100% Renewable energy in Belgium: a new paradigm on energy thinking

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Presentation content

» Purpose of the project (and limits)
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Purpose of the project (and limits)

The study defines different trajectories that can lead to an energy system exclusively based on renewable energy sources.

- How to achieve a 100% renewable target in 2050 (electricity, heating and cooling, transport except aviation and see transport)?
- What technologies are chosen?
- What are the costs of these solutions? What opportunities for society, job creation?
- What are the main obstacles?

The study remains a first approach that needs to be completed.

The study is not completely finalised.

Energy is more than electricity!
(as we all know - but sometimes forget)

Energy balance Belgium; Final energy consumption (PJ, IEA, 2009)
Another bronze medal for Belgium!

Top 10 Countries for Solar Installed Capacity 2011 vs 2010

<table>
<thead>
<tr>
<th>Country</th>
<th>2011</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>24626</td>
<td>17316</td>
</tr>
<tr>
<td>Italy</td>
<td>12777</td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>10419</td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td>4388</td>
<td></td>
</tr>
<tr>
<td>Spain</td>
<td>4267</td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>3091</td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>2655</td>
<td></td>
</tr>
<tr>
<td>Belgium</td>
<td>2012</td>
<td></td>
</tr>
<tr>
<td>Czech Republic</td>
<td>1958</td>
<td></td>
</tr>
<tr>
<td>Australia</td>
<td>1339</td>
<td></td>
</tr>
<tr>
<td>Korea, South</td>
<td>961</td>
<td></td>
</tr>
</tbody>
</table>

Bronze I More than 10% of installed capacity, close to Italy (silver) and somewhat lower than Germany (gold, >15%)

Availability of wind/solar - March 1 – 5 2010

Half hourly observations from 1 to 5 March
And than we started thinking....
What can be done?

1. Improve integration in European network

2. Increase adjustable production (biomass)... availability of fuel?

3. Smart grids - shifting demand
   » Short term
   » Long term: new paradigms in use of capacities (for example in industry)

4. New paradigms in having excess capacity wind and sun (overproduction could be economic if cost of storage/shifting demand exceeds cost of excess capacity)

TIMES Be improvements

1. Cope with uncertainty of supply/demand
   1. Extending the temporal resolution to 78 periods in one year = 26 x 3
   2. Reserve capacity requirement (sum of nominal power of biomass plants, geothermal and storage facilities)
   3. Constraint to assure that BE can be self sustained for 14 consecutive days without counting on wind and solar.

2. Include residential smart grids (day-night shift)

3. Day-night and seasonal electricity storage options

4. Alternative solutions to increase system’s flexibility
   1. Overproduction - grid disconnection
   2. Endogenous steel production timing (not just in time)

5. Simple endogenous transmission- and distribution network (costs)
Renewable potential

» Wind onshore capacity
  » 9 GW_e based on regional studies (can be higher with a mitigation of some constraints (co-visibility, forest exclusion, ...)

» Wind offshore capacity
  » 8 GW_e on Belgian continental shelf derived from the OPTIEP-BCP study (offshore potential can be higher taking into account imports from far North Sea)

» Solar: available built surfaces (heat and PV)
  » \(1.20 \times 10^7\) m\(^2\) in Wallonia
  » \(1.74 \times 10^7\) m\(^2\) in Brussels
  » \(11.25 \times 10^7\) m\(^2\) in Flanders

» Hydro: Capacity (storage excluded)
  » 120 Mwe

» Geothermal: 4 GW_e

Biomass potential

<table>
<thead>
<tr>
<th>Estimated biomass potential (EJ/yr)</th>
<th>WR* - 2020</th>
<th>BE** - 2030</th>
<th>EU25**-2030</th>
<th>EU27*** - 2050</th>
<th>Western/central Europe - 2050</th>
<th>World**** - 2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Crops</td>
<td>0.003</td>
<td>0.004</td>
<td>5.961</td>
<td>15.4-19.9</td>
<td>3-11</td>
<td>44-133</td>
</tr>
<tr>
<td>Forestry and Forestry residues</td>
<td>0.023</td>
<td>0.008</td>
<td>2.311</td>
<td>1.7-2.2</td>
<td>5-9</td>
<td>19-35</td>
</tr>
<tr>
<td>Agricultural residues and organic waste</td>
<td>0.020</td>
<td>0.096</td>
<td>4.010</td>
<td>0.7</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>TOTAL</td>
<td>0.046</td>
<td>0.109</td>
<td>12.282</td>
<td>15.8-22.8</td>
<td>15-21</td>
<td>160-270</td>
</tr>
</tbody>
</table>

* Valbiom (2010)  Appui Technique à la rédaction du plan d'action wallon energies renouvelables - volet biomasse
** EEA (2007) How much bioenergy can Europe produce without harming the environment?
*** BEE (2010) Biomass potential Europe

Sustainable biomass potential at European and World level

• Every human being should be able to consume the same biomass amount?
  ⇒ At Belgian level: 109 PJ (13 \(10^6\) inhabitants in 2050) = Belgian potential
  ⇒ At European level: 445 PJ – 571 PJ (524 \(10^6\) inhabitants in 2050)
  ⇒ At World level: 226 PJ – 381 PJ (9300 \(10^6\) inhabitants in 2050)

• World level seems to be a fair compromise.
  ⇒ Belgium: maximum primary biomass energy consumption equals 300 PJ
## Different scenarios to achieve the 100% target in 2050

### Scenarios

<table>
<thead>
<tr>
<th>nr</th>
<th>Scenario name</th>
<th>Variants</th>
<th>General parameters</th>
<th>Technology parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>REF</td>
<td>NO</td>
<td>Exogenous</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>DOM</td>
<td>NO</td>
<td>Exogenous</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>DEM</td>
<td>NO</td>
<td>Exogenous</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>GRID</td>
<td>NO</td>
<td>Free (but max 10 GW)</td>
<td>250 km², 9 GW, 8 GW</td>
</tr>
<tr>
<td>5</td>
<td>BIO</td>
<td>Low price, High price</td>
<td>Endogenous: price elastic</td>
<td>Free (check &lt; GDP based)</td>
</tr>
<tr>
<td>6</td>
<td>PV</td>
<td>More solar PV</td>
<td>High price</td>
<td>Average of 2003-2010 or 5.8 TWh</td>
</tr>
<tr>
<td>7</td>
<td>WIND</td>
<td>NO</td>
<td>Free (but max 20 GW)</td>
<td>Free</td>
</tr>
</tbody>
</table>

1 Dom scenario (unfeasible) used to estimate the domestic renewable gap
5 « 100% » Scenarios (Dem, Grid, Bio, PV, Wind)

### Results

- Primary energy
- Final energy
- Energy mix
- Costs
- (Cost benefit – GHG)
- Investments
- Storage and space requirements
Primary energy (2050) (GIC as reported by Eurostat - non energy use - fuel consumption by aviation - Maritime bunker)

Final energy (2050)
Sankey PV – primary/final energy 2050

Results

Electricity production and capacities (2050)
Renewable electricity production

- 100%RES scenario’s Belgium
- Policy goals Germany
- Belgian trajectory (NREAP goal of 20.9% in 2020)

Renewable electricity production

- Renewable electricity (Highest)
- Renewable electricity (Lowest)
- Total electricity consumption (2012)
Results: costs in 2050 and beyond (annual M€)

**Total cost**

**Additional cost - REF**

**Annual cost in % of GDP, 2050, additional to REF**
Results: Additional Investments wrt REF

Electricity sector (M€)

Cumulative 2013-2050

Investments in 2050

Remark: cost for grid connection of wind turbines under "wind"

Is it realistic? The German example

Figure 1: Additional investments in the electricity sector, all scenarios, year 2050 (left), Investments in renewable energy sources in Germany, period 2004-2011 (right)

Source: TIMES (September 21, 2011) (left), BNEV RE III (right).
Note: The cost for the grid connection of wind turbines falls under "Wind".
Storage capacities (energy content)

- Dark red: current pump storage Belgium

Conclusions (1/2)

- Technically, a 100% renewable energy system is feasible.
- Economically, it has following impact in 2050 wrt REF:
  1. Cost of energy services*: +20% to +30%;
  2. Reduction of energy services demand: -0% to -10%

  Energy system expenditures: +20% (2% of GDP), as the sum of:
  - Investments: +50% to +100% (1.5 to 3% of GDP);
  - Cumulative extra investment amount to 1 x current GDP
  - Fixed costs: +20% to +30% (0.9 to 1.2% of GDP)
  - Variable costs: -20% to -60% (-0.6% to -2% of GDP)

- Shift from a fuel intensive to a capital intensive society
- A 100% renewable electricity system is in operation in 2030
- A doubling/tripling of electricity production is noted in 2050

(*) close to the concept of welfare loss, that takes disutility costs into account
Conclusions (2/2)

» Current paradigm dominate thinking on RE
   » Electricity market: Consumers are sacred
   » Industry:
      » Just in time production saves money – keeping stocks is expensive
      » Strive for 100% capacity utilisation: 8760 hours per year
      » First priority is energy saving – wasting energy is not done

» New paradigm (under the condition of limited adjustable energy -
egothermal or bio-energy)
   » Overcapacity in intermittent renewable energy sources.
   » Electricity can be “stored” in intermediate/final goods >> change
drastically the demand pattern of some electricity intensive processes
   and allowing overcapacity in these processes

Thank you for your attention

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