in the future renewables-based energy system. Unfortunately, today's markets do not incentivize investments in capacity extensions needed in the generation and transmission grids. Given that energy prices are expected to remain low, there is a need to

- (continue to) develop cross border capacity markets in the power sector, incentivizing long term capacity expansion and reducing long-term risk for investors;
- (continue to) develop cross border balancing products and markets for these, providing price signals that both lead to more efficient resource utilization in the short run and incentives for capacity expansion;
- introduce long term contracts for flexibility, that would deviate from capacity markets in that they explicitly regulate flexibility provisions. This would reduce investment risk and incentivize the building of hydroelectric production capacity and power transmission cables.

With such incentives, additional balancing capacity would be invested to facilitate much higher RES penetration in Europe by making a large amount of flexibility and controllability available.

Considering natural gas, in a transition phase, the Norwegian supply system could provide the same type of flexibility and controllability as the hydropower system, facilitating the phasing out of coal-based power generation in the continent and providing the flexibility to manage the intermittent RES. In present day markets, Norwegian gas exports to the United Kingdom, Germany, Netherlands, Belgium, and France are used and priced as *energy deliveries*. We suggest that gas market designs and products that explicitly value flexibility and controllability rather than energy content be established.

In fact, natural gas pipelines can offer a lot of *flexibility* using different pressure levels to vary the *line-pack*, the actual amount of gas in the pipelines. This means that pipelines can in practice function as storage to balance supply and demand in relatively short horizons from hours to a few weeks. This matches very well with the flexibility needs to manage short-term load variation and intermittency in solar and wind. To sketch the potential, the capacities of the six Norwegian gas export pipelines are between 20 and 41 GW and sum up to 178 GW. Anticipating that future base-load flows will be significantly lower than today, the line-pack in the total pipeline system provides an enormous, and as of today, untapped flexibility potential in the same order of magnitude as the future EU market needs. Currently the Norwegian TSO lacks the incentives to move away from a purely gas grid security focused management to a broader value-based management of the gas grid.

For natural gas to be a sustainable fuel that can contribute to electricity generation in the future energy system, CCS needs to come into play. Studies by the International Energy Agency and the Norwegian Zero Emissions Platform show that developing CCS can save billions of dollars. Thus far, the main hurdles for CCS to succeed have been technology cost and social and political acceptance. Norway has a lead role in CCS technology development. It has a rather stringent CO₂ policy, especially on the continental shelf, which incentivizes CCS. More than 1.5 million tons of CO₂ are annually stored in connection to three oil and gas production fields. Additionally, Norway is putting in place a value chain for capturing and storing an additional one million tons per year by 2020. As part of this, three large industries will develop large-scale CCS facilities. Another development was announced in July 2017. Nuon, Gasunie, and Statoil intend using hydrogen as an input fuel for a power plant in the Netherlands. Removing and storing CO₂ from natural gas at the production location, and transporting pure hydrogen to the power plant, will establish a near zero-emission electricity value chain. If these efforts succeed, a next step will be to develop a wider European infrastructure for CCS.

Conclusion

Managing intermittency and uncontrollability are two main challenges for the future energy systems with high levels of RES. Norway can greatly support the transition to and operation of the future clean European energy system using its hydropower and natural gas resources. However, today's markets do not value the flexibility and controllability aspects of Norwegian energy, they merely price the energy value.

To incentivize investment in transmission and generation and the willingness for market participants to make flexibility services available so that Europe can optimally benefit from the Norwegian flexibility and balancing potential, measures and market instruments are needed. These include:

- (cross-border) products, services, markets, and contracts for flexibility, balancing, and capacity, which provide both long-term risk reduction, investment incentives, and short term efficient resource utilization and security of supply;
- a European infrastructure for CCS (most probably with offshore storage, in the North sea);
- an integrated perspective on the European energy (not just electricity!) system recognizing the need for both distributed solutions like storage, demand response, energy substitution and centralized solutions like hydro power, transmission grid, and natural gas;
- a continued dialogue between the EU and Norway to align perspectives and coordinate activities concerning the design and operation of the future European clean energy system and the role of Norway therein.

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