Implications of Limited Foresight on Wind Park Investments in Norway

wholeSEM (28/04-2016)

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Overview

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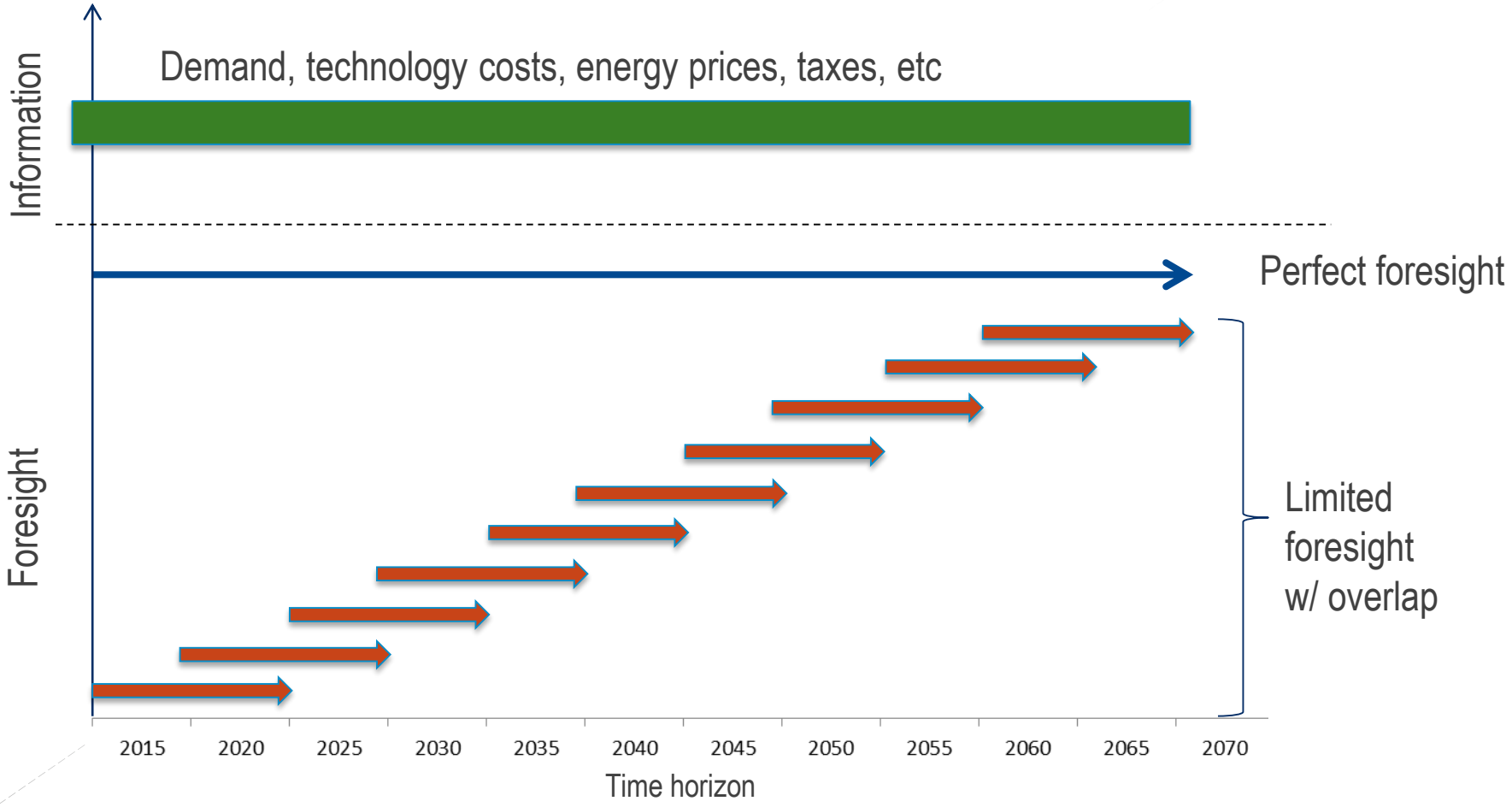
Motivation

- Test the important of the perfect foresight assumption in the following energy system models:
  - TIMES-Norway
  - NET-Model
- In reality, decision makers do not act with full information about the future
  - In practice: A limited horizon is used for their decision making
  - However, the future is predictable to some extent
- From a market point of view, it is not reasonable to use a perfect foresight planning horizon
  - More realistic to use a planning horizon equal to the planning horizon of investment decisions

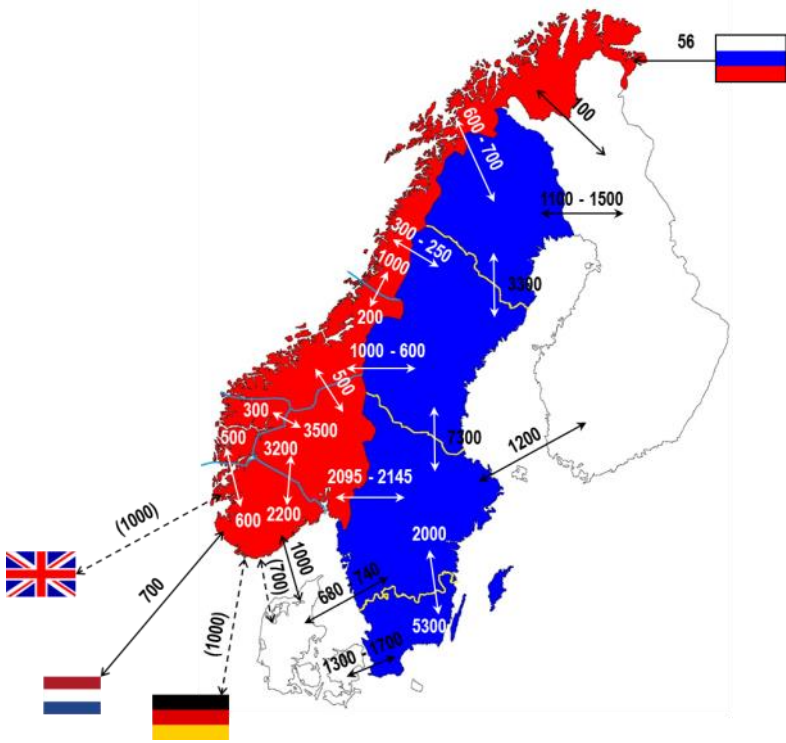
Principle


Information
Demand, technology costs, energy prices, taxes, etc
Perfect foresight
Foresight
Limited
foresight
w/ overlap
2015
2020
2025
2030
2035
2040
2045
2050
2055
2060
2065
2070
Time horizon

Methodology

Modelling framework: TIMES-Norway

- Bottom-up, techno-economic optimisation model describing the Norwegian energy system
  - Optional extension: Hard-linked version including Sweden
- High time resolution
- Model horizon from 2010 to 2050
- Covers five Norwegian (and four Swedish) regions
- Exchange of electricity between regions and neighbouring countries
- Assumes perfect competition and perfect foresight and is demand driven
- Energy demand is exogenous input



More information: A. Lind et al. / Energy Policy 60 (2013) 364–377

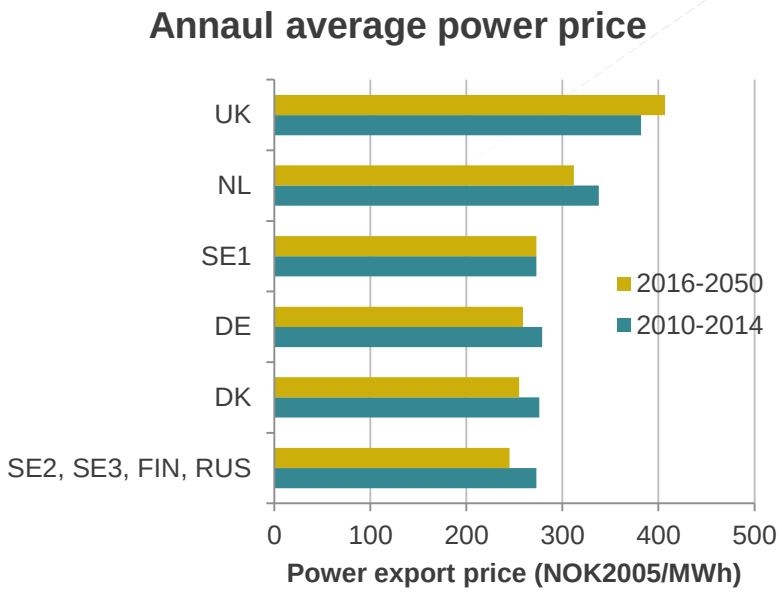
Limited foresight – Implementation in TIMES

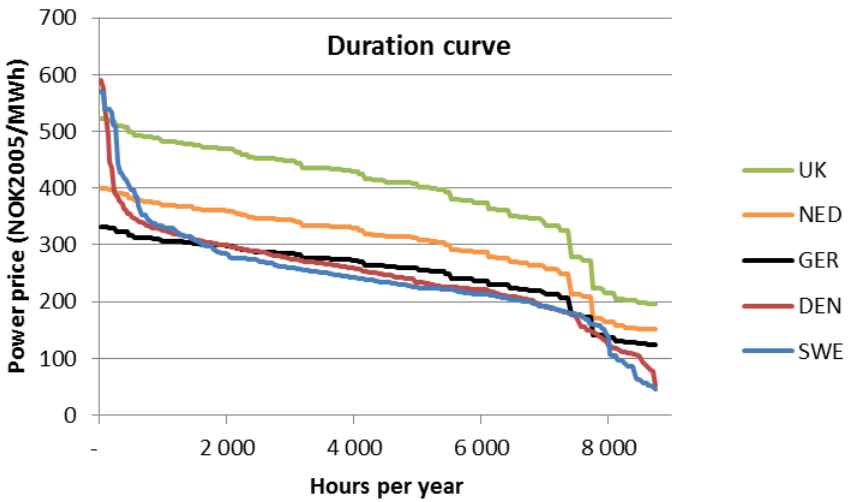
- Variable amount of years optimised in each solution step
- The total model horizon will be solved by successive steps
  - For each step the decision variables are defined only for a time subset
  - In each step the periods to be optimised are advanced further in the future
  - All periods before them are fixed to the solution of the previous step
- The amount of overlapping years between successive steps can be controlled by the user
  - More realistic to use a planning horizon equal to the planning horizon of investment decisions
- The final (optimal) solution consists of accumulated variables
  - Combination of results from each solution step

Scenarios and assumptions

Main assumptions

- Energy prices constant 2016-2050 (purchased energy)
- Present tax policy
  - Energy taxes 2014, constant until 2050
  - Biodiesel tax = fossil diesel after 2020
  - Zero emission cars exempted from purchase tax and VAT until 2020
  - Purchase tax for vehicles based on CO_2-emissions, power and weight until 2050
- Other:
  - Discount rate 4 % (higher for some demand technologies)
  - Enova support programs until 2020
  - Common green certificate market
  - Direct electric heating restricted as in TEK10 (building regulation)





Scenarios

Model alternatives

- Perfect foresight = No timestep
- Limited foresight I = 10 years timestep with 5 years overlap
- Limited foresight II = 5 years timestep with 2 years overlap

Demand alternatives

- REF — CenSES reference demand projections
- DEM — High industry activity
- PRI — Increasing energy prices

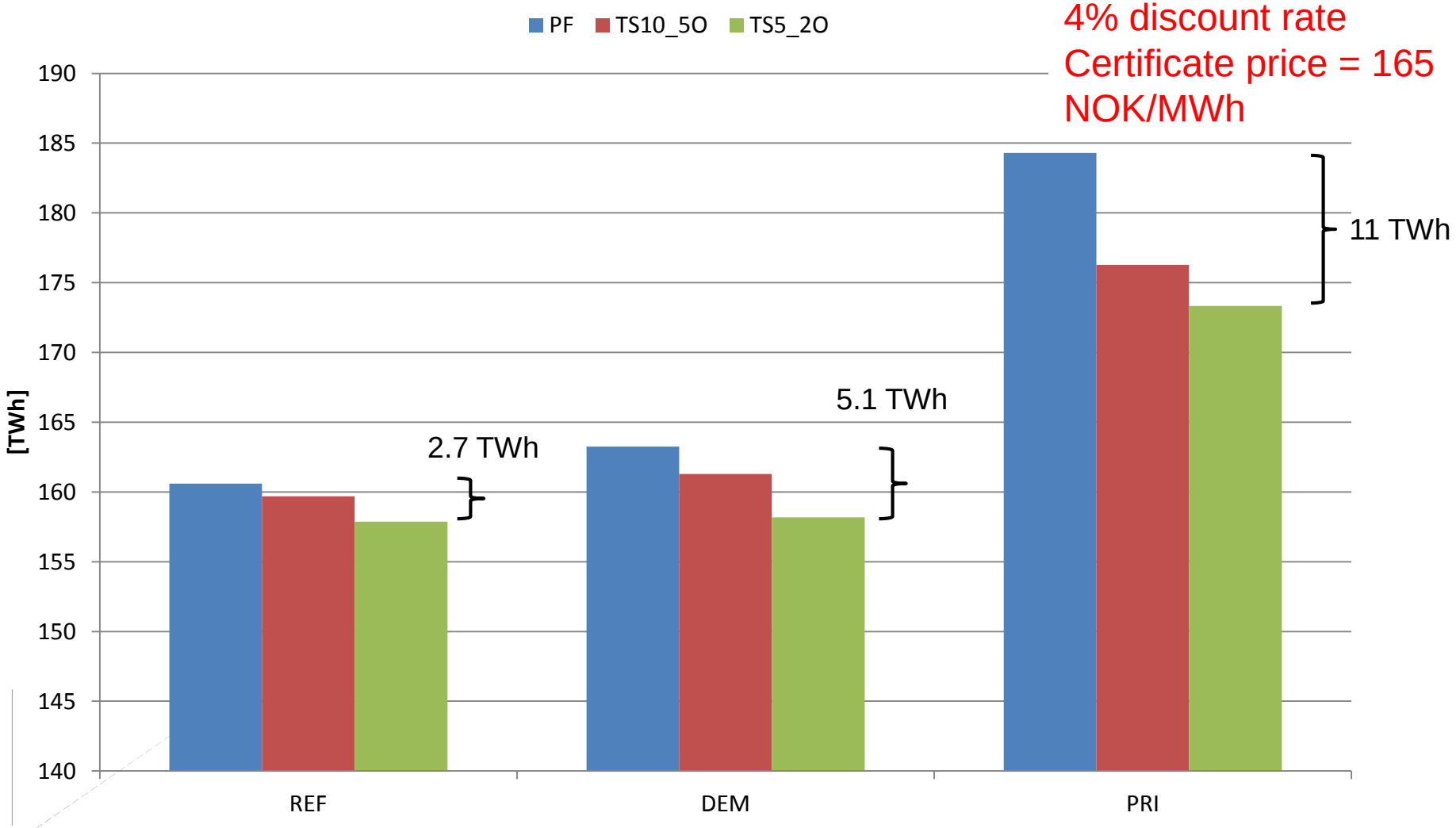
Demand alternatives →

Model alternatives ↓

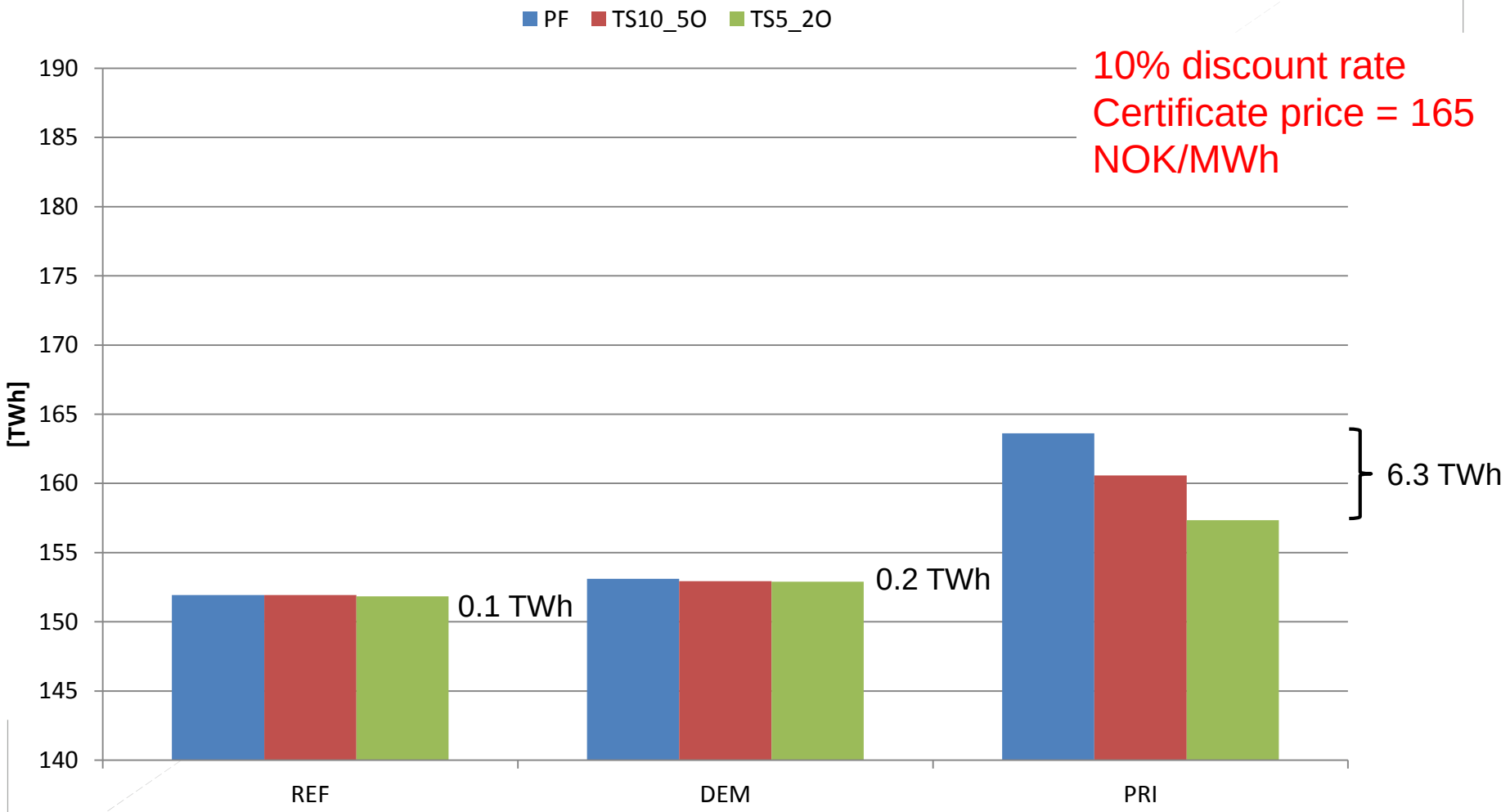
Time step		REF	REF	REF	REF	DEM	DEM	DEM	DEM	PRI	PRI	PRI	PRI
No	Global rate	4%	10%	4%	4%	4%	10%	4%	4%	4%	10%	4%	4%
	Certificate price NOK/MWh	165	165	200	120	165	165	200	120	165	165	200	120
10 yrs	Global rate	4%	10%	4%	4%	4%	10%	4%	4%	4%	10%	4%	4%
	Certificate price NOK/MWh	165	165	200	120	165	165	200	120	165	165	200	120
5 yrs	Global rate	4%	10%	4%	4%	4%	10%	4%	4%	4%	10%	4%	4%
	Certificate price NOK/MWh	165	165	200	120	165	165	200	120	165	165	200	120

Analyses

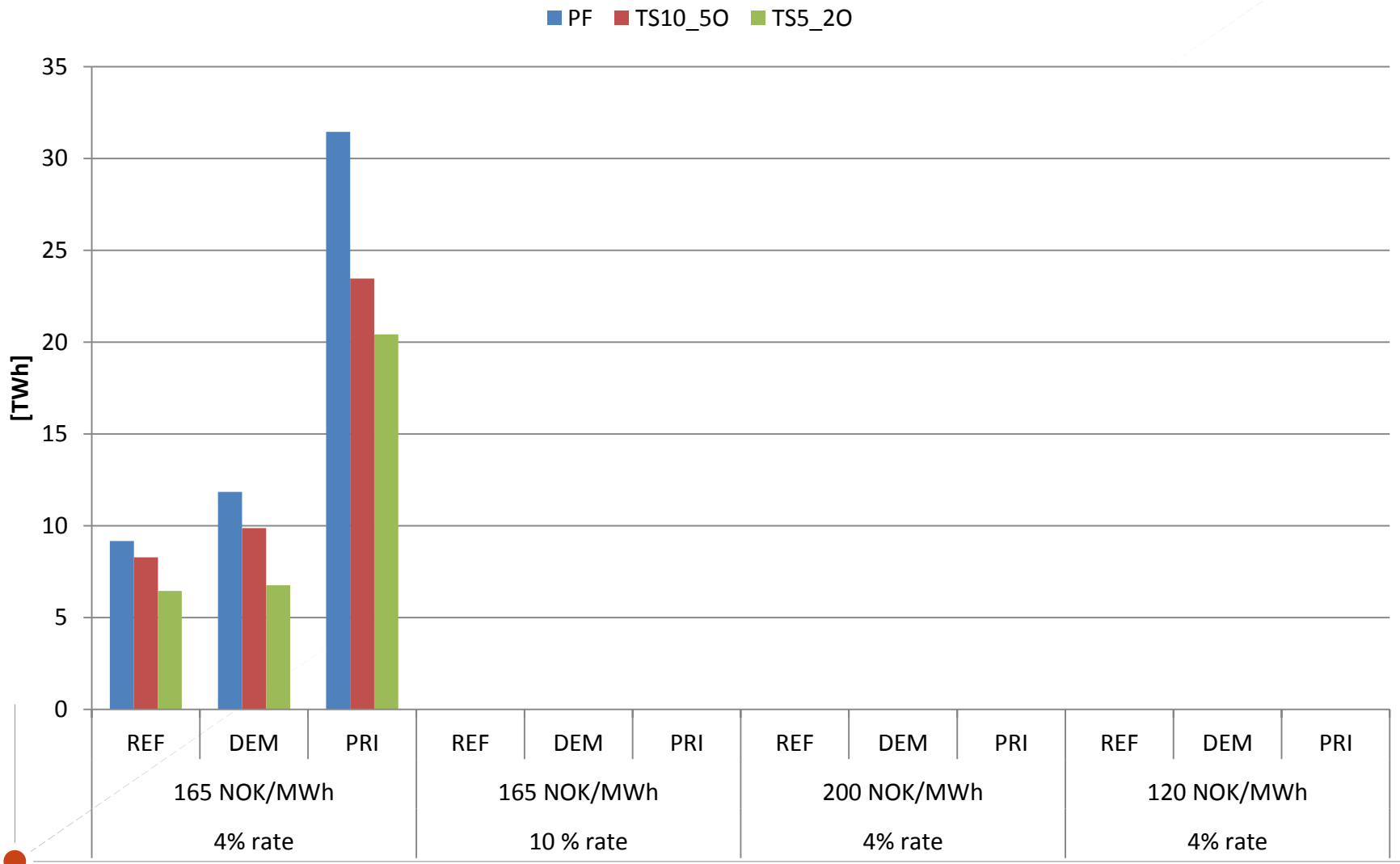
Total power production (2030)



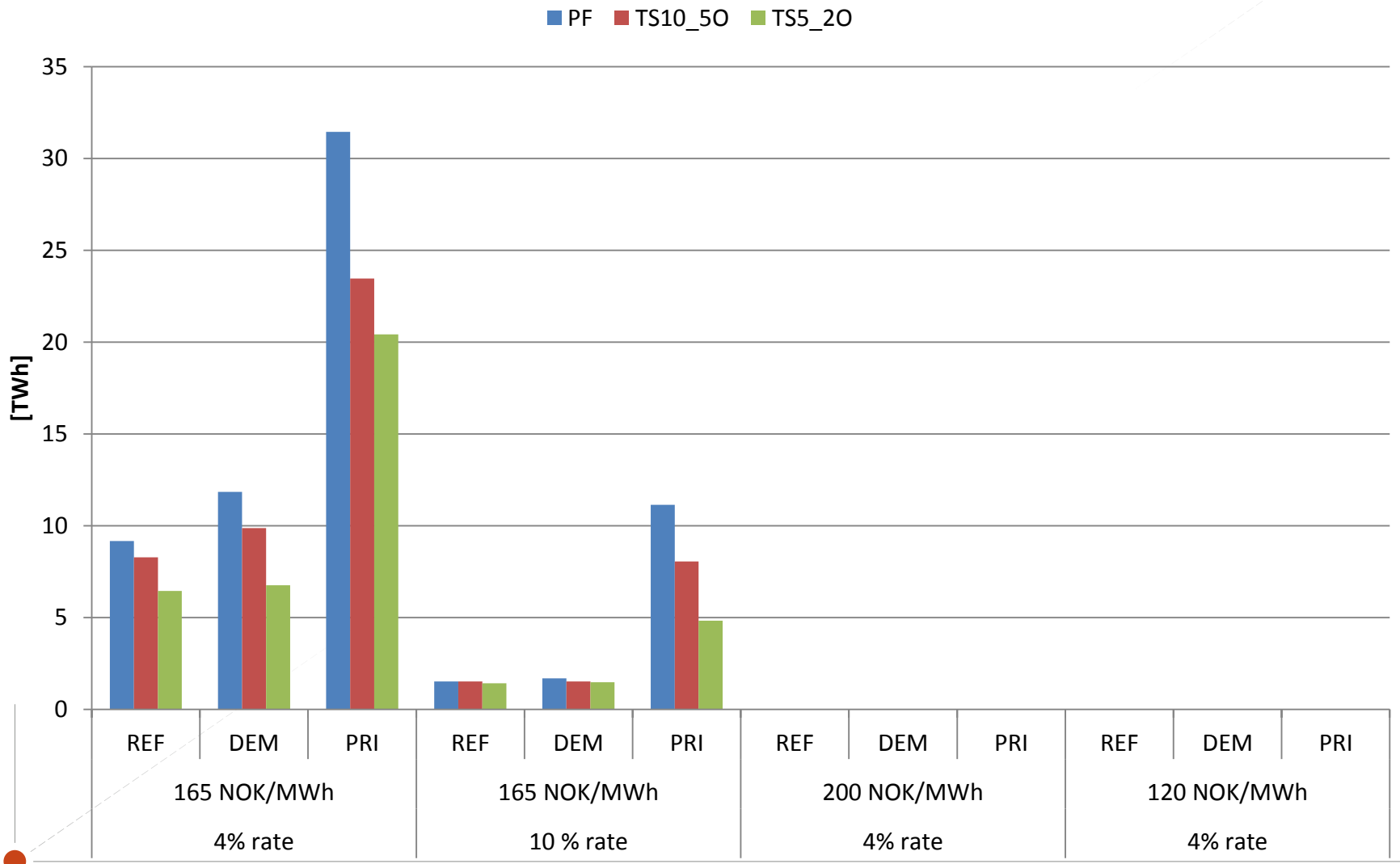
Total power production (2030)



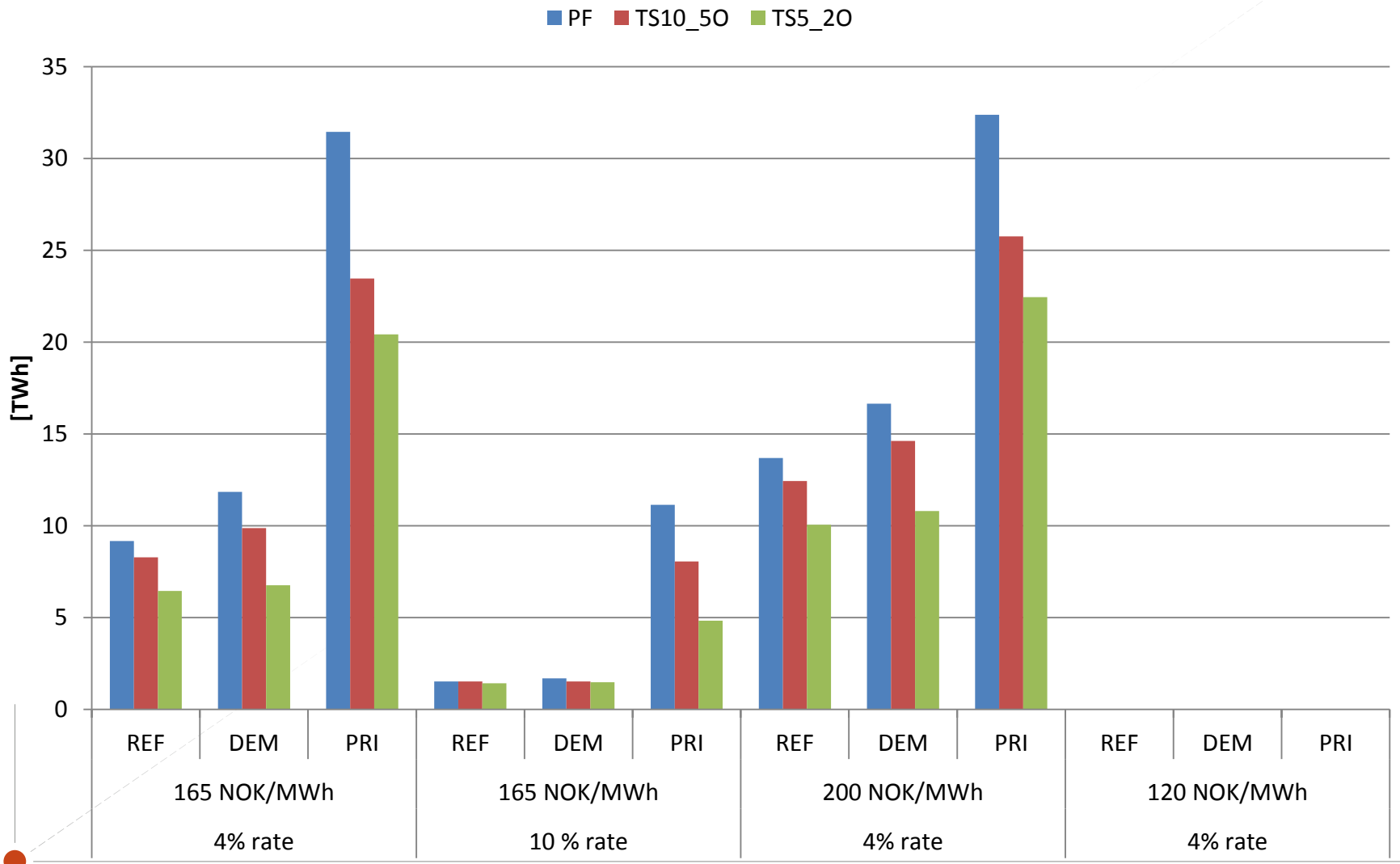
Wind power production (2030)



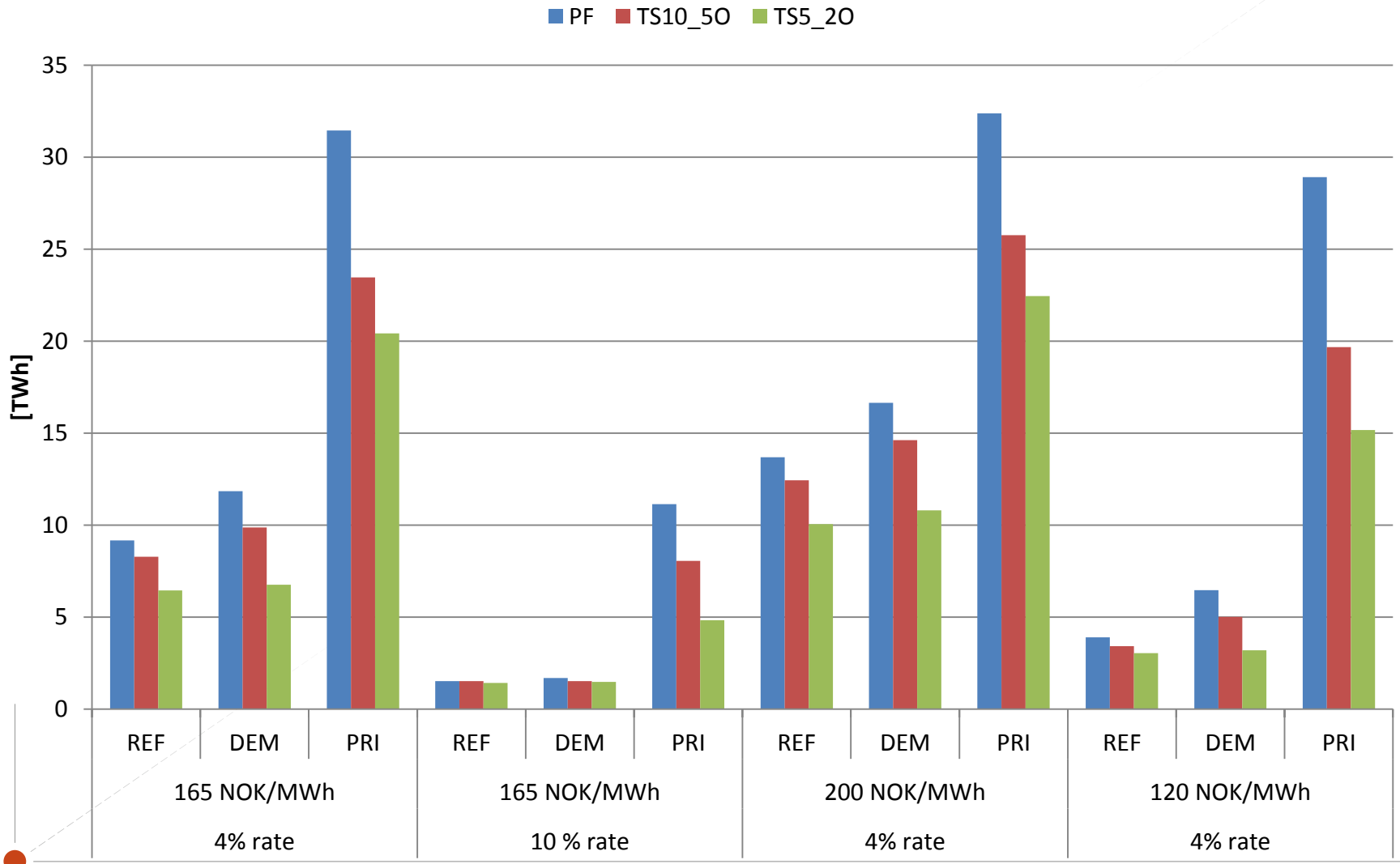
Wind power production (2030)



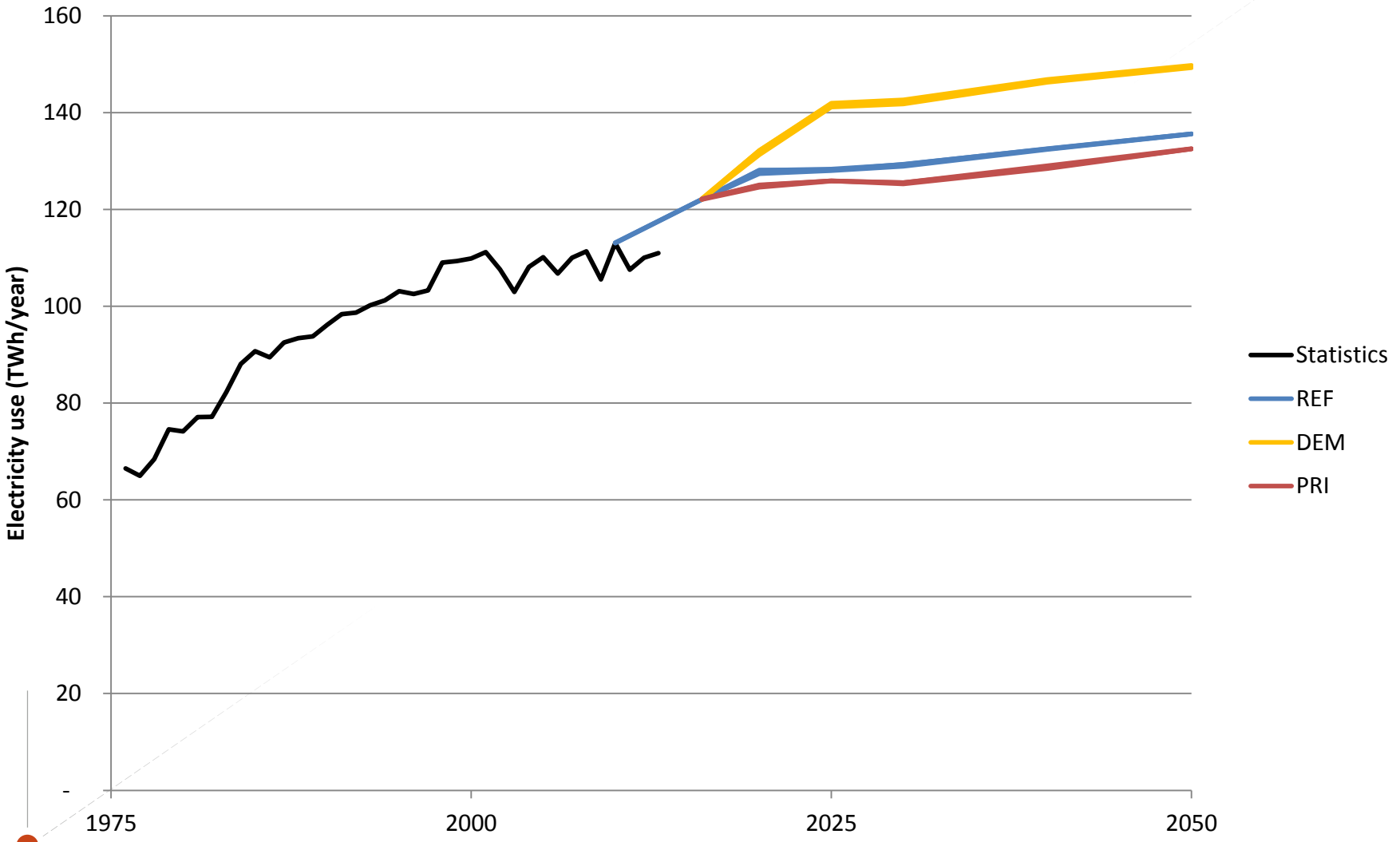
Wind power production (2030)



Wind power production (2030)

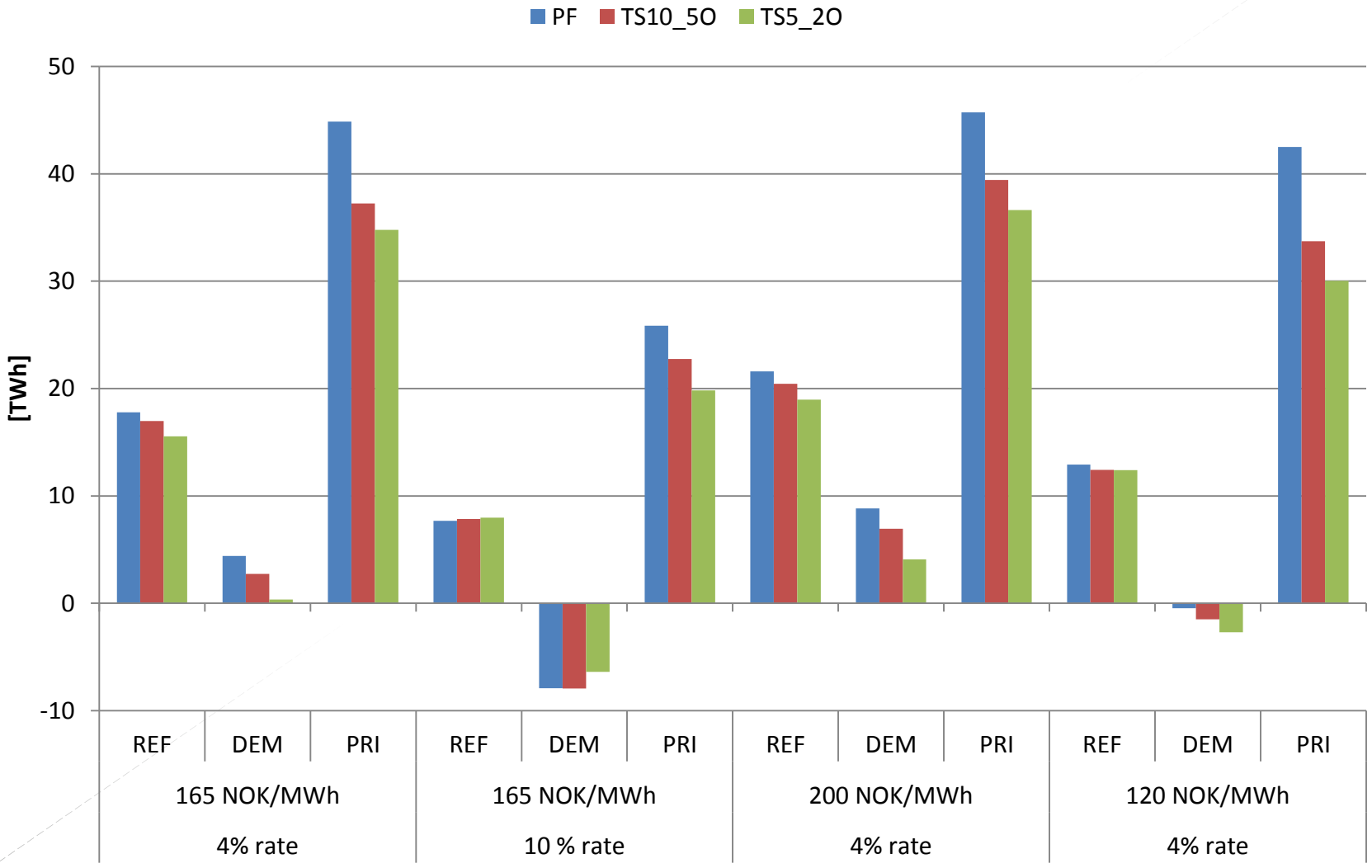


Electricity consumption



Electricity consumption

Net power export (2030)



Concluding remarks

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- For predictive scenarios (forecasts):
  - Small effects of using limited foresight in TIMES-Norway
- For explorative (external) or predictive (what if) scenarios:
  - Occasionally large effects of using limited foresight in TIMES-Norway
- The effects of limited foresight is reduced with a higher discount rate
- The model results show that limited foresight had larger effect on the *production side* than on the *end-use side* of the energy system:
  - Typical features of the *production side*:
    - Large, expensive investments
    - Long technological lifetime
    - Examples: Wind power, hydropower and export connections
  - Typical features of the *end-use side*:
    - Small, “inexpensive” investments
    - Shorter technological lifetime
    - Constant demand -> Change of technology (and energy carrier) possible
- Significant reduced computational time
  - Over 80% for certain scenarios

Thank you!

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