100% Renewable Energies are Possible

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It is technically possible to supply Germany with 100% renewable energy, originated exclusively in Germany. There are several options for such a goal available. The key is a mix of energy sources in combination with effective energy saving methods. One of the possible scenarios is presented in this case study.

Constraints

The major topic of this study is *how* to achieve a 100% supply with renewable energies in Germany, especially to show the technical feasibility of such an effort. Only those technologies are considered, which are available or which are technically proven by pilot systems. The considered geographical area is exclusively Germany and all investigated energy sources are available here.

Today's energy consumption

The primary energy consumption in Germany is approximately 4000 TWh (billion kilowatt hours) per year (in 2002, quite similar as today). 1550 TWh are lost during energy conversion. Therefore, only 2450 TWh are actually available to the consumer as delivered energy (also referred to as "site energy"), including 500 TWh of electrical energy. Only the delivered energy will be considered further.

Delivered energy is used in the several ways. Electrical applications (e.g. light, machines, information) use 350 TWh. Traffic consumes approximately 750 TWh. Here, the used amount of fuel is considered as delivered energy, and the sum also contains an additional part of the electrical energy consumption, e.g. for railways. The industry uses 200 TWh as process heat for temperatures above 200°C, as it is needed – for example – in aluminium or steel smelters. (also partly as electrical energy). The largest consumption of energy is used for heating of private, public and commercial houses. The 1150 TWh used for heating is nearly half of the total energy consumption in Germany.

Energy savings

Supposed,
all houses were thermally insulated according to the state of the art,

the average fuel consumption of cars was only 3.3 l/100km (instead of today's 7.2 l/100km),
2/3 of the long-distance goods traffic were shifted to railways,
stand-by circuits would not need any power, and
high efficient and intelligent lamps were used,
Then
1100 TWh per year could be saved. This corresponds to approximately 40% of the actual delivered energy. In the future, we then would need only 1350 TWh per year.

Renewable energy sources

Solar energy: Supposed, every suitable roof and façade were equipped with solar panels, then an area of 2100 km² would be available for the generation of solar energy. This would produce 190 TWh electrical energy and 42 TWh heat energy per year. Additional areas for solar panels could be acquired above and beside traffic areas and on wasteland remaining from surface mining.

Hydropower: Hydropower can be extended up to 33 TWh per year by re-activating old hydroplants and by building more run-of-river power stations. This would provide 6.6% of the electricity produced in Germany.

Wind energy: Supposed, all inland federal states (especially in southern Germany) increased the density of wind generators to at least 7 per 100 km² (which corresponds to the density achieved in Northrhine-Westfalia),
the existing wind generators were replaced by new models, and
the potential of off-shore wind parks was realized.
Then, more than halve of the current electrical energy consumption could be generated by wind power (in total 270 TWh per year, corresponding to 54% of the yearly electrical energy consumption).
Geothermal Energy: Supposed, district heating grids are extended into all urban areas and supplied by geothermal energy.
Then approximately halve of the future heat demand (225 TWh per year) and 5% of the current electrical energy consumption could be generated by geothermal energy. Furthermore, 150 TWh of heat energy can be generated decentralized using heat pumps.
Biomass: Supposed, forests were managed sustainably,
spare areas (approx. 20% of the agricultural land) were used to grow plants that can be used for alternative fuels and
all organic waste like stray, waste wood, as well as sewage gas were used effectively.
Then the energy needed for the future traffic can be generated by biomass (330TWh per year), mainly as biogas and fluid fuel. Furthermore, 90 TWh per year should be usable as heat from combined heat and power (CHP) generation.

How matches the energy generation the need?

The sum of all energy contributions extends the future energy need of 1350 TWh per year. Figure 1 shows the relation between the different energy sources and the applications. Biomass is preferably used as fuel for the traffic. The heat processes in the industry are supplied by mainly electrical energy and partly by biomass (especially biogas). A mix of geothermal energy, heat pumps and heat from CHP generation, can realize the heating of houses.

Literature

[1] Homepage of the author Eberhard Waffenschmidt: http://www.waffenschmidt.homepage.t-online.de

[2] Homepage of the Solarenergie Förderverein Deutschland e.V.: http://www.sfv.de

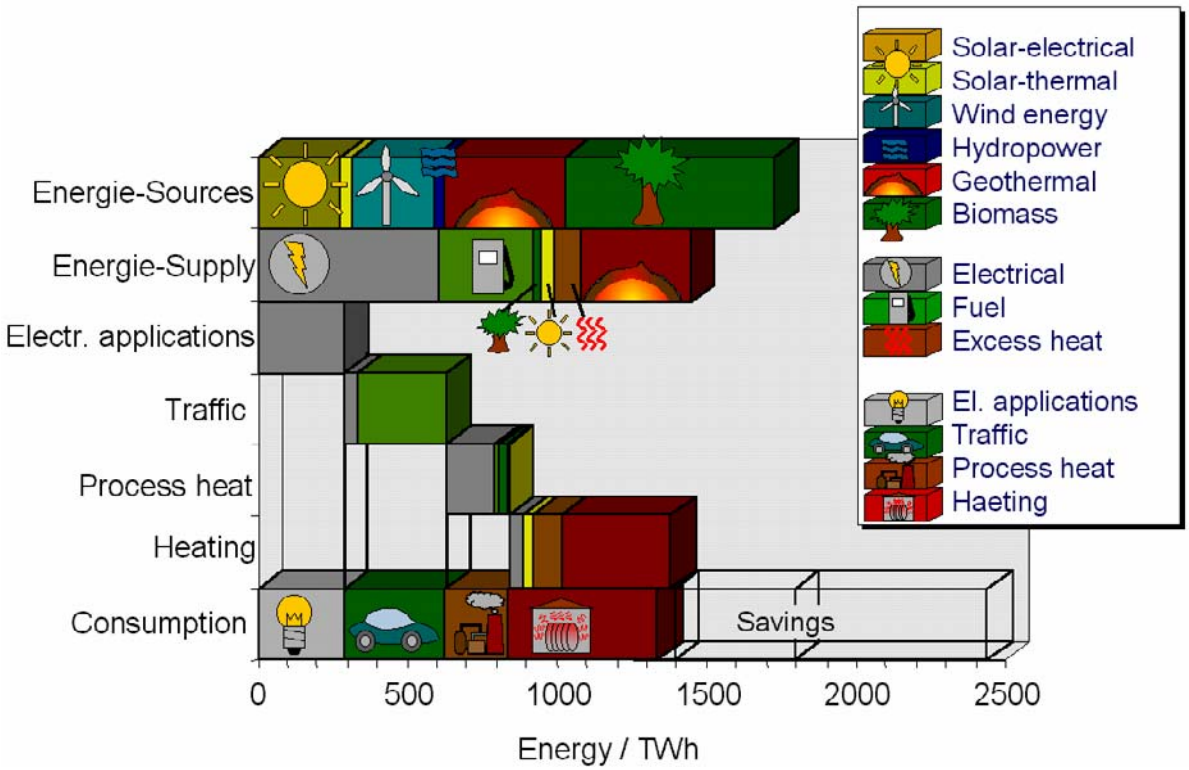

Figure 1: Energy flows in the assumed scenario.