# Renewable energy

How much can we expect it to increase supplies over the next two decades?

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# Main issues – wind power

- The Future
- An illustration (western part of Denmark)
- Big challenges
  - Grid reinforcements
  - Daily forecasting
  - Market design
- Additional costs caused by the irregularity of wind power production

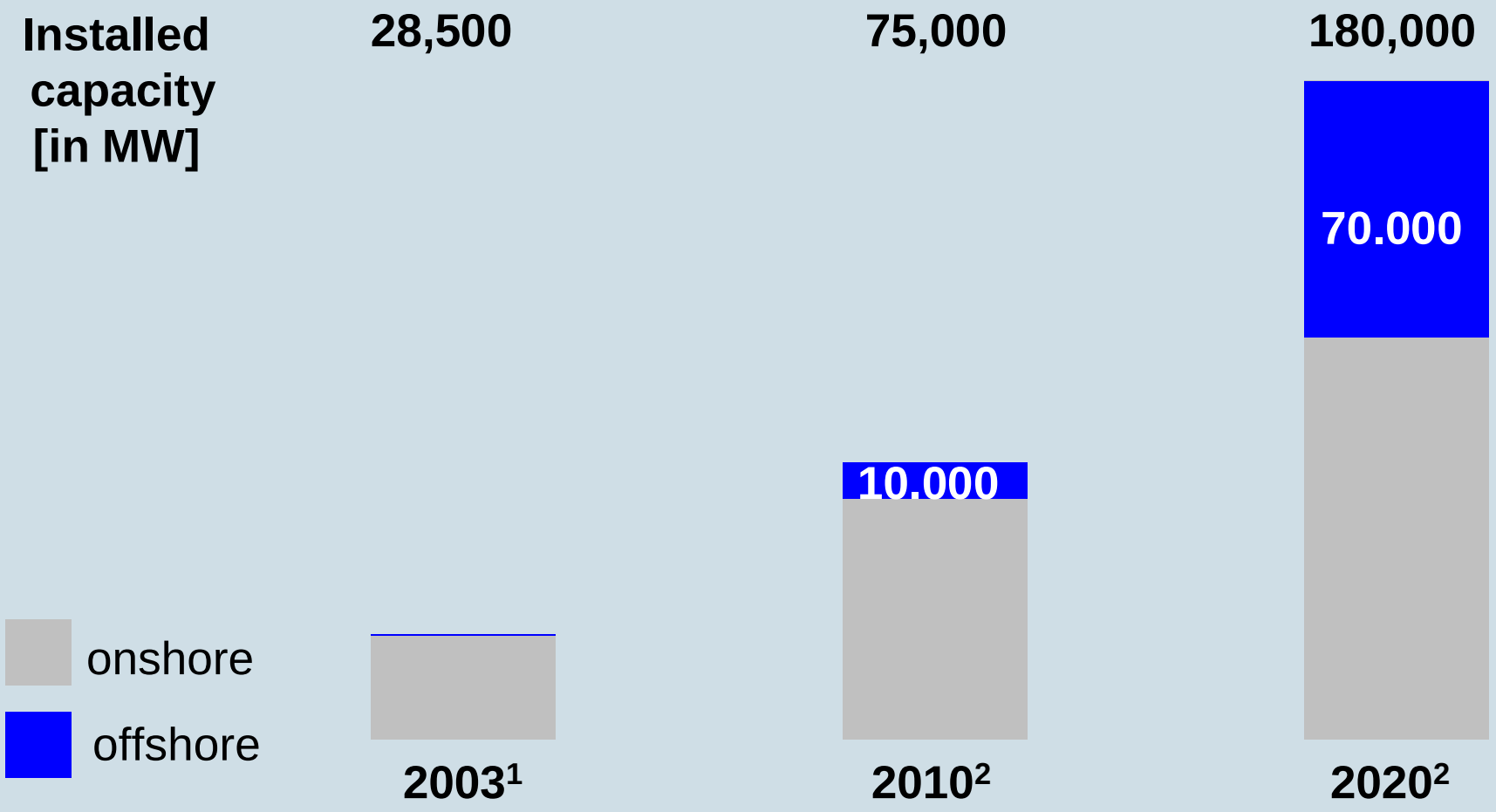
# Wind Power – Basic Characteristics

- No reliable availability
  – The power output is dependent on wind speed

- Limited predictability
  – The Wind prognosis is as good/bad as the weather forecast

- Unfavourable geographical allocation
  – Attractive wind conditions are usually located in sparsely populated coastal areas → energy transportation

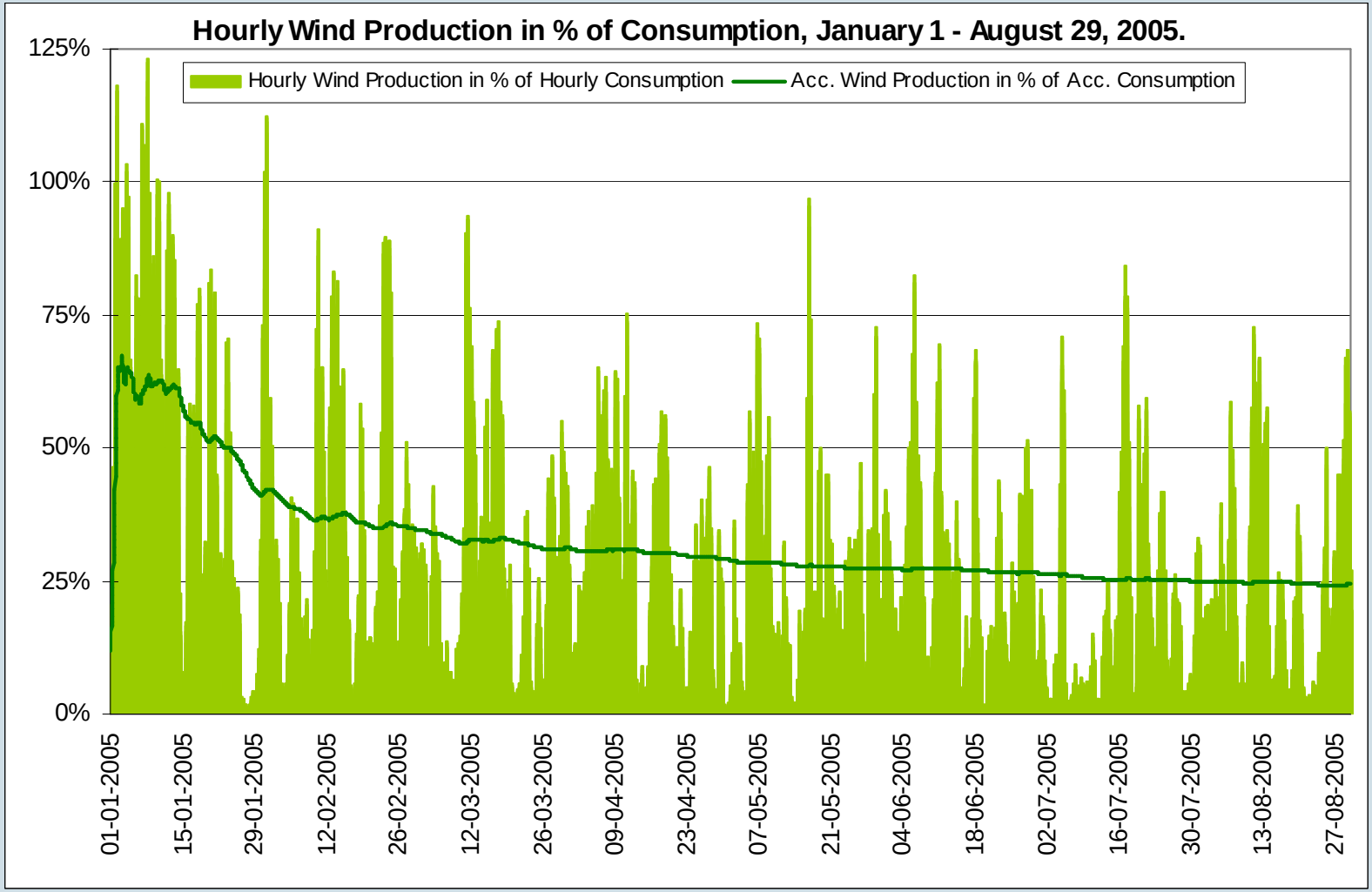
# Offshore – Main Driver for future RES Capacity ?




[1] 2003 /Source: EWEA

[2] Targets EWEA

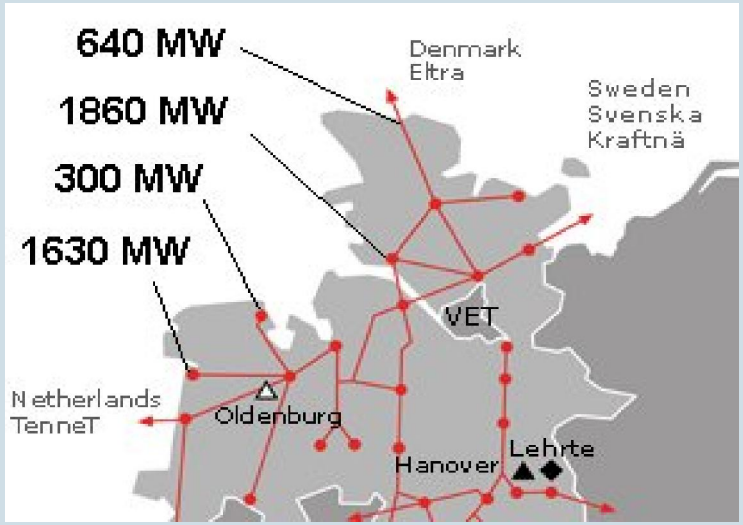
# A System with more than 20% Wind Power



# Additional wind power require additional transmission capacity

Dena Grid Study:
North See wind power 2010

- Dena: North See Wind Power:
  - 2010: 4,430 MW
  - 2020: 18,640 MW
- Grid expansion:
  - Long realization times mainly due to time-consuming approval procedures

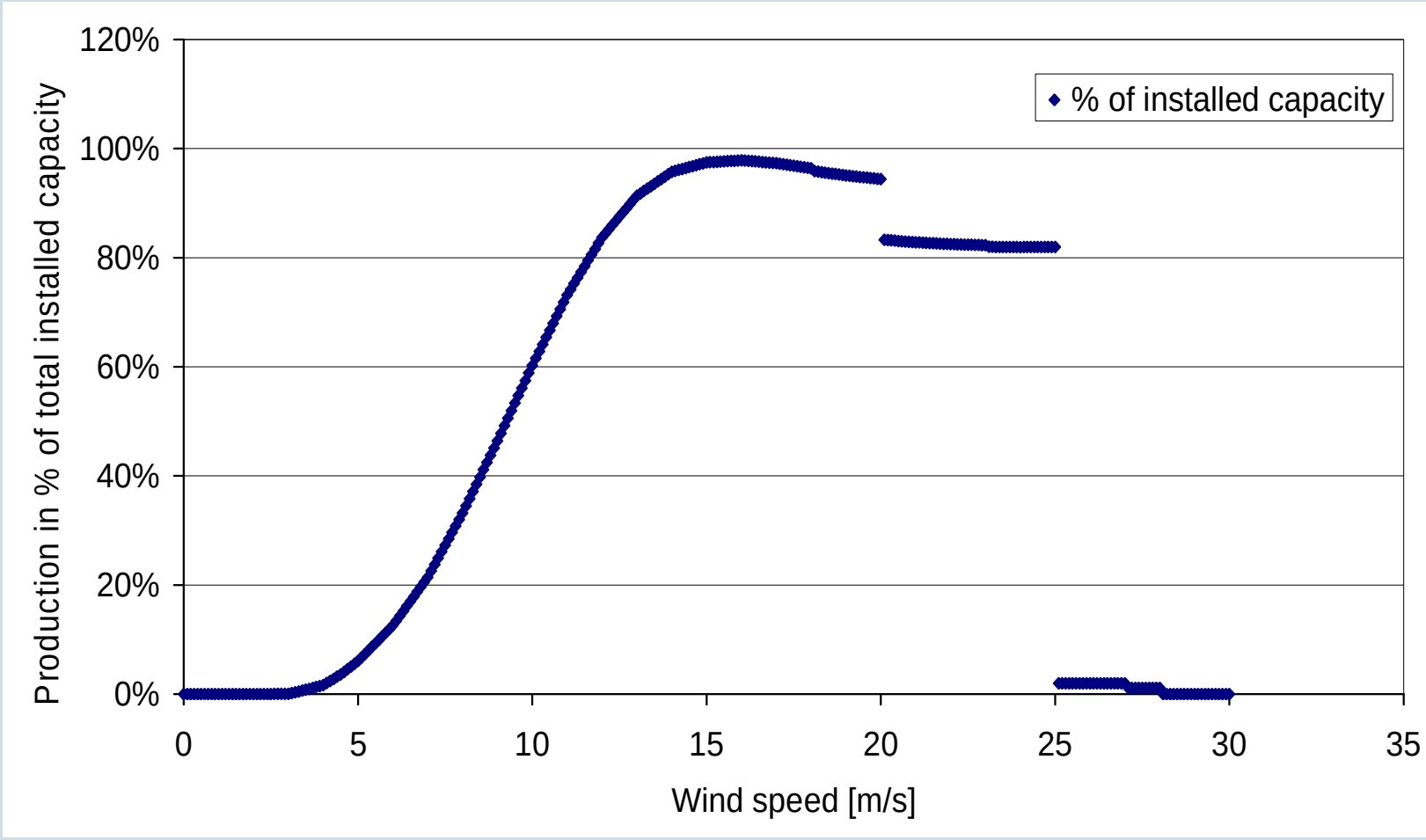


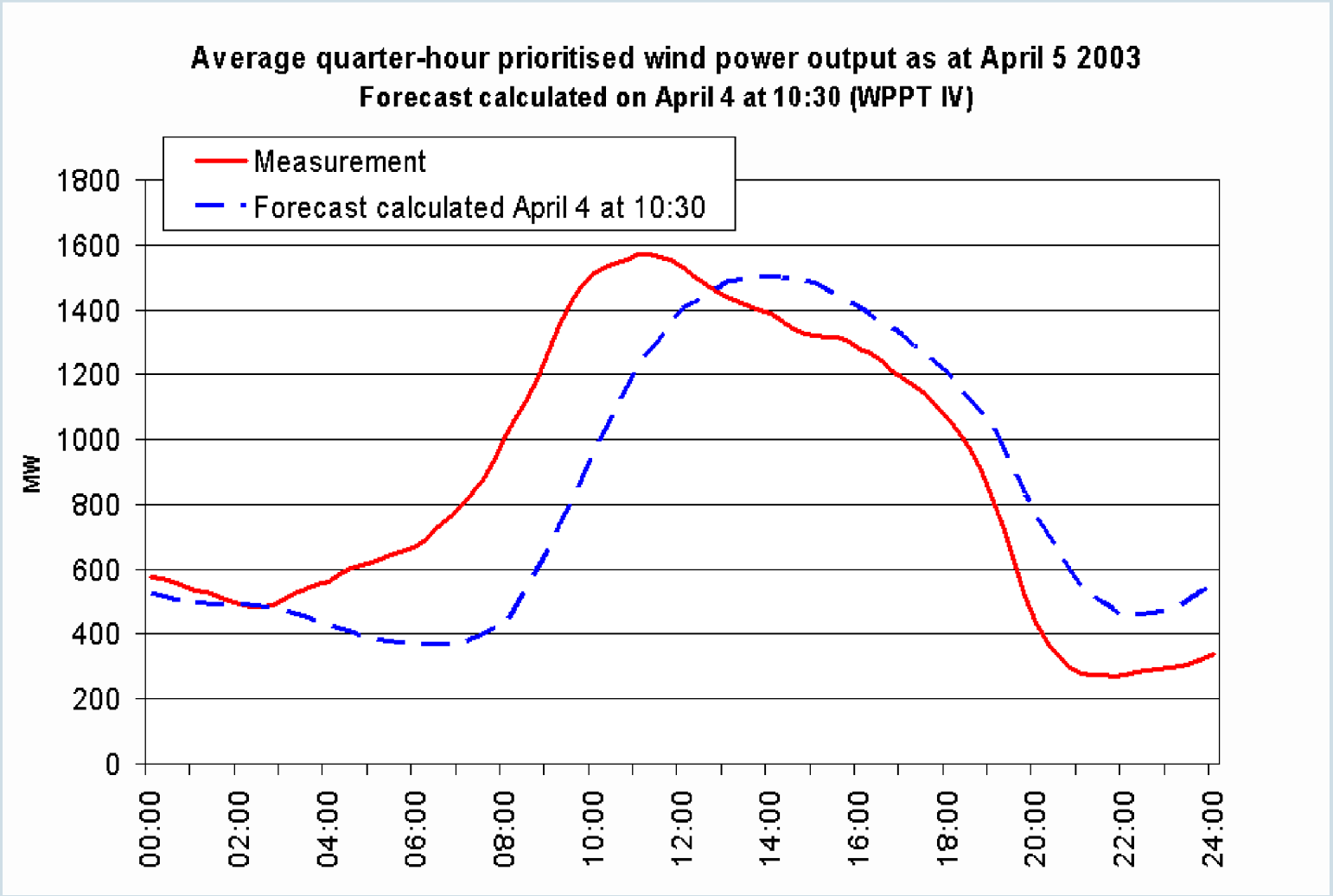

**Grid reinforcements must come before new offshore wind power**

# Wind forecasts

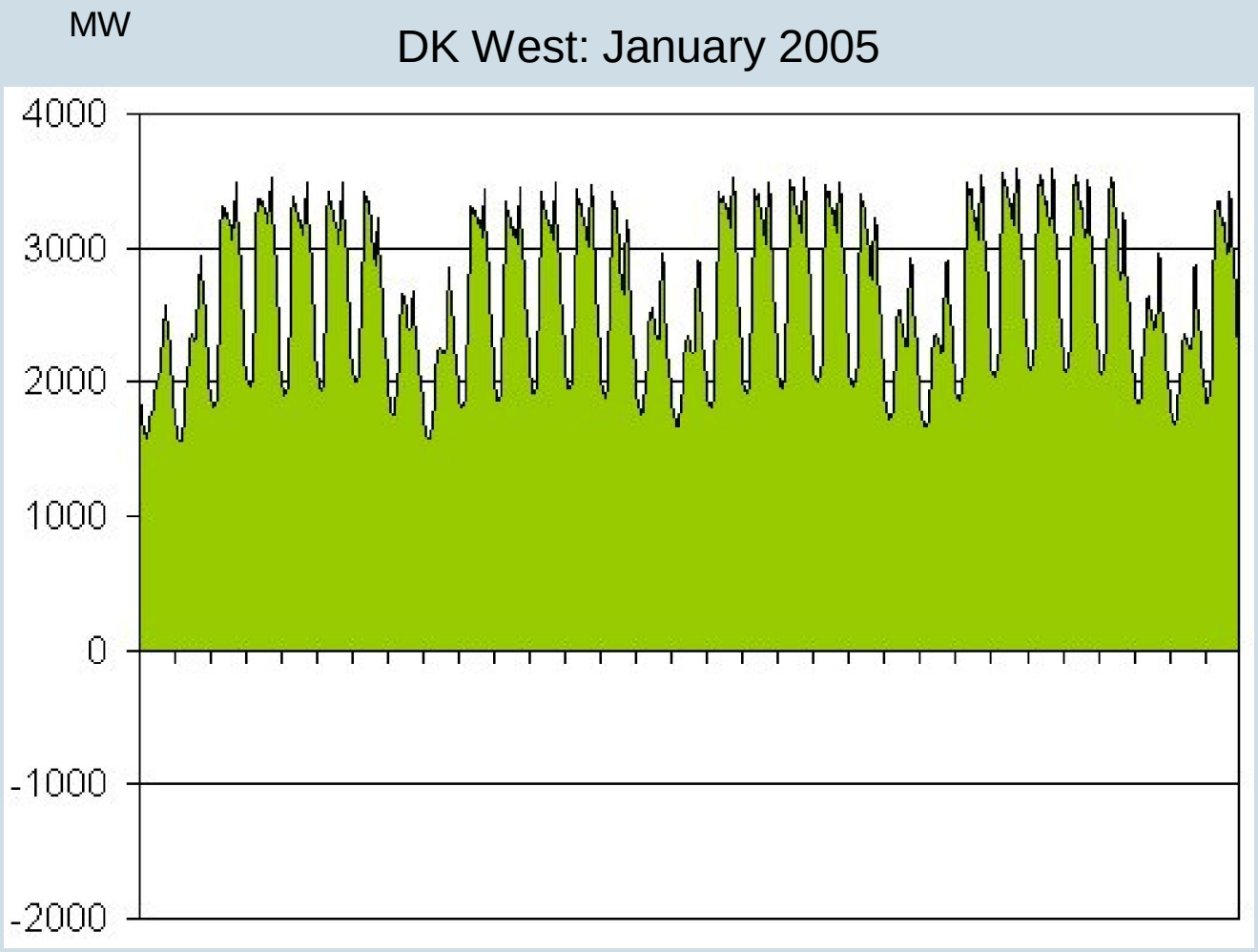
- Based on the forecasts from a met. centre (ex. Danish Meteorological Institute).
- The Wind forecasts for the next 24 hours are very unreliable (ex.average deviation: 35 %).
- In western part of Denmark the wind forecast error typically determine the direction of the imbalance in the system 70-80 % of the time!
- In western part of Denmark imbalances up to 1,800 MW in some hours (8 January 2005)
- The imbalances caused by the unpredictable nature of the wind power is the main reason, why the TSO has to secure a large amount of regulating reserve.

# Aggregated wind production curve
## (All wind turbines in DK West)



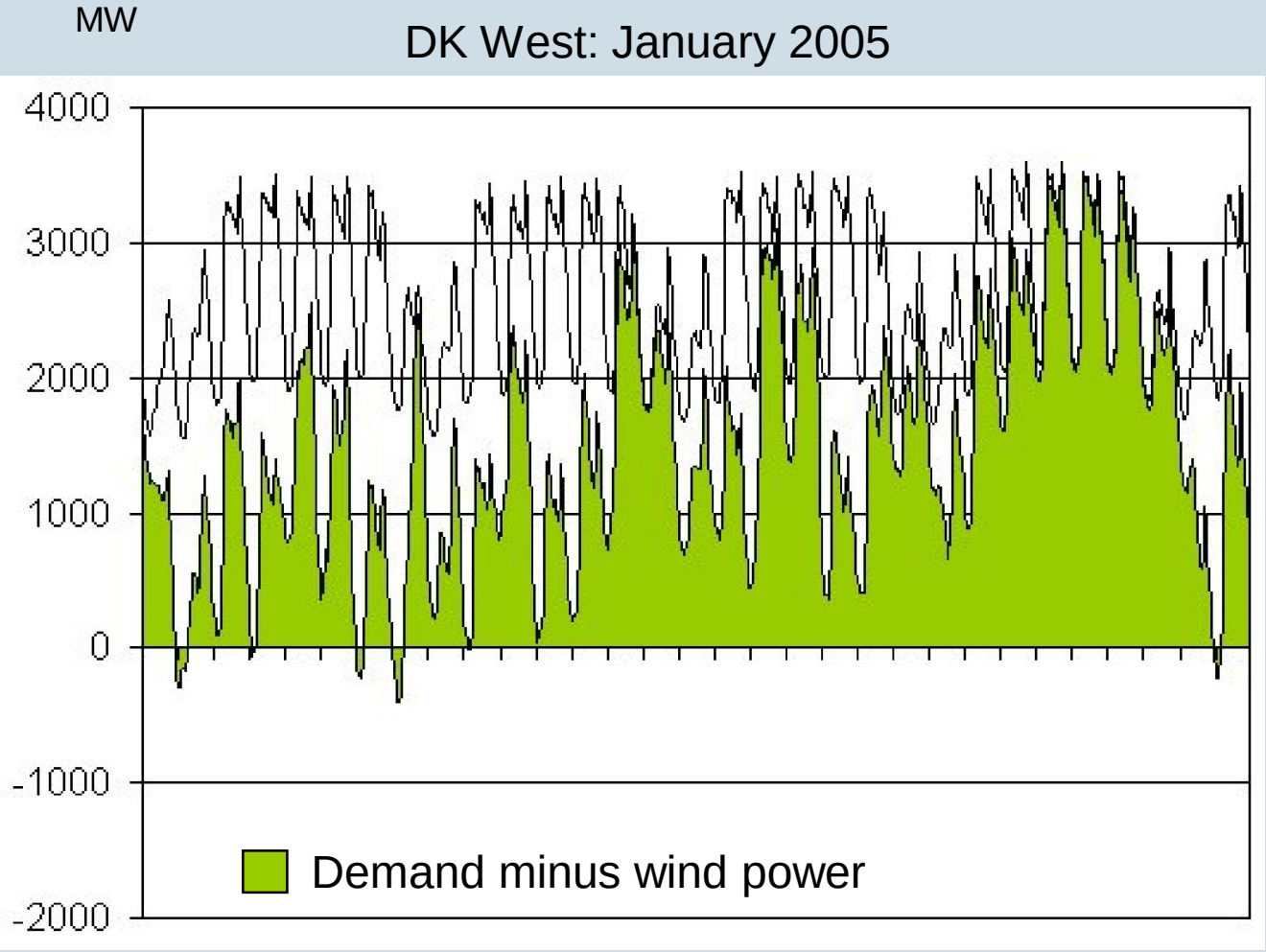

Average quarter-hour prioritised wind power output as at April 5 2003
Forecast calculated on April 4 at 10:30 (WPPT IV)
Measurement
Forecast calculated April 4 at 10:30
MW
1800
1600
1400
1200
1000
800
600
400
200
0
00:00
02:00
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
24:00

# Market Demand




Domestic base load market: about 1,800 MW

# Residual Domestic Market

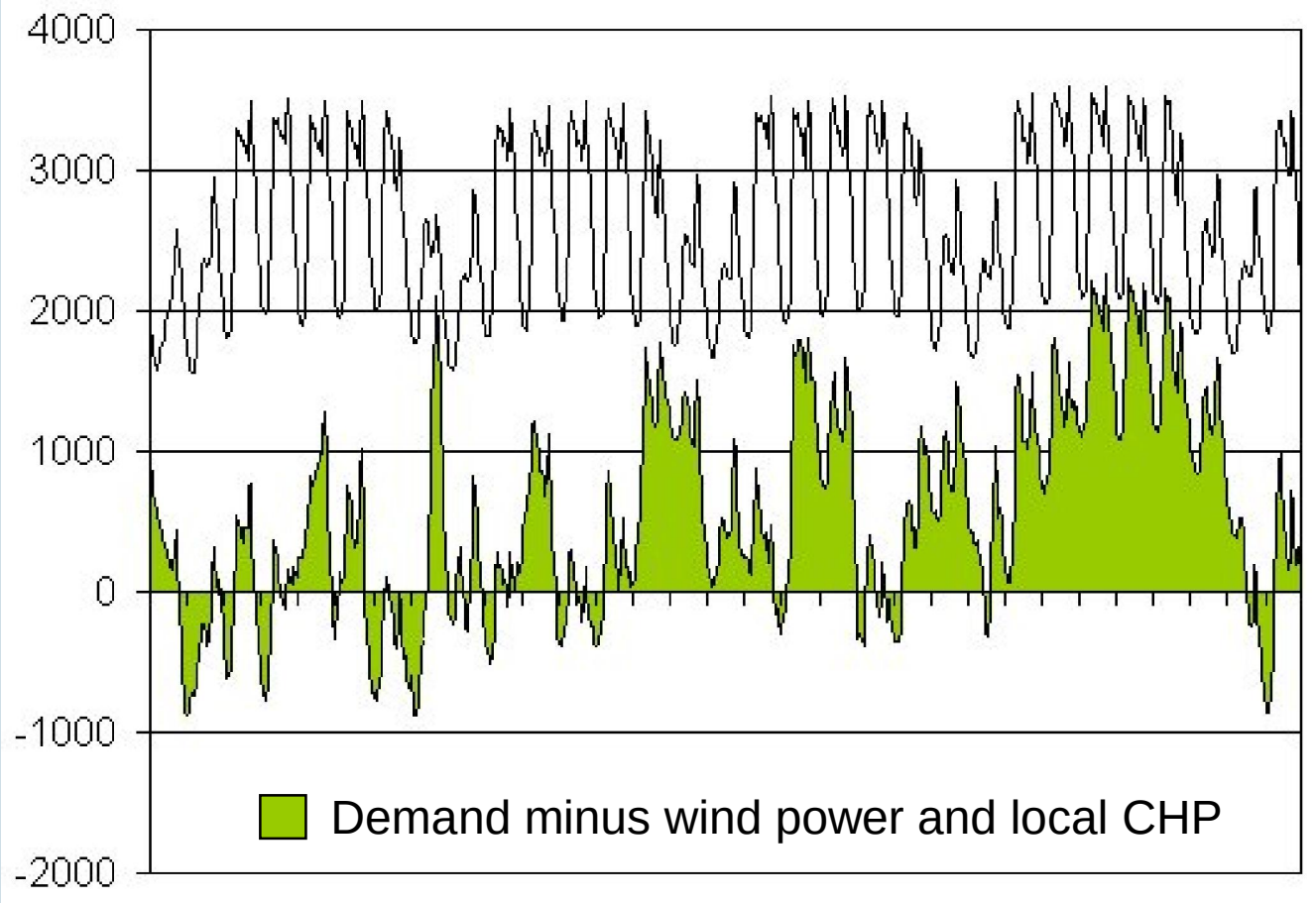



Domestic market for **thermal units** (prioritized and commercial)

Local CHP with priority could not respond to market signals at that time, but to time-of-day tariffs

# Residual Domestic Market

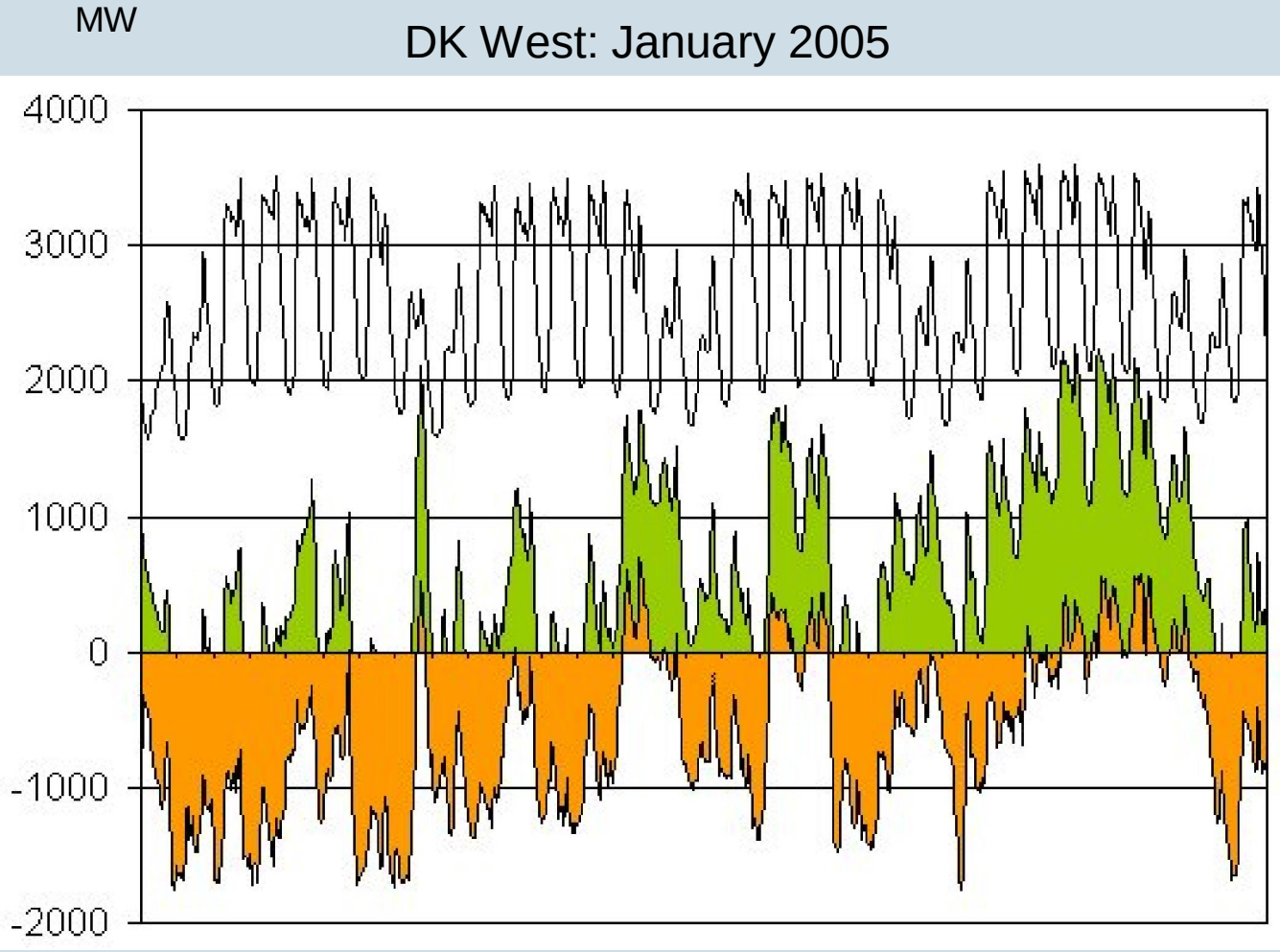
DK West: January 2005




Share of domestic market left for **commercial producers**.

Even these producers have constraints due to district heating and system security

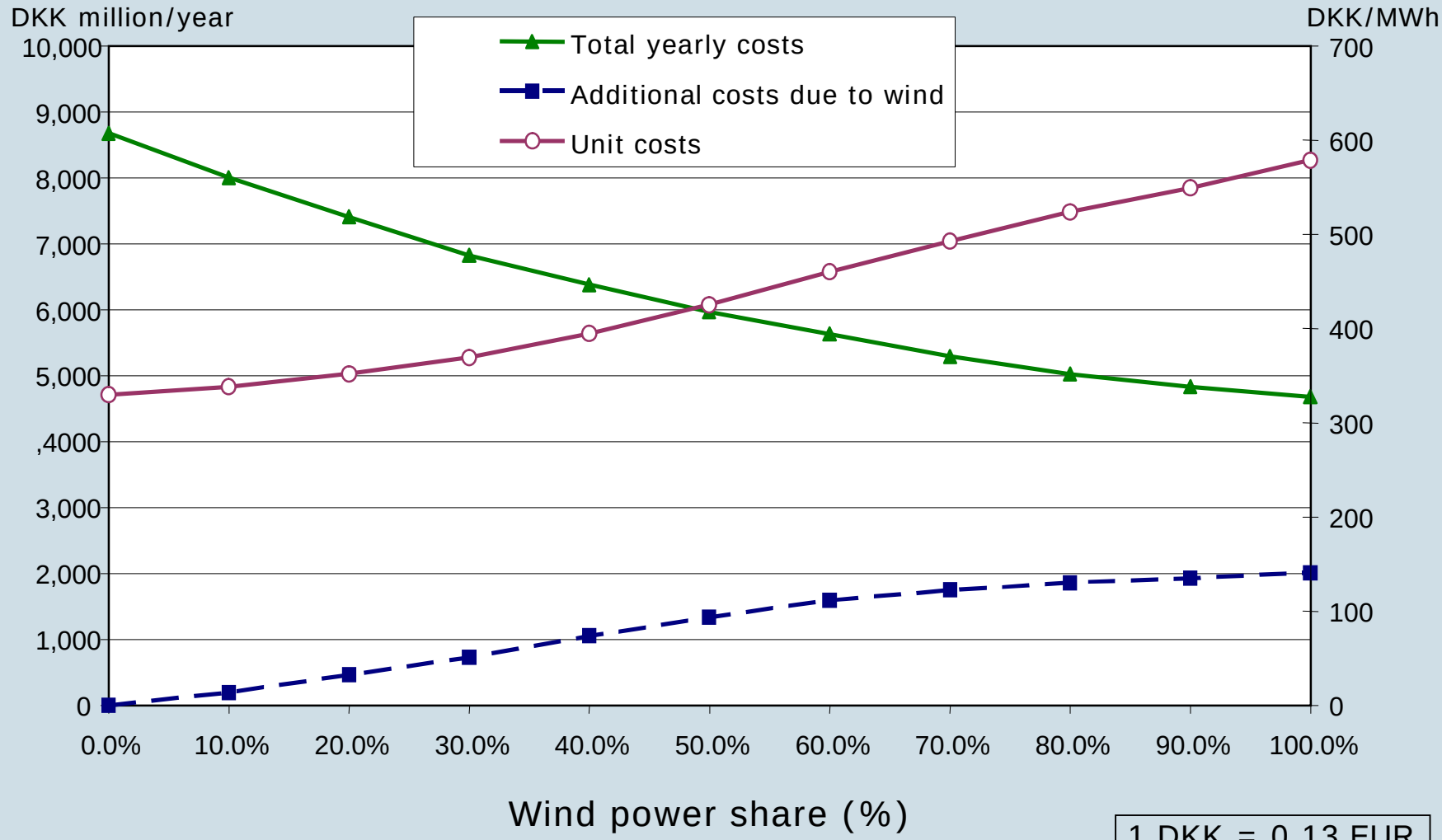
# System Balance




Export is the proper solution when there is an electricity demand in neighbouring countries.

If not, electricity overflow means waste of energy and money.

# Costs of residual supply




1 DKK = 0,13 EUR

Costs relating to residual supply as a function of wind power share