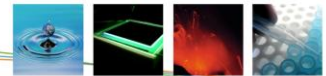

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100% Renewable energy in Belgium: a new paradigm on energy thinking

Wouter Nijs, Jan Duerinck, Pieter Lodewijks

Presentation content

» Purpose of the project (and limits)
» Methodology
» Assumptions
» Scenarios
» Results
» Conclusions

Purpose

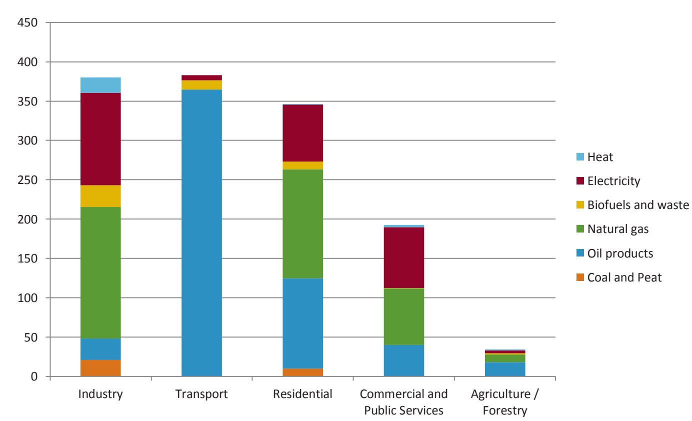
Purpose of the project (and limits)

- 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

Purpose

Energy is more than electricity !

(as we all know - but sometimes forget)



- Energy balance Belgium; Final energy consumption (PJ, IEA, 2009)

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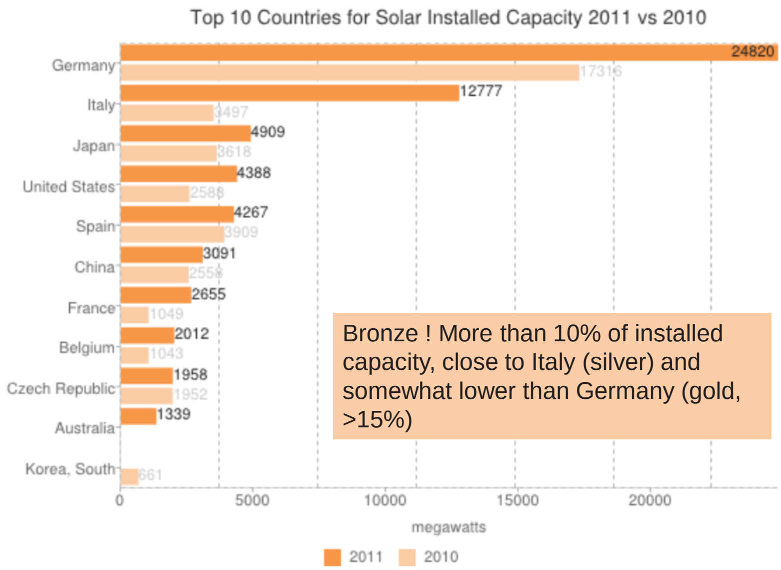
Purpose

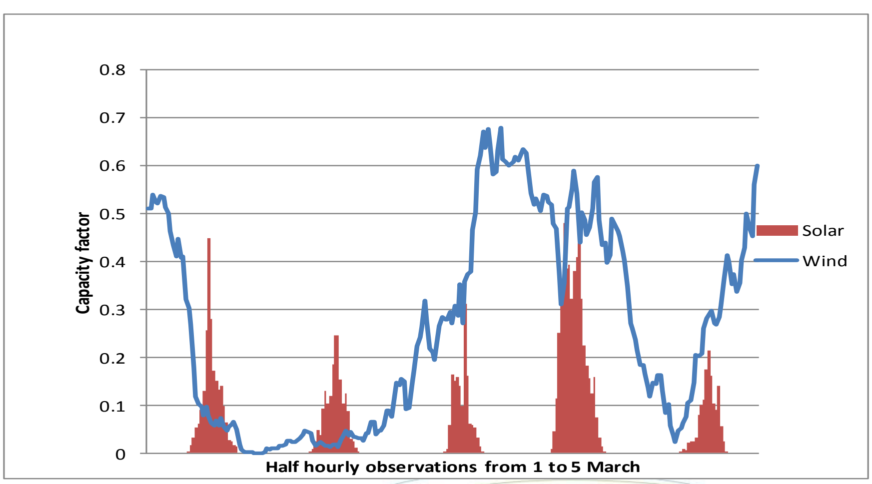
Another bronze medal for Belgium !



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

Methodology

Availability of wind/solar - March 1 – 5 2010



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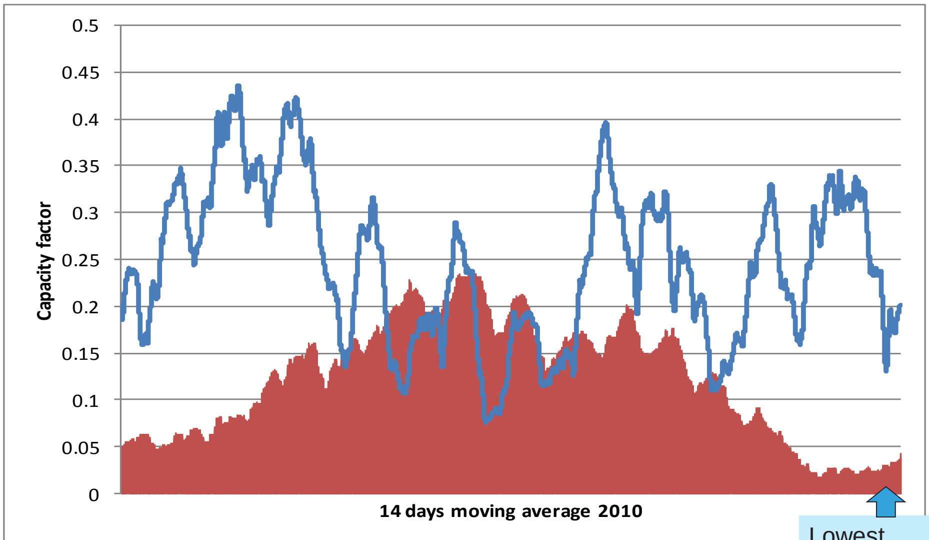
Methodology

14 days moving average availability 2010



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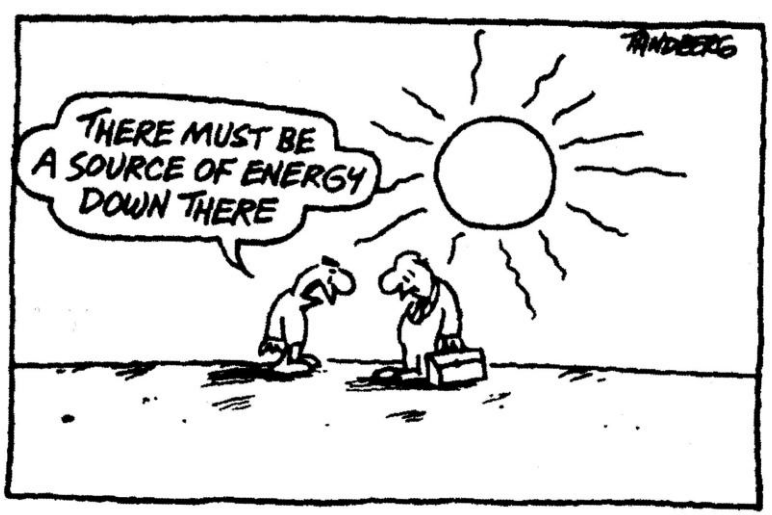
And than we started thinking....



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Methodology

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)

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Methodology

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)
  - 12,02 x 10^7 m² in Wallonia
  - 1,74 x 10^7 m² in Brussels
  - 11,25 x 10^7 m² in Flanders

  approx. 250 km²
- Hydro: Capacity (storage excluded)
  - 120 Mwe
- Geothermal: 4 GW_e

Biomass potential

Estimated biomass potential (EJ/yr)	WR* - 2020	BE** - 2030	EU25**-2030	EU27*** - 2050	Western/central Europe - 2050 ****	World**** - 2050
Energy Crops	0.003	0.004	5.961	15.4-19.9	3-11	44-133
Forestry and Forestry residues	0.023	0.008	2.311	1.7-2.2	5-9	19-35
Agricultural residues and organic waste	0.020	0.096	4.010	0.7	10	100
TOTAL	0.046	0.109	12.282	17.8-22.8	18-31	160-270

* 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
**** Haberl (2010) The global technical potential of bio-energy in 2050 considering sustainability constraints

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

Scenarios

Different scenarios to achieve the 100% target in 2050

SET 1 - EU Roadmap				General parameters			Technology parameters		
nr	Scenario name		Variants	Energy services demand	Import of ELE	Biomass use	PV	Wind onshore	Wind offshore
1	REF	Reference scenario 2020 EU climate-energy package	NO	Exogenous	Average of 2003-2010 or 5.8 TWh				
2	DOM	100% Renewable Energy by 2050; DOMestic check	NO	Exogenous		300 PJ	250 km²	9 Gwé	8 Gwé
3	DEM	Low energy services demand	NO	Endogenous: price elastic					
4	GRID	Flexible electricity imports	NO		Free (but max 10 GWé)				
5	BIO	More biomass imports	Low price High price		Average of 2003-2010 or 5.8 TWh	Free (+check < GDP based)			
6	PV	More solar PV	Low price High price			300 PJ	Free (but < 10% of BE)		
7	WIND	More Wind (onshore and offshore)	NO				250 km²	Free (but max 20 GWé)	Free

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

Results

Results

- Primary energy
- Final energy
- Energy mix
- Costs
- (Cost benefit – GHG)
- Investments
- Storage and space requirements

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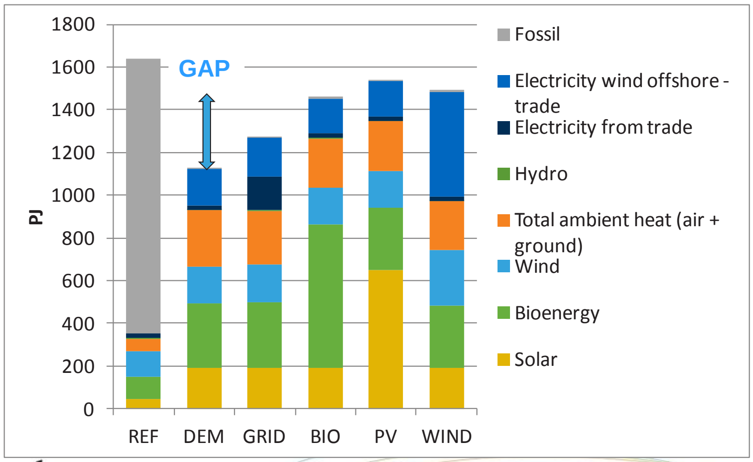
Results

Primary energy (2050) (GIC as reported by Eurostat - non energy use - fuel consumption by aviation - Maritime bunker)



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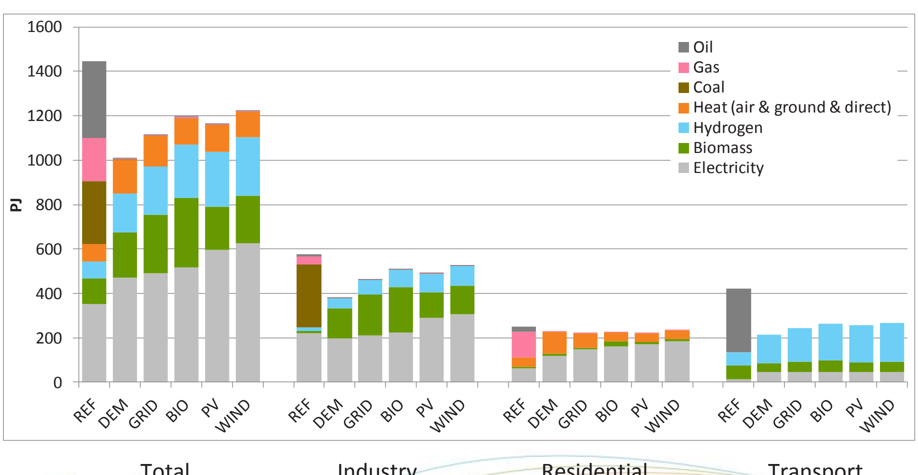
Results

Final energy (2050)



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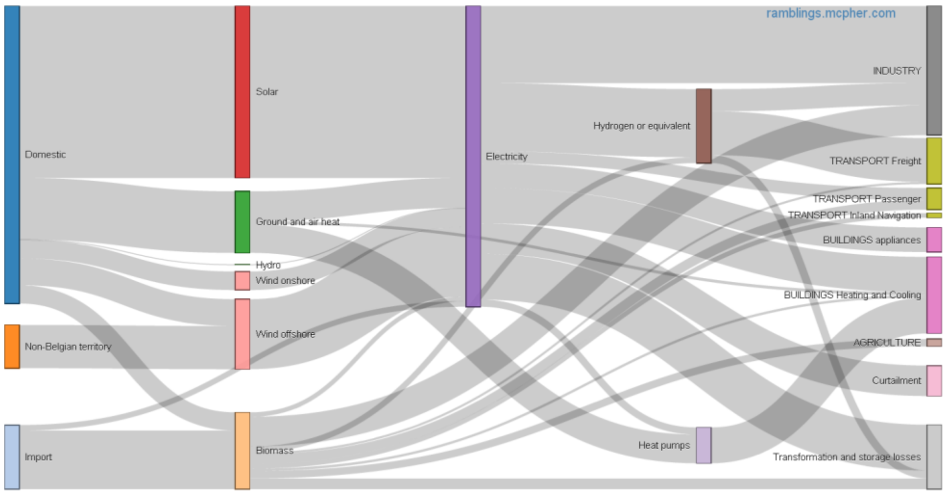
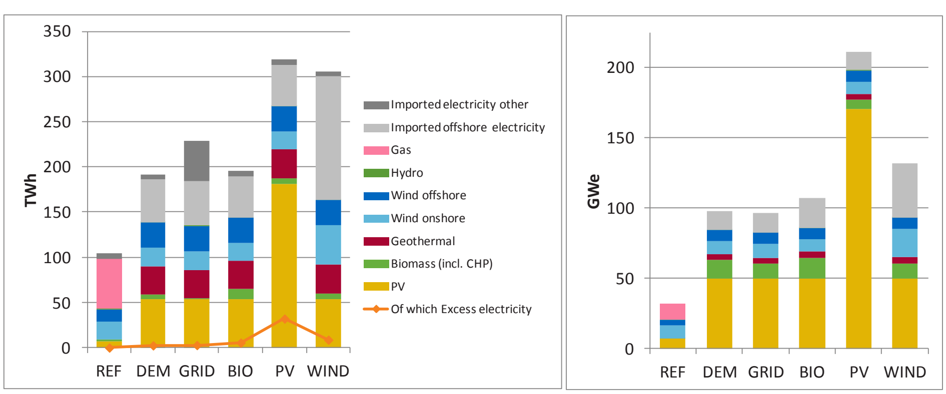
Sankey PV – primary/final energy 2050



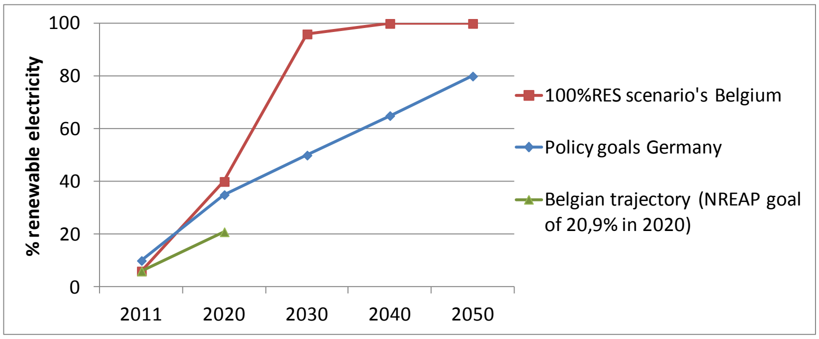
Results

Electricity production and capacities (2050)



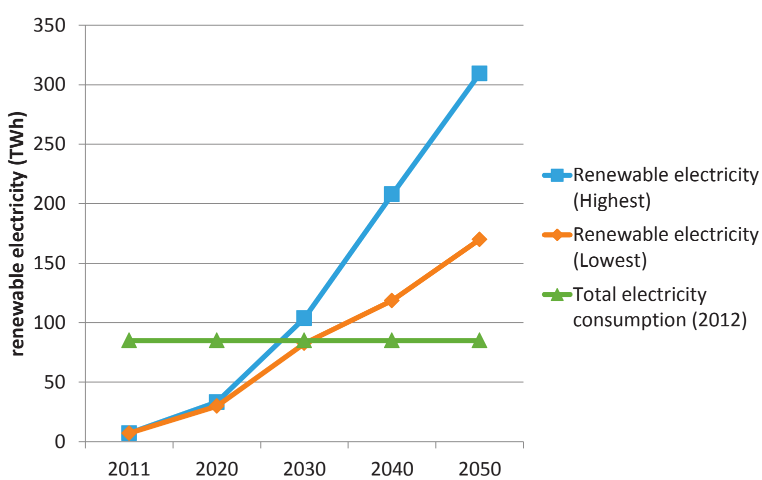
Results

Renewable electricity production



Results

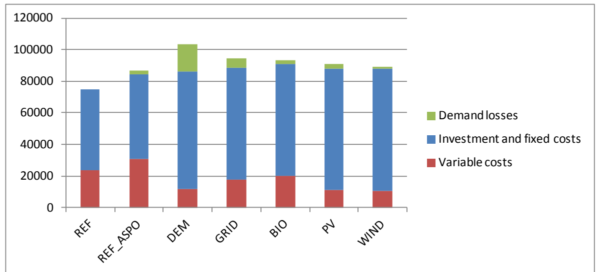
Renewable electricity production



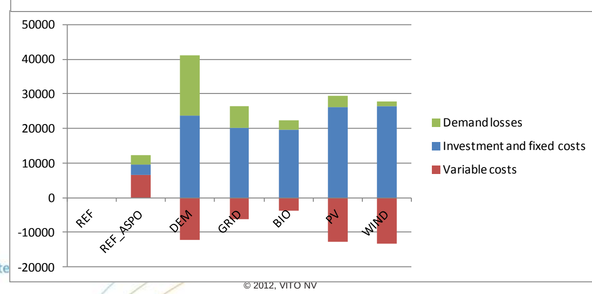
Results

Results: costs in 2050 and beyond (annual M€)

Total cost

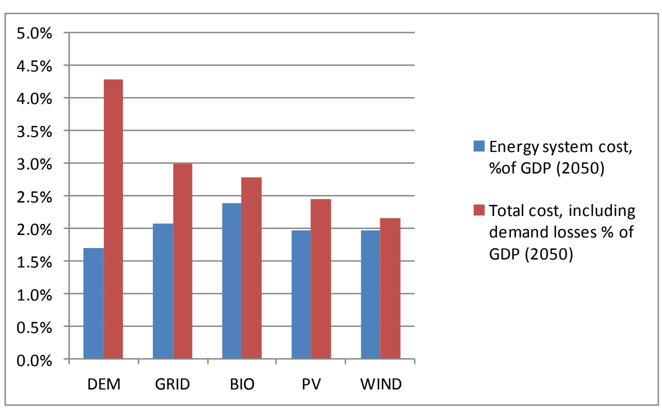


Additional cost - REF



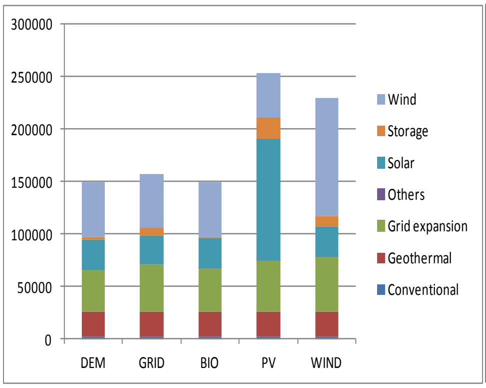
Results

Annual cost in % of GDP, 2050, additional to REF

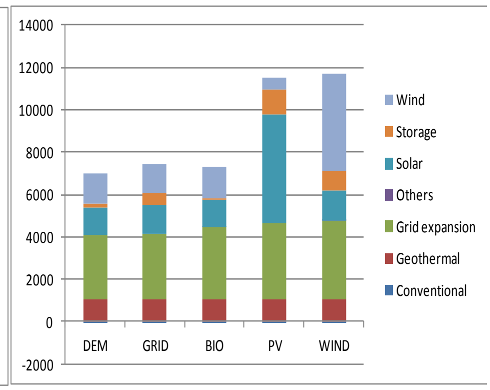


Results: Additional Investments wrt REF

Electricity sector (M€)



Cumulative 2013-2050

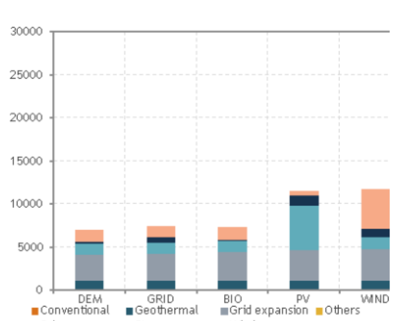


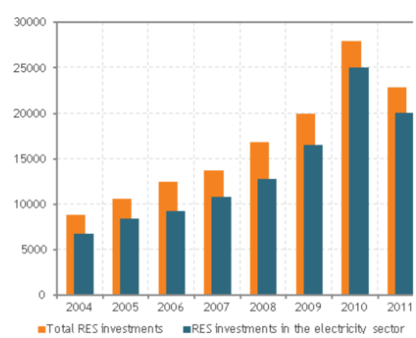
Investments in2050

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)
M€2005

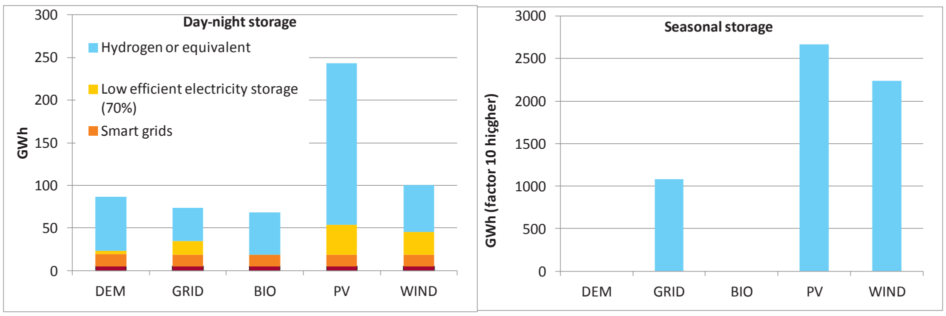




Source: TIMES (September 21, 2012) (left), BMU-KI III1 (right).
Note: The cost for the grid connection of wind turbines falls under 'Wind'.

Results

Storage capacities (energy content)



» Dark red: current pump storage Belgium

included in the graph)

Conclusions

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

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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 - geothermal 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

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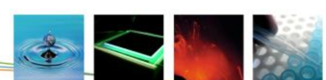

Thank you for your attention

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