



## Project update

# Solar power to provide clean hydrogen energy

### Project details

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| <b>Project title</b> | Nano-structured electrodes for highly efficient solar hydrogen production by means of proton exchange membrane water electrolysis |
| <b>Participants</b>  | Fraunhofer Institute for Solar Energy Systems, Germany, University of South Carolina, United States                               |
| <b>Start date</b>    | 2008  |

### Key aims

- Conversion of solar power electricity into stored hydrogen energy
- Uncouple the link between renewable energy and demand
- Support development of an interim hydrogen energy infrastructure.

### Project summary

E.ON's International Research Initiative is backing a project to accelerate the availability of hydrogen as a clean, multi-purpose fuel produced from solar energy. This work sets out to deliver a high-performance, low-cost electrolysis system, which converts the power of solar electricity into hydrogen energy whose only emission at the point of use is water. The central focus of the research is on innovating a unique type of electrode with nano structures which would generate hydrogen for storage and mobile applications of renewable energy. This approach could help overcome two of the main challenges in renewable energy -

matching availability to demand and the ability to transfer energy to where it is needed. Project co-ordinator from the Fraunhofer Institute for Solar Energy Systems in Freiburg is Dr Tom Smolinka, while the University of South Carolina in Columbia is represented by Professor John Weidner of its Center for Electrochemical Engineering. The new electrodes are to be used in the proton exchange membrane (PEM) electrolysis of water - splitting it into hydrogen and oxygen - which is seen as an important process in future energy systems. The high costs and limited life of electrodes in current electrolyzers are to be overcome

by using nanotechnology to develop the new electrodes which will have three key advantages:

- A high degree of activity in electrolysis of water
- Stability in the acid environment of electrolyzers which use PEM technology
- Low costs, a minimized loss mechanism and a longer life.

PEM electrolysis may serve as a bridging technology, providing local, carbon-free solar-generated hydrogen before centralized, large-scale hydrogen production facilities are developed.

## Progress report - 1

**The initial development work involved the complex materials needed to construct the novel membrane electrode assemblies (MEAs) which are the centerpiece of the project.**

Team members synthesized a selection of structures - called catalyst supports - which will ultimately become the anodes and cathodes in the assemblies.

These structures comprise a highly conductive material based on titanium oxide (TiO<sub>2</sub>) through which electrocatalytic nanoparticles are widely scattered: mixed metal oxides for the anodes and platinum for the cathodes.

This is a new material that is part of a new approach designed to advance

the electrolysis of water using PEM technology.

Catalyst supports were made while applying a number of synthesis conditions. The resulting structures were then examined to characterize their essential properties including crystal structure, electrical conductivity, surface area, catalyst particle size distribution, electrochemical activity and corrosion resistance.

Optimizing these properties has a critical effect on the performance, lifetime and cost of the electrodes.

As part of another work topic, preparations began for testing the MEAs. One focal point will be the MEAs' performance and how it is affected by

fluctuating and intermittent renewable energy sources.

Two purpose-designed test facilities are being constructed. One is a test cell for PEM water electrolysis and the other is a test bench to examine the electrochemical characteristics of individual test cells.

Some initial steps were also taken towards the final stage of the project in which economic assessments will be made of the MEAs in comparisons with current similar state-of-the-art technologies. Information is being gathered on MEA production in conjunction with manufacturers.

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## Project update

# Cooler homes from solar-powered mini-chillers

### Project details

**Project title** Solar cooling for private housing - development of a compact, thermally-driven absorption chiller for domestic air conditioning using membrane and nanotechnology

**Participant** Fraunhofer Institute for Environmental, Safety and Energy Technology, Germany

**Start date** 2008

### Key aims

- Development of efficient air conditioning and cooling units using solar power
- Reduce the high level of consumption of fossil-fuel energy in buildings
- A cooling system technology with no potential to cause ozone depletion or global warming.

### Project summary

A new type of residential cooling system that is scaled down with nanotechnology and powered by solar energy is receiving funding from E.ON's International Research Initiative.

Compact units, which can also provide heating and hot water, will adapt the efficiency and versatility of absorption chillers, whose size and weight have previously prevented their use in homes.

Nano-scale innovation will be applied to develop the advanced heat transfer and cooling technologies.

The use of solar power maximizes the role of renewable resources. As the demand for cooling and ventilation rises in line with the availability of solar energy, this could reduce summer time peak loads on fossil-fuel generating plant.

This project comes from the Fraunhofer Institute for Environmental, Safety and Energy Technology in Oberhausen. It was put forward by Dr Christian Dötsch, Leader of the Energy Systems Department, and Peter Schwerdt, a member of the department.

The concept is to utilize the principles behind absorption chillers which are widely used for cooling in hospitals and universities. This brings the challenges of reducing the sizes of both the heat absorbers and the cooling towers which use water.

The project could make a particular contribution to meeting the need for air conditioning where demand is outstripping generating capacity in some parts of the world and has caused a reversal in the peak demand period from winter to summer.

## Progress report - 1

### Research is moving forward on several fronts with the aim of unlocking the main scientific challenges in this project.

The initial phase of the work was to ensure that accurate, comprehensive, knowledge of the technology being developed was obtained.

This involved compiling published information and market data in four areas:

- Small-scale thermally-driven chillers
- Membrane absorption technologies
- Surface technologies
- Self-cleaning structures.

The focus then moved on to laboratory activities which included the modification of a module for testing absorber membranes, and the design and construction of a new version.

One of the project aims is to apply

nanotechnology to scale down large conventional chillers which operate with falling film heat and mass exchangers.

The team is developing a compact stack absorber using membranes with nano-scale pores and hydrophobic coatings to achieve a high efficiency heat and mass transfer.

To support this work, investigations were made to find suitable membranes for the liquid/vapor interface in the absorption process. Samples for testing were obtained from manufacturers.

Nanotechnology is also being used in the development of the advanced cooler technologies which the new chillers will require.

The cooling tower arrangements in existing chillers will be replaced by a small dry cooler. This will function as a

hybrid unit with the ability to switch to a wet 'spray' cycle when a high level of cooling is required.

Special nano-coatings are being used to make this a viable solution which can operate trouble-free in the long term. The coatings will allow the heat exchanger surfaces to be made self-cleaning, which should overcome the common problems of wet cycles causing fouling and blockages, and requiring costly water treatment.

Development work on this hybrid cooler requires an experimental wind tunnel and the project team is modifying an existing facility to meet these needs.

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