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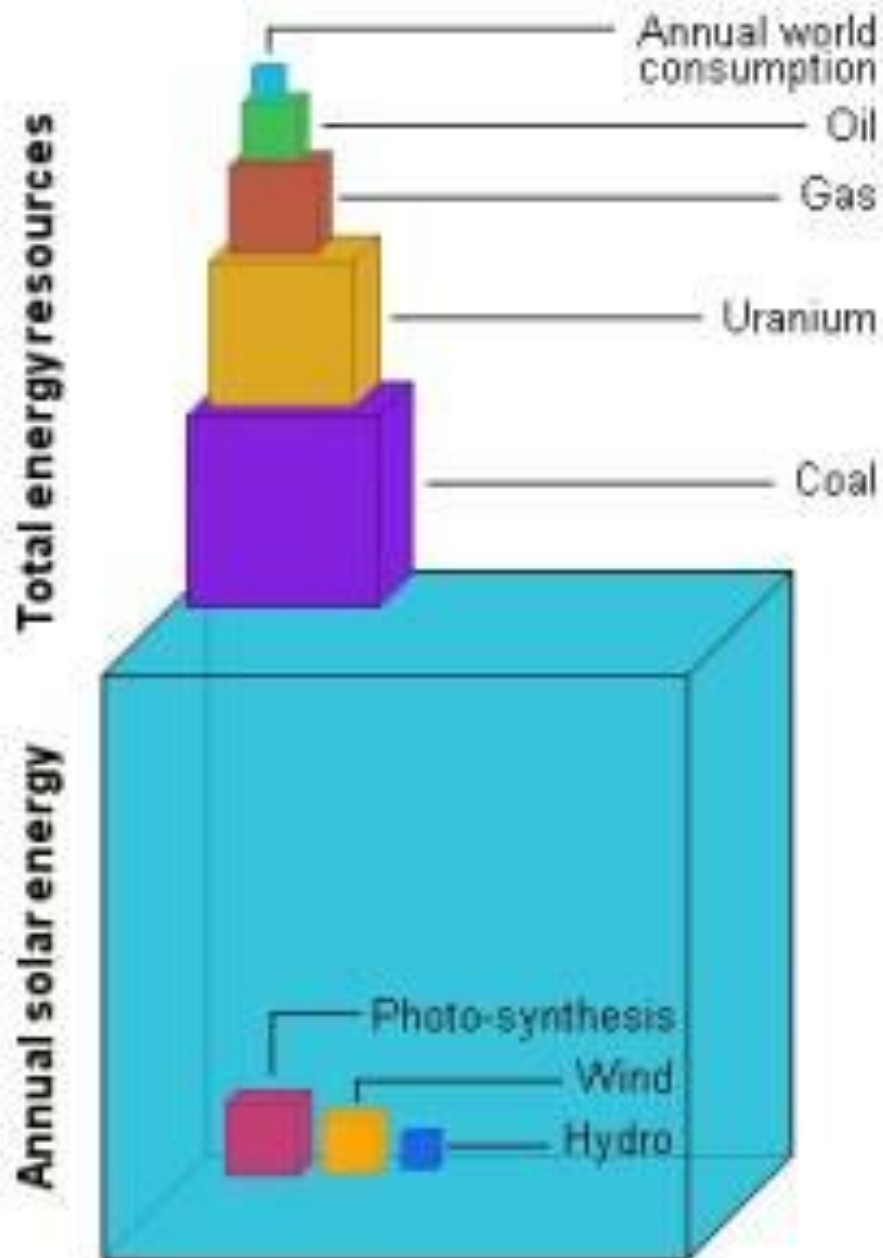
WIND POWER

AGENDA

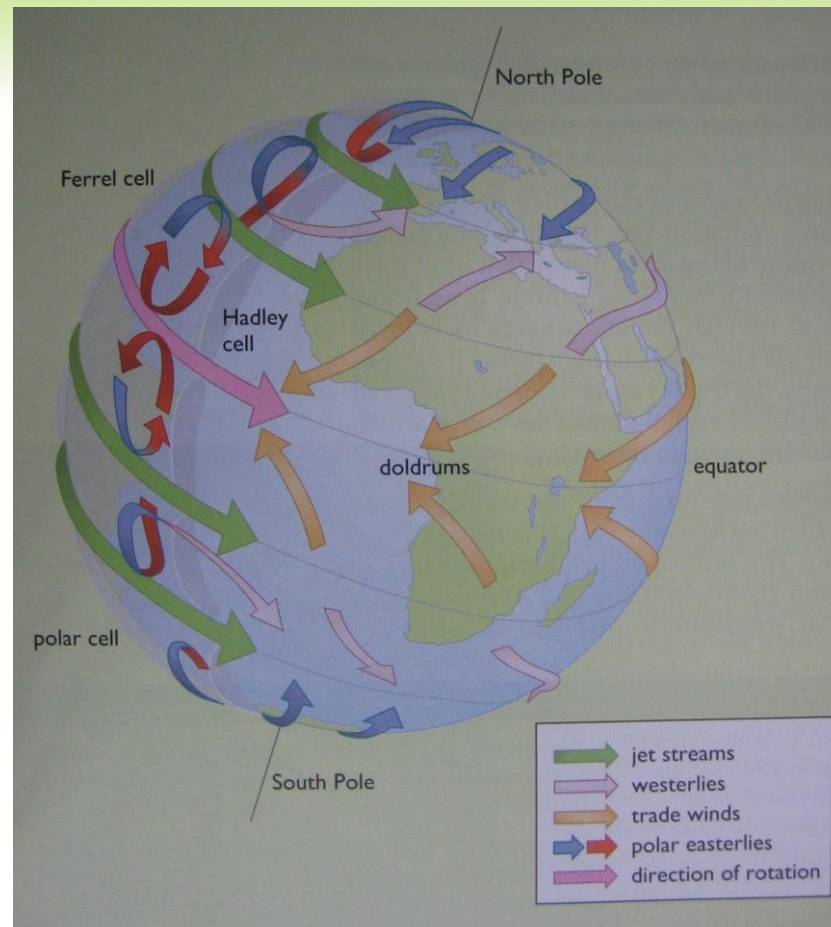
- ⊙ Wind power potential
- ⊙ Wind power – short history
- ⊙ Wind power development
- ⊙ Wind power's role in a power grid
- ⊙ Challenges and problems for the grid
- ⊙ Conclusions

THE WIND POWER

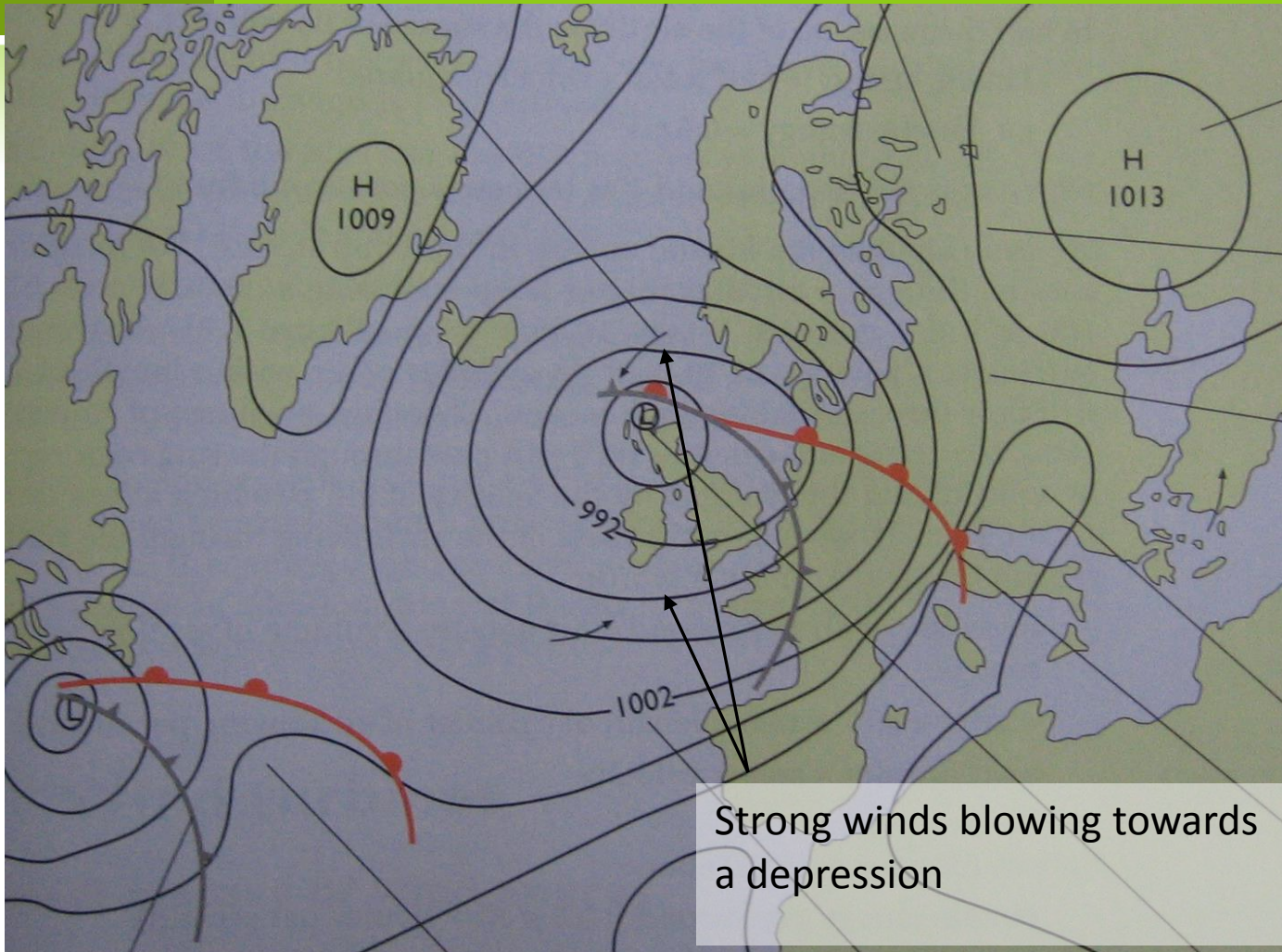
- ③ The available wind energy estimates range from 300 TW to 870 TW.
- ③ Using the lower estimate, just 5% of the available wind energy would supply the current worldwide energy needs.
- ③ Most of this wind energy is available over the open ocean.
- ③ Oceans cover 71% of the planet and wind tends to blow stronger over open water because there are fewer obstructions.



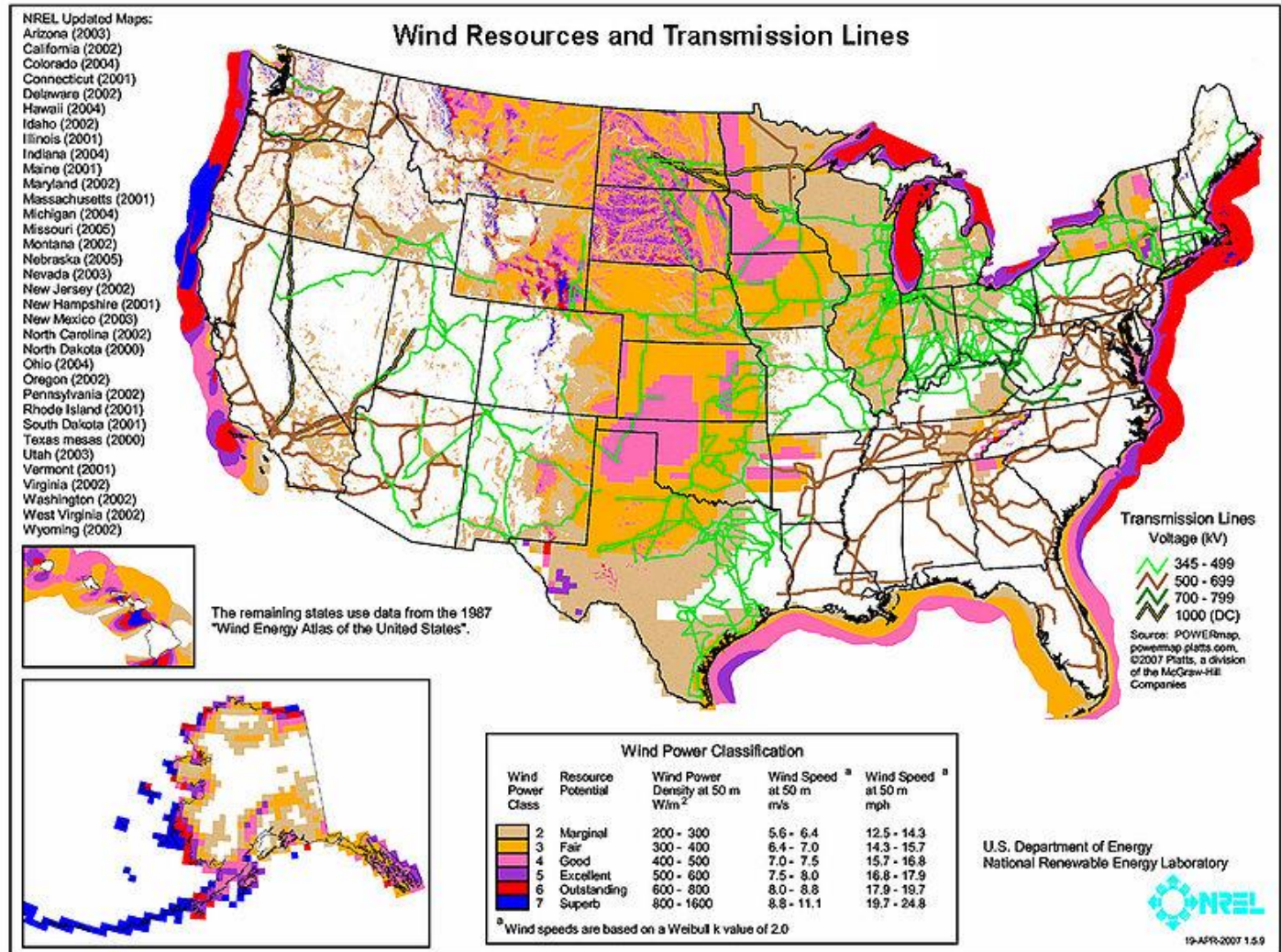
WIND ENERGY: CIRCULATION OF ATMOSPHERIC AIR



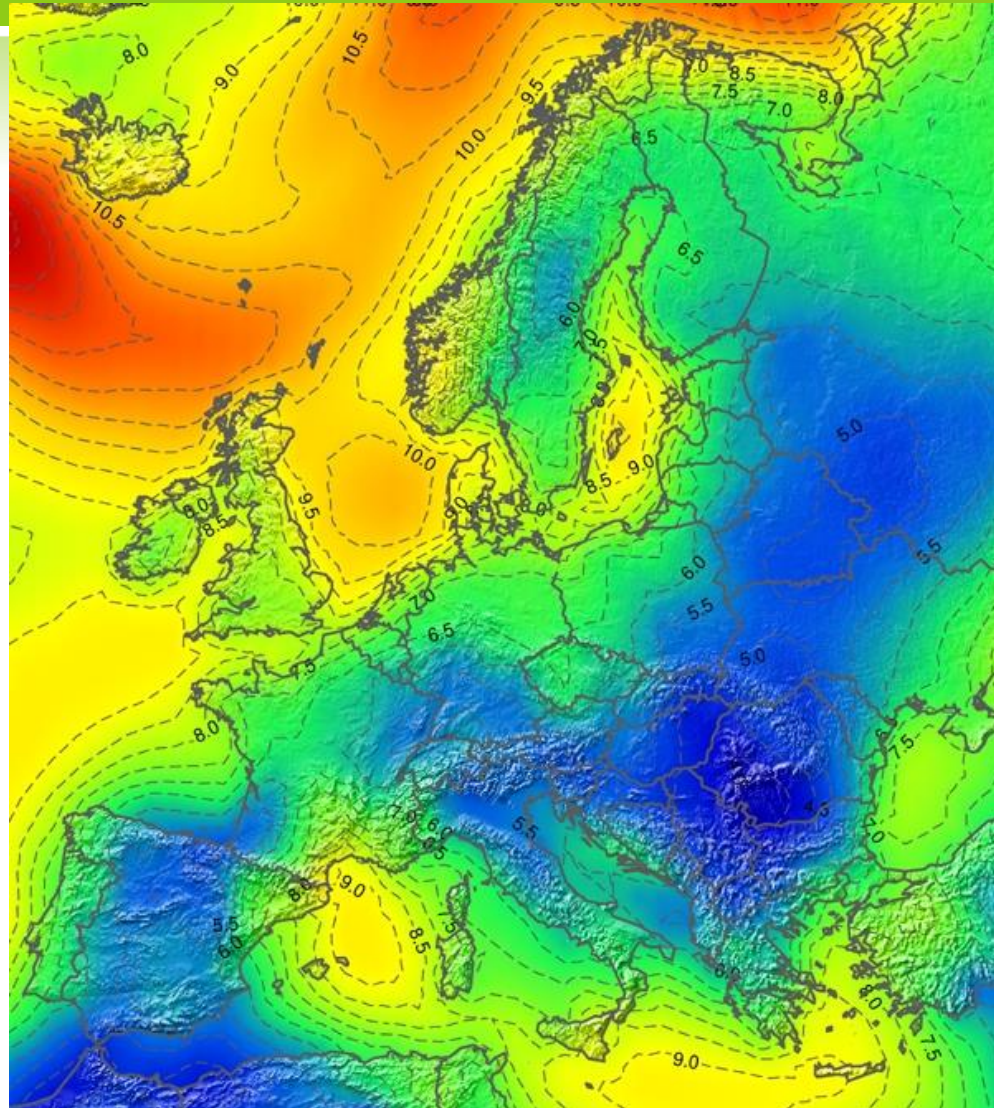
WEATHER-DEPENDENT WINDS

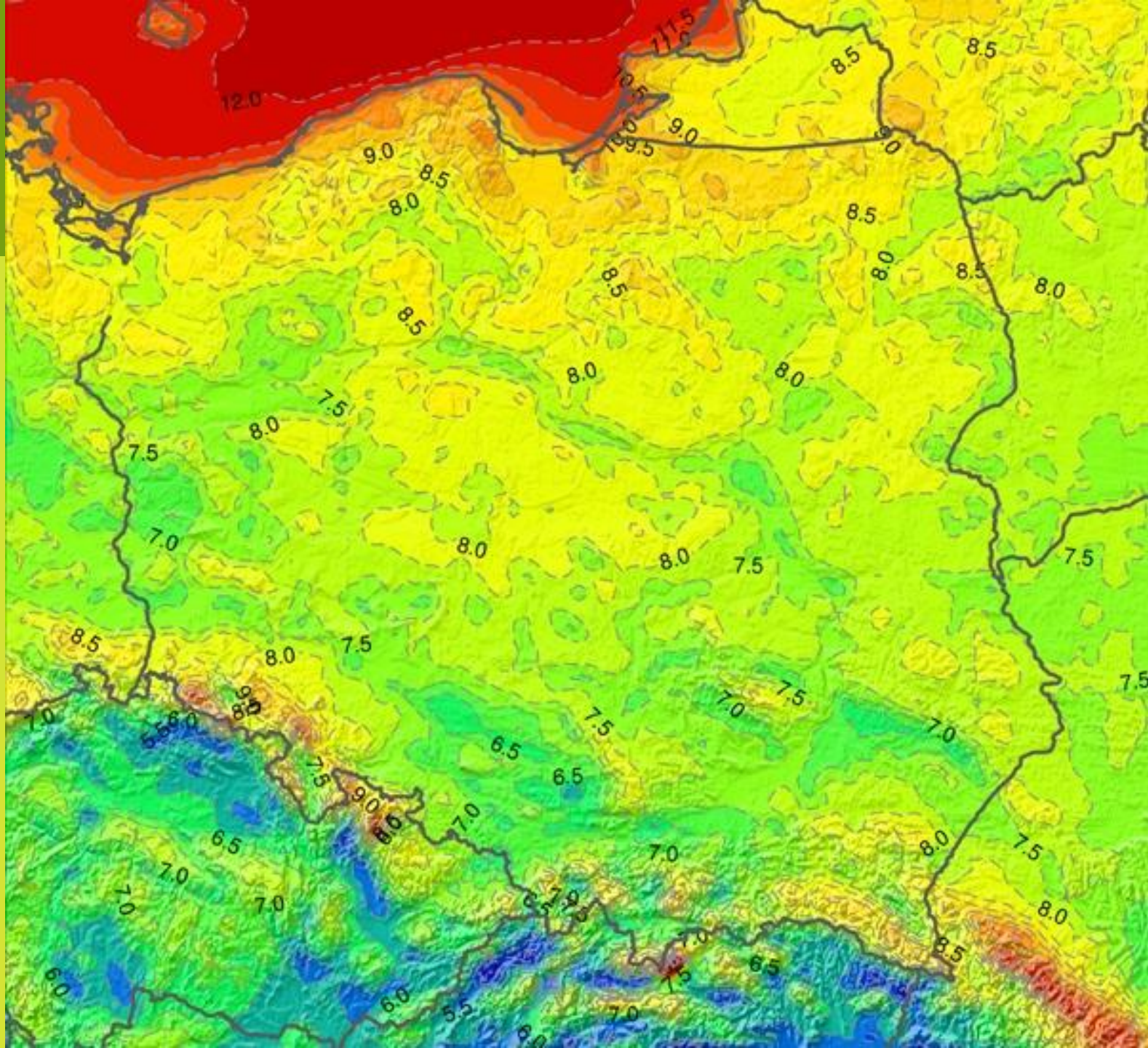


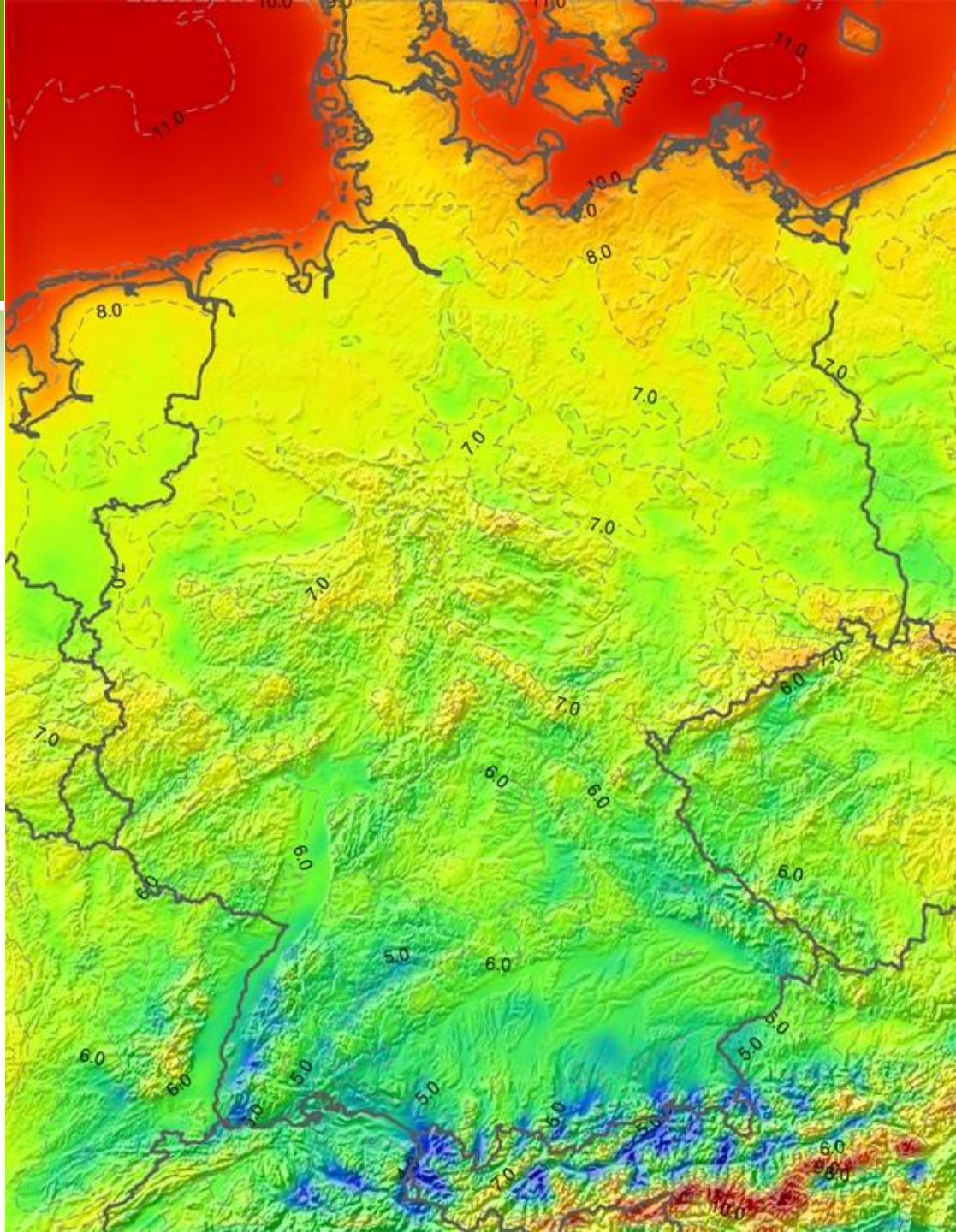
WIND RESOURCES

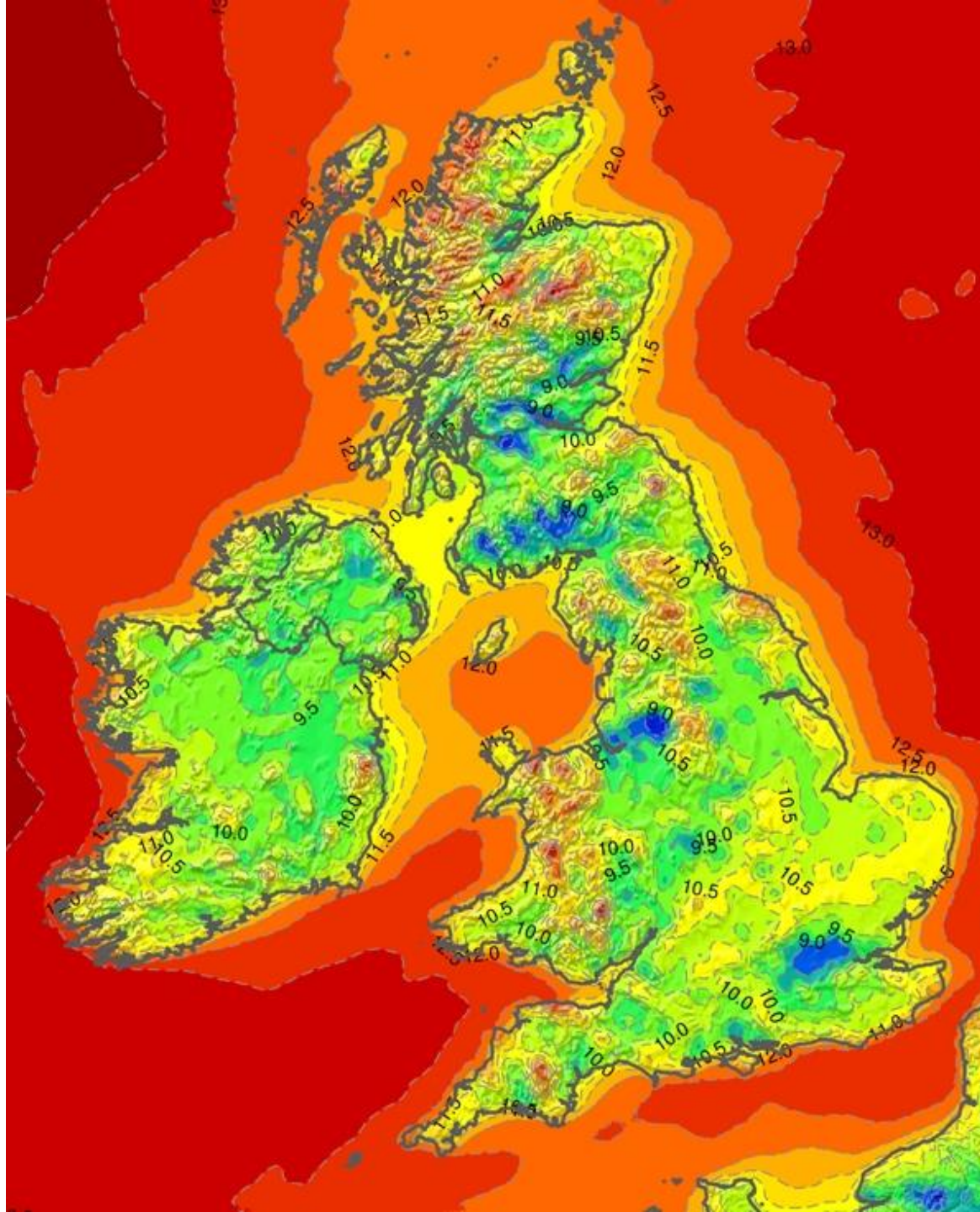


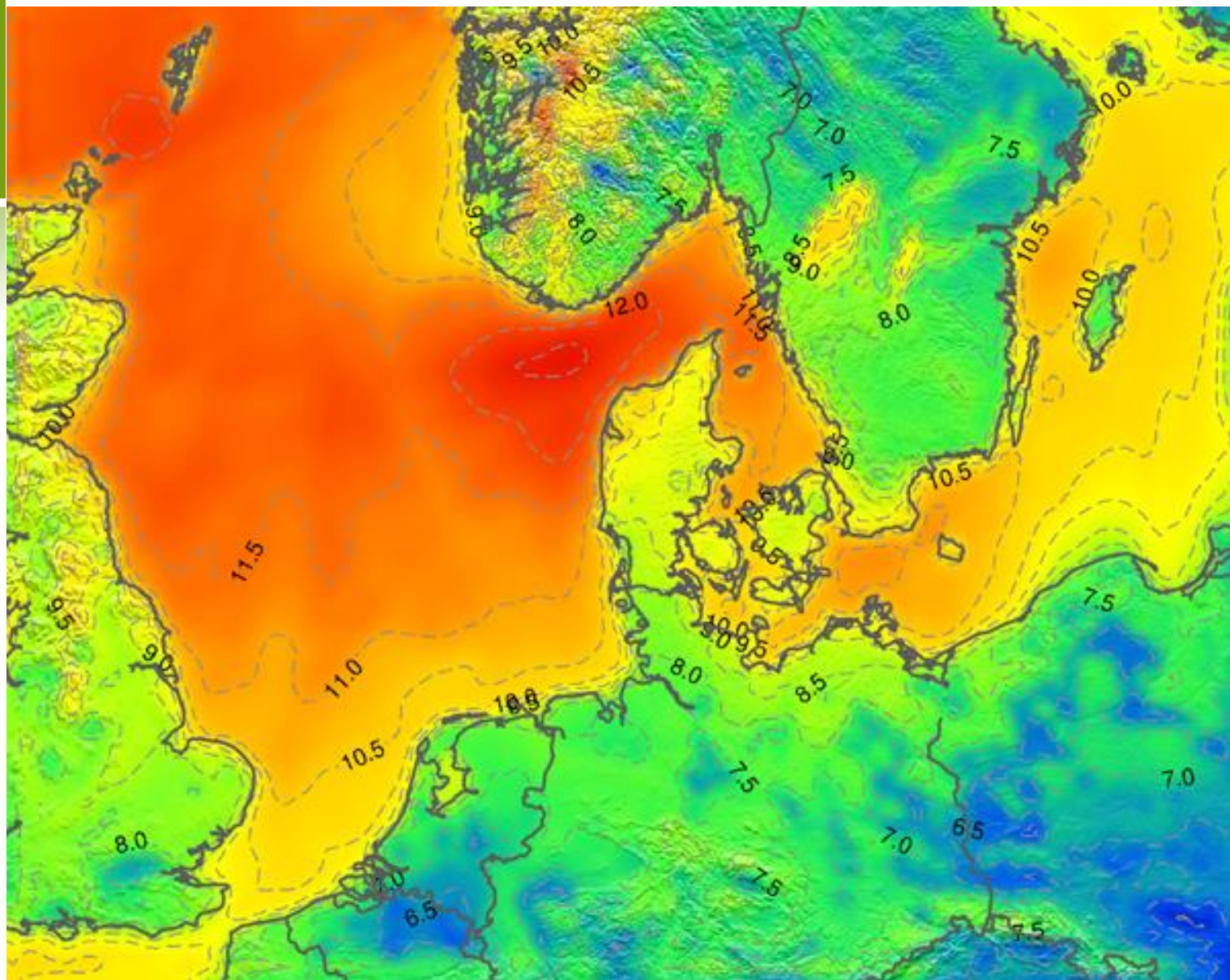
WIND RESOURCES





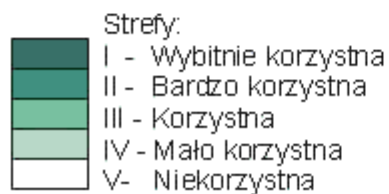
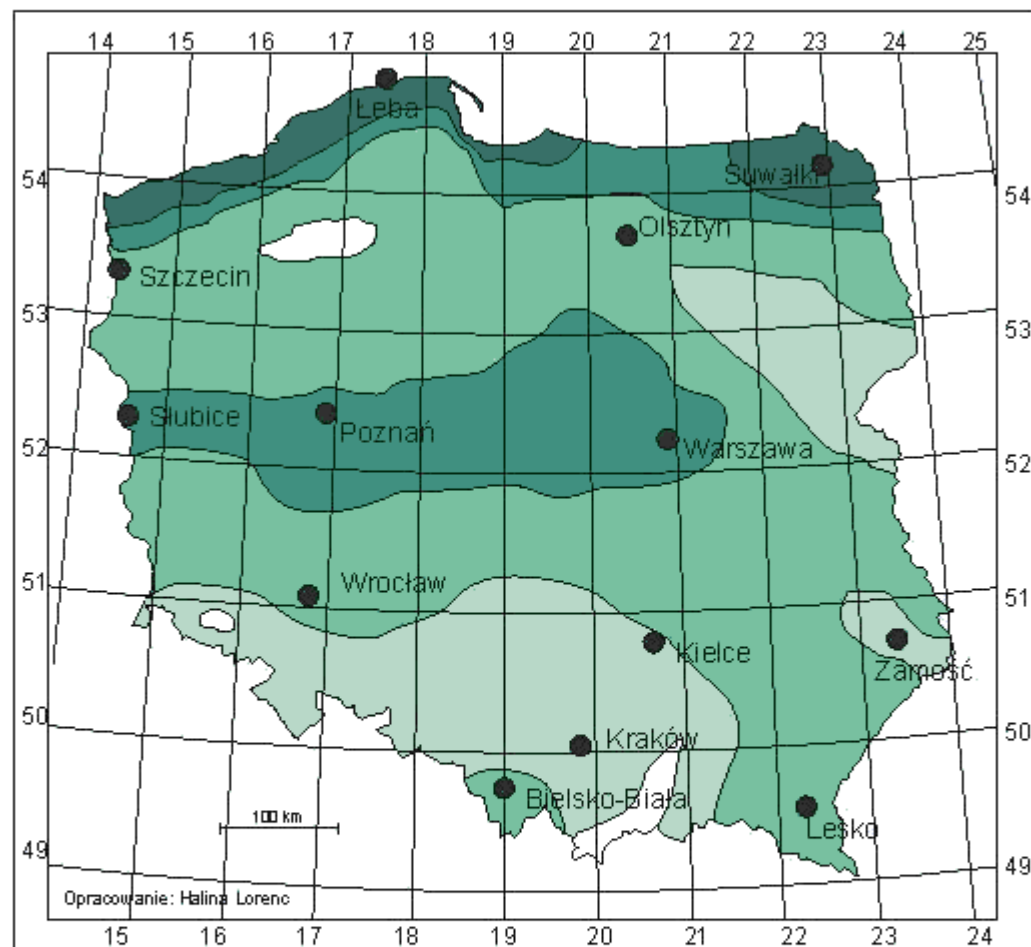






Strefy energetyczne wiatru w Polsce

Mezoskala



**Ośrodek
Meteorologii**



WIND POWER - SHORT HISTORY

100
1757
1888
1955
1981
2001

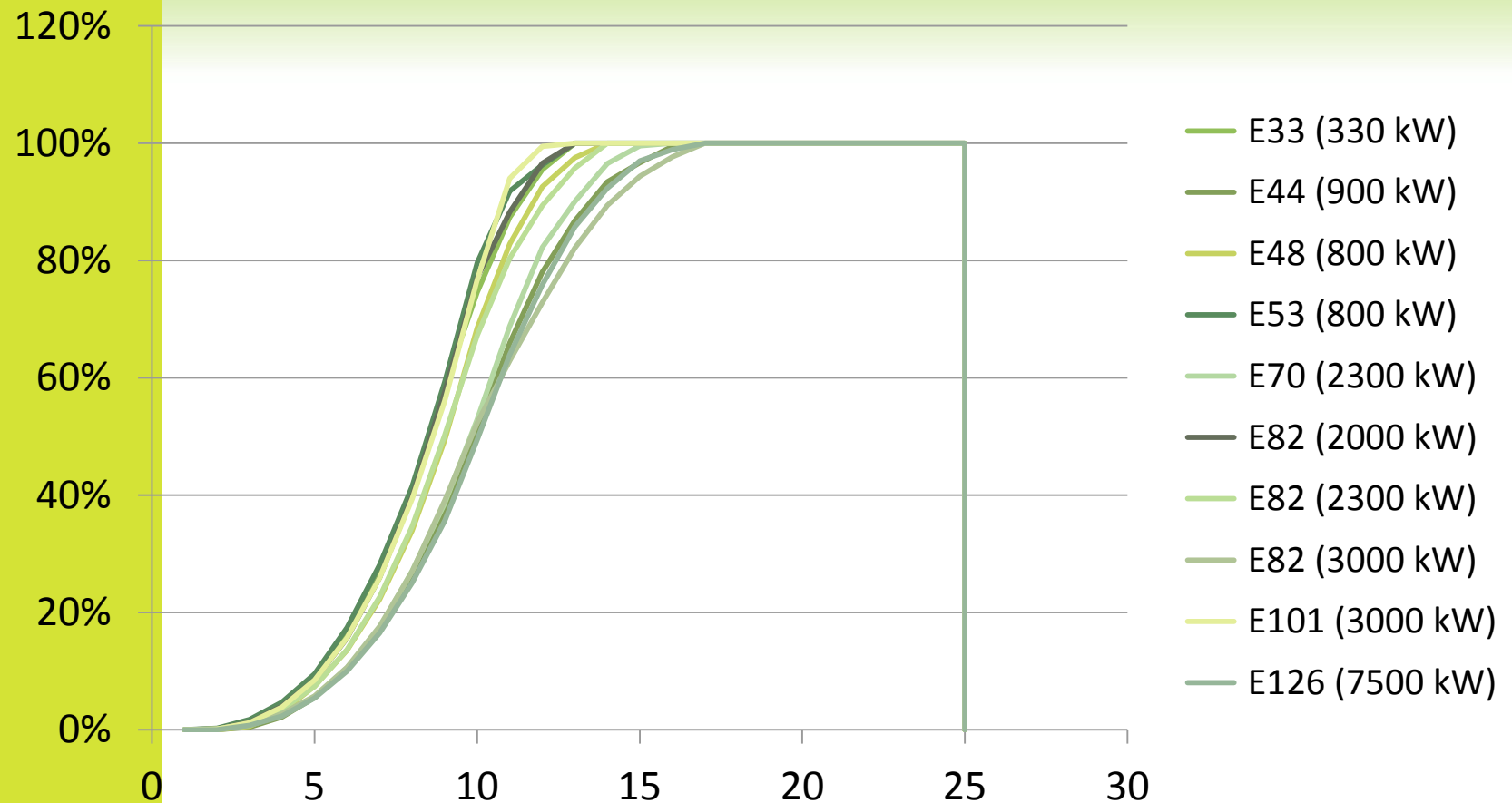


WIND TURBINES TODAY

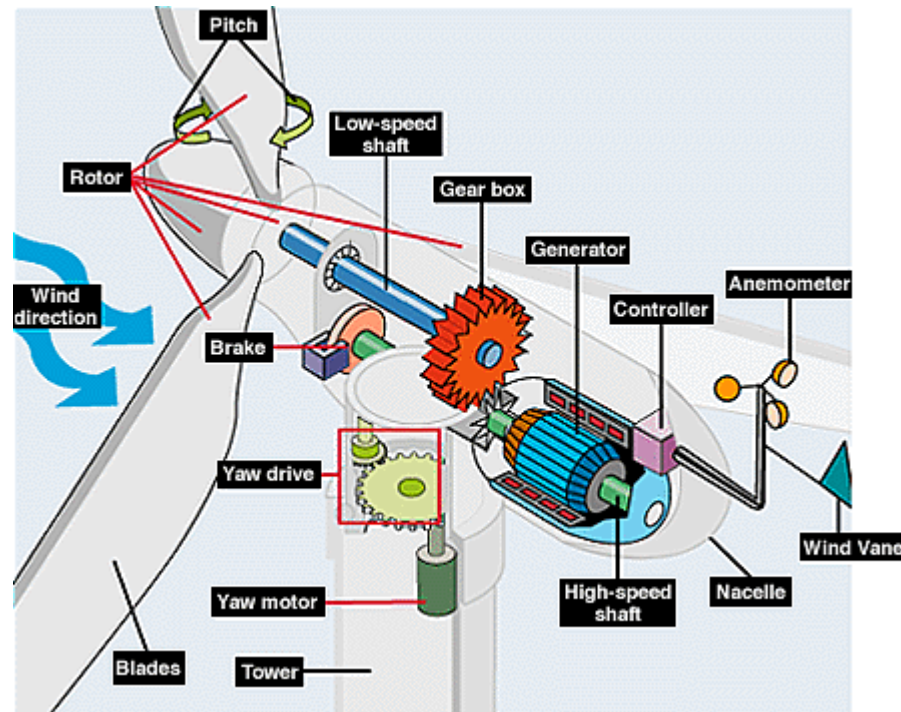
HORIZONTAL AXIS WIND TURBINE

- ⊙ Outputs 1.5...7.5 MW
- ⊙ Three-blade rotors
- ⊙ Variable-pitch blades
- ⊙ Upwind rotors with horizontal axle
- ⊙ Rotor diameters up to 130 m
- ⊙ Rotor speed 10-20 rpm
- ⊙ Blade tip speed up to 350 km/h
- ⊙ Tubular steel towers
- ⊙ Cut-out wind speeds ca 30 m/s

OUTPUT VS WIND SPEED



HORIZONTAL AXIS WIND TURBINE



WIND TURBINE ROTOR



WIND TURBINE TOWERS



WIND TURBINE'S GENERATOR



WIND TURBINE GENERATOR

- ⊙ Constant speed turbine – synchronous generator
- ⊙ Variable speed turbine – geared asynchronous generator
- ⊙ Gearless solutions
 - ⊙ Low-speed synchronous generator with a DC link

WIND TURBINE INSTALLATION



WIND TURBINE INSTALLATION



WIND TURBINE INSTALLATION



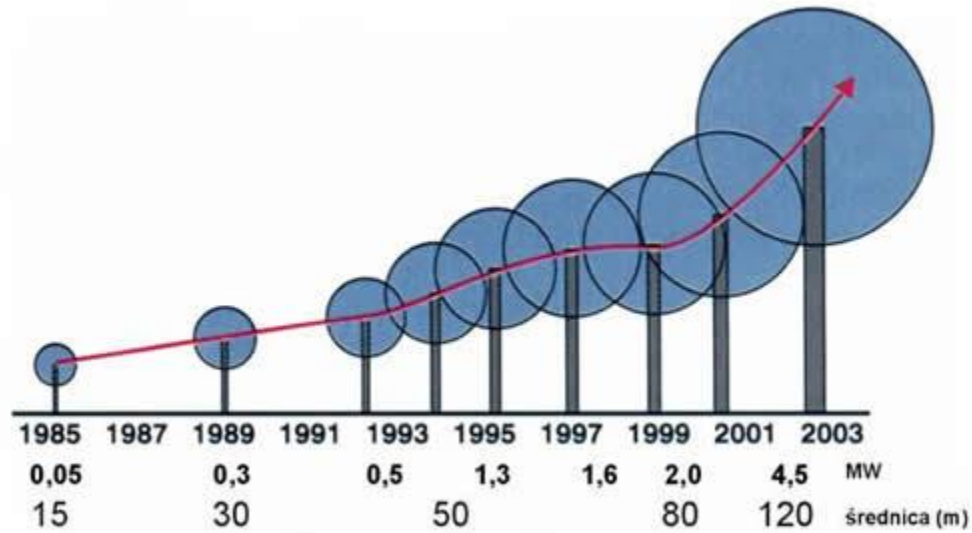
WIND TURBINE INSTALLATION



WIND TURBINE INSTALLATION



WIND TURBINE DEVELOPMENT

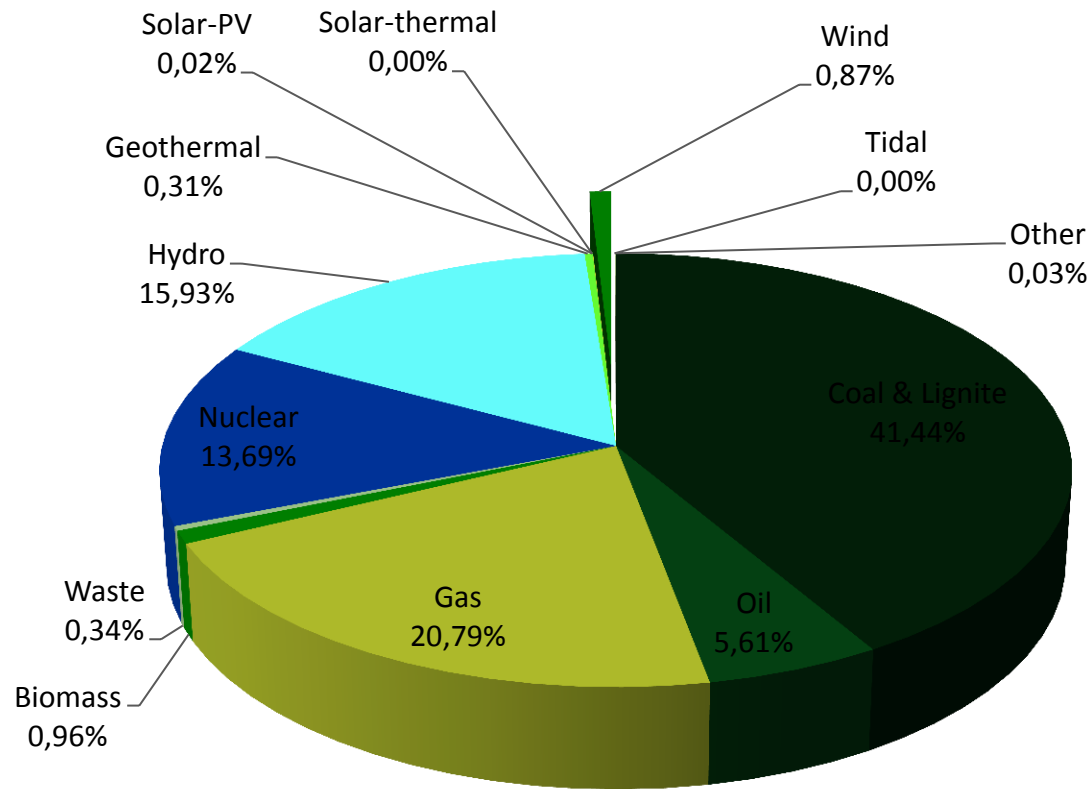


Power (MW)
Diameter
(m)

VERTICAL AXIS WIND TURBINE



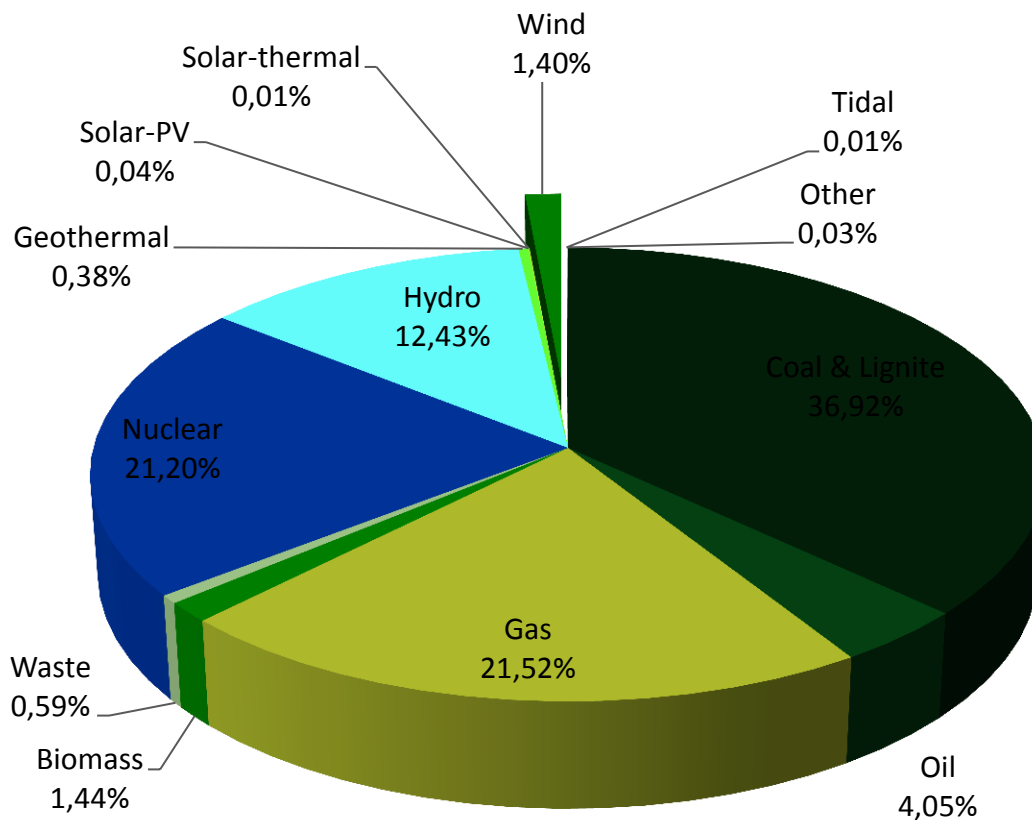
Global electricity generation (2007)



Source: IEA, 2010

Wind total: 173,317 GWh

OECD electricity generation (2007)

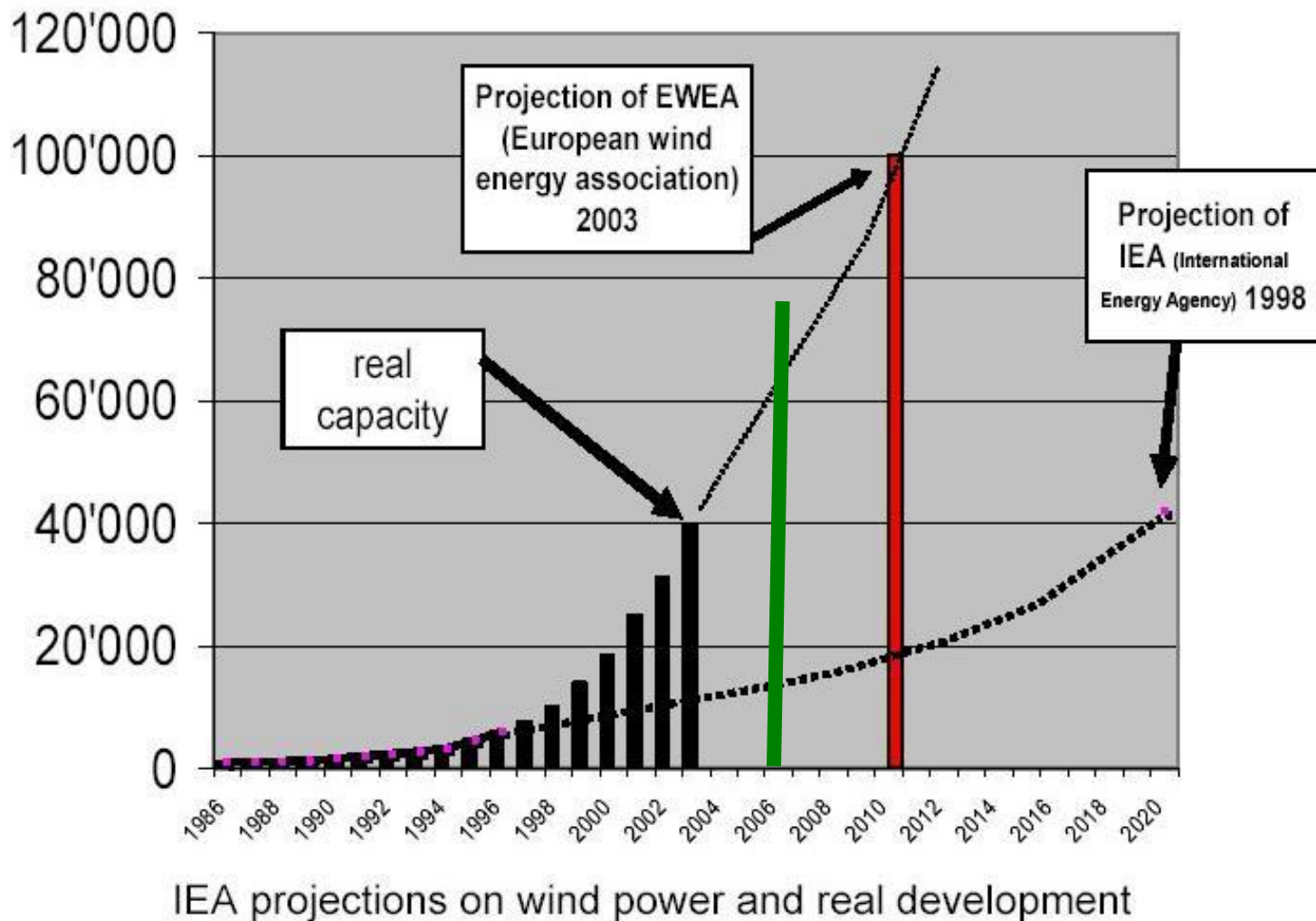


Source: IEA, 2010

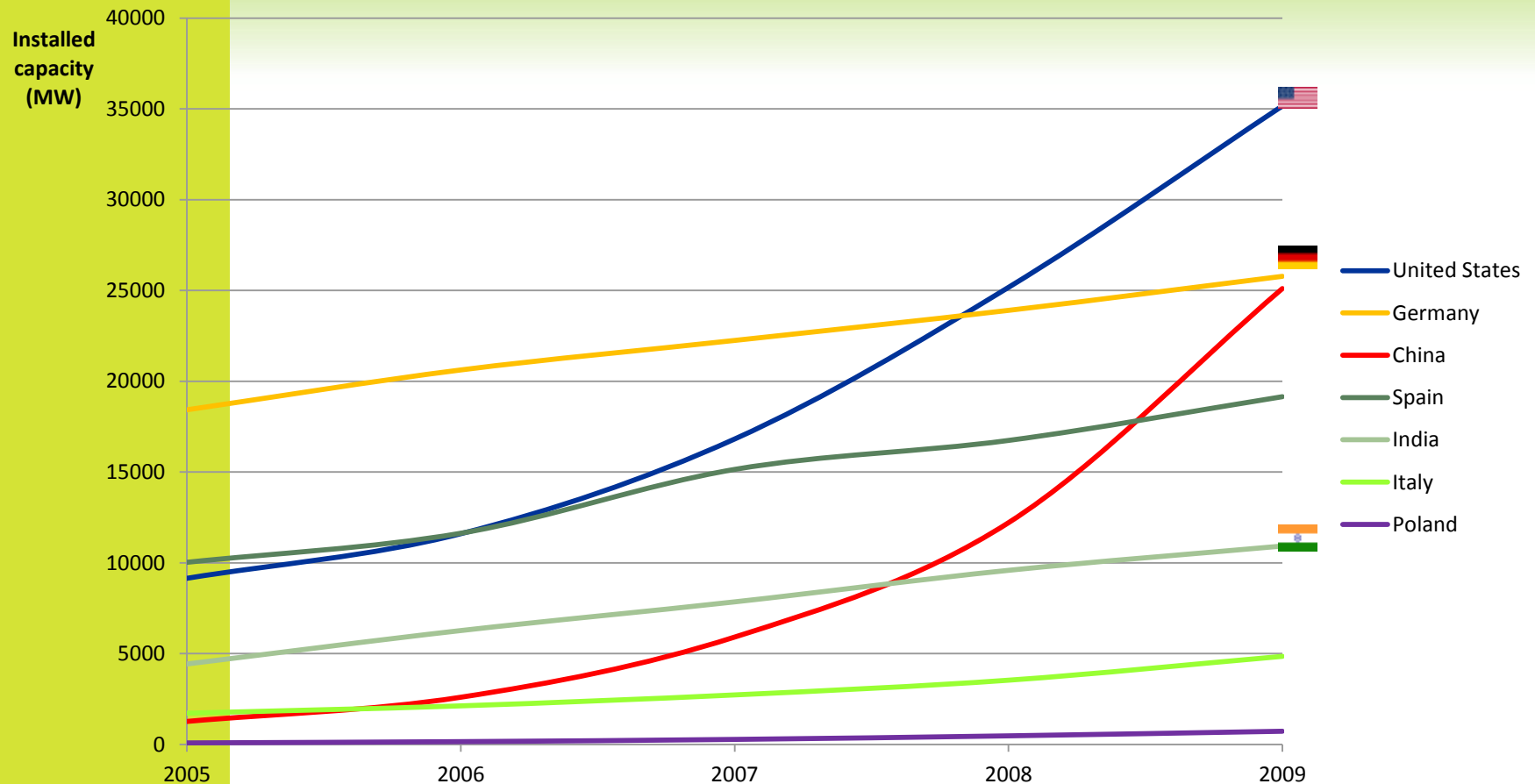
Wind total 149,667 GWh

WIND POWER - INSTALLED CAPACITY REAL GROWTH VS FORECASTS

MW

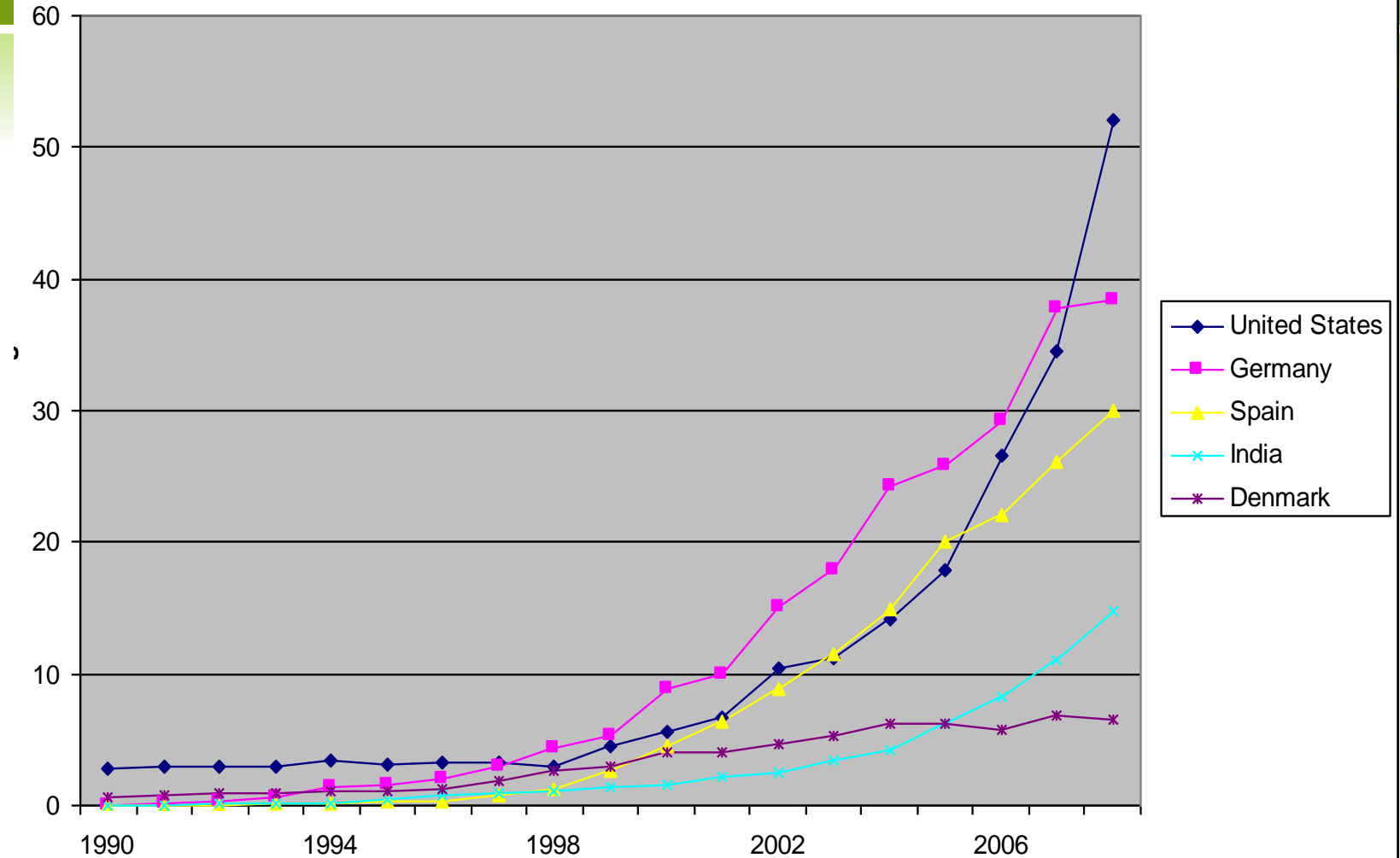


WIND POWER DEVELOPMENT



WIND POWER GENERATION

TWh



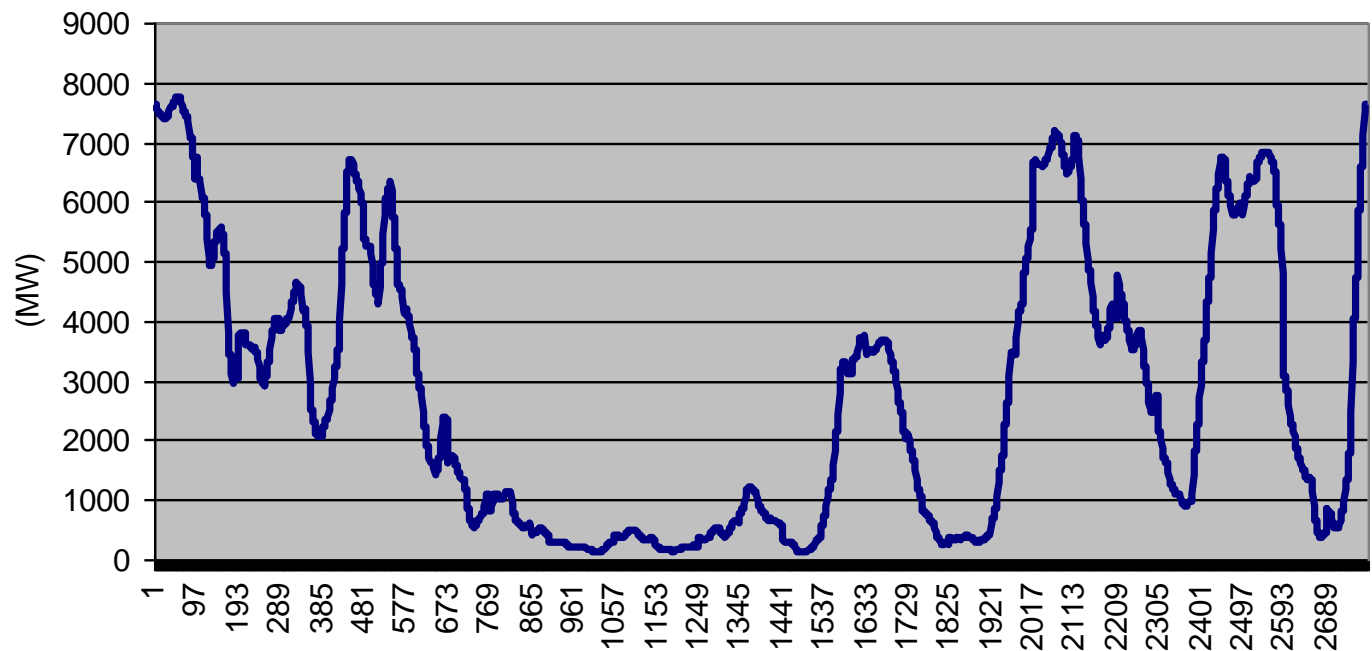
WIND POWER DEVELOPMENT

- ③ From 24 to 160 GW in 2001-2009
- ③ In 2009 36.3 GW of new wind turbines
- ③ Rapid development in Western Europe seems to slow down, with USA, China and India taking the lead

WIND POWER INTEGRATION PROBLEMS

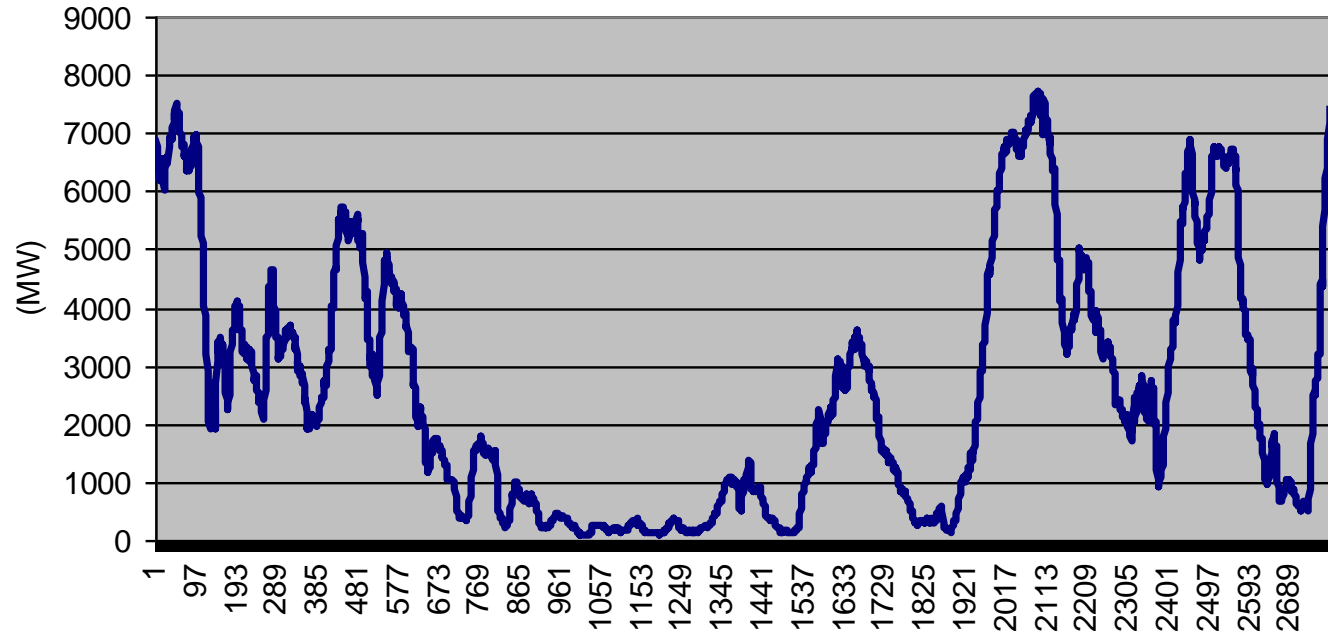
WIND POWER FORECASTING

Forecasting of wind power in E.ON-Netz, Germany
February 2008, 24-hour forecasts



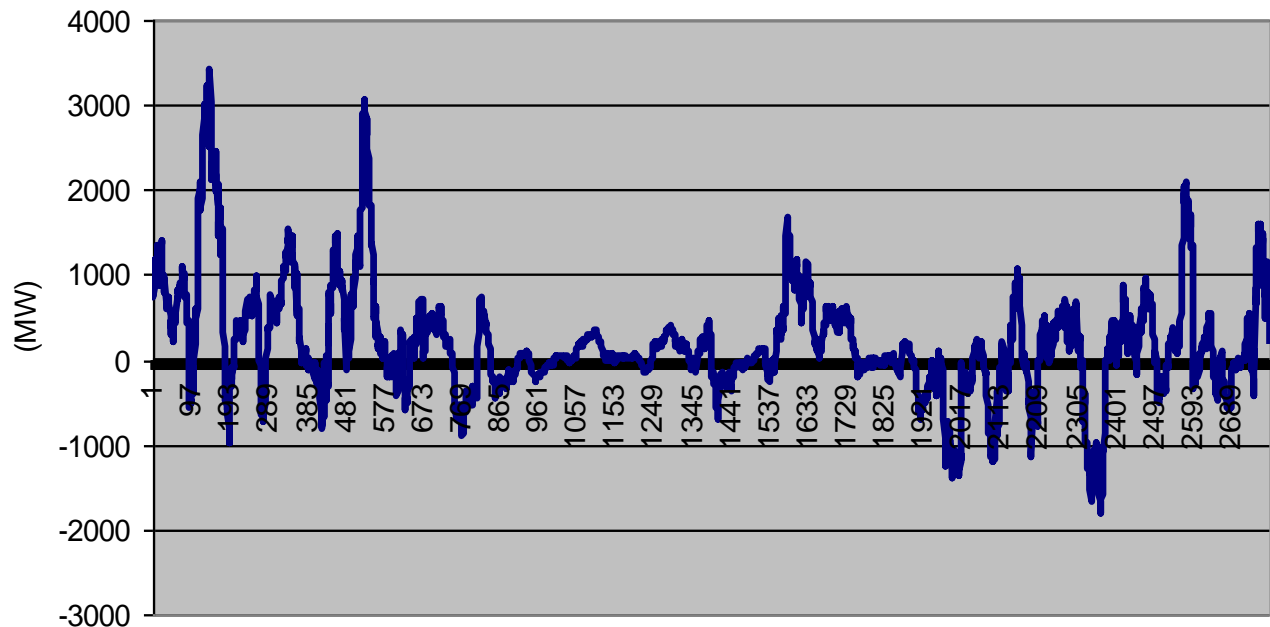
WIND POWER FORECASTING

Real wind power in E.ON-Netz, Germany
February 2008



WIND POWER FORECASTING

Forecast error in E.ON-Netz, Germany
February 2008

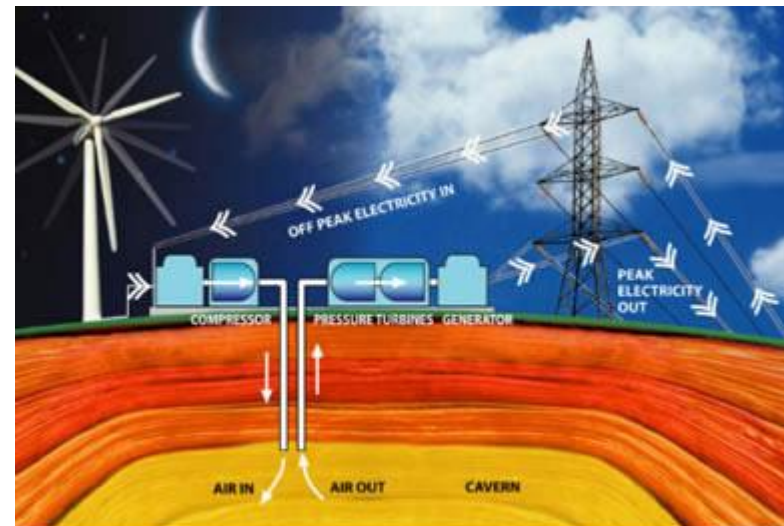


WIND POWER FORECASTING

- ⊙ Wind power introduces uncertainty on power generation output
- ⊙ Flexibility of other elements of the power system must increase
- ⊙ Higher reserve capacity is needed to assure grid stability
- ⊙ In many cases dedicated fast-starting grid-stability plants are required
- ⊙ In some cases modification of grid code is required (shorter balancing periods, enabling forced wind farms shut down)

WIND FARMS INTEGRATED WITH ENERGY STORAGE - E.G. CAES

- ② Wind energy is stored in form of compressed air
- ② Compressed air is released during peak loads



From www.reuk.co.uk/Storing-Wind-Power-with-Compressed-Air.htm

CONCLUSIONS

- ③ Wind power is not a significant part in global energy balance – YET!
- ③ Wind power is among the fastest developing areas of industry
- ③ Integration of significant wind power capacity requires significant changes in entire power system to assure its stability

THANK YOU!