50% Wind Power in Denmark and Power Market Integration

Lars Bregnbæk and Jesper Werling
Ea Energy Analyses

50% Wind in Denmark by 2025

- *How does 50% wind power in Denmark affect the electricity market in Northern Europe?*
- *What is the impact on commercial investments in the market?*
- *What are the costs and benefits of 50% wind power?*
- *How does it affect the adequacy issue?*

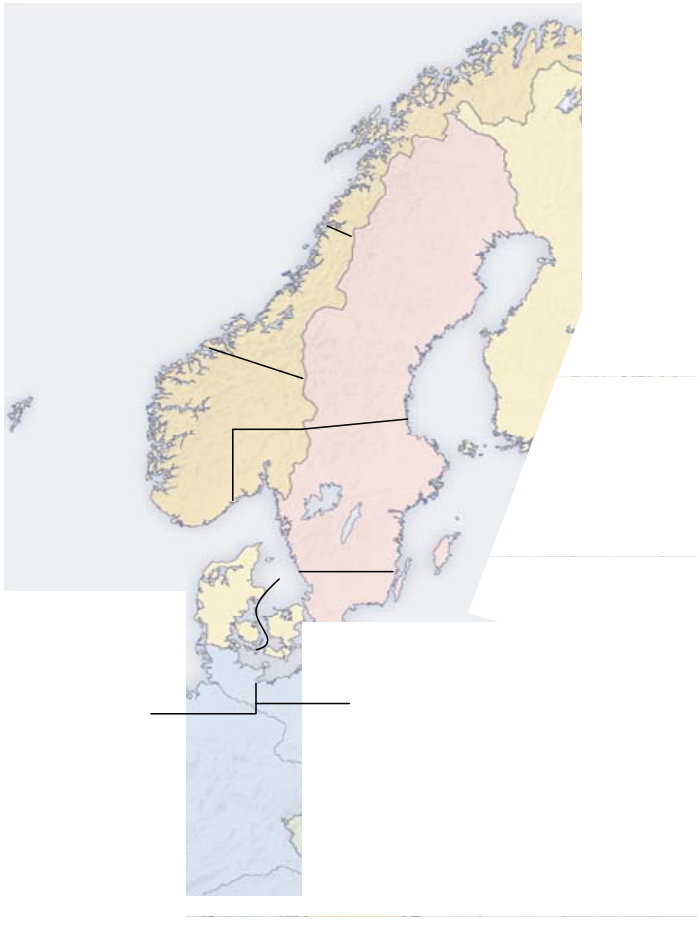
Model analysis

- Denmark and neighbouring countries

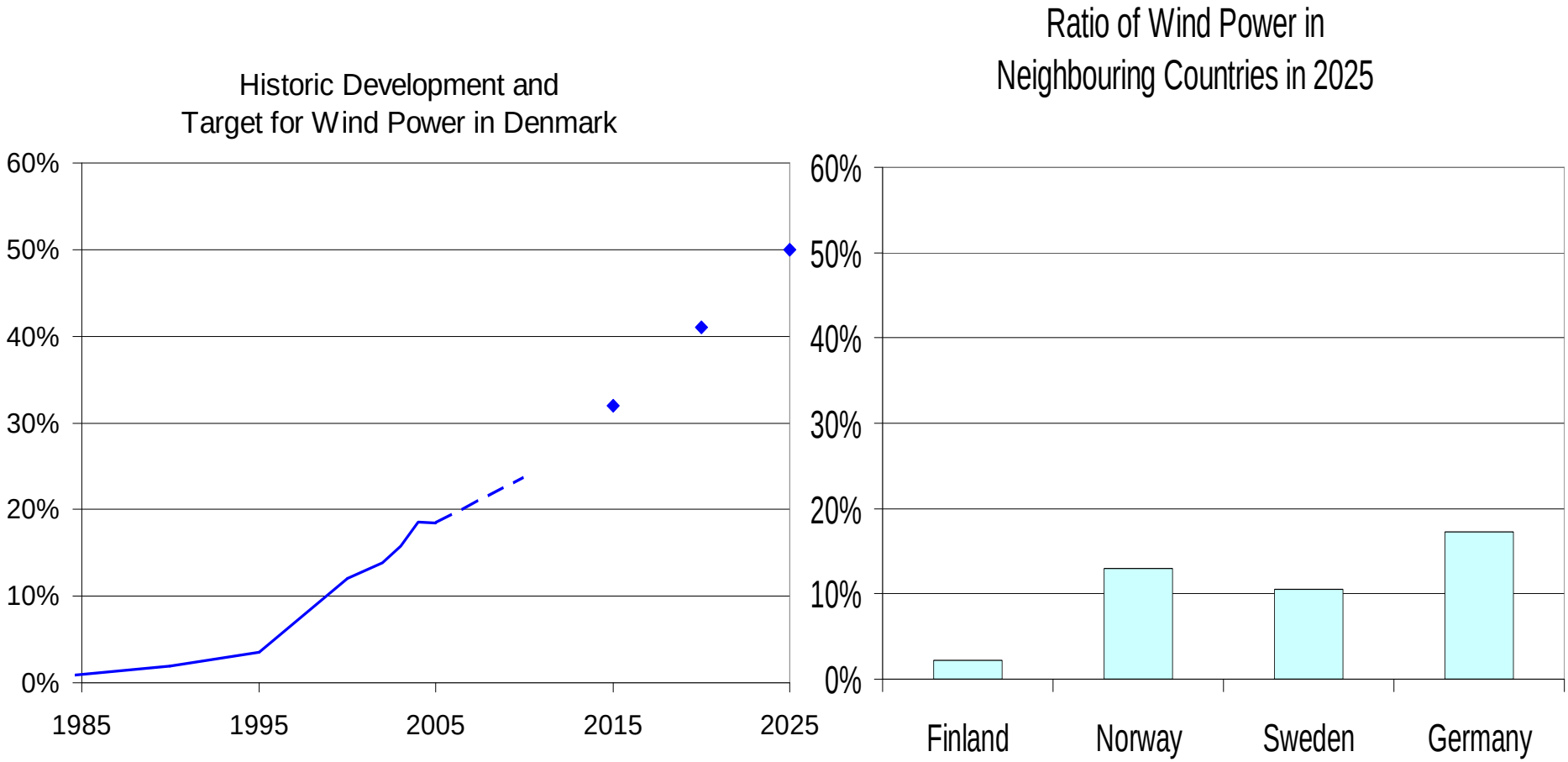
- 2 scenarios:
  - Investments governed by market incentives
  - Market + 50% wind target

Balmorel electricity market model:

- Optimal dispatch within the market framework
- Endogenous investments in generation capacity

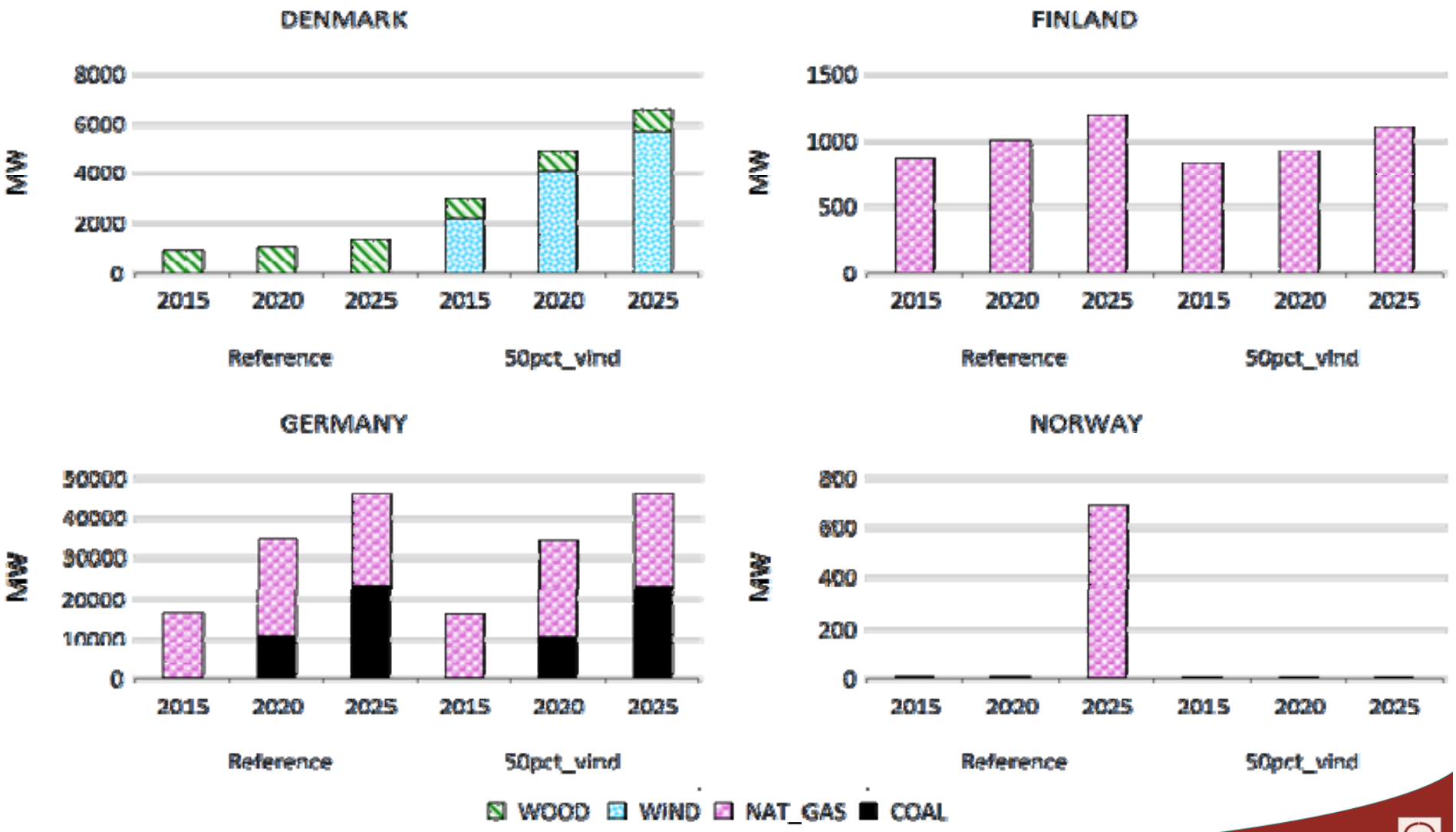


Central assumptions

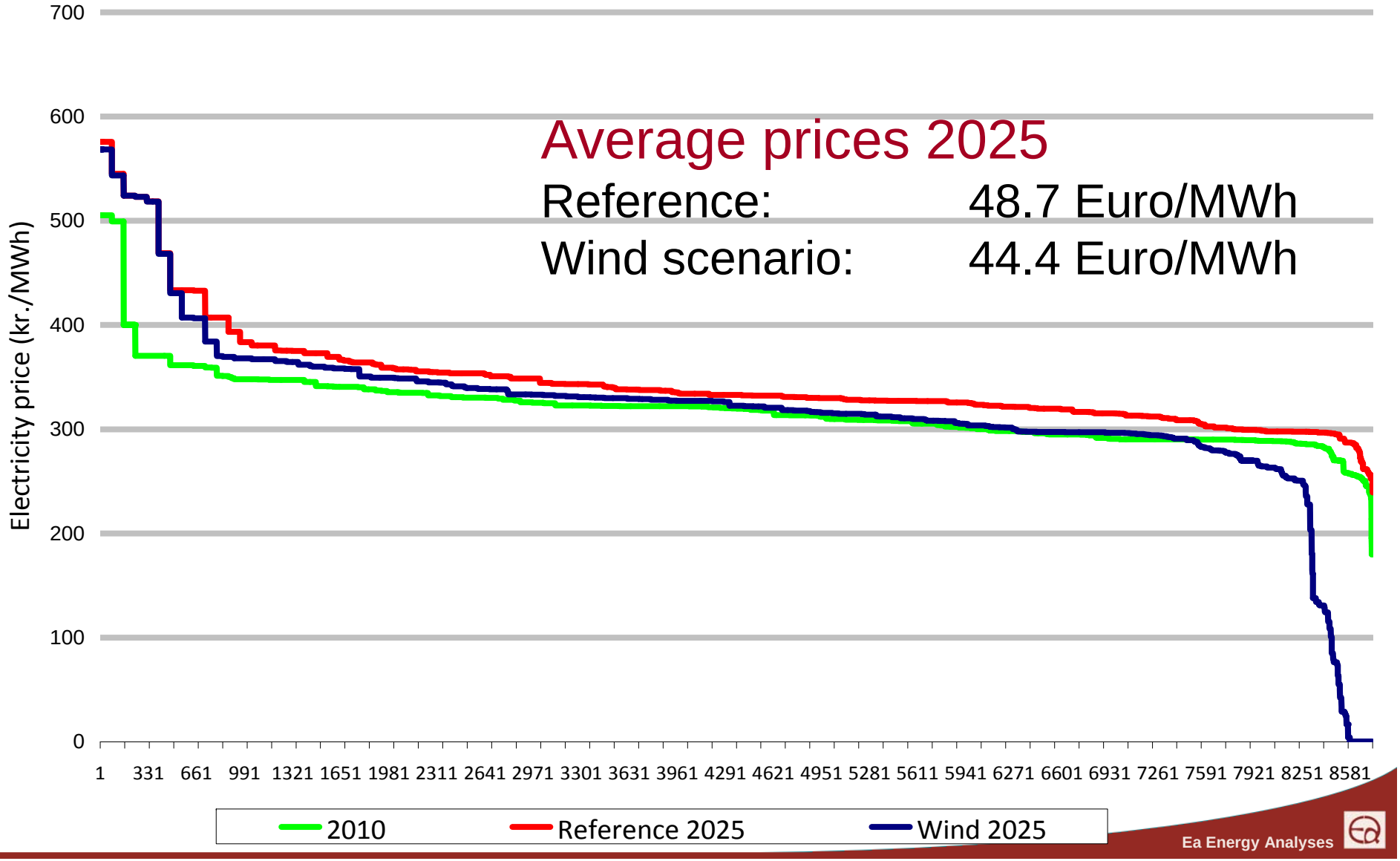


- Fuel prices as WEO 2006 (52$/barrel), CO_2 price 20 €/ton
- 3% annual decommissioning + German nuclear phase-out
- Danish wind power limited by grid expansion plan

Model investments



Electricity prices in Denmark



Costs and benefits

mEuro/year	Denmark	Whole area
Reduced generation costs	17	16
Grid infrastructure	-32	-32
Reduction in cost of environmental impact (SO2 and NOx)	18	105
Total gain	3	89

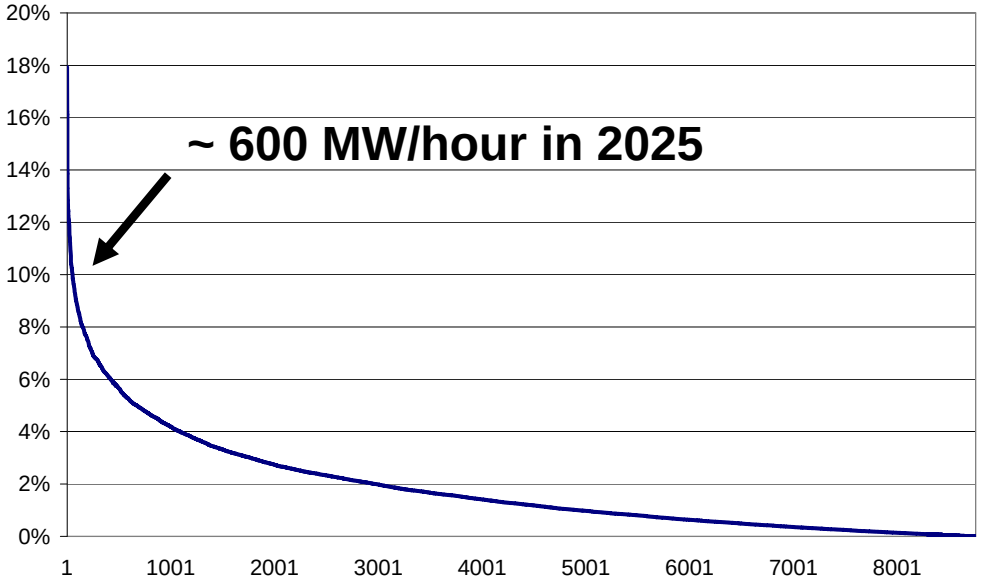
- Generation costs resultant from model analysis
- Grid infrastructure from separate analysis
- Environmental externalities based on CAFE and ExternE, and model emissions

Wind Power Integration

Key issues:

- Generation intermittency
  - Taken into account by the model
- Production gradient
  - Disregarded
- Uncertainty
  - Assumption of increasing balancing costs

Ramping for Danish wind power in 2006
Relative change from hour to hour



Model results and the adequacy issue (1/2)

- Supplementary analyses of 30% and 40% wind in 2025
- The model calculates the impact on thermal investments in the wind power scenarios

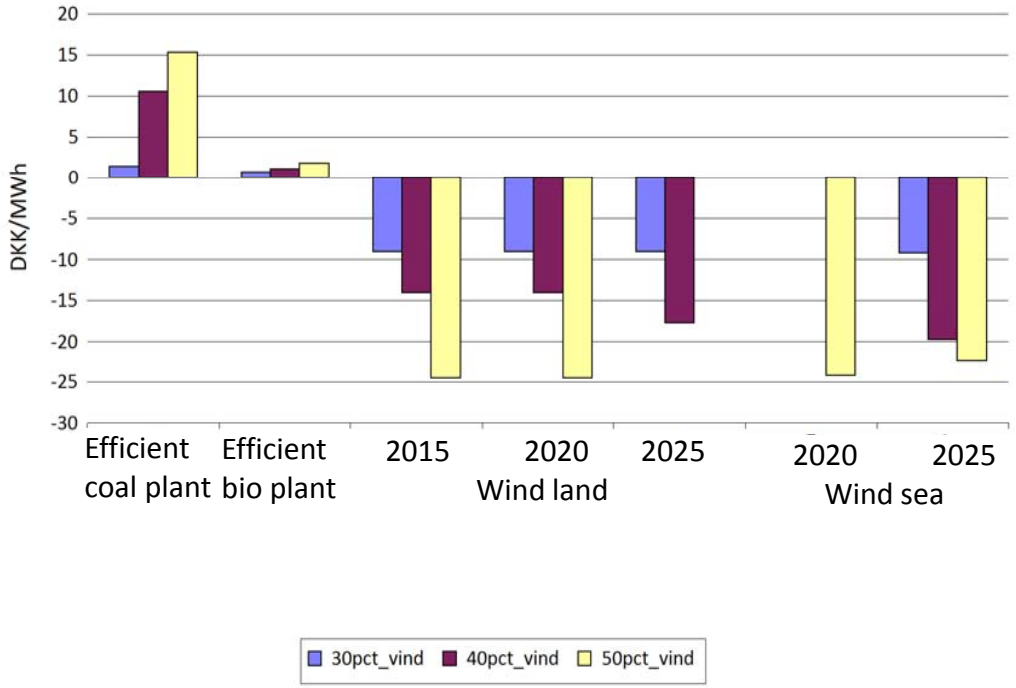
	30 pct. wind	40 pct. wind	50 pct. wind
New investments in wind power capacity (MW)	3,589	4,539	5,670
Reduced investment in thermal capacity compared to the reference scenario (MW)	943	1,132	1,459
Replaced thermal capacity / new wind power	0.263	0.249	0.257

- The investments in wind power displaces 0.25 MW thermal investments pr. MW wind
- The effect on adequacy depends on the capacity value of wind power
- Example: Nordel sets the capacity value to 6%.

Model results and the adequacy issue (1/2)

IEA: “In a market with no specific capacity measure the capacity cost or value of wind power is reflected in the prices in the market”

Model results 2025:



Extra cost of wind power compared to coal plant

- 30%: 1.3 Euro/MWh
- 40%: 3.4 Euro/MWh
- 50%: 5.4 Euro/MWh

Main conclusions

- 50% wind power in Denmark can be integrated without substantial grid investments – but more congestion will occur
- When including environmental externalities the social economy comes out positive.
- The main prerequisite is an efficient electricity market – open international trade.

- Market based investments will change. Adequacy can be reduced in the long term if capacity value of wind is below 25%. Else increased.