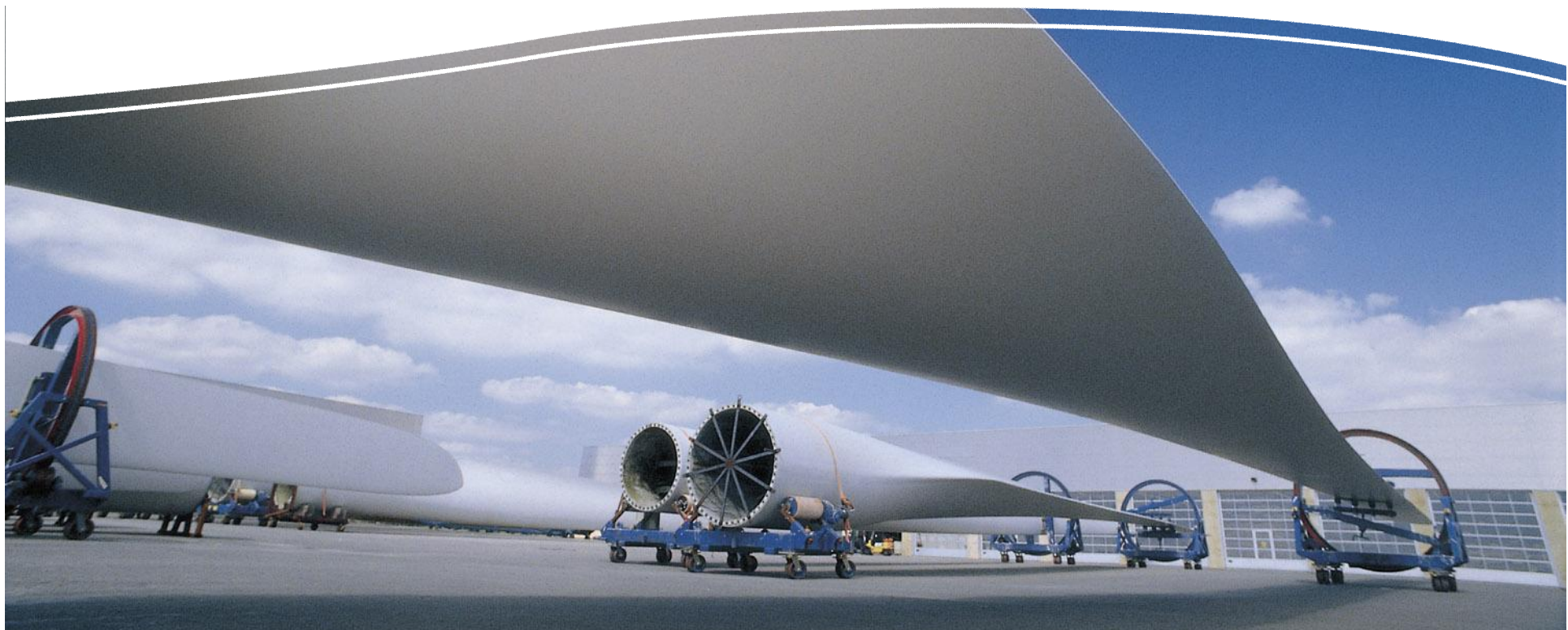




EWEA
THE EUROPEAN WIND ENERGY ASSOCIATION



The economics of wind energy

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Copenhagen & Washington DC

Budapest, 12 June 2009

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Three major global challenges

- Æ Energy Crisis (2015 forward contract: Oil = \$80/barrel)
- Æ Environmental crisis (IPCC: 25-40% reduction by 2020)
- Æ Financial crisis

And a European challenge...

- Æ App. 350 GW of new electricity generating capacity must be built before 2020 (50% of current total)

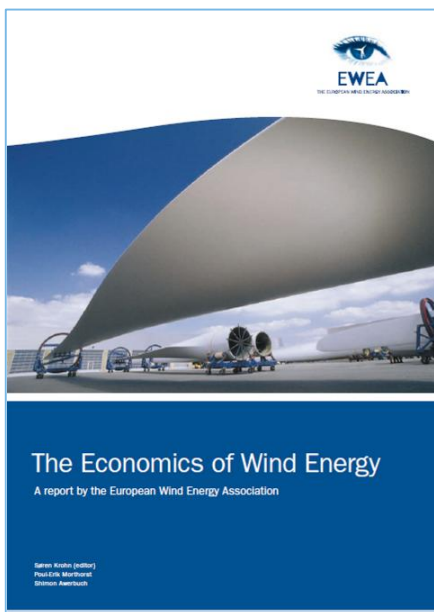
2008 –a turning point?

- Æ EU Directive for renewable energy sources
- Æ By 2020, 20 % of Europe's energy will come from renewable sources
- Æ Now in the process of implementation into 27 binding national targets
- Æ Renewable electricity share increase from 15% to 34%

Economics of Wind Energy comes at the right time

- Æ Strong growth of wind energy sector 1992-2008.
Annual growth rate of more than 25% to 120 GW globally (end 2008)
- Æ Global market: €35 bn (of which EU: €11 bn.)
- Æ Wind energy is fully competitive with new conventional power technologies
- Æ Cost of wind power can be predicted with great certainty: low-risk investment
- Æ Need for consistent economic analysis of costs, benefits and risks of each power generation technology

Financial and economic aspects of wind energy



- Æ Systematic framework for economic dimension of wind energy and energy policy debate
- Æ Methodology for comparing different power generation technologies
- Æ Integration of fuel price risk into the analysis of the optimal energy mix

With EU agreement on putting a real price on carbon pollution, methodology should be expanded to include carbon price risk

Parameters of wind power economics

- Æ Investment costs
- Æ O&M costs
- Æ Electricity production
- Æ Average wind speed
- Æ Turbine lifetime
- Æ Discount rate

Cost structure of a typical 2 MW wind turbine installed in Europe (€²⁰⁰⁶)

	INVESTMENT (€1,000/MW)	SHARE OF TOTAL COST %
Turbine (ex works)	928	75.6
Grid connection	109	8.9
Foundation	80	6.5
Land rent	48	3.9
Electric installation	18	1.5
Consultancy	15	1.2
Financial costs	15	1.2
Road construction	11	0.9
Control systems	4	0.3
TOTAL	1,227	100

Note: calculated by the authors based on selected data for European wind turbine installations

Source: EWEA 2009 report "The Economics of Wind Energy"

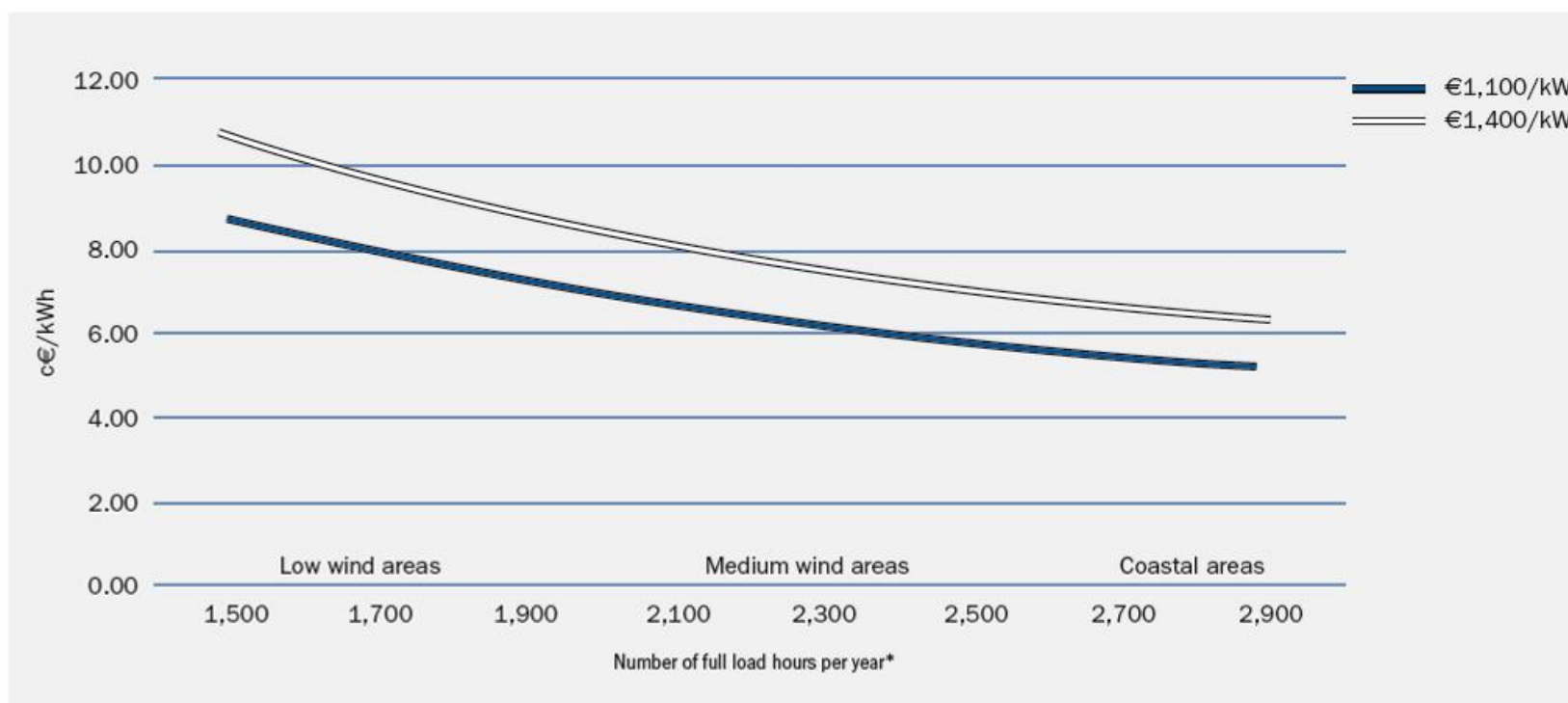
- Æ Wind energy: 75% of costs paid upfront
- Æ Conventional power: less capital intensive – uncertain fuel and carbon costs

How does the wind factor in?

Æ Wind regime defines costs of wind-generated power

Æ Installation costs change electricity cost

Calculated costs per kWh of wind-generated power as a function of the wind regime at the chosen site (no. of full load hours)

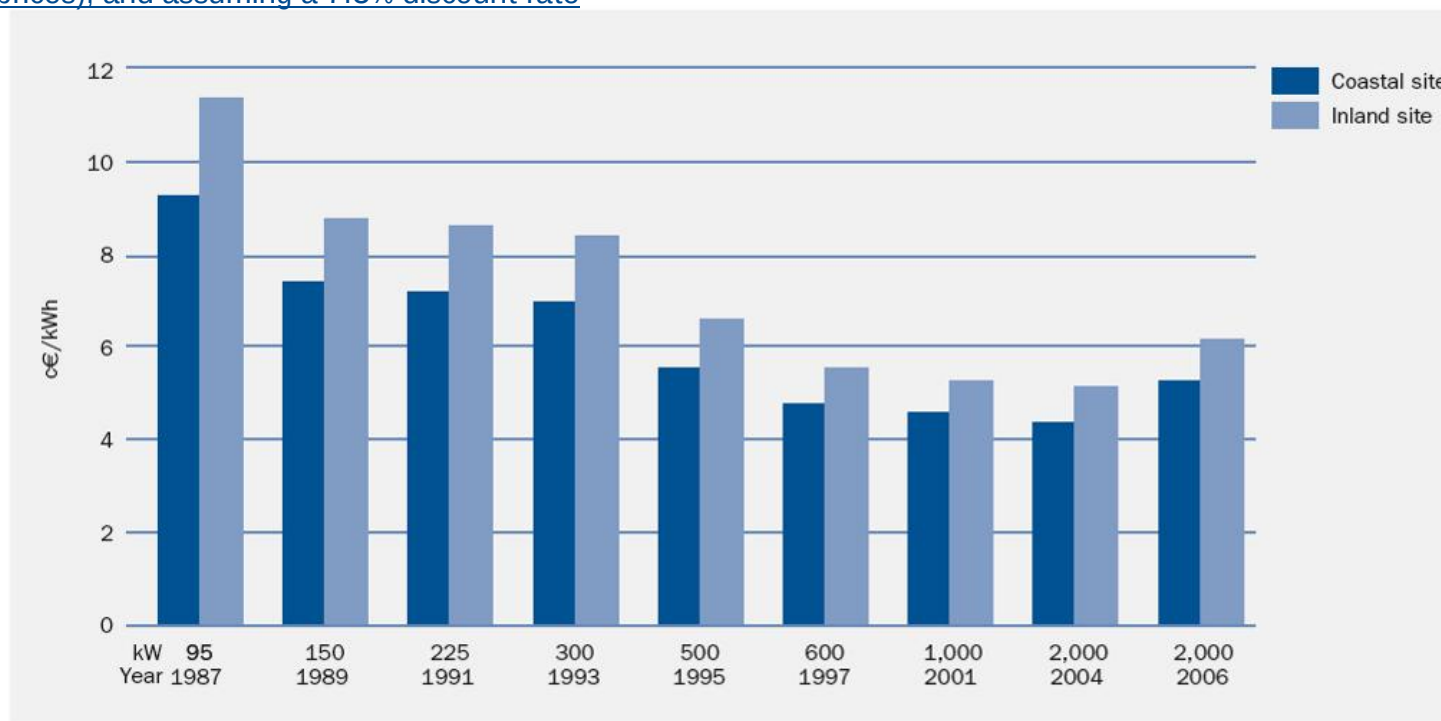


Source: EWEA 2009 report "The Economics of Wind Energy"

Production costs are decreasing

- Æ Trend towards larger turbines
- Æ Trend towards improved cost-effectiveness
- Æ Costs have gone down by more than 40%

Total wind energy costs per unit of electricity produced, by turbine size (c €/kWh, constant €²⁰⁰⁶ prices), and assuming a 7.5% discount rate



Source: EWEA 2009 report "The Economics of Wind Energy"

Wind power avoids fuel and CO₂ costs

CO₂ costs avoided

Æ €2 billion in 2007

Æ €16 billion in 2020

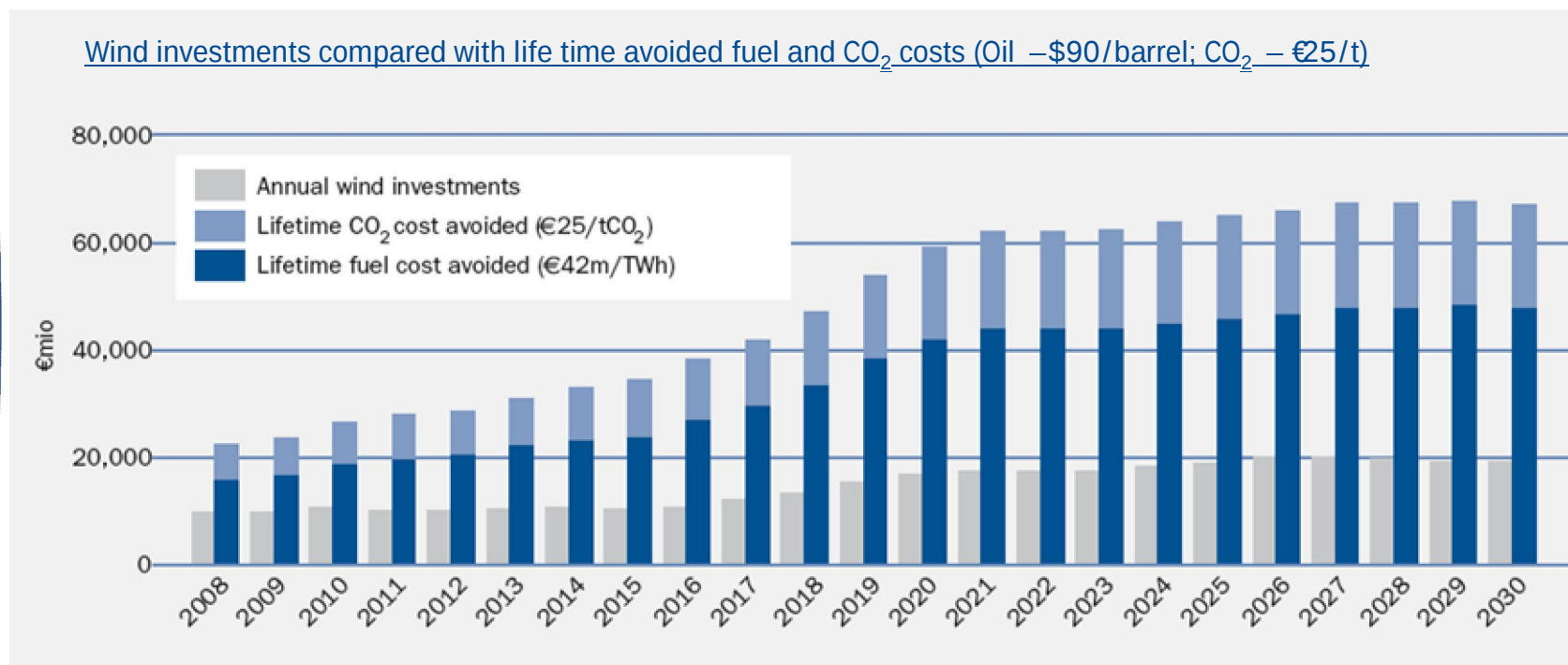
Æ €43 billion in 2030

Fuel costs avoided

Æ €4.4 billion in 2010

Æ €12 billion in 2020

Æ €24 billion in 2030

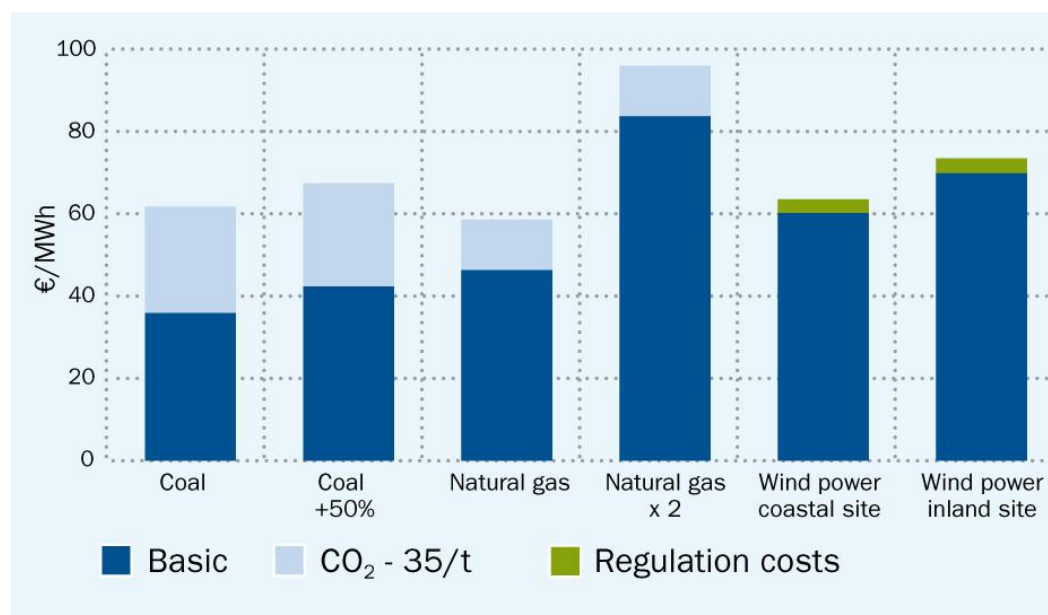


Sources: EWEA 2008 report "Pure Power" and EWEA 2009 report "The Economics of Wind Energy"

Competitiveness of wind power

- Æ Rising fuel and carbon prices increase competitiveness of wind-generated power
- Æ At inland sites, costs become lower than natural gas and only around 10% more expensive than coal
- Æ On coastal sites, wind power produces the cheapest electricity
- Æ Uncertainties of future fuel and CO₂ prices imply a considerable risk for future generation costs of conventional plants
- Æ Wind: zero fuel cost, zero CO₂ cost

Sensitivity analysis of generated power comparing conventional plants to wind power, assuming increasing fossil fuel and CO₂-prices, year 2010 (constant €²⁰⁰⁶)



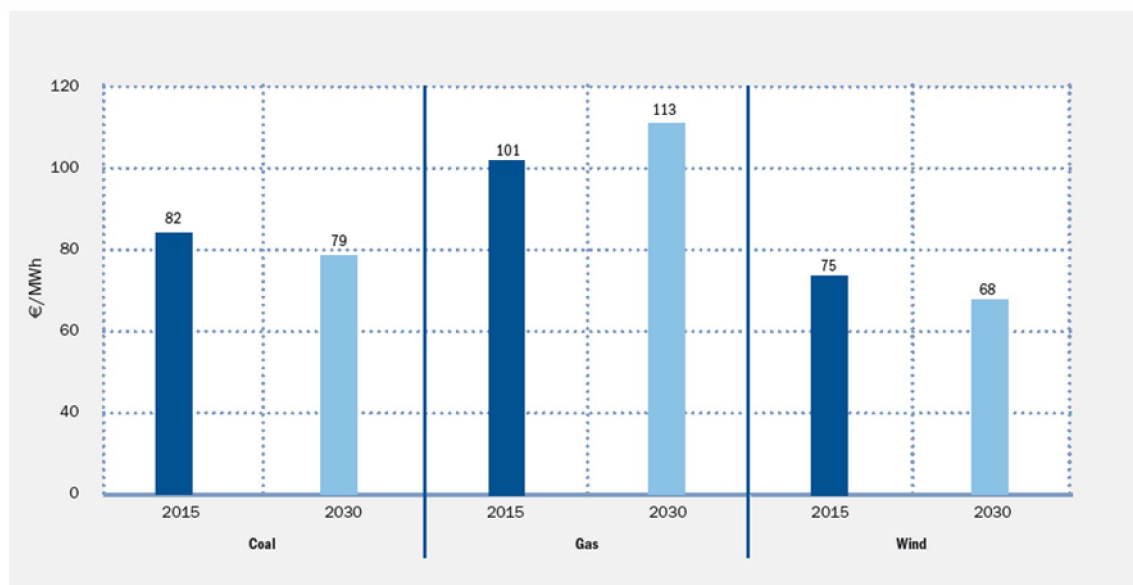
Note: reference equivalent to an oil price of 116 in 2010: natural gas price doubles, coal price increases by 50%, CO₂-price increases from €25 in 2008 to €35.

Source: EWEA 2009 report "The Economics of Wind Energy"

IEA World Energy Outlook 2008

- Æ Revised assumptions on fuel prices and power plant construction cost
- Æ Expects new wind power to be cheaper than coal and gas in 2015 and 2030

Electricity generating costs in the European Union, 2015 and 2030



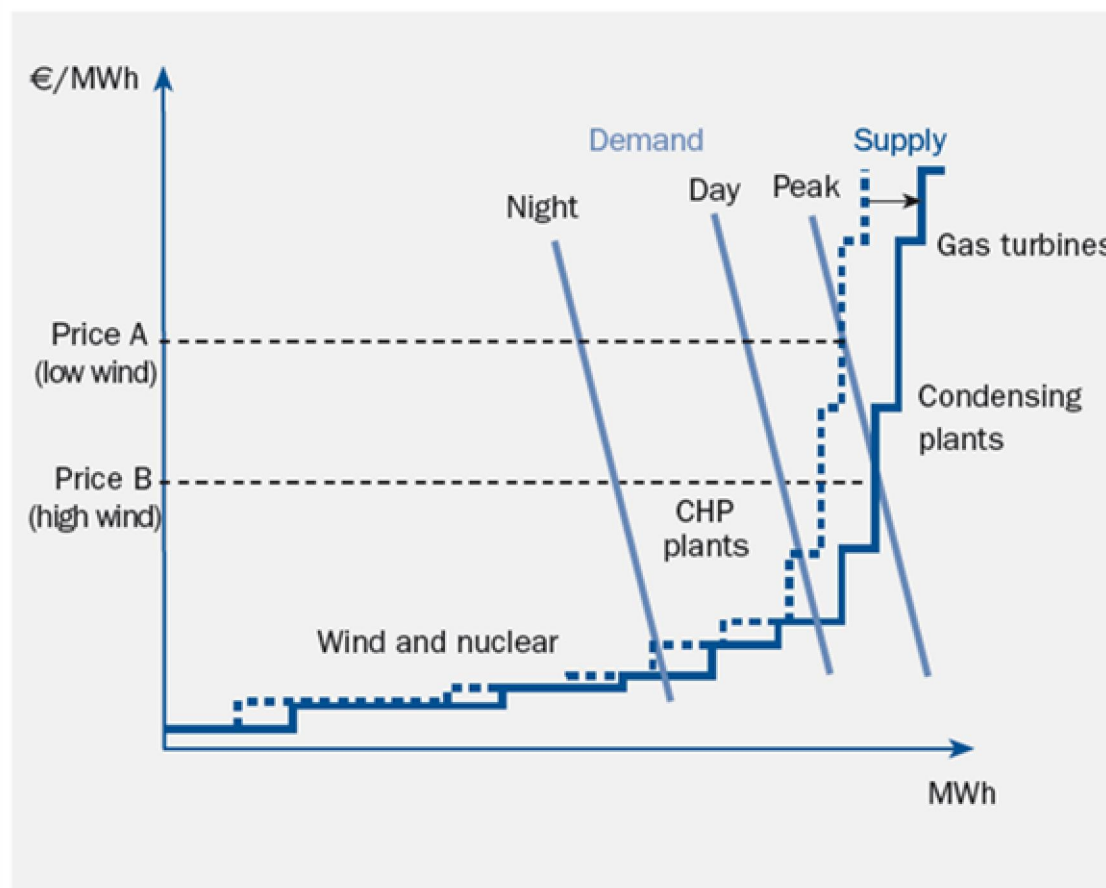
€/ \$ Exchange rate: 0.73

Source: IEA World Energy Outlook 2008

Wind energy reduces power price

- Æ Impact of wind power depends on time of the day
- Æ High demand and high wind impact the spot power price significantly
- Æ Lower power spot price is beneficial to all consumers

How wind power influences the power spot price at different times of day

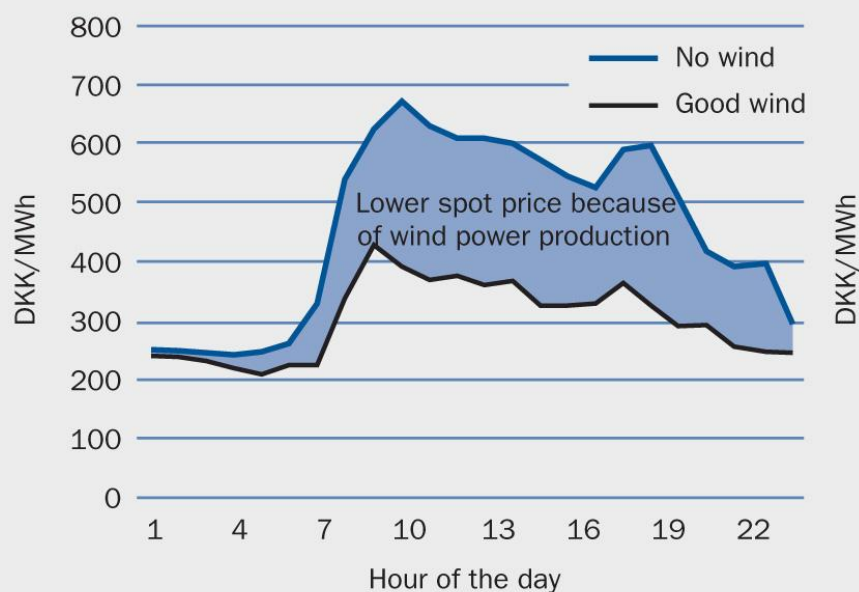


Source: EWEA 2009 report "The Economics of Wind Energy"

Wind energy reduces power price – West Denmark

The impact of wind power on the spot power price
in the west Denmark power system in December 2005

- Æ Graph shows impact of wind power on power price
- Æ At very high levels of wind power production, power price is reduced significantly during the day, less during the night
- Æ Impact on power price might increase with larger shares of wind power

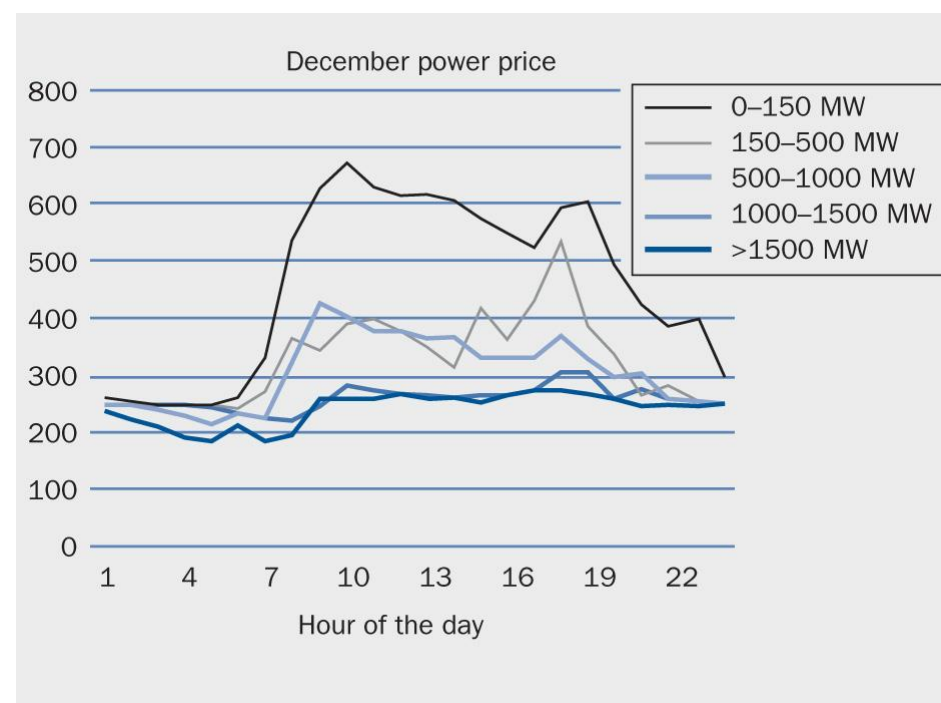


Note: The calculation only shows how production contribution from wind power influences power prices when the wind is blowing.
Source: EWEA 2009 report "The Economics of wind Energy"

Wind energy reduces power price – West Denmark

- Æ Graph shows five levels of wind power production during one day and corresponding power prices
- Æ At very high levels of wind power production, power price is reduced significantly during the day, less during the night
- Æ Impact on power price might increase with larger shares of wind power

The impact of wind power on the spot power price in the west Denmark power system in December 2005



Note: The calculation only shows how production contribution from wind power influences power prices when the wind is blowing.
Source: EWEA 2009 report "The Economics of wind Energy"

Comparing power generation cost

Wind energy

- Æ Capital-intensive
- Æ Predictable costs
- Æ Low-risk technology

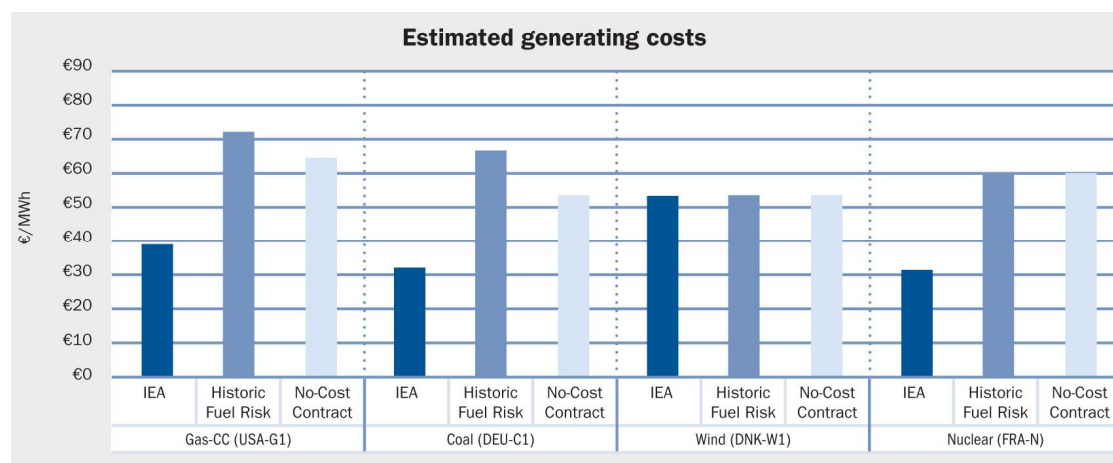
Fossil fuels

- Æ Unpredictable costs
- Æ Have to be imported from politically unstable areas
- Æ Increase fuel import dependency

Discount rates

- Æ Have to be adjusted to reflect carbon and fuel price risks
- Æ Inclusion of fuel price risk in discount rates doubles gas generation costs
- Æ Wind energy costs remain stable
- Æ Inclusion of carbon price risk would make wind even more competitive

Risk-adjusted power generating cost of gas, coal, wind and nuclear



Source: EWEA 2009 report "The Economics of Wind Energy"



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Thank you very much for your attention

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