Electricity from solar cells

In Central Europe, photovoltaic energy conversion from solar cells has by far the greatest proven technological potential for the production of electricity from renewable energy sources. Yet its current contribution to the electricity supply is still at levels that are insignificant in terms of the energy industry. Although photovoltaics has had annual global growth rates of over 30 % for the past decade or so, it will take several decades before it can make a perceptible contribution to German electricity supplies. In the long run, however, this energy conversion technology will prove to be one of the most important pillars of a sustainable energy supply system.

Continued committed market development of photovoltaics technology will be essential if it is to become one of the major components of a future energy system. We may assume that photovoltaic electricity, which is still very expensive in comparison with electricity from the grid in industrialised countries, will fall to price levels which, taking into account external costs in the energy system, will make it economically competitive. Where it is used in standalone applications, where electricity from photovoltaic conversion is able to compete with, say, battery-produced electricity or diesel-electric energy transformation, or compared to the costs of grid expansion, solar electric power is already commercially competitive in most cases. This sector of photovoltaics encompasses a good third of the world market.

The essential condition for a large-scale activation of the potential of photovoltaic electricity production is a further significant fall in costs. This will be supported mainly by research oriented towards the long view, both into the basics of materials and processes and the concrete conversion technologies (cells, modules, systems). This can be achieved particularly by increasing efficiency, reducing material usage and developing high-productivity manufacturing technologies.

Like all regenerative energy technologies, photovoltaics too has big advantages from the ecological point of view compared to conventional technologies for power generation. Using current state-of-the-art system technology, a photovoltaic installation in Central Europe will generate the energy used for its production in about three years. There will be further large reductions in this energy payback time in the near future as new technologies are used.

R&D requirements

As it is not yet possible to finally assess the various technological approaches in respect to their long-term development prospects, it is necessary to continue to support the wide range of different photovoltaic technologies:

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Silicon solar cells

Up to now, progress in solar cell technology has been achieved almost exclusively by developing the already sophisticated silicon wafer technology which dominates the market. This technology consists of processing monocrystalline or multicrystalline wafers that are 200-300 µm thick. The potential for further cost cutting is, however, far from being exhausted.

Above all, this involves developing new technologies aimed at:

- Using thinner and even ultra thin siliconwafers
- New kinds of cell structures
- Achieving higher efficiency
- Simpler process technologies
- Lower-cost production of solar silicon (solar-grade Si) and thin silicon wafers

Thin-film solar cells

Thin-film technologies are considered to have a high potential for cutting costs:

- CIS (copper indium sulphide, a.k.a. chalcopyrite) and CdTe (cadmium telluride) thin-film solar cells
- Silicon thin-film solar cells (amorphous and crystalline)
- Modified production technologies
- Thin-film solar cells based on dyes and organic semiconductors
- Research into materials and processes for thin-film technologies

Module technology

Photovoltaic cells need to be enclosed in order to ensure the reliable long-term operation of the energy converters and to enable their integration into building and technical structures. Research and development issues include the following:

- Development of processes for significantly increasing the service life of the modules
- Development of new electrical circuitry types in the module technology
- Development of modules adapted optimally, from an aesthetic and mechanical point of view, to the respective applications, e.g. flexible modules for curved surfaces.

Basic research

To achieve cost reduction, completely new physical approaches should also be pursued. Examples of these R&D efforts are:

- To develop stacked solar cells having high efficiencies up to 40 %, e.g. by optical concentration of the sunlight
- Development of new building element structures for solar cells
- Solar cells with highly structured absorbers and nanostructured surfaces
- Optimized photon management
- Targeted semiconductor diagnostics

Service life analysis and recycling

As production capacity for solar cells grows, issues regarding recycling, service life and energy payback times will play an important role and will increasingly become the object of R&D projects aimed at:

- Reducing the material and energy input for production
- Reusability of the photovoltaic elements and materials

Photovoltaic power stations and systems

Photovoltaic power stations and systems will in all probability find a market in the medium term for the provision of peak load current (e.g. for operating cooling systems) with a capacity of several hundred kW through to large power stations on a MW scale. A broad range of R&D efforts will be necessary:

- Development of appropriate solar cells, concentrating optics, and mechanical system technology

PV system technology

The objective is to develop cost-effective photovoltaic inverters that deliver high reliability and a service life approximately that of the PV modules. This also includes alternating current photovoltaic modules with high module voltage and integrated long-life power inverters.