Global Challenges

The European Council and the European Parliament have both confirmed the EU’s objective to limit average global temperature increase to a maximum of 2°C compared to pre-industrial level.

Commission of the European Communities, January 2007

Based on general accepted climate models the following consequence are inevitable:

- Stabilisation of global CO₂ concentration below 450 ppm
- Reduction of man-made CO₂ emissions for energy supply from 27 Gt/year to 10 Gt/year in 2050
- Mean emission quota per person in 2050: ~ 1 t CO₂/year
- Reduction of CO₂ emissions in Germany below one tenth compared with today
How does this get along with the actual goals defined by politician all over the world?

Politics is aiming for a reduction of todays CO₂ emissionen until 2050 by 50%.

This would be sufficient, if
- population would grow
- All countries would decrease their emissions by 50%.

But …
- based on prognoses world population will increase from 6 to 10 billion people in 2050
- there will be no justification for a five times higher CO₂ emission in todays OECD countries compared with the rest of the world.

Entrepreneurial and economics challenges

- How will energy supply and power plants mix look like in 2050?
- Which end energy will be used in different applications and what are the consequences for the energy supply infrastructure?
- Do we need quantum leaps which require a parallel installation of a new supply infrastructure?
- Can we develop further existing infrastructures to enhance them for the new challenges?
- Which investments are necessary into long-living supply infrastructures?
Preliminary remarks

- Technology scenarios are based on the assumption that necessary CO₂ reductions must be achieved until 2050.
- Assumption is to maintain the energy service as it is today in OECD countries.
- On the road to 2050 also transition technologies will be used which have no major role in 2050 anymore.
- Transition of the energy supply can not be achieved without strong guidance and decisions from politics and society.
- Not all areas of energy consumption are explicitly mentioned (e.g. cargo transport, air traffic).
- Energy per unit will cost more money in the future.
- But increased energy efficiency can keep the expenses for energy constant for the end user.

CO₂-free energy sources and power plant mix in 2050

- Energy savings
- Electrical power
  - Renewable Energies (wind, photovoltaics, solar thermal, tidal and stream energy, geothermal, hydro power, biomass, …)
  - Coal and gas with CO₂ sequestration (?)
  - Nuclear fission and fusion (??)
  - Transnational and transcontinental electricity networks
- Gas
  - Transition from natural gas to a mixture of natural gas / biogas / hydrogen
  - Hydrogen only in case of significant surplus of energy from renewable sources
- Fuel
  - Liquefied or compressed gas (mixture as above)
  - Synthetic bio fuels (“biomass to liquid” BTL), world-wide trading
CO₂-free energy sources and power plant mix in 2050

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Most relevant technologies for renewable energies

- Electricity
  - Wind
  - Solarthermal power plants (Southern Europe, North Africa)
  - Photovoltaics
  - Biogas
  - Geothermal
  - Hydro power
- Heat
  - Near surface geothermie
  - Solar thermal (non concentrating, passive and active)
  - Biomass
- Fuel
  - Bio fuels (BTL)
  - Hydrogen from thermo-chemical or biological processes
Transition of gas supply

- Beside electricity gas will be most important as energy carrier for the end user for CHP units, industrial processes, long-distance transport, or peak load power plants

- Infrastructure and end users for natural gas must be enhanced for increasing shares of
  - biogas – from decentralised plants and central plants using imported biomass
  - hydrogen – from surplus electricity from CO₂-free sources

Public transport

- In cities only with electricity – with catenaries, batteries, fuel cells
Public transport

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- Required infrastructure
  - Battery charging stations at major bus stops (approx. 100 kW per charging point)
  - Catenaries
  - Gas supply and liquid bio fuels for high temperature fuel cells

Individual transport

- Inside cities only electric driving with batteries (up to 60 - 100 km/day)
- Suburban & highway with plug-in hybrids (batteries plus internal combustion engine or fuel cell) with bio fuels or gas

- Required infrastructure
  - Bi-directional power flow in all grid segments
  - High power connection of public parking lots
  - Energy management and communication
  - Filling stations for bio fuels and gas
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Single dwellings

- Thermal isolation reduced heating demand below 20 kWh / m² / year
- Remaining heating energy from heat pumps (~ 600 kWh/year for 120 m²).
- Hot water from solar thermal collectors
- Additional electricity need for individual transport (~ 1500 kWh / 9,000 km/year)
- Reduction of electricity consumption by 50% due to savings (< 2000 kWh/year)
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- Required infrastructure
  - Existing electricity grids sufficient, but enhancement for bi-directional energy flow
  - Installation of heat pumps

**Apartment, business and public buildings**

- Heating and cooling with combined heat and power (CHP) units
- CHP powered by gas
- Electricity for all other loads
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- CHP powered by gas
- Electricity for all other loads

Required infrastructure:
- gas
- electricity
- energy management
- local heat and cooling distribution systems
- thermal storage (daily and seasonal)

Measures for the stabilisation of the electricity grid with high penetration of fluctuating power generators

- Extension of transnational electricity transport capacities
- CHP operation at times of electricity demand
- Dual use of storage units for electricity grid and transport
- Additional storage systems (large to small call, various technologies)
Thermal storage in CHP units

Forceful change-over to power controlled CHP units:
- Thermal storage systems are much cheaper compared with electricity storage systems
- Daily and seasonal storage device for thermal energy available
- Usage of CHP unit as virtual, distributed and controllable peak load power plants

→ allows levelling of power demand in grids

Prospects from a dual use of storage systems for electricity grids and mobility – plug-in hybrids

Daily usage < 4 hours / day
per vehicle:
20 h/day available
10 kWh storage
5 kW power
Prospects from a dual use of storage systems

- Vehicle fleet in Germany: > 45 Million
- 4 Mill. vehicles (< 10% of fleet) as bi-directional connected plug-in hybrids result in
  - 20 GW power for 2 hours
  - or 8 hours with 5 GW power (exceeds today's installed capacity of pumped hydro storage systems in Germany)
- 35% of the vehicles can supply the average load in Germany for 3 hours

Electrical energy storage vs. transmission

**Storage systems**
- Efficiency depends on technology (30 - 90% electricity to electricity)
- Very flexible power and energy sizing
- Reduced dependencies on third countries, increasing level of energy autonomy
- The smaller the grid segment the bigger the storage system
- Typically significant costs per kWh

**Transmission network**
- High efficiency (high voltage DC ~ 5% losses / 1000km)
- International co-operation and stability for transnational and transcontinental grids required
- DC cable technique allows underground and underwater lines
- Expensive in sparsely populated areas
Technologies for storing electrical energy

- Redox-Flow batteries
- Superconductive coils
- Supercapacitor
- Batteries - lead-acid, lithium, NaS, NiCd...
- Compressed air
- Hydrogen
- Batteries - lead-acid, lithium, NaS, NiCd...
- Pumped hydro
- Flywheels
- Redox-Flow batteries

Betriebsbereich verschiedener Speichertechnologien

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- Installed power: 10 W, 1 kW, 100 kW, 1 MW, 1 GW
- Installed storage capacity: kWh, MWh, GWh, TWh
- Typical discharge time: 10 ms, 1 s, 1 min, 1 hour, ½ day, 1 week, 1 month, 1 year
- Specific power: [kW/kWh]
Conclusion

- Electricity will become the most important end-energy carrier.
- Even though energy savings will be realised, the need for electricity will increase in relative and absolute numbers.
- Existing infrastructures can be upgraded and developed further for future needs. No new infrastructures are needed.
- Merging of electricity supply and individual transport offers a huge technical and economic potential.

- Thermal and electrical storage systems are inevitable …
  - for optimum mobile and stationary utilisation of electricity
  - for reduction of investments in peak power plants
  - for most efficient operation of heat and power co-generation plants
  - for energy efficiency measures especially in the industry

Finally …

The conference will show …

- technologies for storing electricity and heat are available
- there are more different technologies than typically recognised in official studies and future scenarios
- renewable energies for a sustainable energy supply will not be hindered by missing storage technologies

But also …

- especially in Europe strong investments in technology development and demonstration projects are needed.