Norway´s role as a flexibility provider in a renewable Europe

Many scenario studies describe the development of the European power system until 2050. They all include a large increase in power generation from renewable sources such as wind and solar, in line with the EU's ambitious energy and climate change objectives: To reduce greenhouse gas emissions by 20%, rising to 30% if the conditions are right, to increase the share of renewable energy to 20% and to make a 20% improvement in energy efficiency by 2020. These objectives are commonly referred to as the "EU 20-20-20" program. Furthermore, the European Council has also made a long-term commitment to reduce carbon emissions by 80-95% cuts in emissions by 2050.

Due to the variability of wind and solar power, we will see larger variations in power generation over multiple time scales including minutes, hours, days, weeks and seasons, and more balancing capacity is needed to ensure a stable and reliable power supply. Even though the renewable sources in Europe will be able to replace large amounts of fossil energy, scenario studies indicates that we will see periods from hours to several weeks with large amounts of deficit energy, and similar periods with large amounts of surplus energy.

This report examines possibilities for Norway to provide Europe with flexibility services and in particular balancing energy used to smooth the variations caused by power production from variable renewable sources.

In the ongoing research project LinkS (Linking Global and Regional Energy Strategies) we have studied the future energy mix in Europe under several global scenarios with different ambition levels for European and global climate policy. The various scenarios show alternative paths for the development of renewable and environmentally friendly energy in Europe, energy efficiency and the resulting energy demand in the power sector:

- Global 202020 scenario – where we assume that the rest of the world adopts the three policy targets in the European 20-20-20 program but at different points in time
- 450 ppm stabilization scenario – a 450 ppm CO_2 equivalent concentration at the end of the century is generally taken to be consistent with limiting global mean surface temperature change to two degrees centigrade with more than 50 per cent likelihood. However, in this scenario CO_2 equivalent concentrations are allowed to temporarily rise above the 450 ppm limit before being reduced again.
- 650 ppm stabilization scenario – a less demanding climate scenario corresponding to a four degrees temperature increase by the end of the century. CO_2 equivalent concentrations are not allowed to exceed this limit during the century.

The installed generation capacity in Europe in 2050 in these scenarios is shown in Figure 1.

This is an executive summary for the position paper

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prepared in cooperation between:
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Balancing power from Norwegian hydropower

All the scenarios we examined show a potential for storage and flexibility services both between hours within a day, from days to weeks and between seasons. The patterns depend on the renewable energy share in Europe and on Europe's energy policy. For example the patterns within a day are more pronounced when the share of Renewable Energy Sources (RES) is high (see Figure 3). The existing Norwegian flexible hydropower system seems well able to cope with this variation, mainly due to the large storage capacity of 85 TWh in the Norwegian reservoirs. This storage volume has most of the time at least 10-20 TWh free capacity (see Figure 2).

In addition to the flexibility in the existing system, there is a large potential to increase the installed capacity in the Norwegian hydropower system without any additional reservoirs or new developments in unregulated rivers.

Studies performed by CEDREN on the potential for large scale balancing power have a particular focus on the need for wind and hydro balancing on time scales between one day and a season. Scenarios for wind production in the North Sea area from the EU-project Tradewind where used to examine the need of balancing when almost 100 000 MW of intermittent wind power is combined with increased capacity in Norwegian hydropower. The main balancing needs occur due to variability of wind on a weekly scale, with periods of high and low wind, typically from a few days up to a couple of weeks. The need for storage to balance the weekly wind variability could be in the order of 5 TWh or more. This could be achieved by using Norwegian hydropower reservoirs and Pumped Storage Hydropower (PSH) for balancing. More than 20 000 MW of potential for PSH or capacity increase in the Norwegian system have been identified. It will be necessary to build new PSH or to increase capacity in existing plants, but there is no need to build new reservoirs. All balancing will be used within existing reservoirs and existing operational limits of the reservoirs, which lead to less environmental impacts and social conflicts, compared to the construction of new reservoirs.

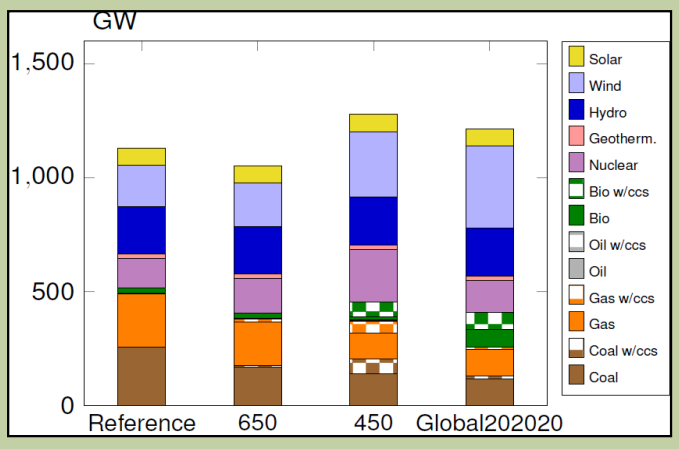


Figure 1: Installed capacity in Europe in 2050 in the three scenarios compared with a reference scenario where the carbon price is zero

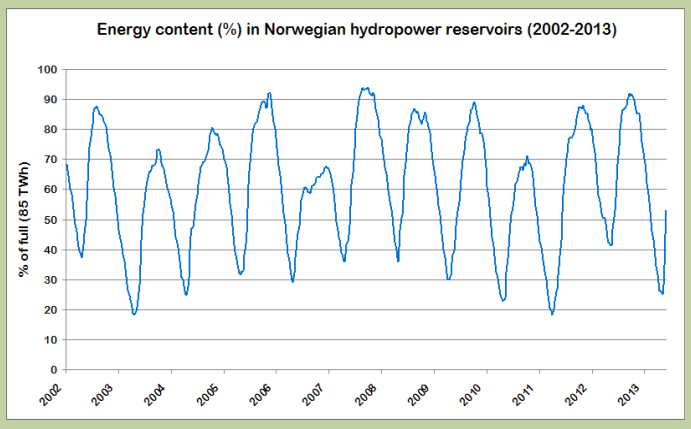


Figure 2: Energy stored in Norwegian hydropower reservoirs. (Data from NVE)

Balancing power from Norwegian natural gas

The balancing capabilities of hydropower are well known, but the potential to provide the same kind of services in the natural gas systems (fields and pipelines) is potentially equally high but less explored. The variation in the consumption patterns in Figure 4 illustrates how also natural gas can play a role as an important flexibility provider for the European power market. It seems that it could be valuable to offer flexible deliveries to Europe from the Norwegian natural gas pipeline system. This is flexibility that is needed in addition to the seasonal, weekly and hourly balancing from the hydropower system. Our analysis of variation here shows that the capacity of the storage in the pipelines will be able to handle this challenge. This can be done by introducing new operational strategies using the export pipelines as flexible storages.

Recommendations

Norway has large energy resources in both natural gas and hydropower, and these resources also have a large potential in storage and energy balancing services. Europe is integrating large amounts of renewable energy with limited storage options, and will probably need several tens of thousands MW in energy balancing capacity and large energy storage volumes. Our analysis show that Norway can contribute to the balancing and storage needs with both hydropower and natural gas. If Norway wants to take a larger role as a provider of flexibility, more investments in HVDC cables to Europe are needed. The need for flexibility in the European system depends on the mix of policy instruments to develop more renewable energy, to introduce CCS in fossil fuel power production and energy savings. It is doubtful if investments in cables of the size needed to handle the future demand for flexibility will happen on the Norwegian side under today's policy uncertainty. We recommend entering into EU-wide collaboration agreements that reduce this uncertainty by addressing the division of costs, revenues and risk between the participants in the relevant value-chains and between the relevant countries.

When it comes to future reserves and capacity markets, developing long term contracts with the buyer of the services will reduce the risk of investments in Norwegian capacity.

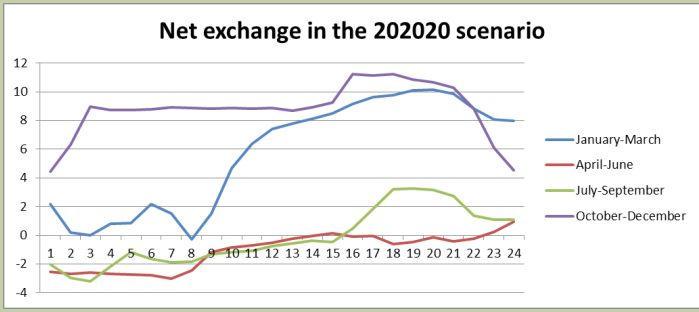
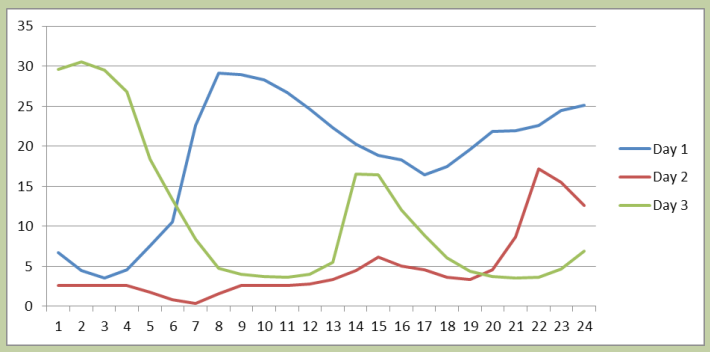


Figure 3: The exchange of electricity to and from Norway in 2050 in the Global202020 scenario. The figure show the net exchange (GWh/h) for 24 hours in four different seasons. Positive values are export of electricity, while negative values are import of electricity

Figure 4: Illustration of the electricity production from natural gas in the four countries where Norway has an export pipeline (UK, Germany, France and Belgium) in the Global202020 scenario. The graph show the variation in production (GWh/h) over 24 hours for 3 different days within the season from January to March.



The cost of new infrastructure for distribution, transmission and export is today financed through the national grid tariffs and in the end fully paid by the consumers. This is reasonable as it benefits the consumers through increased security of supply. However, it is uncertain whether this principle is acceptable also for investments driven primarily to provide commercial balancing and reserve services to Europe.

Capacity markets for generation are expected to be established, and Norway should take an active role to ensure these markets are not introduced nationally and uncoordinated. This is a major governance challenge that must be addressed.

In our opinion an increased focus on providing flexibility services from the Norwegian export system will be a way of securing hydropower and natural gas an important role in the future European energy system.

We have made initial studies of the interplay between natural gas and hydropower, and the results show that both natural gas and hydropower can be used for balancing the varying production from non-dispatchable energy sources in the future European energy system. These new services need to be developed both in terms of business models, commercial terms and legislation for the combined use of both hydropower and natural gas. Today the gas storage capacity in the pipelines is reserved for security of supply purposes. Similar, the hydropower storage is mainly used for seasonal balance due to the large mismatch of inflow to reservoirs and consumption. For both energy carriers, there are large unused volumes of energy storage available. It may require a change in legislation to offer part of this capacity as a commercial service, and Norway should take an active stance in identifying viable pathways for further development in Europe.

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