CITIES
Centre for IT Intelligent Energy Systems

Regulating Power Market; Modelling and Forecasting

Objective

The objective of this CITIES Demonstration Project is to formulate stochastic models for the regulating power market in the Nordic area, however with a special focus on the prices in DK1 and DK2. Ultimately the purpose is to obtain better methodologies for predicting the probabilities for up- or down-regulation, and the related prices and/or volume. Such forecasts will facilitate some other demo projects in CITIES.

Partners

- Ørsted (former DONG Energy)
- DTU Compute
- Enfor

Background

An electricity price area is a zone where the price is the same. The prices typically differs from one price area to another, eg. due to constraints in the transmission grid. The Electricity Price

Area Differentials (EPAD) allows members on the power exchange to hedge against this area price risk. Figure 1 shows the prices areas in the Nordic region.

For many technical applications it is important to be able to predict periods with up- or down regulation, and the associated prices or volumes. This is for instance the case for some ongoing projects in the Nordic area. One such application is the H2020 SmartNet project which aims at supplying regulation services for both DSOs and the TSO while minimising the costs associated with electricity use for owners of summer houses with a swimming pool.

This Demo Project will have a special focus on the DK1 and DK2 price areas - see Figure 1.

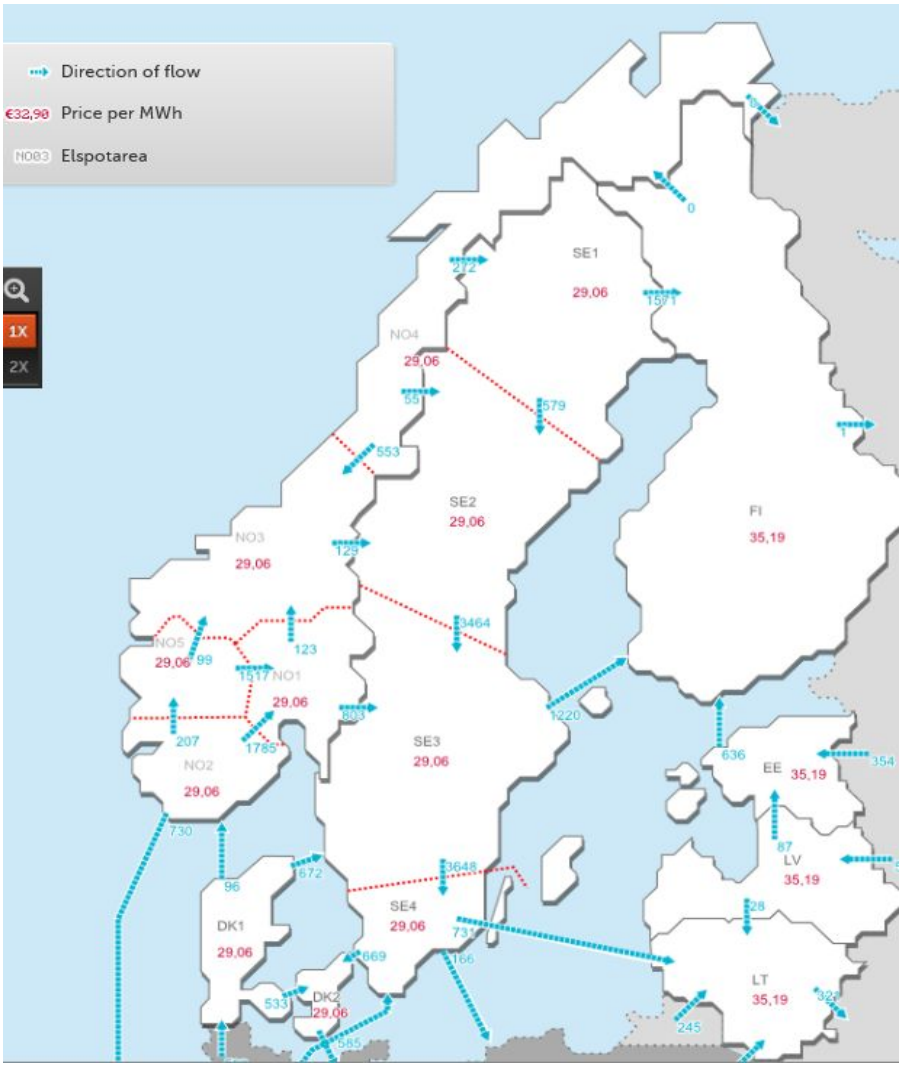

Figure 1: Prices areas in the Nordic Area.

Connection with CITIES WP's

- WP5: Stochastic modelling and probabilistic forecasting
- WP7: Decision making under uncertainty and stochastic programming

Description

For the prices hourly values are metered and settled in Eastern Denmark, while 15 minutes metering is performed in Western Denmark, but the settlement is based on hourly values. The TSO is committed to maintaining the balance within the delivery hour, and this is achieved by buying upward or downward reserves on the regulating power market.

The need for up- or down regulation is often linked to forecast errors of the wind or solar power production or issues with transmission constraints or production issues. It is known that eg. phase errors of the wind power forecasts can cause a significant need for up- or down regulation, and hence it is important to understand the spatio-temporal correlations of wind power production in the Nordic area and Germany. The Northern part of Germany is important due to the well known transmission capacity constraints between the Northern and Southern part of Germany.

Since the need for up- or down regulation might be caused by capacity constraints of the lines and issues with production facilities, it is very important to built on a physical model of the systems. Furthermore it is important to understand the characteristics of the individual price zones in Scandinavia since, for instance, hydropower in some cases is able to provide the needed balancing services, but areas with hydropower constitutes only a fraction of the Nordic price areas.

The available and relevant data for this project represents various challenges which could be taking into account in order to obtain reliable models and forecasts. Some of these challenges are: Data with a different time and spatial resolution, time and spatially correlated data, and information embedded in day-ahead and intra-day bidding curves.

Methodologies - Some initial ideas

Since the price areas are linked to the physical power net in Scandinavia it is assumed that it is important first to establish a semi-physical model of the net with the main constraints and capacities. Similarly it is most likely important to have access to longer periods of joint wind speed (or wind power) data from the relevant areas on eg. an hourly resolution.

Modelling

First of all we need to established operational and simplified models for the physical net, the production capabilities, disturbances, and constraints. An example of a constraint is the DC power lines between Norway and Denmark. As a first step a deterministic model of the physical network and the most important nodes, will be formulation. However, some of the nodes and the capacities are stochastic, and hence a second version of the model will be model with a number of stochastic elements. It might be important to establish a better understanding of the spatio-temporal correlation structures of the wind speed regimes within the Nordic area.

Also the bidding on the day-ahead and intra-day markets will contain important information about the most likely variations of the regulation prices, and hence these bidding curves could be taking into account.

The initial idea is to try to establish a stochastic model describing the spatial-temporal variations of the regulation prices. A first step would be to model the system imbalance in each price area, the second step would be to find probabilistic models for the imbalance volumes and directions, and as the last step is to establish a probabilistic model for the prices conditioned on the direction.

Consequently the first idea is to try to formulate spatio-temporal stochastic models formulated as lumped models, and here we will aim at using stochastic differential equations since this approach reflects a close relation to the physics. This approach is rather ambitious and consequently we have briefly outlined alternative approaches. Here we have discussed to consider to use Hidden Markov models and/or Generalized Linear Models.

To obtain a high success rate in predicting the dominating direction, we believe that it is necessary to consider most of the Nordpool area, and it is assumed that the model should consider:

- The system imbalance in the respective price areas of interest.
- The physical cable limitations between the different price areas
- The netting performed by the TSO's
- The rules of how regulating power is priced, and how the dominating direction is determined.

The areas of interest should at least include Denmark, Sweden, Norway and Finland, which responds to 12 different price areas.

Furthermore, the effect of surrounding price areas like DE, EE, LT and PL could be considered. Here the DE-DK1 border is of particular interest since there is large amounts of special regulation flows from DE to DK1.

Forecasting

Forecast services providing the full probabilistic information are crucial for optimal decision-making, production planning, trading, and for control. Given the stochastic spatio-temporal models we will establish methodologies for obtaining full probabilistic forecasts of the probabilities for up- and down-regulation, as well as the associated prices. This forecasts should aim at describing the observed conditional densities for future values as well as time-dependency of the individual forecasts.

We are also aiming at formulating models and methodologies for being able to generate reliable scenarios which again can be used for decision making or stochastic optimization.

In order to ensure that the models are reliable we will study various methods for evaluating probabilistic forecasts and scenarios.

Deliverables

- Setup of a semi-physical model (Ørsted, DTU Compute, ENFOR)
- Analysis of appropriate time series of wind speed (or wind power) (DTU Compute, ENFOR)
- Formulation of a full stochastic spatio-temporal model (DTU Compute, Ørsted)
- Establish reliable probabilistic forecasts using the formulated model (DTU Compute, ENFOR, Ørsted)
- Evaluation of the probabilistic forecasts (DTU Compute)

Time schedule

November 2017 to September 2018
(Ørsted, DTU Compute, ENFOR)