Clean Coal – Importance for prosperity and growth

Energy Realism - Climate Pragmatism

Working Breakfast, 15th November 2012

Dr. George Milojcic
The external energy bill EU 27

<table>
<thead>
<tr>
<th>Year</th>
<th>Hard coal</th>
<th>Oil</th>
<th>Gas</th>
<th>GDP 1.000 bn €</th>
<th>Share on GDP in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>153</td>
<td>33.5</td>
<td>7.9</td>
<td>10.3</td>
<td>1.5</td>
</tr>
<tr>
<td>2002</td>
<td>139</td>
<td>31.1</td>
<td>6.6</td>
<td>10.4</td>
<td>1.3</td>
</tr>
<tr>
<td>2003</td>
<td>149</td>
<td>35.4</td>
<td>6.3</td>
<td>10.6</td>
<td>1.4</td>
</tr>
<tr>
<td>2004</td>
<td>170</td>
<td>35.2</td>
<td>9.5</td>
<td>10.9</td>
<td>1.6</td>
</tr>
<tr>
<td>2005</td>
<td>245</td>
<td>52.2</td>
<td>11.3</td>
<td>11.1</td>
<td>2.2</td>
</tr>
<tr>
<td>2006</td>
<td>272</td>
<td>72.8</td>
<td>11.8</td>
<td>11.4</td>
<td>2.7</td>
</tr>
<tr>
<td>2007</td>
<td>299</td>
<td>67.1</td>
<td>13.1</td>
<td>11.8</td>
<td>2.5</td>
</tr>
<tr>
<td>2008</td>
<td>410</td>
<td>93.0</td>
<td>21.7</td>
<td>11.9</td>
<td>3.5</td>
</tr>
<tr>
<td>2009</td>
<td>262</td>
<td>75.8</td>
<td>12.5</td>
<td>11.3</td>
<td>2.3</td>
</tr>
<tr>
<td>2010</td>
<td>324</td>
<td>72.8</td>
<td>17.3</td>
<td>11.6</td>
<td>3.6</td>
</tr>
<tr>
<td>2011</td>
<td>428</td>
<td>90.5</td>
<td>23.8</td>
<td>11.8</td>
<td>4.1</td>
</tr>
<tr>
<td>2012</td>
<td>478</td>
<td>102.3</td>
<td>36.0</td>
<td>11.8</td>
<td>4.1</td>
</tr>
</tbody>
</table>

Source: Statistik der Kohlenwirtschaft
The prices for imported oil and gas have risen 10-fold on average since 1970.

Price increase of oil from 200 to 400 €/tce is like a 100 €/t CO₂ price.

Cross-border prices, annual average, 2011

- Raw imported oil €400/tce
- Imported natural gas €230/tce
- Imported steam coal €107/tce

Source: Statistik der Kohlenwirtschaft

Data: partially provisional (position: 03/2012)
Power generation structure EU 27 by comparison 2002 - 2010

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>2002</th>
<th>2010</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>828</td>
<td>1.617</td>
<td>≙ 48 %</td>
</tr>
<tr>
<td>Gas</td>
<td>789</td>
<td>789</td>
<td>0%</td>
</tr>
<tr>
<td>Nuclear</td>
<td>990,2</td>
<td>916,6</td>
<td>-7%</td>
</tr>
<tr>
<td>Hydro</td>
<td>347,3</td>
<td>397,7</td>
<td>+14 %</td>
</tr>
<tr>
<td>Wind/Solar/Biomass/Waste</td>
<td>295,5</td>
<td>78,5</td>
<td>-73 %</td>
</tr>
</tbody>
</table>

Power generation

2002 3.132 + 7 %
2010 3.358

Source: Statistik der Kohlenwirtschaft
EU 27 power plant capacity and balance 2000 - 2011

<table>
<thead>
<tr>
<th>Capacity EU 27</th>
<th>2011 in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>26</td>
</tr>
<tr>
<td>Hydro</td>
<td>15</td>
</tr>
<tr>
<td>Nuclear</td>
<td>14</td>
</tr>
<tr>
<td>Gas</td>
<td>23</td>
</tr>
<tr>
<td>Oil</td>
<td>6</td>
</tr>
<tr>
<td>Wind</td>
<td>10</td>
</tr>
<tr>
<td>Others Photovoltaic</td>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Balance (MW) from 2000 to 2011</th>
<th>Changes in 2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas</td>
<td>116000</td>
</tr>
<tr>
<td>Wind</td>
<td>84000</td>
</tr>
<tr>
<td>Hydro</td>
<td>4300</td>
</tr>
<tr>
<td>Others</td>
<td>6500</td>
</tr>
<tr>
<td>Photovoltaic</td>
<td>47000</td>
</tr>
<tr>
<td>Nuclear</td>
<td>-14000</td>
</tr>
<tr>
<td>Coal</td>
<td>-10000</td>
</tr>
<tr>
<td>Oil</td>
<td>-14000</td>
</tr>
</tbody>
</table>

* In 2147 MW – Out 841 MW

Source: EWEA, Wind in power 2011
Compensation package for „green power“

2000 bis 2011

RES power 2000
≈ 6.6 %

RES power 2011
≈ 20 %

Source: BDEW (2010)/RWI-Position #45; BMU, Juli 2012, Erneuerbare Energien in Zahlen
Net power generation at 17.10.2012

Comment: The eex issued the net generation previous day depending on energy source of basis voluntary information. This presentation includes data for facilities < 100 MW and not for facilities > 100 MW. This data couldn’t directly compared with the sum of obligatory announcements, who will shown as an added constant line. However shows the slide quite demonstrative the proportion and the role of wind and photovoltaic.

Quelle: eex, entsoe
High gas prices are high risk for generators and customers.
Rising coal prices have less effect.
EU ETS is an additional risk to fuel and power prices.

Source: DEBRIV
Fuel cost for coal and gas power generation

German prices

Efficiency coal-fired power plant \( \eta = 38\% \); gas-fired power plant \( \eta = 49\% \)

\( \text{€/MWh}_{\text{power}} \)

\[
\begin{array}{c|c|c|c}
\text{Year} & \text{Hard Coal} & \text{Gas at the Power Plant} & \text{Difference} \\
\hline
1990 & 25.32 & 15.84 & \text{SPREAD 37.09 €/MWh} \\
& & & (\text{OR 57.6 €/CO}_2) \\
\end{array}
\]

* Merit 1. half-year 2012
** gas preliminary, partial estimated

HIGHER CO\(_2\) PRICE

( OR HIGHER COAL PRICE ! )
Cases – High and low price differential

Coal price [€/tce]:
- 97
- 97
- 97

Gas price [€/tce]:
- 273
- 125
- 150

CO₂ price [€/t CO₂]:
- 57,6
- 0
- 10

Fuel costs per MWh
- 2012
- Coal:
  - Price [€/tce]:
    - 97
  - CO₂ price [€/t CO₂]:
    - 57,6
- Gas:
  - Price [€/tce]:
    - 273
  - CO₂ price [€/t CO₂]:
    - 0

CO₂ costs per MWh
- 2012
- Coal:
  - Price [€/tce]:
    - 97
  - CO₂ price [€/t CO₂]:
    - 0
- Gas:
  - Price [€/tce]:
    - 273
  - CO₂ price [€/t CO₂]:
    - 10

Fuel + CO₂ costs per MWh
- 2012
- Coal:
  - Price [€/tce]:
    - 97
  - CO₂ price [€/t CO₂]:
    - 0
- Gas:
  - Price [€/tce]:
    - 273
  - CO₂ price [€/t CO₂]:
    - 10

Euracoal
Coal – clean, efficient and flexible

A three phase modernisation strategy

I. Reducing emissions, increasing efficiency and flexibility in ecologically and economically optimized steps
   - Modernization of existing plants: SO$_2$, NO$_x$, dust, retrofit
   - Construction of new state of the art power plants

II. Development of high-efficiency power stations with the aim to minimize consumption of resources and reduce specific emissions, particularly those of CO$_2$

III. New Technologies for CO$_2$ capture and storage

Clean Coal is a flexible concept which can be implemented by all countries depending on their specific situation.
Energy flow is cash flow

€ 7.0 billion turnover for a 1,000 MW power plant over 20 years operating 7,000 hours/year at a base-load-price of € 50 /MWh

Coal power plant
- plant costs: 2/3 share of turnover
- fuel costs: 1/3 share of turnover
- 70 up to 100 % domestic added value

Gas power plant
- plant costs: 25 % share of turnover
- fuel costs: 75 % share of turnover
- up to 100 % imported

Power generated from coal promotes growth in the EU
### Different Fuels for Power Generation - different questions, answers and views

<table>
<thead>
<tr>
<th></th>
<th>Coal</th>
<th>Oil</th>
<th>Gas</th>
<th>Nuclear</th>
<th>Renewables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Security of supply</td>
<td>++++</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Price risk / competitiveness</td>
<td>++++</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Transport / waste risk</td>
<td>++++</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>CO₂ emissions</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumer acceptance</td>
<td>++</td>
<td></td>
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</tr>
<tr>
<td>Importance for the power sector</td>
<td>++++</td>
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</tbody>
</table>
To the competition between coal and gas power plants

- Assumption: Fuel and CO₂ cost determine on the utilisation of a power plant (marginal cost consideration) GC = generation cost

\[ GC_{\text{power}} = FC + E \times P_{CO2} \]

- \(E = \text{CO}_2\) demand \([\frac{t}{MW\text{h}_{\text{power}}}]\); \(FC = \text{fuel cost} [\frac{\€}{MW\text{h}_B}]\); \(P_{CO2} = \text{CO}_2\) price \([\frac{\€}{t \text{CO}_2}]\)

- Case example:

  \[
  \begin{align*}
  \text{constant:} & \quad \text{coal:} \quad \eta = 38 \% \\
  & \quad \text{gas:} \quad \eta = 49 \%
  \\
  \text{variable:} & \quad FC_C; \; FC_G; \; P_{CO2}
  \\
  \text{I:} & \quad GC_C = FC_C + E_C \times P_{CO2} \quad \rightarrow \quad GC_C = GC_G \\
  \text{II:} & \quad GC_G = FC_G + E_G \times P_{CO2} \quad \rightarrow \quad P_{CO2} = \frac{FC_G - FC_C}{E_C - E_G}
  \end{align*}
  \]
Differencial fuel costs gas – coal and thereof inferred CO$_2$ price

Efficiency coal-fired power plant $\eta = 38\%$; gas-fired power plant $\eta = 49\%$

* Merit 1. half-year 2012
** gas preliminary, partial estimated