Generation of Hydrogen from Concentrated Solar Energy

Robert McConnell,[1] John Turner,[1] John Lasich[2] and Dave Holland[2]

[1] National Renewable Energy Laboratory
1617 Cole Blvd
Golden, CO 80401
USA

[2] Solar Systems
6 Luton Lane
Hawthorn
Victoria 3122
Australia

The production of hydrogen from solar energy has the potential to deliver a total energy solution. While solving the storage problems for solar, it also provides an energy medium which can be distributed as a fuel for transport use or be efficiently converted to electricity by a fuel cell at any point where it is needed. The energy source is inexhaustible and where electrolysis is used and the feedstock is water, requires no dependence on fossil fuel and creates no pollution in the generation or use of the fuel.

In progressing towards this target, it has become evident that solar concentrator systems have a number of unique attributes that could shortcut the development process and increase the efficiency of hydrogen production to a point where economics will then drive the commercial development to mass scale.

This paper will examine a number of different steps and pathways using concentrator technologies to produce hydrogen. Some with near-term promise are under development while others require additional research.

To support a variety of processes for producing hydrogen there are several different types of solar concentrators including low (reflective linear-trough and linear fresnel lens), medium (point-focus fresnel lens) or high concentration (dish-shaped reflective concentrators). Some types are more appropriate to thermochemical processing while all of them can produce electricity to run an electrolyzer.

Solar concentrators producing high temperature thermal energy can dissociate methane gas into hydrogen and concentrated carbon dioxide that can be sequestered. Groups in the U.S. and Australia have been exploring this concept. It is also possible to use solar thermal energy to crack methane (CH4) into hydrogen and carbon black. This approach produces a valuable co-product that can be sold (say to the automotive tire market) and lower the cost of the delivered hydrogen.

Concentrating solar energy to produce electricity can also generate hydrogen by means of an electrolyzer. The hydrogen can be stored on-site or transported via pipeline or truck with subsequent production of electricity from a fuel cell. The ability to transport hydrogen long distances via pipelines further increases the viability of the total system. The solar concentrator system can be sited for optimum utilization of the solar resource, and the transported hydrogen (representing stored solar energy) can provide electric power and transportation needs far away.

Another highly efficient process under development in Australia will use heat and electricity generated from a dish concentrator to produce stored hydrogen from a reversible electrolyser/fuel cell run in the endothermic mode. This system will have the capacity to deliver electricity or hydrogen on demand.

Hydrogen can also be produced from solar driven thermochemical cycles that split water. Cycles that lend themselves to a hot/cold (light/dark) cycle are of interest. A conceptual example here could be a metal (Me)/metal oxide (MeO) cycle or, in general, a metal oxide redox cycle.

We will review these and other solar concentrator systems, hydrogen generation processes and fuel cells, explaining their relative advantages and synergies. Some of the systems have relatively more advantages for the production of hydrogen. Continuing the research and development of the more promising systems increases the chances to produce hydrogen in clean, cost-effective approaches important to the world's energy future.