CES Nordic Project on Climate and Energy Systems

Work Group: Energy System Analysis

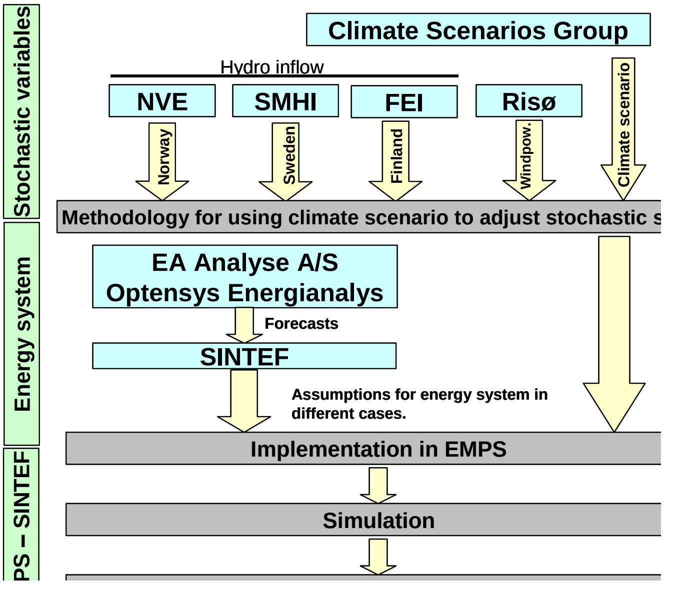
http://www.os.is/ces

Energy System Analysis is a Work Group within the Nordic research project Climate and Energy Systems (2007-2010). This project is in many ways a follow up on the CE-project (2003-2006), where energy system analyses were carried out for the expected energy system in 2010 using future climate (2070-2100). That study illustrated future climate change challenges for the present energy system. In the current project we will look at effects of climate change that already has occurred or will occur in the near future, i.e. within 2020. These changes are important for investment decisions and for hydropower optimization in the present.

Main objectives for Energy System Analysis

Climate change affects the electricity market in many ways. Increasing temperatures gives reduced need for electrical heating, and altered wind-speeds may affect wind-power generation. Altered precipitation will however give the largest climate-change impact on the Nord Pool market because of the large share of hydropower. Previous studies have shown that the geographical and seasonal distribution as well as the annual amount of inflow to reservoirs and run-of-river are affected by climate change. Based on inputs from other parts of the project, the system analysis will quantify renewable electricity production's variability and sensitivity for climate changes, and detailed analysis of the Nord Pool electricity market for 2020 will be carried out using the EMPS model. We will also study the vulnerability of the system and energy balances.

Participants and connections to other Work Groups



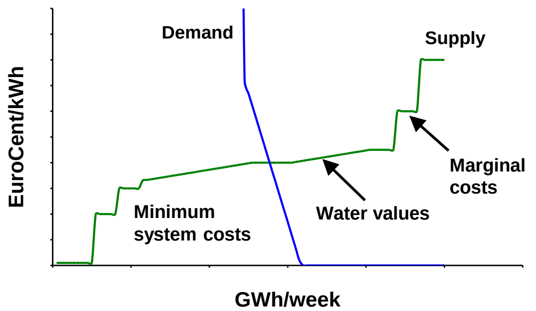
The Climate Scenarios Group will provide climate scenarios to be used in the Energy System Analysis Group. Inputs for inflow to reservoirs in Norway, Sweden and Finland will be provided by NVE, SMHI and FEI respectively, while Risø will prove inputs for wind speed/power. This information will be used to create the probability distributions for weather variables. EA Analyse A/S and Optensys Energianalys will forecast energy system variables, while SINTEF Energy Research will make assumptions for the energy system in different cases, include new inputs in the EMPS model and carry out simulations.

norden Nordic Energy Research

CES Nordic Project on Climate and Energy Systems

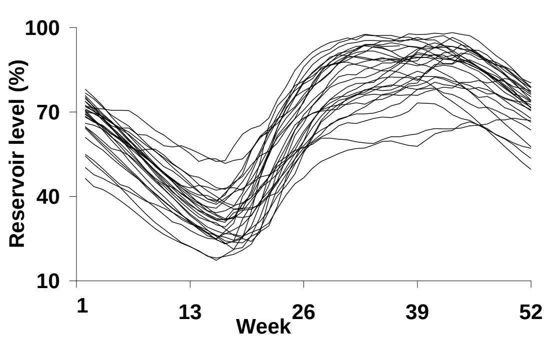
EMPS model optimization

Quantitative analysis of the electricity market will be based on the EMPS model. The inputs to the model is a combination of costs and capacities for supply, demand and transmission, and historical records for inflow (to reservoir, run-of-river), temperatures and wind-speeds. Hydropower is usually modeled very detailed with inflow, waterways, reservoirs etc.. The optimal strategy for hydropower is reflected by water value tables, which are calculated by minimization of expected system costs through a variant of stochastic dynamic programming. In theory, simulated outcomes coincides with the outcomes in a well-functioning market..



Simulating stochastic weather

For each stochastic variable there must be one historical value for each geographical area and week in the simulation period (e.g. 1960 – 1990). When the optimal strategy has been calculated, the operation of the energy system (e.g. 2020) is simulated for each year the using historical (weather) years. Results for all years are used to establish weekly probability distributions for model variables.



Update and climate correction

The stochastic weather variables will be updated within the Work Group. New inflow-variables for hydropower will be used for Norway, Sweden and Finland, and we will use updated values for wind-power and temperatures. In the former CE-project we developed a methodology for adjusting weather variable series to different climate scenario. We will apply this methodology in the current project also. An important difference is however that the assumptions for climate and energy system will refer to approximately the same year.

Energy system in 2020

All capacities and costs will be updated to the expected system in 2020. Some uncertainty regarding the amount of new renewable generation and/or climate will be analyzed in different cases. We will make a model for Norway, Sweden, Denmark and Finland (Nord Pool power market), including trade options with other countries (fixed capacities and prices).

Future development of the electricity system the next 20-30 years will also be outlined taking into account the most recent information regarding climate change.

Automatic calibration

Traditionally, the EMPS model had to be calibrated by the user on basis of simulation results. However, in this project we will use a new functionality for automatic calibration that seeks for the maximum of expected socio-economic surplus. Sensitivity analysis and scenario analysis (e.g. changing assumptions for infrastructure or climate) will in general be be better and more consistent when using automatic instead of manual calibration.

Expected outcomes

The outcomes for stochastic weather variables have considerable influence on the simulated performance for the Nord Pool electricity market, and the EMPS model provides a probability distribution for each variable in every case that is simulated. In particular, we will study renewable electricity production's variability and sensitivity for climate changes. We will also study energy balances and the vulnerability of the system, e.g. the probability for very high power prices or curtailment that may occur in the case of two subsequent very dry years.

For further information, contact:
Birger Mo (birger.mo@sintef.no)

norden Nordic Energy Research