

# Pathways to Solar Hydrogen Technologies

13 Jun 2016 through 17 Jun 2016 @Oort

## Science:

During one week, the workshop *Pathways for Solar Hydrogen Technologies* focused on scientific, economical and societal aspects of the production of solar hydrogen. Each day we discussed in detail specific aspects of solar water-splitting devices, including materials' development, component integration, device engineering, potential industrial applications, and broader societal impact of these types of technologies. Particular attention was given to identifying the hurdles that currently prevent the sustainable production of hydrogen via photoelectrochemical routes, and a roadmap was developed identifying short-term and long-term opportunities, and challenges for the deployment of the technology.

As a result of the discussions, a unified position was reached on technical areas of research that could positively impact the viability of solar hydrogen generators. Also, a roadmap identifying potential routes to bring lab-based technologies to the market (i.e. early-stage niche markets as well as long-term energy markets) was developed. It is our intention to publically disseminate this position in the form of multiple publications, one geared toward the scientific community and another written for the general public. Additionally, the journal *Energy and Environmental Science* sponsored three poster prizes for Ph.D. students that attended our workshop and the recipients were Lai-Hung Lai (AMOLF, The Netherlands), Timothy Rosser (University of Cambridge, UK), and Pieter Westerik (University of Twente, The Netherlands).

A concise vision and roadmap moving forward in scientific research and development for practical means to implementing solar H<sub>2</sub> technology was identified. This consensus is not common among such a large cohort of experts in this field, and therefore we think this is a success.

An eye-opening moment for many was the realization that the economic challenges to bring these technologies to the energy markets appear to be insurmountable in the medium term. This is due to the fact that the production cost of solar hydrogen will need to be reduced below the level of the cost of hydrogen production from fossil fuels (currently at <USD 2/kg of H<sub>2</sub> in the U.S.A.). Based on our current understanding of solar hydrogen technologies, and even considering foreseeable advances in the future, the group believed this target to be unreachable by photoelectrochemical water-splitting devices in the short and medium terms (10+ years).

## Organization/Format:

The workshop brought together 52 participants representing Asia, USA, and Europe, as well as the academic, industrial, and governmental sector. It seems that most found it important to discuss the challenges that need to be overcome to allow implementation of current laboratory-based technologies on a large scale. To break the routine with conventional conferences and workshops, we asked the speakers (3 to 4) of each morning to include a few questions, or to give a general direction in their assigned topic within their 20 min talks. Moreover, we asked them not to focus on their own research activities, but to look at and assess the challenges from a broader community-wide perspective. This was used as an initiator for discussion after each talk. The afternoon sessions comprised small group discussions that were chaired by two young researchers, which also received some guidelines, but had the freedom to include their own points of view.

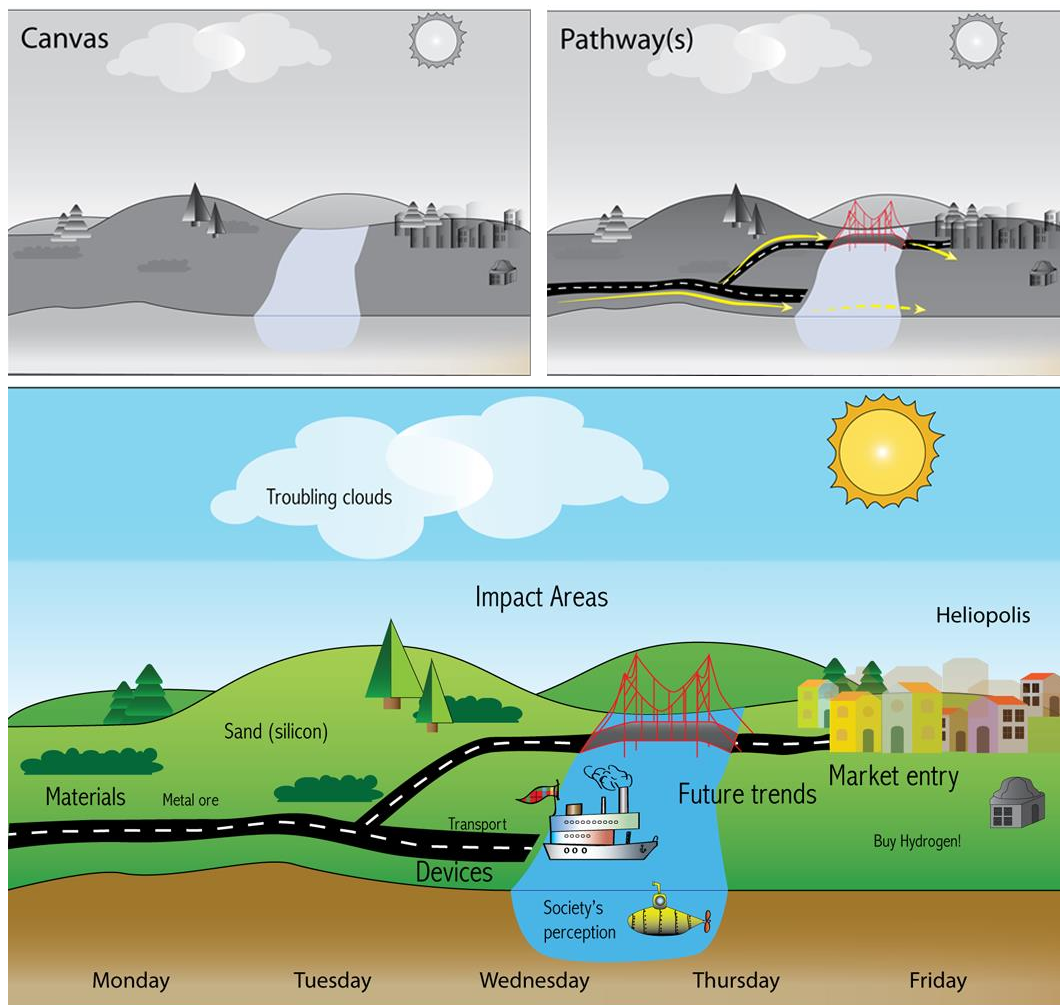
The topics of the talks included state-of-the-art and materials challenges at laboratory scale, device engineering aspects, current industrial applications, and governmental and societal perspectives of solar hydrogen within the future energy landscape. During the discussion sessions the participants were asked to evaluate challenges faced by particular device architectures such as PV+electrolysis, photoelectrochemical cells, and particle-based

suspension reactors. On the policy and market end, the participants debated about the role of solar hydrogen technologies in future scenarios where science and energy policy are driven either by the free market or by governmental policy. Also important, the participants contributed with their ideas of what are the earliest marketable examples of solar hydrogen technologies, and the advances necessary to bring solar hydrogen devices closer to market viability in the energy sector.

**Other comments,**

It seems that all the participants were impressed by the quality of the facilities, logistics, and accommodation provided by the Lorentz Center. As first-time organizers, our expectations were exceeded and we look forward to future event organization experiences.

In the following chart we illustrate how we envisaged the process of the whole workshop.



- Shane Ardo** Irvine, CA, USA
- David Fernandez Rivas** Enschede, The Netherlands
- Miguel Modestino** Lausanne, Switzerland
- Verena Stimberg** Enschede, The Netherlands