



NATURAL RESOURCES
RESEARCH INSTITUTE

UNIVERSITY OF MINNESOTA

Geologic Hydrogen in MN

Presence, Opportunities

Mineland Vision Partnership

25 February 2026



Geologic Hydrogen, Defined

Natural

- Radiolysis of water in old rocks with high radioactivities (e.g. granite)



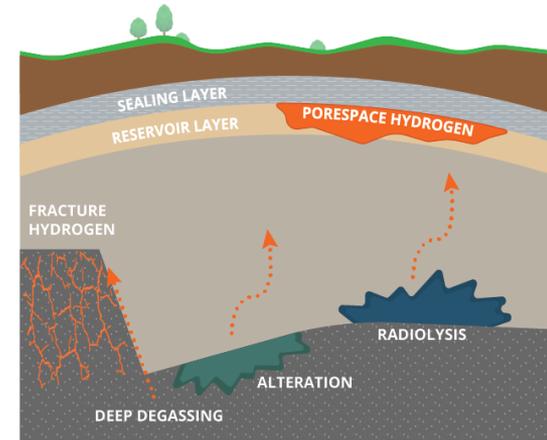
- Microbial activity

Generate and consume hydrogen

- Serpentinization of iron minerals in ultramafic rocks



- Requires “traditional” cap rock; not prevalent in MN
- Abundance and distribution not well understood



Sandia National Laboratory

Geologic Hydrogen, Defined

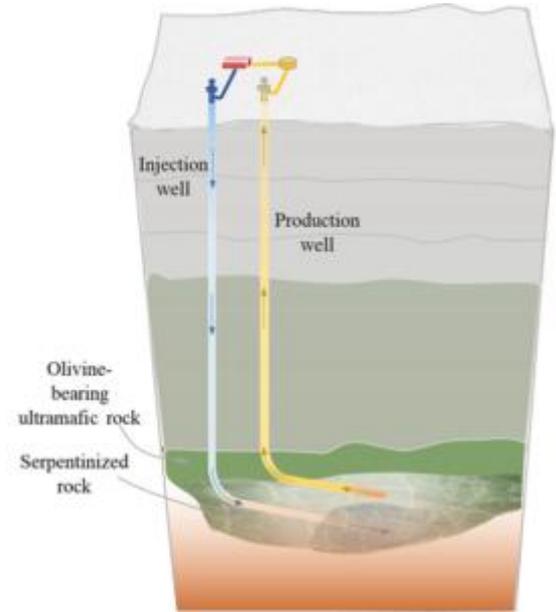
Stimulated

Artificial acceleration of water-rock interactions and fluid flow in ultramafic rock formations

Introduce water, catalysts, heat, and induced fractures to geologic formations to speed up reactions & flow

Uses technology applied in *Enhanced Geothermal Systems (EGS)*

- dynamic fracturing and injection of carbon-rich solutions to increase permeability and surface area for reaction
- electrical stimulation of fractured frameworks
- catalysis



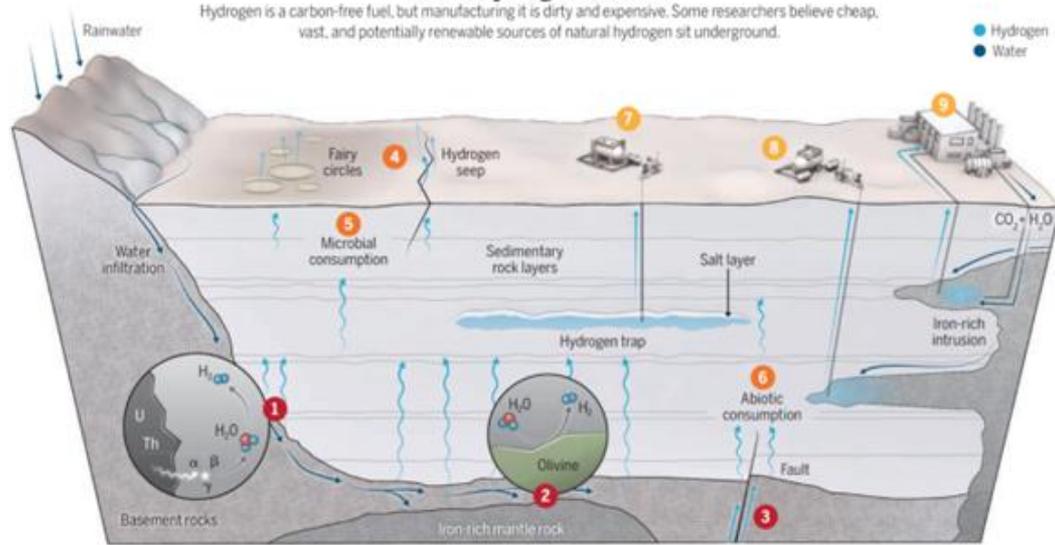
Credit: LBNL

Geologic Hydrogen

Early on the learning curve
 Interesting supply of energy
 Some pilot efforts under way
 DOE supporting research;
 industry is leading investment

Earth's hydrogen factories

Hydrogen is a carbon-free fuel, but manufacturing it is dirty and expensive. Some researchers believe cheap, vast, and potentially renewable sources of natural hydrogen sit underground.



CREDITS: (IMAGE) C. BOGUE/SCIENCE (DATA) GEOPHYSICAL RESEARCH BOARD

Generation

- 1 Radiolysis**
Trace radioactive elements in rocks emit radiation that can split water. The process is slow, so ancient rocks are most likely to generate hydrogen.
- 2 Serpentinization**
At high temperatures, water reacts with iron-rich rocks to make hydrogen. The fast and renewable reactions, called serpentinization, may drive most production.
- 3 Deep-seated**
Streams of hydrogen from Earth's core or mantle may rise along tectonic plate boundaries and faults. But the theory of these vast, deep stores is controversial.

Loss mechanisms

- 4 Seeps**
Hydrogen travels quickly through faults and fractures. It can also diffuse through rocks. Weak seeps might explain shallow depressions sometimes called fairy circles.
- 5 Microbes**
In shallower layers of soil and rock, microbes consume hydrogen for energy, often producing methane.
- 6 Abiotic reactions**
At deeper levels, hydrogen reacts with rocks and gases to form water, methane, and mineral compounds.

Extraction

- 7 Traps**
Hydrogen might be tapped like oil and gas—by drilling into reservoirs trapped in porous rocks below salt deposits or other impermeable rock layers.
- 8 Direct**
It might also be possible to tap the iron-rich source rocks directly, if they're shallow and fractured enough to allow hydrogen to be collected.
- 9 Enhanced**
Hydrogen production might be stimulated by pumping water into iron-rich rocks. Adding carbon dioxide would sequester it from the atmosphere, slowing climate change.

Credit: USGS



Consumption mechanisms #1:

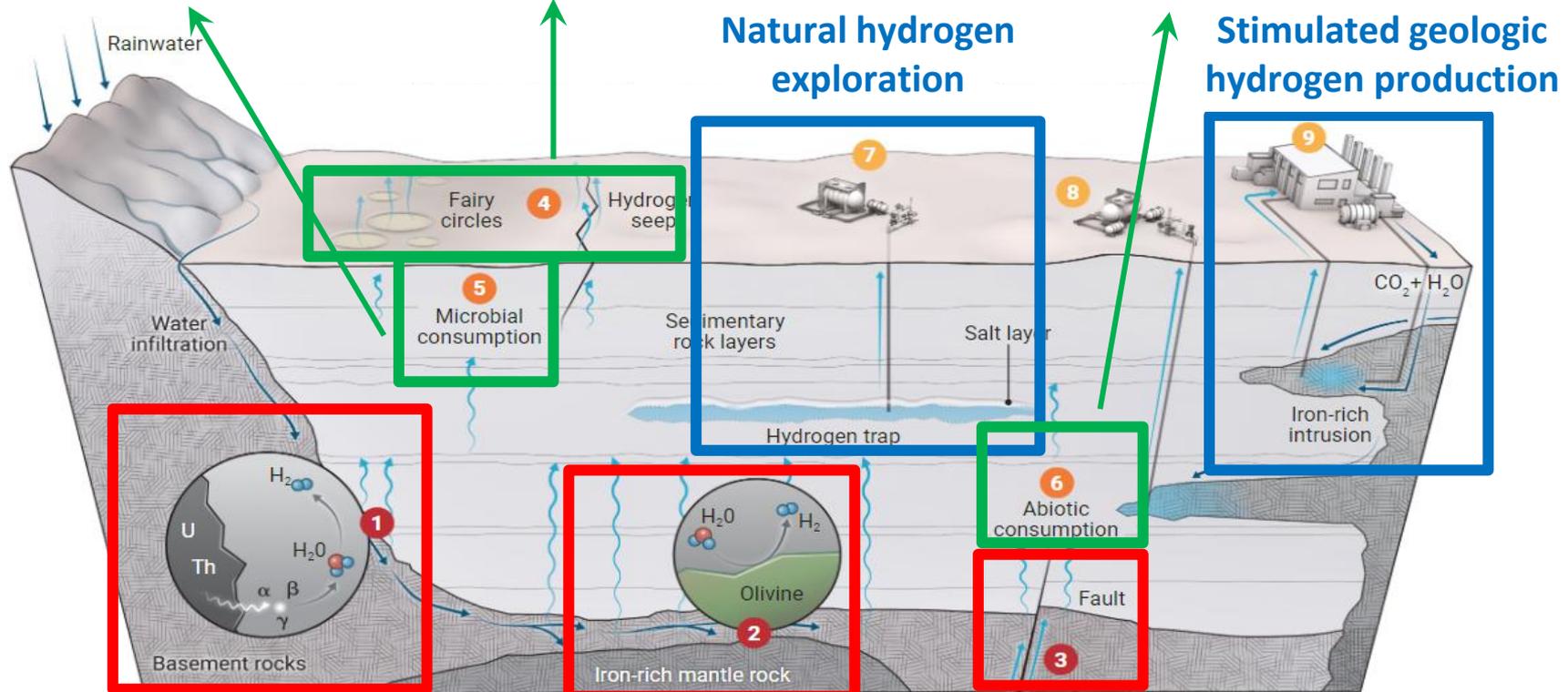
Microbial activities

Consumption mechanisms #2:

Seeps and fairy circles (low conc.)

Consumption mechanisms #3:

Abiotic reactions



Production mechanism #1:

Radiolysis

Production mechanism #2:

Serpentinization

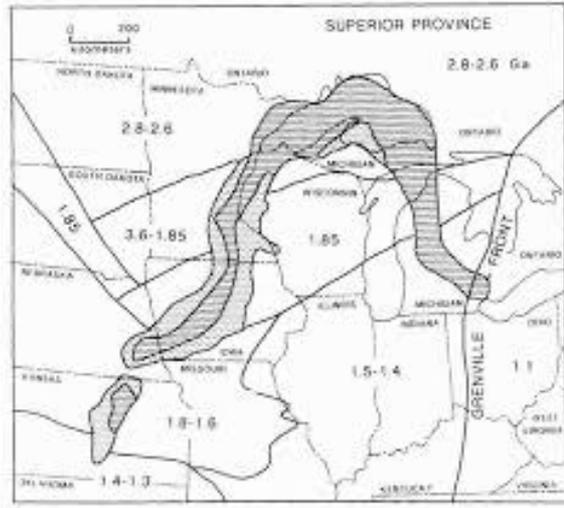
Production mechanism #3:

Primordial or magmatic H_2

Modified from Hand et al., 2023



Geologic Hydrogen & Midcontinent Rift

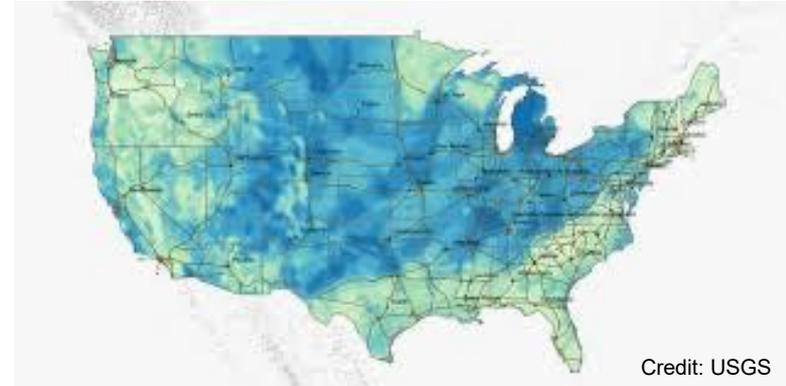


Credit: USGS

National models of natural hydrogen generation:

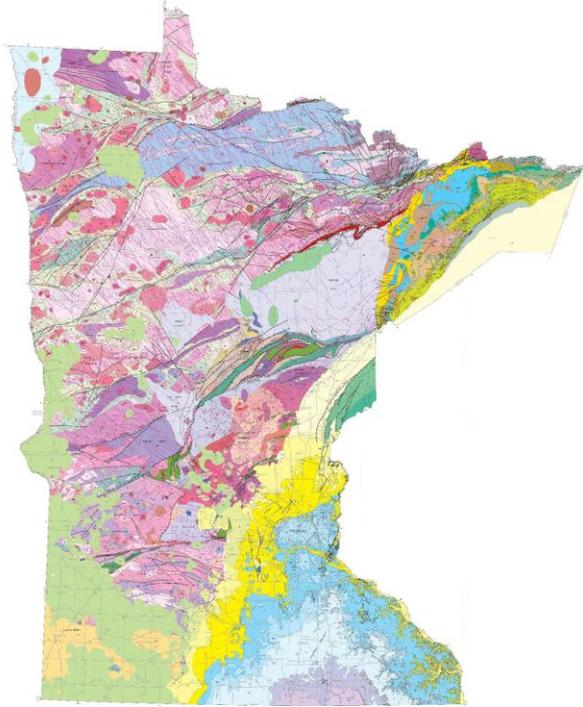
- **States along the Midcontinent Rift:** Michigan, Minnesota, Wisconsin, Iowa, Nebraska and Kansas
- **States with olivine-rich rocks:** Michigan, Washington, Minnesota, Oregon, Alaska, Hawaii and others
- **States with U-Th rich granitic rocks:** Wyoming, Idaho, Colorado, Virginia, Alaska and others

National Natural Hydrogen Potential



Credit: USGS

Geologic Hydrogen – MN potential



Minnesota Geological Survey

Geologic highlights

- Archean Granite greenstone in the north
old rocks with high radioactivities
- Paleoproterozoic Banded Iron Formation
high iron content and surface area from mining activities
- Mesoproterozoic Midcontinent Rift System
naturally fractured systems for flow
- Duluth Complex and Tamarack intrusion
high iron content

Geologic Hydrogen – Concerns

Exploration permitting

Hydrogen safety

Groundwater impacts vs. fracturing

Coordination of regulatory and research to be competitive

Geologic Hydrogen – Opportunities

Significant role in industrial transformation

- Fuel (Hydrogen/NG mixtures; fuel cell generation)
- Energy storage (ammonia, hydrocarbon fuels)
- Reactant for production of iron, steel, critical metals/materials
- Reactant for production of hydrocarbon fuels (SAF, diesel)



Credit: Boundary Power

Investment in hydrogen infrastructure and adoption requires

DEMAND



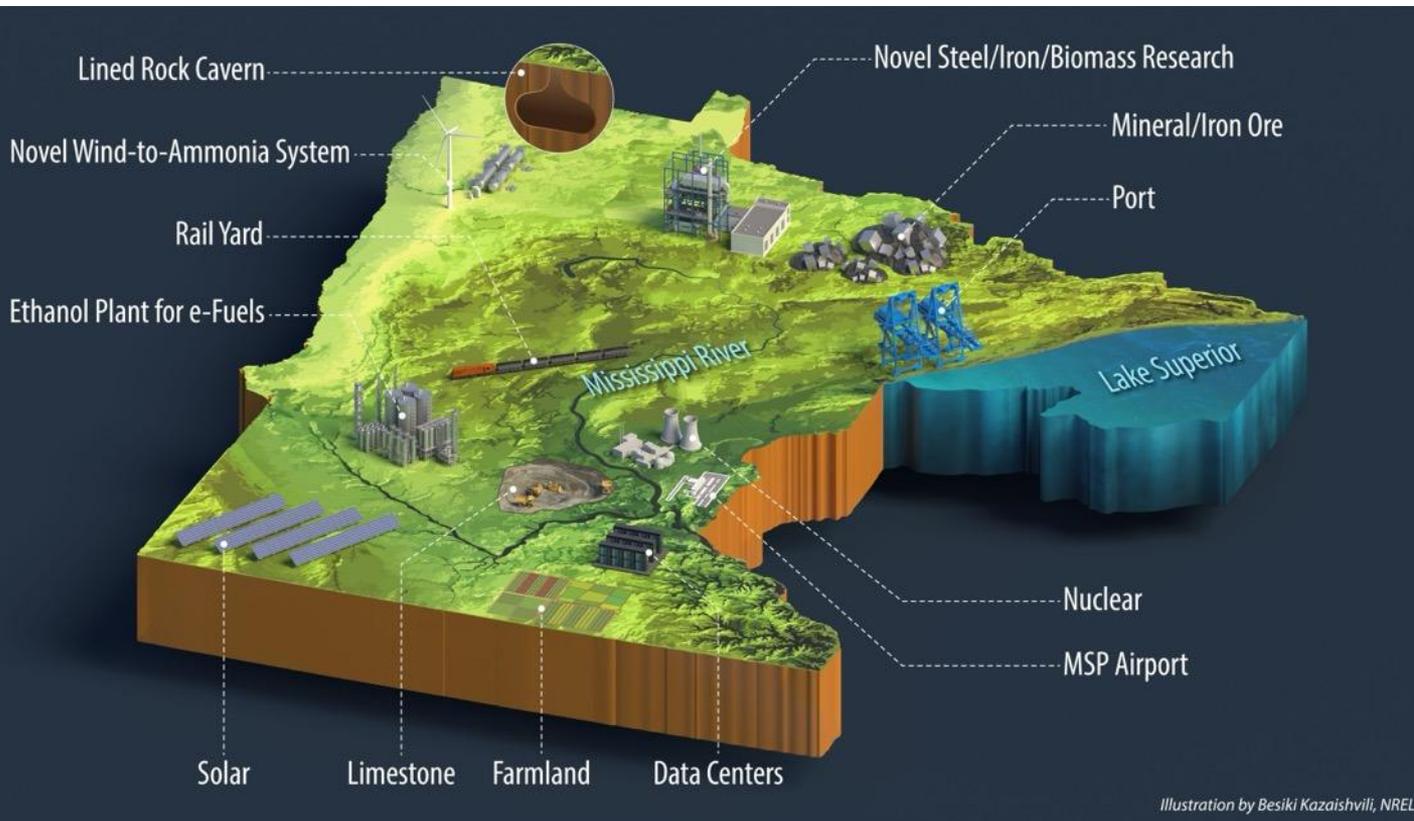
Midwest Industrial Transformation Initiative



NATIONAL
LABORATORY
OF THE ROCKIES



Minnesota: All the Key Attributes

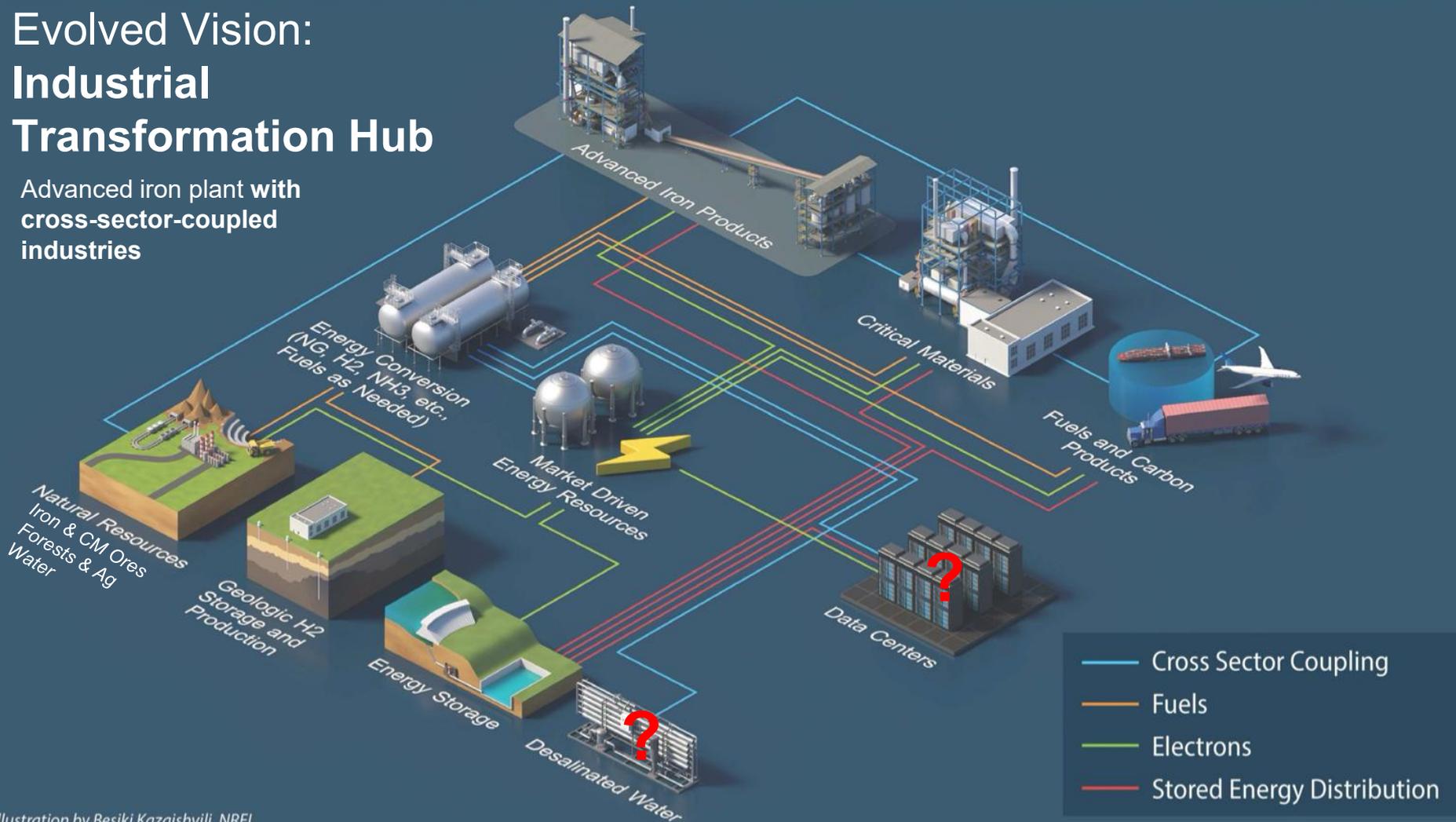


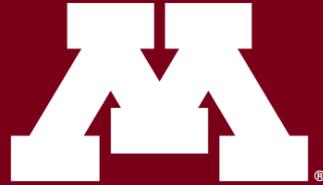
- ✓ **Natural Resources**
 - Water
 - Minerals
 - Forest products
 - Agriculture
- ✓ **Power**
 - Generation portfolio
 - Grid distribution
 - MN 2040 commitment
- ✓ **Infrastructure**
 - Multimodal transport
 - Industry
- ✓ **Manufacturing**
 - Iron
 - Fuels
 - Forest products
 - Materials & equipment
 - Water management
- ✓ **Regional Engagement**



Evolved Vision: Industrial Transformation Hub

Advanced iron plant with
cross-sector-coupled
industries





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