WIND POWER ELECTRICITY

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Agenda

* Introduction and background
* Countries that are producing wind electricity (wind maps, wind corridors, maps of countries using it)
* Costs related to this type of energy and efficiency.
* Offshoring or not?
* Future developments.

* **What is wind power?**
  * Wind power or wind energy is the energy extracted from wind using wind turbines to produce electrical power.
* **Alternative to fossil fuel.**

* **Effects on the environment are generally less problematic than those from other power sources.**

* **FYI: Denmark→ more than a third of its electricity from wind.**

BACKGROUND

* Not relevant before 2008.
* Commitment of EU-27/8 to increase the use of wind power to 20% in 2020.
* In 2008, it accounted for around 4.8% of the EU's total electricity consumption.
* Since 2008, the number of wind farm installations across the EU has increased.
* Important to ensure that such a rapid expansion is sustainable in all respects and is done in accordance with EU environmental legislation, including the Habitats and Birds Directives.

BACKGROUND

* **EU´s policies:**
  * 1997 → adoption of the Commission's White Paper entitled: 'Energy for the future: renewable sources of energy'
  * 2001 → Directive 2001/77/EC on the 'promotion of electricity from renewable energy sources'

  * Directive 2003/30/EC "on the promotion of the use of biofuels or other renewable fuels for transport".

  * January 2008 → 'Climate Change and Energy Package' :
    * Cutting greenhouse gas emissions by at least 20% by 2020 compared to 1990 levels .
    * Increasing the use of renewable energy sources to 20% of Europe's gross final energy consumption by 2020
    * Cutting energy consumption by 20% of projected 2020 levels by improving energy efficiency.
  * April 2009, Directive 2009/28/EC8 on the promotion of the use of energy from renewable sources (the 'RES' Directive)

BACKGROUND

	Share of energy from renewable sources in gross final consumption of energy, **2005**	Target for share of energy from renewable sources in gross final consumption of energy, **2020**
Belgium	2,2 %	13 %
Bulgaria	9,4 %	16 %
The Czech Republic	6,1 %	13 %
Denmark	17,0 %	30 %
Germany	5,8 %	18 %
Estonia	18,0 %	25 %
Ireland	3,1 %	16 %
Greece	6,9 %	18 %
Spain	8,7 %	20 %
France	10,3 %	23 %
Italy	5,2 %	17%
Cyprus	2,9 %	13%
Latvia	32,6 %	40 %
Lithuania	15,0 %	23 %
Luxembourg	0,9 %	11%
Hungary	4,3 %	13 %
Malta	0,0 %	10 %
The Netherlands	2,4 %	14 %
Austria	23,3 %	34 %
Poland	7,2 %	15 %
Portugal	20,5 %	31 %
Romania	17,8 %	24 %
Slovenia	16,0 %	25 %
The Slovak Republic	6,7 %	14 %
Finland	28,5 %	38 %
Sweden	39,8 %	49 %
United Kingdom	1,3 %	15 %

Countries that are producing wind electricity

- In 2012, installed wind power capacity in the European Union totaled 105,000 megawatts, enough to supply 11.4% of the EU's electricity.

- The EU wind industry has had an average annual growth of 15.6% over the last 17 years (1995-2011)

Germany:

- At the beginning of 2014, the installed capacity of wind power was 33,225 megawatts (MW) of which 508MW were offshore.
- More than 21,607 wind turbines are located in the German federal area and the country has plans to build more wind turbines.

Denmark:

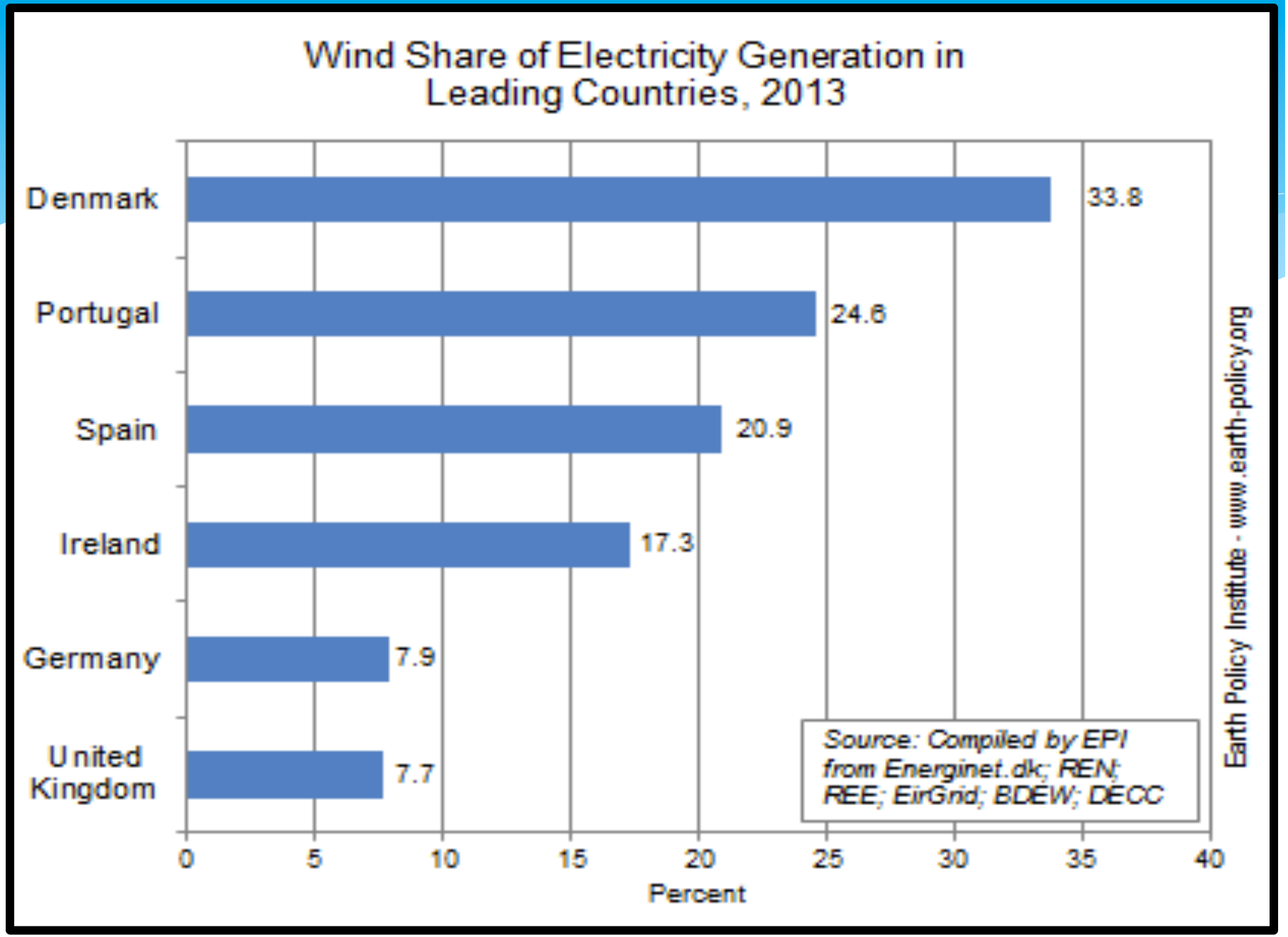
- Wind power in Denmark provides some 20 percent of Danish domestic electricity and Denmark is a leading wind power nation in the world.

Spain:

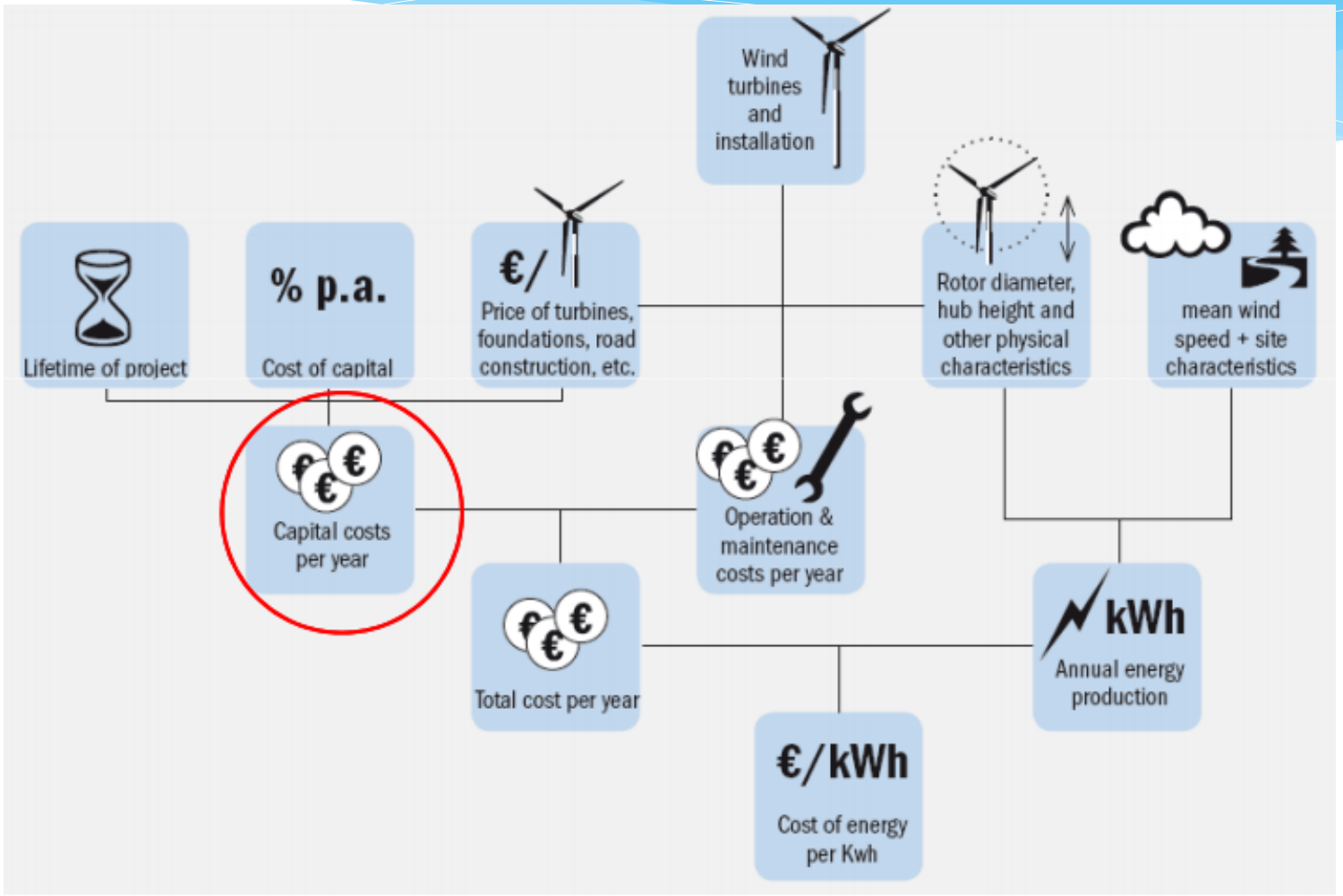
- Leading generator of wind energy in Europe and the second country (after Germany) in installed capacity as of 2011
- 22,785 MW of installed capacity in 2012.
- Wind power alone covered 16.6% of the total electricity demand in Spain in 2010

United Kingdom:

- the installed capacity of **wind power in the United Kingdom** was 8,445 megawatts (MW), with 362 operational wind farms and 4,158 wind turbines in the United Kingdom.
- The United Kingdom is ranked as the world's eighth largest producer of wind power.

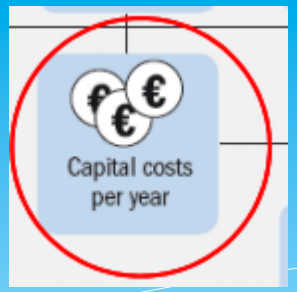

Wind Share of Electricity Generation in Leading Countries, 2013
Denmark
33.8
Portugal
24.6
Spain
20.9
Ireland
17.3
Germany
7.9
United Kingdom
7.7
0
5
10
15
20
25
30
35
40
Percent
Source: Compiled by EPI from Energinet.dk; REN; REE; EirGrid; BDEW; DECC
Earth Policy Institute - www.earth-policy.org

Cost of wind energy



Source: EWEA, 2009

Capital/investment costs



	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**

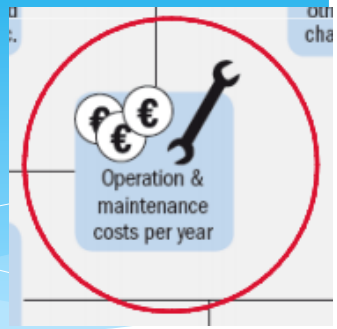
Note: Calculated by the author based on selected data for European wind turbine installations

	SHARE OF TOTAL COST (%)	TYPICAL SHARE OF OTHER COST (%)
Turbine (ex works)	68-84	-
Grid connection	2-10	35-45
Foundation	1-9	20-25
Electric installation	1-9	10-15
Land	1-5	5-10
Financial costs	1-5	5-10
Road construction	1-5	5-10
Consultancy	1-3	5-10

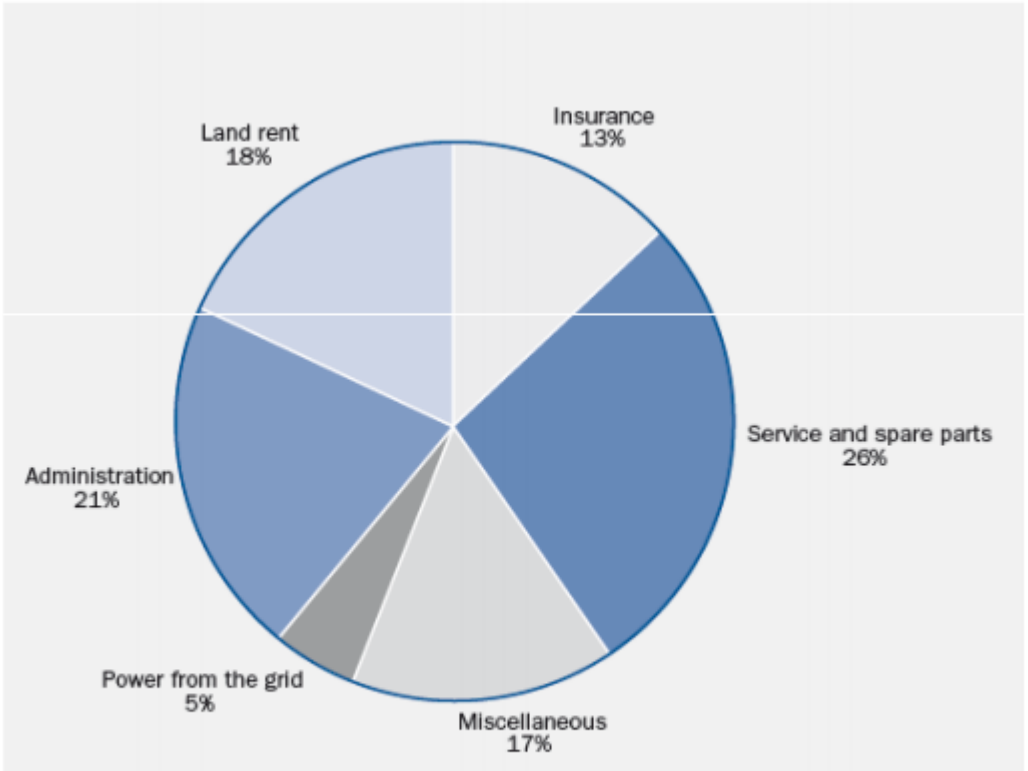
Note: Based on a selection of data from Germany, Denmark, Spain and the UK adjusted and updated by the author

Source: EWEA, 2009

Operation and maintenance costs (O&M)



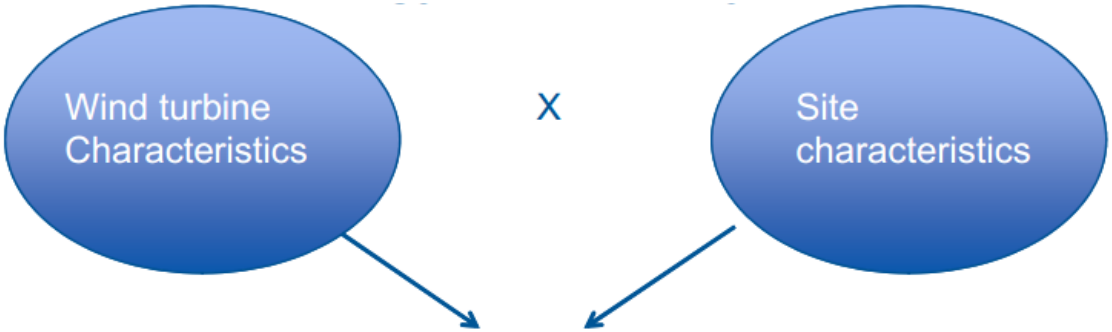
* Variable costs that run throughout the lifetime of the project
* Basic components:
  - Insurance
  - Regular maintenance
  - Repair
  - Spare parts
  - Administration

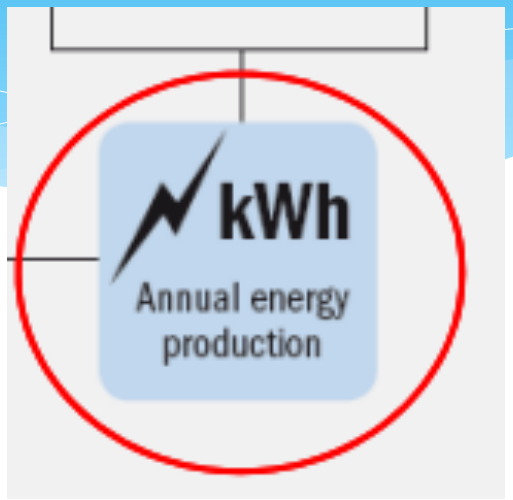


Influencing parameters

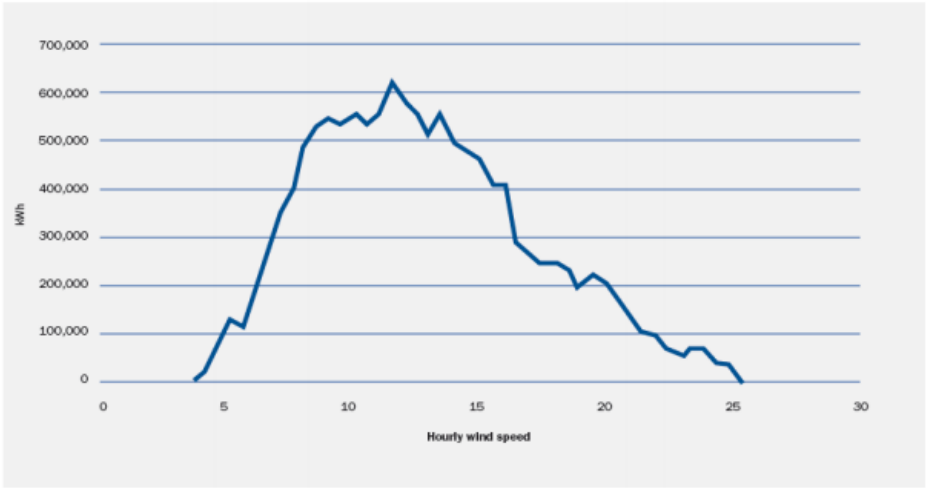
* Economies of scale – technology learning (cost reduction)
* Price of raw materials – status of the economy (cost fluctuation)

Electricity production





Annual Energy Production in kWh

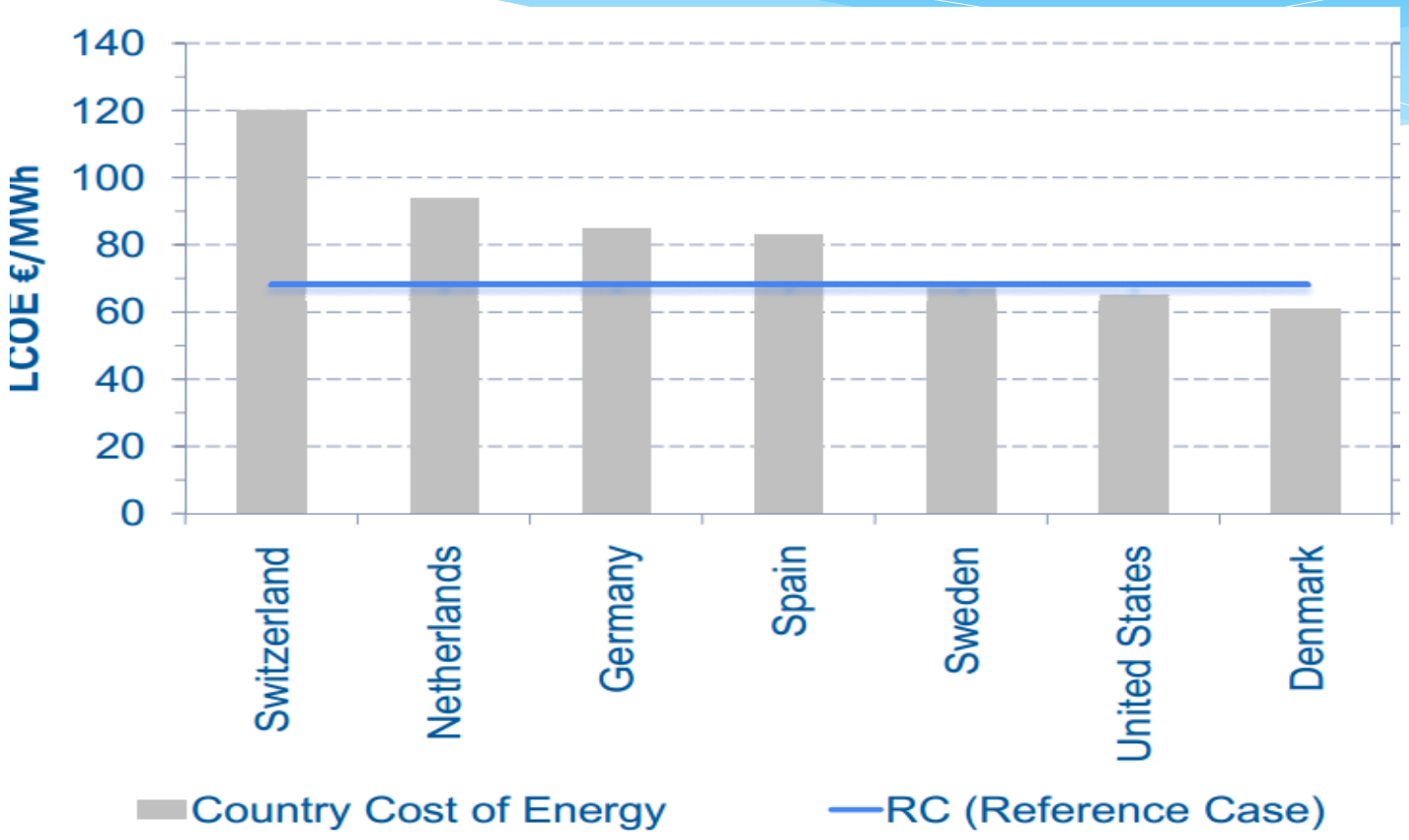


Source: Dewi, 2002

Cost of wind energy in different countries

* Wind Levelised Cost of Energy **(LCOE):** A Comparison of Technical and Financial Input Variables
  - Unit size
  - Full load hours
  - Economic life
  - Investment costs
  - O&M costs
  - Project financing characteristics (taking into account the price of wind energy in each country)

Country Specific LCOE and the Reference Case (€68/MWh)



Reference Case value based on median country parameter value

Offshore Wind Power: An Overview

- Annual investment of 3.4bn-4.6bn Euros
- Europe is world leader in offshore wind power
- Start of 2014 annual average capacity was 6,562MW
- United Kingdom has largest capacity of offshore farms (3,681MW)
- Denmark is second, followed by Belgium and Germany.
- Projections for 2020 incidate that european capacity for wind power would reach 40GW, providing for4% of EU's demand for electricity
- Offshore installations are growing faster than onshore installations

FIGURE 3.3: ANNUAL ONSHORE AND OFFSHORE INSTALLATIONS (MW)

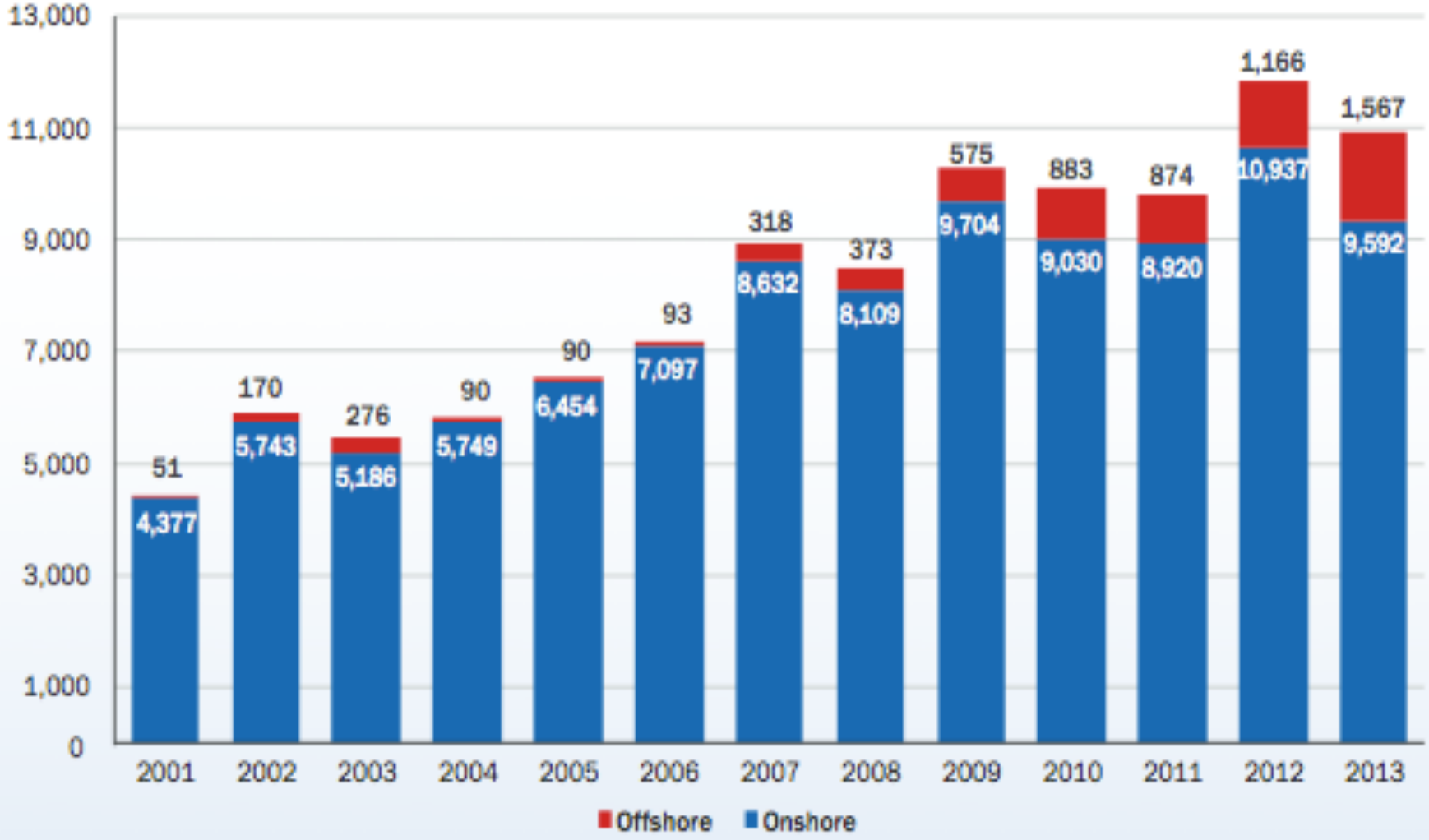


TABLE 1: WIND ENERGY SHARE OF EU ELECTRICITY CONSUMPTION[2]

Total EU electricity consumption	Onshore wind energy production	Offshore wind energy production	Share of EU consumption met by onshore wind	Share of EU consumption met by offshore wind	Share of EU consumption met by wind
3,280 TWh	233 TWh	24 TWh	7.1%	0.7%	7.8%

Benefits

- Help reduce energy imports
- Reduce air pollution/greenhouse gas
- Meet renewable electricity standards
- Create jobs
- **Wind is stronger off the coast**
- **Wind is generally stronger in the afternoon, coinciding with higher energy usage periods**
- **Offshore turbines can also be near highly populated coastlines, reducing need for overland transmission lines**

Negatives

- Offshore wind power is the most expensive energy generating technology used on a large scale
- Under-modeled: difficult to predict performance accurately
- Under-developed: much of the cost lies with maintenance, running costs and diagnostics
- Environmental impacts remain uncertain. Common concerns include risks to seabirds being hit by turbines or habitat loss, underwater noise, physical presence of farms impacting natural behaviors of sea animals

Research and development projects can help to reduce these negative factors

Financing: Who Pays?

- Owing to the expensive nature of offshore wind farms, the European offshore wind energy industry needs to attract between 90bn and 123bn Euros by 2020 to meet deployment targets of 40GW

Main Investor: Power producers

Secondary Investors: Engineering firms, construction companies, turbine manufacturers...

Risk Management: Infrastructure funds, development banks and Export Credit Agencies

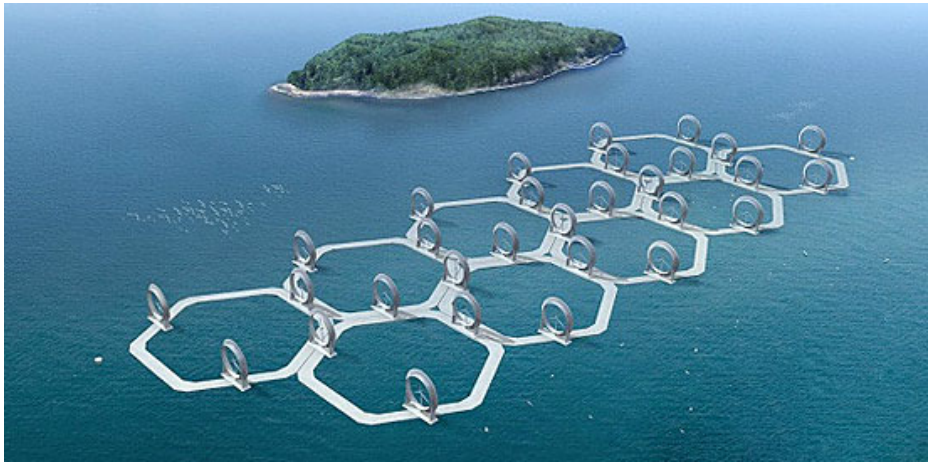
Risk Remains: Regulatory instability

Offshore or No?

YES

IF: Agree to a binding 2030 renewable energy target at the EU level to control risk of regulatory instability for investors

RECOMMEND: Withhold large scale installations until further research and development render offshore wind processing more economically viable.



Future Developments

* 2007: share of wind power in total electricity production 3.7% in Europe
* Denmark: Today, 20% of the city's energy is produced by wind energy
* WIND POWER INDUSTRY OBJECTIVE: provide 20% of final EU electricity consumption by 2020
* How? By moving wind turbines offshore in order to profit from the more favorable wind conditions on the sea.
* This requires research efforts targeting in particular costs reductions of wind turbines, improved reliability and grid integration.

Predictions for 2020 & beyond

* According to the Commission's Renewable Energies Roadmap, 34% of all electricity consumption in 2020 is expected to come from renewable sources and around 12% could be generated by wind power alone.

* This would entail a threefold increase in the current share that wind power has in the EU's electricity consumption (some 4.8% in 2008).

Why is wind power expanding so rapidly?

* Wind power technology has evolved significantly in the past 20 years.
* Turbine size onshore has increased from less than 50 KW in the 1980s to more than 3 MW today.
* Rotor diameter has also increased from an average of 15m to 100m or more.
* Cost of installing wind turbines has dropped over the years, leading to more affordable wind farm developments, making it more attractive to investors

The EWEA (European Wind Energy Association) estimates that 230 gig watts (GW) of wind capacity will be installed in Europe by 2020, consisting of 190 GW onshore and 40 GW offshore.

This would produce 14-17% of the EU's electricity, avoiding 333 million tonnes of CO_2 per year and saving Europe €28 billion a year in avoided fuel costs

Conclusions

* Wind energy (on and offshore) is becoming more preferable not only as a renewable energy technology but also as an investment which will not suffer from unpredictable and volatile costs compared to high volatility of fuel and carbon prices.

* The cost for an investor for generating electricity from wind energy depends on the market that the electricity is traded as well as the region where the wind park is located.

* In order to compare the electricity generating technologies in terms of cost, a fair basis has to be established, where the appropriate risks are taken into account.

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