

Blue Hydrogen, Meaning, Process, Significance and Challenges

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Blue hydrogen refers to hydrogen produced **from natural gas** through a process called **steam methane reforming** (SMR), combined with **carbon capture and storage** (CCS) technology to reduce carbon emissions. It aims to **mitigate greenhouse gas emissions** associated with traditional hydrogen production methods.

While **not entirely carbon-free**, blue hydrogen offers a **lower-emission alternative to conventional fossil fuels**, positioning it as a bridging solution as the world transitions towards more sustainable energy sources like **green hydrogen**.

About Blue Hydrogen

Depending on the nature of the **method of its extraction**, hydrogen is categorised into three categories, namely, **Grey, Blue and Green**.

Blue hydrogen is a form of hydrogen produced from natural gas using **carbon capture and storage (CCS) technology**. In this process, **natural gas and heated water (steam)** are combined, which produces hydrogen as

the main output. However, **carbon dioxide (CO₂)** is also produced as a **by-product**.

- The CO₂ generated during this process is **captured and stored** underground, preventing its release into the atmosphere.
- Hence, blue hydrogen is a **lower-emission alternative** to natural gas and other fossil fuels.

Blue Hydrogen Production

To extract the blue hydrogen, the main processes include the Shell Blue Hydrogen Process (SBHP), steam methane reforming (SMR) and auto thermal reforming (ATR).

- **Natural gas extraction:** Natural gas is extracted from underground reservoirs through drilling and fracking operations.
- **Hydrogen separation:** The methane in natural gas is subjected to a chemical process, such as steam methane reforming or auto-thermal reforming, which separates the hydrogen molecules from the carbon atoms.
- **Carbon Capture and Storage (CCS):** The **CO₂** generated during the hydrogen production process is captured using various technologies such as absorption, adsorption, or membrane separation.
 - The captured CO₂ is then **transported and stored underground** in geological formations or depleted oil and gas reservoirs.

Blue Hydrogen Significance

Blue hydrogen holds a variety of uses and possibilities. It can act as a **bridging fuel** for current systems, particularly in areas where direct electrification might not be practical or economical. It offers several benefits:

- **Lower emissions:** Blue hydrogen produces significantly lower emissions compared to natural gas and other fossil fuels.
 - The CCS technology captures and stores the CO₂ generated during hydrogen production, preventing its release into the atmosphere.
- **Compatibility with existing infrastructure:** Blue hydrogen can be produced using existing natural gas infrastructure, making it a more cost-effective and efficient transition from fossil fuels to cleaner energy sources.
- **Flexibility:** Blue hydrogen can be used in various applications, including power generation, transportation, and industrial processes, making it a versatile energy source.

Blue Hydrogen Challenges and Limitations

Blue hydrogen faces several challenges and limitations, primarily related to its production process and environmental impact:

- **Carbon capture efficiency:** Achieving high capture rates is technically challenging and expensive. Current technologies may not capture all emitted CO₂.
- **Methane leakage:** Natural gas extraction and transport can result in methane leaks, a potent greenhouse gas that undermines the benefits of blue hydrogen.

- **Energy intensity:** The production of blue hydrogen is energy-intensive, requiring significant amounts of energy to extract natural gas and produce hydrogen.
 - This can lead to increased greenhouse gas emissions and energy consumption.
- **Competition with Green Hydrogen:** Green hydrogen, produced using renewable energy sources like wind or solar power, is considered a more sustainable and environmentally friendly alternative to blue hydrogen.
 - The competition between blue and green hydrogen may affect the adoption of either technology. Green hydrogen's cost is anticipated to decrease by 50% by 2030, aligning it with blue hydrogen costs by 2050.

Blue Hydrogen UPSC PYQs

Question 1: With reference to 'fuel cells' in which hydrogen-rich fuel and oxygen are used to generate electricity, consider the following statements : **(UPSC Prelims 2015)**

1. If pure hydrogen is used as a fuel, the fuel cell emits heat and water as by-products.
2. Fuel cells can be used for powering buildings and not for small devices like laptop computers.
3. Fuel cells produce electricity in the form of Alternating Current (AC).

Which of the statements given above is/are correct?

1. 1 only
2. 2 and 3 only
3. 1 and 3 only
4. 1, 2 and 3

Answer: (a)

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