Long and Mid Term Planning Models

- Current version (LTM 9.3)
- New projects

Users' conference Generation Scheduling 2013-05-22

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EMPS, EOPS, ProdRisk
Models under development

- These models are continually being developed
  - New problems arise e.g. because of developments in the market
  - Increased computer power, improved algorithms provide new possibilities
    - better solutions
    - more details

- Drivers for some recent developments have been expectations of
  - A stronger coupling to the rest of the continent
  - More wind power, small hydro and other new renewables
  - Greater short-term price variation and uncertainty
  - A need for consolidation after many years of development

EMPS, EOPS, ProdRisk
Models under development

- Recently focus shifted towards :
  - Finer time resolution
  - Coupling between simulated results and historical input (calendar data)
  - More detailed description
    - ‘Sequential’ hydro power results

- More complex models and calculations
  - Increase in computation time
  - Parallel processing

EMPS: Latest development

- LTM 9.3 ‘official’ version
  - Data automatically converted from version 8
  - Definition of load periods defined only in new file: PRISAVSNITT.DATA
    - Can combine definition of accumulated and sequential load periods
    - Generated automatically when converted from version 8
      (includes sequential periods if converting using DOGNKOBLING.DAT)
- 168 Load periods
- Temperature with 24 hour resolution
- Transmission capacity
  - With hourly time resolution
  - Tied to consumption or wind power
  - With repetitive transmission maintenance
- Exogenous given price series

EMPS: Latest development

- Automatical calibration
  - Additional calibration factor???
- Investment analysis
- Multiple wind farms per subsystem
  - New ‘koblingsfil’ for Samlast / Samnett

- List of all available functionality (latest available in bold)
  Varying degree of availability
  - ‘Freely’ available (but at additional cost)
  - Buy into ongoing projects
  - Remunerate another customer (for cost of implementation)
  - Not clarified (may depend on new agreement between Powel and SINTEF Energy Research)
- Poster session

Function	Comments	Terms for access (Prices given in NOK)
Thermal unit start-up costs	Start-up costs for thermal units and definition of reserve capacity requirements	150 000,-
Gradual adaptation of consumption	Gradual adaptation of consumption to changes in power price	50 000,-[1]
Dynamic optimizing adaptation of consumption	Adapted to modelling large industrial consumers	Not determined [2]
Wind power	Modelling of wind power separated from hydro power; allows wind power input with hourly time resolution	150 000,- [1]
Wind power extension	Allows utilization of fine time resolution for wind without requiring use of thermal start-up costs	Not determined; assumed price 50 000,-
Several wind parks	**Allows modelling of more than one wind park for each area**	**Not determined[2]**
Automatic calibration	**Automatic calibration of the model based on maximizing socio-economic surplus and/or reaching target reservoir levels**	**Not determined; assumed price 160 000,- [2]**
Additional calibration parameter	**In addition to the three standard calibration factors, a requirement for minimum available generation capacity for hydro may be specified**	**Not determined[2]**
Short-term temperature forecast	Allows modification of temperature statistics for near future	Not determined[2]
Parallel processing	Reduced calculation time for water value calculation and simulation by used of parallel processing on multi-processor computers	Not determined[2]
Mid-term model	Mid-term model of same type as available in the EOPS model. In the EMPS model individual water values are calculated for each river system is automatically	Not determined[2]

Function	Comments	Terms for access (Prices given in NOK)
Short-term inflow forecast in long-term forecast period	Allows use of short term inflow forecast within the long-term (snow-melting) forecast period.	Powel[3]
HBV-based inflow forecast	Use of inflow forecasts from an HBV model in the EMPS model	Powel[3]
Factor-files for inflow forecast	Inflow forecast may be given from factor-files. Historical statistics are multiplied by the factors given for each week.	Not determined[2]
Factor-files for climate	Assumed climatic changes to inflow may be given from factor files. Historical statistics are multiplied by the factors given for each week.	Not determined[2]
System price	Calculation of system price	Powel[3]
Transmission capacity tied to consumption or wind power	**Transmission capacity between areas may be a function of time series for firm load or wind power**	**Ongoing project; access for 1 new participant: 150 000,-**
Repetitive transmission maintenance	**Allows definition of annually repeating maintenance on transmission lines**	**Not determined[2]**
Transmission capacity with hourly time resolution	**Transmission capacity between areas may be input from designated file with hourly time resolution. Each "year" in data period has 8736 hours (52 × 168)**	**Ongoing project; access for 1 new participant: 200 000,-**
Temperature dependent firm load	Firm load may be tied to temperature time series	Powel[3]
Temperature dependent CHP capacity	CHP capacity may be tied to temperature time series	Not determined[2]
Temperature with 24-hour resolution	**The load (and CHP capacity, if function is available) is modified using 24-hour resolution for temperature, not weekly average temperature as in the standard model**	**Ongoing project; access for 1 new participant: 300 000,-**

Function	Comments	Terms for access (Prices given in NOK)
Investment analysis	**The model determines optimal investment in specified thermal generation plants and transmission capacity**	**Ongoing project; access for new participants: 337 500,-**
Green certificates	The model may simulate prices in the market for green certificates	Not determined[2]
Exogenously given time series for price	**Prices may be tied to a time series for price, e.g. price for thermal power, imports, exports, etc. Each unit may be tied to one or two time series (Ax_1+Bx_2+C, where x_1 and x_2 are prices from series 1 and 2)**	**Not determined[2]**
Load flow models	**Samlast and Samnet with a detailed electric grid using load flow calculations**	**Not determined[2]**
168 load periods	**Up to 168 accumulated load periods per week**	**Not determined[2]**
Extra long data horizon	Allowed data horizon extended to 25 years; the standard limit is now 10 years.	Powel
Multi-year load profiles	Load profiles may be given for the whole data horizon, allowing variable profiles from year to year within the horizon. In the standard model load profiles are only given for a 52-week period which is repeated for the whole data period.	Not determined[2]
Dry-or-wet scenarios	Allows user-controlled construction of scenarios containing defined inflow scenarios for parallel simulation. For example, a series of particularly dry or wet years may be collected in one scenario	Powel[3]

Recently finished projects

- Automatic calibration of EMPS
  - Optimizes socio – economic surplus. Tunes all calibration factors. Includes additional criterion - Reservoir levels.
  - Appr. 1.4 mill NOK over 2 years: 2011 and 2012

- Gradual adaptation of load for optimizing players
  - Appr. 700 kNOK: 2012 – 2013

Ongoing projects

- BIP: 'Verdien av fleksibel vannkraft '
  - Objective: Establish stochastic models and tools for operation and analysis in a power market with unpredictable short term variations in inflow, demand and price. The models will be applied for hydropower scheduling, maintenance, refurbishment and investments, system analysis.
  - ProdRisk and ReOpt (enhancement to EMPS simulation).
  - Appr. 14 mill NOK over 4 years: 2010 - 2013

Ongoing projects

- Functionality for investment-analysis to the EMPS model
  - Implement a script based investment model in the EMPS – model.
  - The model analyses investments in transmission lines, thermal power plants and wind & solar power.
  - Appr. 1.4 mill NOK over 2 years: 2012 and 2013.

- El – sertificates in EMPS
  - Objective is to implement tool for forecasting of el-sertificates
  - Appr. 2.9 mill NOK over 2 years: 2013 and 2014.

New project

- SOVN: 'Stokastisk optimaliseringsmodell for Norden med individuelle vannverdier og nettrestriksjoner'

  (ENERGIX - Innovation project for the industrial sector)

  Objective: Establish new computer model for stochastic optimization for the Nordic power market, with individual water values and detailed representation of the transmission grid.

  - Appr. 14.5 mill NOK over 4 years: 2013 – 2016
  - Status: Application accepted. Project started.

Potential new project

- Integrating Balancing Markets in Hydropower Scheduling Methods (Knowledge-building project for the business sector – ENERGIX)
- The primary objective is to address the impact of balancing markets in hydro scheduling methods used in a hydropower producer's planning process. The project will focus on the impacts balancing markets have on seasonal and long-term hydro scheduling, but this requires consideration of the whole planning process.
- Secondary objectives leading to achievement of primary objective include:
  - Identify which markets and part of planning process
  - develop and test models both for clearing of multiple markets and for balancing market prices
- Appr. 16 mill NOK over 4 years: 2014 – 2017
- Status: Not yet approved by the Research Council of Norway

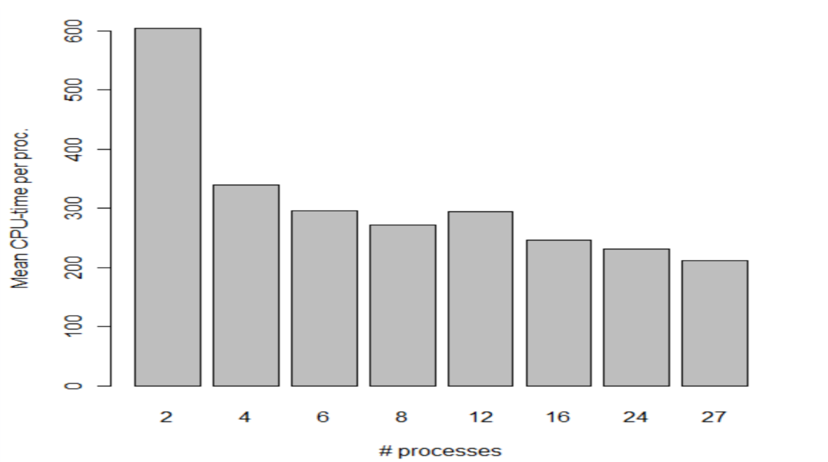
Some ideas

- Time series input and results with hourly time resolution
  - Calendar data
  - API: Introduce input and result files using file formats with available third party programmable interface (e.g. HDF5 with libraries and tools available)

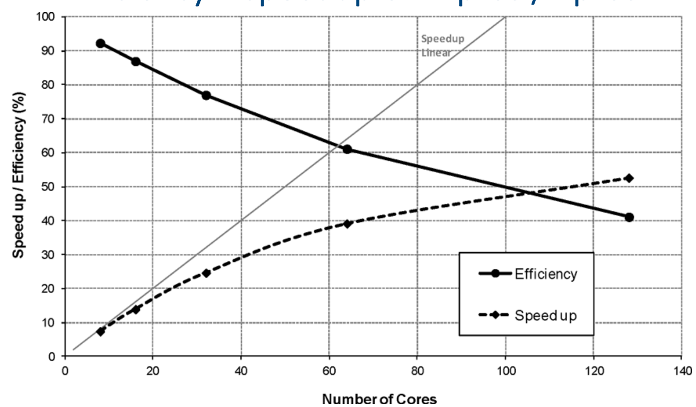
- Improve parallel algorithm in ProdRisk
  - Objective: Increase scalability of ProdRisk from todays 8 – 10 cores to 10's or 100's of cores by removing unnecessary synchronization and by introduction of master and – slave processors.
  - IPN – project or industry project
    (Follow-up of 'Verdien av fleksibel vannkraft')

Parallelization of ProdRisk

- ProdRisk:
  - Uses predefined distribution cores
  - Much synchronization
  - Only scales well to appr. 8 cores
  - Test on small dataset
    (19 modules, 4 load periods)



- NEWAVE (CEPEL)
  - Master – slave processors
  - Acceptable scaling up to 128 cores
    - Speedup = execution time sequential/ execution time on n processors
    - Efficiency = speedup on # pros / #pros



  - Example:
    Reduction in elapsed time: 42 hours on one core -> ~36 min on 128 cores

'An Efficient Parallel Algorithm for Large Scale Hydrothermal System Operation', Pinto, et.al., IEEE Transactions on Power Systems

Some ideas

- Further development and verification of ReOpt
  - Potential: Replacement, supplement or alternative to ‘draw-down’ model
  - Model too optimal? Need further development (valuation of individual end reservoirs and more system constraints) to give a better representation of system behaviour (e.g. price simulated price variations).
  - IPN – project or industry project
    (Follow-up of ‘Verdien av fleksibel vannkraft’)

ReOpt – eksempel? Fra EEM 13 – presentasjon?