energy [r]evolution

A Sustainable World Energy Outlook

Wolfram Krewitt
It is not important to predict future, but it is important to be prepared for the future.

*Perikles, 500 B.C.*
Projection of technology development and socio-economic change

Forecasting

‘business-as-usual’ future world

Alternative policy options

required interventions and investments

Backcasting

Normative target world

source: anonymous
EU target: to limit average global temperature increase to a maximum of 2°C compared to pre-industrial level.

- Stabilisation of global CO$_2$-concentration below 450 ppm
- reduce energy related CO$_2$-emissions from 27 Gt/a today to ~ 10 Gt$_{CO_2}$/a in 2050
- per-capita emission rights in 2050: ~ 1 t$_{CO_2}$/a
a sustainable world energy outlook: the energy [r]evolution scenario

key targets:

- climate change: limit global mean temperature rise to less than 2° C
- phasing out of nuclear energy on a global level
- incentives for sustainable economic development
10 world regions
population development
GDP development projection

average annual GDP growth rates in %

OECD Europe
OECD North America
OECD Pacific
Trans. Economies
China
East Asia
South Asia
Latin America
Africa
Middle East
World

2003-2020
2020-2040
2040-2050
development of global final energy demand

‘Business as Usual’ – extrapolation based on IEA-WEO 2004 Reference Scenario
increase in global energy productivity by factor 4
global final energy demand by sector

Reference Scenario

energy [r]evolution Scenario
final energy demand: China

Reference Scenario

energy [r]evolution Scenario
final energy demand: OECD North America

Reference Scenario

energy [r]evolution Scenario
a broad range of renewable energy technology options is available

- **PV** – boosting global markets, high innovation potential

- **Ocean energy** – variety of successful demo projects in place, huge potentials

- **Concentrating solar thermal power** – new incentives triggered market in Spain, base load RES electricity

- **Solar heating** – high solar shares achievable with district heating networks & seasonal storage

- **Off-shore wind** – large scale commercialisation about to start

- **Biomass** – efficient combined heat and power production
potential of CO₂ reduction by CCS technologies
(example: coal IGCC)

\[ \eta: \text{50\%} \rightarrow \text{42\%} \quad \text{transp.} \quad \text{storage} \quad \text{88\% CO₂ capture} \]

-78% gas fired CC-CHP
OECO North America 2°C Scenario

1) with heat credit
global electricity supply – 2° Scenario

Y-Axis: TWh/a

X-Axis: Years 2003-2050

Energy sources: Efficiency, Ocean Energy, Solar Thermal, PV, Geothermal, Wind, Hydro, Biomass, CHP fossil, Gas&oil, Coal, Nuclear

Legend:
- Efficiency
- Ocean Energy
- Solar Thermal
- PV
- Geothermal
- Wind
- Hydro
- Biomass
- CHP fossil
- Gas&oil
- Coal
- Nuclear
future electricity supply structure - China

Reference Scenario

energy [r]evolution Scenario

- Efficiency
- Import RES
- Ocean Energy
- Solar Thermal
- PV
- Geothermal
- Wind
- Hydro
- Biomass
- CHP fossil
- Gas&oil
- Coal
- Nuclear
global primary energy demand

- Efficiency
- Ocean energy
- Geothermal
- Solar
- Biomass
- Wind
- Hydro
- Natural gas
- Crude oil
- Coal
- Lignite
- Nuclear

Graph showing the energy demand from 2003 to 2050 in PJ/a.
global primary energy demand

- 50% energy savings compared to ‘business-as-usual’
- 50% renewables
costs of global electricity supply

<table>
<thead>
<tr>
<th>crude oil $^{2000}/bbl</th>
<th>62</th>
<th>75</th>
<th>85</th>
<th>93</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂ $/t</td>
<td>10</td>
<td>20</td>
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![Graph showing costs of global electricity supply](image)
costs of global electricity supply

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- energy [r]evolution Scenario - efficiency measures
- energy [r]evolution Scenario - electricity generation
- Reference - electricity generation
global investment in renewable electricity technologies – energy [r]evolution scenario

- geothermal, ocean energy
- concentrating solar thermal
- PV
- biomass
- wind
- hydro

billion $ per year

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<tr>
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<th>2030</th>
<th>2040</th>
<th>2050</th>
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<tbody>
<tr>
<td>Value</td>
<td>50</td>
<td>150</td>
<td>250</td>
<td>350</td>
<td>450</td>
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Discussion

- achieving the 2°C target is technically feasible
- societal and structural innovation is required to facilitate the transformation process
- exploitation of energy efficiency potentials is a huge challenge
- adaptation of energy supply infrastructure
- investment in renewable energy technologies offers industrial development options
- current ‘real world’-trends deviate from 2°C-Scenario → strong policy action is required!
- use a target oriented scenario as a policy benchmark!
electricity supply OECD North America
Energy savings per measure in 2050

- Increase secondary aluminium
- Efficient cooling equipment
- Iron and steel - electricity
- Reduce stand-by losses
- Efficient buses
- Improved process control
- Membrane product separation
- Iron and steel - fuels
- Reduce electricity use during non-office hours
- Efficient motor systems
- Efficient electric appliances
- Efficient lighting
- Heat integration / pinch analysis
- Agriculture
- Efficient freight vehicles
- Efficient passenger cars (hybrid fuel cars)
- Improved heat insulation
- Improved energy-efficiency other industries