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World's First Nuclear Process-Heat Hydrogen Plant at Kalpakkam

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WHY IN NEWS

India inaugurated the world's first hydrogen production facility that draws process heat from a nuclear reactor, using the indigenous Copper-Chlorine (Cu-Cl) thermochemical cycle, at the Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam, Tamil Nadu. The plant was commissioned on June 26, 2026.

THE KALPAKKAM HYDROGEN FACILITY

The facility, developed by the **Bhabha Atomic Research Centre (BARC)**, is the first in the world to produce hydrogen by tapping the high-temperature **process heat** of a nuclear reactor rather than relying on grid electricity. It was inaugurated by **Ajit Kumar Mohanty**, Secretary of the Department of Atomic Energy (DAE) and Chairman of the Atomic Energy Commission (AEC).

The heat is sourced from the **Fast Breeder Test Reactor (FBTR)**, a sodium-cooled reactor operated by IGCAR at Kalpakkam. By using nuclear heat directly to split water, the plant avoids the heavy electricity demand of conventional water electrolysis.

Key Facts at a Glance

FEATURE	DETAIL
Location	IGCAR, Kalpakkam, Tamil Nadu
Developer	Bhabha Atomic Research Centre (BARC)
Heat source	Fast Breeder Test Reactor (FBTR), sodium-cooled
Process	Copper-Chlorine (Cu-Cl) thermochemical cycle
Inauguration	June 26, 2026
Inaugurated by	Ajit Kumar Mohanty (DAE Secretary, AEC Chairman)

HOW THE COPPER-CHLORINE (CU-CL) THERMOCHEMICAL CYCLE WORKS

In conventional **electrolysis**, electricity is passed through water to separate it into hydrogen and oxygen. The **Copper-Chlorine (Cu-Cl) thermochemical cycle** is fundamentally different. It is a closed-loop chemical process in which water is split through a sequence of chemical reactions driven by moderate-temperature heat, with copper and chlorine compounds acting as reusable intermediaries. The copper and chlorine are recycled within the loop and are not consumed, so the only net inputs are water and heat, and the outputs are hydrogen and oxygen.

The advantage is efficiency. Thermochemical cycles can use the reactor's heat directly, sidestepping the conversion losses that occur when heat is first turned into electricity and then back into chemical energy through electrolysis.

WHERE NUCLEAR HYDROGEN FITS IN THE COLOUR SPECTRUM

Hydrogen is classified by the energy source used to make it. **Green hydrogen** uses renewable electricity for electrolysis; **grey hydrogen** comes from fossil gas; **blue hydrogen** is grey hydrogen with carbon capture. Hydrogen produced using nuclear energy is sometimes called **pink or red hydrogen**. Because the Kalpakkam plant uses nuclear heat with negligible direct carbon emissions, it qualifies as low-carbon hydrogen.

LINK TO THE NATIONAL GREEN HYDROGEN MISSION

The facility supports the **National Green Hydrogen Mission**, launched in 2023, which targets the production of **5 million metric tonnes (MMT) per year** of green hydrogen by 2030. While the mission is centred on renewable-powered electrolysis, nuclear process-heat routes offer a complementary, round-the-clock and weather-independent source of low-carbon hydrogen.

ANALYSIS AND WAY FORWARD

Hydrogen is critical for decarbonising **hard-to-abate sectors** such as steel, fertiliser and refining, where direct electrification is difficult. A nuclear-heat route provides a stable baseload supply of clean hydrogen that does not fluctuate with sunlight or wind, addressing one of the key limitations of renewable-only pathways.

The way forward lies in scaling the Cu-Cl cycle from a demonstration plant to commercial volumes, coupling it with India's expanding fleet of fast reactors, and integrating nuclear hydrogen into industrial clusters. Sustained research into materials that withstand the corrosive, high-temperature environment of thermochemical cycles will be essential to long-term viability.

UPSC RELEVANCE

GS Paper 3: Achievements of Indians in science and technology, indigenisation (https://ujiyari.com/vocab/indigenisation/) of technology, energy security, and environmental conservation.

Prelims pointers: Cu-Cl thermochemical cycle splits water using heat, not electrolysis; FBTR is sodium-cooled and located at IGCAR Kalpakkam; BARC developed the plant; nuclear hydrogen is called pink or red hydrogen; National Green Hydrogen Mission launched 2023, target 5 MMT per year by 2030.

Mains question: "Nuclear-sourced hydrogen can complement renewable green hydrogen in India's energy transition. Discuss the technological and strategic significance of the Copper-Chlorine thermochemical route demonstrated at Kalpakkam." (15 marks, 250 words)

FACTS CORNER

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Plant: World's first nuclear process-heat hydrogen facility, inaugurated June 26, 2026.

Location: Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam, Tamil Nadu.

Developer: Bhabha Atomic Research Centre (BARC).

Heat source: Fast Breeder Test Reactor (FBTR), a sodium-cooled reactor.

Process: Copper-Chlorine (Cu-Cl) thermochemical cycle, splits water using heat, not electrolysis.

Inaugurated by: Ajit Kumar Mohanty, DAE Secretary and AEC Chairman.

Colour code: Nuclear-sourced hydrogen is called pink or red hydrogen; it is low-carbon.

National Green Hydrogen Mission: Launched 2023; target 5 million metric tonnes (MMT) per year by 2030.

Use: Decarbonising hard-to-abate sectors such as steel and fertiliser.

Sources: Bhabha Atomic Research Centre (https://www.barc.gov.in), Department of Atomic Energy (https://dae.gov.in), Press Information Bureau (https://pib.gov.in)

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