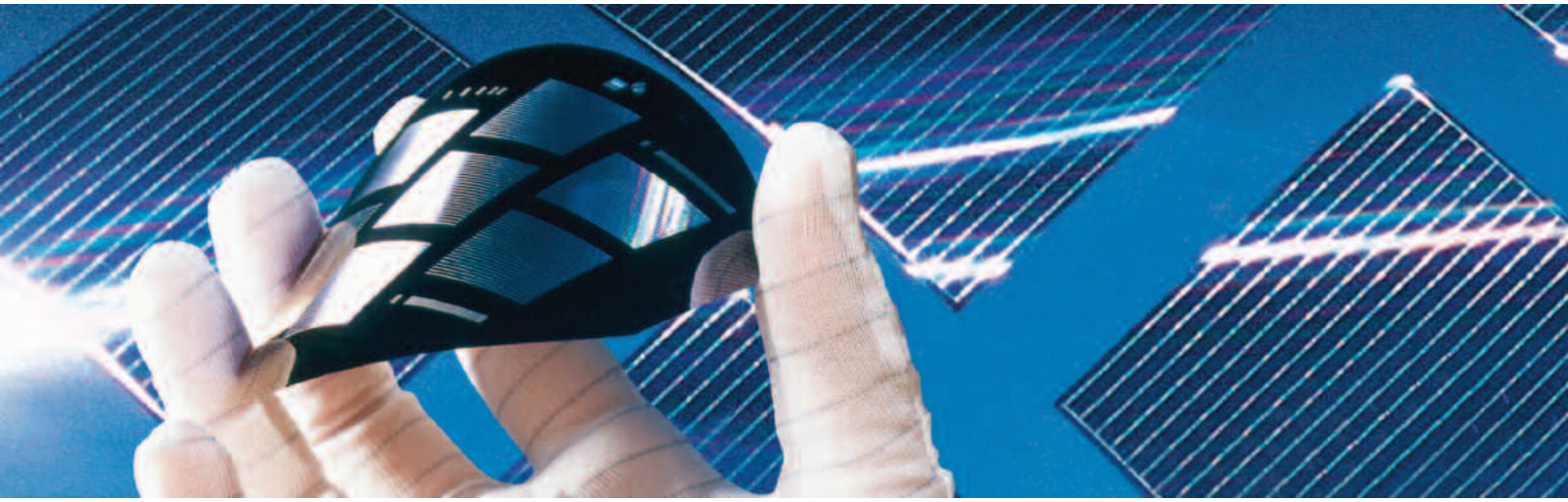
Electricity from solar cells



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, photovoltaics 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. Solar electric power is already commercially competitive in most standalone applications where it is able to compete with battery-produced electricity or diesel-electric energy transformation, or with the costs of grid expansion respectively. 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 cost reduction. This will be supported mainly by research oriented towards the long run, both into the basics of materials and processes and the specific conversion technologies (cells, modules, systems). This can be achieved particularly by increasing efficiency, reducing material usage and developing high-productivity manufacturing technologies.

Like all renewable energy technologies, photovoltaics offers major benefits from the ecological point of view compared to conventional technologies for electricity generation. Using current state-of-the-art system technology, a photovoltaic installation in central Europe will generate the amount of 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.

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Research and development 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:

Basic research

Completely new physics approaches are necessary to reduce costs. Some examples are:

- The development of solar concentrator cells with efficiencies of up to 40 %
- The development of new component structures for solar cells
- Solar cells with highly structured absorbers and nanostructures on the surface
- The development of photon management
- Target-oriented semiconductor diagnostics

Silicon wafer 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 silicon wafers
- New kinds of cell structures
- Achieving higher efficiency
- Simplified 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 (chalkopyrite) and CdTe thin-film solar cells
- Chrystalline silicon thin-film solar cells
- Amorphous silicon
- Nanocrystalline silicon
- Modified production technologies
- Thin-film solar cells based on dyes and organic semiconductors
- Research into materials and processes for thin-film technologies

Organic solar cells

Organic solar cells based on fluid semi-conducting mixtures can be applied to large flexible substrates by means of screen-printing. Despite their relatively short service lives and relatively low efficiencies, these cells could dominate niches on the market for off grid photovoltaics. The following areas are being researched for the further development of organic solar cells:

- Evaluation of new organic semiconductor systems with improved absorption of these solar spectrum and optimized charge transport properties
- Further development of current cell concepts
- Modified production technologies
- Module wiring
- Encapsulation, especially of flexible solar cells
- Light management

Module technology

Photovoltaic cells must be encapsulated to ensure the long-term, safe operation of these energy converters and allow for integration in construction and technical structures. The research and development issues include:

- The development of methods to greatly expand the service life of modules
- The development of new electrical wiring methods in module technology
- The development of module technologies optimally modified for the aesthetics and mechanics of specific applications, such as flexible modules.

Photovoltaic power plants and systems

In the midterm, photovoltaic power plants and systems will probably be available with an output ranging from several 100 kW to several MW to cover a peak loads (such as for the operation of cooling systems). Greater research and development is required for:

- The development of appropriate solar cells, concentrating optics, and mechanical system technologies

PV system technology

The goal is to develop inexpensive photovoltaics inverters that are highly reliable with long service lives that match those of PV panels. At the same time, the wide variety of system configurations that require customized inverters solutions must be taken into consideration.

To this end, cooperation with system analysis is necessary for the evaluation of PV systems and components in order to improve the reliable operation and design of PV systems.

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Lifecycle analysis and recycling

As production capacities grow for solar cells, recycling issues, technical service lives, and energy payback increasingly play an important role and move more into the focus of research and development projects:

- Reduction of material and energy consumption in manufacture
- Reusability of photovoltaic elements and materials
- Calculations of aging and creation of kinetic models for damage to PV panels