Wind Energy The Facts – Integrating wind power in Sweden

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IEE PROGRAMME

WIND ENERGY - THE FACTS PUBLICATION

BENEFITS OF WIND ENERGY
INTELLIGENT ENERGY EUROPE (IEE) PROGRAMME

- Wind Energy – The Facts: IEE financed project (Renewable electricity area) of 2 years (01/11/07 - 31/10/09)

- IEE: EU's funding tool to encourage the use of renewable energy sources and energy saving and move towards a more energy intelligent Europe
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III. The Economics of Wind Power

IV. Industry and Markets

V. Environment

VI. Scenarios and Targets
WIND ENERGY THE FACTS: Authors

- **Volume I**: Paul Gardner, Andrew Garrad, Lars Falbe Hansen, Peter Jamieson, Colin Morgan, Fatma Murray and Andrew Tindal of Garrad Hassan and Partners, UK; José Ignacio Cruz, Luis Arribas of CIEMAT, Spain; Nicholas Fichaux of the European Wind Energy Association (EWEA).


- **Volume III**: Poul Erik Morthorst of Risø National Laboratory, Technical University of Denmark; Hans Auer of the Energy Economics Group, University of Vienna; Andrew Garrad of Garrad Hassan and Partners; Isabel Blanco of UAH, Spain
WIND ENERGY THE FACTS: Authors

- **Part IV**: Angelika Pullen of the Global Wind Energy Council (GWEC), Keith Hays of Emerging Energy Research; Gesine Knolle of EWEA.
- **Part V**: Carmen Lago, Ana Prades, Christian Oltra and Yolanda Lechón of CIEMAT, Spain; Angelika Pullen of GWEC, Hans Auer of the Energy Economics Group, University of Vienna.
- **Part VI**: Arthouros Zervos of the National Technical University of Athens, Greece (www.ntua.gr) and Christian Kjaer of EWEA.
I. TECHNOLOGY: Wind resource estimation 1/2

Wind maps are a good starting point

But at each site wind measurements and topography needs to be taken into account

Onshore wind energy resource, as computed on a broad scale for the European Wind Atlas.
I. TECHNOLOGY: Wind resource estimation 2/2

Computational flow modelling initiated from wind conditions at mast

Input - topography

Have predicted wind conditions at each turbine location

In this example annual mean wind speed varies by 30% over site area

Output normalised wind speed
I. TECHNOLOGY: Wind turbine 1/2

WIND TURBINE – WHAT’S INSIDE?
I. TECHNOLOGY: Wind turbine 2/2

WIND TURBINES

How big will they get?
II. GRID INTEGRATION 1/4

- Wind power fits well in power systems, the need for additional ‘integration efforts’ depend on:
  - Wind power penetration
  - Flexibility of the power system in question:
    - Generation (up and down regulation capability)
    - Demand management and storage
    - Interconnection (available capacity)
    - Power market characteristics (e.g. for balancing services): time, geographical area.

- Flexibility varies widely in EU. Integration efforts (e.g. moving to more flexibility) can be implemented by suitable market design (rules, incentives).
II. GRID INTEGRATION 2/4

THE MAIN CHALLENGES

- Increased power flows as wind power capacity increases
- Distance of wind power from load centres

ISSUES

- European grid is weak on interconnections
- Often weak distribution grids
- Interconnection projects face long lead times (10 years) due to planning obstacles.
- Cost allocation: example approach = Infrastructure planning law in Germany (offshore grids for wind power to be built by TSO’s).
II. GRID INTEGRATION 3/4

The need for interconnexion: spatial smoothing effect

December 2000 wind speeds, 2030 MW amounts

- Netherlands 7000 MW
- BeNeLux+Fra+Ger 111 500 MW
- UCTE 226 000 MW
- UCTE+GB+Nordel 268 300 MW
II. GRID INTEGRATION 4/4

- Large amounts of wind power (2020, 2030 scenarios) will increase congestions in interconnectors
- Strong adequate interconnectors will allow for a 27 GW firm generating capacity for 2020 (200 GW scenario).
III. ECONOMICS OF WIND: Costs 1/2

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

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

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

Source: EWEA 2009 report "The Economics of Wind Energy"
Production costs are decreasing

- Trend towards larger turbines
- Trend towards improved cost-effectiveness
- 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 energy reduces power price - merit - order effect

- Impact of wind power depends on time of the day
- High demand and high wind impact the spot power price significantly
- 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"
IV. INDUSTRY AND MARKETS: Support schemes for RES-E 1/2

- National support schemes
  - Each Member State can choose its own support scheme
  - Strong tendency towards:
    - Feed-in tariffs
    - Quota obligations with tradable green certificates
IV. INDUSTRY AND MARKETS: Support schemes for RES-E 2/2

1. Feed-in tariffs (FIT)
   • Renewable electricity can be fed into the grid at a guaranteed tariff for a determined period of time

2. Quota obligation with tradable green certificates (TGC)
   • Additional revenue above market price from selling TGCs

3. Tender procedures
   • In a bidding round projects with the lowest generation costs can obtain financial support

4. Incentives
   • Tax incentives or investment grants
The EU wind energy sector directly employed approximately 108,600 people in 2007.

Including indirect jobs, the sector employed 154,000 people.

Direct employment has increased by 60,237 (125%) since 2002.

On average, the wind energy sector in Europe has created 33 new jobs every day, seven days a week over the past five years.

Wind turbine and component manufacturers are responsible for the 59% of direct wind energy employment.
IV. INDUSTRY AND MARKETS: Employment 2/2

Employment breakdown across sectors

- Component manufacturers: 22%
- Manufacturers: 37%
- IPP/Utility: 9%
- Developers: 16%
- Installation/Repair/Operations & maintenance: 11%
- Consultancy/Engineering: 3%
- R&D/University: 1%
- Financial/Insurance: 0.3%
- Others: 1%
V. ENVIRONMENT

- Global environmental benefits
  - Wind energy is a clean energy source

- Local environmental impacts
  - Are site-specific, vary among the different species and should be put in context
  - Can be avoided/minimised: the role of environmental assessments, mitigation and compensation measures

- Conclusions and recommendations
  - Achieving the 20% RES target while respecting biodiversity
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IEE PROGRAMME

WIND ENERGY - THE FACTS PUBLICATION

BENEFITS OF WIND ENERGY
EU IS IMPORTING 54% OF ITS ENERGY...

<table>
<thead>
<tr>
<th></th>
<th>EU share of proven global reserves</th>
<th>Years of domestic production</th>
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<tbody>
<tr>
<td>Oil</td>
<td>0.5% - 0.8%</td>
<td>7.7 - 7.8 years</td>
</tr>
<tr>
<td>Gas</td>
<td>1.4% - 2%</td>
<td>14.4 - 14.8 years</td>
</tr>
<tr>
<td>Coal</td>
<td>3.5%</td>
<td>50 years</td>
</tr>
<tr>
<td>Uranium</td>
<td>1.9%</td>
<td></td>
</tr>
</tbody>
</table>

Source: European Commission 2008
WIND LEADS THE EU POWER SECTOR

NEW POWER CAPACITY INSTALLED IN 2008
Total installed: 23,851 MW

Note: Preliminary figures for solar photovoltaic installations
Source: EWEA, EPIA and Platts PowerVision
NEW CAPACITY INSTALLED BY ENERGY SOURCE IN EU (2000-2008)

Source: Platts PowerVision 2008
EU TOP 5 WIND ENERGY CAPACITY

European Union: 64,935 MW
Candidate Countries: 452 MW
EFTA: 442 MW
Total Europe: 65,933 MW

Source: EWEA Wind Map 2008
WIND ENERGY IN EU-27 - 2008 FACTS (I)

△ 65 GW installed capacity, incl. 1.47 GW offshore
△ Annual installations of 8.5 GW, incl. 0.35 GW offshore
△ Electricity production of 142 TWh
△ Meeting 4.2% of total EU electricity demand
△ Providing power equivalent to the needs of 35 million average EU households
Avoiding 108 Mt of CO2 – equivalent to taking more than 50 million cars off the road (20% of the EU car fleet) and equal to 31% of the EU-15’s Kyoto obligation

Annual avoided fuel cost of €5.4 billion

Annual avoided CO2 costs of approximately €2.4 billion

Annual investments in wind turbines of €11 billion
ONSHORE MARKETS ARE DEVELOPING AT THREE SPEEDS

Source: Emerging Energy Research
WIND ENERGY EXPANSION

Rising energy demand and contribution from wind power

**1980s-1990s**
Two decades to install 0.9% of EU electricity demand

Demand: 2,577 TWh

**2008**
Accelerating pace: reaching 4.2% end 2008

Demand: 3,380 TWh

**2020**
11.6%-14.3% despite growing demand

Demand: 4,107 TWh

**2030**
Meeting between 20.8% & 28.2% of the EU need

Demand: 4,503 TWh

Source: EWEA
How to reach the 20% target

From 15.2% to app. 35%

RES-E 2005 Eurostat 2020 Target

RES-H 2005 Eurostat 2020 Target

RES for transport

2005 Eurostat 2020 Target

How much RES-E?
How much Wind Power?


Wind power 34.8%

2020 RES-E

Biomass 18.1%

Hydro 28%

Photovoltaic 13.1%

Geothermal 2.3%

Solar thermal 3.1%

Ocean 0.4%

12 – 14% electricity demand.
CUMULATIVE WIND ENERGY INSTALLATIONS

Source: EWEA
EUROPEAN WIND ENERGY EVENTS

Come to this year’s offshore wind event in Stockholm (14 - 16 September 2009)
  - Over 80% of the exhibition space has already been sold.
    - 2000 participants expected
    - More information: www.eow2009.info

EWEAs annual event will take place in Warsaw, Poland (20 – 23 April 2010).
  - More information: www.ewec2010.info
Thank you very much for your attention