Stochastic modelling of short-term uncertainty in TIMES - A case study of wind power in Denmark

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Energy Modelling in Denmark WS

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Introduction

- Short-term uncertainty = availability of intermittent renewables
- Stochastic modelling of intermittent renewables
  - Operational models - state of the art
  - Investment models - not as common
- TIMES
  - Deterministic constraint that ensure back-up capacity
- We use stochastic programming
  - Case study: TIMES model of the Danish heat and electricity sector
  - Stochastic parameter:

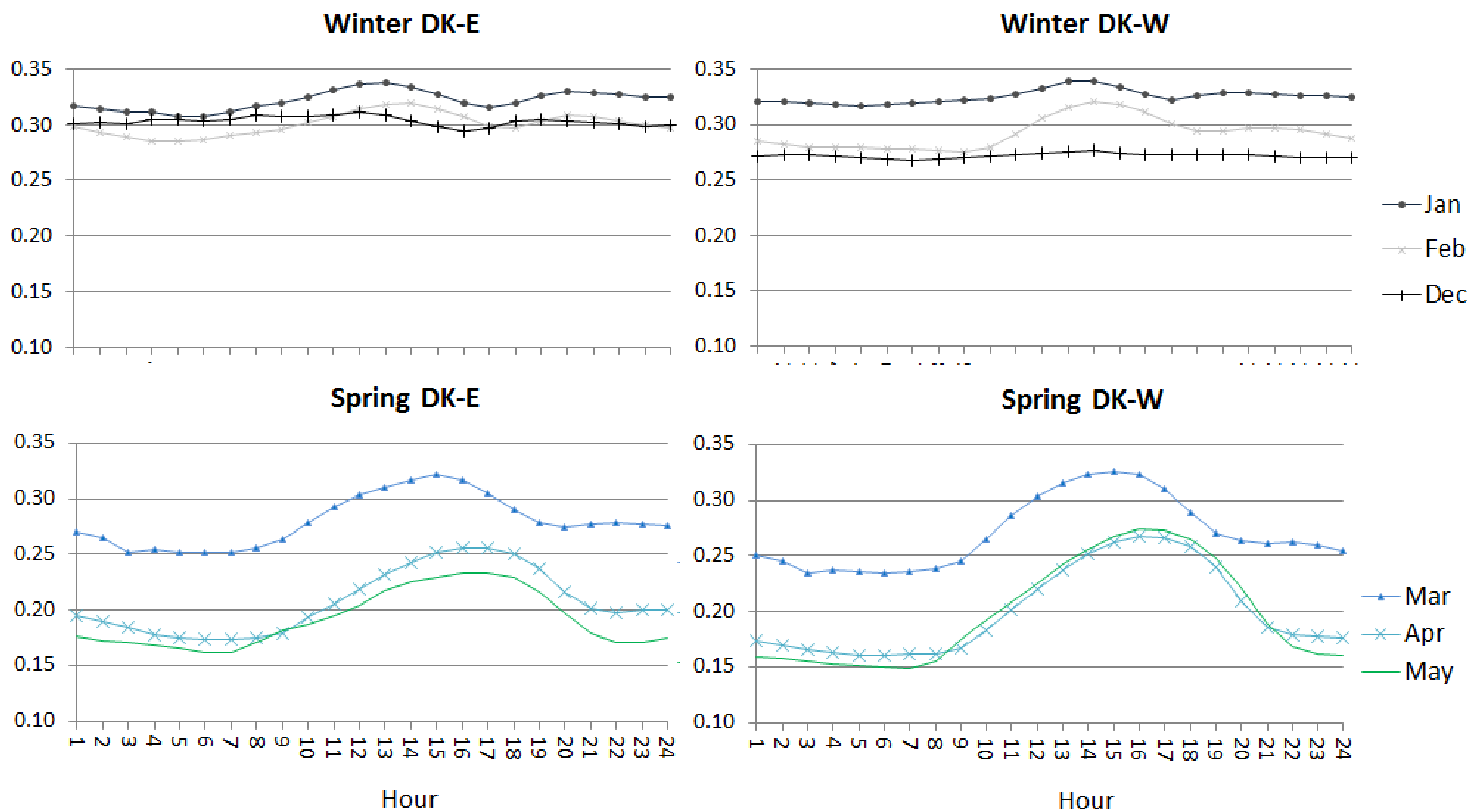
    wind availability = wind production / max theoretical production

Model description

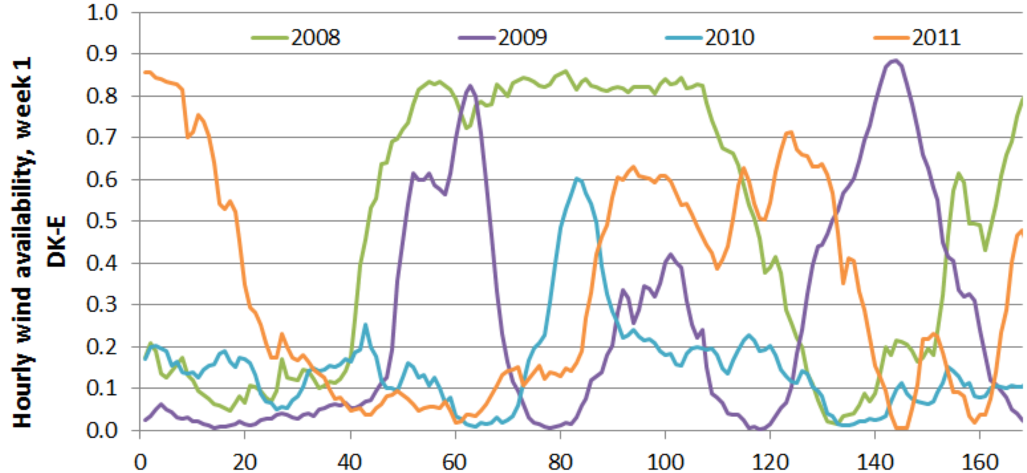
- TIMES model of the Danish heat and electricity sector
  - Linear Programming model
  - Model regions DK-E, DK-W
  - Model periods 2010, 2015, 2020, 2030, 2040, 2050
  - Period split 4 seasons, 12 two-hour periods
  - Obj. function minimize total energy system costs
  - Perfect foresight

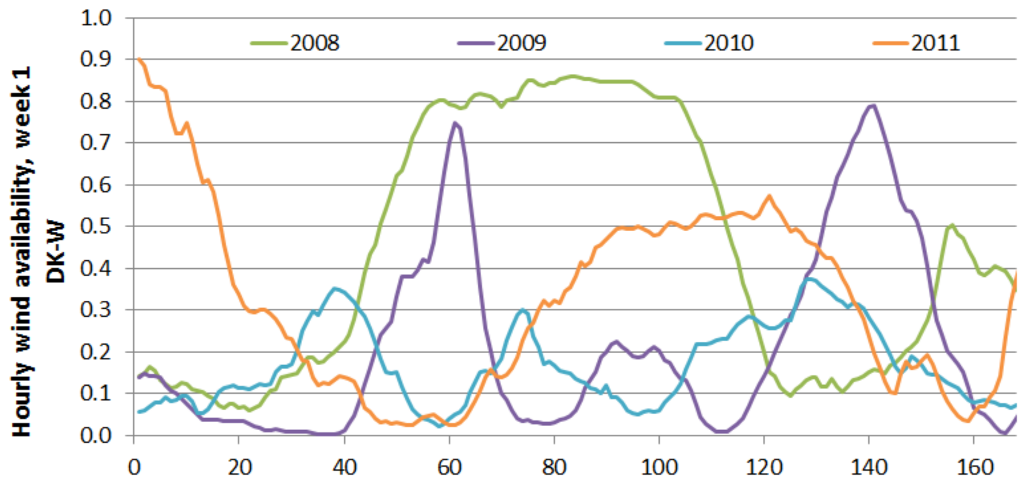
Wind power characteristics

- Average wind availability (2006 - 2011)

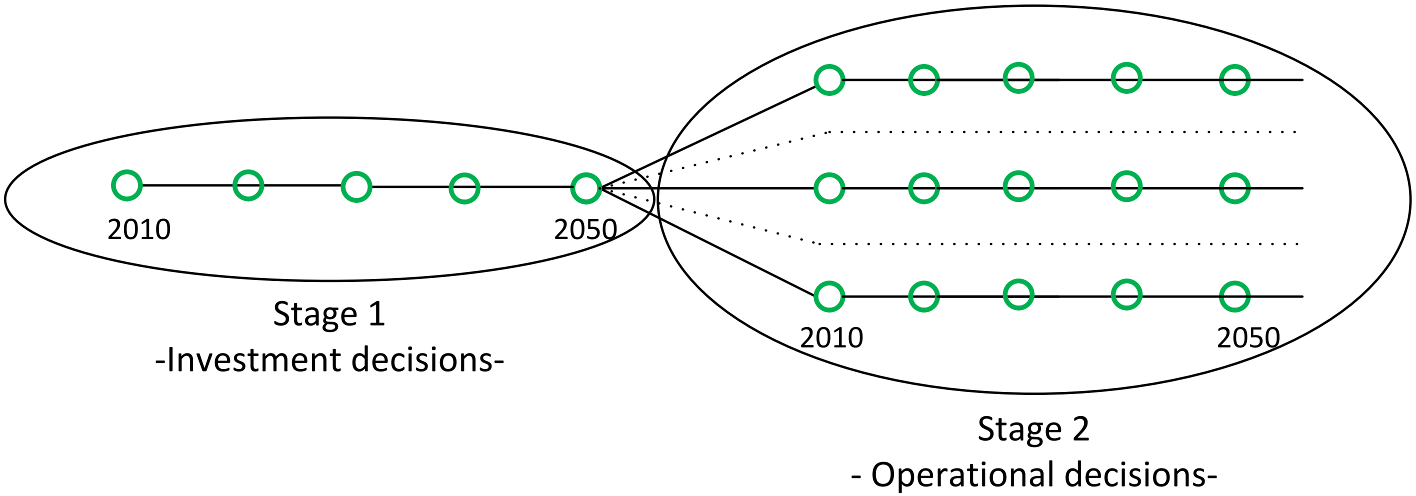


Wind power characteristics





Modelling uncertainty

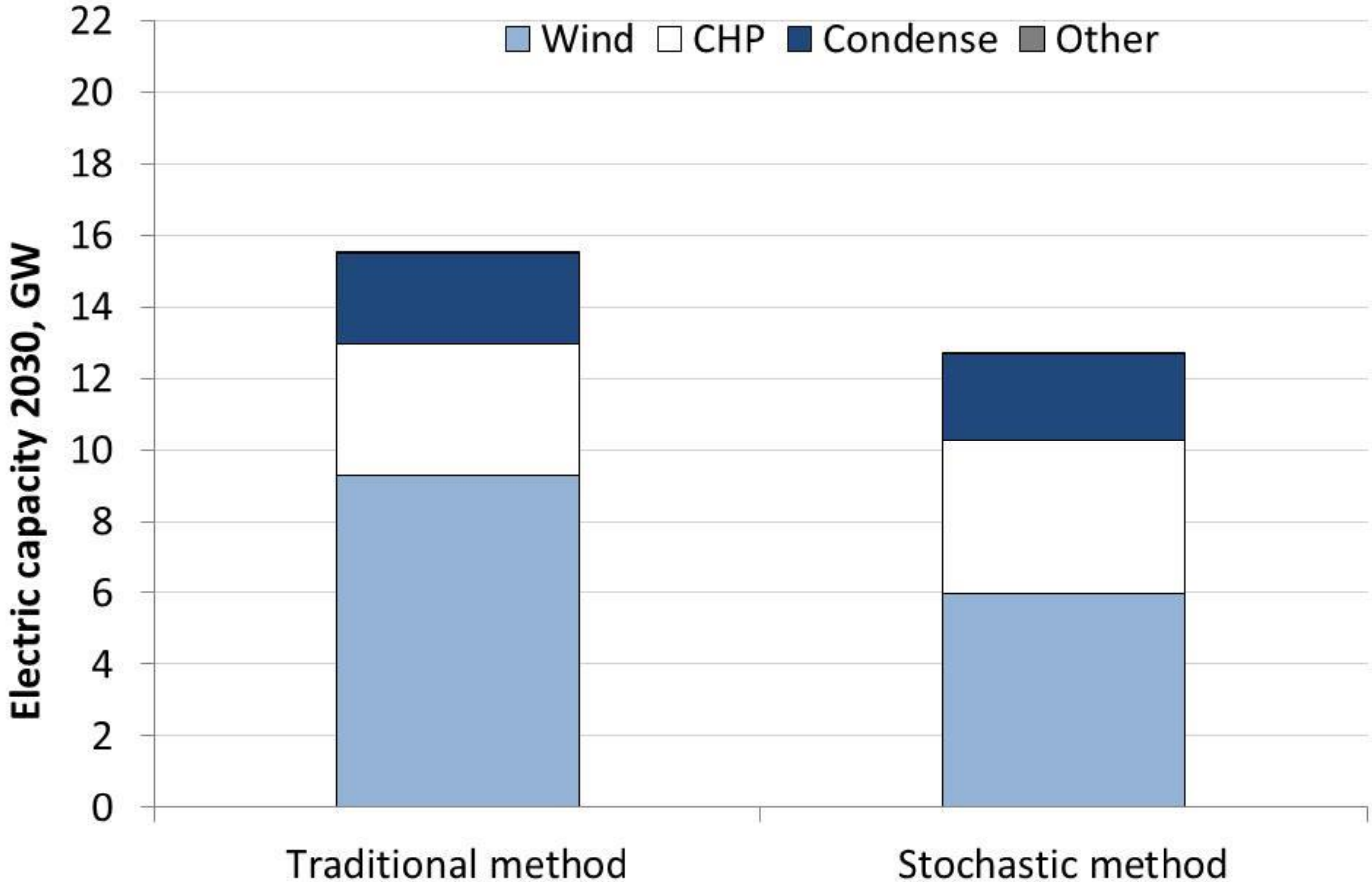


- Optimal investments given short-term uncertainty
- 1 stage= investment decisions 2010 - 2050
  - wind availability unknown
- 2 stage = operational decisions 2010 - 2050
  - wind availability known

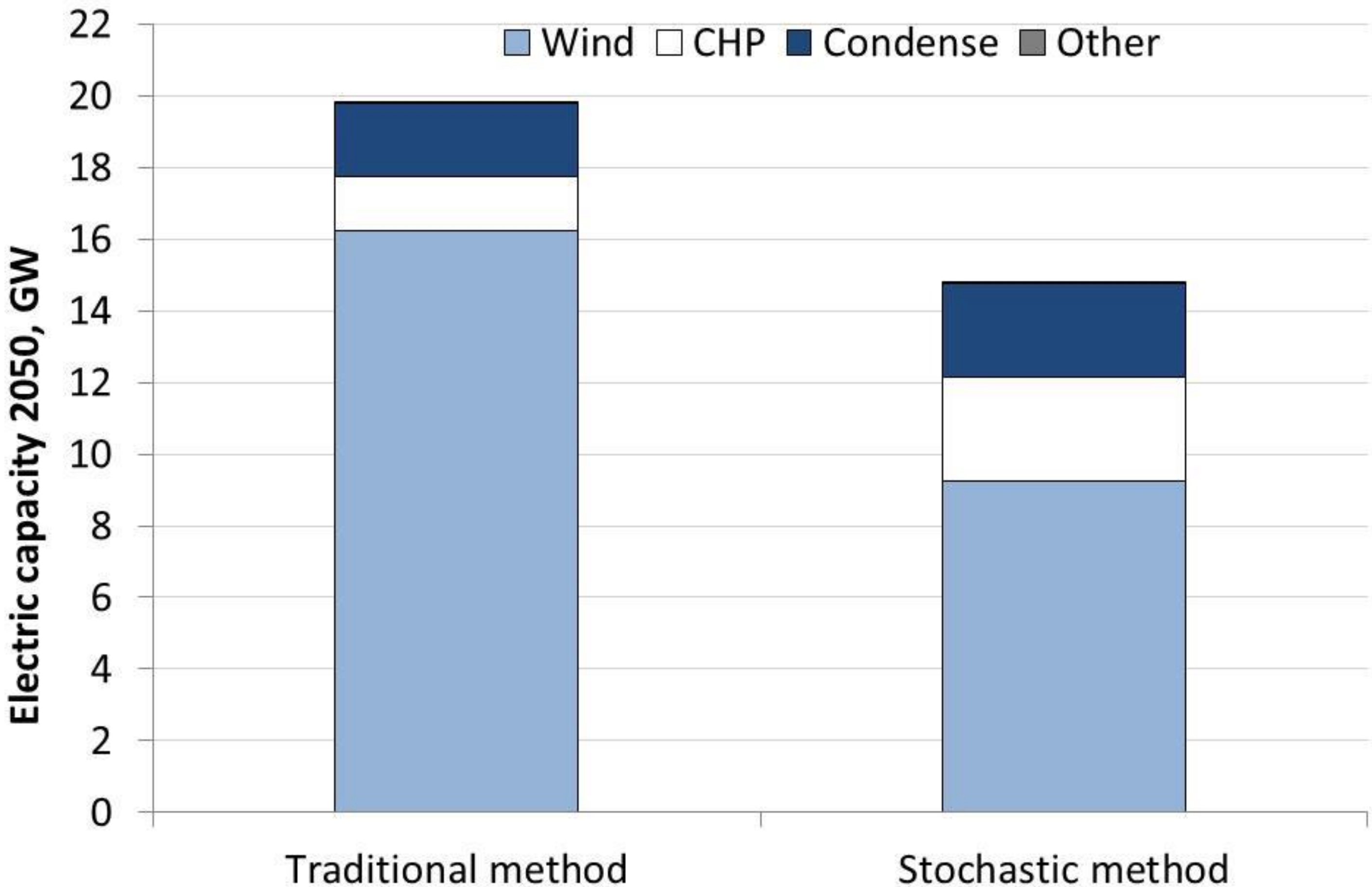
Scenario generation

- **We have used hourly historical data from 2006 - 2011**
  - Wind availability = Actual wind production over installed capacity
  - Same hour used for both model regions
    - Capture regional correlation
  - Chronological order of historical data is used
    - Capture correlation in time
- **A sub-set of historical data - possible future realisations**
  - Moment match between historical data and sub-set
- **Number of scenarios**
  - Stability tests - 90 scenario

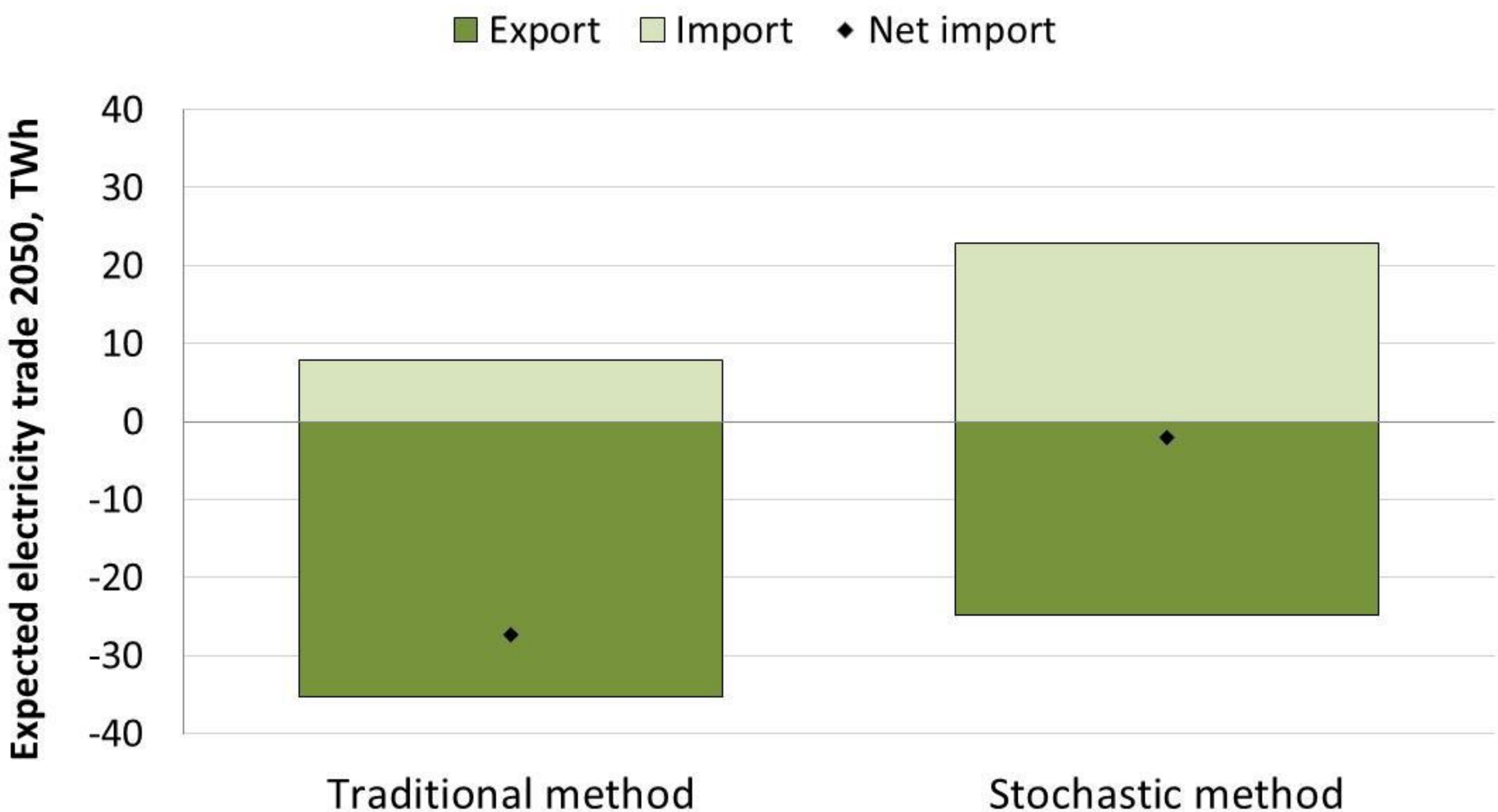
Result – Electric capacity 2030



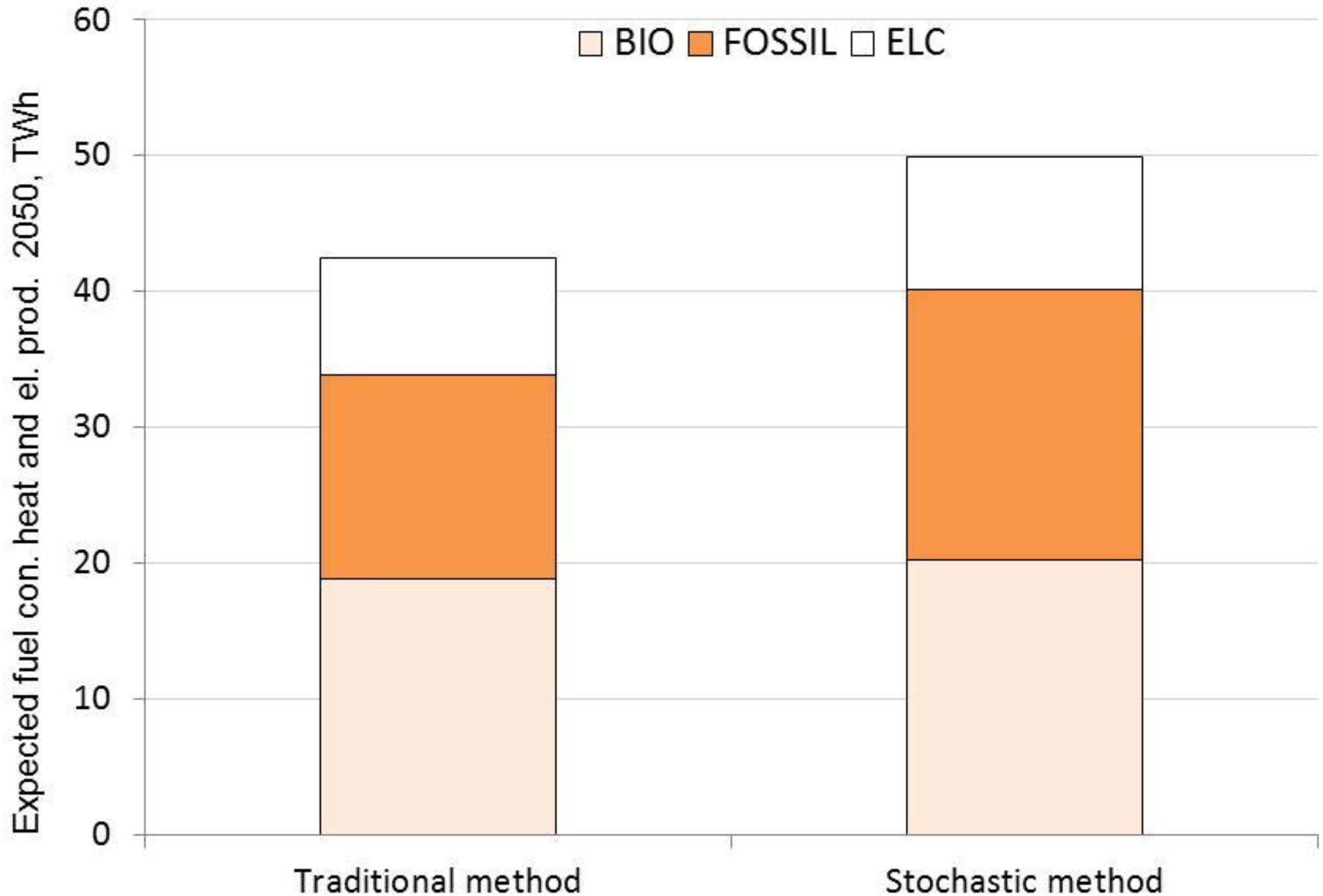
Result – Electric capacity 2050



Result – Electric trade 2050



Result – Fuel consump. 2050



Results – Value of Stochastic solution

- Value of Stochastic Solution
  - « Cost of disregarding uncertainty»
  - Is stochastic modelling worth the effort?

- Using “ traditional” and deterministic investment strategy gives
  - Infeasibility in one or more wind availability scenarios (Peak reserve factor = 30 %)
  - 5 % higher energy system cost compared to using a “stochastic” investment strategy (Peak reserve factor = 0 %)

Conclusions

- Result depend on modelling approach
- Simplified deterministic approach give:
  - more investment in wind power, higher electricity export & lower fuel consumption
  - infeasible or higher energy system costs
- Stochastic approach gives better results
- Proper modelling of intermittent renewables is also important in long-term investment models

Thank you for the attention!

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