Policy and Action Programs for Hydrogen Energy

K. Ochi, K. Itoh, H. Uchida

This document appeared in

Detlef Stolten, Thomas Grube (Eds.):
18th World Hydrogen Energy Conference 2010 - WHEC 2010
Parallel Sessions Book 4: Storage Systems / Policy Perspectives, Initiatives and Co-operations
Proceedings of the WHEC, May 16.-21. 2010, Essen
Schriften des Forschungszentrums Jülich / Energy & Environment, Vol. 78-4
Institute of Energy Research - Fuel Cells (IEF-3)
Forschungszentrum Jülich GmbH, Zentralbibliothek, Verlag, 2010
ISBN: 978-3-89336-654-5

Policy and Action Programs for Hydrogen Energy

Kazuyuki Ochi, Coordinator for Industry-Academia-Government Collaboration, Industrial Promotion Section, Planning and Economics Division, Saijo City, Japan
Kotaro Itoh, Mayor of Saijo City, Japan
Hirohisa Uchida, School of Engineering, Tokai University, Japan

1 Introduction

In 1981, the then-largest scale solar power testing facility in the world was installed in Saijo city (Figure 1), and thus largely influenced the expansion of solar power systems in Japan. Since that time, upon making “a city full of warmth, vitality, and ideal amenities” the goal for Saijo, we have laid out a new earth environment friendly policy that puts new-energy and reduced-energy at the focus. Since 2001, with the support of the Ministry of Trade, Economy, and Industry, NEDO (The New Energy and Industrial Technology Development Organization), and Tokai University, we have been able to implement carbon-cutting initiatives as well as reduced-energy technology into the agricultural sphere. Also, using the MH (Metal Hydride) freezer System powered by hydrogen storage alloys and waste heat, we have developed a detailed method for delivering clean hydrogen energy to farms and fisheries in Saijo.

Figure 1: A solar system test facility of 1,000 kW with 22,000 solar panels.

From 2007, the cooling technique made possible through factory emissions and the MH of hydrogen storage alloys were applied to hydrogen strawberry cultivation and above-ground fisheries, both of which have been successful. The cultivation of strawberries all year-round is now possible due to hydrogen energy. Furthermore, compared with Freon-based cooling systems or oil heater-based temperature control systems in greenhouses, this MH cooling technique is much more effective in cutting carbon emissions and cutting energy use levels. In this study, we shall detail potential applications of the MH of hydrogen storage alloys in both agriculture and fishery endeavours, as well as examples of how hydrogen energy is a clean energy source which acts kindly towards the environment while still aiding in food production technology.

Saijo city is blessed by a year-round temperate climate and a 5,000ha agricultural plain which is host to a multitude of crops produced, with a production value exceeding 15 billion yen (150 million dollars) annually.

The wide-open bay stretching to the north of Saijo is also blessed with natural resources, full of sea vegetation and sea creatures. The factories that stretch along this bay produce goods in value of 850 billion yen (8.5 billion dollars) annually, and the single most invaluable resource supporting these industries is water.

Within Saijo city, crystal clear underground water that is known as the “most delicious in Japan” springs forth naturally from myriad places, and is estimated to exceed 90,000 m³ daily. It is named “uchinuki” water and is beloved by all citizens.

Aiming for the independence and success of local neighbourhoods, we have initiated a new, forward-thinking policy towards the global environment which we hope will be continued by generations to come.

2 Experiments

2.1 MH cold water production system (Figure 2)

Figure 2: MH cold water production system.

Aiming from the fact that hydrogen energy is clean and kind to the environment and establishing the merits of hydrogen as an unwavering secondary energy source with a fixed unit price, in 2001 we established an MH freezer [1] research plan using hydrogen storage alloys where exothermic and endothermic heat reactions are used, and freezing is made by cyclic steps as defined in Figure 3.

The F-class MH freezer we established in December, 2002, had an output of approximately 11.6 kW/hr, and compared with a typical Freon-based refrigeration unit, it used 70% less power and less CO_2 emissions [2], thus proven to be more environment-friendly. In 2005, test plants were installed by the Ehime-based LLP "Tryout Ehime" for a C-class MH freezer with cold water production function with an output of approximately 2.3 kw/hr. Because the test plants actually manufactured a large amount of 5 °C water, they were converted for practical agricultural use in 2007, and experiments by Saijo city were begun.

2007 Condition and Performance of MH freezer with cold water production function

MH Water Cooling Device: Japan Steel Works, LTD.

Output: approx 2.3kw/hr(converted)

Type of Alloy: Low-heat use Titanium Alloy

Number of Alloy Tanks:

- High Temp Level (2 sets) (Φ: 210.7mm×L: 1,259×2set)
- Low Temp Level (2 sets) (Φ: 210.7mm×L: 1,099×2set)

Weight of Alloy Tanks:

- High Temp Level (20kg)
- Low Temp Level (18kg)

Alloy Weight:

- High Temp (36.0kg×2set)
- Low Temp (30.0kg×2set)

Energy Source:

- 420°C Metal Treatment Factory emissions (vapour),
- 95°C water made from that vapour,
- 20°C groundwater and purchased electrical power

Cycle Time (Please refer to Figure 3 for the definition.): 11 minutes as a base

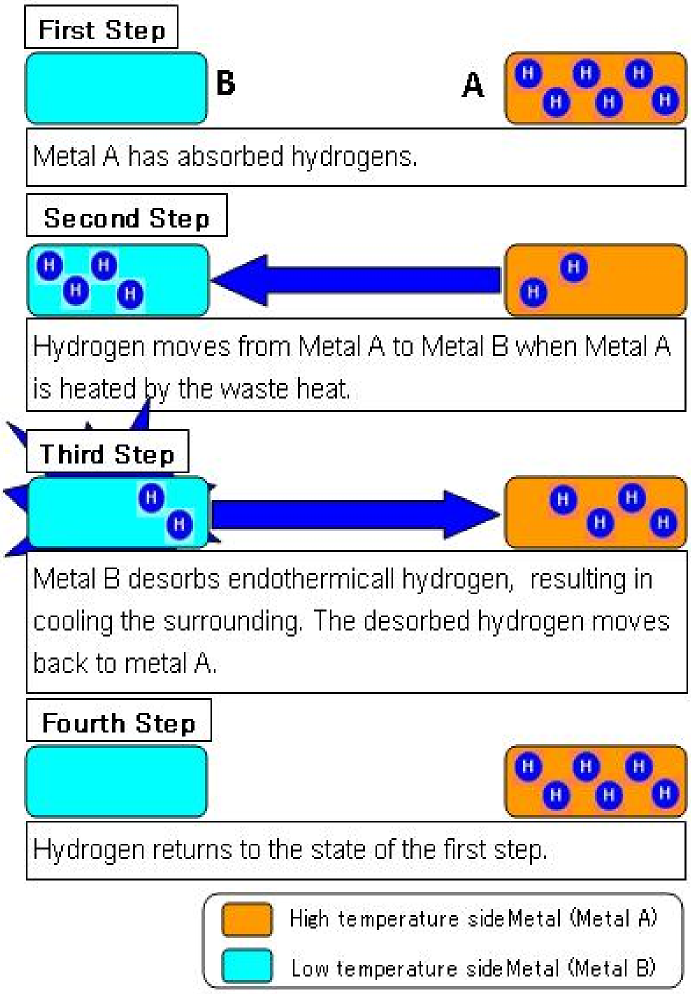

Figure 3: MH heat pump operation. One cycle is defined as completion of the above-mentioned 4 steps.

In the hydrogen strawberry cultivation experiment, the temperature of the water used for the greenhouse was a minimum of 0.98 °C, a maximum of 9.08 °C, and an average of 2.17 °C. From 2008, the area of the greenhouse was expanded to 97 m², and refrigerating units with the same cooling power as the MH Cold Water Production Systems were used in an experiment. Each of the devices was shown to have the capability to produce 4.8 tons of 5 °C cool water per day.

In October 2009, while continuing the experiments at the 97 m^2 greenhouse, the construction of an agricultural greenhouse for the demonstration of daily-use practical purposes, measuring at 1,000 m^2, was completed to conform to the MH Cold Water Production System standards. Also, in February 2010, an above-ground fishery was also completed according to the MH Cold Water Production System standards.

The properties and conditions of the two newly-installed MH Cold Water Production System installations are detailed below.

2009 Condition and performance of MH Cold Water Production System

Per Installation:

- MH Cold Water Production Devices：Japan Steel Works, LTD.
- Types of Alloys: equal to the condition and the performance as in 2007.
- Number of Alloy Tanks： equal to the condition and the performance as in 2007.
- Weight of Alloy Tanks： equal to the condition and the performance as in 2007.
- Amount of Alloy： equal to the condition and the performance as in 2007.
- Source of Energy： The 200°C water vapour from the power unit of a chemical factory, the 95°C water reduced from it, 20°C ground water & purchased electrical power.
- Cycle Time： It is equal to expression Condition and the performance in 2007.

2.2 Hydrogen strawberry

The harvest of strawberries in Japan usually occurs from December until the following May, and from June to November, the temperature inside agricultural greenhouses exceeds 35 °C on many days, causing high-heat exposure problems. In Saijo as well, strawberries are considered to be a fruit difficult to produce, and properly controlling the heat environment in which they are grown is a crucial cultivation condition.

In 2007, connecting the MH Cold Water Production System with the 16 m^2 agricultural greenhouse, an environmentally low-cost and heat-environment controllable strawberry cultivation experiment facility was constructed, and an experiment was begun with 68 strawberry plants. In 2008, an MH Cold Water Production System was implemented in a larger greenhouse of 97 m^2, and approximately 660 strawberry plants were used in a study of early harvest techniques, harvest prolongation techniques, and heat-environment control techniques. In controlling the heat-environment, an expansion of the piping from 43.5 m to 283.5 m was necessary, and as a result, the heat of the water rose 150 % while being circulated through the piping. In 2009, a 1,000 m^2 daily-use practical purpose greenhouse was installed (Figure 4) and 6,200 strawberry plants were planted in late September.

Figure 4: Greenhouse of 1,000 square meters.

The necessary piping for heat-environment control was increased to 1,500 m.

2.3 Fish cultivation on Land

In order to increase food supply production via fisheries using the successes of the year-round strawberry cultivation experiments, a new MH Cold Water Production System was installed at 4 different locations using 5 ton tanks, and an above-ground fishery facility was born in September 2009. With the support of the Fisheries Research Agency and the Natural Center for Stock Enhancement, this above-ground fishery system was able to implement sustained water temperatures, and also installed a closed-circulation system [3] to enhance savings on the fishery’s overall water waste. With the assistance of the School of Marine Science, Tokai University, we are continuing to farm “Satsuki Trout” with a success rate unheralded in the past.

2.4 Circulation of energy

The facilities established in 2009 have the MH Cold Water Production System at their core, and through it, the circulation of energy has become possible. (Figure 5) It is estimated that the approximate yearly carbon dioxide emission cut will be nearly 74 tons over all the facilities. Also, the MH Cold Water Production System offers a 89.9% energy reduction when compared with common Freon-based cooling systems [4].

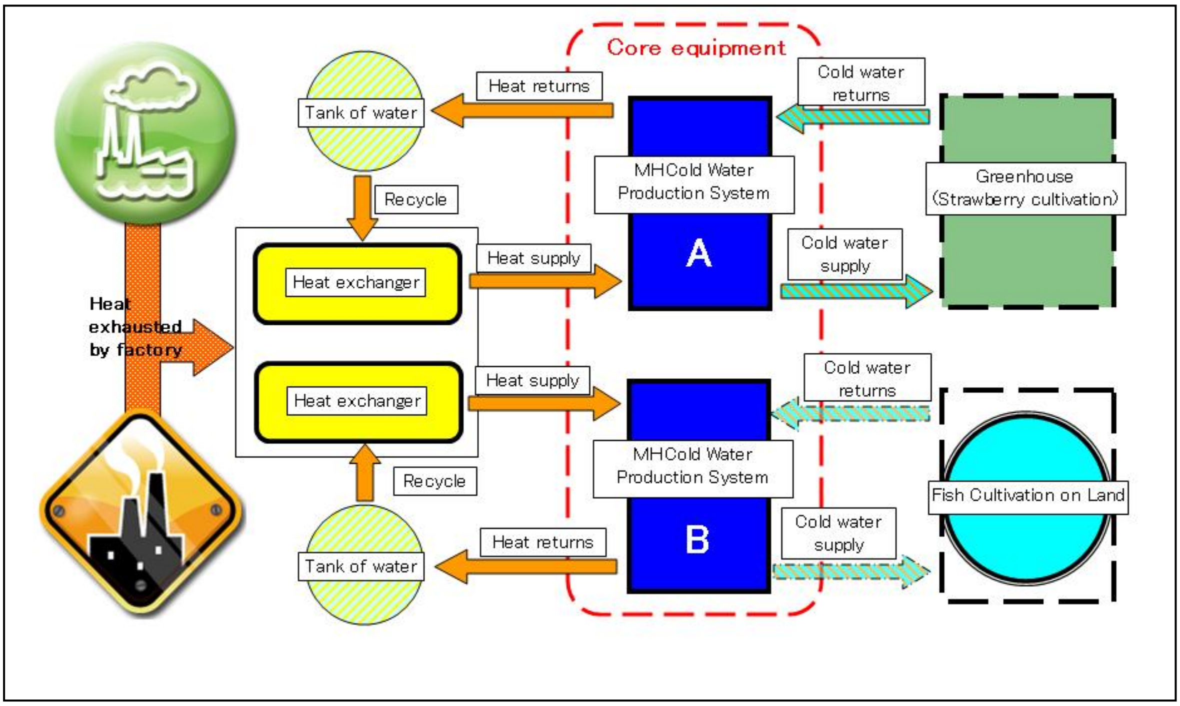

Figure 5: Energy cycles in Saijo city.

3 Results and Discussion

3.1 MH cold water production system

The specified temperature environment was able to be controlled regardless of the temperature change of the house for agriculture as a result of the temperature environment controls in the root sphere part beginning by booting up a system in May, 2009. Given a modification to the heat exchange efficiency of the system, the MH Cold Water Production System implemented in 2009 shows a 200 % increase in output production (4.0kw/h) when compared with the earlier 2007 model. Also, the predictability of the heat-environment control system was modified by an output control function as well as a water-temperature source gauge, and this allows the system to be used throughout the entire year. Furthermore, the space required to install the system was successfully reduced by 70 % to a small-scale model. The MH Cold Water Production System used for the fishery successfully offers an 8 % increase in output (4.3 kw/h) and a 36 % reduction in size from the agricultural greenhouse, as well as a 30.5 % reduction in manufacturing cost, bringing it down to 15 million yen (approx. $150,000).

3.2 Hydrogen strawberry

In 2007, due to the MH Cold Water Production System's heat-environment control, all of the strawberry plants were able to avoid heat damage in the summer months. Also, the start of the harvest became aligned with the harvest of strawberries force-flowered through the use of a Freon-based refrigeration system, and was estimated to accomplish an 85 % reduction in energy consumption. In 2009, the amount of strawberries harvested from the 6,200 plants in the 1,000 m^2 greenhouse was an estimated 10kg per day. From here on, we will be aiming for a stable harvest amount even during Japanese mid-summer, during which in-house temperatures will exceed 40 °C.

3.3 Fish cultivation on land

On October 30th, 2009, 800 "Amago" Trout (*Oncorhynchus masou macrostomus*) minnows (approx. 18 cm long & 100 g in weight) were used to begin the fishery, and by late May, 2010, they are estimated to grow to 45cm long, 1kg "Satsuki Trout." In each of the 4 tanks there are 200 fish. Three of the tanks are filled with man-made seawater, and the fourth tank is filled with fresh water, to be used for comparative purposes. The fish being bred in the man-made seawater tanks have reached 30cm in length and 250 g in weigh over a 3 month period, and are growing swiftly.

3.4 Development in the future

The MH Cold Water Production System is planned to be compartmentalized, allowing for a simpler construction, and for a reduction in installation costs.

Concerning Hydrogen Strawberries, we strive to successfully implement a year-round cultivation schedule and an increased prevalence of the strawberries. For the above-ground fishery project, we hope that the fruits of the MH Cold Water Production System can be further utilized in order to successfully breed "Satsuki Trout" well into the future.

All of the MH Cold Water Production Systems implanted after 2007 are examples of a new production form, in which facilities producing factory emissions and farms (including fisheries) become the pipeline for a physical cooperation in the construction of this form. In the example of a factory, in keeping with the human cultural tradition of the factory, factories will continue to function, yet their emissions will be yielded to farmers, who will in turn be able to use the emissions in producing agricultural goods, thus allowing them to cut back severely on their oil and electricity costs. This will allow for an overall reduction in the cost of production, and furthermore, it is expected to result in a massive reduction in carbon dioxide emissions. From this research, we are aiming to implement a low environmental load made possible through a locally active production model policy.

As the Japanese government is thoroughly endorsing environmental problem solutions such as the reduction of greenhouse gases [5], we are acting in accordance with this policy strengthening position. This study is a perfect match for the national policies being implemented and should thus be considering a leading model when grappling with environmental issues.

Acknowledgement

We are grateful to many organizations for support and indications:

- Ministry of Economy, Trade and Industry,
- Ministry of Agriculture, Forestry and Fisheries,
- Ehime Prefecture,
- New Energy and Industrial Technology Development Organization,
- Japan Foundation for Regional Vitalization,

- National Institute of Advanced Industrial Science and Technology in Shikoku,
- School of Engineering, and School of Marine Science and Technology of Tokai University,
- Center for Environment, Health and Field Science, Chiba University,
- Faculty of Agriculture, Ehine University,
- National Center for Stock Enhancement, Fisheries Research Agency,
- Kuraray CO., LTD.,
- TANIGUCHI HEAT TREATMENT CO.,LTD.,
- Saijo Industry and Information Center, for Support,
- LLP-TRYOUT Ehime and Itoh Engineer CO., LTD.

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