To: New Energy and Industrial Technology Development Organization (NEDO) Hydrogen Production Technology Division

Submitted by: Nobuo Furuno, Ph.D. (Kyoto University, Doctor of Engineering No. 1869) 260712

Affiliation: Tritium Water Cluster Forum (TCF)　(A citizens' group established in 2020, held at Osaka Ekimae Dai-2 Building 6F, Osaka Metropolitan University Cultural Exchange Center – Small Seminar Room, and other venues) Organizer of multiple submissions to Tokyo Electric Power Company (TEPCO), Mitsubishi Research Institute, and the "ALPS Treated Water Measures" public calls (details posted at http://www.fineclay.co.jp/)

Career: Founder and former CEO of Fineclay Co., Ltd. (wet classification and hydraulic separation business; dissolved in 2018) Author in *Journal of the Society of Powder Technology Japan*, Vol. 32, p.644 (1995)　　Former engineer at Nippon Paint Co., Ltd. (electrodeposition coating, anti-corrosion technologies, hydrogen permeation) 1985 Doctoral Dissertation: *Electrochemical Studies on Electrodeposition Coating*

Address: 1-3-8 Osho-kita, Amagasaki City, Hyogo 660-0063 **Email:** furuno.nobu@gmail.com

1. Title of the Proposal

Fundamental Reduction of Water Electrolysis Cost through Light-Water-Rich Feedwater, Cylindrical Membrane Electrodes, and Thin-Layer Swirling Flow

2. Executive Summary

This proposal presents a method to fundamentally reduce the cost of water electrolysis by resolving structural inefficiencies inherent in current technologies—specifically: electrolysis of natural water containing 150 ppm heavy water, concentration of electric field lines at plate-electrode corners, electrode temperature rise, bubble retention, and excessive requirements for direct high-pressure hydrogen generation.

The proposed technological framework consists of three pillars:

1. **Use of Light-Water-Rich Feedwater (RO / FFOF / Thin-Layer Swirling Flow "Petacrons")** → Faster electrolysis kinetics, improved bubble detachment, reduced power consumption
2. **Adoption of Cylindrical Membrane Electrodes (international standard in electrodeposition coating)** → Elimination of bubble retention, maximization of effective electrode area, controllable temperature, scalable system size
3. **Bubble-Free Electrolyzer via Communicating-Tube Configuration** → Suppression of bubble formation on electrode surfaces, fundamentally improved gas collection efficiency

All components can be constructed using existing industrial equipment, membrane technologies, and electrode technologies—no new materials or special-purpose machinery are required. Light-hydrogen production is not a domain to be monopolized by any single company, industry, or nation; it is an urgent global challenge. This proposal aims to contribute substantially to lowering the foundational cost of water electrolysis.

3. Background

3-1. Structural Inefficiencies in Current Water Electrolysis

Problems with Plate-Type Stacked Electrodes

- Concentration of electric field lines at plate corners, leaving heavy-water decomposition unaddressed
- Electrode temperature rise increases electrical resistance
- Bubble retention reduces effective electrode area
- Large capital expenditure required for scale-up
- Excessive demands associated with direct high-pressure hydrogen generation

Electrolysis of Heavy-Water-Containing Natural Water

Natural water contains approximately 150 ppm of heavy water (D_2O). Compared with light hydrogen (H_2), heavy hydrogen (D_2) generation causes:

- Slower electrolysis reaction rate
- Higher required voltage
- Poorer bubble detachment
- Increased power consumption

Societal Impact

These inefficiencies reinforce the perception that "electrolytic hydrogen is expensive," casting doubt on the feasibility of decarbonization.

4. Details of the Proposal

4-1. Active Use of Light-Water-Rich Feedwater (RO / FFOF / Pitacrons)

Principle of Light-Water Enrichment

In RO and UF membrane permeation, light water (H_2O) permeates more readily, while heavy water (D_2O) tends to remain. This proposal emphasizes permeation-driven separation rather than pressure-driven filtration.

- Begin with widely available RO membrane cartridges
- Gradually transition to FFOF (Final Frontier Osmosis Filtration), which utilizes hydrostatic head for forward osmosis
- Combine with Petacrons (compound dual-stage cascade centrifugal settling) to raise the light-water ratio to significantly higher levels

Feasibility

RO membranes are mass-produced for seawater desalination. FFOF can be implemented by repurposing existing permeation systems. Petacrons' communicating-tube configuration is based on publicly disclosed technologies (Patents 4495918 and 6666176).

4-2. Adoption of Cylindrical Membrane Electrodes (International Standard in Electrodeposition Coating)

Origin of the Technology

Cylindrical electrodes originated from research at Nippon Paint Co., Ltd. during the early development of electrodeposition coating (1969). They evolved into membrane-equipped coaxial elements now used as international standards in the automotive industry.

Benefits for Water Electrolysis

- Circulation between the membrane chamber and external tank minimizes bubble retention
- Electrolyte injection through the cylindrical core enables temperature control
- Upward flow along the electrode surface rapidly removes bubbles, maintaining maximum effective area
- Cartridge expansion allows virtually unlimited scale-up

5. Expected Outcomes

- **Fundamental reduction of water electrolysis cost** Significant savings in both capital and operating expenses
- **Effective use of surplus renewable electricity** Mitigates solar curtailment and accelerates adoption of emerging technologies such as perovskite solar cells
- **Realization of regional hydrogen circulation models** Light-water-rich feed → light-hydrogen generation enables integration with local power and gas networks
- **Acceleration of hydrogen-society implementation** Overturns the perception that "hydrogen is expensive," advancing decarbonization and the emergence of a light-hydrogen society

6. Conclusion

Water electrolysis is not inherently expensive; current methods are simply inefficient. By reconstructing existing technologies, hydrogen production costs can be fundamentally reduced, contributing directly to the infrastructure of a future hydrogen society. Your consideration of this proposal is sincerely appreciated.