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HOME
CURRENT ISSUE
NEWS
Stories
Briefly Noted
Events
Transitions
FEATURES
Opinion
Book Review
Opportunities
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ARCHIVES
H&FCL Back Issues
Bulletins

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Solar Hydrogen Technologies Are Highlighted at Solar PACES Conference

BERLIN – Hydrogen and solar fuels were high on the agenda of the 15th Solar PACES conference here September 15-18, the first of what will now be an annual event instead of the previous two-year cycle.

The conference is the gathering point of representatives of 15 countries that make up Solar PACES (Power And Chemical Energy Systems), an international implementing agreement launched 30 years ago by the International Energy Agency (IEA). Its six tasks include development of concentrating solar electric power systems, solar chemistry research; concentrating solar technology and applications; solar heat for industrial processes; solar resource knowledge management; and solar energy, water processes and applications.

Of the roughly 200 papers and posters presented to the more than 700 participants during the four-day meeting, almost two dozen dealt with solar hydrogen production or solar water-splitting, including policy and marketing aspects.

The most newsworthy presentation perhaps was a paper describing "Test Operation of a 100 kW Pilot Plant for Solar Hydrogen Production from Water on a Solar Tower," by almost two dozen researchers from five countries. It described the first successful tests last year of the plant for two-step thermochemical water splitting on a solar tower at the "Plataforma Solar de Almeria" in Spain.

Watersplitter Developed by German DLR Agency

The HYDROSOL and HYDROSOL-2 concepts, developed by the German aerospace center DLR is based on the two-chamber solar receiver-reactor built earlier and tested in a solar furnace at DLR's operations center in Cologne, Germany (H&FCL Nov. 2004).

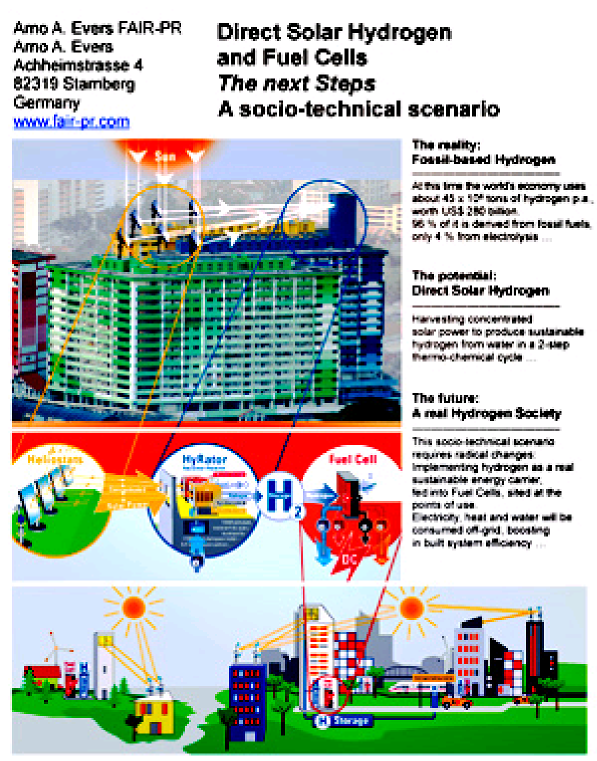
The process employs multi-valent iron-based mixed metal oxides as reactive materials which are coated on honeycomb absorbers inside the receiver-reactor. The device employs two reaction chambers for the two steps, permitting both steps to be run at the same time, the water-splitting process itself in which the reactive material is oxidized, freeing the hydrogen, and the subsequent regeneration step where the material is reduced again in "quasi-continuous" water splitting.

Thermal tests were run last summer to validate operational and measurement strategies, to check the controllability of the whole system, and other aspects. For example, the feasibility of using air flow mass as a means of controlling operating temperatures was tested since they influence the conditions of the chemical process. Ultimately, the scientists determined the preferred way of controlling process temperatures is by adjusting the mirrors themselves using different types of mirrors, some with very sharp-edged foci and others with very big images and low solar flux.

Overall, 93 individually tracking mirrors - heliostats - were available for water splitting (The total power of the Plataforma facility is about 1.5 MW), only a part of the total mirror field. In the two-chamber operation, steam is fed into the "east" chamber for the actual water splitting at 800 deg. C. At the same time, nitrogen is fed into the "west" chamber as flushing gas operating at 1,200 deg. C to release the oxygen from the metal oxide redox system. After a half-cycle of 20-30 minutes, a part of the heliostats are refocused from the west to the east chamber to achieve the needed temperature increase up to 1.200 deg. C, while the west chamber is cooled down to 800 deg. C., to proceed again with water splitting.

Up to 30% Steam Conversion

The bottom line, wrote the authors, was that "significant concentrations of hydrogen were produced with conversion of steam of up to 3o%."



Arno Evers' colorful poster, "Direct Solar Hydrogen: The next Steps," shown in somewhat different form at the Solar PACES conference. It shows heliostat-equipped multistory buildings and solar hydrogen power plants located in urban residential settings, among other things.

Analyzing the viability of different metals for hydrogen production in two-step thermo-chemical cycles, three Israeli researchers from the Weizmann Institute of Science, Rehovot, presented a paper, "Boron, Zinc, Tin and Cadmium as Candidates for Thermal Chemical Redox Cycles for Solar Hydrogen Production." Irina Vishnevesky, Alexander Berman and Michael Epstein reported metals with a lower molecular weight-to-valence ratio and with stronger metal-oxygen bonds demonstrated better hydrogen productivity and higher conversion and heat release during the hydrolysis reaction, but require higher temperatures or multiple steps for the oxides production. Their experimental results for these four metals confirmed that "the easier the oxidation (hydrolysis) step, the more difficult the reduction and vice versa."

Zinc represents a best compromise, accounting for its preferred use in earlier work (H&FCL Sept. 05). Next best was tin with lower temperature reduction and acceptable hydrogen productivity, they said. Boron is more difficult because of the higher cost of reduction equipment, and cadmium is "limited by serious technological challenges" in the hydrolysis step, they added.

A paper by three French researchers, Sylvain Rodat, Stephane Abanades and Gilles Flamant, of Promes-CNRS Laboratory, Font-Romeu, discussed "Co-Production of Hydrogen and Carbon Black from Solar Thermal Methane Splitting in a Tubular Reactor Prototype." It described a 10 kW solar reactor concept and prototype operating in the 1,740-2,070 K (1,466-1,797 deg. C) range. Carbon black is described as a high-value nano material, and unlike conventional steam reforming of natural gas, there are no carbon dioxide emissions.

The most important byproduct is acetylene with a mole fraction of up to 7%, depending on gas residence time, and the acetylene content in turn drastically affects the carbon yield. The researchers said higher temperatures allows more methane conversion, but long residence times lower the acetylene content in the off-gas and increase carbon yield. The paper also included a process analysis for a proposed 55 MW solar tower plant which, they said, could produce 1.7 tons of hydrogen per hour and 5 tons of carbon black at costs competitive with conventional steam reforming, if the carbon black is sold at current market prices. A 50 kW solar reactor is now under construction to provide more data.

Looking at policy and marketing aspects, Arno A. Evers, founder of Arno A. Evers FAIR-PR and retired head of the Hannover Fair's Hydrogen + Fuel Cells Group Exhibit, outlined some long-range global perspectives in his poster presentation, "Direct Solar Hydrogen - The Next Steps." Key points included a call for utilizing all existing renewable energies to produce hydrogen in only one conversion step, to be used principally in fuel cells. Ideally, this should be implemented in an - as yet not invented - Personal Power Provider, scaleable from milliwatt to megawatt as a collection, conversion and storage device for installation in homes, small companies, public facilities and small towns in the shape of not-yet-existing clusters of decentralized energy producing and distributing systems.

In Evers' view, a new global perspective regarding production, distribution and use of energy is unavoidable and has to come soon. Today, hydrogen is not used directly by the final consumer, but it has to become a common commodity, traded locally in the context of a worldwide, but personalized market.

Some of the other papers:

– "Solar thermochemical hydrogen production via sulfur-ammonia cycle" describes development steps for an advanced solar thermochemical water-splitting cycle in a joint project by Science Applications International Corp. (SAIC), San Diego, CA and the Florida Solar Energy Center, Cocoa, FL. The main goal is hydrogen cost of $3/kg by 2017;

– "Solar fuel production through the thermochemical decomposition of carbon dioxide" describes a process under development at Sandia National Laboratories, "Sunshine to Petrol" (S2P), which employs a two-step thermochemical cycle to produce syngas via water or CO_2 decomposition for conversion to a liquid hydrocarbon fuel;

– "Solar H_2 production with rotary-type solar reactor in international collaborative development between Tokyo Tech (Japan) and CSIRO (Australia)" describes scheduled testing of the solar concentrating device developed by CSIRO;

– "On the modeling of monolithic reactors for solar hydrogen production" by researchers from four Greek research institutions reports on efforts to fine tune and optimize process parameters of the HYDROSOL solar reactor concept. *Contact/Source: Arno A. Evers, arno@fair-pr.com. Solar PACES website, http://www.solarpaces.org/*