# Rethinking Coal's Role in Low-Carbon Hydrogen

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**2025-IP03**

**Citation: IEAGHG, "Rethinking Coal's Role in Low-Carbon Hydrogen", 2025-IP03, June 2025, doi.org/10.62849/2025-IP03.**

## Context

The global discourse on energy transition is increasingly underpinned by policy frameworks that call for the systematic phase out of unabated coal use. While these efforts are critical for climate mitigation, the prevailing discourse often casts coal, beyond just its unabated form, as incompatible with a low carbon future. This broad-brush treatment risks overlooking the evolving role of carbon capture and storage (CCS)-abated coal, particularly in the production of low carbon hydrogen.

**Using best available technologies, CCS-abated hydrogen produced from coal can achieve life cycle environmental impacts similar to those of renewable hydrogen.**[1] So, what's all the fuss about abated coal? After all, it is intended to serve as a bridge until electrolytic hydrogen can scale up to meet global demand. Hydrogen from CCS-abated coal represents a strategic opportunity for coal-rich regions, addressing the dual need for secure energy supply and decarbonisation.

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[1] Zhu, Q. (2023) *Hydrogen Economy and the Role of Coal*. March 2023. International Centre for Sustainable Carbon.

Notably, at less than 0.1%[1] of global production, electrolytic hydrogen is still more of a trace element than a game changer in the near term. This limitation underscores the importance of exploring alternative low-emission hydrogen pathways, particularly those that can scale more rapidly.

This insight paper draws on two key reports that explore the potential of coal-based hydrogen production with CCS:

- Hydrogen Economy and the Role of Coal – International Centre for Sustainable Carbon (ICSC)
- Evaluation of Options for Production of Low-Cost $CO_2$ - Free Hydrogen from Victorian Brown Coal – Commonwealth Scientific and Industrial Research Organisation (CSIRO)

# ICSC and CSIRO Perspectives on Hydrogen from CCS Abated Coal: Key Findings

## 1 . Hydrogen from coal can be as clean as renewable hydrogen

Although coal gasification is among the most carbon intensive hydrogen production routes, integrating CCS at capture rates exceeding 98%, can significantly reduce $CO_2$ emissions from about 20 kg $CO_2$ per kg $H_2$ to as low as 0.4 to 0.6 kg $CO_2$ per kg $H_2$.

Further, cogasifying coal with sustainably sourced biomass with CCS presents a cost effective and scalable pathway for producing net zero or even negative emission hydrogen.

## 2. Cost competitiveness

Hydrogen produced from coal can improve the economic viability of low emission hydrogen, with a production cost of approximately $1.60/kg $H_2$ via coal gasification with CCS ($3.50/kg $H_2$ for brown coal gasification with CCS), compared to $6.00–$9.30/kg $H_2$ for water electrolysis (USDOE, 2020). This cost advantage supports early and broader deployment and positions coal-based hydrogen as a practical transitional pathway toward renewable hydrogen in the longer term.

## 3. Strategic importance of coal-based hydrogen in regional contexts

Coal has a role to play in certain regions and markets, where it can support the growth of a hydrogen economy and facilitate the transition to net zero emissions. The studies acknowledge that different hydrogen pathways will suit different regional contexts, depending on domestic resource availability, infrastructure, and policy readiness

- Geopolitically, countries like China and India are expected to rely on domestic coal-based hydrogen due to coal availability and energy security needs.

- In parallel, for hydrogen importing countries like Japan and South Korea, low emission hydrogen from coal presents a cost competitive alternative to other imported hydrogen sources, making it an attractive option for securing supply while supporting decarbonisation goals.
- Meanwhile, coal-exporting nations such as Australia and Indonesia can leverage low-emission hydrogen and ammonia production as a strategic shift from fossil fuel exports, and which presents a significant economic opportunity, enabling them to supply low and stable priced hydrogen to importers

## 4. Land and water requirements:

The feasibility of producing hydrogen via electrolysis using wind or solar energy is constrained by access to vast land area required and the significant volumes of deionised water needed, particularly in remote locations where supporting infrastructure may be limited.

Land requirements further reinforce this challenge. Producing 1.76 million tonnes of hydrogen per year via electrolysis powered by renewables could require up to 5750 $km^2$ of land, compared to just 17 $km^2$ for coal gasification with CCS and 14 $km^2$ for natural gas steam methane reforming (SMR) with CCS.

For photovoltaic (PV) systems specifically, generating 9.4 GW of electricity would require approximately 15000 hectares of bare panels, or 23000 hectares once installed. For context, the largest PV farm in Australia, the 102 MW Nyngan Solar Plant in New South Wales, occupies 250 hectares. Meeting the 9.4 GW target would thus require the equivalent land area of 92 Nyngan Solar Plants.

Electrolysis also relies on high purity water, and when multi-stage compressors with intercooling are included, total water consumption can reach 30 to 90 kg $H_2O$ per kg $H_2$. In comparison, coal gasification, depending on coal type and process conditions, requires 31 to 70 kg $H_2O$ per kg $H_2$. Overall, water consumption for coal-based hydrogen is broadly comparable to that of electrolysis.

## 5. Materials requirements

Electrolytic hydrogen production relies heavily on critical minerals. Scaling up electrolysis to meet global hydrogen demand could place significant pressure on these mineral supply chains. In contrast, coal gasification with CCS is less mineral intensive, relying mostly on bulk construction materials (e.g. steel, concrete). While CCS infrastructure (e.g. pipelines, injection wells) also requires materials, the overall dependence on critical minerals is substantially lower than that of renewable-based electrolytic hydrogen systems.

## 6. Electrolytic hydrogen is the long-term goal

Both studies acknowledge that renewable hydrogen is the preferred long-term objective in a net zero energy system. However, its scalability in the short to medium term is limited by several factors, including land intensity, high purity water requirements, and the slow roll out of electrolyser production at scale. Even if electrolyser manufacturing ramps up, deployment will continue to be constrained by the availability of affordable and reliable renewable electricity, which itself requires substantial investment in generation, transmission, and storage infrastructure. In addition, ongoing supply chain constraints particularly for critical minerals, components, and specialised materials pose further challenges to scaling up renewable hydrogen production globally.

In the long term, renewable hydrogen is expected to outcompete fossil-based options in most markets. In this context, coal-based hydrogen with CCS can serve an essential bridge to support growing demand and enable the development of international hydrogen trade routes.

## 7. Lock-in risk:

Although not explicitly stated, without clear policy direction and long-term planning, there is a potential risk that investments in abated fossil-based hydrogen production could delay the transition to renewable hydrogen. This lock-in effect occurs when infrastructure, capital, and supply chains become tied to fossil fuel-based systems, making it more difficult and costly to pivot to renewable alternatives later on.

## 8. Low hydrogen yield limits competitiveness of pyrolysis pathway

The direct extraction of hydrogen from pyrolysis gas is not considered competitive due to the low hydrogen yield and the requirement for a large-scale facility, including briquetting systems.

## 9. Environmental impact

Extraction of coal poses challenges for land disturbance, ecosystem disruption, and water resource management. Ensuring proper mine site rehabilitation and closure is essential to mitigate legacy environmental liabilities, including soil contamination, subsidence risks, and the visual impact of abandoned sites.

*The nuances associated with net-zero aligned technologies across eight primary energy resources, including gas, coal, biomass, nuclear, hydro, wind, and hybrid renewables are currently being examined in an ongoing IEAGHG study. This study evaluates each technology against a set of key performance indicators, including deployment potential, cost, global warming potential (GWP), land use, mineral and fossil resource scarcity, and water consumption. It aims to provide insights into the comparative performance and trade-offs associated with large-scale deployment. In addition, the study will explore the* *development of tools to test regional assumptions and incorporate locally specific data inputs, with the objective of enhancing the study's relevance and practical applicability across different geographic and policy contexts.*

## Conclusion

Hydrogen from CCS-abated coal presents a pragmatic and cost-effective pathway to support the energy transition, particularly in regions with abundant coal resources. While renewable hydrogen remains the long-term objective for achieving net zero, the current limitations in electrolyser manufacturing, renewable electricity infrastructure, and critical mineral supply chains necessitate parallel development of alternative low-emission hydrogen routes.

The evidence from the ICSC and CSIRO studies demonstrates that, with best available technologies, coal-based hydrogen with CCS can achieve life cycle environmental performance comparable to renewable hydrogen. Moreover, it offers near-term scalability, economic viability, and strategic alignment with regional energy contexts and trade opportunities.