



## **Cost-Effective Green Hydrogen Without Electricity**

MARCH 2024

## HGenium Overview

- Green hydrogen thru thermochemical water splitting
- Founded in February 2022 by Professor Mark Davis and Idealab
- Founded with the express goal of commercializing thermochemical water splitting cycles at less than 1000 °C
- Located in Monrovia, CA & Pasadena, CA
- Broad foundational patent coverage for novel process; significant additional IP potential

(12) **United States Patent**  
Davis et al.

(54) **METHODS AND MATERIALS FOR THE THERMOCHEMICAL PRODUCTION OF HYDROGEN FROM WATER**

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(73) Assignee: California Institute of Technology, Pasadena, CA (US)

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 120 days.

(21) Appl. No.: 13/855,180

(22) Filed: Apr. 2, 2013

(65) **Prior Publication Data**  
US 2013/0266504 A1 Oct. 10, 2013

**Related U.S. Application Data**

(60) Provisional application No. 61/621,325, filed on Apr. 6, 2012.

(10) Patent No.: **US 8,940,269 B2**  
(45) Date of Patent: **Jan. 27, 2015**

The Director of the United States Patent and Trademark Office

Has received an application for a patent for \_\_\_\_\_  
The Director of the United States Patent and Trademark Office

Has received an application for a patent for a new and useful invention. The title and description of the invention are enclosed. The requirements of law have been complied with, and it has been determined that a patent on the invention shall be granted under the law.

Therefore, this

**United States Patent**

Grants to the person(s) having title to this patent the right to exclude others from making, using, offering for sale, or selling the invention throughout the United States of America or importing the invention into the United States of America, and if the invention is a process, of the right to exclude others from using, offering for sale or selling throughout the United States of America, or importing into the United States of America, products made by that process, for the term set forth in 35 U.S.C. 154(a)(2) or (c)(1), subject to the payment of maintenance fees as provided by 35 U.S.C. 416). See the Maintenance Fee Notice on the inside of the cover.

Margaret A. Fournier  
Commissioner for Patent of the United States Patent and Trademark Office



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Ph.D. University of Kentucky, Chemical Engineering



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Co-founder and Senior Scientist

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PATENTED TECHNOLOGY

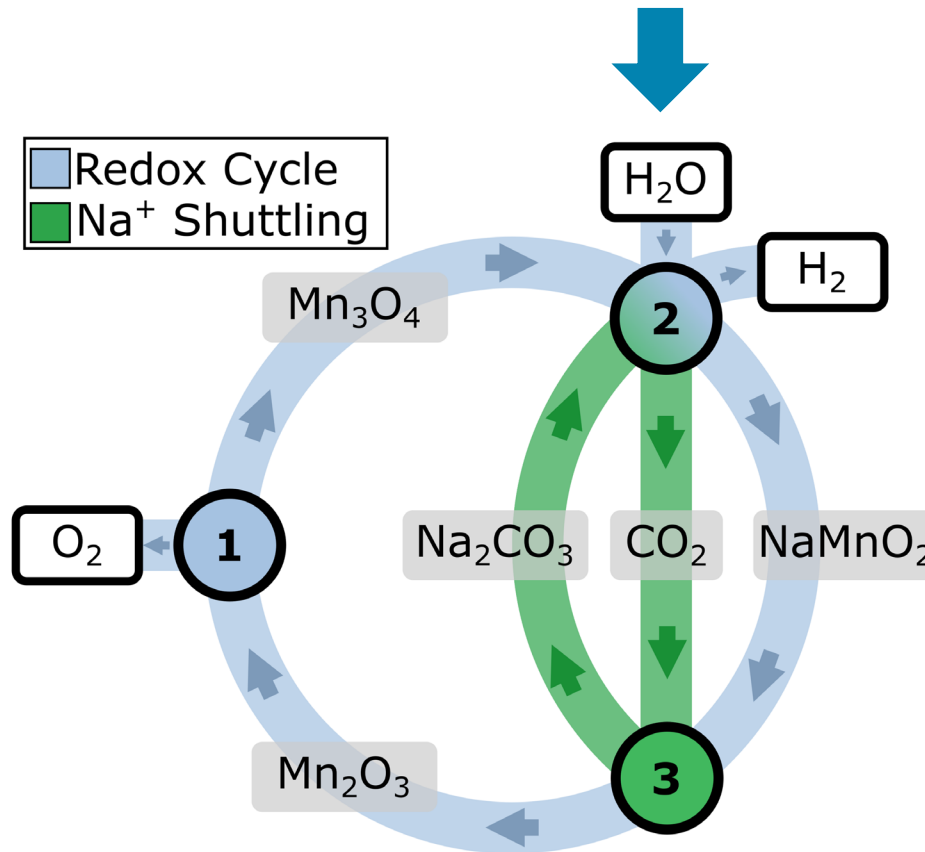
# HGenium's proprietary Na-Mn-CO<sub>2</sub> process uses common, scalable industrial equipment

Non-toxic components and low cost, earth-abundant materials

Continuous cyclic process doesn't require ultra pure water or inert gas



**Integrated heat source**  
creates renewable superheated steam (2H<sub>2</sub>O)



**REACTION 1**

Thermal Reduction Reactor  
 $3 \text{ Mn}_2\text{O}_3 (\text{s}) \rightarrow 2 \text{ Mn}_3\text{O}_4 (\text{s}) + \frac{1}{2} \text{ O}_2 (\text{g})$

**REACTION 2**

H<sub>2</sub> Generation Reactor  
 $2 \text{ Mn}_3\text{O}_4 (\text{s}) + 3 \text{ Na}_2\text{CO}_3 (\text{s}) + \text{H}_2\text{O} (\text{g}) \rightarrow 6 \text{ NaMnO}_2 (\text{s}) + 3 \text{ CO}_2 (\text{g}) + \text{H}_2 (\text{g})$

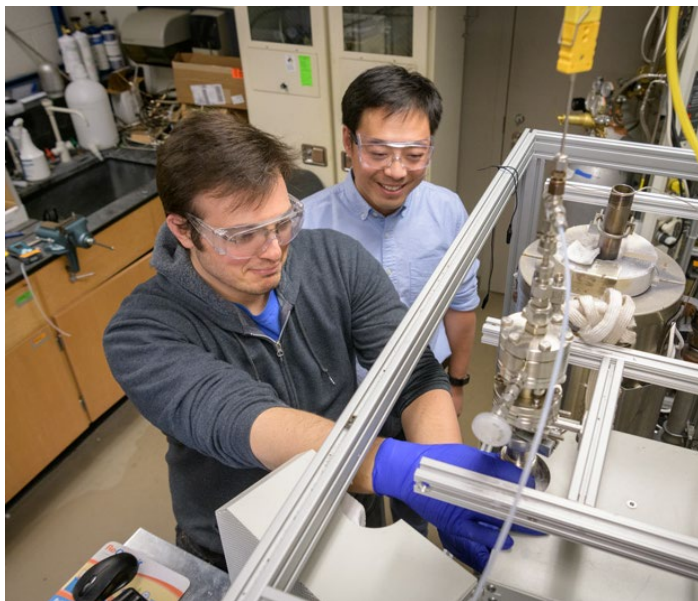
**REACTION 3**

Na<sup>+</sup> Extraction Reactor  
 $6 \text{ NaMnO}_2 (\text{s}) + 3 \text{ CO}_2 (\text{g}) \rightarrow 3 \text{ Mn}_2\text{O}_3 (\text{s}) + 3 \text{ Na}_2\text{CO}_3 (\text{aq})$

## We've proven the technology

### 2022-2024

Lab scale proof-of-concept with multiple continuous flow reactors, leveraging years of university-based research



## ...and now we're building a Pilot Scale Plant and establishing commercial relationships

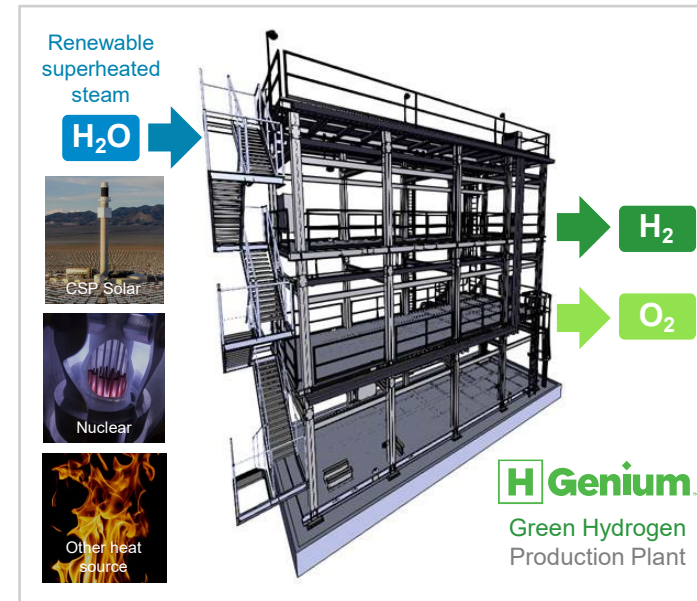
### 2023-2026

Design, build, and operate a pilot plant to de-risk and inform engineering design for commercial scale



### 2026 + beyond

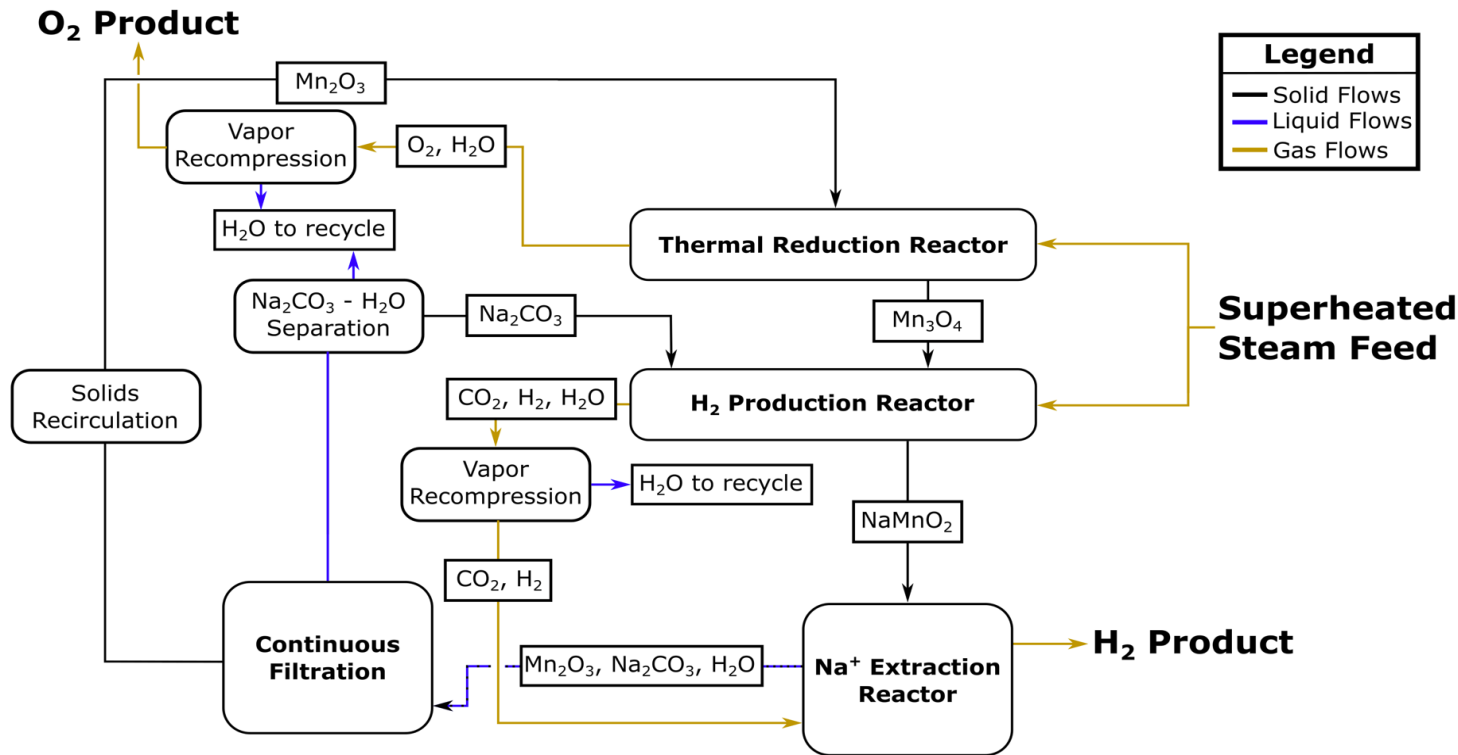
Build and operate full commercial manufacturing plants with heat source integration



PROJECT STATUS

# Pilot plant engineering and design plans are complete

# We're ready to build and operate



- SwRI design and costing completed
- Plan to build and operate on SwRI site
- Preferred vendors selected
- Finalizing plans to order long lead time equipment