

NETL Overview and Interests in Ammonia

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The National Energy Technology Laboratory



Organization Snapshot

MISSION

Driving innovation and delivering solutions for an environmentally sustainable and prosperous energy future:

- Ensuring affordable, abundant and reliable energy that drives a robust economy and national security, while
- Developing technologies to manage carbon across the full life cycle, and
- Enabling environmental sustainability for all Americans.

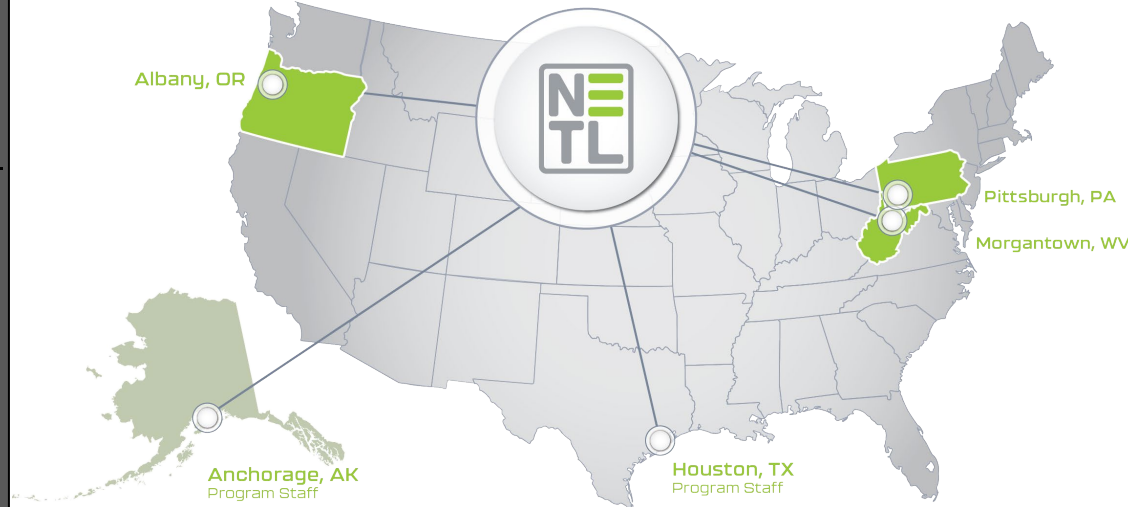
VISION

To be the nation's premier energy technology laboratory, delivering integrated solutions to enable transformation to a sustainable energy future.

MAJOR INITIATIVES

- Decarbonization & Carbon Management
- Environmentally Sustainable Supply Chains
- Integrated Energy & Industrial Systems
- Advanced Data & Computing Solutions for Applied Energy Challenges

3 RESEARCH LABS & 2 STRATEGIC OFFICES



- One of 17 DOE national laboratories
- **One of three applied research national labs**
- **Government owned & operated**
- **1000+** R&D projects in 50 states
- **\$5.0B** total award value
- **\$1.3B** FY23 budget

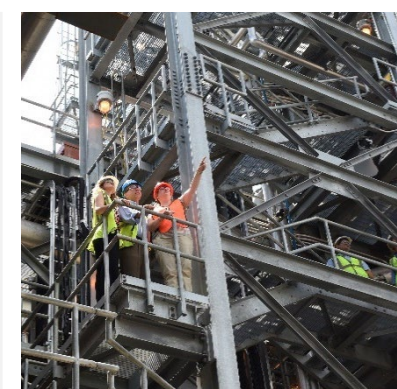
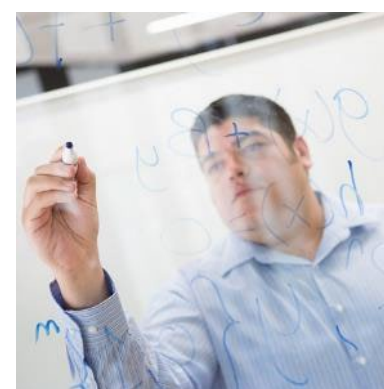
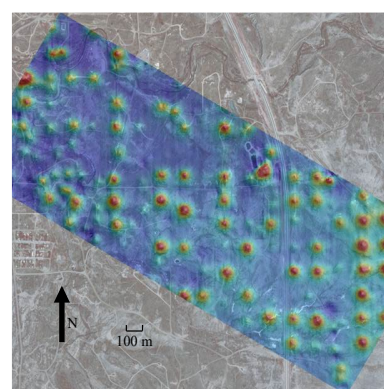
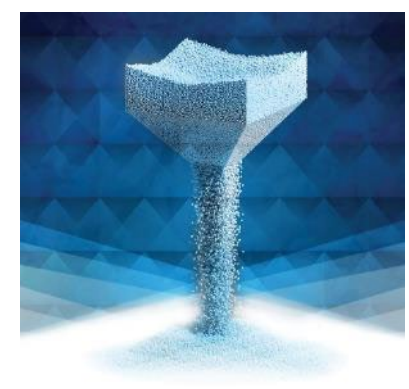
IMPLEMENTS R&D PROJECTS FOR DOE'S OFFICES OF:

- **Fossil Energy & Carbon Management**
- Energy Efficiency Renewable Energy
- Electricity
- Cybersecurity, Energy Security, & Emergency Response
- Manufacturing, & Energy Supply Chains
- Grid Deployment
- Clean Energy Demonstrations

NETL Core Competencies



CARBON MANAGEMENT • EFFICIENT ENERGY CONVERSION • RESOURCE SUSTAINABILITY



**COMPUTATIONAL
SCIENCE &
ENGINEERING**

**MATERIALS
ENGINEERING
& MANUFACTURING**

**GEOLOGICAL &
ENVIRONMENTAL
SYSTEMS**

**ENERGY
CONVERSION
ENGINEERING**

**STRATEGIC SYSTEMS
ANALYSIS &
ENGINEERING**

**PROGRAM
EXECUTION &
INTEGRATION**

**High Performance
Computing**

**Multi-Scale Modeling
Atomistic to Device**

**Artificial Intelligence
& Machine Learning**

**Structural &
Functional Materials**

**Design, Synthesis,
& Performance**

Characterization

**Geo-Analysis &
Monitoring**

**Reservoir
Engineering**

Geochemistry

Reaction Engineering

Design & Validation

Thermal Sciences

**Advanced System
Engineering**

**Energy Process &
System Engineering**

**Multi-scale
Modeling, Simulations
& Optimization**

Energy Markets Analysis

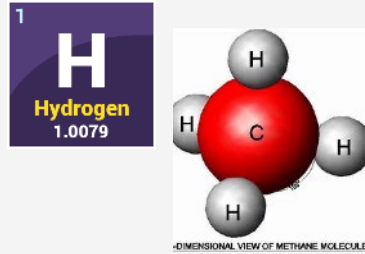
R&D Planning

**Technical Project
Management**

Finance & Acquisition

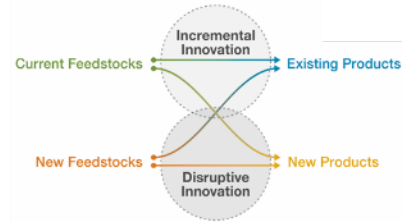
Carbon Innovation & Solutions for Industrial Sector

The Center for Sustainable Fuels & Chemicals Technical Offerings



Developing Lower Carbon Footprint Feedstocks

Select **feedstocks** for a more agile supply chain.



Increasing Processing Efficiency

Enhance materials, conversion and separation, microwave matched with **scale up**.



CO₂ Management

Manage the engineering, integration, and policy to **economically transition**.



Disposition & Recycling

Manage the product **life cycle** to collect, move, disassemble and re-create.



Cross-Cutting Decision Making

Quantify emissions and evaluate benefits of investment options via **LCA**.

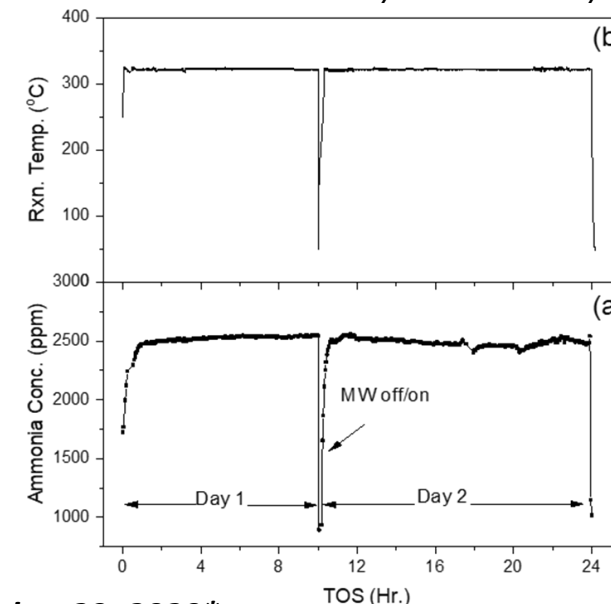
Ammonia mWave Technology & Catalytic Processes



Attractive alternative to traditional ammonia synthesis

- NETL's world-class expertise in microwave-assisted catalytic processes was applied to an alternative to traditional ammonia synthesis.
 - Utilized microwaves to develop a low temperature/pressure, economically viable modular scale version of the ammonia synthesis process by targeting specific catalytic ammonia reactions
 - Further demonstrated in an ARPA-E project to be capable of generating ammonia within a very short time after startup (on demand), allowing the process to be used for storing intermittent and renewable sources of energy as carbon neutral fuel.
 - This ammonia conversion is NOT Haber-Bosch and bypasses the syngas phase
 - Demonstrated ammonia production as carrier for hydrogen

Durability test of mWave catalyst with daily shut-downs



November 23, 2020*

NETL's pioneering Microwave Ammonia Synthesis (MAS) took home the 2020 IChemE Global Awards in the category of Research Project for its potential to aid in agriculture, energy production and other applications while also lowering costs and overall energy use.

<https://www.icheme.org/about-us/press-releases>

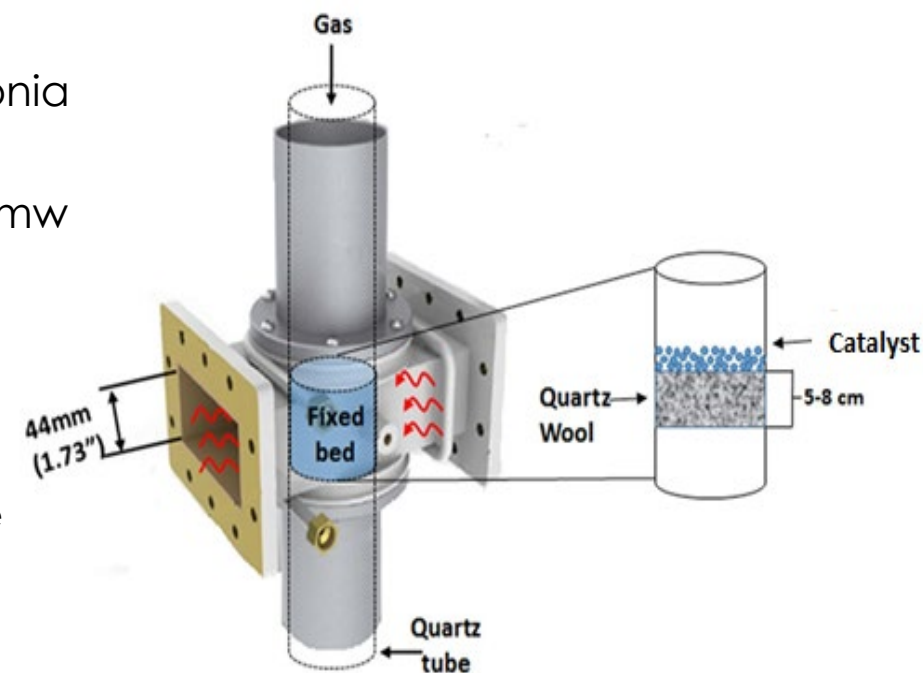
Microwave Ammonia Decomposition μ Wave

Cracking Ammonia Project using Microwave Enhanced Processing

Value of Microwave Use

- ✓ Rapid direct heating
- ✓ Direct reaction routes
- ✓ Higher selectivity and product distribution
- ✓ Lower processing conditions

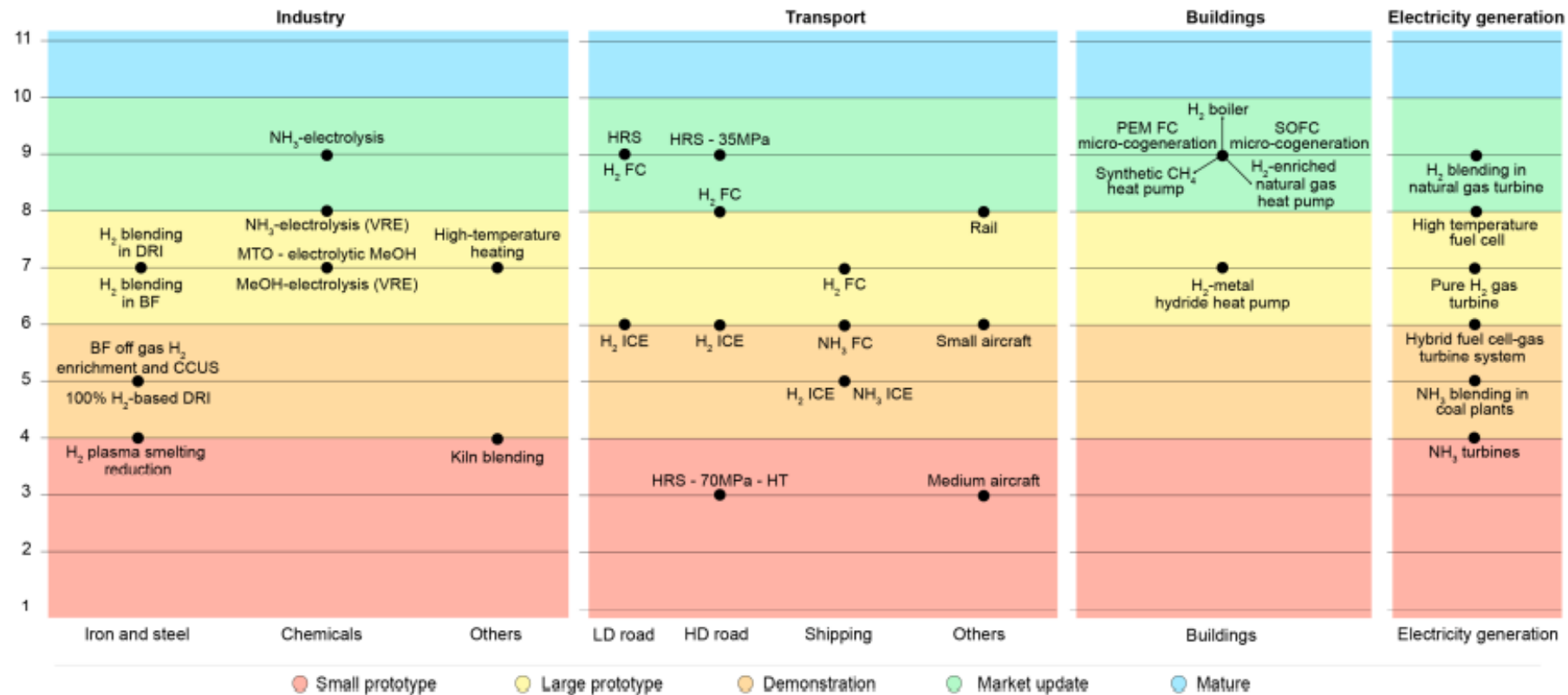
- Developing catalyst for ammonia decomposition below 500°C
 - Extensive experience with mw catalyst development
 - Preliminary results with Ru based catalyst show decomposition at 340 °C
- Study underway on non-noble metal catalysts
 - Ru catalyst will serve as a baseline
- Target more than 70% decomposition under 500 °C
- Understand microwave inputs vs other decomposition methods



Hydrogen & Ammonia Technologies

Global Hydrogen Review 2021 – Analysis - IEA

Technology readiness levels of key hydrogen end-use technologies



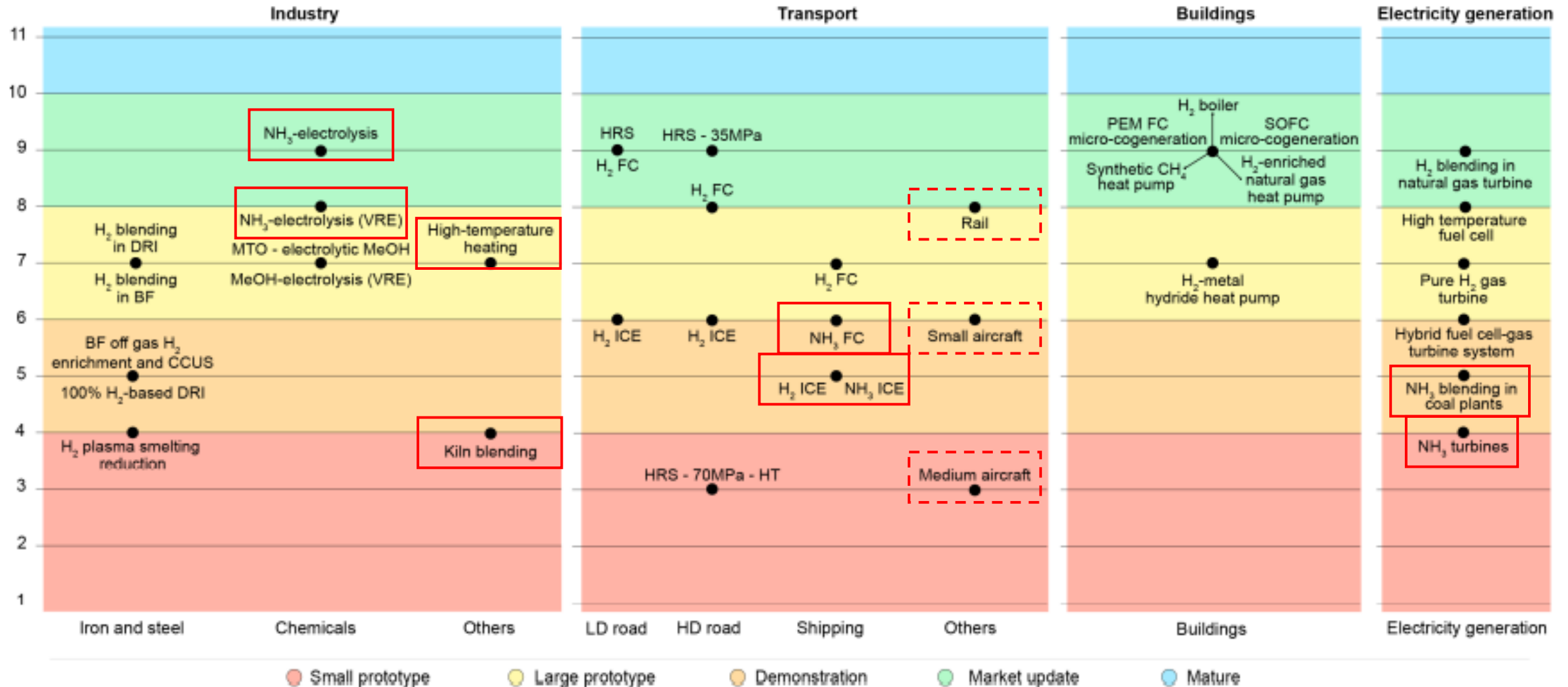
IEA. All rights reserved.

Notes: BF = blast furnace. DRI = direct iron reduction. FC = fuel cell. HRS = hydrogen refuelling station. HD = heavy-duty. HT = high throughput. ICE = internal combustion engine. LD = light-duty. MeOH = methanol. MTO = methanol to olefins. PEM FC = polymer electrolyte membrane fuel cell. SOFC = solid oxide fuel cell. VRE = variable renewable electricity. Co-generation refers to the combined production of heat and power. Technology readiness levels based on [Clean Energy Innovation \(2020\)](#), p. 67.

Source: IEA (2020), [ETP Clean Energy Technology Guide](#).

Hydrogen & Ammonia Technologies

Global Hydrogen Review 2021 – Analysis - IEA



Data infrastructure to enable and accelerate H₂ deployment



InsigH₂t Dashboard

- Hosted via the DOE EDX platform
- Optimized to **connect** community users to H₂ resources
- **Underpinned** by core EDX workflows, hardware, etc
- Enhanced and branded to **amplify** the tri-lab/office data management, virtualization, and digitalization capabilities

Putting H₂ data resources to work -

- Stakeholders/Community access to authoritative data, analytical, visualization, and virtual data infrastructure capacity
- H₂ Ecosystem – data curation and collaboration platform, includes both public and private data sharing capabilities, entire life-cycle of data, data discovery, transformation and integration.
- Multi-cloud deployment to enhance access by the H₂ stakeholder community to virtualized H₂ data and models to accelerate H₂ commercial, regulatory, social and environmental goals.