

Course Outline

Hydrogen Fundamentals



3-Part Course | 7 Hours

Live: December 6th, 7th, and 8th, 2022 from 2 - 4:20 PM Eastern

On-Demand: available December 22nd

An Introduction to Hydrogen - Applications, Technological Challenges, and the Long-Term Potential

The level of interest in hydrogen has grown rapidly in the past year, with many new multi-billion dollar projects being announced in various sectors of the emerging hydrogen economy. A recent report from the Hydrogen Council has identified over \$500 billion of projects, with 131 large-scale projects announced in the five months between February and July 2021.

The greatest emphasis is on green hydrogen – produced from water through the application of renewable energy, but there are also blue hydrogen projects involving carbon capture and storage. As project volumes increase, costs along the entire hydrogen value chain continue to fall. Some estimates foresee these costs declining by as much as two-thirds by 2040. In some markets – especially where carbon pricing improves the overall economic profile - green hydrogen may become cost-competitive with fossil fuels as early as 2035.

What does this mean for our clean energy transition? What are the key technological hurdles, applications, and resulting economics – especially in the electric power grid? Is the long-awaited hydrogen economy nearly here?

This Smart Electric Power Association course will address these questions and provide attendees with the understanding they need to grasp the key issues related to the emerging role of hydrogen in the evolving energy economy.

Learning Objectives

Attendees will understand:

1. The distinctions between green, blue, purple, and grey hydrogen.
2. The value of hydrogen in a carbon-free energy economy, in industrial and transportation applications, but most especially in the power grid.
3. The technical, physical and economic barriers that must be addressed for hydrogen to play a critical role in future power grids.
4. Efficiency losses along the hydrogen supply chain, from initial creation to transportation, storage, and conversion back to electricity.
5. Potential hydrogen applications of hydrogen, especially in turbines and fuel cell applications
6. Use cases, and projected investments along the hydrogen supply chain
7. Critical technological achievements and economic milestones

Outline

1. The Initial Push for Hydrogen – Starting with Industrial Applications
 - a. Hydrogen in the Industrial Sector Will Create Scale
 - i. Steel
 - ii. Cement
 - b. Potential Transportation Applications
 - ii. Long-Haul Trucking
 - iii. Rail
 - iv. Maritime
 - c. Long-Term Energy Storage

2. The Chemistry: Advantages and Challenges
 - a. Molecular Structure (why that matters)
 - b. Energy Density
 - c. Flame Speed
 - d. Other Essential Characteristics
3. Necessary Price Points and Comparisons: Technology, Costs and Current Applications
 - a. Grey Hydrogen (Steam Methane Reformation)
 - b. Blue Hydrogen (Carbon Capture and Storage)
 - c. Purple Hydrogen (Nuclear)
 - d. Turquoise Hydrogen (Pyrolysis)
 - e. Green Hydrogen (Electrolysis from Renewables)
4. Green Hydrogen: From Creation to Consumption - Challenges Along the Entire Chain
 - a. Electrolyzer Technologies, Current Costs and Challenges
 - i. Solid Oxide
 - ii. Alkaline
 - iii. Polymer Electrolyte Membranes (PEMs)
 - iv. Anion Exchange Membrane
 - v. Wright's Law and Future Cost Projections
 - b. Transportation
 - i. Compressed – Advantages and Disadvantages
 - ii. Liquefied - Advantages and Disadvantages
 - iii. Liquid Organic Carriers
 - iv. Inorganic Carriers, e.g., Ammonia
 - c. Storage
 - i. Caverns
 - d. "Well to Wheel" Efficiency Losses in Chain
5. Electric Power Grid Applications
 - a. Behind-the-Meter Generation for Reliability/Resilience – Emerging Use Cases
 - b. Grid-Scale Inter-seasonal Storage to Decarbonize the Grid
 - c. Carbon-Light Electricity Generation: Methane/Hydrogen Fuel Mixtures: Current Turbine Capabilities
6. Government Programs Driving Scale
 - a. Japan
 - b. China
 - c. Australia
 - d. EU
 - e. US
7. Grid Applications and Proposed Projects
 - a. Intermountain (LADWP)
 - b. New Fortress/GE - Hannibal Ohio
 - c. Florida Power and Light
 - d. San Diego Gas & Electric
 - e. Douglas County PUD No. 1

8. Meaningful Hydrogen Production Projects Announced To Date
 - a. Australia
 - b. North Sea
 - c. United States
9. What to Watch For in the Coming Years