Energy & Environmental Research Center (EERC)

SCALE-UP OF HYDROGEN FUEL CELLS FOR FREIGHT APPLICATIONS

Josh Stanislowski
Director of Energy Systems Development

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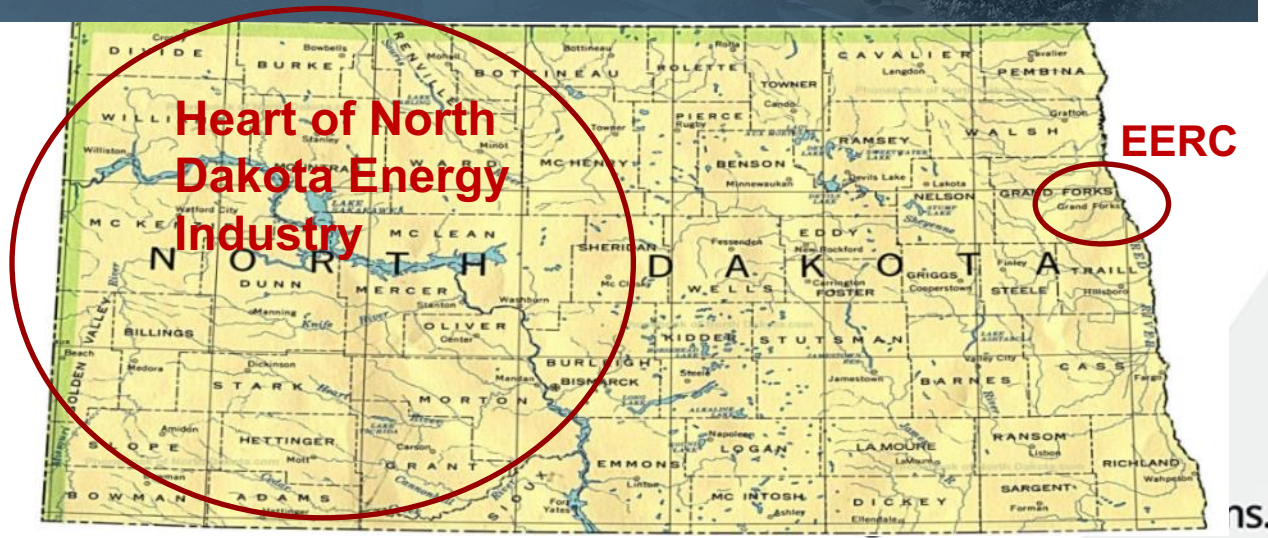
ENERGY & ENVIRONMENTAL RESEARCH CENTER (EERC)

- Nonprofit branch of the University of North Dakota.
- Focused on energy and environmental solutions.
- More than 254,000 square feet of state-of-the-art laboratory, demonstration, and office space.



FUEL CELL DEVELOPMENT FOR U.S. ARMY GROUND VEHICLE SYSTEMS CENTER (GVSC)

- Develop a 125-kW fuel cell engine and validate performance in a heavy-duty fuel cell hybrid electric vehicle against GVSC requirements.

Nuvera® Fuel Cell Engine

usarmygvsc.com

PROJECT PARTNERS

- Nuvera Fuel Cells
- Roush Defense
- GVSC
- EERC

HYDROGEN AND DECARBONIZATION

- Hydrogen provides a pathway for decarbonization of the transportation sector and is suitable for heavy-duty applications.
- Hydrogen comes from almost anywhere, which can increase resiliency.
- Hydrogen has multiple advantages over batteries:
  - Refueling times similar to gasoline- or diesel-fueled vehicles
  - More power, longer range
  - Not dependent on an electricity source

Former U.S. Senator Byron Dorgan (ND) in the driver's seat of a Chevy Equinox fuel cell vehicle in September 2008 at the EERC.

PROJECT OVERVIEW

- Phase I: Develop a 145-kW fuel cell stack, and design a 125-kW engine:
  - Initiate impurities testing and durability
  - Vehicle selection, specifications, and greenhouse gas life cycle assessment

- Phase II: Build the 125-kW fuel cell engine, and initiate verification testing:
  - Complete impurities testing and durability
  - Develop design for vehicle integration

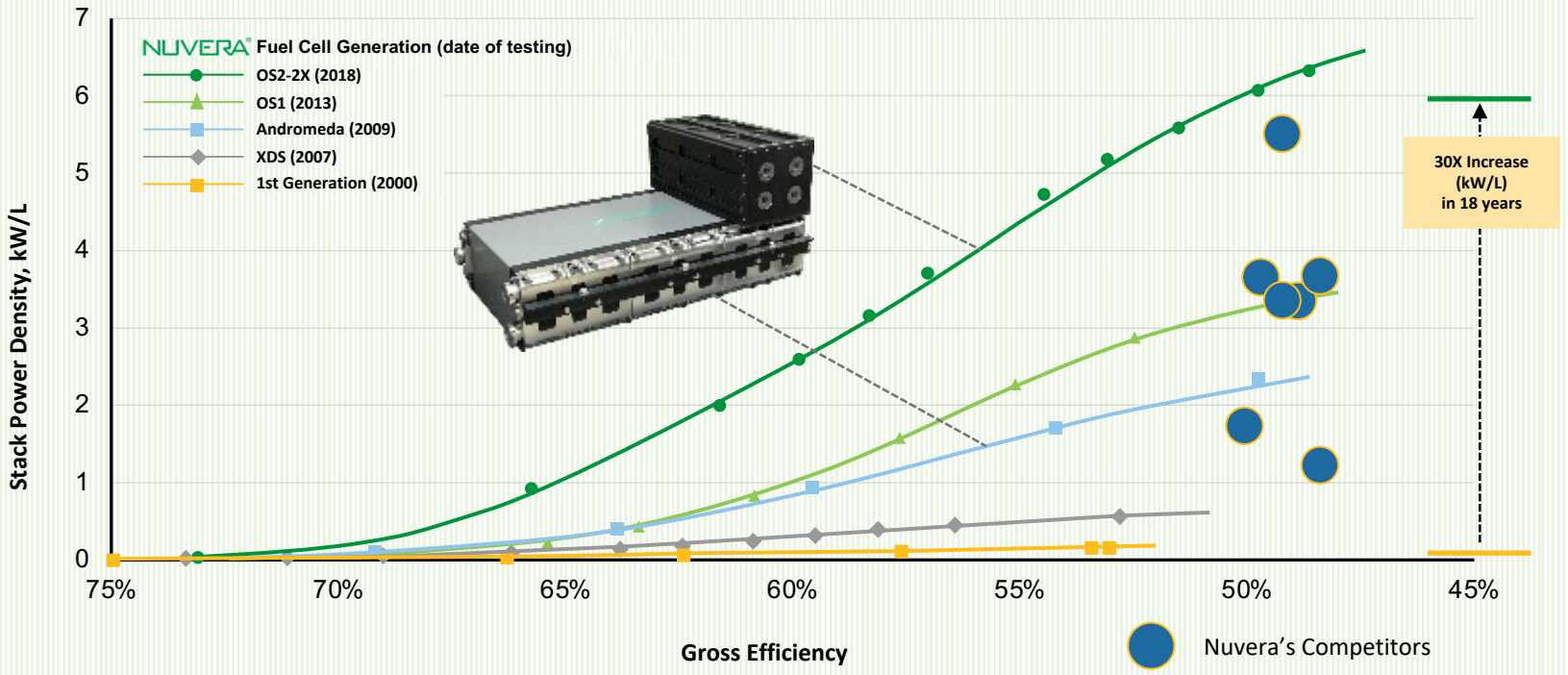
- Phase III (future phase):
  - Integrate the 125-kW fuel cell engine into a heavy-duty vehicle platform, and deliver to GVSC for testing

KEY TASKS FOR PHASE I

- 125-kW stack design and build
- Impurities evaluation
- Proof-of-concept engine design and procurement
- Vehicle selection and preliminary life cycle analysis (LCA)

STACK DESIGN

Nuvera's Best-in-Class Fuel Cells Significantly Outperform Peers



- Current generation of Nuvera fuel cell technology produces 30× greater power in kW/L at a similar efficiency relative to Nuvera's first-generation units.
- Closest competitor's fuel cell performance is comparable to Nuvera's previous generation (OS1 fuel cell), generating ~1/3 less power per liter at similar efficiency levels than the current OS2-2X.

BEST-IN-CLASS POWER DENSITY

TASK 3 – TEST STAND PROCUREMENT AND COMMISSIONING

- The EERC will evaluate the impact of impurities on fuel cell performance.
- Trace impurities such as sulfur (diesel emission by-product) or chlorine (operations near the coastline) have the potential to influence fuel cell performance, and this must be evaluated to ensure a durable system.

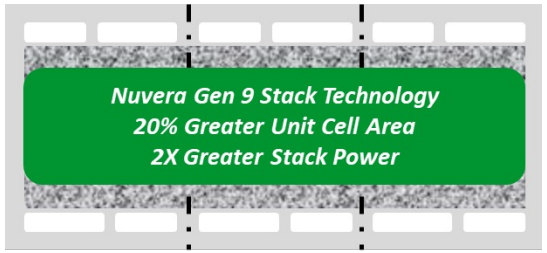
ENGINE DESIGN

Compact stack provides enhanced packaging flexibility.

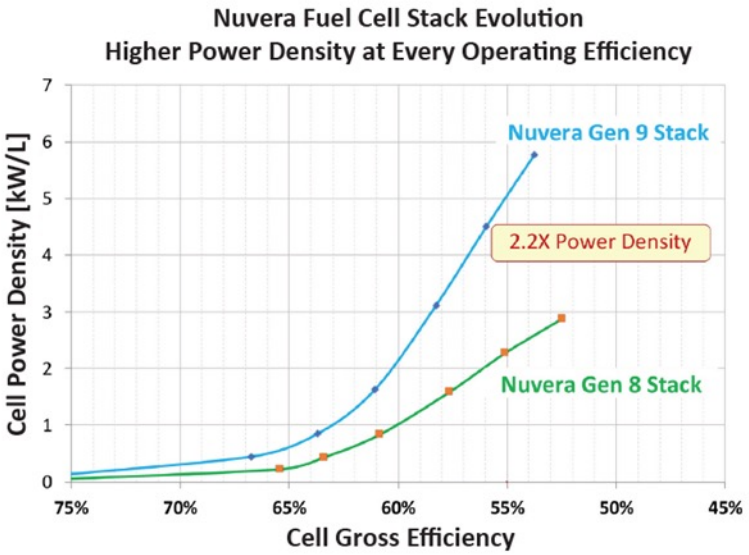
M-11 Module (BBR Product)

E-45-HD Engine

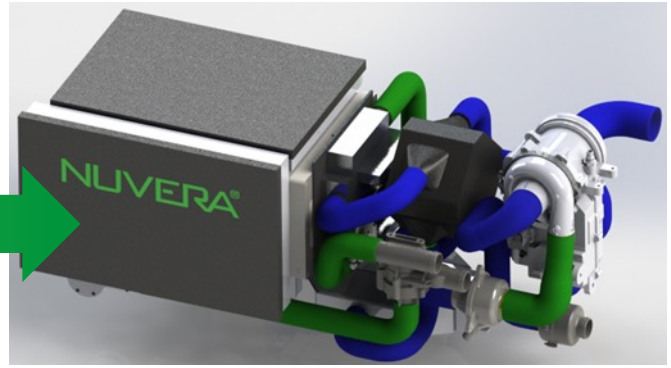
E-60-HD-CF Engine



Compared to Gen 8 Stack



EN-125-HD-CFI Engine



Current Products

NUVERA®

VEHICLE SELECTION AND LCA

- The project team will work closely with GVSC to determine the appropriate heavy-duty vehicle to demonstrate for Army applications.
- The vehicle will be in the public domain, i.e., nonclassified, such that the results of the project can be used to inform commercial applications of the technology.
- For this project, the vehicle will not be used for extreme service.
  - Not an M1 Abrams tank!
  - Supply and logistics?
  - Snowplow?
- Field support is of high interest because the vehicle itself can also serve as an electric generator for remote needs.

LIFE CYCLE ANALYSIS

- The EERC performs LCAs to evaluate the impact of a project on the environment.
- This involves accounting for the environmental impact of all inputs for a process, the supply chain for those inputs, the outputs including emissions, and disposal of any waste, etc.
- The carbon footprint of the hydrogen fuel cell vehicle will be compared to a vehicle operating on traditional fuels.

openLca

SUMMARY

- This project will result in the development and build of a 125-kW fuel cell engine suitable for utilization in military applications.
- The engine developed will be suitable for long-haul freight applications as well.
- In a future Phase, a vehicle will be delivered to the GVSC for testing.

EERC-LED HUBS

- Heartland Hydrogen Hub (HH2H)

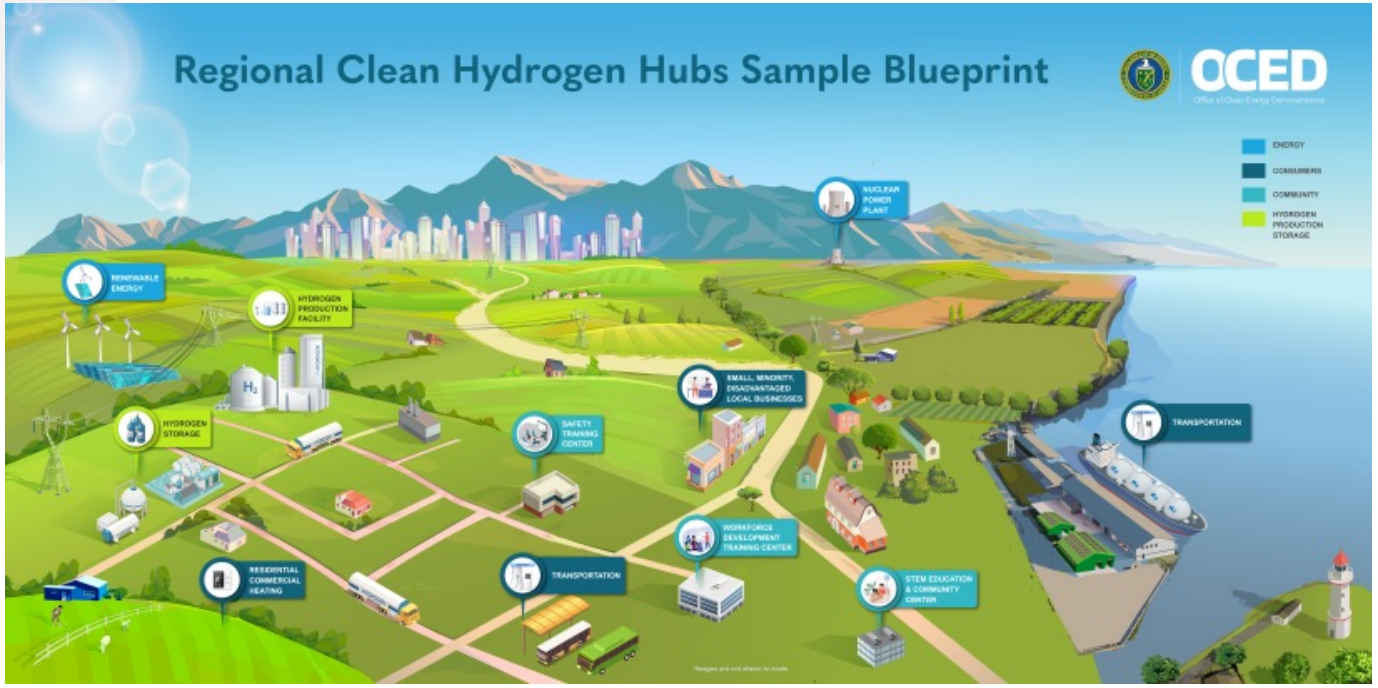


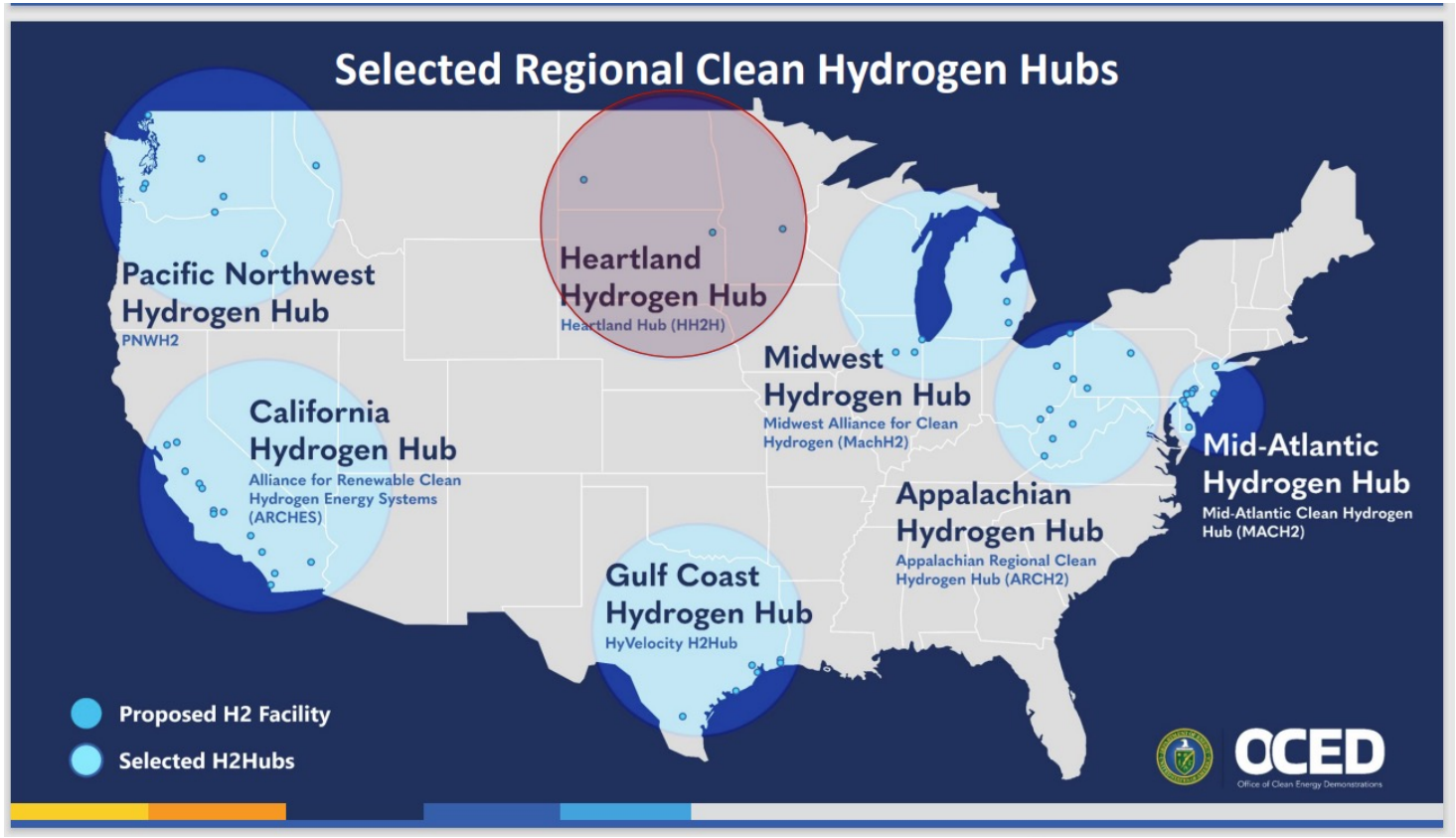
Image courtesy of DOE OCED

- Prairie Compass DAC Hub
  - $12,500,00 from DOE OCED
  - First project in North Dakota
  - Partnership with Climeworks

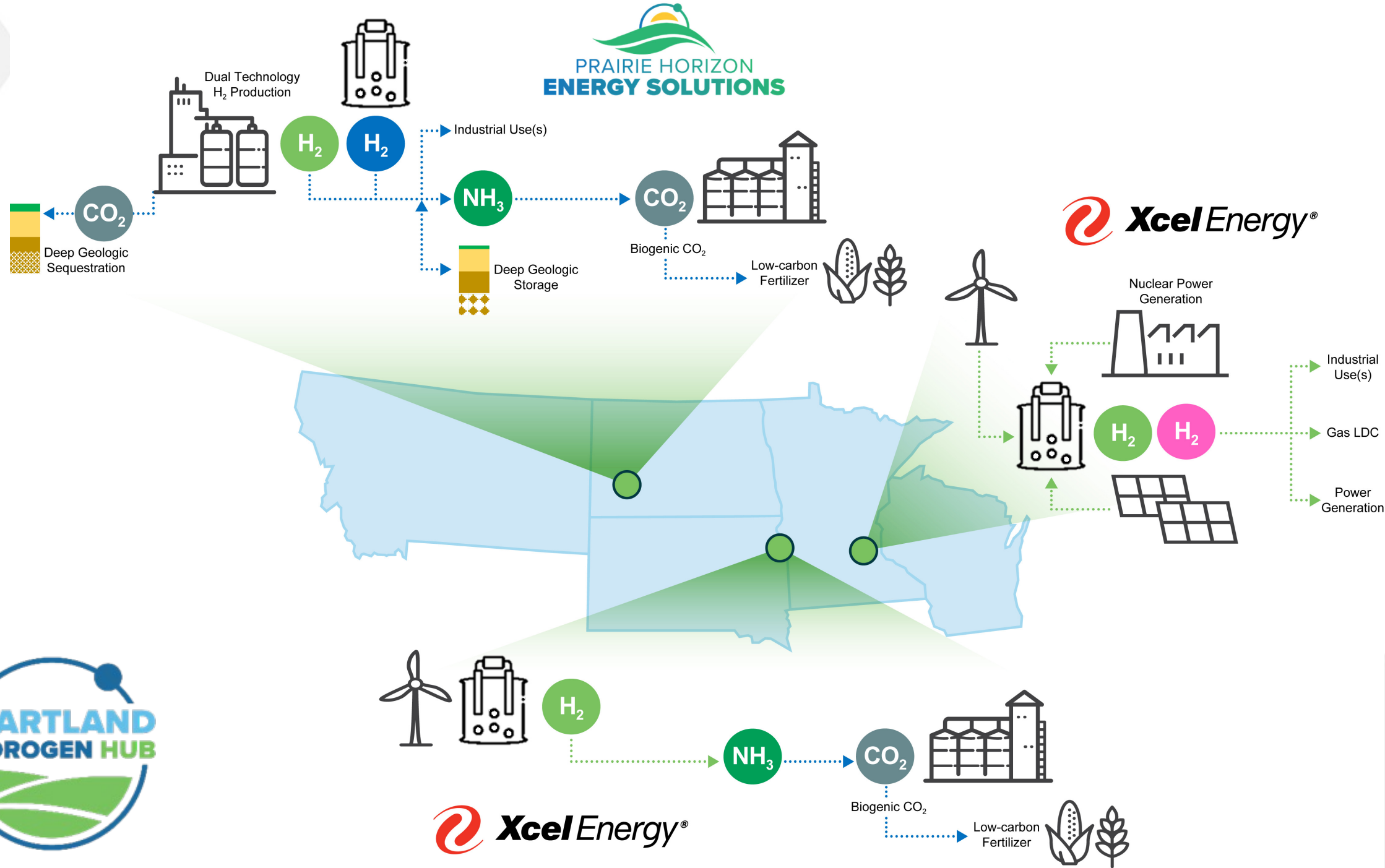
PRAIRIE COMPASS DAC HUB

HH2H – SELECTED!

- Up to $925,000,000 from DOE OCED
- Includes Minnesota, Montana, North Dakota, Wisconsin, and South Dakota
- One of seven hubs selected for $7 billion in funding!



CLEAN HYDROGEN LIFTOFF



Josh Stanislowski
Director of Energy Systems Development
jstanislowski@undeerc.org
701.777.5087

Energy & Environmental Research Center
University of North Dakota
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

www.undeerc.org
701.777.5000

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