

# Integration of renewable energies into electricity and heat supply

The challenge of today’s global primary energy demand and its expected increase can be met by renewable energy sources, which are known to have a sufficient potential (Figure 1). In terms of quantity, the sun and the wind could even meet the demands alone but they are subject to great fluctuations and their availability depends on the geographical location. The task is thus essentially defined as the technical and economical development of renewable energy sources, their integration into the supply structures and the transformation of energy systems.

## Where are renewables today?

Photovoltaics presently have a global share of only one-tenth of a percent but their learning curve shows a decrease in costs by 20% for each doubling of installed capacity. The global share of wind energy is already at around 1.5%. In recent years, wind energy had annual growths rates of 30-40%.

The coming years will be slightly lower, although the learning curve here shows a decrease in costs by 10% for each doubling of installed capacity.

Looking at the costs plotted against the generated energy is a feasible economic comparison (Figure 2). One can see that all renewables become competitive with conventional fossil fuels when their share is at approximately 20%. This applies to them all equally; cost-effectiveness is not a fundamental but rather a temporal question.

Any sole supply with renewable energies should be based on several pillars due to fluctuations in the availability of the wind and the sun. These include, for example:

- Use of energy stored in biomass
- Demand side management
- Appropriate integration of large pumped storages for medium to long-term compensation
- New storage approaches for short-term grid support as they may arise, for example, with electromobility

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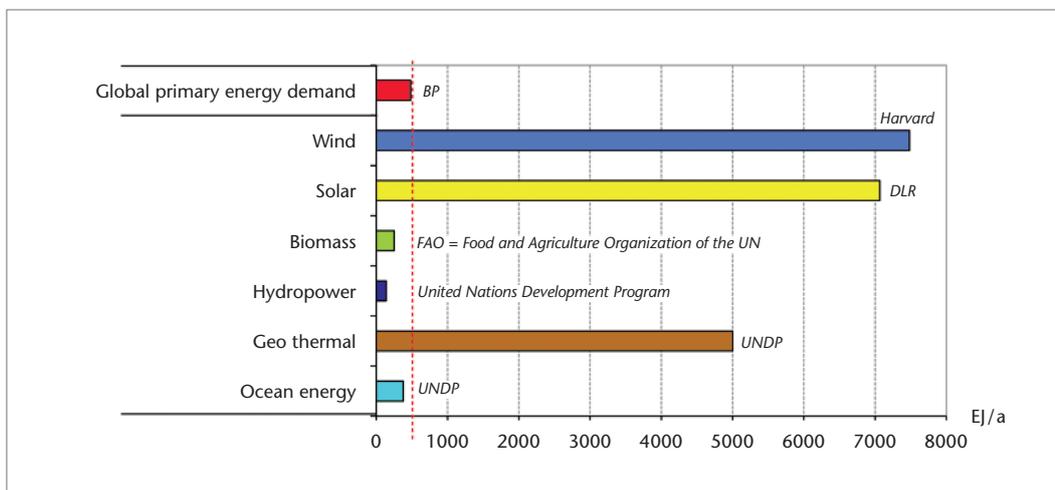
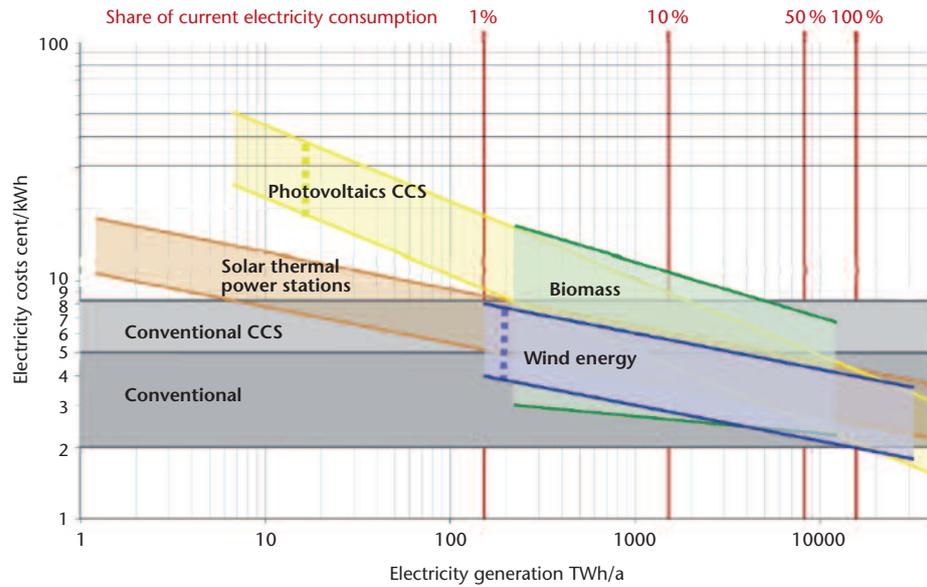


Figure 1  
 Technological potential of renewable energies worldwide

The sources are noted in the chart next to the corresponding bar.

**Figure 2**  
Development potential of the costs of electricity from renewable energies

(Source: Fraunhofer IWES 2007)



### How can we significantly increase the efficiency of our energy supply?

Two-thirds of the primary energy stored in the energy source are lost as waste heat in conventional power plants.

For every kilowatt-hour generated directly from renewable energy sources, three kilowatt-hours are replaced on the primary side of conventional power plants (Figure 3). On the other hand, we have to utilise the heat losses for our own thermal demands via a rapid and widespread

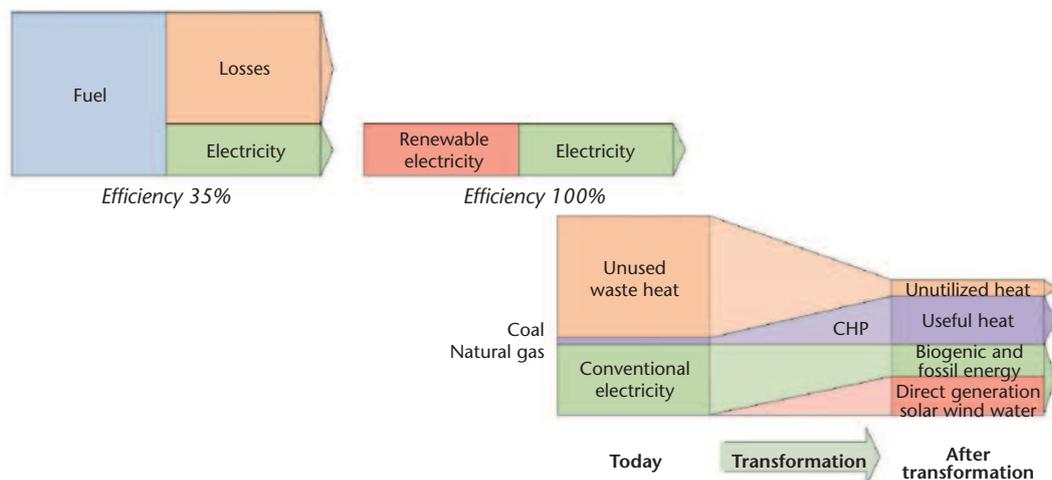
application of combined heat and power generation.

Another important component is the electrically powered heat pump.

It utilises 75 percent environmental heat from the air or the ground and 25 percent operating energy to power heating and water heating. The higher the portion of renewable electricity used, the better the heat pump's efficiency and environmental balance (Figure 4).

The third major portion of primary energy is used for our mobility needs in the transport sector, with current average efficiencies of

**Figure 3**  
Efficiency leap in the electricity sector by promoting direct electricity generation from renewable energy sources and combined heat and power (CHP)



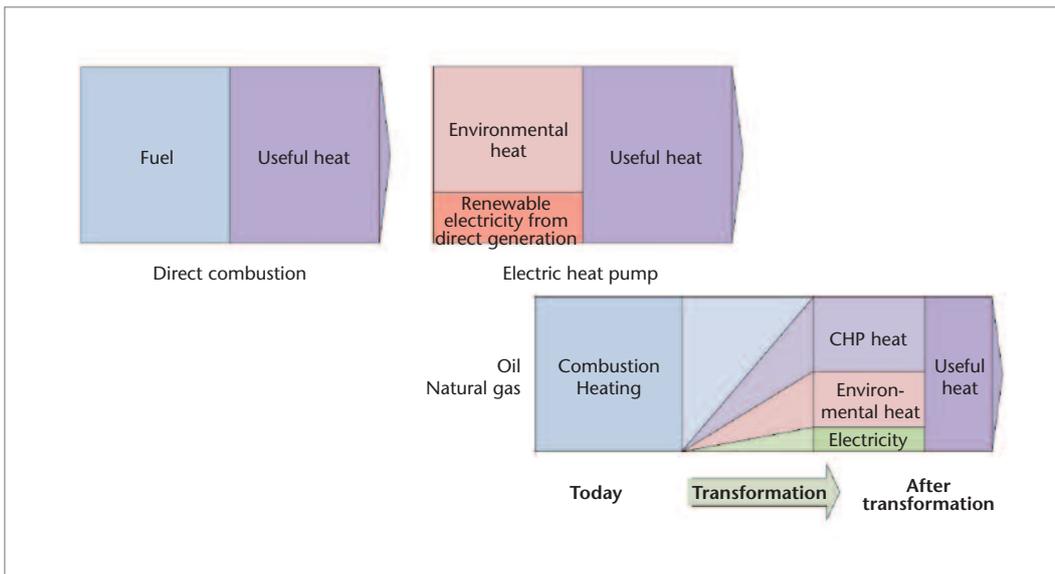


Figure 4  
Efficiency leap in the heating sector thanks to regenerative heat pumps and combined heat and power (CHP)

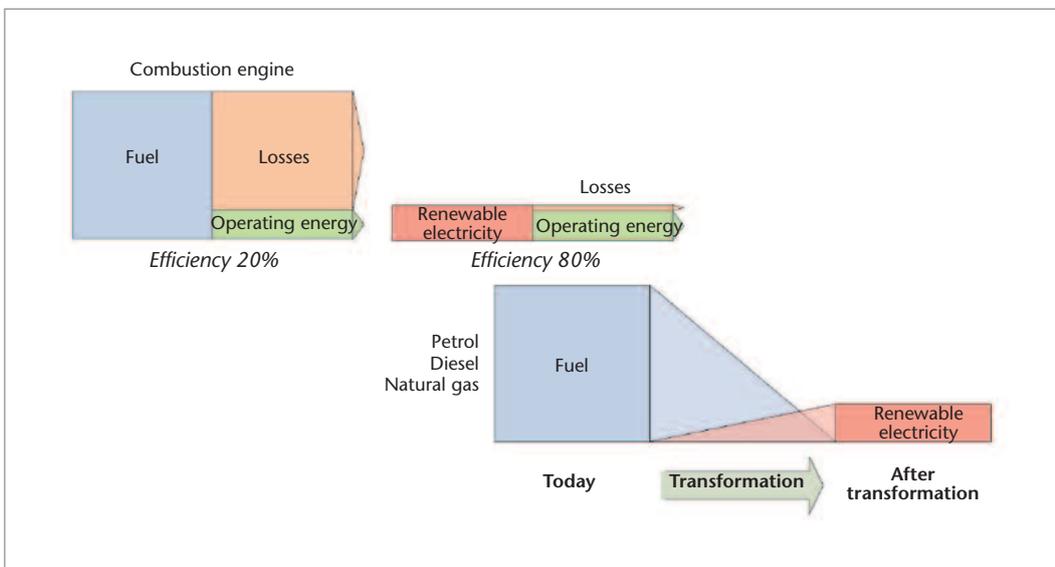


Figure 5  
Leap in the efficiency of the transport sector owing to electro-mobility

around 20%. Here, electromobility powered by regenerative energy is the most efficient alternative (Figure 5).

## Transformation of energy systems

The transition from today's energy system to a sustainable, zero emission system has to be conducted in a way that avoids misguided technological developments while ensuring supply during the transformation phase (no regret strategy).

As is already becoming apparent today, the increasing shares of renewable energies from wind and the sun in the energy mix will see the current load supply types – base, intermediate and peak load – disappear.

With an increasing share of fluctuating electricity sources, Europe needs a new, highly efficient electricity transmission system that on the one hand compensates the fluctuations resulting from local generation on a large scale (the wind will always blow somewhere in Europe) and on the other allows for the integration of the enormous storage power plant capacities, especially of those in Norway.

If the expansion of this trans-European super-grid takes too long or is incomplete, so-called residual-load power plants would have to compensate on a national level. In contrast to previously employed base and intermediate load power plants, these would include the fast-reacting gas power plants with combined heat and power and virtually connectable small-scale systems such as CHP stations, microturbines and fuel cells. Electrical energy storage as it is often proposed could, in principle, also provide for this compensation but it is not competitive with strong grids or residual-load power plants, at least not in the foreseeable future.

Today's large-scale power plants are not suitable for any kind of fluctuation compensation because they do not adapt quickly enough to power fluctuations. Suitable power plant types would include: gas power plants and combined heat and power plants (engine generators, microturbines, fuel cells) that can be controlled via the appropriate communications facilities.

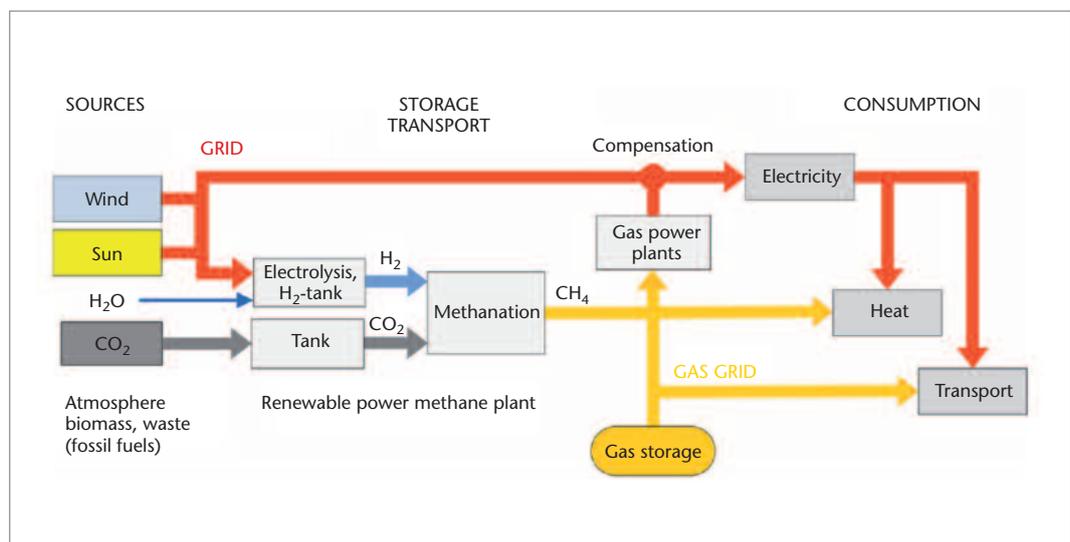
The expansion of natural gas-based power plants and combined heat and power could be started immediately. The initially growing demand for fossil natural gas is compensated in the medium term by the dropping demand for natural gas heating systems (with increasing combined heat and power and electric heat pumps).

The long-term natural gas demand will eventually drop to zero due to its substitution with sustainably produced biomethane and synthesised methane from electrical surpluses (Figure 6). This methane supply also implies that the future natural gas grid – just like the future electricity grid – must be able to handle varying directions of flow. To this end, new management strategies are required (smart grids). The current expansion rate of liquid gas terminals should be upheld in order to allow for an adequate capacity of, for example, methane produced by wind energy surpluses from particularly high-yield locations.

To offset the sharp increase in future fluctuations in solar and wind energy production, the following instruments are available:

- High-performance, high-voltage direct current transmission networks in Germany and Europe for coping with optimally located energy sources from wind and sun, for the large-scale horizontal compensation of power fluctuations and for the connection to large storage power plant capacities, for example to those in Norway.

**Figure 6**  
Conversion of wind, sun and biomass into SNG for storing renewables and distributing them with the existing infrastructure by coupling the electricity and gas grid  
(Sources: Sterner, Fraunhofer IWES and Specht, ZSW)



- Responsive, decentralised power plants (preferably combined heat and power plants or gas power plants) that are supplied via natural gas grids from biomass and waste-gasification plants with CCS or renewable methane produced from electricity surpluses.
- Interactive grids for electricity and gas (smart grids) in conjunction with load and feed-in management (combined power plants).

The environmental friendliness of electric heat pumps and electric vehicles, including trains, trams and buses, is improved with an increasing portion of renewable energies in the electricity mix.

A consistent implementation of this strategy does not require additional storage capacities for stabilising the electricity grids. However, this is true only for a pan-European concept. Close coordination on the one hand between all European member states and on the other by, for example, the European Commission is key for successful implementation.