IEA Wind Task 26
Denmark

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Ea Energy Analyses

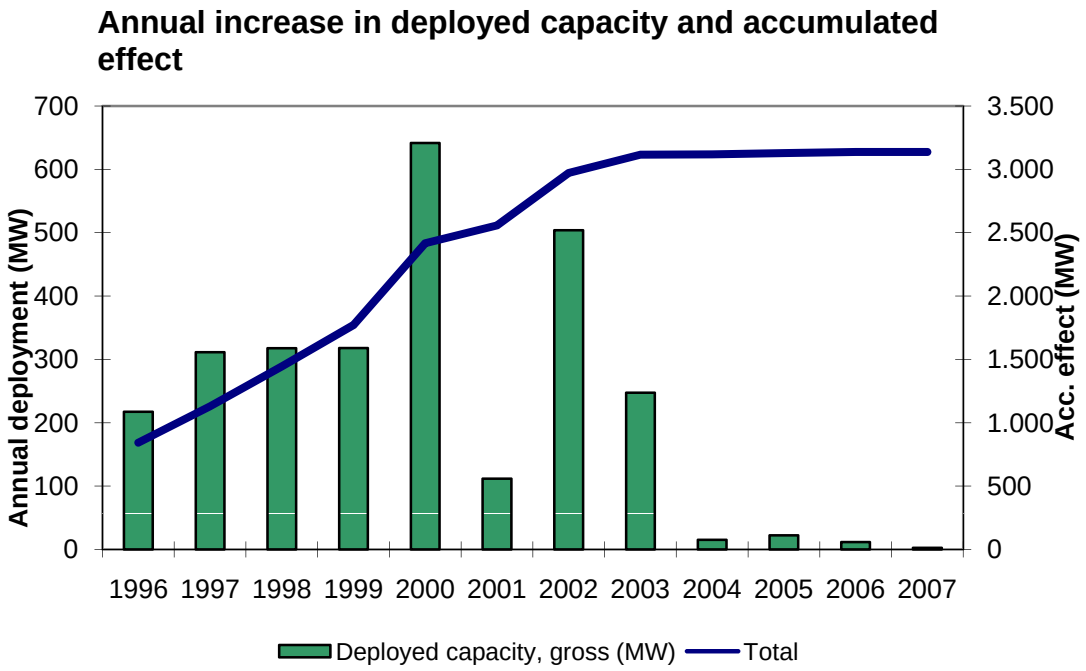
- Danish consulting company providing consulting services and performing research in the field of energy and climate change.
- Analyses of energy systems, energy and climate policy, modeling of power and heat systems in a liberalised market, scenarios for developing sustainable energy systems
- Integration of wind turbines into existing power systems is a core competence of Ea. Recent projects include
  - The economy of wind turbines
  - Integration of wind power in New Brunswick, Canada
  - Nordvind - Coordination of wind power experience in the Nordic countries
  - System costs related to wind power
  - 50 per cent wind power in Denmark in 2025
  - RECaBS - Renewable Energy Costs and Benefits for Society
  - Integration of fluctuating generation using coordinated control of demand and wind turbines - the island of Bornholm as a case

Presentation

1. Status of wind power in Denmark
2. Market and economic issues influencing the cost of wind energy in Denmark
3. Work in process on cost of wind energy
4. Contribution to work packages 1, 2 & 3
5. Learning from participation in task 26

1. Status of wind power in Denmark

- Deployed wind turbine capacity has stagnated in Denmark since 2003
- Only 18 MW of new production capacity added from 2004 to 2007
- Remuneration policy changed in 2002 reducing economic incentives for deployment
- Increased competition from other countries for investments in wind power



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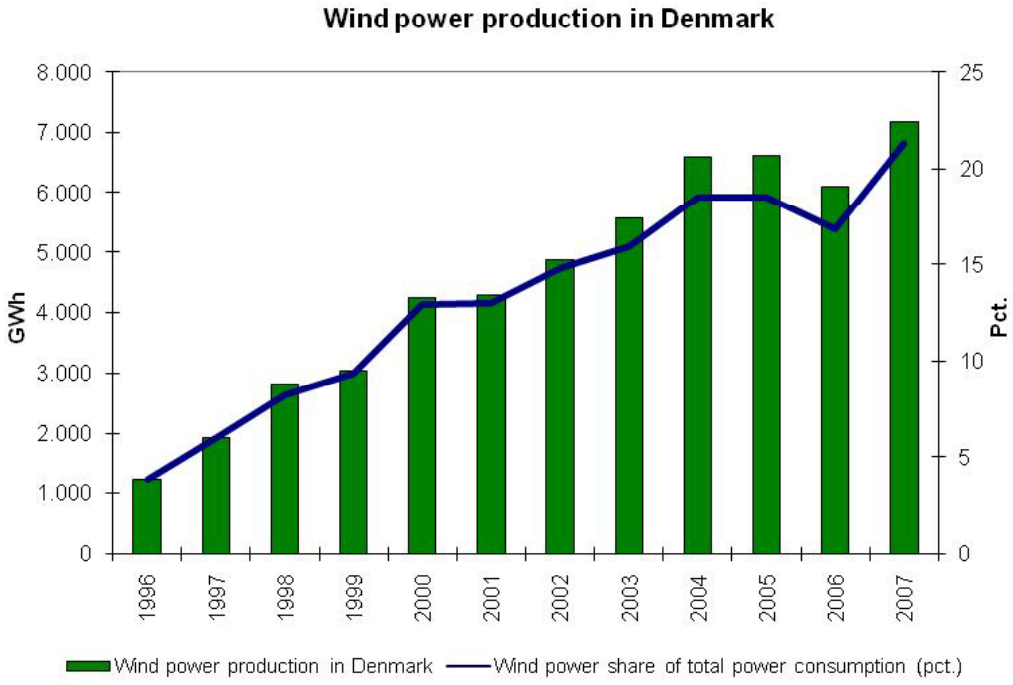
Status of wind power in Denmark cont.

- Growth in share of total power consumption in 2007 predominantly due to windy year in Denmark
- Government targets for RE introduced in 2007. 30 % RE by 2020
- New economic incentives introduced in mid 2008 to promote deployment
- 29 MW installed in 2008 compared to 3 MW in 2007



Status of wind power in Denmark, offshore

8 offshore wind farms totalling 423 MW and producing a total of approximately 1.500 GWh annually

2 wind farms currently under construction

Horns Rev II – 91 × 2.3 MW turbines to be commissioned in 2009. Produce app. 800 GWh annually

Rødsand II – to be commissioned in 2011 to produce app. 800 GWh annually

Wind farm	Year commissioned	Turbine capacity	Total capacity	Estimated annual production
Vindeby	1991	11 × 450 kW	5 MW	Ca. 10 GWh
Tunø Knob	1995	10 × 500 kW	5 MW	Ca. 15 GWh
Middelgrunden	2001	20 × 2 MW	40 MW	Ca. 95 GWh
Horns Rev I	2002	80 × 2 MW	160 MW	Ca. 600 GWh
Samsø	2003	10 × 2.3 MW	23 MW	Ca. 80 GWh
Rønland	2003	4 × 2 MW & 4 × 2.3 MW	17 MW	Ca. 70 GWh
Frederikshavn	2003	2 × 2.3 MW + 1 × 3 MW	8 MW	Ca. 20 GWh
Nysted/Rødsand I	2003	73 × 2.3 MW	165 MW	Ca. 600 GWh

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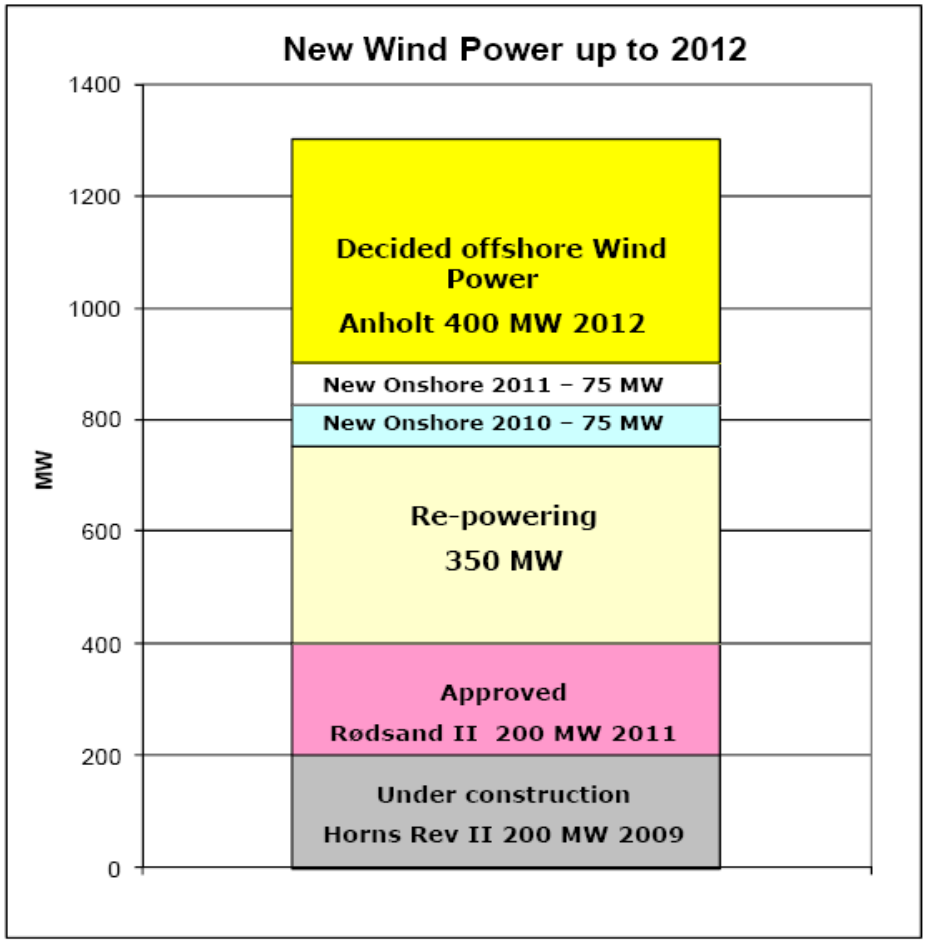
Status of wind power in Denmark, future deployment

1.300 MW of new wind power capacity planned up to 2012 to fulfil government's new RE target

Plans for Horns Rev II and Rødsand II were originally scrapped in 2001. Resurrected again under new RE targets

Re-powering programme – replacement of older, existing turbines with larger, modern turbines – not an increase in total capacity of 350 MW



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2. Market & economic issues influencing wind energy in Denmark

Incentives until 1999

- Capital investment subsidy of 30 %
- Power purchased at 85 % of domestic tariff + government subsidy, total feed-in tariff of app. €0.08/kWh
- Distributors obliged to connect wind turbines to grid
- Power producers obliged to establish certain number of turbines

Feed in tariff reduced to €0.06/kWh in 2000

In 2003 incentive reduced to NordPool market price + €0.015

2. Market & economic issues influencing wind energy in Denmark, onshore.

New economic incentives for wind turbines onshore introduced in 2008

- Market price + €0.03/kWh for first 22.000 full load hours (app. 9 years)
- Scrapping agreement for first 12.000 full load hours
- €o,oo4/kWh compensation for balancing expenses

Green Fund receives small state subsidy per kWh produced by each wind turbine for 1st 22.000 full load hours. Fund provides subsidies to initiatives that promote local acceptance of installation of wind turbines

2. Market & economic issues influencing wind energy in Denmark, onshore cont.

Other issues in new RE law of 2008 that influence cost of wind power

Compensation to neighbours

- Possibility for compensation to neighbours for devaluation of property due to building of wind turbines in vicinity (onshore)
- Compensation determined by assessment committee. No precedence yet.

Local ownership

- Wind power developers must offer minimum 20 % ownership share to local residents.
- 1st priority to those within 4,5km of turbines. 2nd priority to residents of municipality turbines are situated
- Energinet.dk provides loan guarantee for feasibility studies for local residents wishing to erect wind turbines. Local resident = same municipality or max. 4.5km from nearest turbine.

2. Market & economic issues influencing wind energy in Denmark, offshore.

Tender – Cheapest, fastest and most beautiful

Fixed price 10 TWh, max. 20 years from connection to grid

Lowest bid for Horns Rev 2 = app. € cent 7 per kWh

Lowest bid Rødsand II (after re-tendering) app. € cent 8,5 per kWh

Market price + premium = bid price. If market price exceeds bid price, difference has to be refunded by wind farm owner

Network tariff paid by state if required

Open door policy for establishment of offshore wind farms also permitted – follow same incentives and regulation as for onshore turbines

Danish cost project

Background: Existing data for investment and O&M cost is mainly from turbines before 2000 and less than 750 kW.

Goal: Validated data from 250 turbines greater than 600 kW in the years 1995-2007.

During 2008 a questionnaire will be sent to turbine owners about investment operation and maintenance costs.

The costs will cover on-shore and off-shore turbines.

Danish cost project cont.

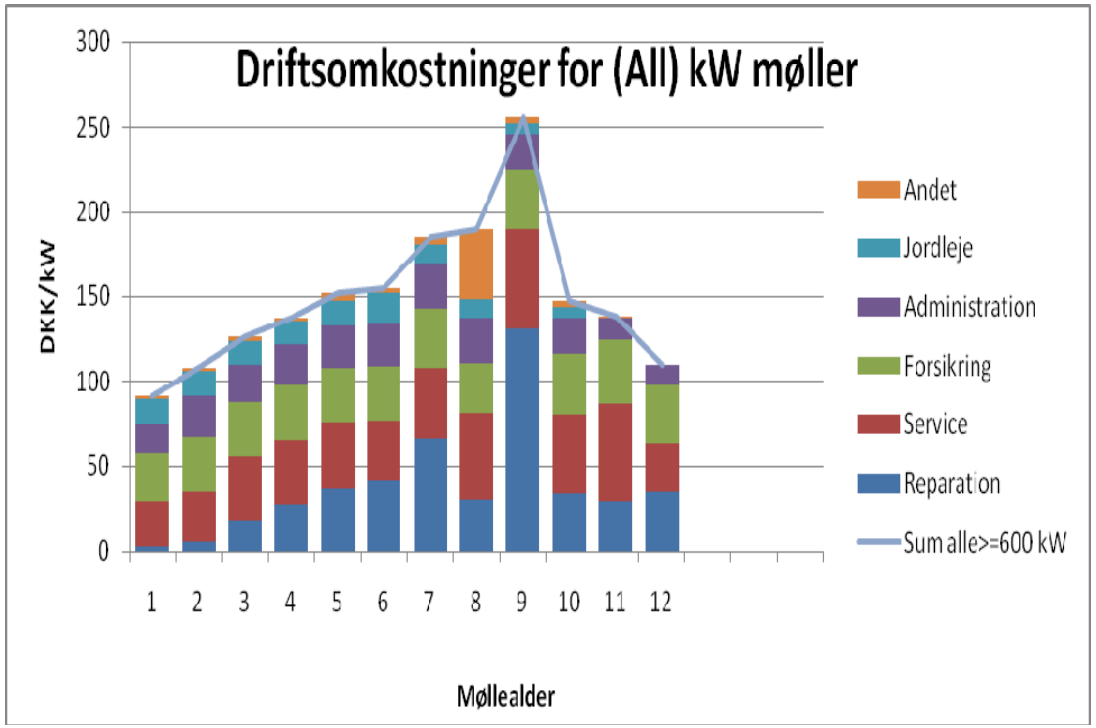
- Investment costs will be divided into turbine, foundation, connection etc.
- The O&M costs include insurance, regular service, repair, spare parts, administration, etc.
- The operation costs are compared to the wind conditions and electricity production
- Special investigations:
  - Development of learning curves and risk premium
  - Calculation of production cost now and in the future.
- Participation in IEA Task 26

4.1 WP 1, Develop transparent methodology for estimating cost of wind energy and identify major cost drivers

Costs of wind power determined by number of factors including administration, insurance, O & M, renting of site, grid tariffs etc in Denmark.

Figure shows annual costs of production for wind turbines larger than 600 kW

Spike in year 9 is for gear change in 600 and 660 kW turbines. For 750 kW gear change is generally required after 7 years



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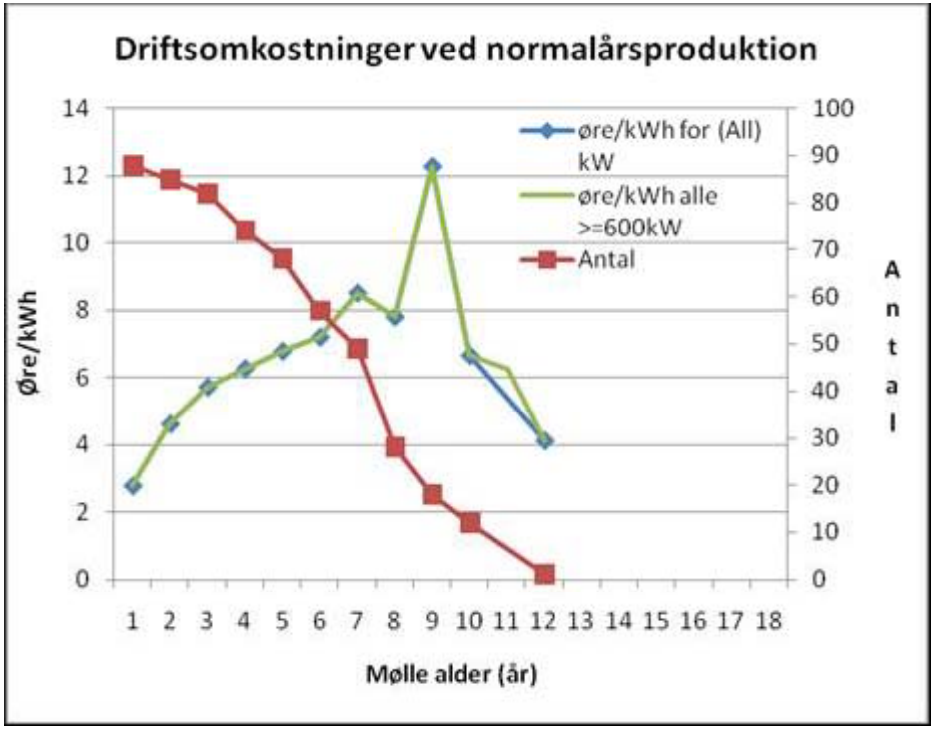
4.1 WP 1, Develop transparent methodology for estimating cost of wind energy and identify major cost drivers

Running costs for a normal production year for wind turbines and age of wind turbines in Denmark

Average price increases over time due to warranty expiring, increased maintenance etc.



4.2 WP 2, Estimate future cost and performance of land-based and offshore wind projects

- The learning curve for cost of wind is difficult due to changes in turbine size and design, demand side, material costs etc.

- O&M, financing costs, life length, wind resource and other site specific conditions affect costs

4.2 WP 2, Estimate future cost and performance of land-based and offshore wind projects cont.

- Danish Wind Industry publishes statistical database on sales, turnover and production
- Reported annual turnover divide with the annual production as index for the turbine prices per unit
- Accumulated production for 1996 to 2007 gives following learning curve

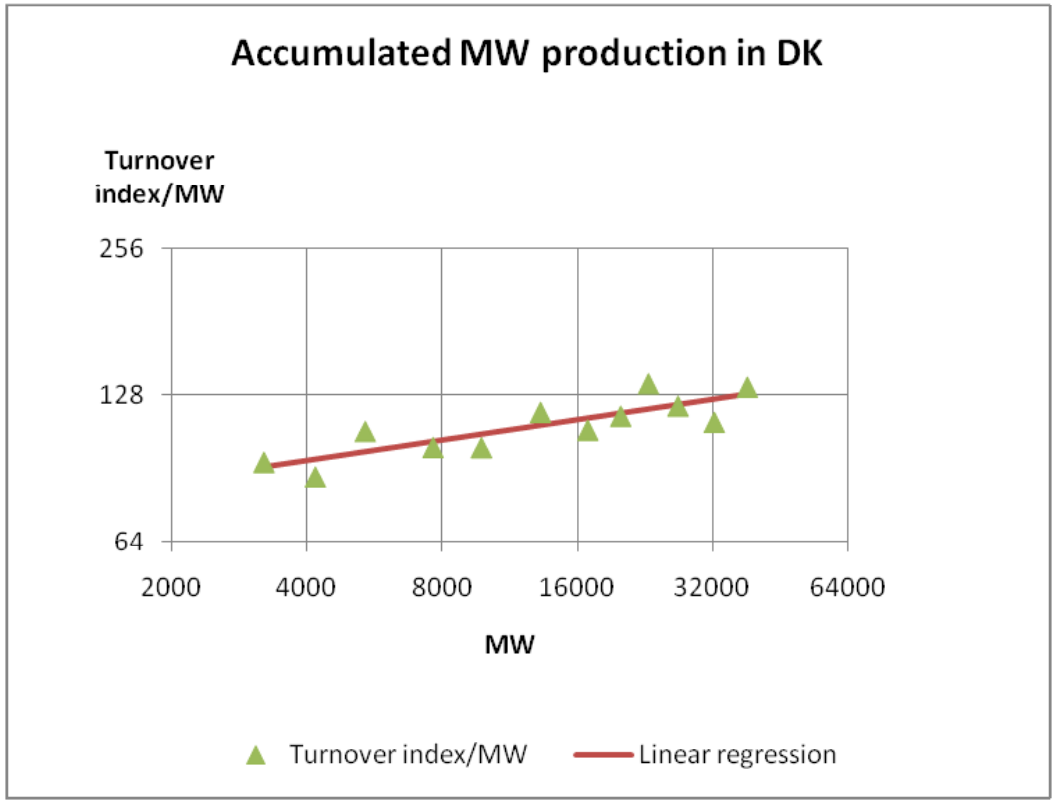
4.2 WP 2, Estimate future cost and performance of land-based and offshore wind projects cont.

The learning curve shows a progression ration of 110 %

The price of turbines increases 10 % every time production doubles

This does not necessarily mean that the price of power produced increases over time

Average size of turbines has increased fourfold in same period

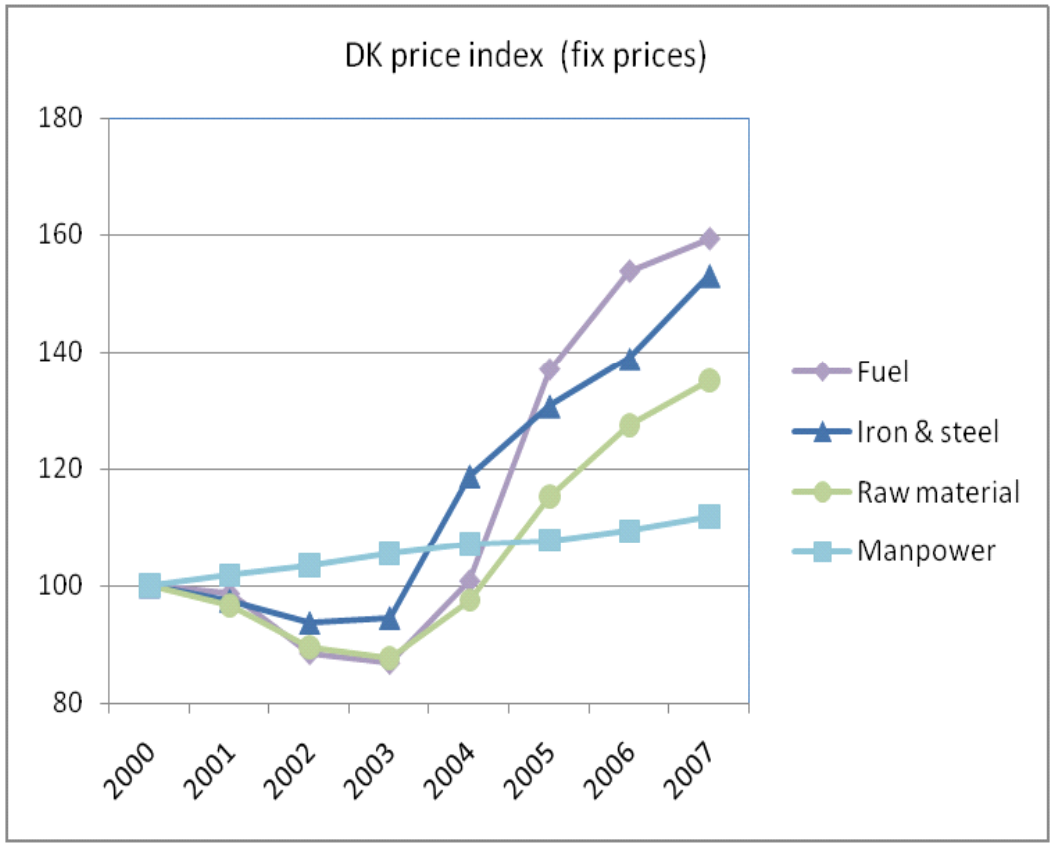


4.2 WP 2, Estimate future cost and performance of land-based and offshore wind projects cont.

Life cycle costs may be lower due to improvements in materials leading to lower maintenance costs, higher production etc.

Other effects such as increases in costs related to raw materials, manpower, lack of production capacity, high subsidies in some countries distorts costs in Denmark, higher quality demands

Cost of wind is sensitive to economic climate and state of the market. Learning curves should be used with caution



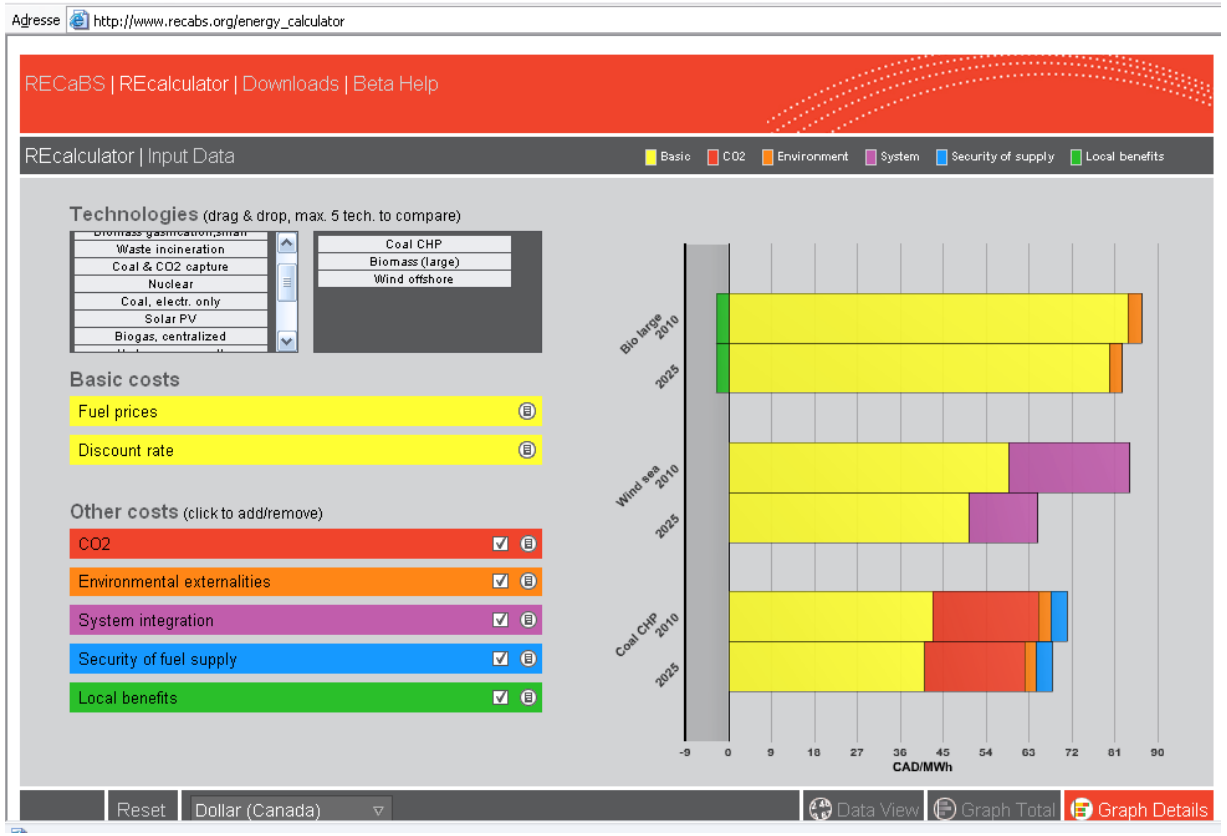
4.3 WP 3, Estimate system level costs and value of wind energy in relation to conventional generation technologies

- Project carried out for IA RETD
- Objectives
  - Provide web-based tools and data regarding the costs and benefits of RET
  - Compare RET with conventional sources of energy
  - Shed light on the externalities related to electricity production
  - Show examples of policies and frameworks that distort the market
- Estimate and compare the costs and benefits of a range of electricity generating technologies for 2010 and 2025
- Web-based interactive energy calculator, REcalculator www.recabs.org

4.3 WP 3, Estimate system level costs and value of wind energy in relation to conventional generation technologies cont.

Web based, interactive tool to compare the costs and benefits of each technology

User determines discount rate and relative cost factors e.g. system integration, security of supply etc.



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5. Learning from participation in Task 26

Determine actual cost of wind power in each participating country based on database from wind projects developed over previous 10 years without subsidy

Provide investors and decision makers with real costs of wind power and allow comparison between countries

Cost of turbines varies greatly from country to country

Provide opportunity to develop more accurate learning curves for each country and increase transparency in international market for wind turbines