Impacts of the North Atlantic Oscillation on the Energy Sector: the Norwegian example

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THE NAO IMPACT ON SCANDINAVIAN CLIMATE

Temperature in Norway, Denmark, Finland and Sweden is strongly correlated with the Hurrell (1995) NAO index, as shown below. Unlike in Norway, precipitation in Denmark, Finland, and Sweden is not strongly correlated with the index; the impacts of the NAO there are thought to be mediated by the presence of the Baltic Sea and the Kjolen Mountains, between Norway and Sweden. Precipitation in Norway is closely linked to both interannual variability in the NAO and the decadal-scale trends.

ENERGY IN NORWAY AND SWEDEN

Norway is endowed with enormous energy resources. It is the leading OECD exporter of oil and gas, and the second largest oil exporter in the world. This makes Norway an important market for world energy security. Norway’s climate and topography also make it ideal for hydropower power generation. More than 99% of electricity generation in Norway comes from hydropower. Norway has the highest electricity consumption per capita in the world, due in part to its cold climate. A major shift from fuel oil to electricity in the heating market has contributed to an increase in electricity consumption of about 36%. Norway has the highest electricity consumption per capita in the world. In 1994, 45% of typical household energy consumption was for heating and water heating. (IEA, 1997)

Norway generates 47% of its electricity from hydropower and 47% from nuclear. Sweden normalizes its nuclear electricity production downward during the period from March to October because electricity consumption is low and water reservoirs can produce plenty of hydropower. Households depend on electricity for only 39% of their heating. (SPA, 1999)

Both Norway and Sweden underwent market deregulation and increased privatization during the 1990s. This made international trade in electricity feasible in Scandinavia. In 1995, Nord Pool was established as the world’s first multinational exchange for electric power trading. Nord Pool is a joint venture between the two national grid companies, Statnett SF in Norway (50%) and AFF in Sweden (50%).

In 1996, the large swing in the phase of the NAO brought international attention to the physical connection between the NAO and the availability of water in Scandinavia for hydropower. Norway enjoyed a large hydropower surplus during the late 1980s and 1990s coincident with the strong positive phase of the NAO, which brought a large amount of precipitation to Norway. Following deregulation in the electricity market, Norway began trading power with Sweden. During 1995, contracts were sold by Norwegian producers to provide power to end-users locally and abroad. When the country faced drought during the winter of 1996, hydropower stations could not produce enough electricity to meet those contracts. In order to do so, producers had to buy power on the short-term markets at a high cost to the industry.

Hydropower

Norway: Temperature and the NAO

Norway: Electricity Imports

Norway: Electricity Exports

Correlation Coefficients between Norwegian Hydro-Power Streamflow and the NAO Index (p<0.001)

Norway: Electricity Net Production

Correlation Coefficients between Norwegian Hydro-Power Streamflow and the NAO Index (p<0.001)

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The NAO returned to a positive phase in 1997 and the reservoirs filled again. The Scandinavian hydropower market is site-limited rather than capacity-limited. Norway is operating the closest to capacity, but still has the infrastructure to produce 5-10% more power given an increase in streamflow.

DEREGULATION, COMPETITIVE ADVANTAGE, THE ROLE OF TRADE AND RISK MANAGEMENT

One goal of privatization and market deregulation in Scandinavia is to increase market efficiency. In hydropower production, the fixed costs of infrastructure are high, independent of the amount of power produced. Variable costs—the incremental cost for each incremental increase in production, are low. As long as the costs for long-distance transmission are lower than the revenues, trading power is quite profitable.

Because the climates in Norway and Sweden are impacted somewhat differently by the NAO, and the electricity generation sources are distributed differently between hydropower, nuclear power, and fossil fuels, each country may have a natural competitive advantage under particular climate events. If the NAO is in a negative phase and precipitation is low, power producers can meet supply contracts by buying nuclear power from Sweden. Clearly, this already occurs on the seasonal scale.

CORRELATION OF THE NAO WITH MOVEMENTS IN ELECTRICITY MARKETS

No Way Back to Norwegian Electricity Imports

No Way Back to Norwegian Electricity Exports

Impact on Norsk Hydro Production

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HYDROELECTRIC POWER

For this study, Norsk Hydro, a Norwegian utility company, provided data on the streamflow through several of their power stations. This streamflow is highly correlated with the NAO.

Reservoir inflow varies widely by month. The peak is in summer, though there is much month-to-month variability. In Scandinavia, Norway has the greatest volume of water in reservoirs and also the highest amplitude of variability.

Streamflow through the hydropower stations in Norway is shown to have a strong correlation with export and import of electricity, largely to Sweden. Enertdata (1997) was the source for energy statistics.

ENERGDATA: Electricity Imports

ENERTDATA: Electricity Exports

There are several markets in which contracts for physical delivery of power are traded. Each of them operates on a different time scale.

Nord pool has two main products for physical delivery. The first, “Elbas” are contracts sold the day before power is delivered and their price is determined by auction. “Elbas” are sold on the regulating power market for Sweden and Finland, which means they are one-hour contracts issued the same day as the power is delivered. In this way, delivery is fine-tuned. The long term contracts contain the most risk and are the least expensive to purchase. Regulation markets are an expensive but nearly instant way to meet demand.

The sustained peak of Elspot prices during 1996 shows a significant impact in the market from the NAO. Producers bought many short contracts at a high price. Perhaps they expected streamflow to return to the 1986-1995 average level by midsummer. Either the precipitation increased by the next winter, or expectations about precipitation were adjusted and trade shifted to longer-term contracts, bringing down the price.

In addition to markets for physical delivery, there are financial markets in Scandinavia that trade futures and options to manage the risks of trading electric power. Futures and forward contracts have a trading horizon of up to four years; this is well within a time scale that could be affected by large swings in climate.

SUMMARY

Recent trade and deregulated markets in Scandinavia have begun to elucidate the relationship between NAO-driven climate and energy during an anomalous event. As these markets mature and further observations of NAO variability are made, it may be possible to estimate the value to the energy sector of an NAO forecast in Norway. In any case, the energy sector should be made aware of the NAO and its relationship to the production of hydropower.

REFERENCES

LDEO, NOAA NCDC GCPS monthly stations from http://ingrid.ldeo.columbia.edu
Nordpool: http://www.nordpool.com


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Norway: Electricity Imports

Finland: Electricity Net Production

Norway: Electricity Net Production

Norway: Temperature and the NAO

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