The intelligent energy system infrastructure for the future

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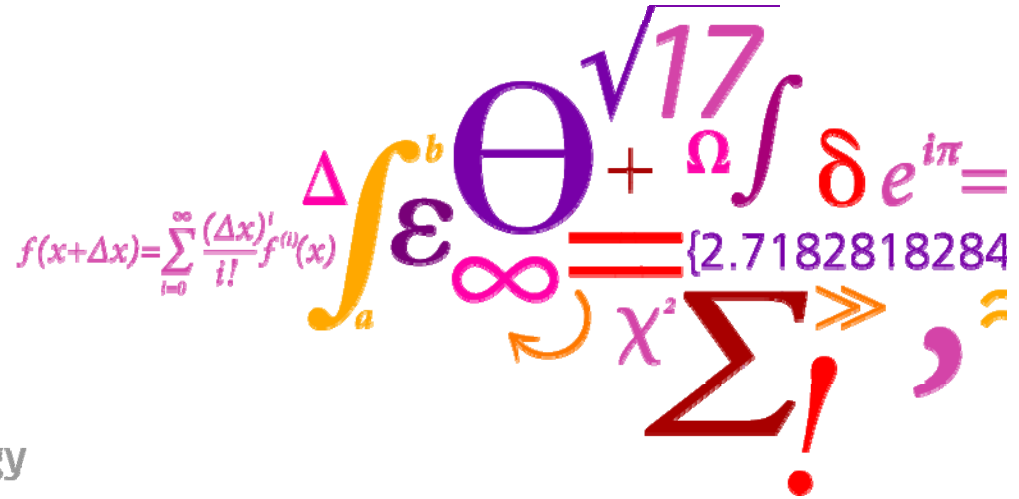
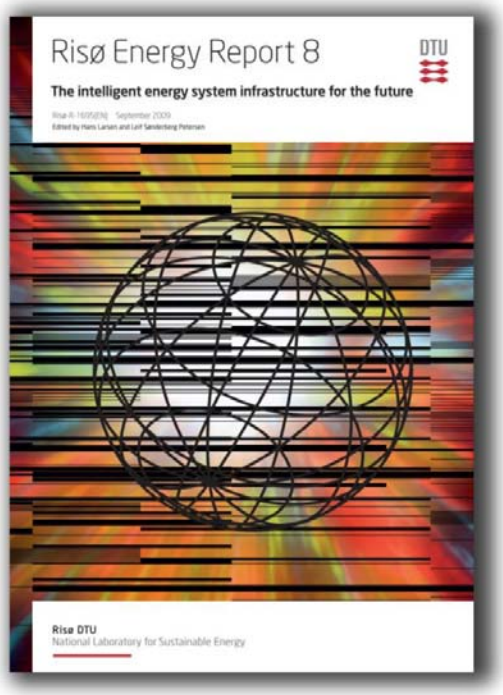


Risø DTU
National Laboratory for Sustainable Energy

Risø Energy Report 8

The report is volume 8 in a series that began in 2002

- The report presents the need for the development of a highly flexible and intelligent energy system infrastructure which facilitates substantial higher amounts of renewable energy than today's energy system
- This is necessary to achieve the goals set up by IPCC in 2007 on CO_2 reductions
- The report presents a generic approach for future infrastructure issues on local, regional and global scale with focus on the energy system itself



- Written by researchers from DTU together with other Danish and International experts
- Based on the latest research results together with available international literature

The global energy scene

- Within the energy sector **energy security and climate change** are the two overriding priorities. This is especially true for industrialized countries and the more rapidly developing economies.

- Many developing countries, on the other hand, still face basic energy development constraints which give quite a different meaning to the concept of energy security.

- Today 1.6 billion people have no access to modern energy

The global economy

- The global economy has in recent years faced a number of changes and challenges.

- Globalization and free market economics have dominated the last decade, but the current financial crisis is rapidly changing the political landscape.

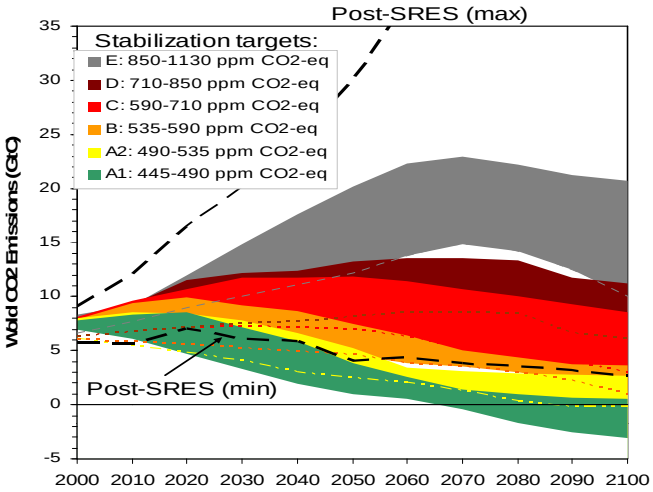
- The need to provide energy services with due respect to economic growth, sustainability and security of supply

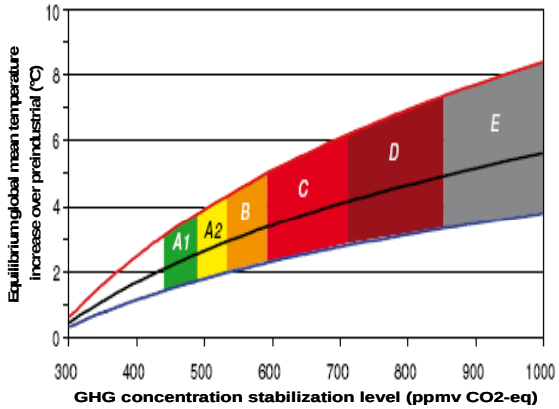
Climate change

- IPCC - 4. assessment report in 2007
- Nobel peace price
- COP15 in Copenhagen in December 2009

Climate Change:

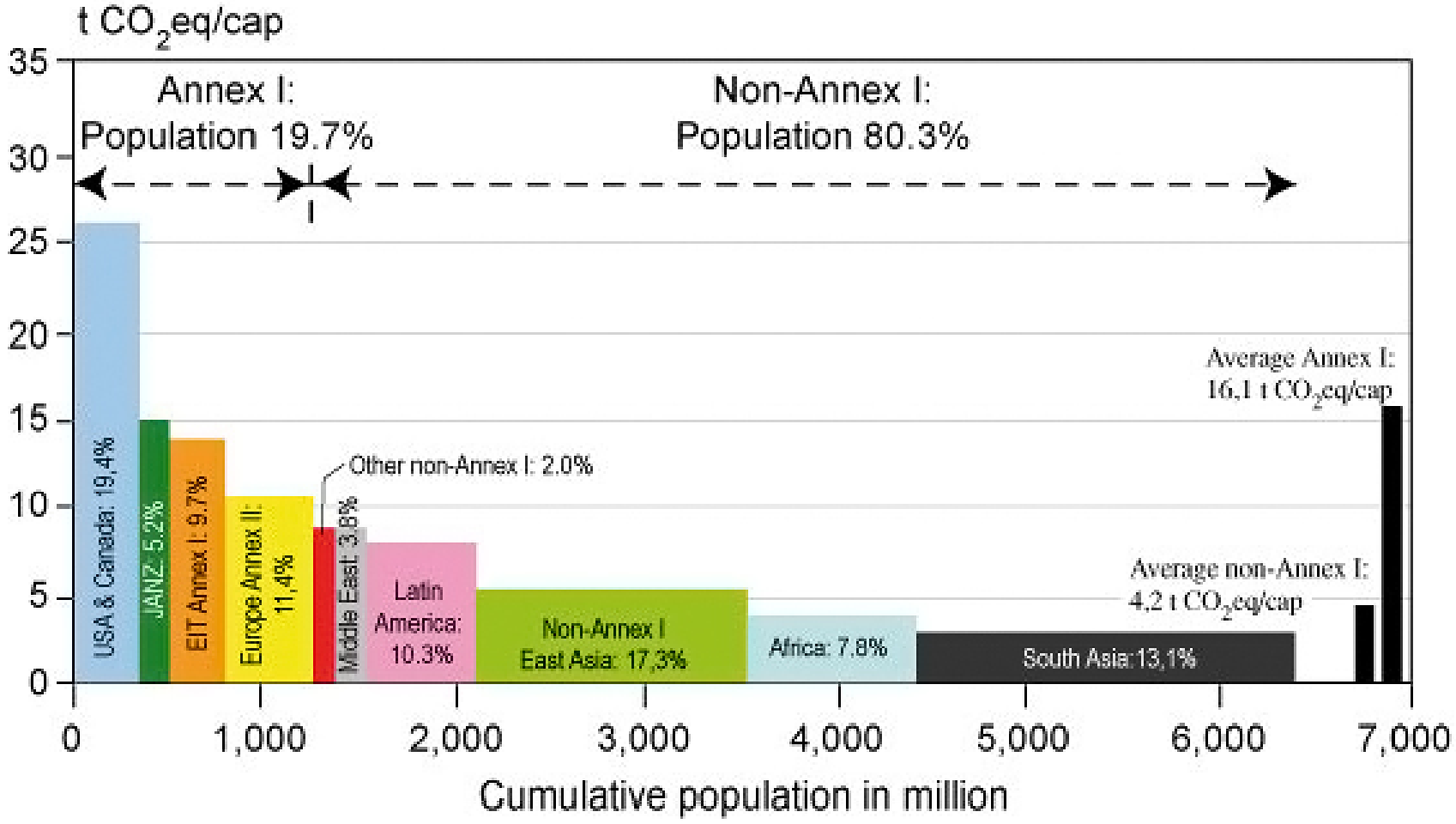
- The need to ensure a peak in CO_2 emissions before 2020 and at least a 50% reduction in the long run on a global scale e.g. in 2050 and later close to zero or even negative



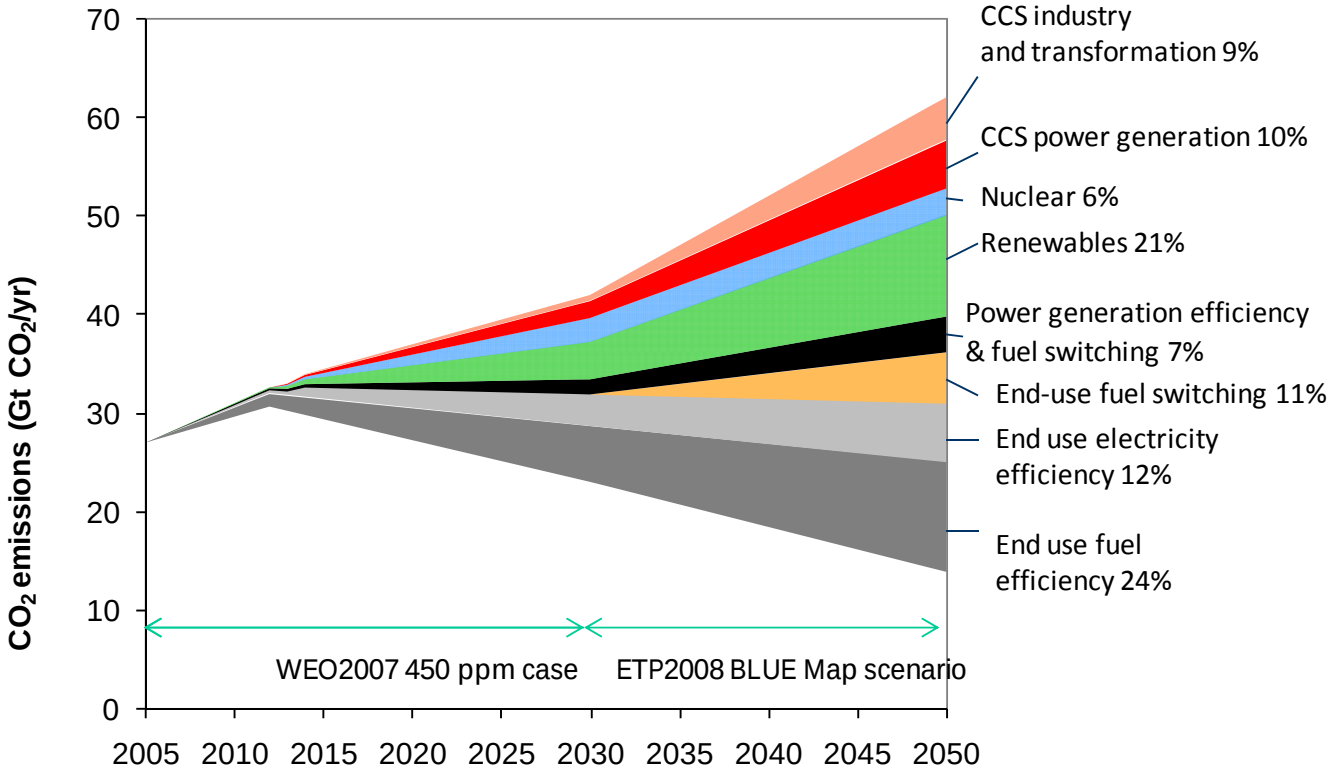


Source: IPCC 4 Assessment Report 2007

CO2 eq/cap IPCC AR4



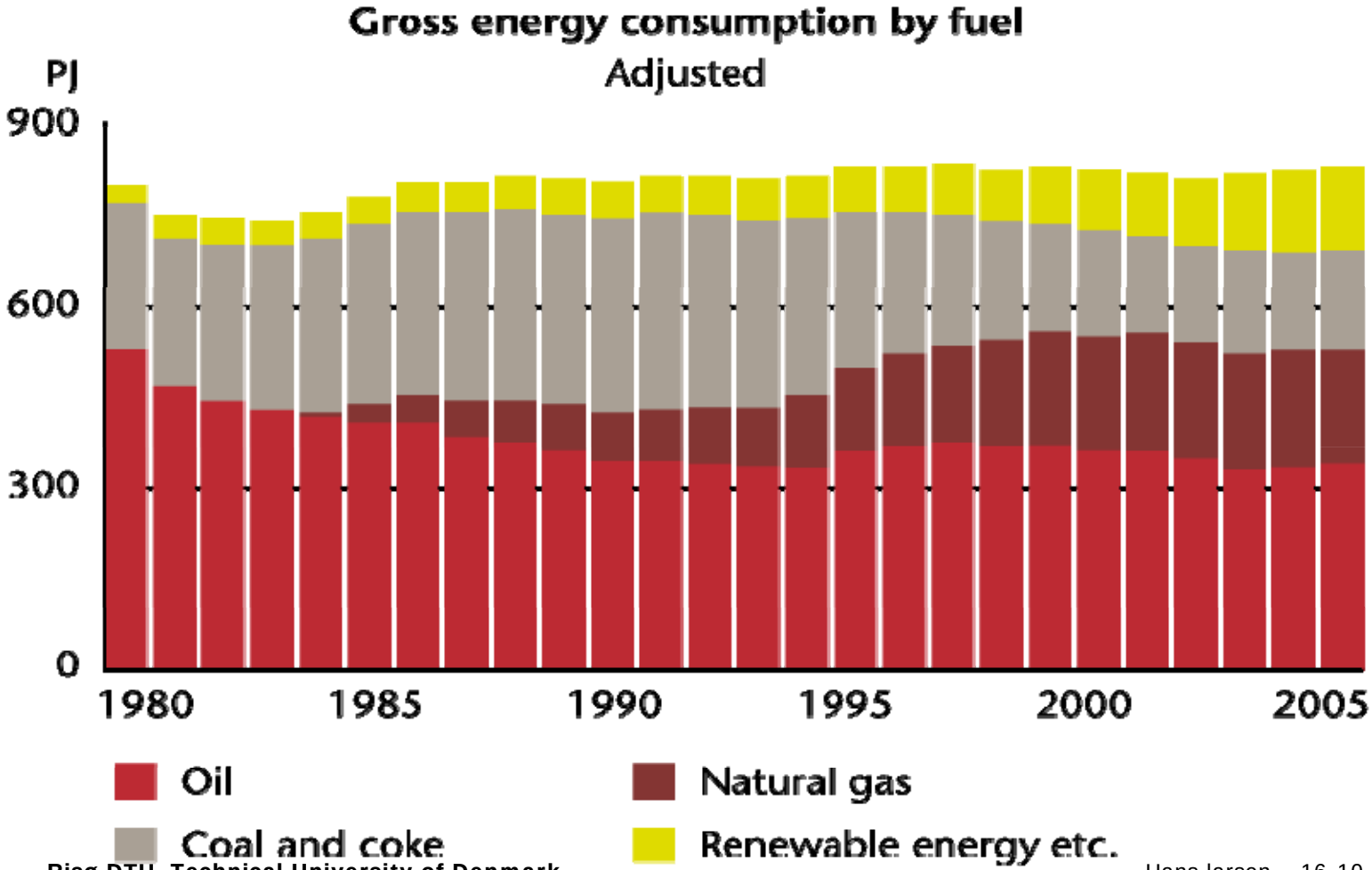
CO_2 emissions



Source: IEA

Danish energy consumption has been stable over the last 25 years

- Is it possible to continue …?

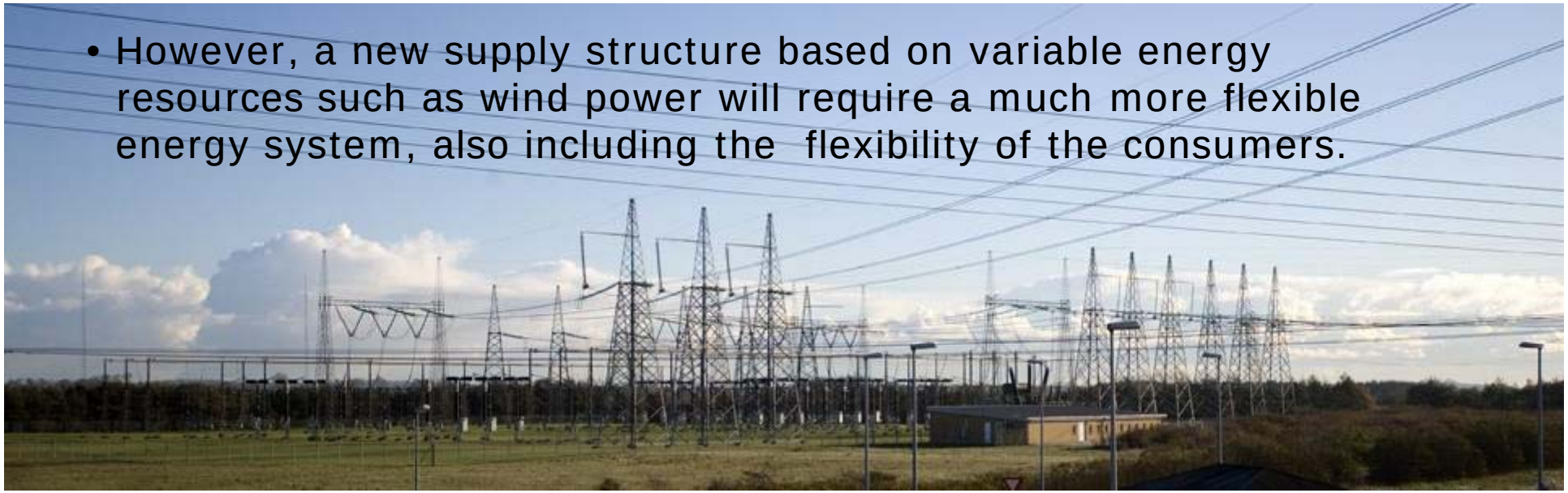


The energy system

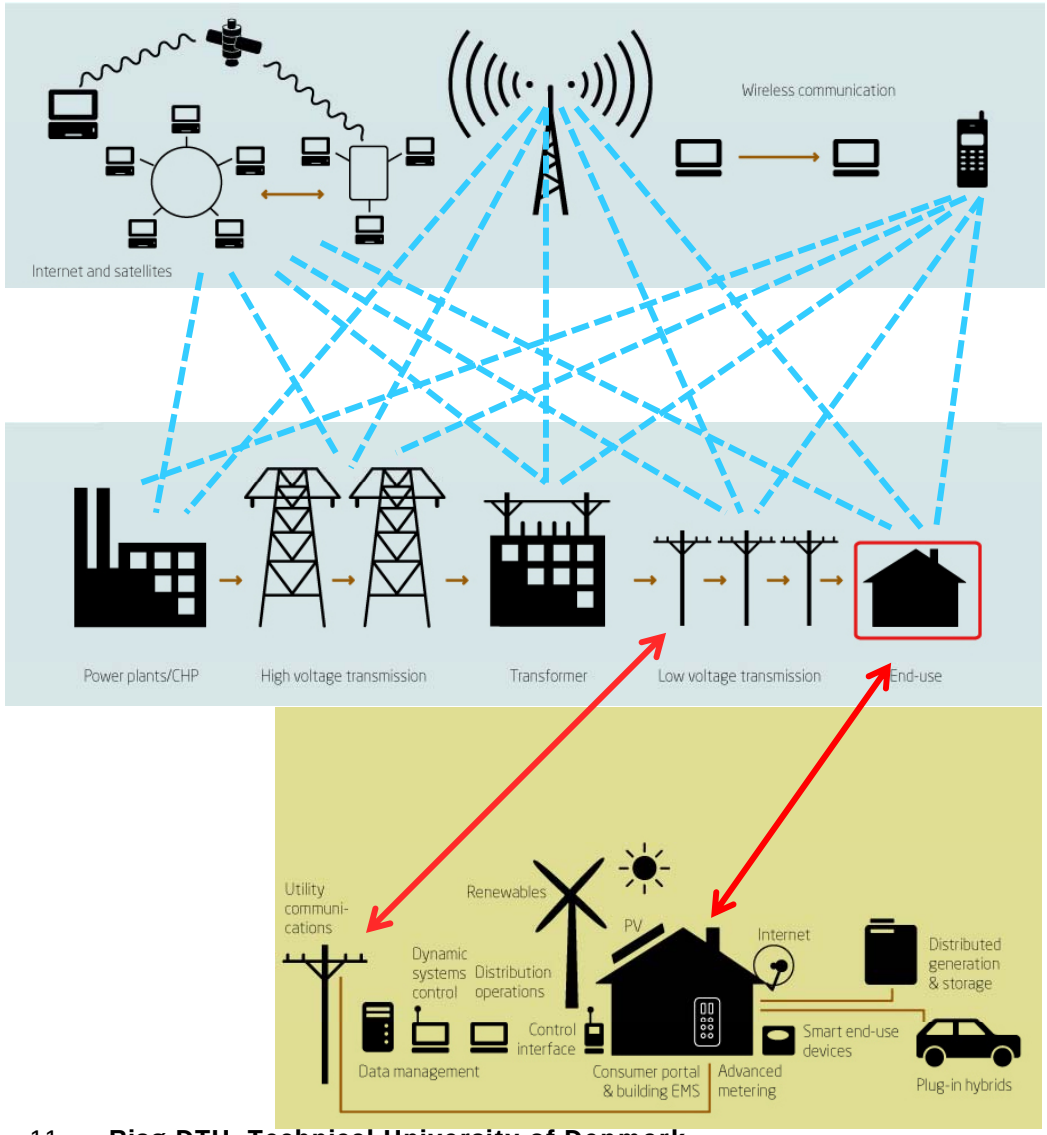
- Today's energy system is the result of decisions taken over more than a century.

- This long-term development is reflected in the structure of the energy system, which in most cases was developed according to basic engineering requirements: energy is produced to meet the needs of consumers.

- However, a new supply structure based on variable energy resources such as wind power will require a much more flexible energy system, also including the flexibility of the consumers.



The future intelligent energy system



Information and Communication Technologies

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Traditional power system structure

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Distributed generation and efficient building and transport systems

=

The future intelligent energy system emerges

Structural changes in the power system

- The power system is currently undergoing fundamental structural changes.

- The causes are:
  - the rapidly increasing amount of fluctuating renewable energy
  - the use of new types of production and end-use technologies.

Information and Communications Technology (ICT)

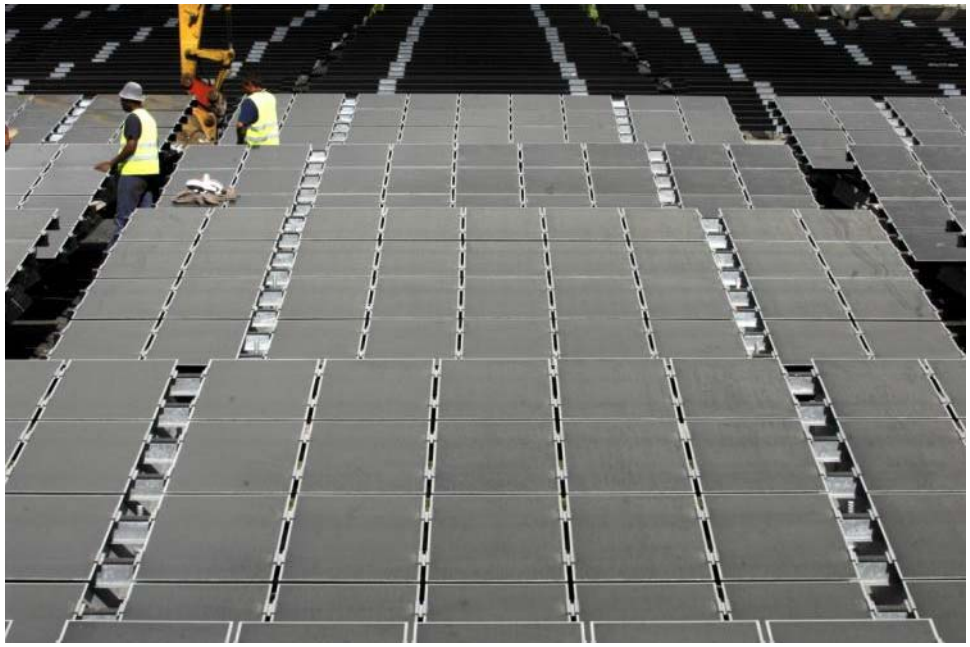
- Increased use of Information and Communications Technology (ICT)
- The rapidly increasing capabilities, and falling costs, of ICT open the way to two-way communication with end-users
- Making this one of the most important enabling technologies for the future power system.

Renewable energy sources

- Renewable energy resources used to occupy an almost insignificant niche, are gradually expanding their role in global energy supply.

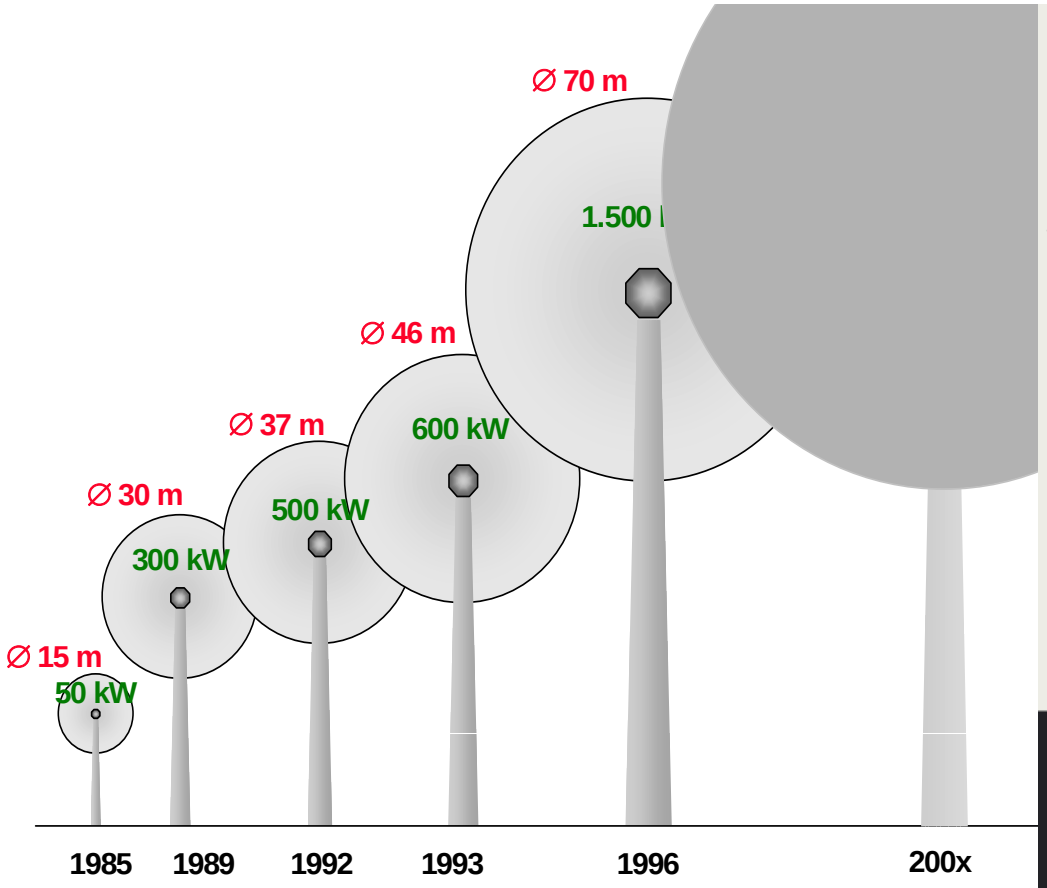
- Today the largest contributors are traditional biomass and hydropower

- “New renewables” such as photovoltaics, wind power, small-scale hydro, biogas and new biomass plays a minor role, but are expanding rapidly.

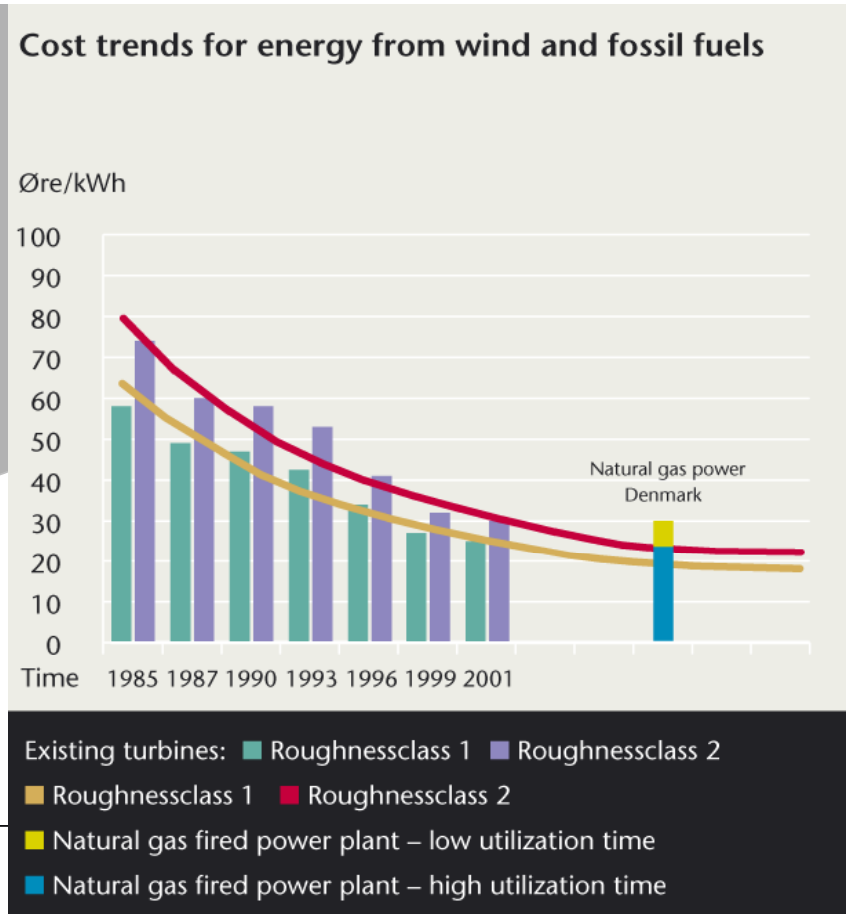


Wind energy

Development of wind turbines

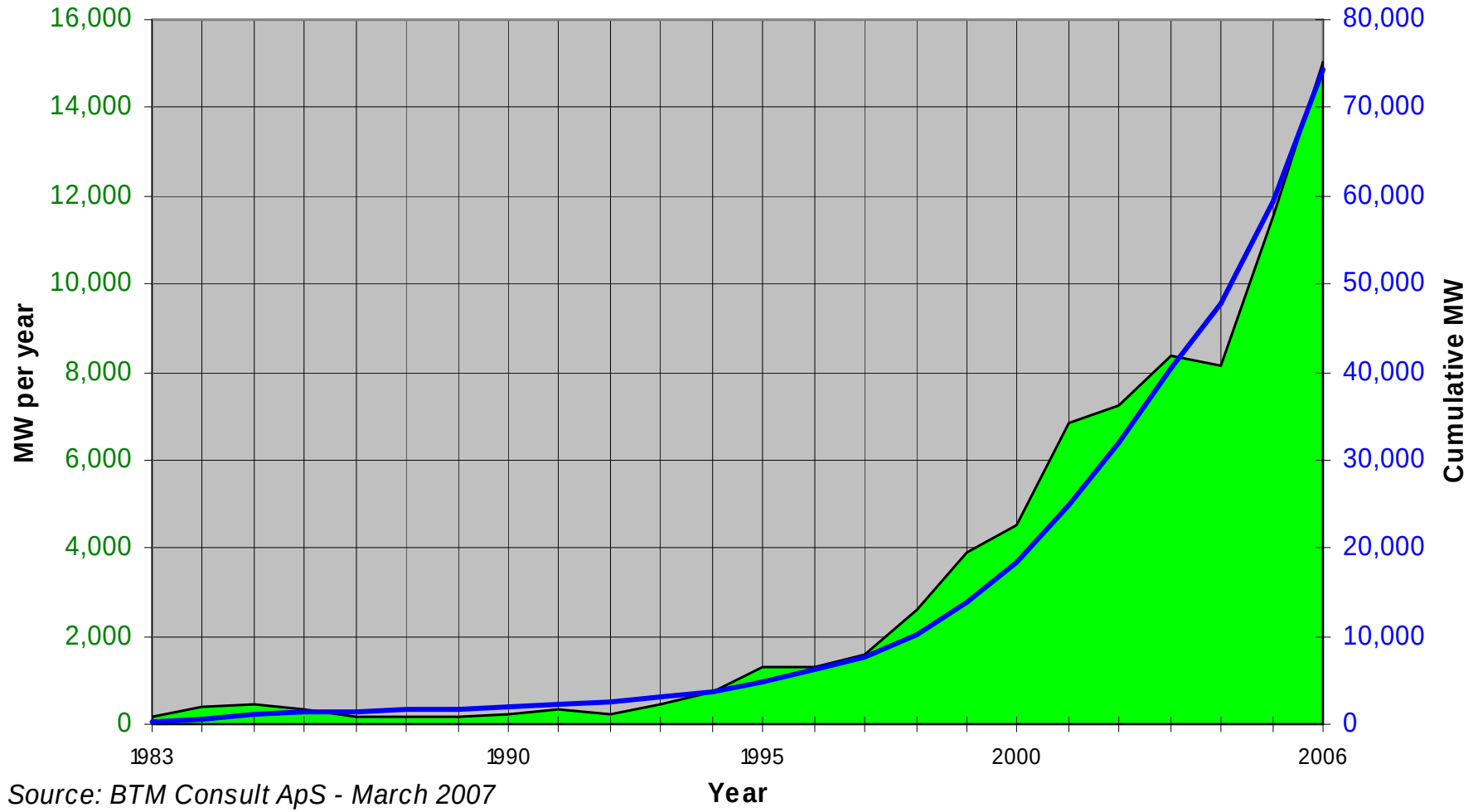


Cost of energy from wind and fossil fuels



Installed Wind Power in the World

- Annual and Cumulative -



Source: BTM Consult ApS - March 2007

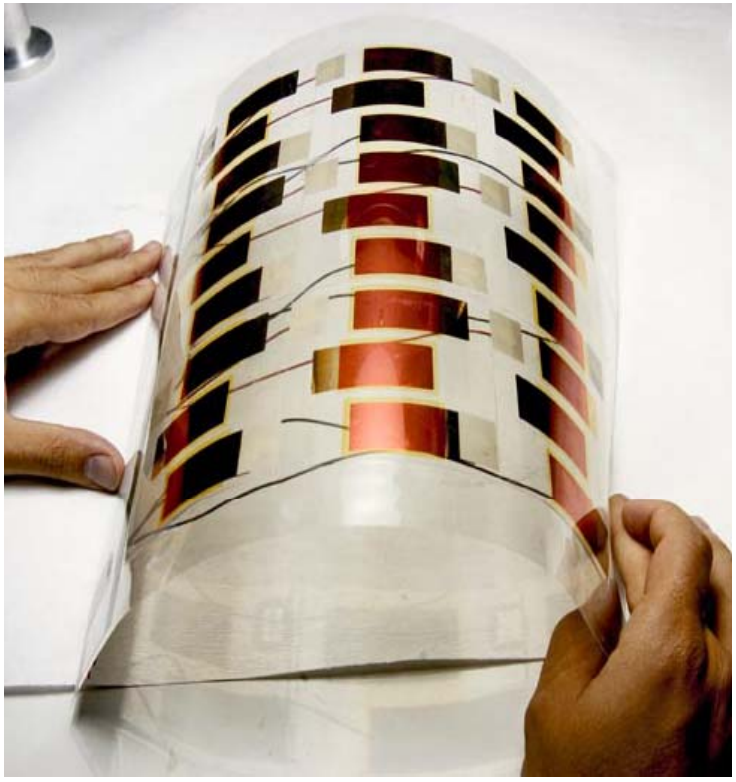
Technology for sustainable energy supply - Bioenergy

- Production and properties of biomass
- Biomass conversion and co-production
- The production of

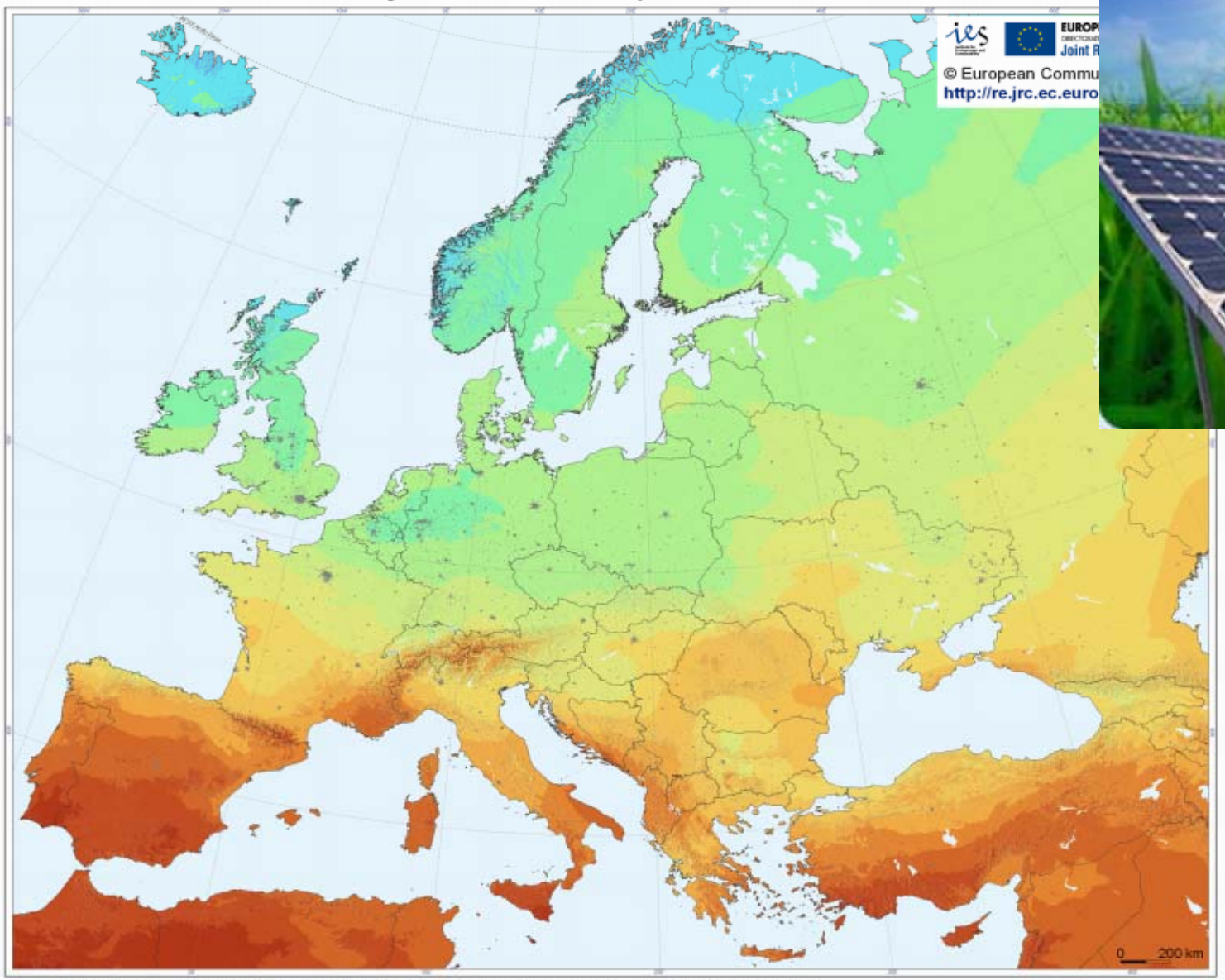
  2 generation bio-fuel from straw by means of an internationally unique method

Photovoltaics

- The market for photovoltaic's has grown at an average of more than 30% annually over the last 10 years
- Crystalline silicon remains the standard PV technology with a market share above 90%
- Although efficiencies of solar cells continue to rise, high cost remains the principal barrier to PV as a large scale energy producers
- Polymer solar cells may succeed where silicon has failed because they are cheap to make



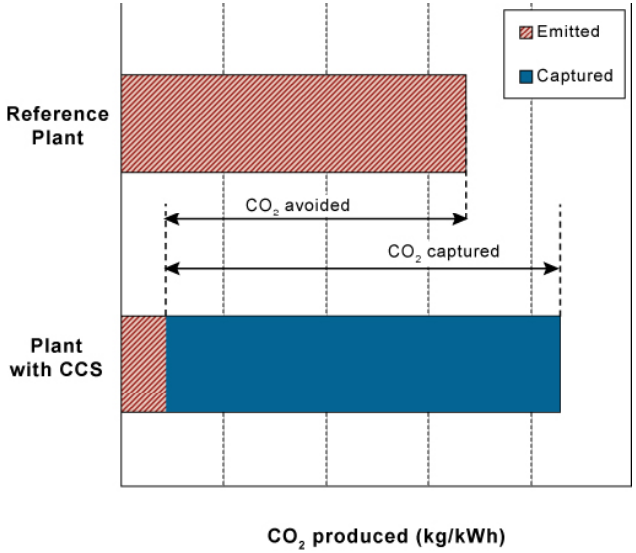
Photovoltaic Solar Electricity Potential in European Countries

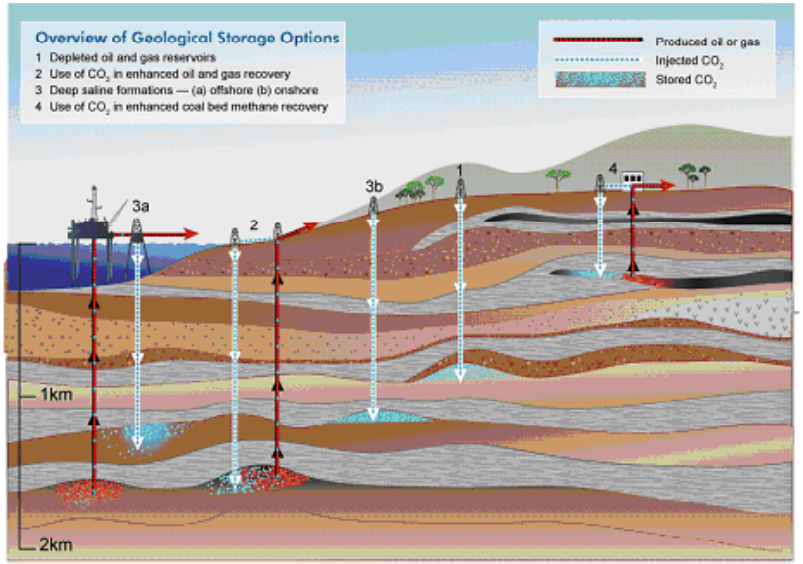


Different potentials in North and South

Carbon Capture and Storage - CCS

- Additional energy use of 10 - 40% (for same output)
- Capture efficiency: 85 - 95%
- Net CO_2 reduction: 80 - 90%
- Assuming safe storage





Storage

- Energy storage is needed in a future energy system dominated by fluctuating renewable energy depends on many factors:
  - the mix of energy sources,
  - the ability to shift demand,
  - the links between different energy vectors, and
  - the specific use of the energy.
- Storage costs and energy losses need to be considered.

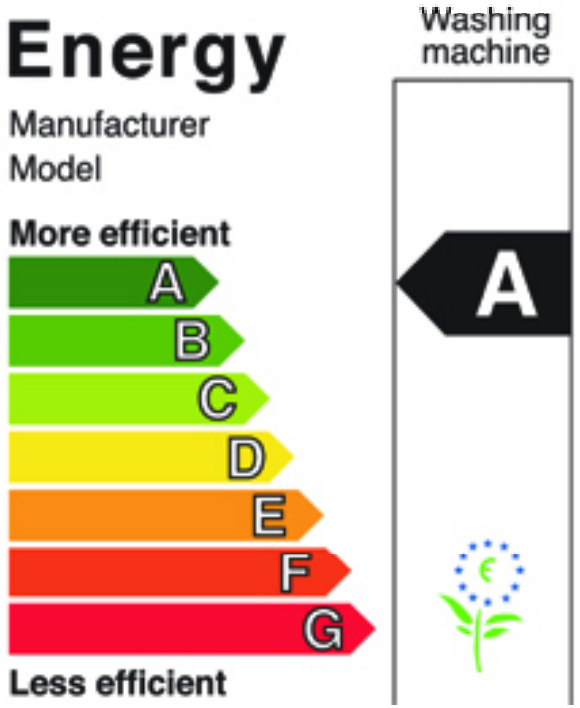
Transport sector

- Modern transport depends heavily on fossil fuels. Ways to reduce emissions from transport are to shift to renewable or at least CO_2-neutral energy sources, and to link the transport sector to the power system.

- Achieving this will require new fuels and traction technologies, and new ways to store energy in vehicles.

Efficiency improvements

- High emphasis on efficiency improvements in both industry and private households changing demand patterns are going to generate new challenges to system operators and utilities.



Self sufficient costumers

- The customers are becoming increasingly independent as they in long periods can be self-sufficient with energy by producing some of their limited need for electricity and heat by solar collectors, fuel cells etc.
- In short periods of time they are expecting the system to supply all their needs.

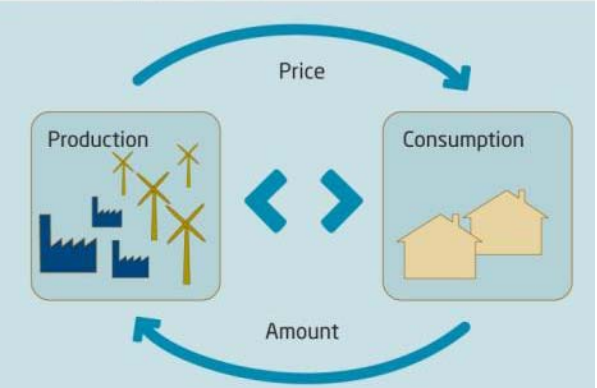
Volatile hourly prices

- A future electricity system with a considerable amount of fluctuating supply implies quite volatile hourly prices at the power exchange.

- Persuading customers to react to hourly prices would improve market efficiency, reduce price volatility, and increase welfare.

- Increasing the proportion of wind power in the system increases the benefits to consumers of acting flexible.

Dialogue between energy producers and consumers can match demand to supply by adjusting prices.



Flexible and intelligent energy system

Prerequisites:

- effectively accommodate large amounts of varying renewable energy;
- integrate the transport sector through the use of plug-in hybrids and electric vehicles;
- maximise the gains from a transition to intelligent, lowenergy buildings; and
- introduce advanced energy storage facilities in the system.

A high share of fluctuating energy sources

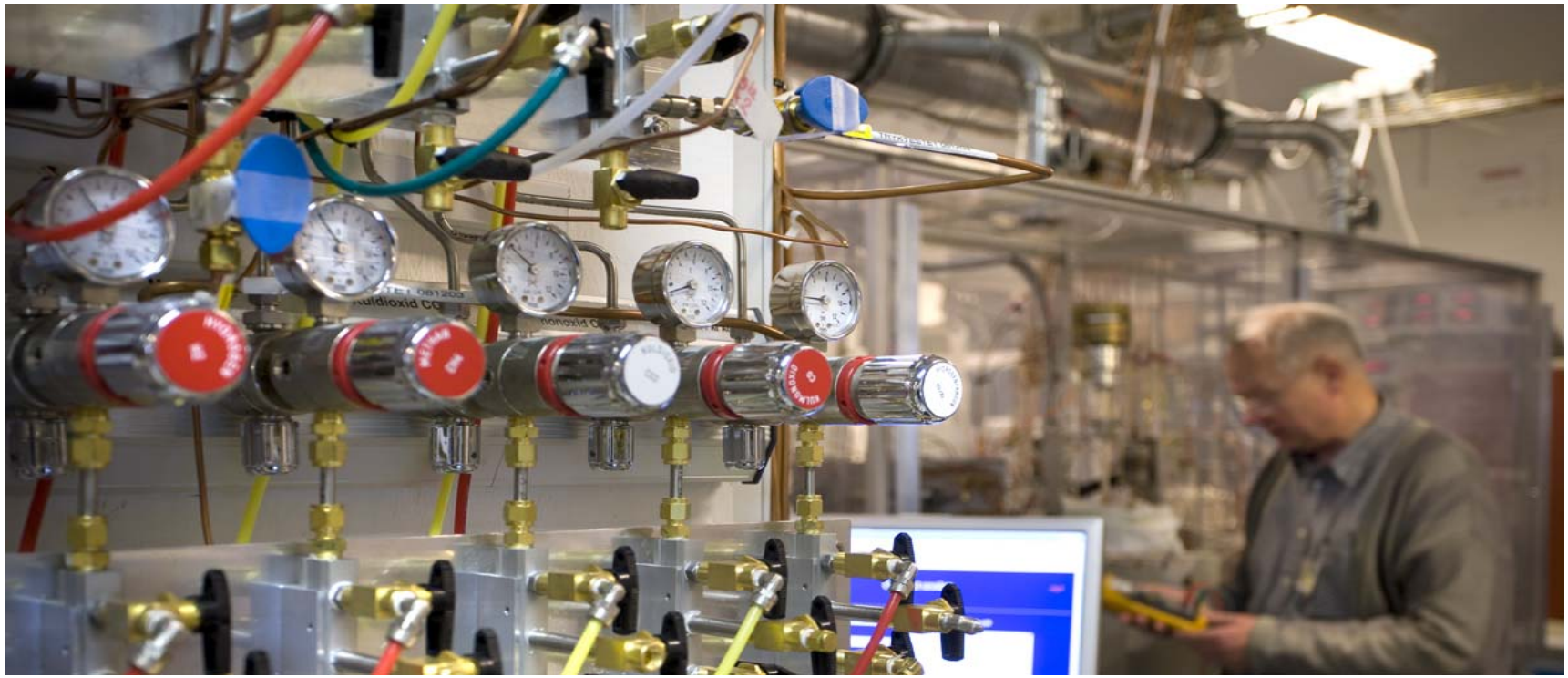
- Long-term targets for renewable energy deployment and stable energy policies are needed in order to reduce uncertainty for investors.
- A mix of distributed energy resources is needed to allow system balancing and provide flexibility in the electricity system.
- Electric vehicles, electric heating, heat pumps and small-scale distributed generation, such as fuel-cell-based microCHP, are promising options.

Long term development

- Apart from development of the future highly flexible and intelligent energy system infrastructure which facilitates substantial higher amounts of renewable energy than today's energy system
- there is also the need for development of new sustainable supply and end-use technologies for the period after 2050 where CO_2 emissions should be almost eliminated

Long-term research

- Hence, there is a strong need to pursue long-term research and demonstration projects on new energy supply technologies, end-use technologies, and overall systems design. Existing research programmes in these areas should be redefined and coordinated so that they provide the best contribution to the goal of a future intelligent energy system.



Thank you for your attention