

# **Regional TIMES model for Norway with high time resolution**

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## **Extended Abstract**

### **Introduction**

In Norway hydropower is the by far most dominant source of electricity production. However, the potential for further growth is limited and therefore other sources of power production such as wind and gas power plants has been constructed during the last years. The annual production from hydropower plants may vary significantly from year to year due to changes in precipitation. Therefore, planning tools for hydropower production has been widely applied. Since 1991 electricity has been traded at the Nord Pool spot market and thus several electricity market models has been applied to analyse short term market conditions.

During the last years it has been an increased focus on energy demand and especially options to reduce electricity demand. Typically, in existing power market models applied for the Norwegian and Nordic region, electricity demand is modelled with only a few sectors and exogenously given price elasticities. In order to improve modelling and analysis of demand side options and especially options for substitution of electricity demand a regional TIMES model with a detailed modelling of the demand side has been developed by Institute for Energy Technology (IFE) on commission of the Norwegian Water Resources and Energy Directorate (NVE).

### **Model development**

The overall aim of this modelling work has been to develop a model that could be used in connection with the hydropower/power market model Multi-area Power-market Simulator (EMPS). Further, a stand-alone version which covers both energy generation and demand options is developed.

The basis of the modelling work has been the existing MARKAL models at IFE. These models cover a single region MARKAL model for whole Norway and regional models for selected counties (Oslo, Telemark and Rogaland). All these models cover all sectors (energy generation, household, service, industry and transport) with analysing periods towards 2050. However, these models apply the typical MARKAL time slices with 3-4 seasons in addition to day-night. In order to develop a model that could be used in iteration with the EMPS model we have increased time resolution to cover all weeks

during each year and five time slices per week<sup>1</sup>, equally 260 time slices annually. When we use the model in connection with the EMPS model we apply electricity prices (spot prices) from the EMPS model for each region into the TIMES model. The TIMES model return electricity demand for each time slice to the EMPS model.

When the TIMES model is applied in the stand alone version the possibility of storing water from a week to the next improves the model significantly, in a hydropower dominated system such as in Norway.

The TIMES model covers seven regions in Norway with exchange of electricity between regions and with neighbouring countries. The seven regions are the same in the two models and are defined based on limitations in the transmission and production capacities.

With the level of detail on the demand side and especially the high time resolution we have experienced challenges to solve the model. Therefore, the flexible options in TIMES allowing to run either single regions and/or only selected years has proven to be very useful.

### **Energy demand**

The model has a wide range of demand sectors; especially the industry is modeled in detail. In general the industry is divided in pulp & paper, aluminum, other metal production, chemical industry, refineries and other industry. Most major electricity consuming plants are modeled as individual units and the rest are either a group of well defined plants or the rest of that industry sector. The commercial sector is modeled as eight sub-sectors and the residential sector consists of five sub-sectors. In addition there is agriculture and transport (seven sub-sectors). With seven regions and a specification of demand for heat, non-substitutable electricity, materials, cooling and transport this gives a total of approximately 500 demand figures.

Electricity statistics are available at a very detailed level both regarding end-use sector and geographically divided in communities. In addition consumption of most large industry plants were specified. These are very important sources, since electricity use is approximately half of the Norwegian total final energy use and 2/3 of final stationary use.

The energy statistics of other energy carriers are not as detailed and it has been both time consuming and difficult to find statistics on the level of detail required. Statistics Norway has energy statistics on a detailed sub-sector level for the whole country and aggregated for a few sectors on a community level. In addition the Norwegian Pollution Control Authority has plant specific data for industries with emission permission. By a combination of sources and the use of qualified estimates in some cases, all the figures for end-use demand have been calculated.

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<sup>1</sup> Day1 (7:00-11:00), day2 (11:00-17:00), day3 (17:00-23:00), night (23:00-7:00, Monday-Friday) and weekend.

## **Load profiles for energy demand**

A major challenge before starting with the actual modelling work was to develop load profiles for thermal and electricity demand for the demand sectors considered. In the literature several load profiles are available, but none of these could fit directly into the sectors or time resolution chosen for the model. Therefore the load profiles have been developed based on measurements and modelling of sector specific load profiles and measured electricity data.

The doctoral thesis of (Pedersen<sup>2</sup>, 2007) was used to determine load profiles for the service sector, households and small industries. The thermal load profiles are a function of outdoor temperature. Load curves for large power intensive industry and refineries were made constant throughout all time slices. The profiles were then calibrated on outdoor temperature in 2006 in 7 different regions, and compared to the national hourly electricity demand in 2006 received from Nord Pool ASA. Finally the profiles were transformed to present average normal outdoor temperatures.

## **Iterations with the EMPS model**

The initial iterations on a single region applying electricity prices from the EMPS model into the TIMES model and vice versa showed good agreement with expected load curves/price development during the year. Ongoing work will focus on iterations with a complete TIMES model and corresponding EMPS model with all seven regions. Further work will focus on comparisons of results from the stand alone TIMES model and the iterations between TIMES and the EMPS model.

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<sup>2</sup> Pedersen, Linda, "Load Modelling of Buildings in Mixed Energy Distribution Systems", Doctoral thesis, February 2007, The Norwegian University of Science and Technology (NTNU)