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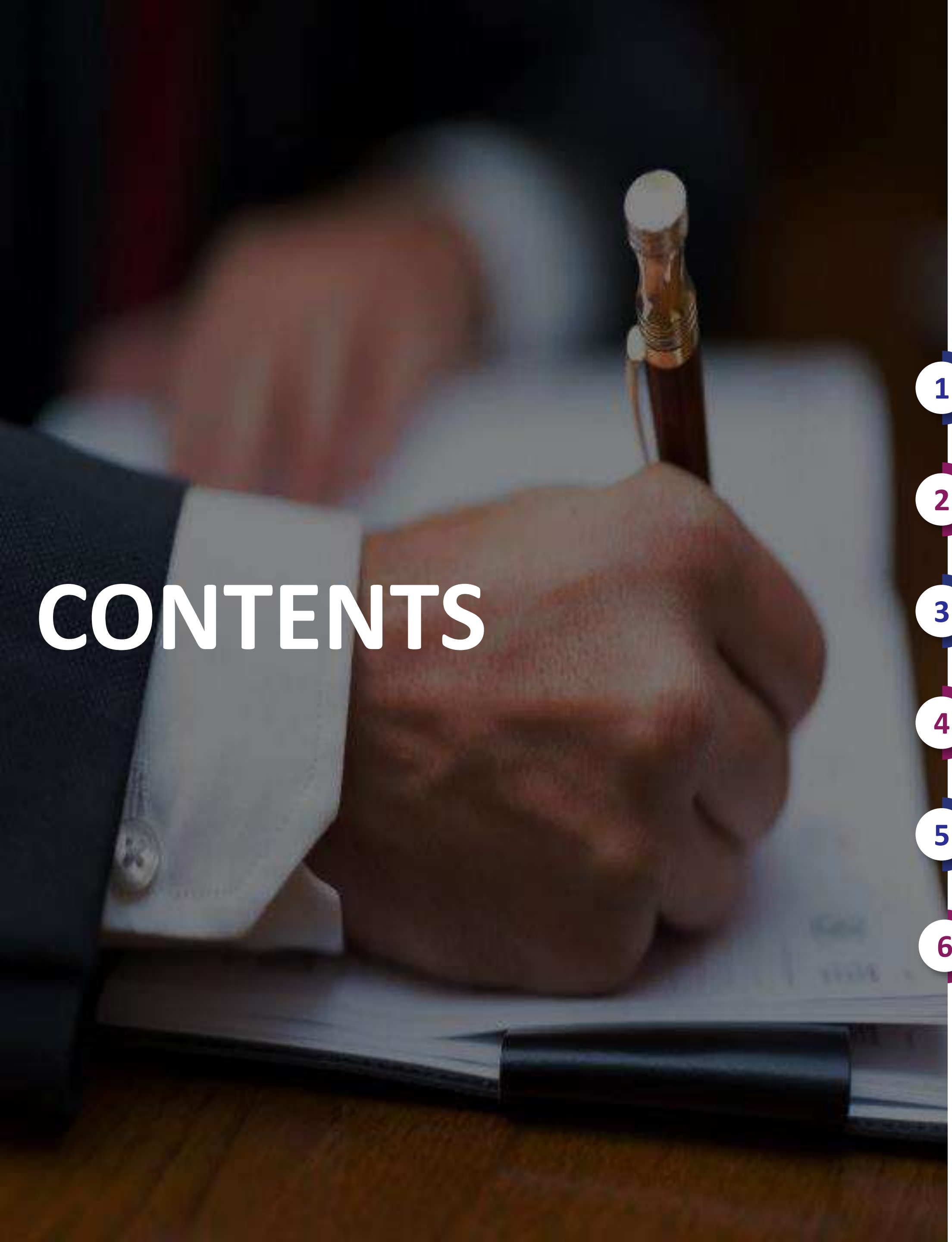
REPORT ON GREEN HYDROGEN

THE H_2ERO OF NET ZERO?

16 DECEMBER 2024



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EXECUTIVE SUMMARY

Increased usage of hydrogen essential for deep decarbonisation in hard to abate sectors
A typical method of greening a sector is to replace the energy source with electricity and then sourcing that from renewables. However, this technique fails in cases where greenhouse (GHG) emissions are released as part of the use of a material as feedstock. Some examples include the use of coke as a reducing agent for iron which releases CO_2 and the use of H_2 in NH_3 production via Haber process (H_2 so used is produced using fossil fuels as of now)]. In these processes, usage of H_2 becomes essential to alleviate GHG emissions. It is estimated that the annual use of H_2 in India will go up from 5-7 mn tonnes currently to 15-20 mn tonnes by 2030
Growth in H_2 consumption depends on changing its colour from grey to green
Given the imperative for increasing the usage of H2 lies squarely on its credentials in reducing GHG emissions, a corollary is that the H_2 so used must be produced sustainably. Traditional processes to produce H_2 use fossil fuels and thus unsuitable. Green H2, which uses the electrolysis path and renewables, emerges as the solution. It must be remembered that the source of growth in H_2 consumption will be this greening – as traditional demand sources such as fertilisers and petroleum industry stagnate, a third of the demand by CY30 globally (total 150 mn tonnes) will come from new uses. Accordingly, 13% of the hydrogen use in India by 2030 will be from new sources (power, transport, residential and buildings)
High cost of green H2 the key constraint in increasing usage, more incentives needed to bring costs in line with grey H2
The cost of production of green H_2, at USD 3.4-12/kg is multiple times that of grey H_2 which costs USD 1-3/kg. The increased costs are attributable to the prohibitive cost of electrolysers (due to miniscule scale of production) and expensive electricity. While in India, green H_2 costs are expected to be at the lower end of the this range, additional reductions to the USD 2/kg mark will be contingent on waiver of power banking charges across states, more affordable storage, and reduction in GST for electrolysers from 18% to 5% to complement natural dips in their cost of production as scale picks up. Finally, access to cheap green finance will be pivotal in bringing parity between the colours of H_2
India has inherent advantages in green H_2 production, Green H_2 hubs and SIGHT schemes to crown this kingly position
Given its ample renewable potential and generous demand for fertilisers and petroleum (key end user industries), India is well positioned to be a leader in green molecule production – with possibility of even exports to Japan etc. Recognising this and keeping in mind net zero goals, the Government has announced the ambitious National Green Hydrogen Mission (NGHM) which seeks to achieve 5 mn tonnes per annum production of green H_2 by 2030. As part of this, multiple components of the SIGHT programme with a cumulative outlay of Rs. 175 bn have been launched. The schemes involve a clever mix of not only supply side subsidies, but also guaranteed demand incentives, to reduce the offtake risk.
Investments of Rs. 8-10 trn needed by 2030 to develop Green H_2 ecosystem; financing ecosystem must evolve to accommodate this opportunity
Given much of the capacity for green H2 has to be set up from scratch, a massive Rs. 8-10 trn would be needed by 2030. Of this, ~Rs. 1.6 trn will go towards building sufficient electrolyser capacity, while Rs. ~4.2 trn will be for setting up facilities for manufacturing green molecules. Importantly, an additional Rs. 4.5 trn would be needed in setting up associated renewables capacity to fuel these new factories. To achieve these aims, it is important to solve issues plaguing projects right now, which include uncertain demand offtake and a vicious loop of low scale and high costs of capex. Achieving these milestones can not only ensure deep-decarbonisation in hard to abate sectors, but also open up new applications for green H_2.

HYDROGEN AND ITS COLOURS: AN INTRODUCTION

GLOBAL HYDROGEN USE TO INCREASE BASED ON NEW USES

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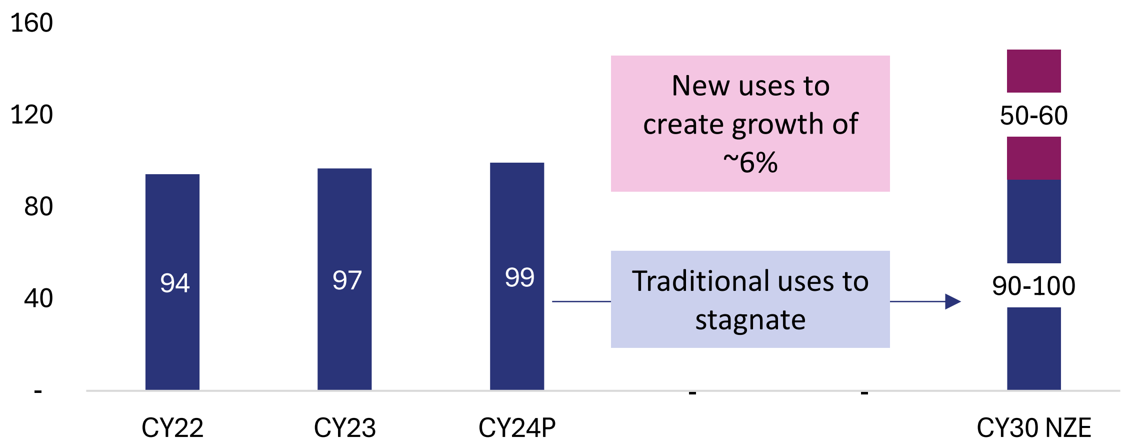
TOTAL GLOBAL HYDROGEN USE (mn tonnes)



Note: NZE = Net Zero Emissions by 2050 Scenario in 2030

USES OF HYDROGEN

FEEDSTOCK

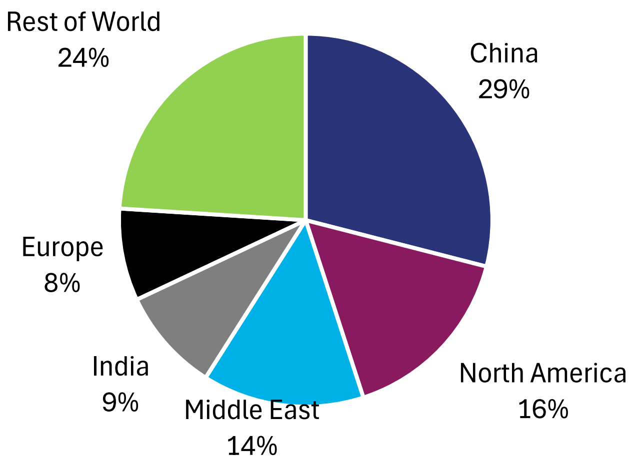
Traditional Uses:
- Ammonia production using Haber process
- Desulphurization of fossil fuels to reduce pollution
- Methanol production

New Uses:
- Reducing agent in steel production
- Caustic soda production

FUEL USE

- Blending with conventional fossil fuels
- Electric arc furnaces in steel & iron making
- Fuel cells or in heavy-duty and long-distance transport

REGION-WISE HYDROGEN USE (CY23)

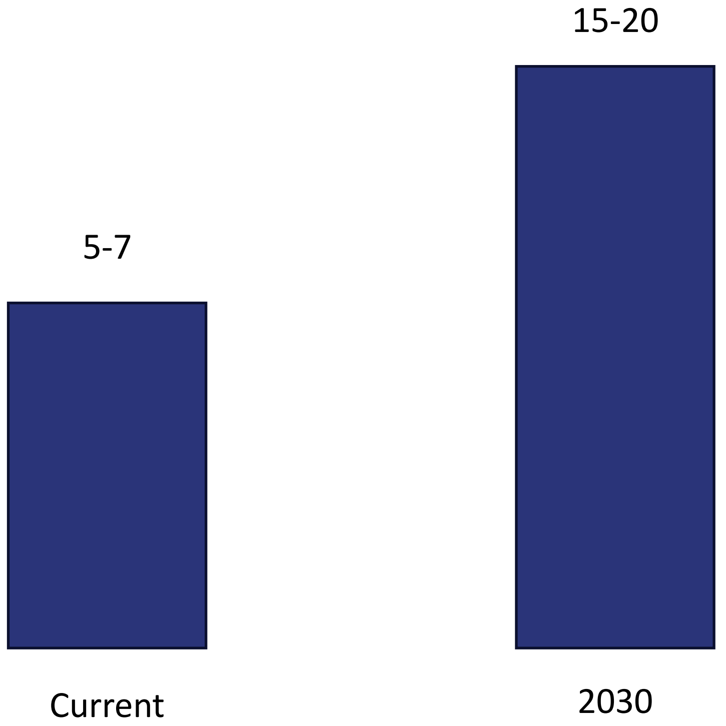


- Hydrogen use could reach ~140-160 mn tonnes by 2030. India is one of the largest users of H_2 in the world
- Hydrogen is an important industrial chemical. The current uses of H_2 are as feedstock in fertiliser production and cleaning of fossil fuels
- New feedstock uses for H_2 will be contingent on solving challenges associated with its production. Fuel use is likely to remain minor even in the future

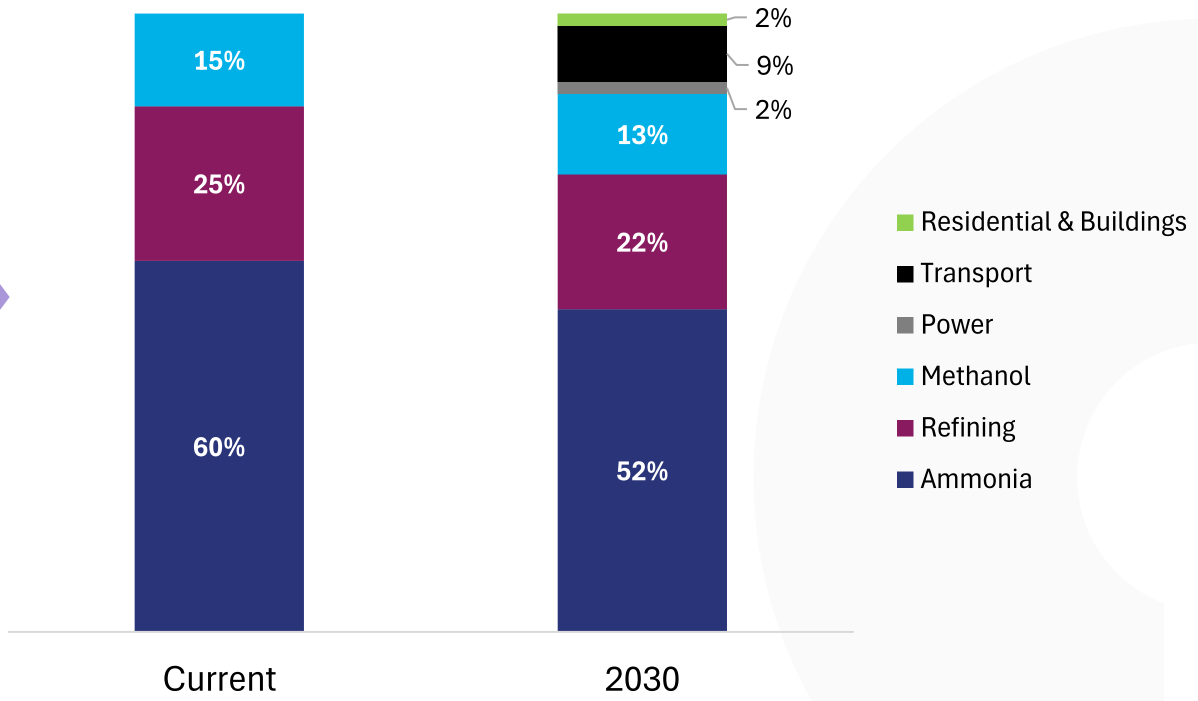
Source: IEA, BofA, BNEF, SBICAPS

INDIA'S HYDROGEN USE TO BE FASTER THAN THE GLOBE

INDIAN HYDROGEN USE (mn tonnes)



INDIAN HYDROGEN USAGE BY SECTOR



- Hydrogen use will triple in the next few years in India – much faster than the global growth rate. Besides domestic use, India has export potential as well
- Industrial uses shall dominate in India just like the world, with limited use for transport – especially heavy-duty long-distance shipping and trucking

Source: TERI, NITI Aayog, SBICAPS

CHALLENGES CONSTRAINING HYGROGEN ADOPTION

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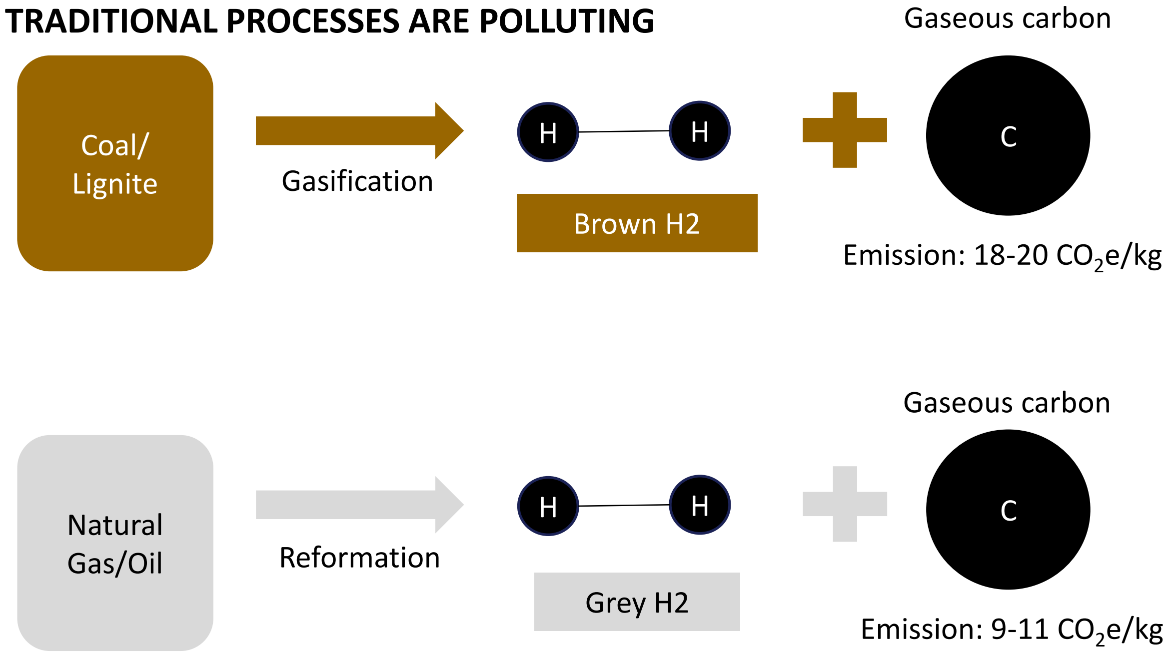
Challenge 1: Polluting Production Pathway

Challenges in increasing H_2 use

Challenge 2: Difficult to Store & Transport

TRADITIONAL PROCESSES ARE POLLUTING



HARD TO STORE AND TRANSPORT

STORAGE OPTIONS: UNATTRACTIVE COST-SCALE-LOCATION TRADEOFF

GASEOUS STATE STORAGE
- Typically have lower cost
- Availability is restricted geographically, especially for large volumes

LIQUID STATE STORAGE
- Typically have higher cost
- Large volume storage is possible without geographic issues

TRANSPORTATION INFRASTRUCTURE INFEASIBLE AT SCALE

ROAD TRANSPORT
- Suitable only for low range (<500 km)
- Limited carrying capacity

PIPELINE
- Cheapest upto 5,000 km
- Retrofitting gas pipelines is expensive

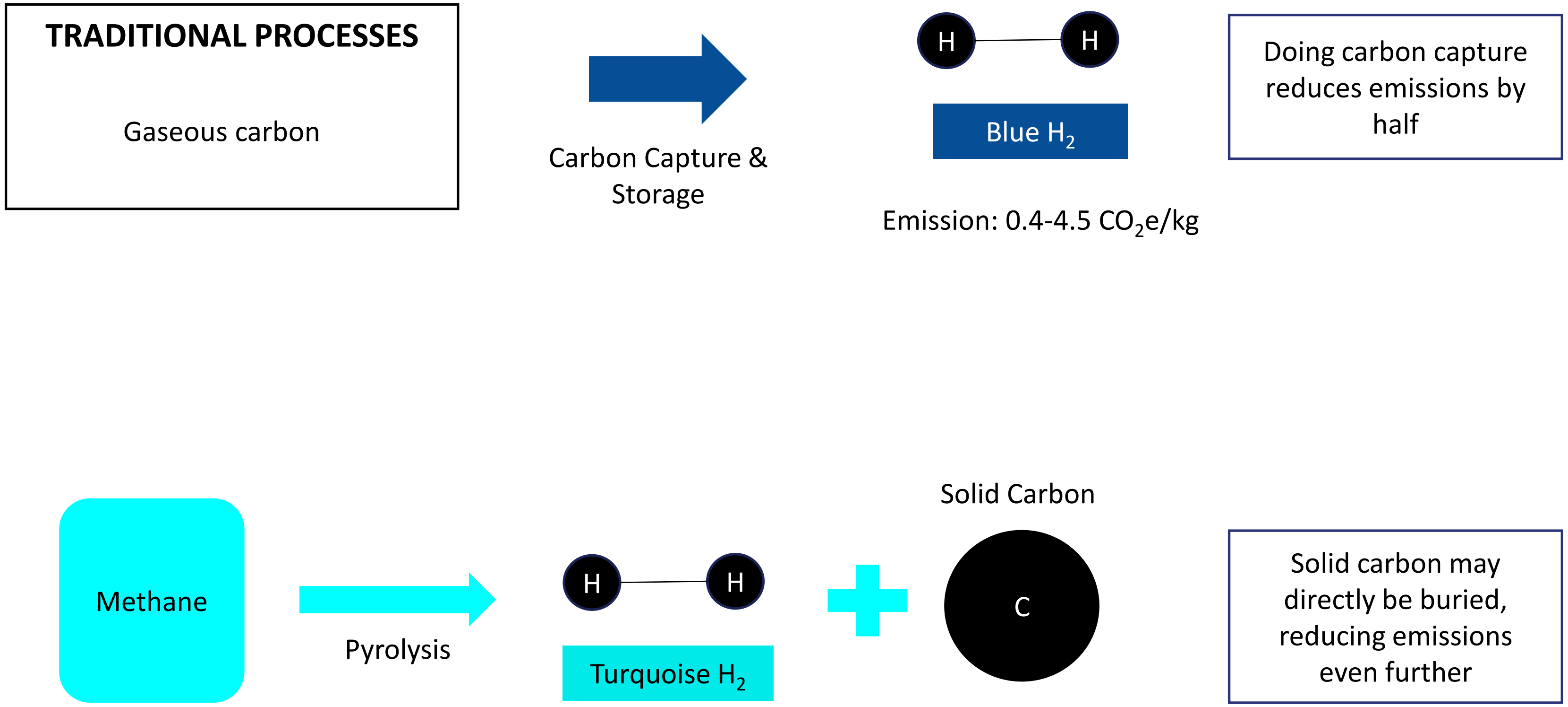
SHIPPING
- Suitable only for offshore and > 500 km
- Most expensive, but large volumes possible

>95% of the world's H_2 production is using dirty traditional processes. H_2 production is responsible for ~2% of all GHG emissions

Its light and explosive nature makes large-volume, low-cost universal storage and transport tough, restricting it to mostly on-site uses

Source: US Department of Energy, BNEF, EY, SBICAPS

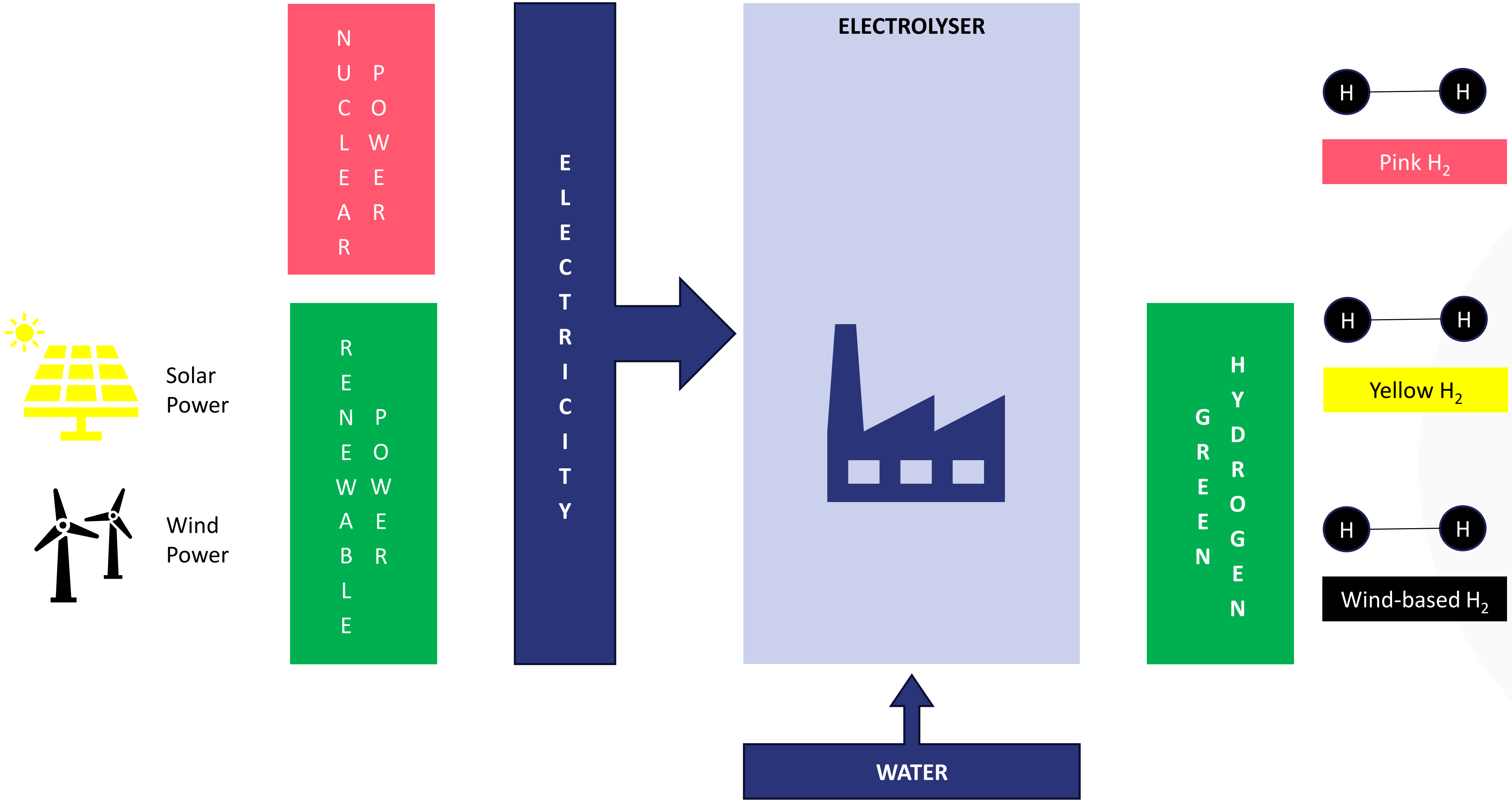
CUTTING GHG EMISSIONS BY MODIFIED FOSSIL-FUEL PATHWAYS IS ONE SOLUTION…



Blue H2 pathway is marginal, and methane pyrolysis remains in early stages

Source: US Department of Energy, Greentech, WEF, National Grid, Forbes, SBICAPS

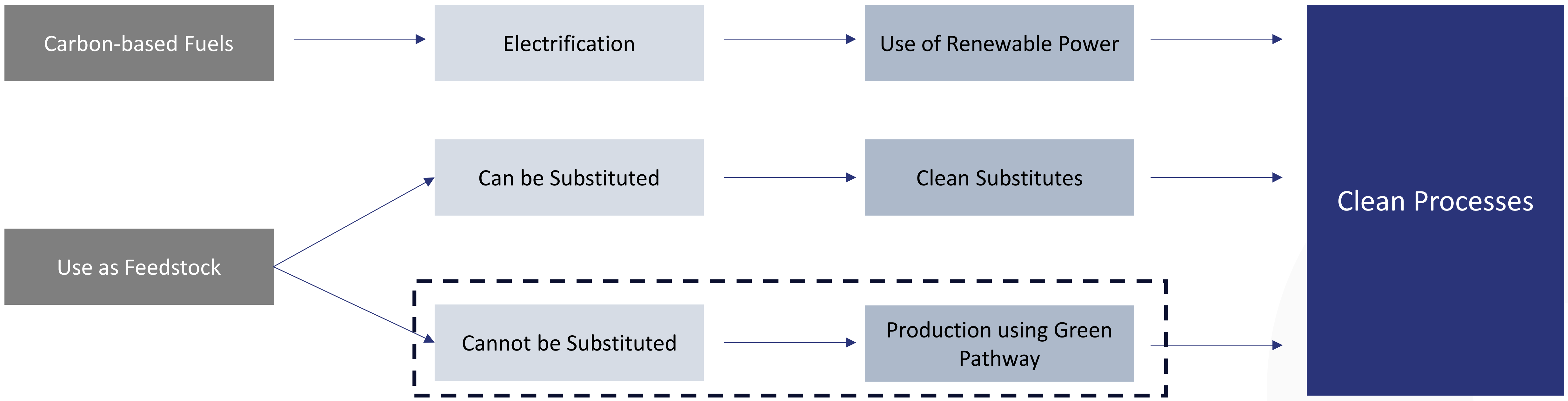
… GREENING PRODUCTION BY SUSTANAIBLE ELECTROLYSIS IS THE ULTIMATE ANSWER



Currently, only ~1% of the world's H2 production is currently green, as it remains costly compared to dirty variants

Source: National Grid, IEA, IRENA, SBICAPS

WHY NOT USE RENEWABLES DIRECTLY INSTEAD OF GREEN HYDROGEN?



Green Hydrogen is useful in these "Hard to Abate" sectors where H2 is used as a feedstock, and not a fuel.

Examples:

- In production of ammonia, methanol, and caustic soda, H_2 is a raw material and not a fuel, hence it cannot be replaced
- In steel industry, the traditional reducing agent is coke – here H_2 helps replace carbon

~12% of the of the abatement in CO_2 emissions to be done between now and 2050, to achieve 1.5° C scenario will come from H_2 and its derivatives

Source: IEA, IRENA, SBICAPS

GREEN H_2: COMPRESSING COSTS VITAL TO MAKE AN IDEAL GAS

GREEN HYDROGEN CURRENTLY MUCH MORE EXPENSIVE THAN OTHER SOURCES

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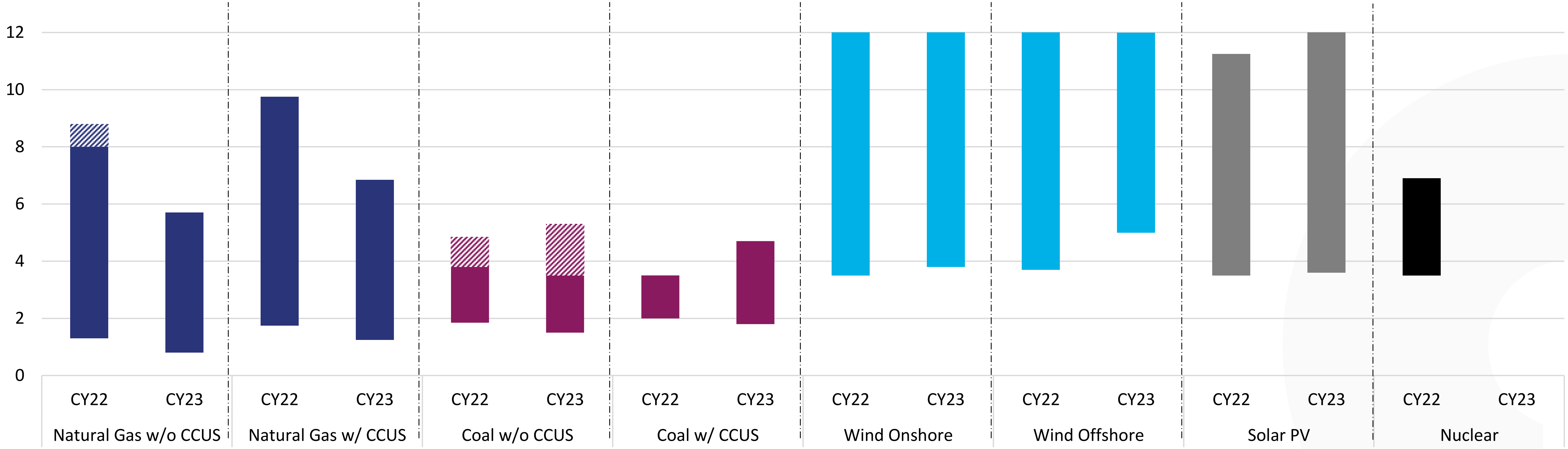
PRICE OF HYDROGEN BY COLOUR (USD/kgH_2)



Notes: 1. NZE = Net Zero Emissions by 2050 Scenario in 2030 2. The dashed area represents the CO_2 price impact, based on USD 15-140/t CO_2 for the NZE Scenario.

- **Currently, green H_2 costs USD 3.4-12/kg vs. USD 1-3/kg when using unabated fossil fuels. Much of the incremental costs come from capex on electrolysers and electricity cost**
- **In the Indian context, cost of producing green H_2 is at the lower end ~USD 3.5-5/kg (for 2024) vis-à-vis <USD 2/kg for grey H_2. Some countries have bridged this differential using tax incentives – US provides USD 3/kg tax incentive for production, for instance**

Source: IEA, WEF, SBICAPS