The Hydrogen Landscape: Production, Policy and Regulation (G575)

Tutor(s)

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Overview

Future energy scenarios foresee a prominent and growing role for hydrogen. Demand is likely to rapidly exceed the capacity of typical above-ground energy storage technologies, necessitating the need for the geological storage of hydrogen in engineered hard rock caverns, solution mined salt caverns, depleted gas fields and saline aquifers. This course will provide participants with an overview of the current hydrogen landscape, including its likely role in the energy transition, production and economic challenges.

Duration and Logistics

Classroom version: A 1-day course comprising a mix of lectures, case studies and exercises. The manual will be provided in digital format and participants will be required to bring a laptop or tablet computer to follow the lectures and exercises.

Virtual version: Two 4-hour interactive online sessions presented over two days. Digital course notes and exercise materials will be distributed to participants before the course. Some exercises may be completed by participants off-line.

Level and Audience

Fundamental. Intended for subsurface scientists involved in hydrogen projects.

Objectives

You will learn to:

1. Appreciate the role of geoscience in the hydrogen economy and the contribution hydrogen can make to the energy transition in support of Net Zero emission targets.
2. Describe the different processes involved in hydrogen production and the associated lifecycle carbon intensity of this production.
3. Recall details of the developing hydrogen supply chains, including infrastructure considerations, distribution networks and pathways for market growth.

Course Content

Course Details

Lectures

- Role of hydrogen in the energy transition (is it more than the last 20% of clean power?)
    - energy storage to balance renewables
    - decarbonizing hard to abate sectors

- Energy system integration
    - power to X
    - existing energy system overview
    - renewable energy and curtailment
    - grid scale energy storage requirements / challenges
- Policy and regulatory landscape
    - policy drivers
    - legal and regulatory frameworks
    - licencing and permitting
    - safety standards and gas regulations
    - just transition
- Existing / planned hydrogen projects globally
- Hydrogen production – the full rainbow
    - natural hydrogen accumulations (white hydrogen)
    - methane (SMR), autothermal (ATR) reformation, partial oxidation (POX) or pyrolysis of hydrocarbons (grey hydrogen) and coal (brown / black hydrogen)
    - above with capture and secure geological storage of the CO2 (blue hydrogen)
    - electrolysis using renewable electricity (green hydrogen)
    - metabolic microbial processes using light energy to produce hydrogen from water
    - fermentation of biomass to produce hydrogen
    - pyrolysis or gasification of biomass
    - photoelectrochemical Water Splitting
    - Solar Thermal Water Splitting (yellow hydrogen)
    - electrolysis powered by nuclear energy (pink hydrogen)
    - in-situ hydrocarbon combustion
    - methane pyrolysis to produce hydrogen and solid carbon (turquoise hydrogen)
- Lifecycle carbon intensity of hydrogen production
- Storing and moving hydrogen
    - properties of hydrogen as an energy carrier
    - pressures of hydrogen within the entire chain
    - storing compressed / liquid hydrogen (line pack – tanks – geological)
    - hydrogen carriers and adsorbents, including ammonia, liquid organic hydrogen, metal hydrides
    - pipelines
        - suitability to hydrogen (e.g. embrittlement)
        - hydrogen blending / de-blending
        - repurposed vs new systems
- Costs and efficiency penalties
    - hydrogen production methods
    - cost, efficiency and infrastructure considerations in compression and liquification application.
- Developing hydrogen supply chains for a just energy transition (uses)
    - approaches to hydrogen market growth
    - scaling up

    - development of the hydrogen distribution and storge infrastructure
    - industrial clusters and hubs
    - hydrogen value chain
    - innovation and technology opportunities
    - hydrogen / carbon trading
- Impact of increased hydrogen concentrations form fugitive emissions in the atmosphere
- Assessment of critical mineral needs in batteries versus fuel cells

Activities

- Using the MacKay Carbon Calculator, creating pathways to find out how we might reduce the UK’s greenhouse gas emissions to Net Zero by 2050 and beyond, and highlight the opportunities for hydrogen
- Estimating emission savings associated with a range of different hydrogen switching options.