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Norway Preparing for Balancing European Wind Power

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*This is a guest post by **Paul-Frederik Bach**. Paul-Frederik has more than 40 years experience in power system planning. He worked with grid and generation planning at ELSAM, the coordinating office for west Danish power stations, until 1997. As Planning Director at Eltra, Transmission System Operator in West Denmark, he was in charge of West Denmark's affiliation to the Nordic spot market for electricity, Nord Pool, in 1999. Until retirement in 2005 his main responsibility was the integration of wind power into the power grid in Denmark. He is still active as a consultant with interest in safe and efficient integration of wind power.*

Since 2007 the end of year water level in hydro storages in Norway has been steadily falling. In 2010 a low inflow of water combined with a substantial increase in electricity consumption has caused Statnett to classify the energy balance in Southern Norway as on “Alert”. This is step 2 of 5, where step 5 is rationing.

Currently, the market seems to be ignoring the decline of such short term energy reserves. This article is an attempt to understand the reasons and perspectives underlying current changes in Norwegian electricity supply policy.

The Skagerrak HVDC link

The Norwegian hydro power system has unique properties. It was designed for the supply of a certain annual quantity of electrical energy (MWh) as needed for electricity supply in Norway, with the consequence that it also offered a surplus of power (MW) as a side effect. Other properties include the considerable flexibility of the generators, and large hydro storage capacity.

The annual inflow of water varies. In wet years it may be 20% above average and in dry years 20% below average. For many years it was Norwegian policy to be self-sufficient in nine years out of ten. The result was a surplus of energy and, in some cases, spilled energy.

In the thermal power system in West Denmark the design criteria was security of supply during peak hours. Due to a low load factor Denmark had a surplus of energy available during most hours of the year.

In 1977 the Skagerrak HVDC power line between West Denmark and Norway went into service with two cables. The total capacity of Skagerrak 1 and 2 was 500 MW.

The agreement between Norway and Denmark on the Skagerrak link made it possible for both countries to save installed capacity. Norway could rely on energy supply from Denmark during dry years, and Denmark could import power during peak hours. Furthermore the agreement included rules for the pricing of Norwegian overflow energy.

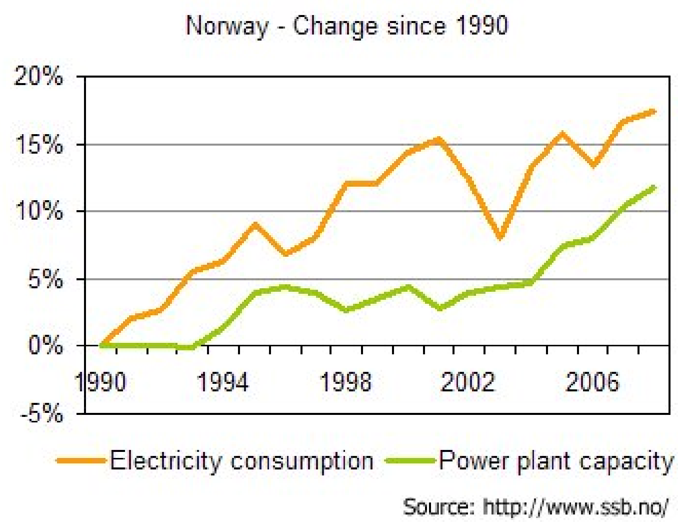
The link has been successful, both technically and economically. After the Danish affiliation to the Nordic power market in 1999 the handling of the Skagerrak link was transferred to the market operator, NordPool Spot. Since then approved market operators have access to the capacity of the link on equal terms.

In 1993 Skagerrak 3 (500 MW) was commissioned. An agreement on Skagerrak 4 has been signed, and the 700 MW link is expected to be operational by the end of 2014.

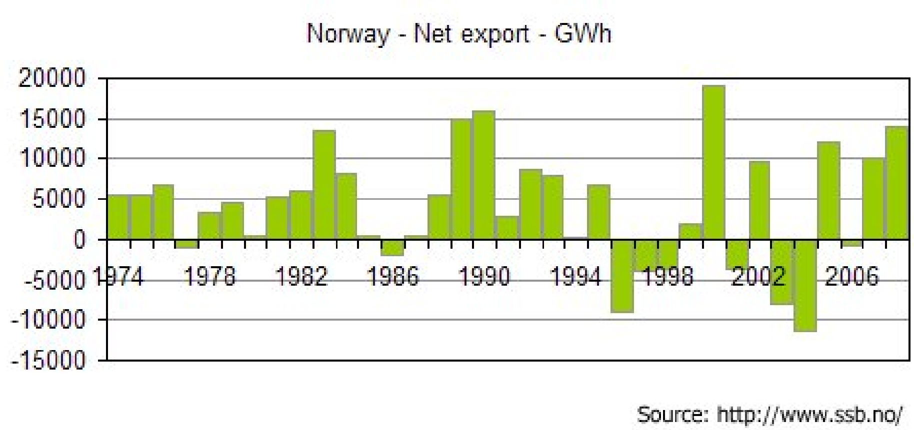
Norway introducing the deregulated electricity market

In 1991 the Norwegian Parliament decided to deregulate the market for trading with electrical energy, with the aim of ending the monopoly era for the power industry and introducing competition. The main objective changed from security of supply to efficiency of the sector.

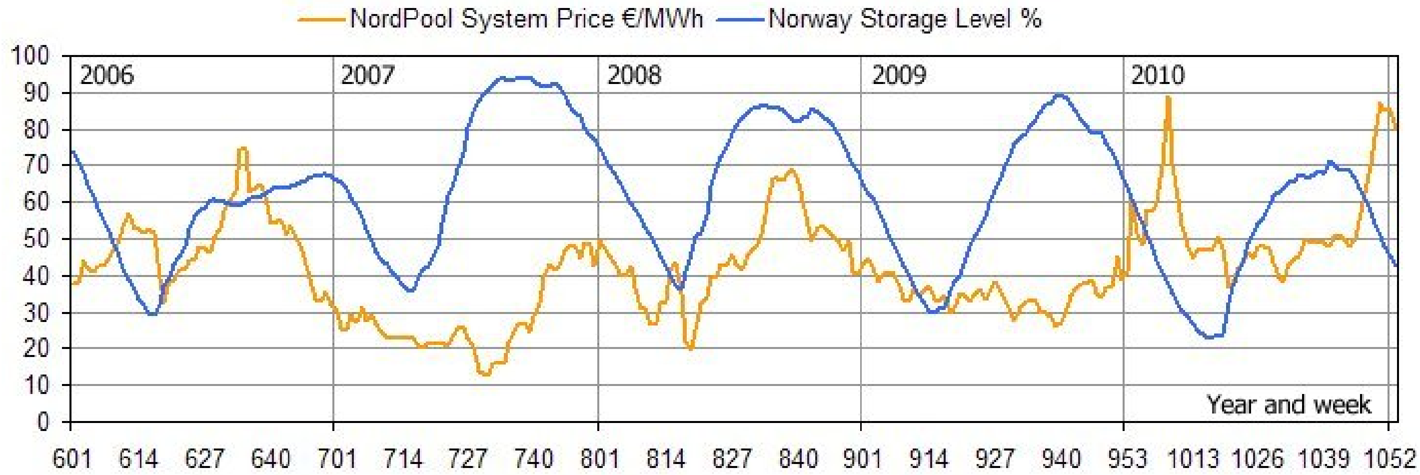
The immediate consequence was an increased risk to investors and a reluctance to install new power plants, and after a few years the result was a new balance between supply and demand of electricity.



Due to the Norwegian self-sufficiency policy Norway had mainly been a net exporter of electricity, but after 1991 years with substantial net import of electricity also occurred. This indicates a better balance between electricity demand and supply capacity in Norway.



The inflow of water is very low during the winter. Therefore it is necessary to store sufficient energy for the electricity supply until the spring flood, usually at the beginning of May. This is one of the main purposes of the large hydro reservoirs in Norway.



Sources: http://www.nve.no/ and http://www.nordpoolspot.com/

From the end of 2007 to the end of 2010 the storage content has been reduced from 77% to 45%. The falling water level from 2008 to 2010 right before the spring flood seems to indicate that the owners of the storage prefer to sell energy rather than store it.

The year 2010 looked more or less normal during the first half of the year, but during the third quarter a reduced inflow of water and a sustained increase in demand for electricity combined to create a deficit. At the end of 2010 the supply gap was up 30 TWh compared with the previous year.

Norway	Electricity production	Con-sumption	Export	From storage	Inflow of water
	TWh	TWh	TWh	TWh	TWh
2008	138.7	124.8	13.8	7.2	131.5
2009	132.0	123.0	9.1	2.8	129.2
2010	123.2	130.6	-7.3	15.4	107.9

Sources: http://www.nve.no/ and http://www.statnett.no/

The shortfall has been met by transforming a 9.1 TWh export into a 7.3 TWh import, and by drawing 15.4 TWh from hydro storage.

Total, theoretical, Norwegian storage capacity is estimated to be about 80 TWh, but since the end of 2007 the end of year content has been reduced by 25 TWh.

There are good reasons for the apparently relaxed Norwegian attitude to low short term energy reserve:

- Considerable resources abroad will be available for export to Norway if needed. Besides interconnections with Sweden and Denmark, the NorNed interconnection to Netherlands has been in service since 2008.
- Market prices will respond to a real shortage of electricity. The Norwegian electricity consumption per capita is very high. Therefore the market should be able to balance demand and supply in a reasonable way.

An ambitious interconnection program

Statnett's Grid Development Plan 2010 ("Nettutviklingsplan 2010") presents ambitious plans for the extension of interconnections. The plans are based on the following expectations:

- increasing Norwegian surplus of energy in years with normal inflow of water
- increasing occurrence of extreme wet and dry years
- increasing demand for Norwegian system and balancing services

The plan includes the following list of projects, but with reservation for uncertainties:

Country	Project	Capacity	Operation	Status
Denmark	Skagerrak 4	700 MW	2014	Under construction
Germany	Nord.Link	1400 MW	2016-18	Applied for
Germany	NordGer	1400 MW	2016-18	Applied for
Netherlands	NorNed 2	700 MW	2016-18	Project
Great Britain	NSN	1600 MW	2017-20	Project
Sweden	Southwest Link	1299 MW	2016-17	Project

The Norwegian investments are estimated to between 12 and 20 billion NOK.

Denmark, Germany, the Netherlands, the UK and Ireland are all installing wind power plants in order to reduce carbon emissions and dependency on fossil fuels. These plans all rely on the future availability of foreign services for balancing wind power variations. Smart grid measures for domestic balancing are being developed, but a large scale implementation of such internal measures will probably lag very much behind the policy targets for rapid growth in wind power capacity.

Norway has seen the forthcoming opportunity to sell system services to this market, and new interconnections can go into service in due time for meeting the demand. The total capacity of the interconnection projects may seem tremendous, but it is rather modest compared to the wind power variations which they are supposed to absorb.

This growing business will not affect the security of supply in Norway. The storage capacity is ample for the balancing services and the new interconnections will add to the opportunities for purchasing energy abroad. The bottleneck will be the interconnector capacity.

The European grid expansion will be an important contribution to the integration of an increasing wind power capacity, but it should not be an excuse for the customer countries to postpone the development of local alternatives. Most countries will need to integrate energy systems for electricity, gas supply, heating and transport in order to meet the long term energy policy targets. This will require increased use of electricity and a substantial thermal generation capacity. These changes will require a broad range of new technologies.

The price of the Norwegian services will depend on the alternatives in the countries concerned. If the customer countries have no alternatives, the trade in balancing services will be a seller's market, with the consequence that the overall cost of wind energy will be needlessly high.

Therefore the customer countries should proceed with the development of clean and flexible generators and local smart grid measures.