NOBEL SYMPOSIA

Report from the lecture presented by Joachim Luther

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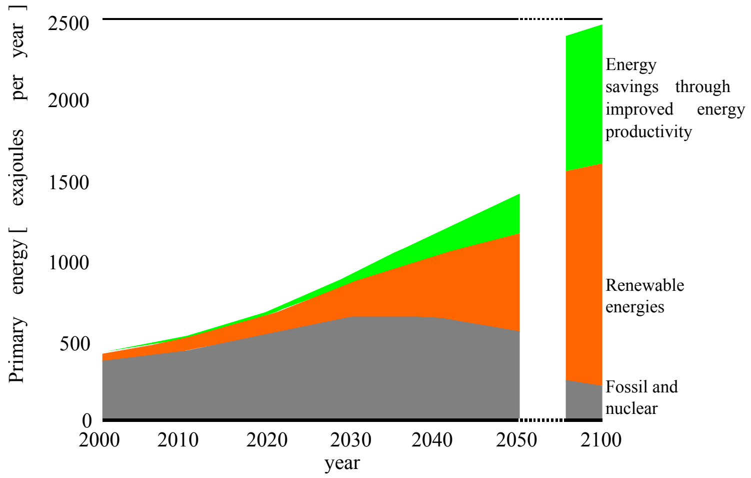
Joachim Luther is the director of the Fraunhofer Institute for Solar Energy Systems, in Freiburg, Germany (see http://www.ise.fraunhofer.de/). Luther started off his interesting and inspiring presentation by establishing three objectives that sustainable energy systems have to meet: (i) Protection of the environment, (ii) eradication of poverty in developing countries and (iii) the promotion of peace by reducing dependence on oil. He then moved on to focus on environmental issues, in particular the problem of climate change.

He established two criteria for climate protection: that the global average annual surface temperature should not increase by more than 2°C above pre-industrial levels, and that the rate of temperature change should remain below 0.1°C/year. He then presented a global energy scenario that met these criteria at the same time as global income grew at a rapid rate. The scenario was developed by the Advisory Council to the German Government on Global Change (WBGU, www.wbgu.de).

Rough primary energy portfolio, exemplary path of WBGU



Source : www.wbgu.de

The reduction in carbon emissions was achieved through a combination of improved energy efficiency, an increased use of renewables and carbon capture and storage applied to fossil fuels.

When it comes to renewables, Luther pointed out that hydro already makes an important contribution but that the physical potential is rather limited. Adding social and environmental constraints imply that it cannot be expected to play anything but a minor role in the global energy system. Biomass is a low cost option that can make a larger contribution than hydro, perhaps in parity with the current global oil supplies, but due to the land intensive nature of biomass land constraints will also limit biomass to perhaps 10-30% of the global energy supply.

Luther pointed to the large physical potential for solar energy. He showed a map which demonstrated that only a very minor share of the earth's surface, if covered with solar PV, would be required to provide the world with enough energy to meet the expected needs over the coming century. Also Carlo Rubbia, in a separate presentation, showed a similar map.

Nuclear energy also has the potential to supply the world with large amounts of essentially carbon free energy. Nuclear energy comes in two forms, fission and fusion.

Since fusion is still far from being a proven commercial technology, Luther focused on conventional nuclear and concluded that its problems, primarily with nuclear proliferation are too large to make it an attractive technology for the future. One problem is that the fuel production for light water reactors (the dominant design) requires uranium enrichment and this technology can also be used to make bomb grade uranium (and in a sense become a "virtual" nuclear weapons state). Another problem is that some 200 kg plutonium is produced in nuclear reactors per year (and this material can be used to make plutonium bombs). Interestingly, also Rubbia shared Luther's views on the problems with conventional fission reactors (see the review of his talk).

He then spent the remaining half of his presentation on describing the principles solar energy, in particular solar PV, and the current status and the future potential. Solar energy technologies can be used to produce electricity, heat or hydrogen. As for electricity production, there are two distinct technologies solar thermal and solar pv. Thermal technologies function in the following way: concentrators reflect solar energy onto a medium, e.g., water, which vaporises and flow through a steam turbine and electricity is produced in a generator.

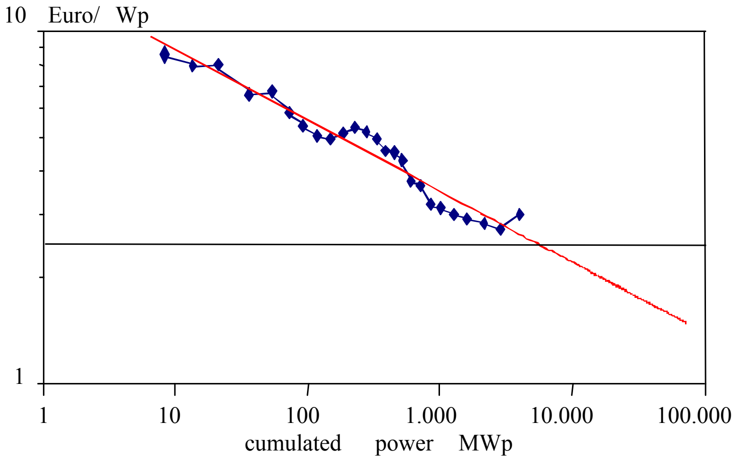
Solar PV converts sunlight directly into electricity without any moving parts. Photons in the sunlight knock out electrons in the photovoltaic cell. In order for this to generate useful electricity the solar cell material needs to have an internal voltage difference. The amount of useful energy a photon can generate is equal to the bandgap in the material. If the energy content of the photon is higher than the bandgap, then the excess energy will be released as heat. If the photon energy is lower, then no electricity will be generated. Thus, given that solar energy contains a spectrum of photon energies, it is important that the bandgap is neither too high nor too low.

Crystalline silicon is the most common choice of material for solar cells. They are typically a few hundred microns thick, but efforts to bring down costs focus on ways to cut the thickness. In laboratory experiments, tests on cells with a thickness of 50 microns are now tested.

Other materials include amorphous silicon, GaAs, Cu(In,Ga)Se_2, or CdTe. In order to raise the conversion efficiency, multijunction cells, where a combination of materials with appropriate bandgaps are combined, are tested. One may also increase the efficiency by using concentrators in combination with solar cells.

Luther pointed out that research on solar energy technologies alone is not sufficient. It is also necessary that niche markets are found and exploited by companies so that learning-by-doing in real commercial situations is made possible. He showed a graph that demonstrated that such learning-by-doing is actually taking place today. World wide, the sales of PV cells have increased by more than 20%/year for the past two decades, and costs have come in down in line with the experience gained.

Si Flat Plate PV Modules, Price Experience Curve



1 Euro = 1,2 USD

Source: PSE GmbH, 2005

Finally, some personal reflections. Luther did not discuss much politics or economics of the energy systems transformation (of course discussing both future energy scenarios and solar cells technologies in 40 minutes is quite an achievement in itself). Clearly, technological change in the energy system is not only a question for scientists and engineers. Rather, there is a need for government policies that offer incentives to use renewable energy and disincentives to conventional uses of fossil fuels. The perhaps most important incentive would be to raise the cost of emitting CO_2. In the absence of such policies, it is likely that coal will dominate the global energy supply during this century (the coal reserves are very large!).

In addition, there is also a need to increase government spending on not only research and development on the more advanced renewable energy technologies, but also to create niche markets (e.g., government subsidies to PV sales) so that learning by doing is enabled. Similarly, there is also a need for governments to introduce policies that lead to improved energy efficiency in the economy. Luther agreed in response to a question from the audience that such policies, e.g., energy efficiency standards in buildings, are of importance.

Last, but not least, such policies are clearly controversial for a variety of reasons, but they are probably needed if we are to be able to solve the perhaps biggest environmental problem humanity has ever faced. It would have been interesting if there had been a discussion about which role scientists can and perhaps even should play in such controversies (and here I am not only thinking of global warming and energy issues, but also of controversies in other fields).