FUNDING PROGRAM FOR NEXT GENERATION WORLD-LEADING RESEARCHERS

Project Title: Development of Thermochemical Water-Splitting Hydrogen Production System utilizing Concentrated Solar High-Temperature Heat	
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1. Background of research

The greatly insolated “sun-belt” regions of the world include the South-western United States, southern Europe, Australia, north Africa, Middle East, etc. The reflection and concentration of direct insolation can be achieved by sun-tracking mirrors called collectors or heliostats. The concentrated solar radiation is focused upon a solar reactor where maximum temperatures can exceed more than 1000˚C in the sun-belt regions. The concentrated solar high-temperature heat in the reactor has the potential to produce solar hydrogen *via* multi-step thermochemical water splitting cycles.

2. Research objectives

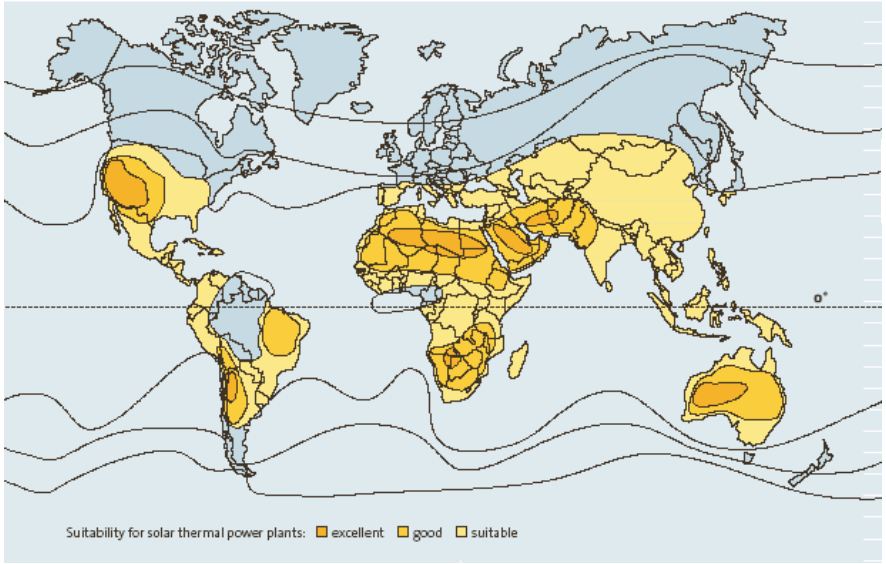
The project leader has developed a two-step thermochemical water splitting cycle by a metal oxide redox pair, capable of working below 1400˚C. The project leader also has proposed new concepts of windowed solar water-splitting reactor for the two-step water splitting cycle, “a foam device reactor” and “a particle internally-circulating fluidized bed reactor. These two reactor concepts have been successfully demonstrated in laboratory-scale experiments. The objectives of the research project are to examine which reactor concept is more promising in a lager scale, and to demonstrate performances of the promising one at solar in a large scale, combined with a solar concentrating system. The project aims at developing a prototype of highly efficient “solar thermochemical water-splitting system”.

3. Research characteristics (incl. originality and creativity)

Each of solar reactor proposed by the project leader has some scientific/engineering merits to improve reaction kinetics and energy efficiency in comparison to conventionally-developed solar water-splitting reactors —1) two cyclic reactions can be performed in one solar reactor, alternately or simultaneously, 2) larger surface area of the reactive redox metal oxides can react with steam for the gas-solid reaction, etc.

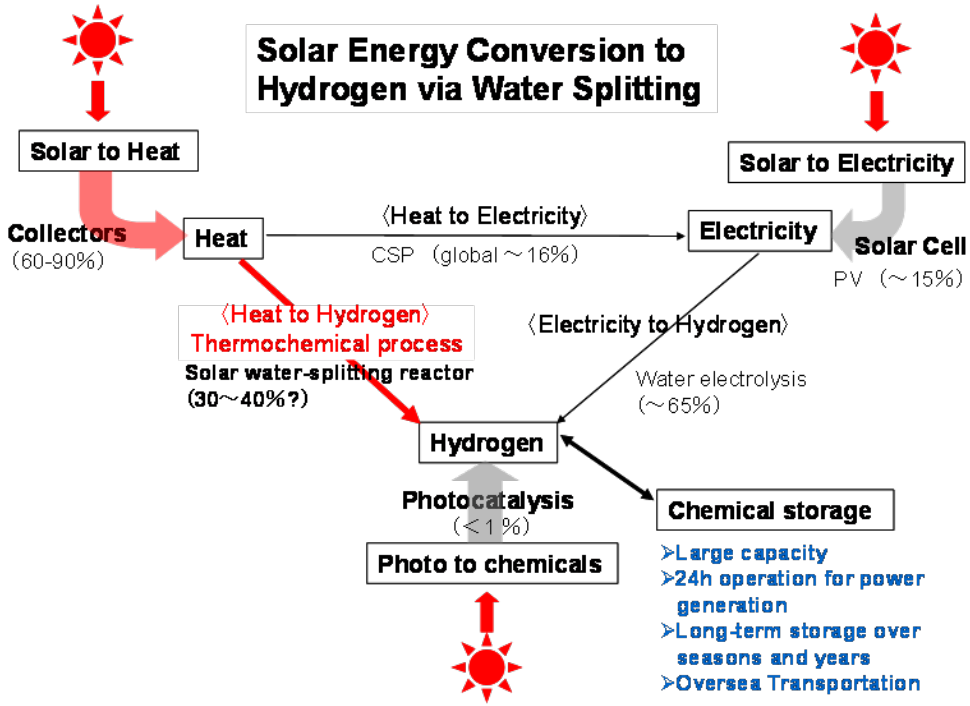
4. Anticipated effects and future applications of research

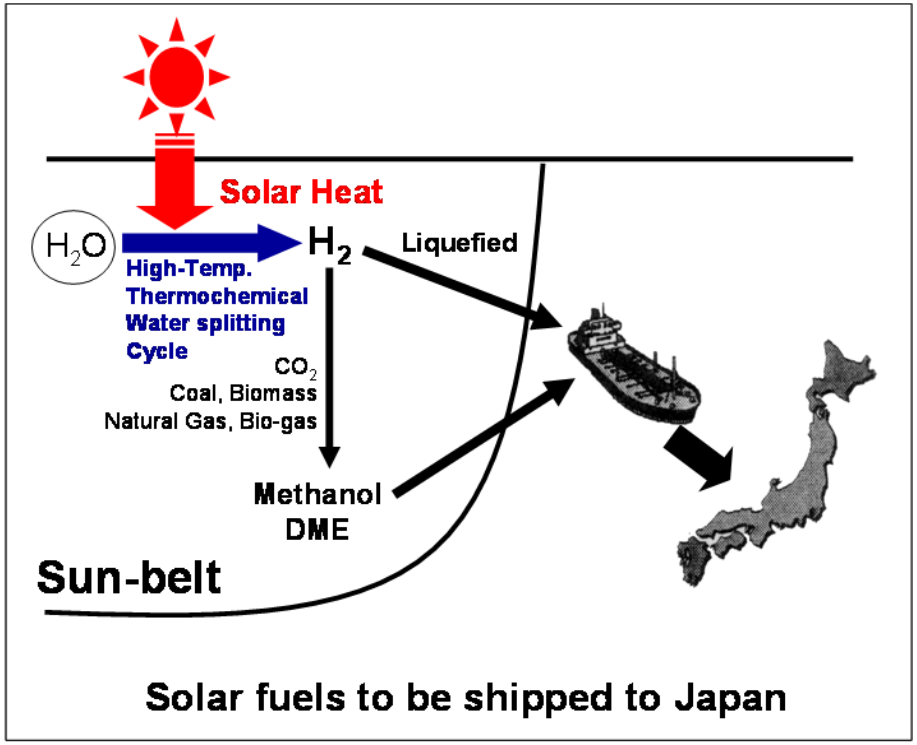
Economical and massive CO_2-free hydrogen production may be realized by applying the project-developed technologies. The solar processed fuels in sun-belt regions is expected to be shipped by tankers to Japan.



"Sun-belt" or "Solar-belt"
in which the strong and abundant solar radiation energy can be obtained.

- **The maximum direct insolation reaches 1 kW/m^2 in the sun-belt.**
- **The concentrated solar radiation is focused upon a solar reactor where maximum temperatures can exceed more than 1000˚C in the sun-belt regions. The concentrated solar high-temperature heat in the reactor has the potential to produce solar hydrogen *via* multi-step thermochemical water splitting cycles.**
- **The solar processed fuels, such as hydrogen, in sun-belt regions is expected to be shipped by tankers to Japan.**





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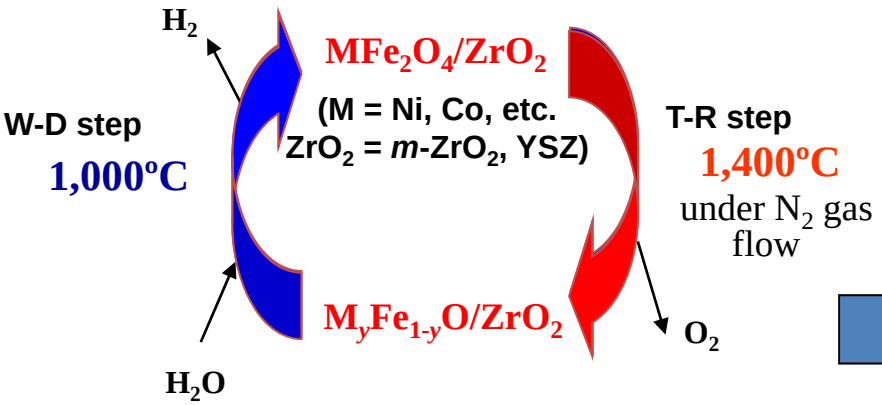
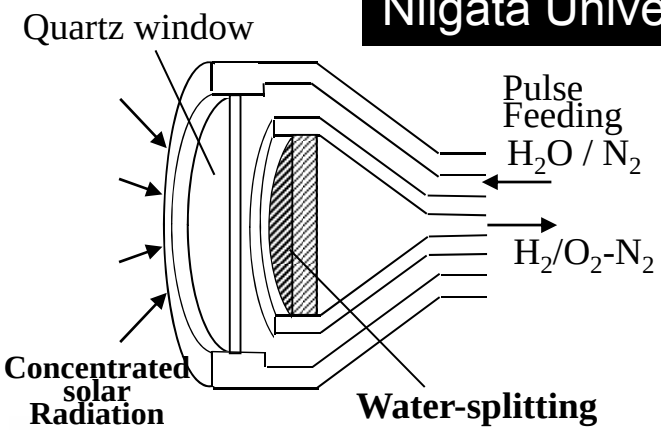
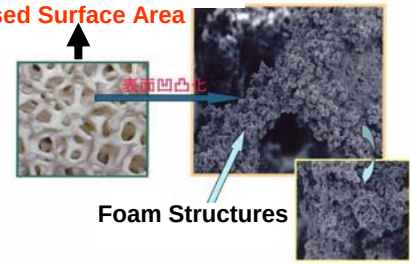
Two-step water splitting cycle by metal-oxide redox pair





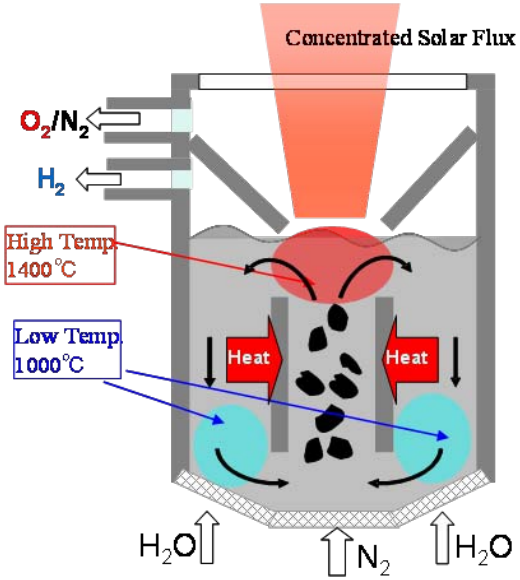
Much loading of redox material

Increased Surface Area



Coating with Redox Materials

Compare performances of two reactors, then select a promising one



Particle internally-fluidized bed reactor

To demonstrate performances of the promising one at solar in a large scale, combined with a solar concentrating system

Solar water-splitting reactor developed

Solar Concentrating system