Short-term uncertainty in TIMES

ETSAP WS, Seoul 4th of November 2013

Pernille Seljom & Asgeir Tomasgard

11.11.2013

Motivation

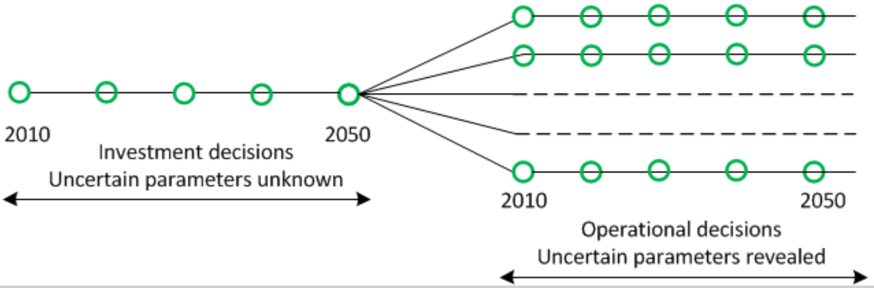
- **Short-term uncertainty**
  - Affect operational decisions and not investment decisions
  - Occur systematically throughout the model period
  - Availability of renewable resources and electricity trade prices
  - More and more short-term uncertainty in the energy system
- **Stochastic modelling of short-term uncertainty**
  - Operational models (Unit Commitment) - state of the art
  - Investment models (TIMES) - not as common
- **Short-term uncertainty in TIMES – unpredictable renewables**
  - Traditionally modelled by Peaking Reserve Constraint
  - New modelling option: SPINES

Methodology

- **SPINES**
  - Documented in «Stochastic Programming and Tradeoff Analysis in TIMES»
  - A variant to model recurring uncertainties
- **Stochastic modelling in TIMES**
  - Objective function: Minimise expected costs
  - Possible scenarios are assigned a given probability
  - $ SET SPINES NO → Scenario <u>dependent</u> investment decisions
    - Long-term uncertainty, example future climate targets
  - $ SET SPINES YES → Scenario <u>independent</u> investment decisions
    - Short-term uncertainty, example wind power availability

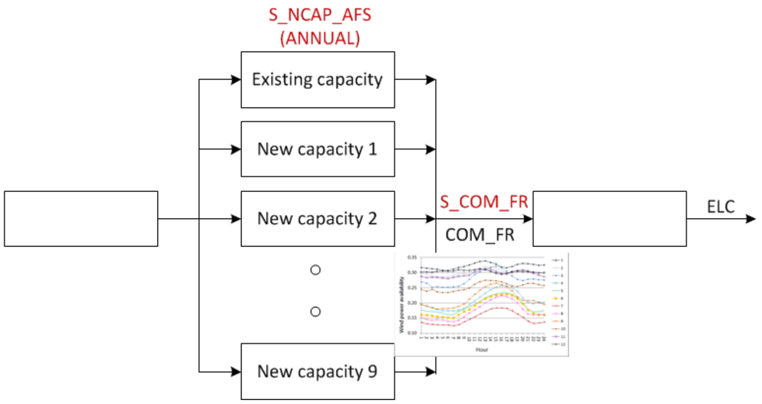
Methodology

- **SPINES**
  - Stage 1: Uncertain parameters are unknown
    Investment decisions are set
  - Stage 2: Uncertain parameters are revealed
    Operational decisions are set



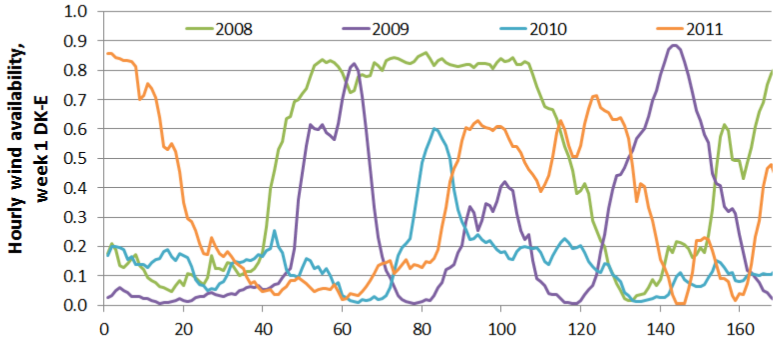
Short-term uncertainty of wind power

- **Stochastic parameters:** S_NCAP_AFS Annual
  S_COM_FR Sub-annual



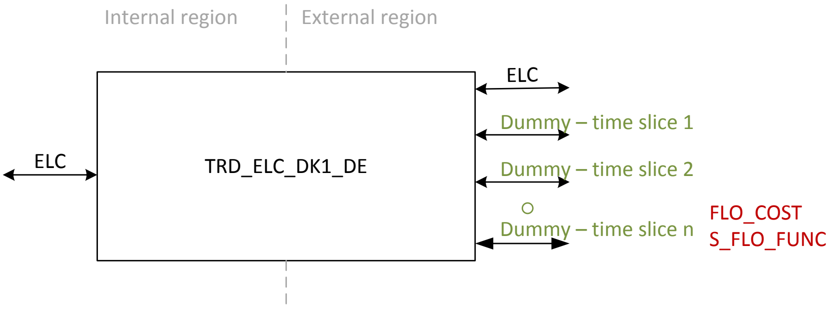
Wind power characteristics

- **The availability of wind power is highly stochastic!**



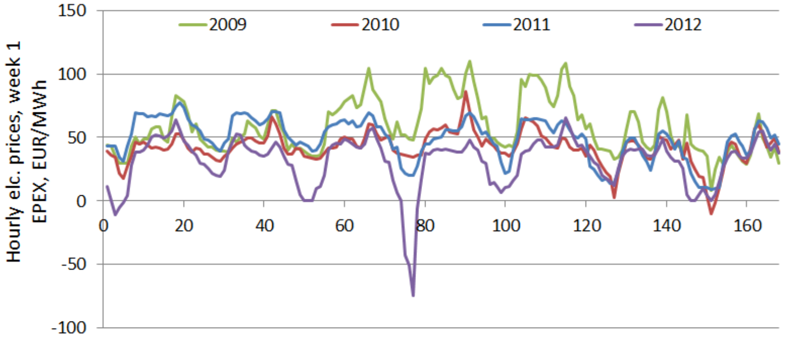
Short-term uncertainty of electricity trade prices

- **Stochastic parameters:** S_FLO_FUNC



Electricity trade price characteristics

- **Electricity prices are stochastic!**



Scenario generation

- **We have used hourly historical data from 2006 - 2011**
  - Wind availability = Actual wind production over installed capacity
  - Sub-annual variations on electricity prices in external regions
    - Annual price projections from external source
  - Same hour used for both stochastic parameters
    - Capture correlation between wind availability and electricity trade prices
  - Same hour used for all model regions
    - Capture regional correlation
  - Chronological order of historical data is used
    - Capture correlation in time

Scenario generation

- **A sub-set of historical data is used to present possible future realisations**
  - Sub-set selection based on best possible moment match between historical data and sub-set
- **The number of scenarios used affect the model results**
  - In-sample and out-of sample stability tests
  - More stochastic parameters – require more scenarios
- **Stochastic scenario generation**
  - Model specific
  - Not straight forward

Example

- **TIMES model of the Danish heat- and electricity system**
  - Model regions Denmark East & Denmark West
  - Model horizon 2010 - 2050
  - Time slices 4 seasons, 12 two-hour periods
- **Short-term uncertainty**
  - Stochastic parameters: Wind power availability & electricity trade price
  - Two-stage stochastic model
  - 90 scenarios

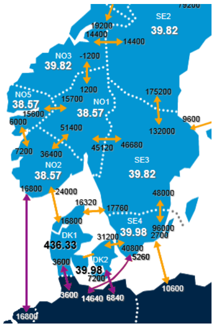
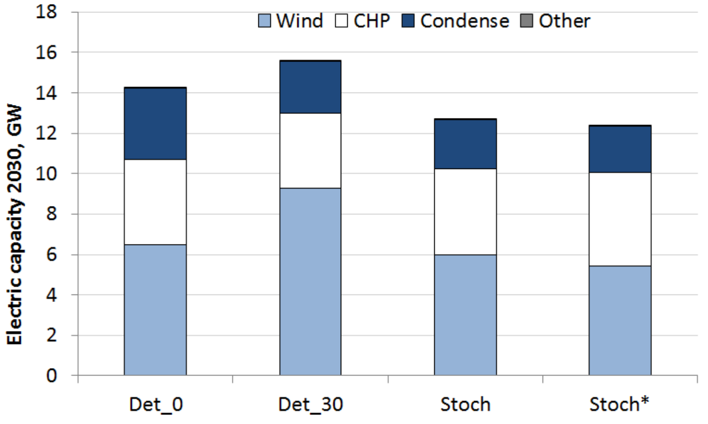


Figure: Nord Pool Spot 07.06.2013

Example

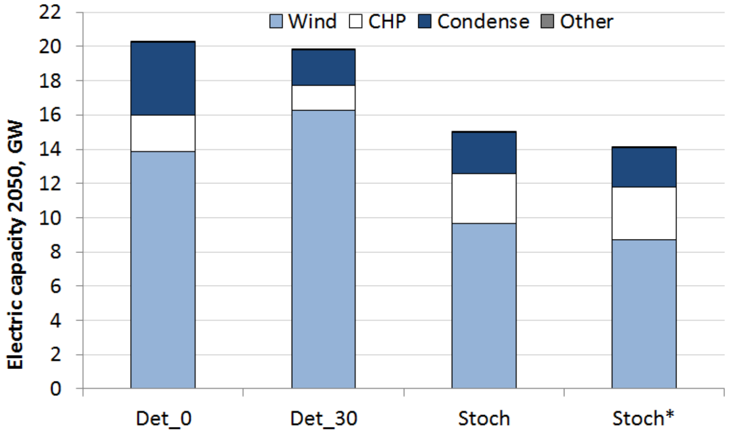
	Wind power	El. trade prices
Det0	Deterministic 0 % wind contribution to peak reserve constraint	Deterministic
Det30	Peak constraint Max. 30 % wind contribution to peak reserve constraint	Deterministic
Stoch	Stochastic wind availability	Deterministic
Stoch*	Stochastic wind availability	Stochastic

Results 1 – Electric capacity 2030



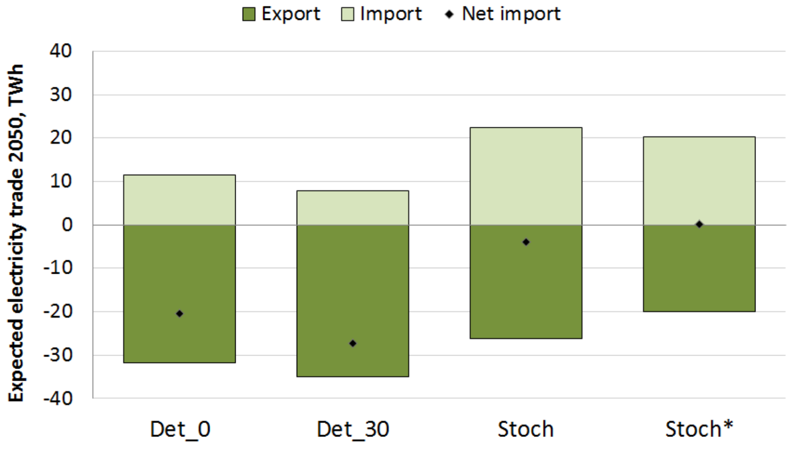
11.11.2013

Results 2 – Electric capacity 2050



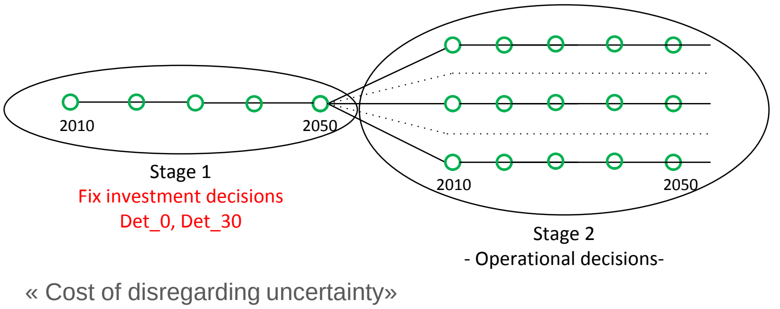
11.11.2013

Results 3 – Expected electricity trade 2050



11.11.2013

Results 4 – Value of Stochastic Solution



- « Cost of disregarding uncertainty»
- Fixed investment - Det_30 = Infeasible
- Fixed investment - Det_0
  - Stoch 5.0 % more expensive compared free inv. decisions
  - Stoch* 7.7 % more expensive

11.11.2013

Conclusions

- Competiveness of wind power depend on the method used to model the unpredictable characteristics of wind power
- The model results vary if electricity trade prices are modelled stochastic or deterministic
- Using the peaking reserve constraint can
  - Overestimate the competiveness of wind power
  - Give infeasible or more costly solutions
- Stochastic modelling of short-term uncertainty
  - Requires stochastic scenario generation
  - Return cost effective investment decisions

Thank you for the attention!

Pernille Seljom, pernille.seljom@ife.no