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Sustainable Energy Systems

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A transformation of today's global energy systems towards sustainability is necessary for at least three reasons:

- Protection of the natural life-support system
- Eradication of energy poverty in developing countries and
- Promotion of peace by reducing dependencies upon oil reserves

Sustainable energy systems have to fulfil not only ecological criteria, but social and economic criteria as well.

An exemplary sustainable energy scenario, developed by the Advisory Council to the German Government on Global Change (WBGU, www.wbgu.de), will be presented. This scenario is approximately characterised by (i) a strong global economic growth, (ii) the efficient use of energy, (iii) a restricted use of fossil fuels (including carbon sequestration for a limited time span) and (iv) eventually an extensive use of renewable energy sources. Among the different renewable energy sources, solar energy has by far the largest potential. The utilisation of wind, hydro and biomass will contribute considerably to a future energy supply system, their potential, however, is limited when applying strict sustainability criteria.

According to the WBGU analysis, the main (traded) energy carrier of the future will be electricity and probably hydrogen (or hydrogen derivatives). By the end of this century, electricity will be produced mostly via photovoltaic energy conversion (solar cells) and solar thermal power plants.

The principles of photovoltaic energy conversion, its status and its future potential will be discussed. This will include a short thermodynamic analysis of this conversion technology for solar radiation. An efficiency value for conversion well beyond 40% seems feasible.

The levelling out of variations and fluctuations in electricity flows in a global energy system (based strongly on renewable energy sources) will be addressed briefly.

For several years, the global photovoltaic market has shown growth rates of more than 30%/a. Average price reductions of 20% at each doubling of the global shipment have been achieved. In spite of these results, both a further cost reduction for renewable energies as well as the inclusion of social costs in the prices of fossil and nuclear energy are essential. Since global energy production on the basis of renewable sources is just starting, the transformation of the global energy system will – even under the growth rates mentioned – require the time span of almost a century.