Quarterly Progress Report

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Project Title: IEA Task 25: High Temperature Hydrogen Production Processes

Project Period: January 1, 2010 to March 31, 2010
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Other Key National Lab Researchers: Nathan Siegel (SNL/NM)

Sub-Contractors Funded through AOP Task: none

Industrial Partners: DOE STCH Project Consortium and IEA Member Countries and their Industrial Partners

DOE Managers: Rick Farmer, Hydrogen Production & Delivery Team Lead,

Project Objective: The objective of this Task 25 expert group working within the IEA/HIA (International Energy Agency / Hydrogen Implementing Agreement) is to enhance and create synergy between the different international research institutes and potential industrials involved in hydrogen production using high temperature processes (HTPs). This project is also the opportunity to gather the nuclear and solar community in a common task.

Background: The Task 25 work program is divided into 4 subtasks:
A) technical review of the different HTPs, B) comparative analysis of the HTPs, C) definition of a HTP project to be deployed within the next 10 years to demonstrate industrial feasibility and to validate techno-economic evaluations, D) development of communication tools. The task was initially a 3-year project, approved by the ExCo in May 2007. But in December 2009 an extension period of 1 year was approved in order to fulfil the Task objectives.

Status: The 5th official meeting of the group occurred on March 22nd in San Francisco. The meeting gathered 13 participants coming from 7 different countries and 9 different research institutes and universities or industrials. Due to location of the meeting, there were only few European attendees this time. In addition of the introducing round table, two general presentations were made concerning high temperature electrolysis (INL, USA), and thermochemical cycles (ENEA, Italy).

Firstly, S. Herring (INL) presented the global situation on energy consumption and particularly US Hydrogen consumption. Considering the different types of nuclear reactor developed in Gen IV Energy Conversion Program, high temperature steam electrolysis (HTSE) is the only H_2 production process able to be coupled with any reactor, even if high temperature reactor would lead to a better efficiency of the process. In July 2009, an independent review team for DOE recommended HTSE to be integrated with the NGNP in 2021. They also gave recommendations for further research (see Figure 1).

Figure 1: Recommendations for further research on HTSE

As H_2 will first be used to enhance gasoline, diesel and jet fuel production (on-board storage problem to be solved), co-electrolysis in a Solid Oxide Cell, to produce synfuel through syngas, is also developed by INL. To face the problem of long-term cell degradation, a global approach has been proposed (see Figure 2).

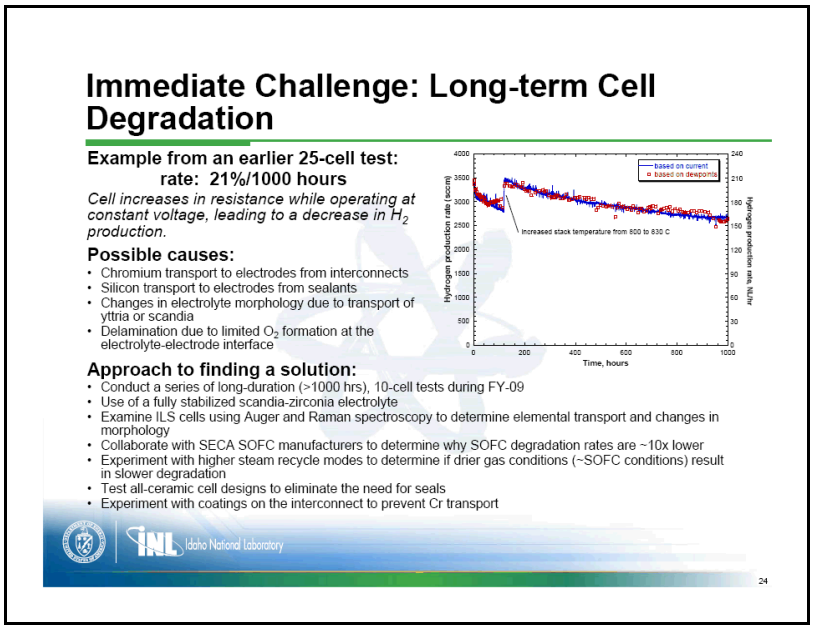


Figure 2: Long-term cell degradation

S. Herring concluded by presenting the progressive steps in the use of hydrogen produced through nuclear energy, from the upgrading of the heavy crude oils now, to the use in fuel-cell-powered vehicles in 2050.

R. Liberatore (ENEA, Italy) presented the main activities of ENEA on HTPs. The first one deals with solar methane reforming through the project MET.I.SOL, which is a global project, integrating all the different steps from the production to the end use. The second activity is ethanol reforming. Other activities at ENEA on HTPs: SI cycle and mixed ferrites cycle, are developed thanks to the national funding project TEPSI (Innovative Technologies and Processes for the Hydrogen System), and European project HYCYCLES. On the SI cycle, many research activities on the various steps of the process are in progress. A SI cycle bench plant (10 Nl/h) is now in operation (see Figure 3), in order to improve the know-how on the SI cycle management and demonstrate the feasibility before scaling up.


Figure 3: SI bench plant at ENEA

Future plans of ENEA are to continue research on bottlenecks and critical operations, especially experimental studies on a reactive distillation lab apparatus, and find funding for the pilot-scale demonstrator (100 m^3/h).

Subtask A - technical review of the different HTPs

C. Sattler (DLR) recalled the first objective of the "state of the art" in subtask A: updating the INNOHYP-CA database continuously, to give input on demand to the other Tasks. The main recent inputs are: new developments on HTPs and material (summarised in a chapter of the book to be published at WHEC 2010), additional countries (South Africa and Korea), revision of HTSE. Sattler described the current trends in solar fuels: the gas-to-liquid route (see Figure 4), the ferrites as dominant redox system (see Figure 5) and sulphur cycles, and pilot scale solar chemical reactors (50-500 kW) (see Figure 6).

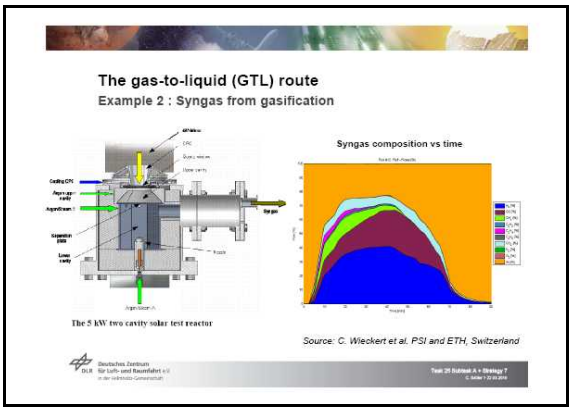


Figure 4: example of gas-to-liquid route

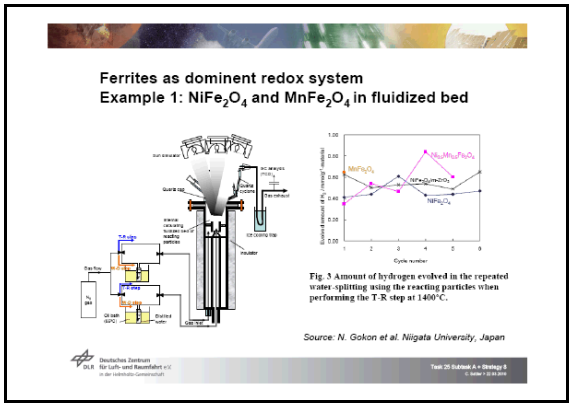


Figure 5: example of Ferrites studies

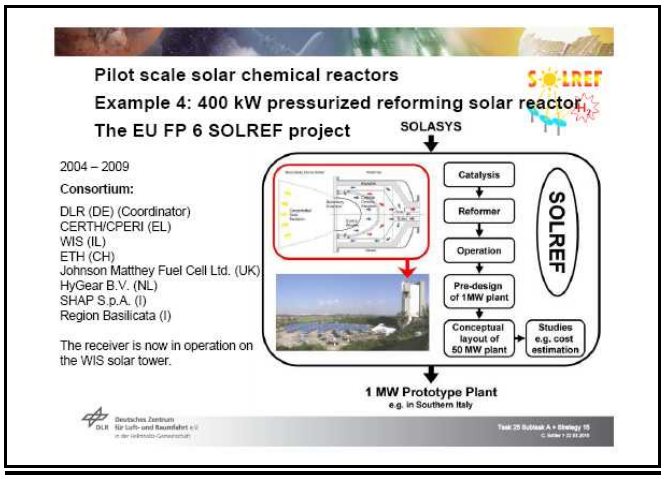


Figure 6: Pilot scale solar chemical reactor: SOLREF project

Concerning the trends in the nuclear field, the main studied HTPs are HyS (USA, Finland), CuCl (USA), SI (Japan, and Korea), HTSE (USA, France). The progress on VHTRs in South Africa and China is not well known to date.

Subtask B – Comparative Analysis of the HTPs

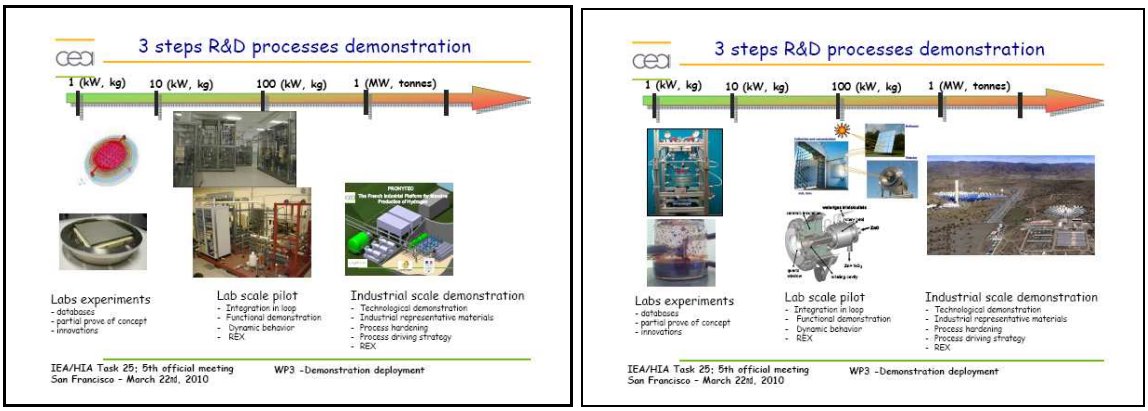
A multi-criteria decision analysis technique is being used by the working group to evaluate the HTPs that survived initial screening by the USA's STCH project and other international groups. The CO2-free cycles under consideration are shown in Table 1. The evaluation is being led by CEA and will be performed during the next 6 months. A rough draft of a future proposed journal article was prepared during the quarter that describes the technique.

Table 1 Cycles being evaluated by IEA working group

Cycle	Nuclear	Solar
AlkalineElectrolysis (baseline)	X	X
Sulphur Iodine	X	X
Hybrid Sulphur	X	X
Copper Chloride	X	X
Cadmium Oxide		X
Ferrite Oxide		X
High Temp Electrolysis	X	X
Zinc Oxide		X

Subtask C – Definition of HTP Demonstration Project

It appears that high temperature electrolysis will be the first HTP demonstration project and that France may be the leading contender for this project. François Le Naour (CEA, France) stated that oil and gas companies do not believe in water splitting except for long term scenarios, and energy and electricity companies bet on alkaline electrolysis using CO2-free electricity in the near term. Research institutes have to propose demonstrations at representative industrial scale to convince industrials and politicians of the technological feasibility and economic competitiveness (including the environmental impact) of HTPs. The demonstrations can be divided into 3 steps: lab experiments, lab-scale pilot, and industrial scale demonstration (see Figure 7). The CEA roadmap has focused on HTSE and foresees a 1 – 5 MW nuclear demonstration after 2018.



.Figure 7: 3-step R&D demonstration

Subtask D - Communications

Concerning communication, an oral presentation has been accepted for WHEC 2010 in the session dedicated to the IEA/HIA: “IEA-HIA Task 25: High Temperature Process for Hydrogen Production: Three year-progress review of the project”.

The web site e-doc developed for Task 25 has been continually updated. To date there are more than 180 relevant documents in this database. The group is asked to continue to send some documents to fill it. Fourteen flyers have been validated, thanks to the active participation of all the experts. The process flyer on HTSE will nevertheless be sent to S. Herring for a final validation.

Plans for Next Quarter and Key Issues: The IEA group will begin to implement the multi-criteria decision analysis technique and will prepare materials to be presented at the next meeting, tentatively scheduled for September 2010 in Helsinki, Finland.

Publications / Presentations:
“A multicriteria approach for evaluating advanced hydrogen production processes,” CEA, et. al., Rough draft.