Trends in Wind Energy Costs and Markets

Wind Power Status by the End of 2005

Wind Energy Has Become a Mainstream Energy Source

Today World Wide:

- **Meets the electricity needs of more than 100 million people.**
- **New installations of wind power have surpassed new nuclear installations since 1999.**
- **Over 85.000 wind turbines installed today.**
- **Employs more than 150.000 people.**
- **Worth more than 12 billion Euro annually.**
- **Growing at a rate of more than 25% per year.**
- **The world's fastest growing energy source.**

Wind Energy Success in European Markets

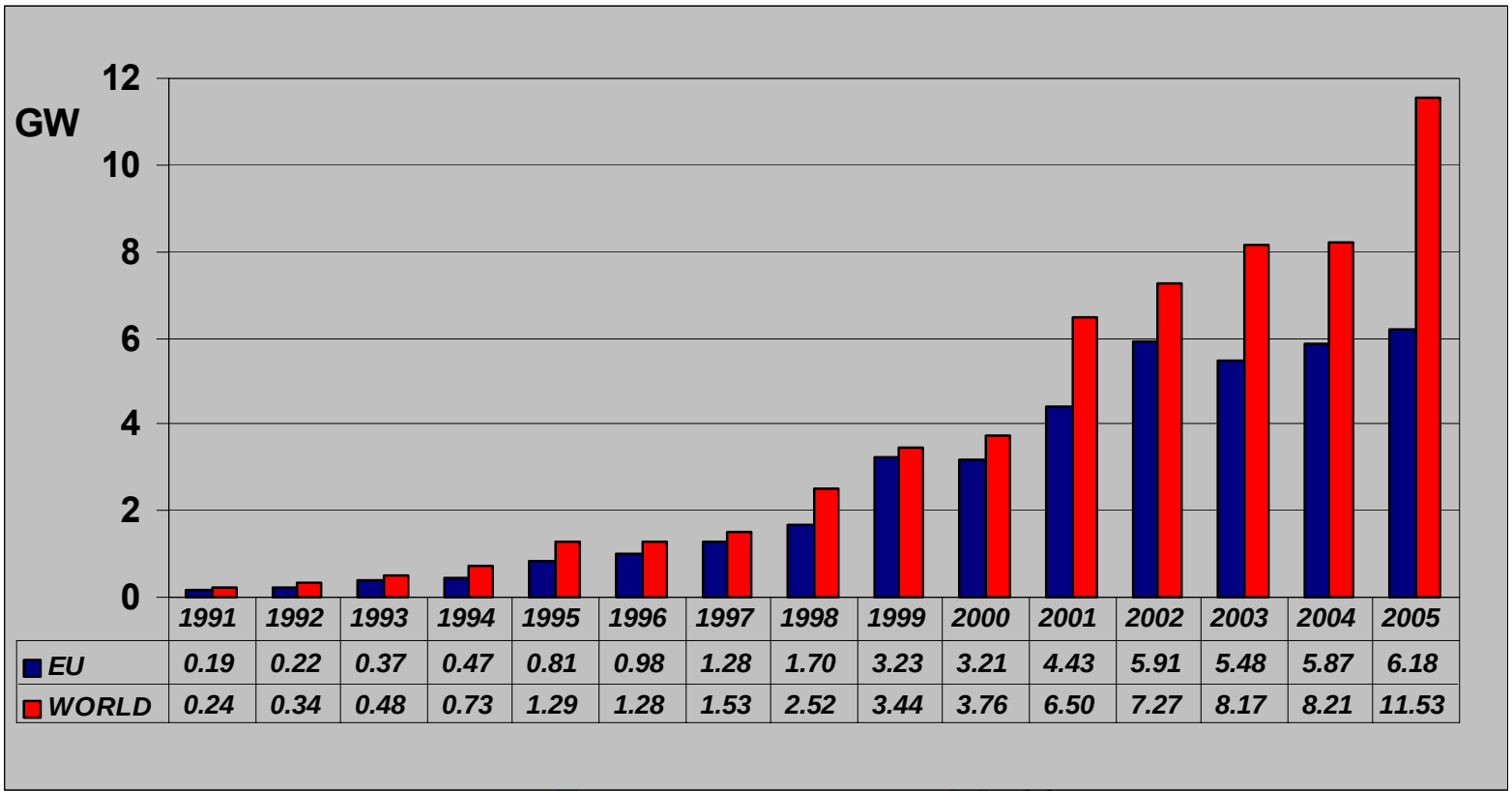
- In Denmark, wind power already satisfies 20% of electricity consumption

- In Spain the installed wind capacity already exceeds nuclear and combined cycle gas, and will this decade overtake coal and large hydro

- In northern Germany, the federal state of Schleswig-Holstein gets 30% of its power supply from wind

Annual Wind Energy Installed Capacity

40% Global Market Growth in 2005 !!



	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
EU	0.19	0.22	0.37	0.47	0.81	0.98	1.28	1.70	3.23	3.21	4.43	5.91	5.48	5.87	6.18
WORLD	0.24	0.34	0.48	0.73	1.29	1.28	1.53	2.52	3.44	3.76	6.50	7.27	8.17	8.21	11.53

Average Annual Growth Rates

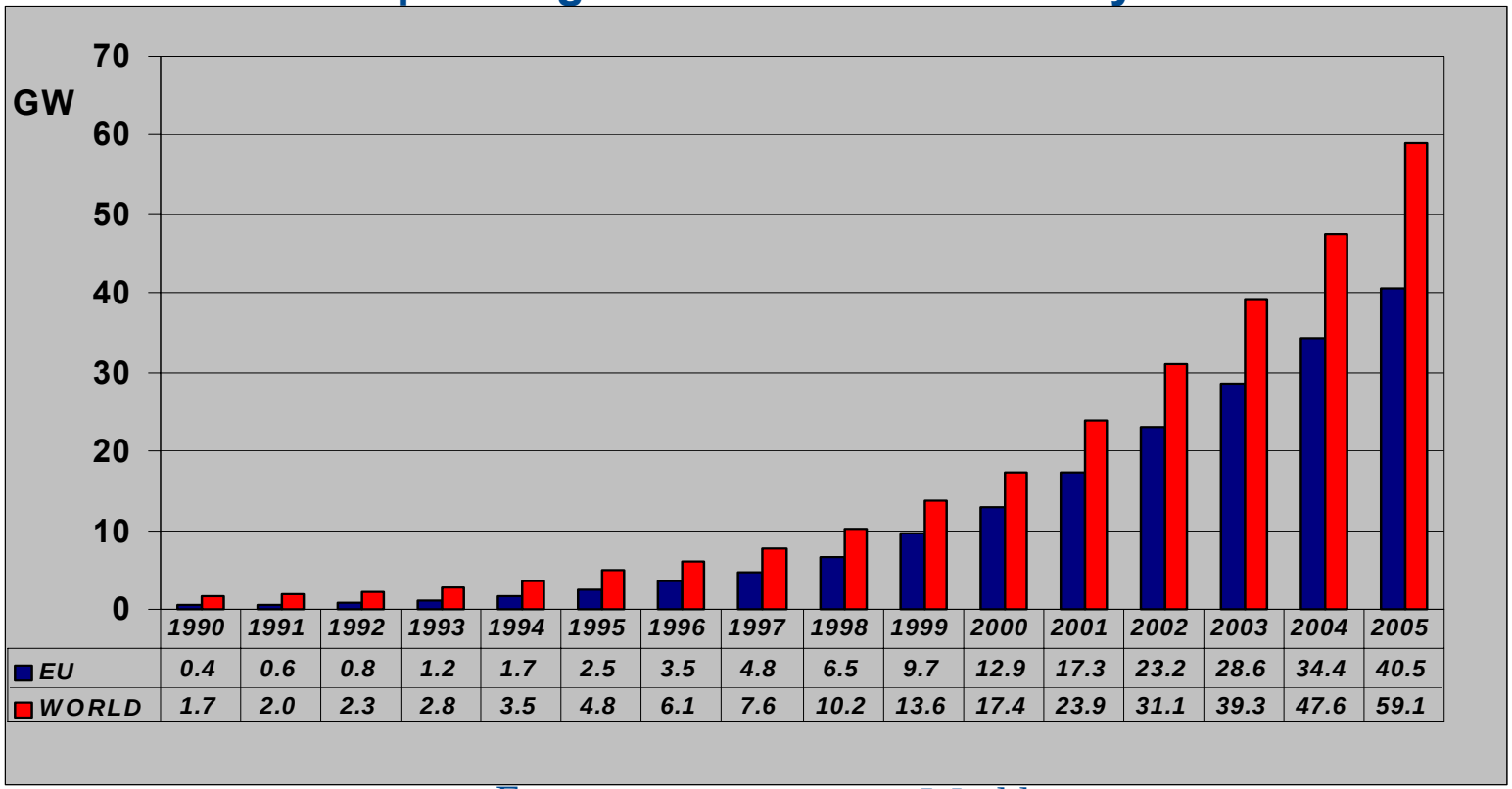
Europe
1995-2000 31.7%,
2000-2005 14.0%

World
1995-2000 23.8%,
2000-2005 25.1%

Source: EWEA, GWEC

Cumulative Wind Energy Installed Capacity

The EU White Paper Target has been achieved 5 years earlier

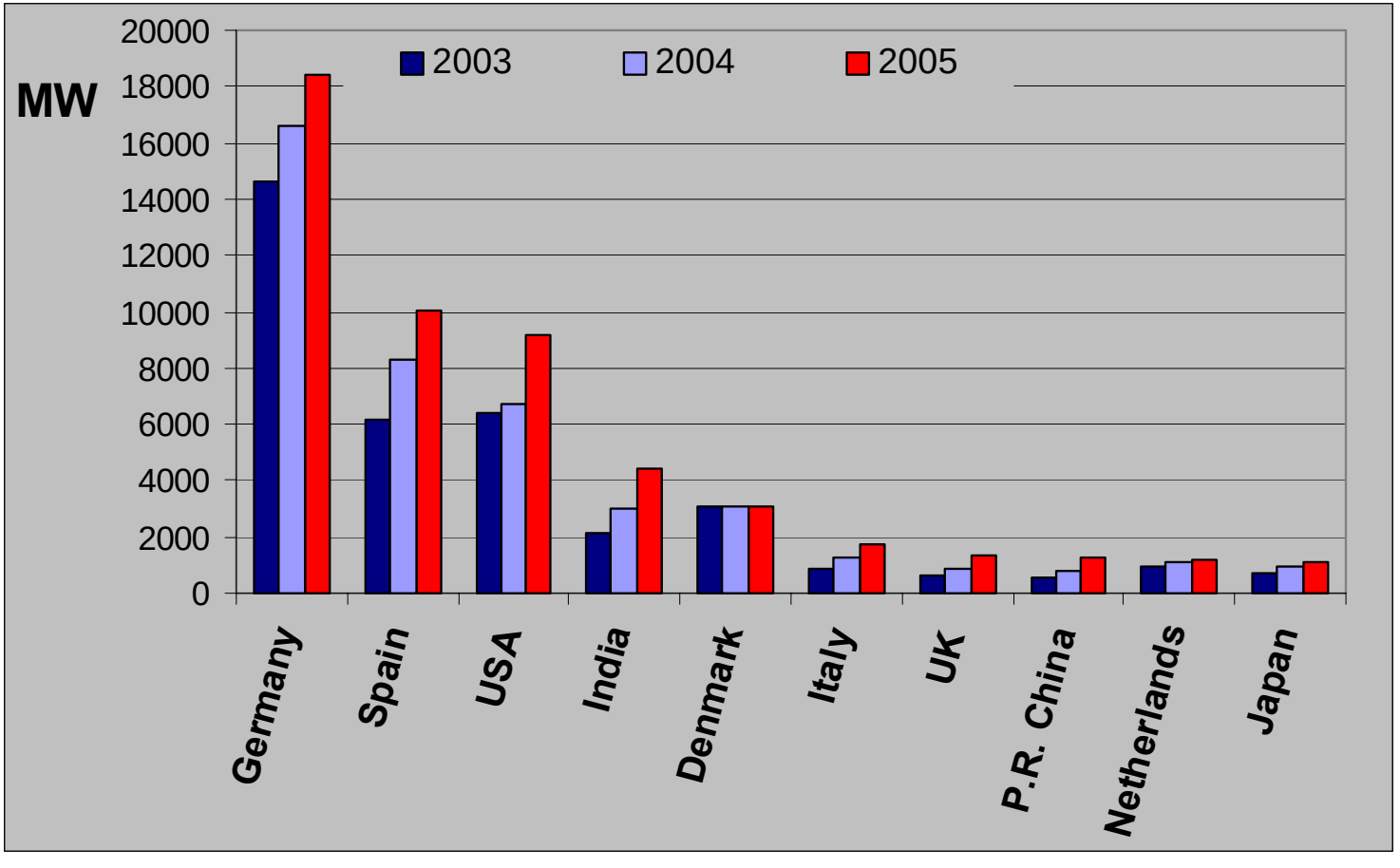


	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
EU	0.4	0.6	0.8	1.2	1.7	2.5	3.5	4.8	6.5	9.7	12.9	17.3	23.2	28.6	34.4	40.5
WORLD	1.7	2.0	2.3	2.8	3.5	4.8	6.1	7.6	10.2	13.6	17.4	23.9	31.1	39.3	47.6	59.1

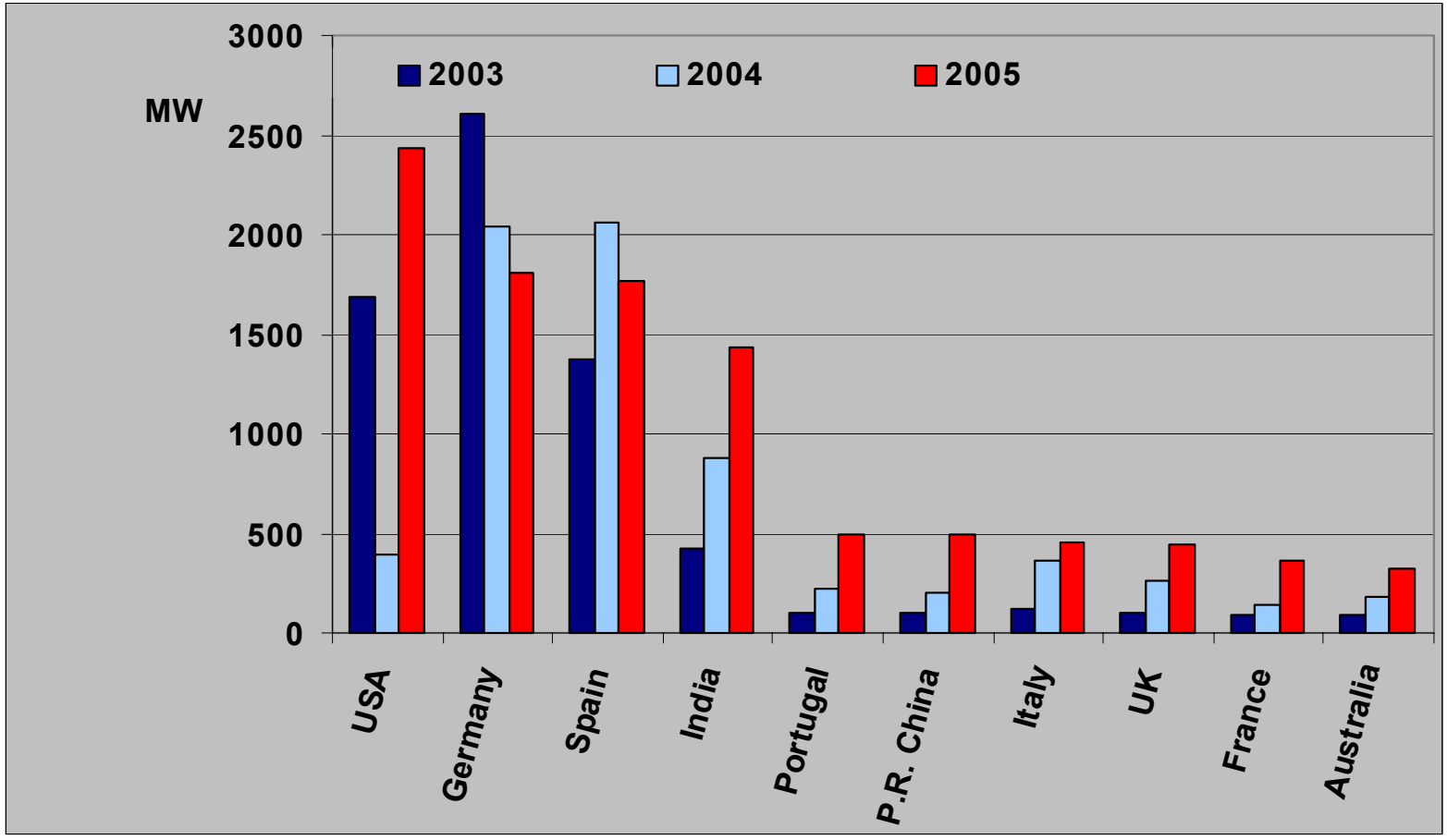
Source: EWEA,GWEC

	Europe	World
Average Annual Growth Rates	1995-2000 38.8%, 2000-2005 25.7%	1995-2000 29.4%, 2000-2005 27.7%

The Top-10 Cumulative Markets in the World

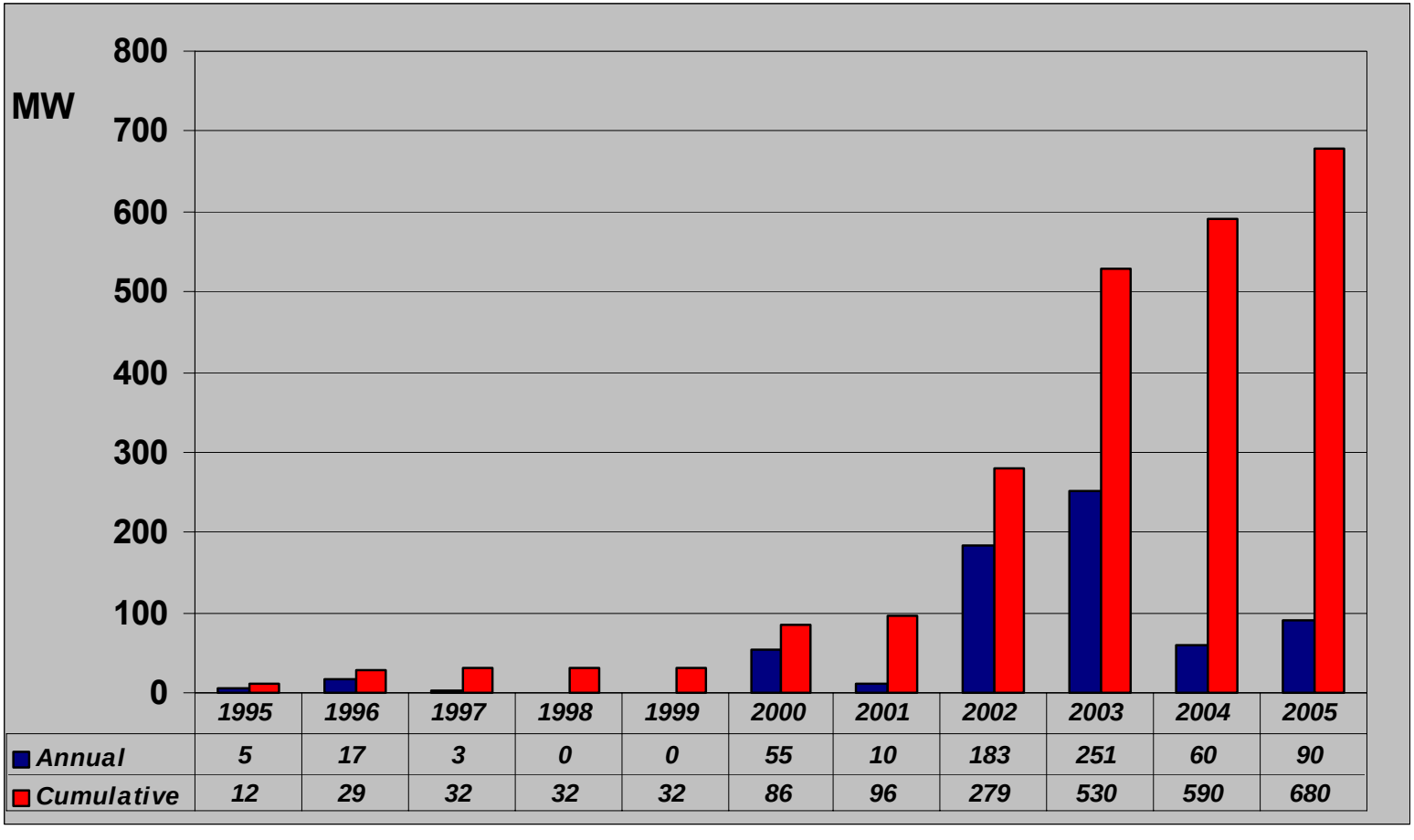


The Top-10 Annual Markets in the World



Source: EWEA,GWEC

Annual and Cumulative Offshore Capacity (1995 – 2005)



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Annual	5	17	3	0	0	55	10	183	251	60	90
Cumulative	12	29	32	32	32	86	96	279	530	590	680

Source: EWEA

Attitude of the General Energy Sector and Big Investors Towards Wind Energy

➢**10 years ago**

Wind sector was practically ignored

➢**5 years ago**

Interest starts, but the perception is that wind can only play a marginal role

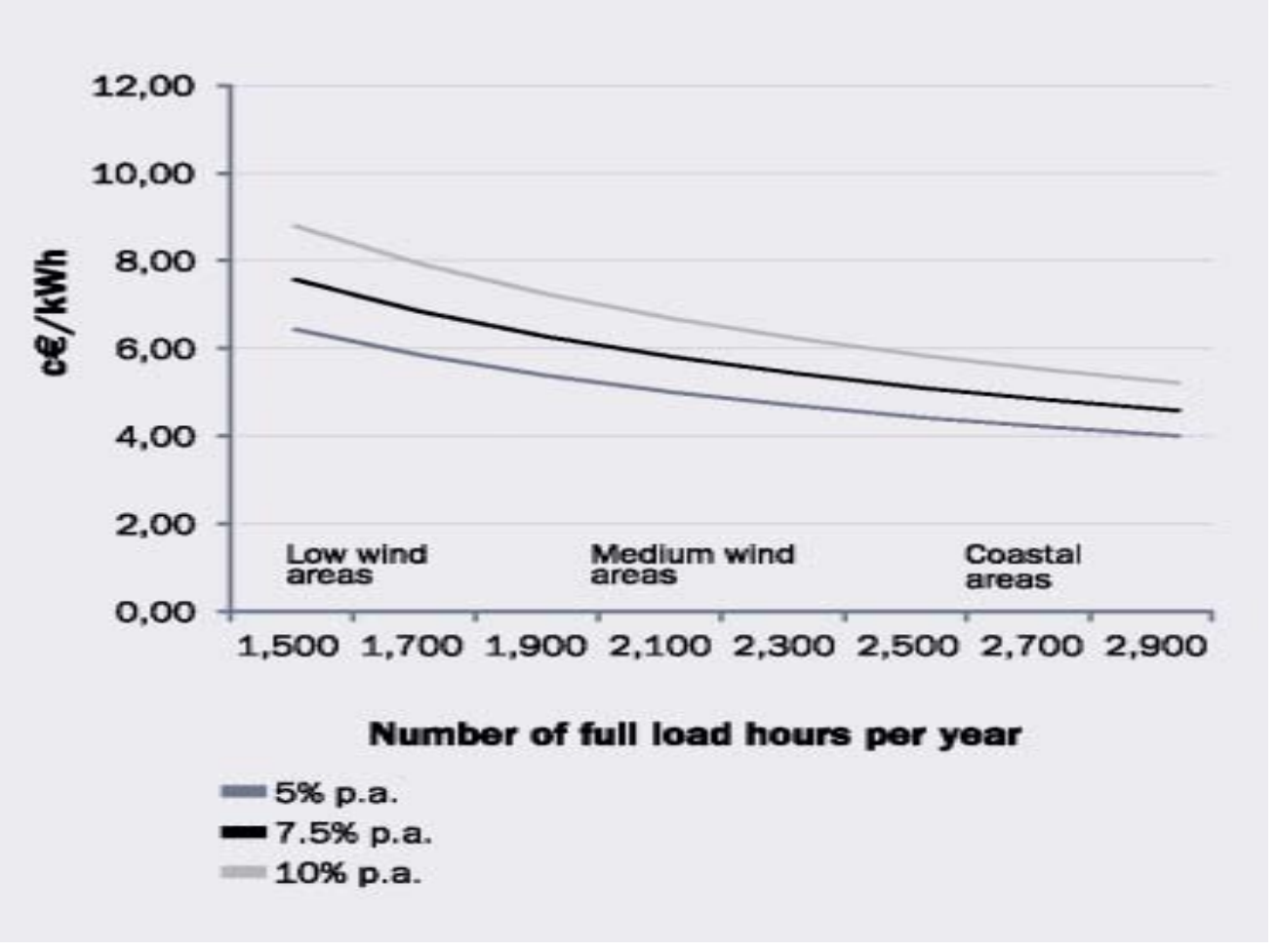
➢**Today**

Big energy players and investors are a major and growing part of the wind sector:

- Manufacturing (GE, Siemens, Areva)
- Development (Shell, BP, Iberdrola, Scottish Power, even EDF and EON outside Germany)
- Finance (Allianz, Englefield Capital, Babcock and Brown, Goldman Sachs)

Costs and Prices

Cost of Wind Power as a Function of Wind Speed and Discount Rate



System operation – balancing

Impact of wind power depends on **penetration** and **system characteristics**

Large power systems have flexible mechanisms, this favours integration of variable-output wind power

Balancing solutions: conventional power, interconnection, load management and energy storage

At 10 % penetration, increase in reserves is 2-4% of wind power capacity.

The economic impacts of wind power integration, additional costs

Additional balancing costs:

- €1-3/MWh (wind), penetration 10%
- € 2-4/MWh (wind), penetration 20 %

Additional network costs:

- € 0.1-4.7/MWh (wind)

System integration costs:

- 0-4 €/MWh

Consumer electricity price:

- increase less than 5%

The economic impacts of wind power integration are beneficial

Additional system costs of wind are outweighed by its benefits:

- Substantial future **cost decrease of wind power** is expected (20% onshore, 40 % offshore by 2020)
- Benefits of **CO2 emissions reduction** and other environmental benefits
- Wind **reduces generation portfolio costs (and/or risks)** as a fixed cost zero fuel technology.

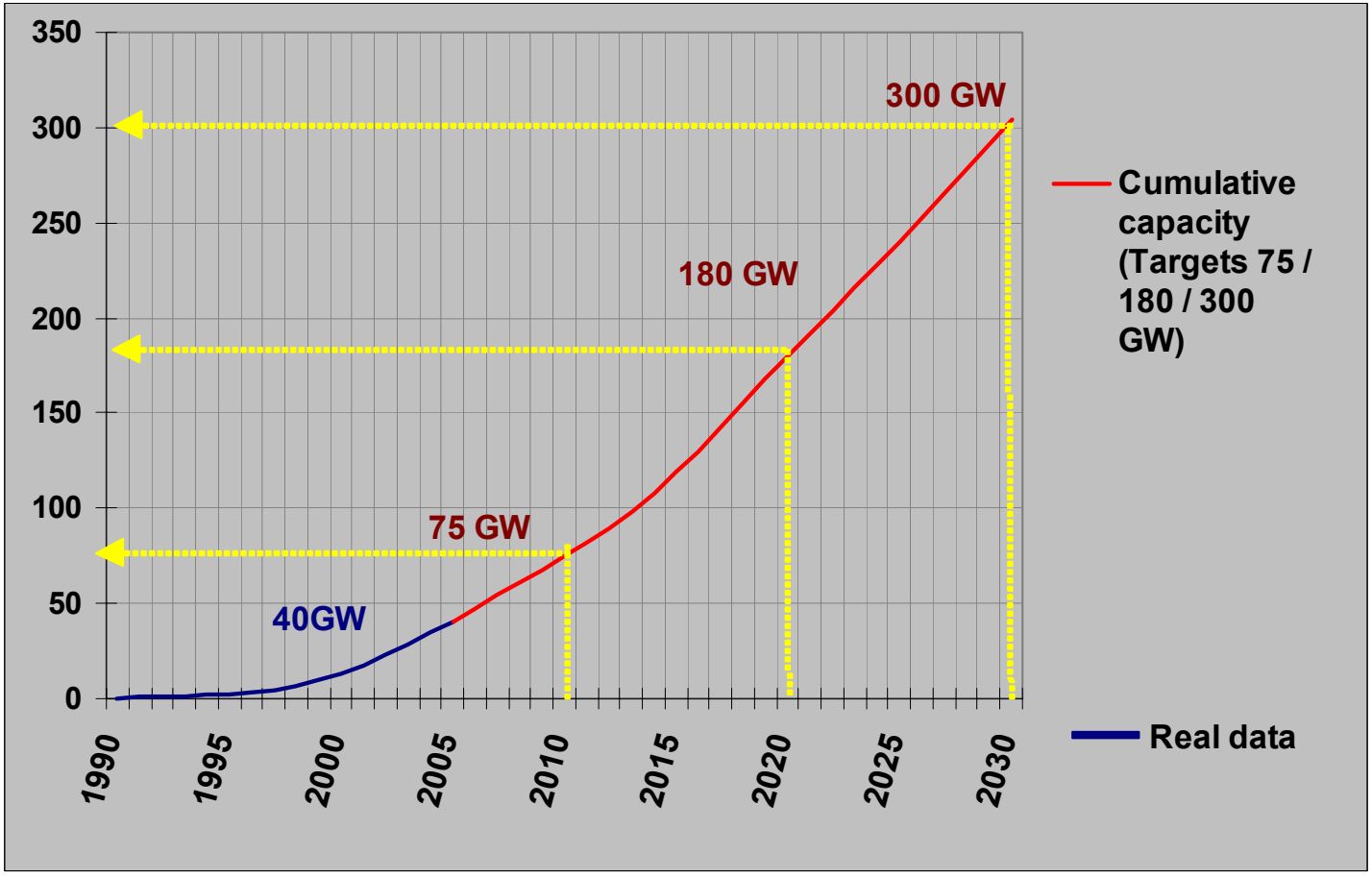
Turning the energy challenge in a competitive advantage

The fact that the wind power source is free and clean is, of course, economically and environmentally significant but the more fundamental point at issue is that **the cost of the electricity is fixed**, once the plant has been built.

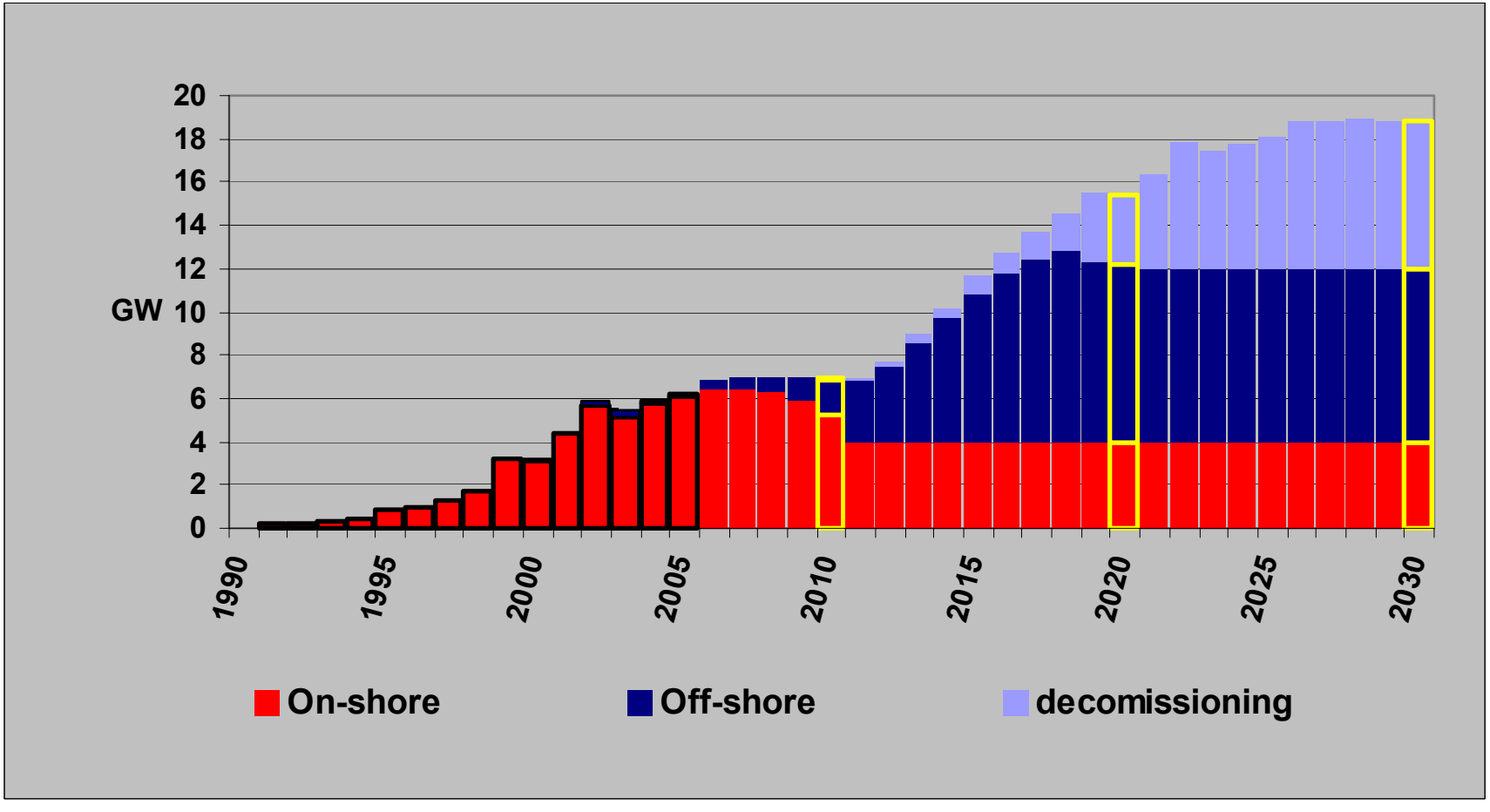
Most countries and institutions continue to ignore the risk element of volatile fuel prices when making cost comparisons between different electricity generating technologies.

Large-scale integration of wind energy in the European power supply

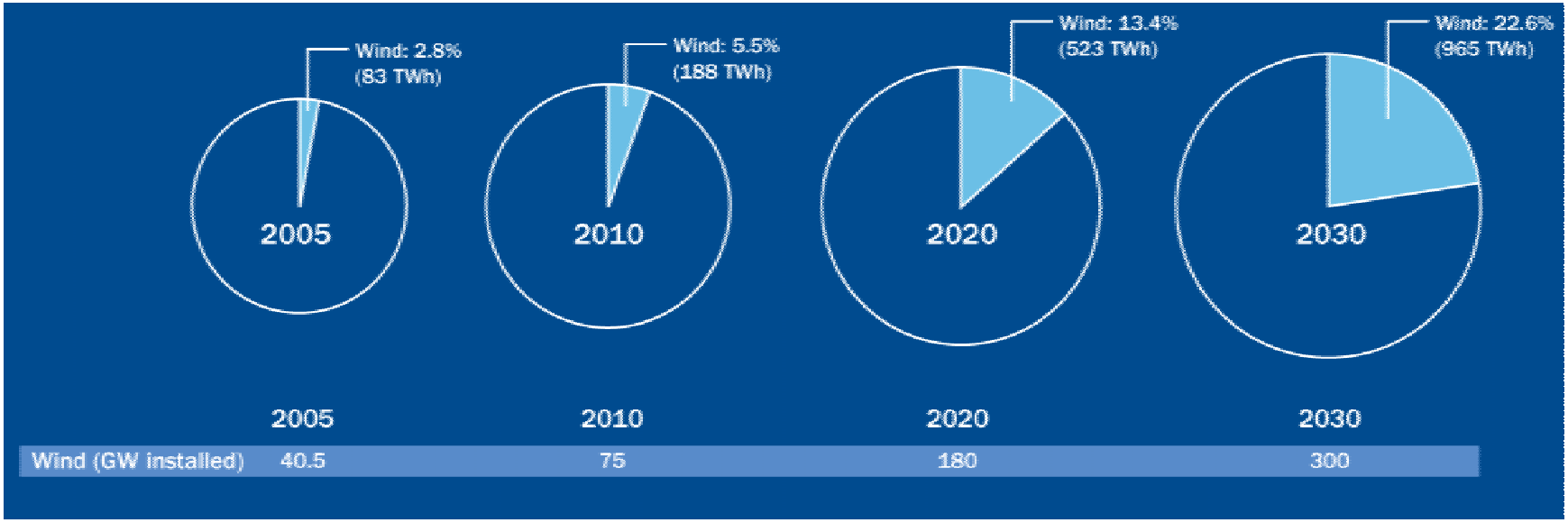
EWEA Targets for the European Union



Projections of Annual Installations (2006 – 2030)

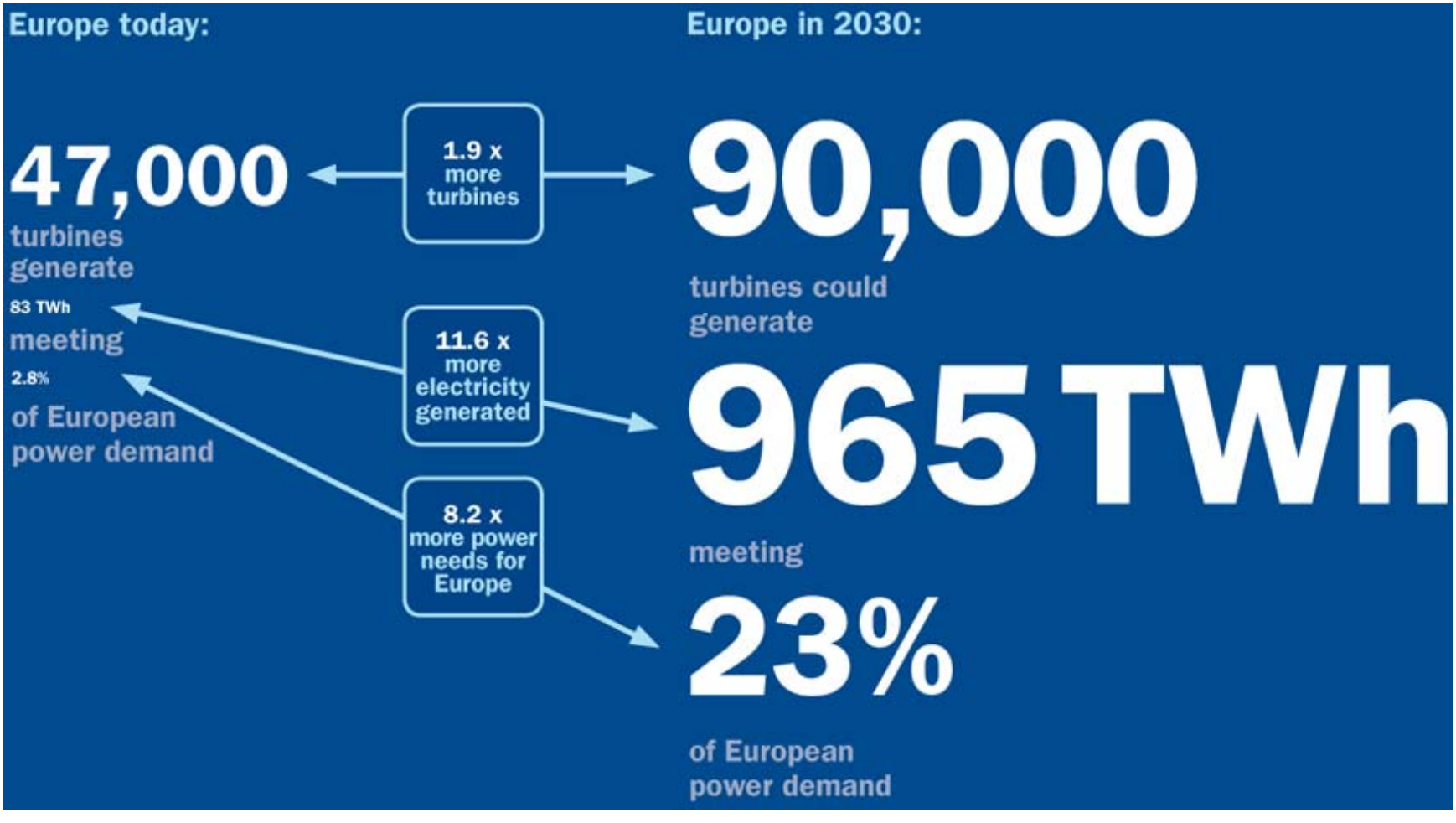


Contribution of Wind Power (TWh) to Electricity Generation 2005-2030, EU



	2005	2010	2020	2030
Wind (GW installed)	40.5	75	180	300

More energy with fewer machines



Circumstances favouring a change: EUROPEAN ENERGY POLICY

RES-E Directive (2001)

Sizable share of RES

Fair grid access

Presidency Conclusions Spring Council (March 2006)

RES: 15 % in 2015

Priority Interconnection and infrastructure Plan….

FP7 priority for energy

Commission Comm: ‘Green paper’ (March 2006)

Single European grid

European Regulator

Priority Interconnection Plan

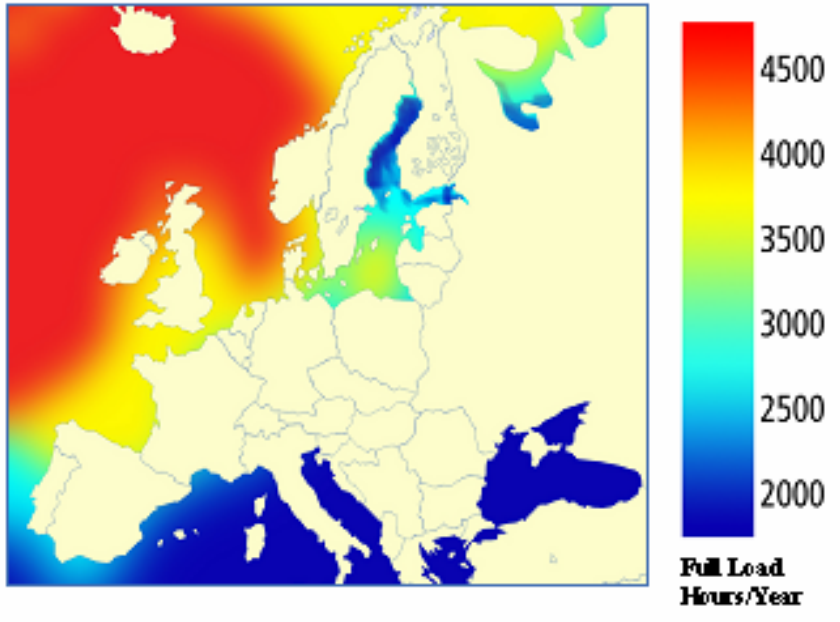
Adequate budget for TEN-E Networks

Promise to make a Renewable Energy Roadmap

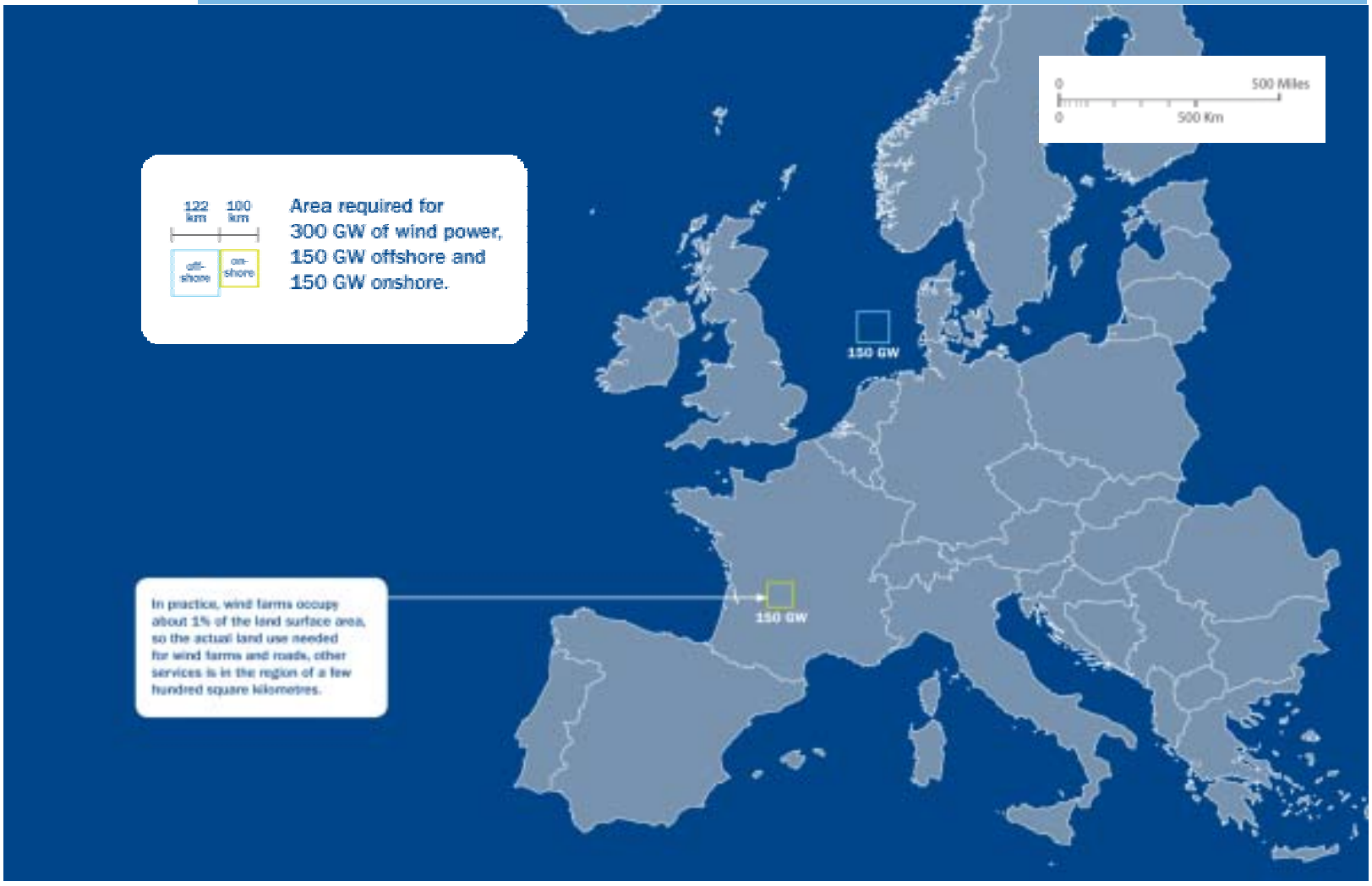
….

Technical prospects favouring a change
Europe's wind resource

- Among richest in the world
- Sufficient to provide all of EU's electricity requirements
- Technically efficient and commercial competitive to exploit
- Predictable fuel cost
- Independent of external political influences
- Clean

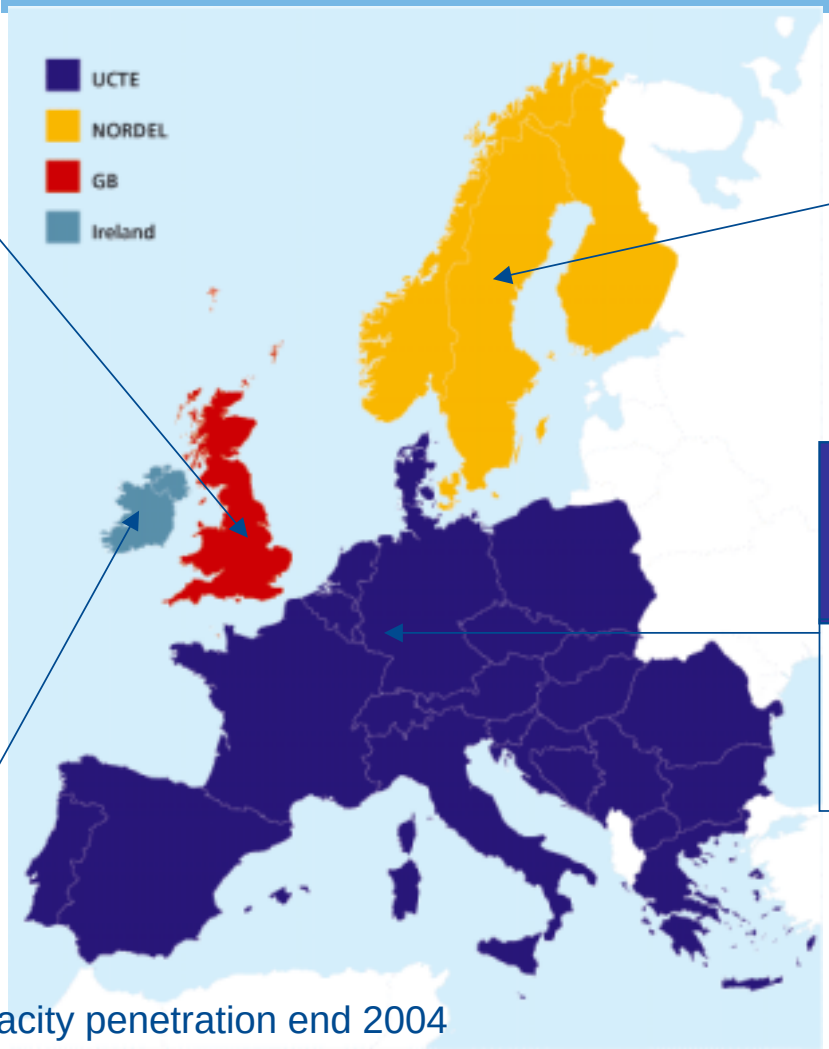


Technical prospects favouring a change
Wind power is quite resourceful ….



Technical prospects favouring a change
…but there is still a long way to go to reach 25 %

GB	Nordic
81 GW	90 GW
1 GW	3.1 GW
1%	5%



UCTE	Ireland
603 GW	7.6 GW
30 GW	0.5 GW
5%	7%

Total 781.5 GW

Wind 34.2 GW (4%)

Wind power capacity penetration end 2004

Economic prospects favouring a change: Remarks to system integration costs

- **Wind power reduces portfolio generation costs.** When added to a risky, fossil-dominated generating portfolio, wind as a fixed cost zero fuel technology reduces overall generating cost and risk.
- **Balancing costs, grid extensions and reinforcements come with all electricity generating technologies, not only with wind power.**
  There is a lack of proper studies about such costs for non-wind technologies.
- **Most countries and institutions continue to ignore the risk element of volatile fuel prices when making cost comparisons between different electricity generating technologies.**
  Rather than using the commonly applied levelized cost approaches, it is recommended to adopt cost calculating methods allowing a proper economic interpretation of (easily quantifiable) cost and risk of volatile oil, gas and coal prices.

Wind power: variable and predictable

Wind power has its proper variability characteristics, these should be taken into account in future power system design. In general, power systems need to be **more flexible**, diverse and smart to accommodate variable output Distributed Generation.

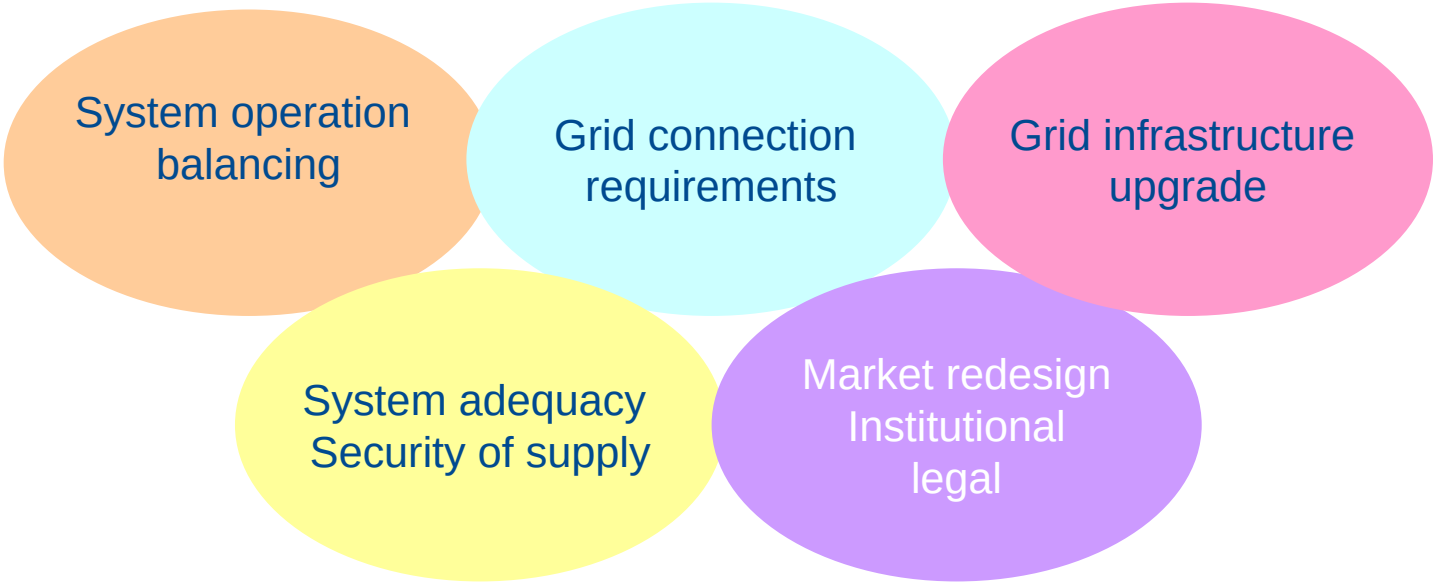
REMARKS

Wind power is just another variable in the system. In the context of power system balance, wind power variability always has to be considered in relationship to the demand variability, and other supply intermittencies.

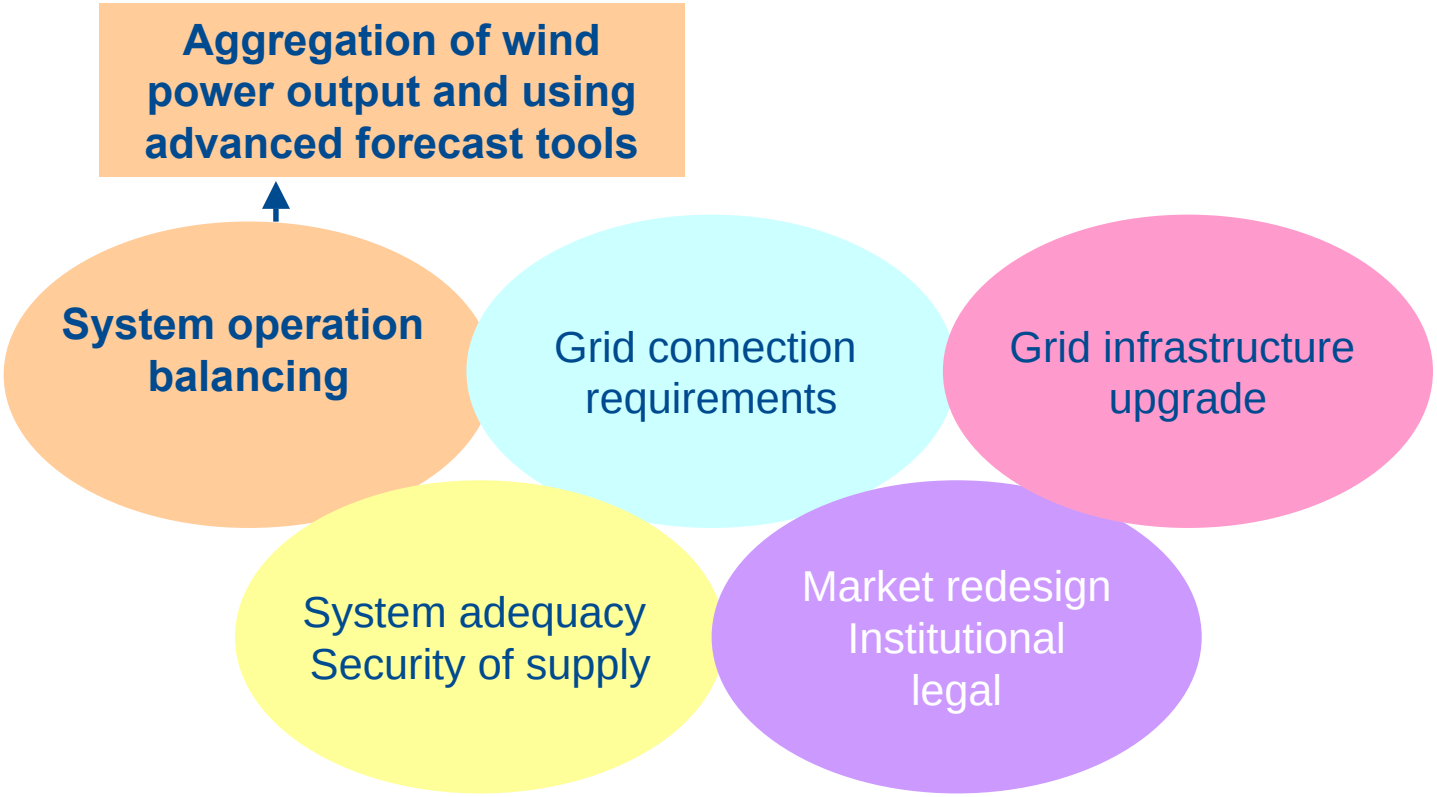
Wind power output can be **fairly well predicted on the short term** with accurate and industrially available forecast methods

Preconditions for reaping maximum benefit of large scale wind integration

5 steps to properly address the integration issues



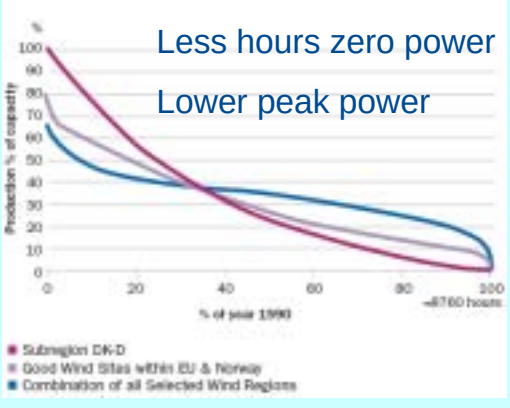
Preconditions for reaping maximum benefit of large scale wind integration



Aggregation and forecasting to mitigate wind power variability costs

Geographical aggregation is smoothing wind power output variations and improving the predictability **leading to lower balancing costs**.

A basic requirement is appropriate interconnection and cross border exchange possibilities.



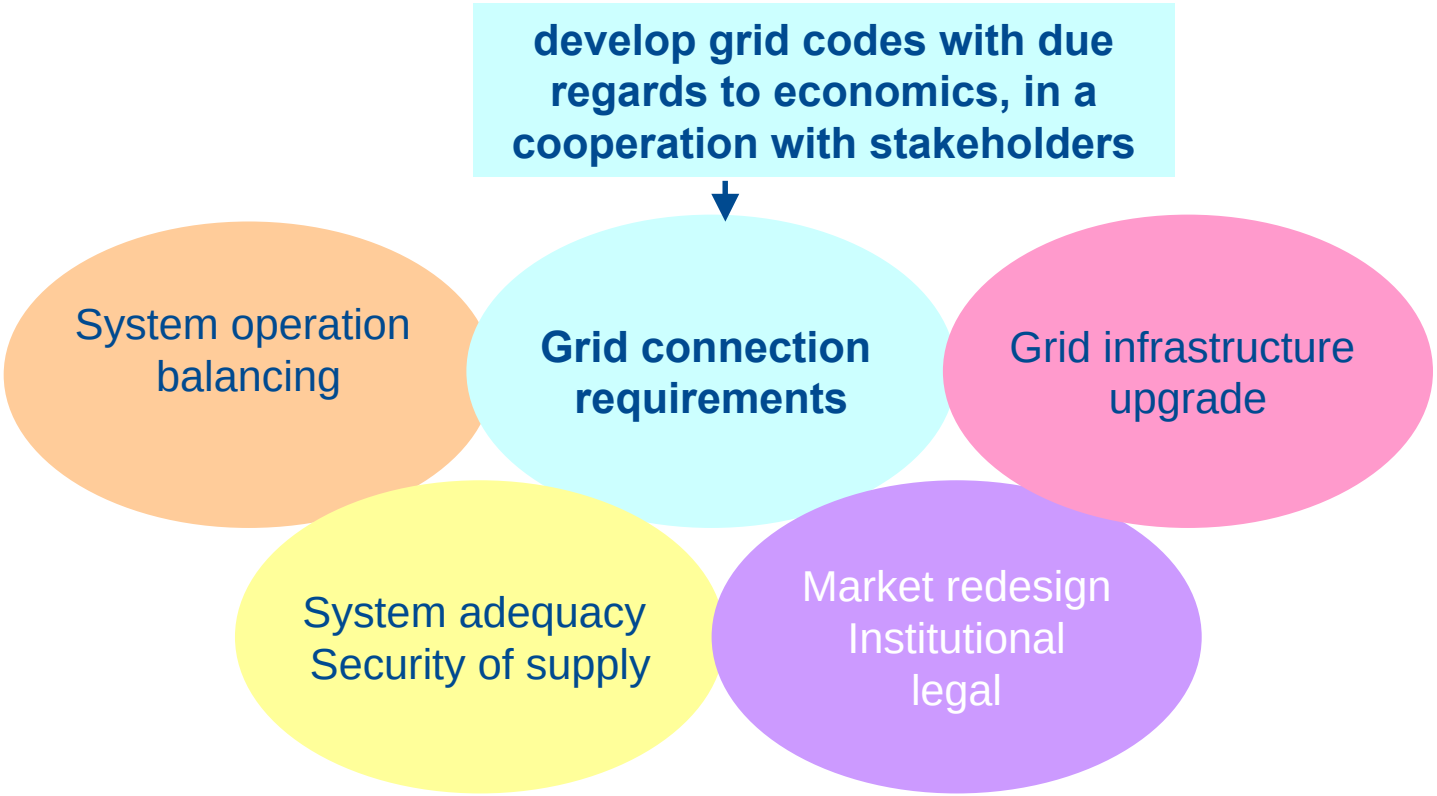
At 10 % wind energy penetration, system needs additional reserve capacity in the order of 2-8% of wind power capacity (from system studies in Germany, Skandinavia, UK).

High quality forecast combined with intraday trading reduces additional balancing capacity substantially.

Power system operation: recommendations

- The institutional and market set-up should take into account that **balancing costs should reflect the aggregate imbalance rather than the individual wind farm or wind turbine output variation**, as is often the case.
- **Long gate-closure times should be reduced for variable output technologies**. The shorter the gate-closure time for wind power is, the lower the overall cost to consumers.
- More effective **balancing and settlement procedures** that do not discriminate against variable output technologies must be introduced.
- **Curtailment** of electricity production should be managed according to least-cost principles from a complete-system point of view.
- The balance market rules must be adjusted **to improve accuracy of forecasts** and enable temporal and spatial **aggregation of wind power output forecasts**.

Preconditions for reaping maximum benefit of large scale wind integration



Grid codes and connection requirements for wind power

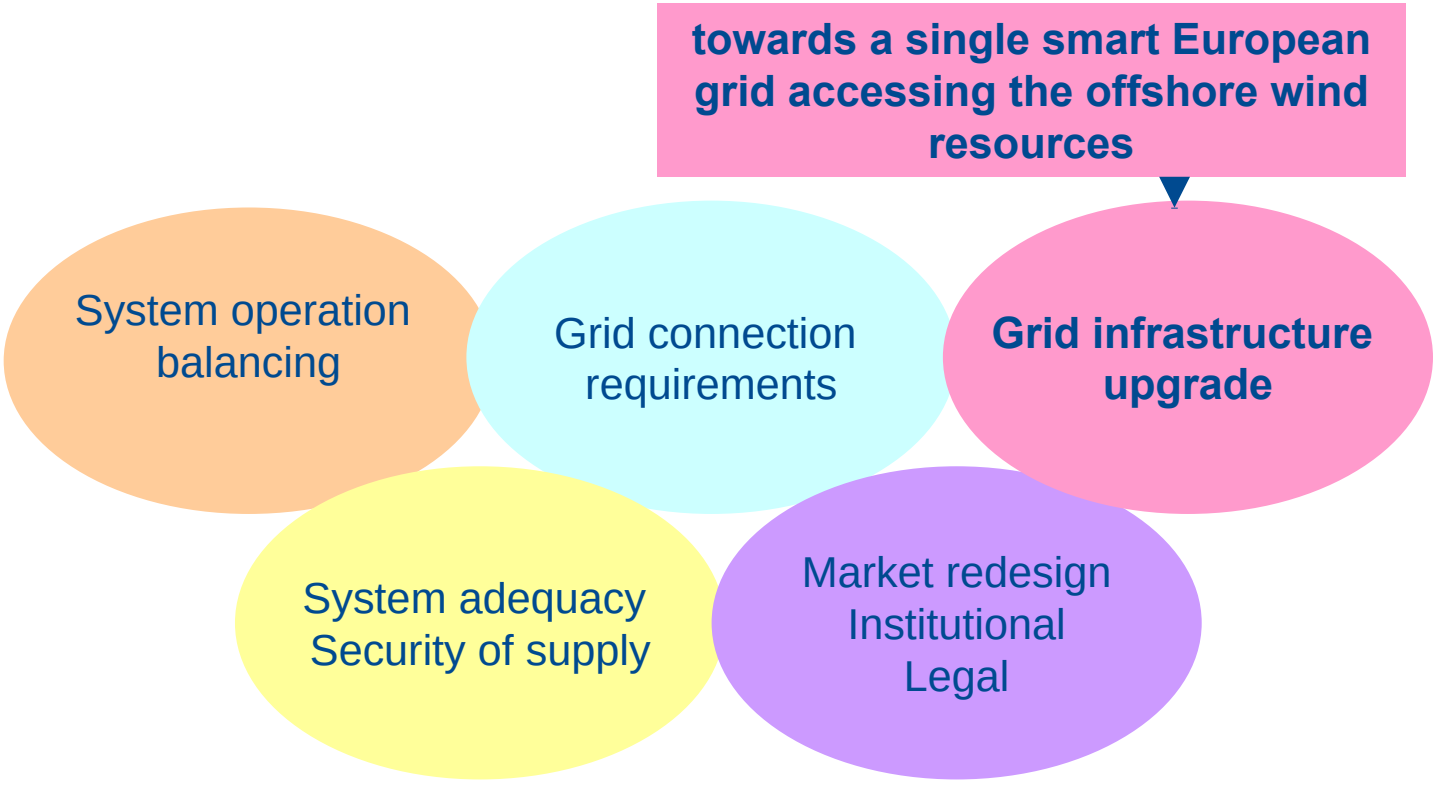
TSO/DSO connection requirements are based on dynamic stability studies; there is a lot of variation all over Europe, and a need for harmonisation
EC has called for a European grid code in its recent Green Paper: European regulator and European Centre of Energy Networks

EWEA recommends:
Costly technical requirements should only be applied if their introduction is **required for reliable and stable power system operation** (= not at low wind power penetration levels).

Development and implementation of **grid codes should be done in a transparent and non-discriminatory way** in co-operation between industry and the power sector.

R&D should continue to further improve the knowledge on **dynamic interaction of system and wind power plants.**

Preconditions for reaping maximum benefit of large scale wind integration



Towards a single smart European grid accessing the offshore wind resources

HIGH VOLTAGE GRID

More interconnection serves both wind power integration and the European policies towards an improved internal market

Bottlenecks in the process are time (delays) and money (structural funding)

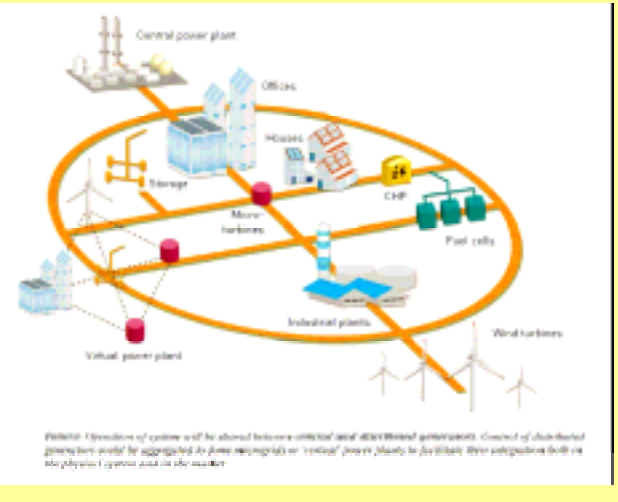
European Parliament in April 06 adopted amendments: TEN-E Declaration of European interest - allocation of European coordinator for priority projects

SMART GRID

Smart Grids concepts (e.g. more communication, grid management at DSO level) will facilitate wind power integration

System operation shared between central and distributed generators.

More customer-centric networks are the way ahead.



Grid infrastructure upgrade and costs: not an isolated wind power issue

Grid extensions and reinforcements will benefit the whole power system and should not be attributed to a single power source like wind power.

Grid upgrades are a precondition for creating real competition in the emerging EU internal electricity market. Grids are natural monopolies and should be regulated as such.

As a consequence the **grid extension costs should be properly socialized**. Good example is the recent decision in UK to extend the regulated approach to the offshore transmission grids.

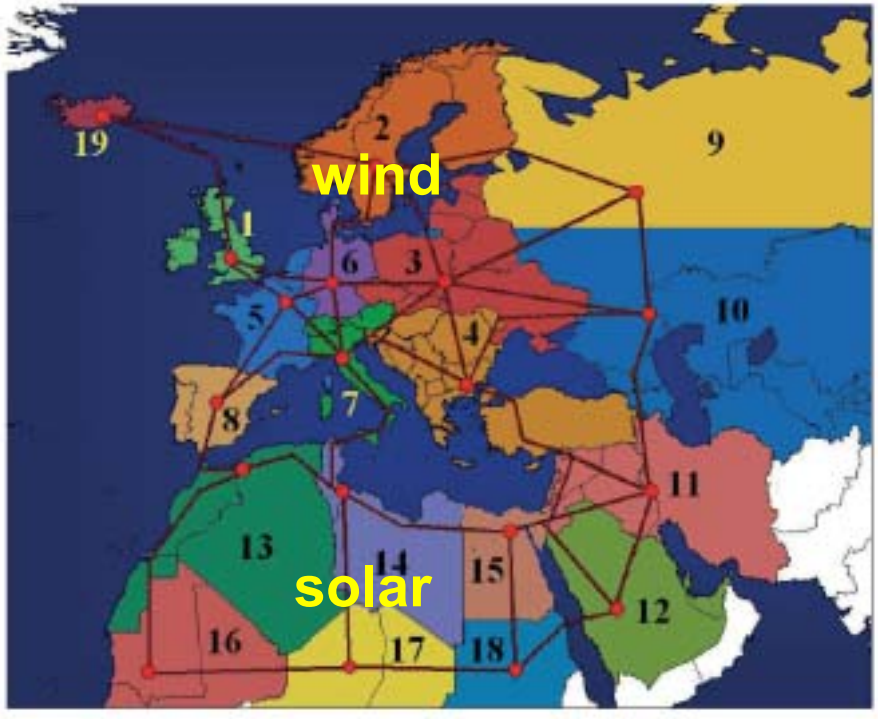
Cross-border transmission of wind power is less a technical issue than a trade and market issue. Making priority slots available would enable cross-border trade in wind power according to internal electricity market principles.

European Offshore Supergrid© will bring multiple benefits

- Ability to **sell wind farm output to more than one country**
- **Aggregation/smoothing of wind farm output**
- Interconnection capacity provides **firm power**
- Trading power between countries
- Better utilisation of grid capacity

Airtricity

Offshore super grid and intercontinental transmission overlay grid



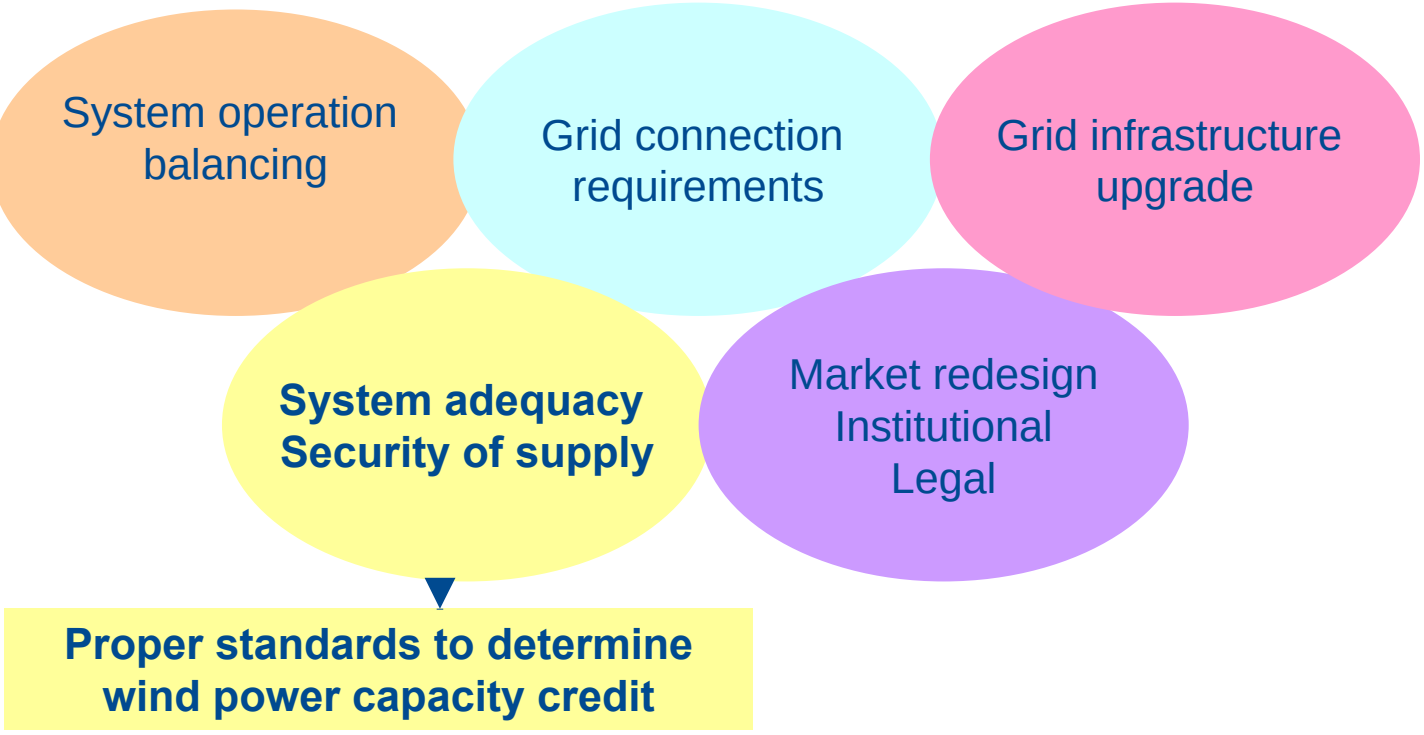
G. Czisch ISET

Airtricity

A European policy for offshore wind energy is needed.

Offshore grids – not new!

Preconditions for reaping maximum benefit of large scale wind integration



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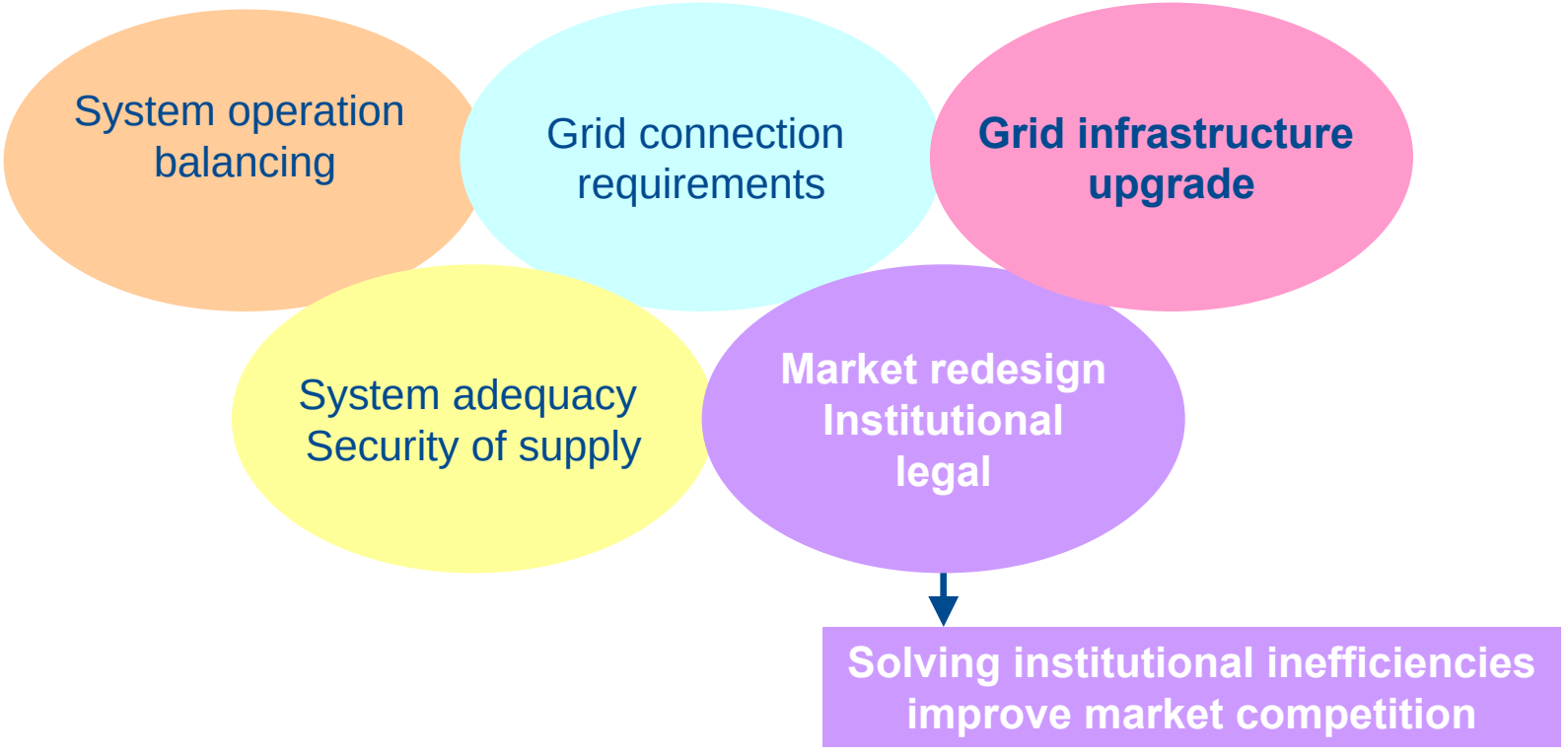


Solving institutional inefficiencies

Reduce market dominance and abuse of dominant positions

Effective **competition policies** in the power sector

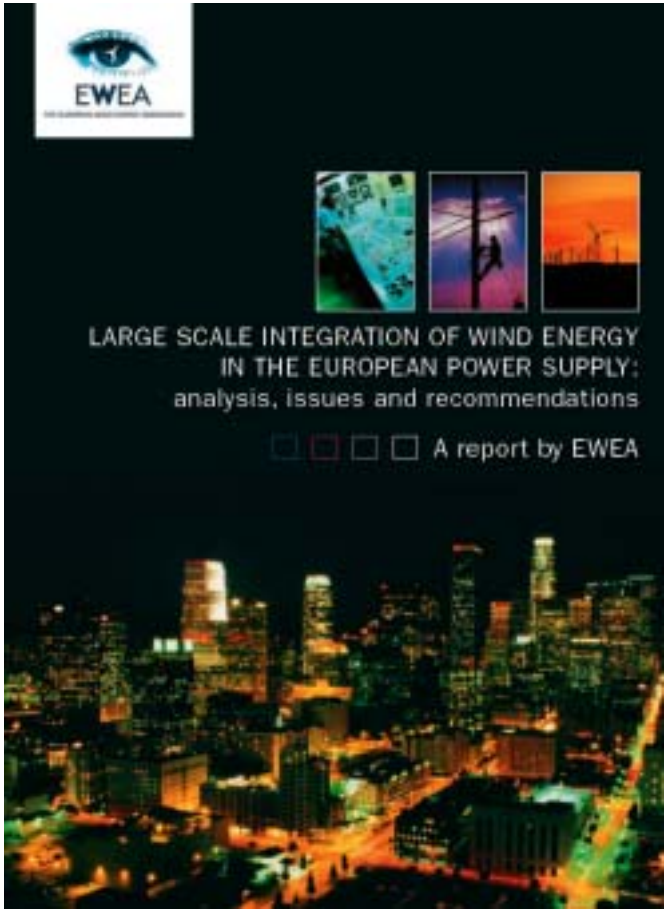
Full legal and ownership **unbundling** between transmission/distribution, production and trading activities

Improve and expand **cross-border interconnections** between Member States

Undistorted third party access to the grids at fair tariffs and removal of discriminatory practices

Adequate grid codes that reflect the nature of the technologies, developed in cooperation with industry and regulators

EWEA GRID REPORT



LARGE SCALE INTEGRATION OF WIND ENERGY IN THE EUROPEAN POWER SUPPLY: analysis, issues and recommendations

A report by EWEA

www.ewea.org

Market Development-Policy Link

Wind Energy:

- **has the technological potential to become a mainstream energy source.**
- **is integral part of the energy supply in many countries today.**
- **has tangible economic, ecological and social benefits.**

BUT: market development depends on a coherent, predictable, supportive political & legal framework.

Thank you

Contact: report@tky.ieej.or.jp