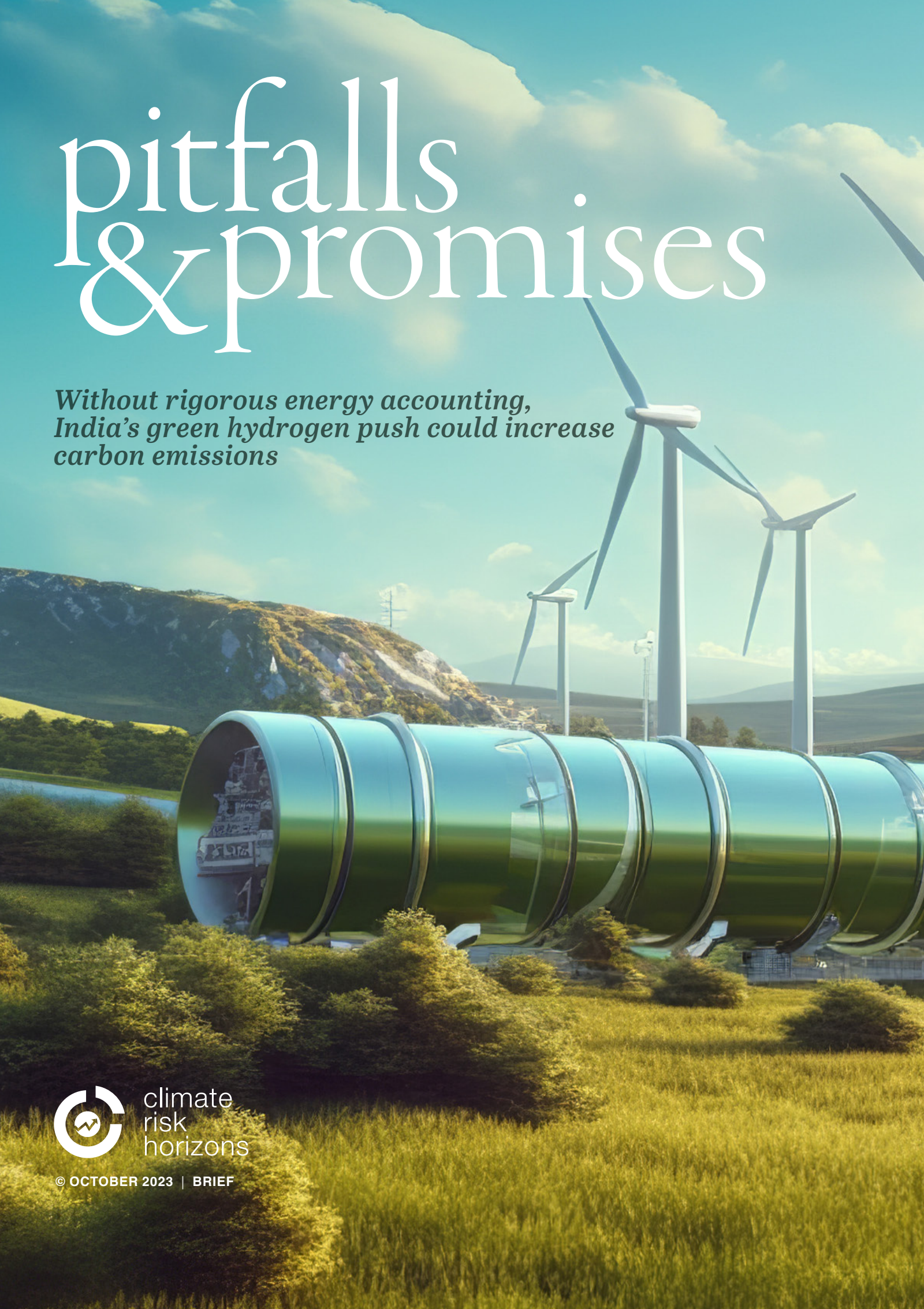
pitfalls & promises

Without rigorous energy accounting, India's green hydrogen push could increase carbon emissions



climate risk horizons

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key points

01» Embodied emissions from grid-connected hydrogen electrolysis could be multiple times worse than conventional 'grey' hydrogen produced from fossil fuels.

02» A growing body of research shows that requiring hydrogen producers to procure carbon-free electricity matching their annual consumption ***does not reduce emissions at all.***

03» Reliance on the Renewable Energy Credit (REC) market runs the same risk, as the REC market is itself not rigorous and does not meet the requirements of hourly matching, additionality or deliverability.

04» However, ***requiring hourly matching of electricity consumption with new clean generation*** can minimise emissions from hydrogen production.

05» While a detailed cost analysis based on specifics of the Indian grid is required, similar analysis undertaken in the United States suggests that an hourly matching requirement has only a small impact on the cost of hydrogen production.

the promise

The Ministry of New and Renewable Energy is in the process of finalising the accounting/certification methods for green hydrogen. The integrity of this methodology will be crucial; an accounting system that is lax or shoddily designed could, perversely, end up subsidising the production of so called "green hydrogen" that is, in fact, more carbon intensive than the "business as usual" grey hydrogen derived from fossil fuels.

Green hydrogen can go a long way to addressing the GHG emissions of carbon intensive industrial sectors such as fertiliser, steel and chemicals. India's cheap and plentiful Renewable Energy (RE) resources can be used to generate clean electricity that can in turn be used to run electrolysers that will split water to generate hydrogen with minimal carbon emissions.

India's green hydrogen mission has a 2030 production capacity target of 5 MMT (million metric tonnes), with an associated renewable energy capacity addition of about 125 GW.[1] Approximately 250 TWh of electricity would be needed to generate 5 MMT of green hydrogen; this is equivalent to about 13% of India's current electricity generation.[2]

As of August 2023, India's total renewable capacity (excluding large hydro) stood at 131 GW; the 2030 green hydrogen figure thus envisages adding an equivalent RE capacity by 2030. This would be in addition to the existing 500 GW non-fossil target submitted as part of India's Nationally Determined Contribution under the Paris Agreement. In FY 2023, India installed 15 GW of new solar and wind capacity, against the ~45 GW per year needed to reach the 2030 target.

1. *National Green Hydrogen Mission*.
2. *Ministry of Power, 2023. Growth Of Electricity Sector In India From 1947–2023*.

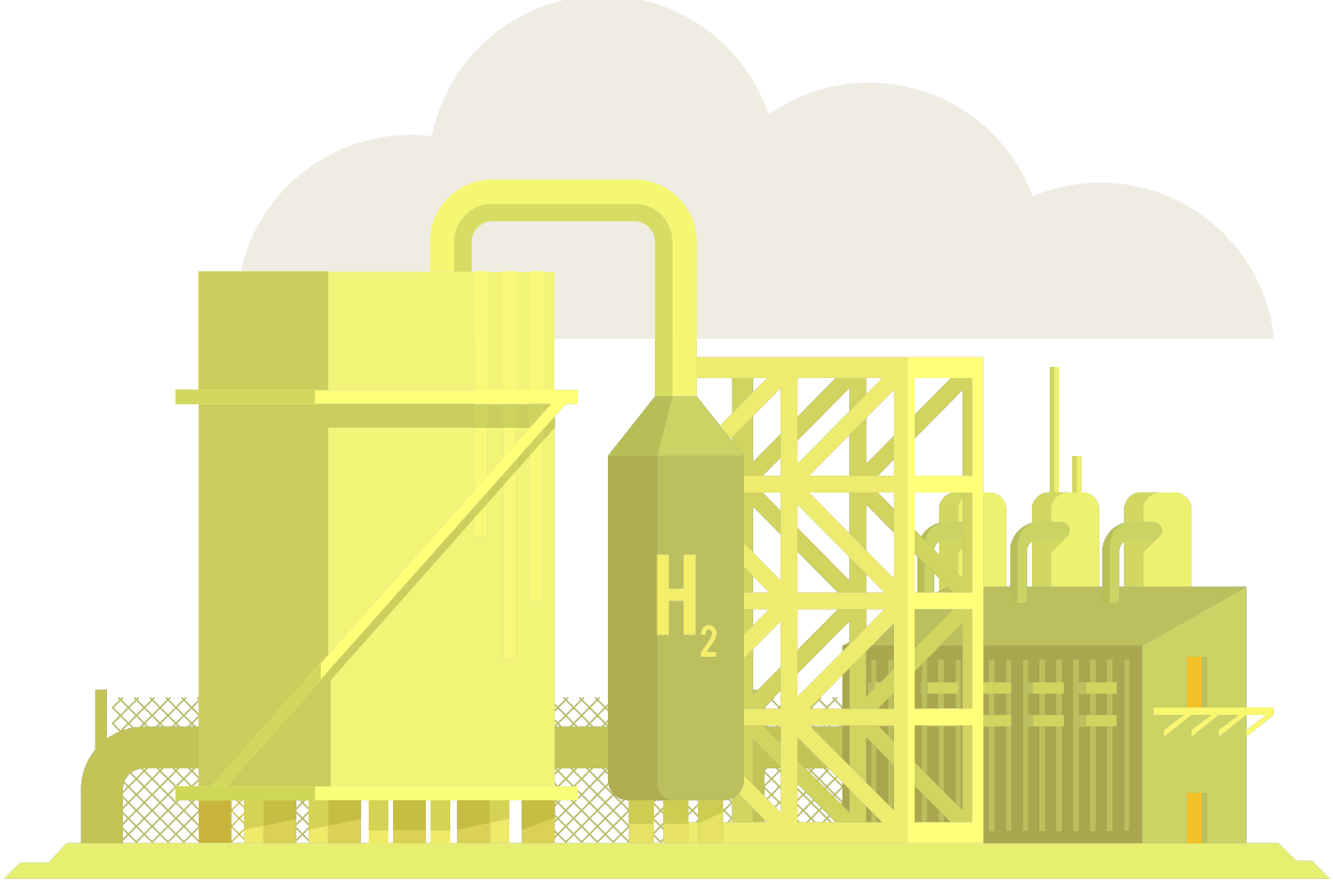
In August 2023, the Ministry of New and Renewable Energy (MNRE) released[3] its definition of green hydrogen, specifying an "emission threshold of 2 kg/CO_2 equivalent per kg of hydrogen as a 12-month average." While a detailed methodology is awaited, the definition as it stands leaves a lot to interpretation.

For instance, does the threshold of 2 kg CO_2 per kg of hydrogen include Scope 2 emissions, that is emissions embodied in the source of electricity used? The existing EU standard includes both Scope 1 and Scope 2 emissions.[4]

3. National Green Hydrogen Mission.

4. EU Rules for Renewable Hydrogen: Delegated regulations on a methodology for renewable fuels of non-biological origin.

The MNRE definition also includes the use of biomass, which in itself is problematic both in terms of carbon emissions from the gasification process, as well as the source of the biomass itself. This could lead to unintended effects such as the diversion of edible crops or other unsustainable practices.



the pitfalls

If electrolysers are run 24x7, they will operate even in non-RE generating periods. Where will the electricity come from? If it comes from India's coal-powered grid in general, it will in fact increase carbon emissions, since about 70% of the electricity on the grid is coal-generated — more in non-daylight hours when solar generation is nil.

Annual or monthly matching of hydrogen electrolyser consumption with carbon-free electricity will not reduce emissions. If electrolysers are powered during non-RE generating periods with electricity from the grid, carbon emissions will rise, as over 70% of India's grid power is coal-based.

Research in the United States suggests that embodied carbon emissions from "green" hydrogen produced using loose accounting standards would in fact be several times more than those from traditional "grey" hydrogen produced from fossil fuels and drive tens of millions of tonnes of additional emissions into the atmosphere.[5] Given the Indian grid's higher dependence on coal for electricity, particularly during non-sunlight hours, the carbon intensity of "green hydrogen" produced with electricity from the grid will likely be much worse. The average Indian grid emissions range from a low of 0.68 to a high of 0.89 tonnes/CO_2 per mWh.[6] The periods of highest CO_2 intensity are during the night time hours and the lowest are during daytime, when solar generation is highest.

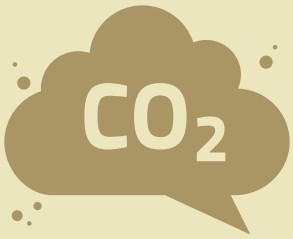
In theory, electrolysers could be run only during solar producing hours. However, at a capital cost of US $1700–2100/kW depending on type of system,[7] the incentive to run an electrolyser 24x7 will be high.

5. *Wilson Ricks et al 2023 Environ. Res. Lett. 18 014025.*
6. *Based on MERIT India data from 2022 to May 2023.*
7. *IEA 2023. Global Hydrogen Review.*

Only 15% of the green hydrogen production capacity announced so far (266,000 metric tonnes per annum from a total of 1.7 million MT/p.a.) have announced renewable energy PPAs or captive RE generation to meet their electricity demand.[8] The vast majority of projects have not disclosed their source of electricity. It is also not clear if those few projects that have committed to renewable PPAs or captive RE generation intend to meet 100% of their requirement from these sources.

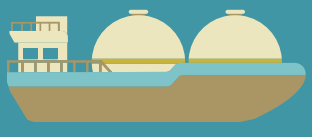
Reliance on REC's to meet all or a part of a 100% RE requirement will not deliver emissions reductions, as the REC does not guarantee that additional renewable electricity was produced, nor does it ensure that the underlying renewable energy was produced at the same time as its electricity was consumed by the green hydrogen production facility. The Indian REC market is also oversupplied. In effect, RECs would offer hydrogen producers a cheap way to claim they are 100% RE dependent, while in fact using fossil electricity that would increase system-level emissions.

8. *CRH analysis of data from Bloomberg New Energy Finance, September 2023.*



emissions risk

Weak guidelines for green hydrogen will squander the promise and effectiveness of truly green hydrogen as a decarbonisation tool and will probably increase emissions, which is in direct conflict with the aims of the green hydrogen mission. This could also jeopardise India's clean hydrogen industry as a whole, as a polluting and contentious start to the sector would damage international credibility, reduce access to export markets and undermine public trust.



export market risk

Ensuring India's green hydrogen is truly green and does not embody emissions from fossil fuel powered electricity is essential if the country is to tap into the anticipated global green hydrogen export market. In the absence of a rigorous carbon accounting system, India's green hydrogen producers might find anticipated export markets closed to them. The EU has implemented new green hydrogen standards that are based on the three pillars of hourly matching, additionality and deliverability. These rules are currently (as of September 2023) under consideration in the US as well. Producers of "green hydrogen" that do not match these standards will likely find EU/US markets closed to them.

wider economic risks

Market restrictions such as the Carbon Border Adjustment Mechanism currently under consideration in the EU could impact Indian industrial consumers of green hydrogen hoping to command a premium in international markets on account of the lower carbon embedded in their product. Green hydrogen is key to the Indian steel industry's global ambitions. As the demand for green steel grows, failure to decarbonize the industry effectively, including through the use of green hydrogen where applicable, risks undermining export demand for steel from India.

the solution

The MNRE has promised a detailed methodology for measurement, reporting, monitoring, and on-site verification and certification of green hydrogen. The future of India's green hydrogen ambitions rests on MNRE getting this right.

01

Scope 2 emissions must be included in the accounting, so as to ensure that the emissions of the source of electricity used in the green hydrogen manufacturing process are accounted for.

02

Utilising RECs in their current form to satisfy the RE requirement would offer a significant loophole, as today's REC system does not guarantee temporal or spatial matching.

03

Delivering on the decarbonisation potential of green hydrogen would require it to be based on three principles: ***hourly matching, additionality*** and ***deliverability***.

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hourly matching

A growing body of research[9] suggests that the electricity requirement for electrolysers must be matched with clean energy supply on an hourly basis, not a monthly or annual basis. Studies (from the United States) show that using fossil-generated electricity or existing renewables (that are subsequently back-filled by fossil-fuelled electricity) to operate electrolysers generates at least twice the carbon emissions that status-quo natural gas-derived hydrogen emits. In a coal-heavy grid like India, this number will be even higher.

9. *Zeyen, Elisabeth, Riepin,Iegor, & Brown, Tom. (2022). Zenodo. Hourly versus annually matched renewable supply for electrolytic hydrogen (0.1).*

additionality

Secondly, the clean energy used for hydrogen electrolysis must be additional. Green hydrogen should not cannibalise existing RE supplies. Decarbonising India's grid is the first climate priority to reduce emissions. If existing or already planned RE (~21% of annual generation as of 2023) is diverted to green hydrogen production, it will delay grid decarbonisation. Due to efficiency losses, utilising clean energy for green hydrogen delivers significantly lesser carbon reductions than clean electrification for the grid.[10,11] Opportunity cost analysis demands that in a resource-constrained environment, renewable energy should first be deployed to clean the grid.

Any green hydrogen standard should require that hydrogen production use clean energy from new sources. However, even this will not resolve the issue of "cannibalisation" of grid renewables entirely.

Requiring hourly matching of green hydrogen electricity consumption with new clean generation that is connected to the point of consumption can minimise emissions from hydrogen production.

In a constrained environment with high cost of capital, there is a danger that RE for green hydrogen will crowd out needed investment in grid RE, with negative consequences in terms of meeting India's climate commitments. This point is especially relevant given India's ambitious RE targets — 500 GW of non-fossil capacity by 2030.

The green hydrogen mission calls for 125 GW of RE to facilitate the production of 5 million tonnes of green hydrogen by 2030. This 125 GW is, presumably, in addition to India's existing 500 GW non-fossil target, indicating an even greater need for capital investment. This is no easy task when India is yet to achieve its 45 GW per year annual requirement of new RE capacity, installing only about 15 GW in FY 2023.

10. *S&P Global Tom DiChristopher, 24 June 2021. Hydrogen technology faces efficiency disadvantage in power storage race.*

11. *Alex Hogeveen Rutter, October 2023. Can Surplus RE be used to Generate Green Hydrogen?*

deliverability

Renewable energy electrons must actually be physically deliverable from generation to consumption point, in the hour in which it is consumed — that is the RE facility and the green hydrogen facility should be connected on the same grid. Moreover, if the grid is congested, then the electrolyser's demand would be met by generators on the grid (mainly coal) rather than the clean energy source. Given recent advances in grid connectivity, this is probably the least problematic principle to implement in the Indian context, but is still worth noting.

Behind the meter production, wherein electrolysers are powered directly by on-site clean generation would be the gold standard, as long as such facilities restrict electrolyser operation to the hours when their electricity sources are actually generating. Enforcing additionality, deliverability and hourly matching requirements on grid-based hydrogen production would ensure near identical emission outcomes between facilities with on site clean generation and those procuring renewable electricity via PPAs or open access.

The future growth and profitability of the green hydrogen industry requires that Indian definitions and standards be in line with those already globally accepted.

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