Green Ammonia

Low-hanging Hanging Fruit in the Green Hydrogen Economy India

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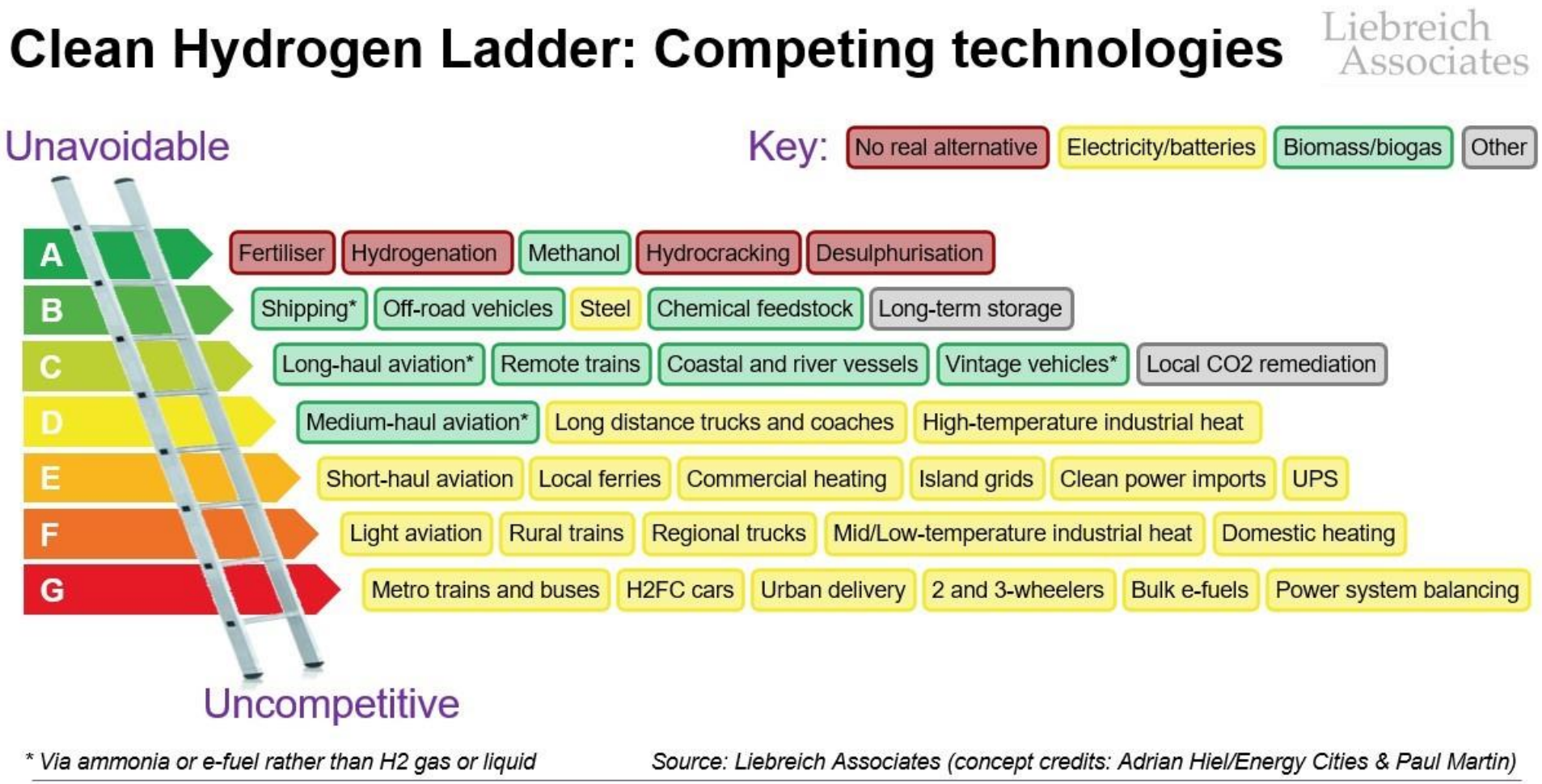
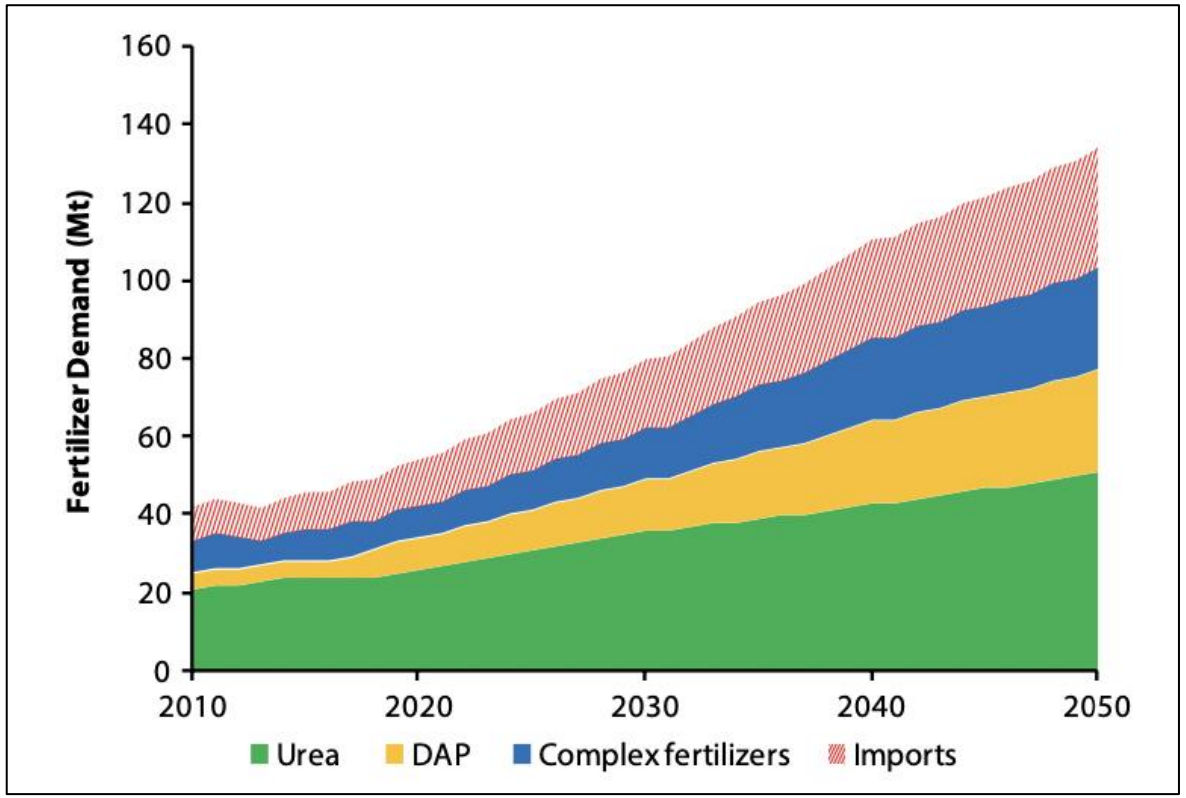
Institute for Energy Economics and Financial Analysis
IEEFA.org

Clean Hydrogen Ladder: Competing Technologies



Fertilisers in India

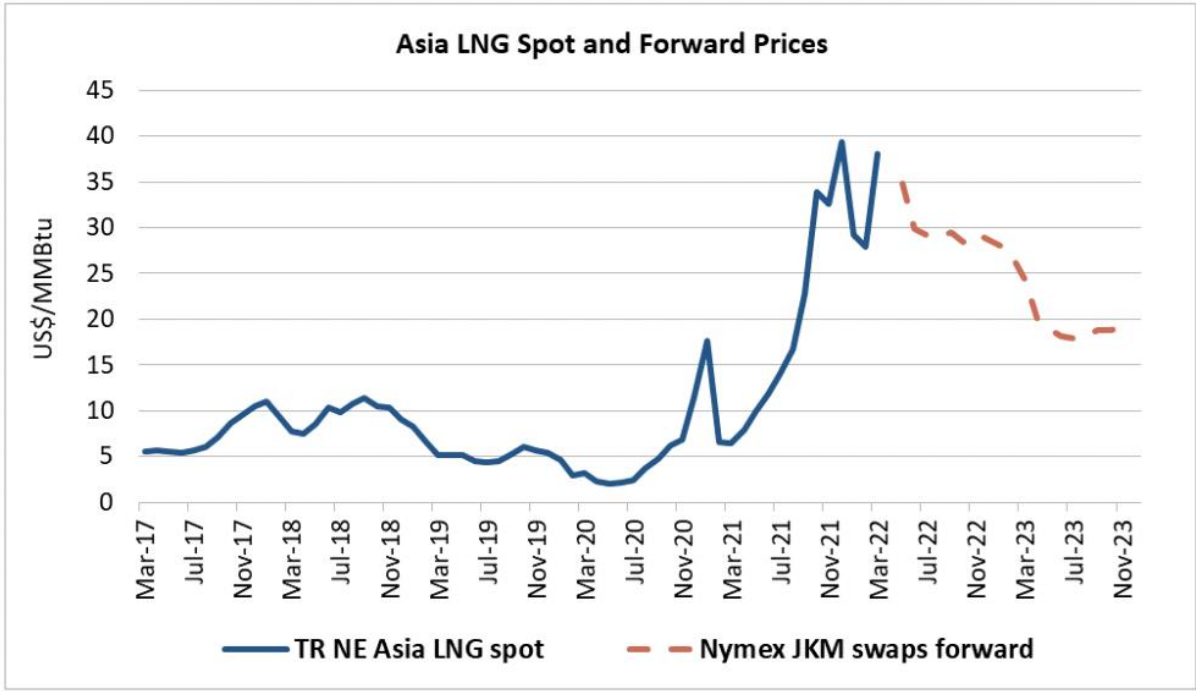


- India's fertiliser demand has been strong during the last decade – more than 50 million tonnes (MT) of chemical fertiliser were used annually on average. It is expected to more than double by 2050.
- Natural gas is used to produce ammonia, which is the main intermediary for providing nitrogen in all nitrogen-containing fertilisers.
- Urea (CH_4N_2O) is the main nitrogenous fertiliser in India, constituting about 55-60% of total fertiliser demand.

Source: TERI IEEFA

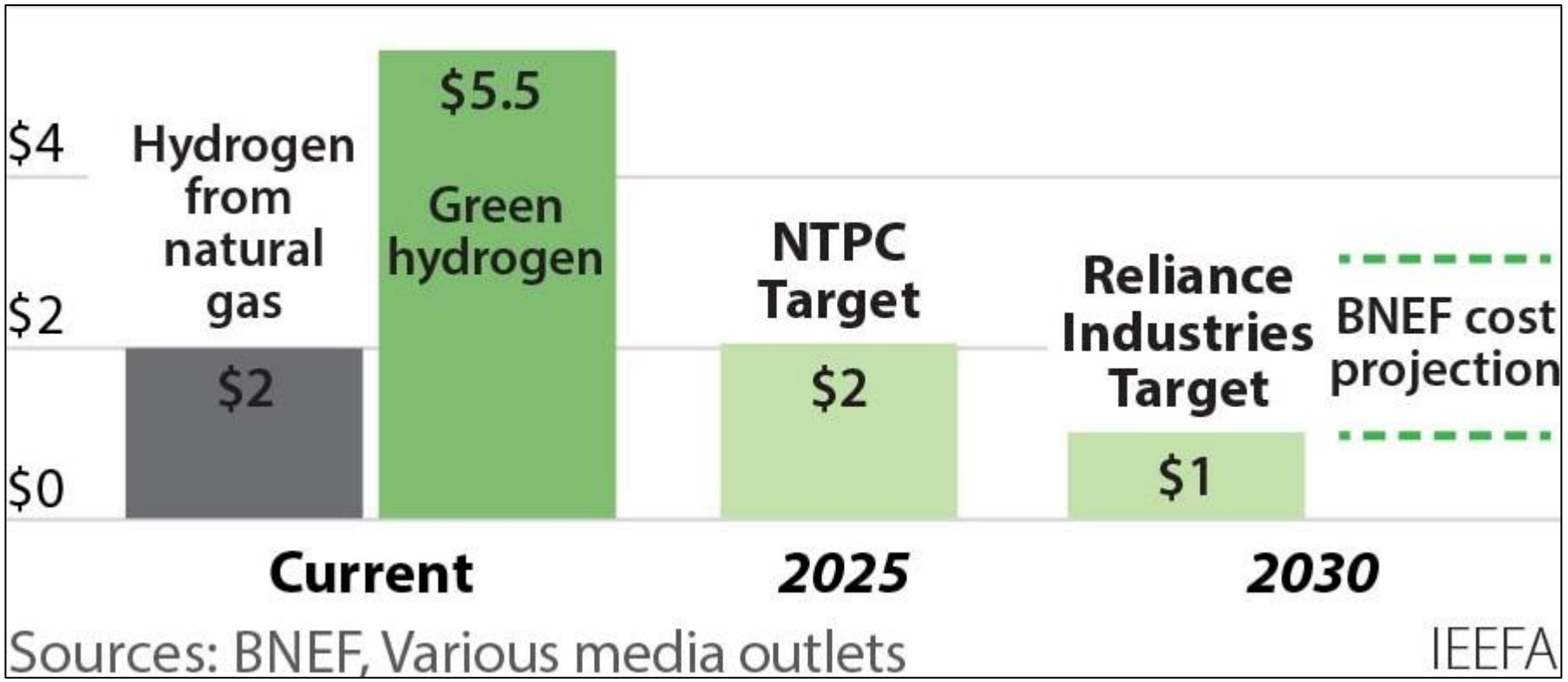
Heavy Dependence on Government-funded Subsidies

- India's Union budget for FY2022/23 pegged the fertiliser sector subsidy at Rs1.05 trillion (US$14.2bn), above a trillion rupees for a third year in a row
- The subsidy budget accounts for a direct relief through regulated subsidised pricing for fertilisers and favourable gas pricing
- **Gas pricing** - Urea units are connected to a national grid to ensure supply of gas at a uniform price by pooling the price of domestic gas and imported LNG
- Currently, Urea is sold at subsidised rate of Rs5.6/kg against the actual international price of Rs60.1/kg. This accounts for a 90% subsidy

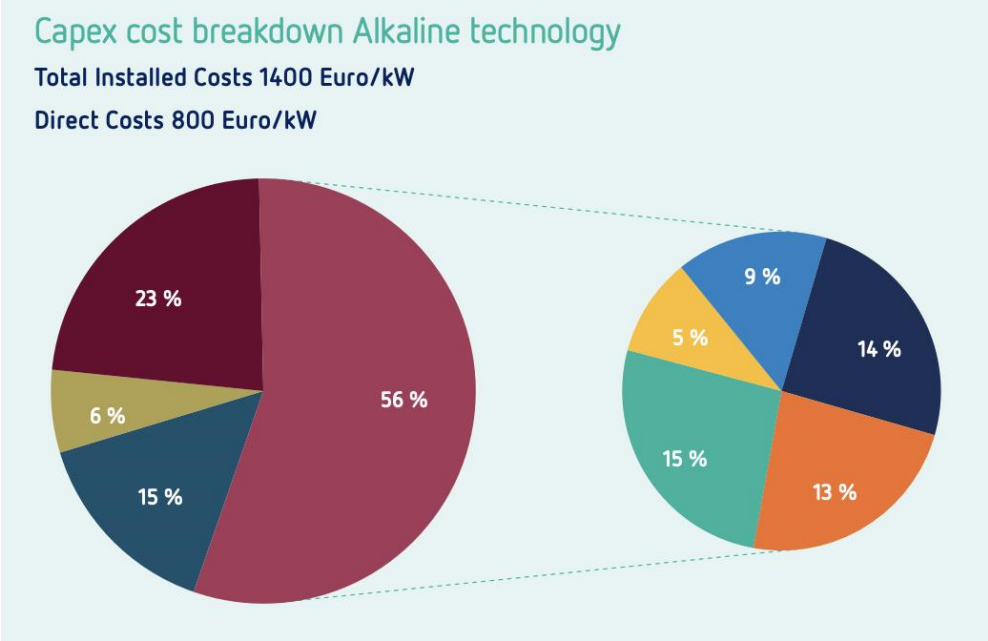


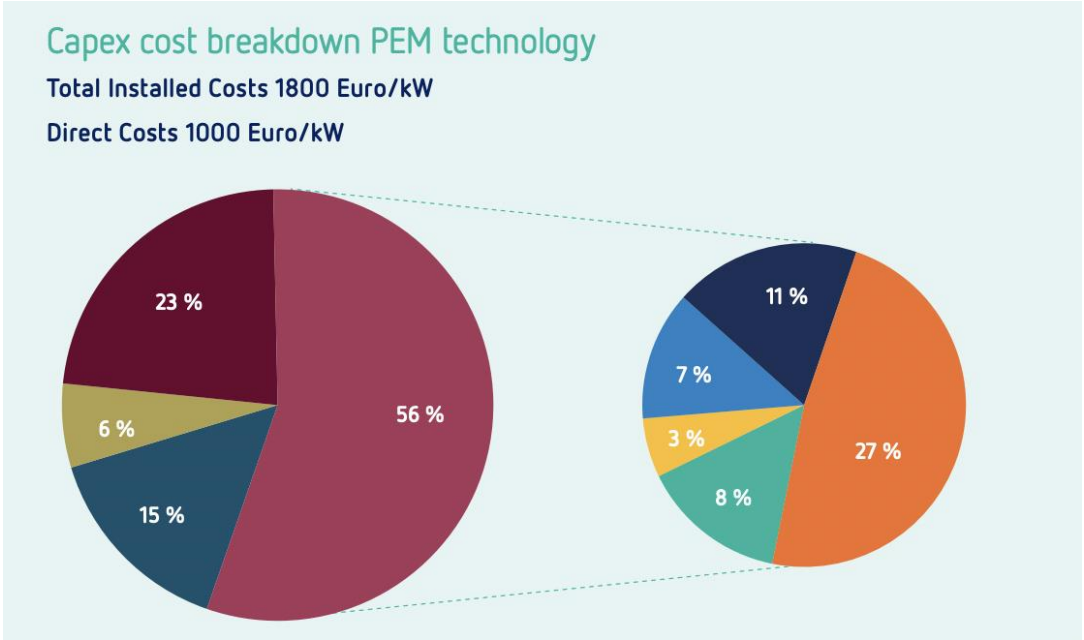
Green Ammonia from Green Hydrogen to reduce the Subsidy Burden

Green Hydrogen Cost Reduction Targets in India



System and Electrolyser Costs

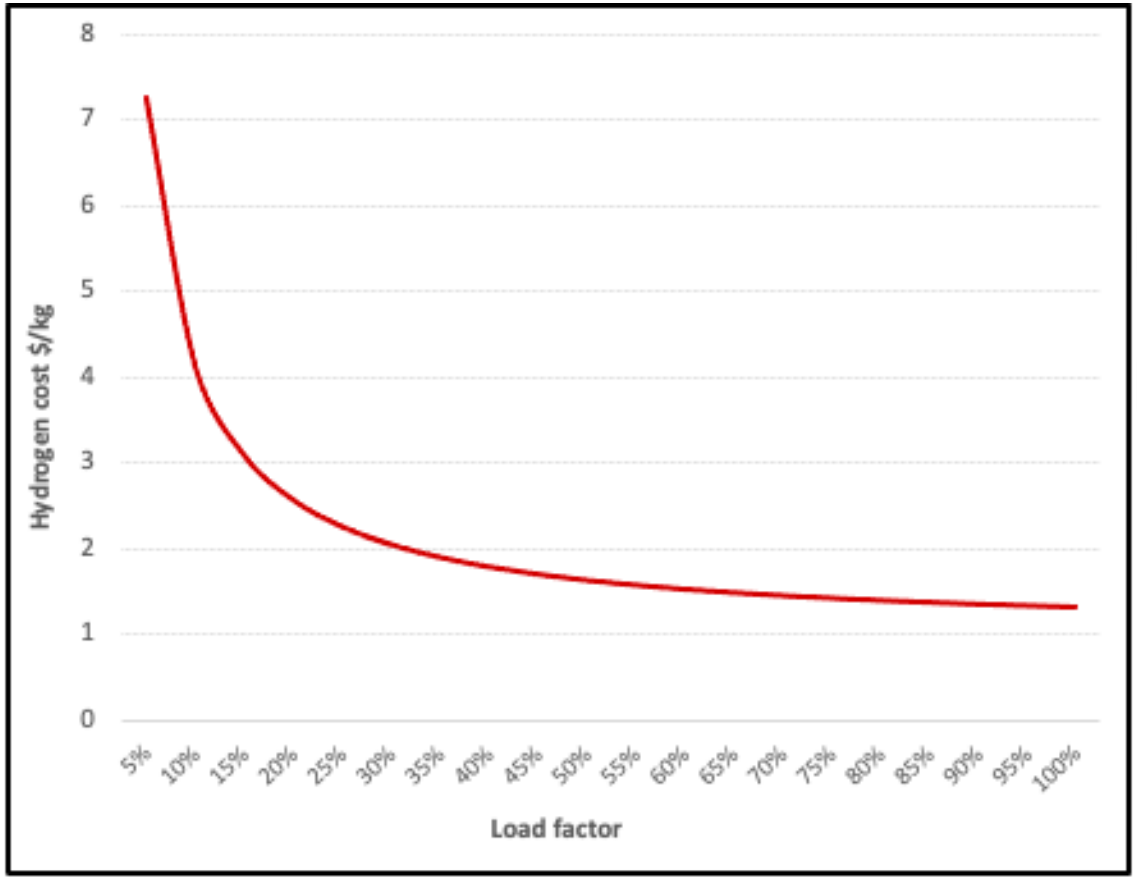




Capex in USD:
Alkaline – US$1.4 million/MW
PEM – US$1.8 million/MW

Source: **Gigawatt green hydrogen plant ISPT**

Factors in the Cost of Hydrogen



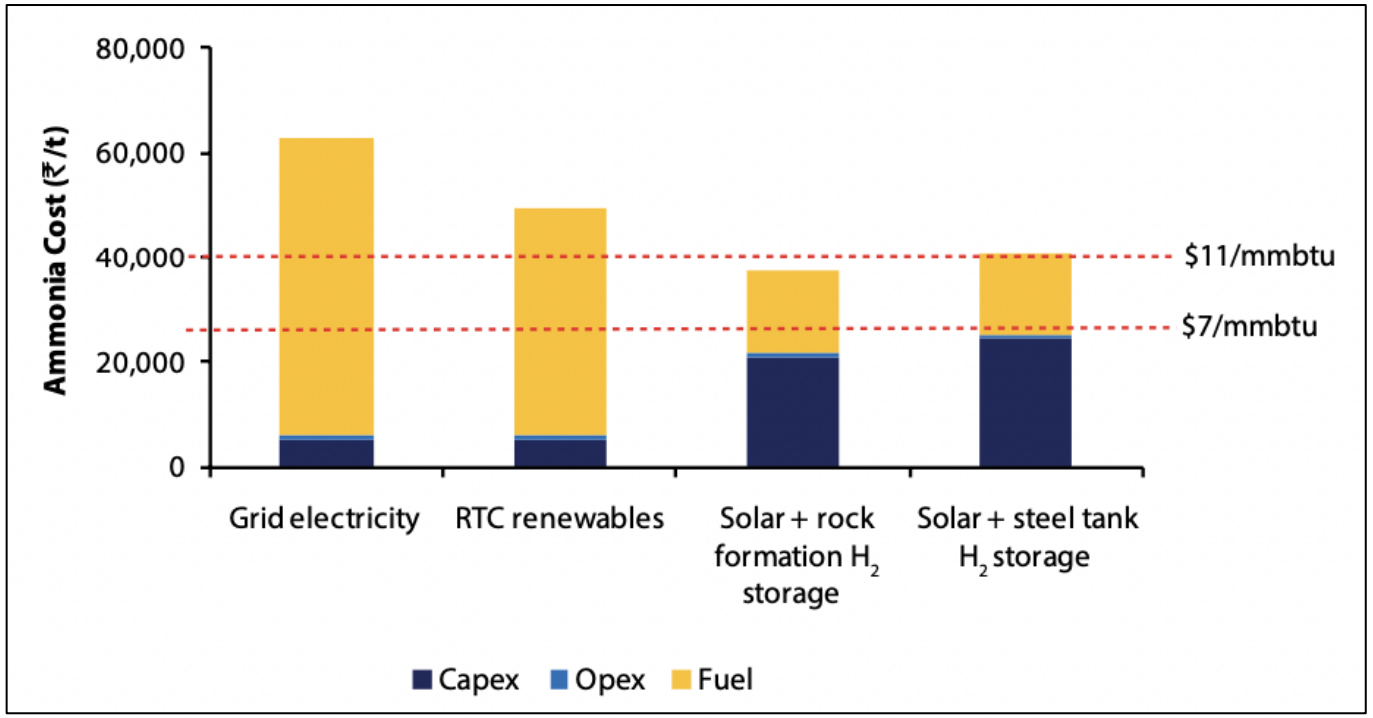
		INPUTS
Electrolyzer capacity	kW	1,000
Installed cost of electrolyzer	***$/kW***	**250**
O&M cost (annual, fixed)	*% of installed*	2%
Electricity usage	***kWh/kgH2***	**50**
Electricity cost	***$/MWh***	**20**
Water usage	*l/kgH2*	10
Water cost	*$/m3*	1.0
Value of oxygen	*$/kg*	0.05
Oxygen sold	*%*	0%
Grid services value	*$/MW/h*	30
Flexible operation time	*% of operating*	0%
Cost of capital / discount rate	**%**	**15%**
Stack lifetime	*hrs*	60,000
Required payback period	***yrs***	**10**

At very low load factors, low capital recovery makes hydrogen expensive

Moving to higher load factors may mean less ability to select exclusively clean or cheap electricity input

Source: Grey Cell Energy

Cost of ammonia production from different modes of operation, 2030

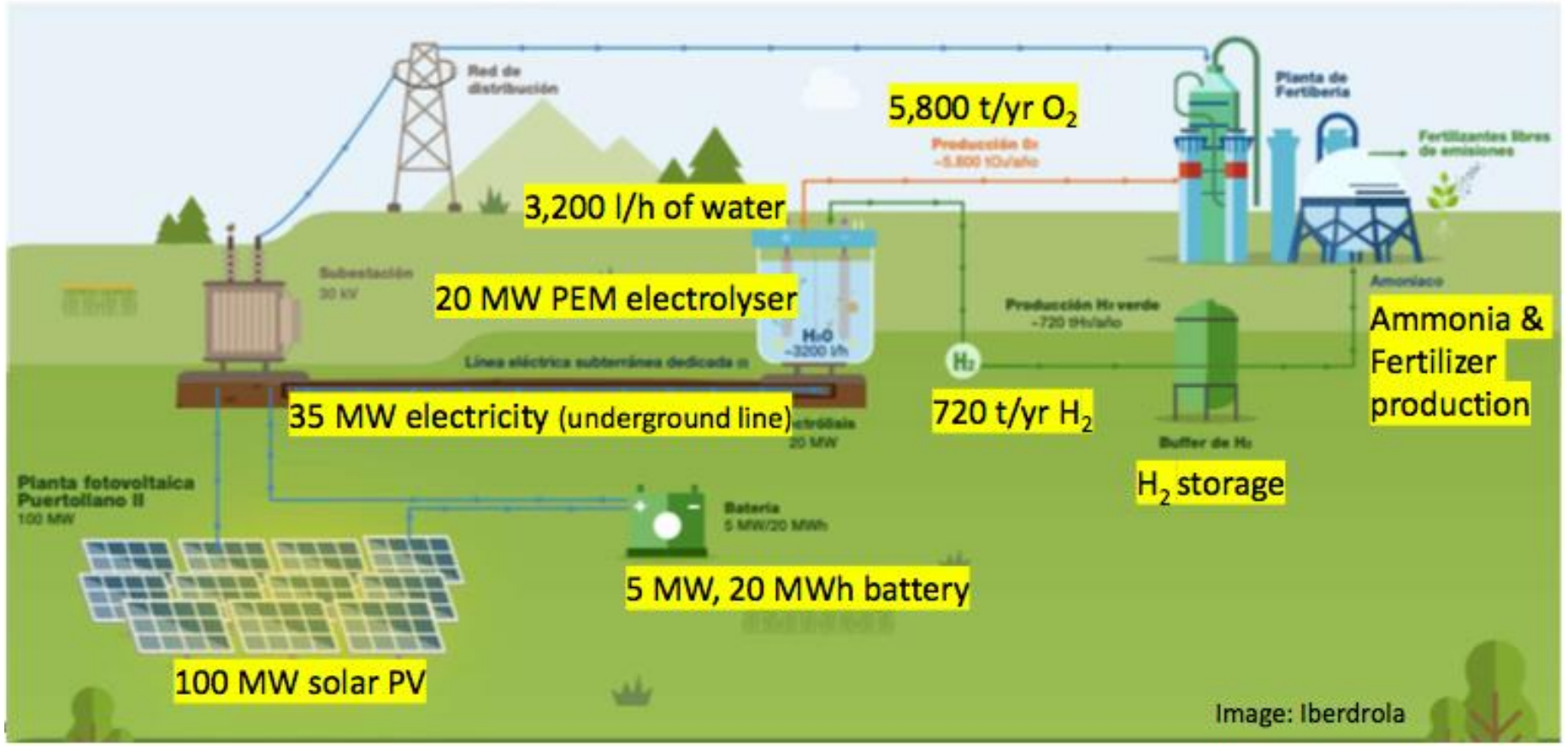


- Higher utilisation rates of electrolysers require constant supply of power either through a grid-connection or round the clock supply of renewable energy.
- With a co-located solar plant electrolysers could access electricity prices of approximately Rs1.6/kWh (US$20/MWh) in 2030
- At this price of electricity input, grey ammonia becomes competitive with grey ammonia with gas pricing pegged at US$7-11/MMBTU according to TERI's analysis

Source: TERI

Integrated Green Hydrogen to Green Ammonia Facility

Fertiberia's Puertollano fertiliser facility



Source: Iberdrola, Grey Cell Energy

Green Ammonia Projects Globally

According to the IEA's hydrogen project database as of October 2021, there is 8MT of green hydrogen to green ammonia production capacity planned globally

Project name	Country	City	Electrolyser Capacity	Green Ammonia Production Capacity	Investment	Proponents
H2-hub	Australia	Gladstone, Queensland	3GW	1.8MT/year	AU$4Bn+	The Hydrogen Utility (H2U)
Hoasis	Chile	Antofagasta, Chile	2.1GW	0.25MT/year	US$5.3Bn	TCI Gecomp
GERI	Australia	Geraldton, Western Australia	1.5GW	1MT/year		BP Australia Pty Ltd and GHD Group Ltd
HNH	Chile	Magallanes, Chile	1.4GW	0.85MT/year	US$3Bn	Austria Energy, Okowind, Copenhagen Infrastructure Partners
HØST PtX	Denmark	Esbjerg, Denmark	1GW	0.6MT/year	US$1Bn	Copenhagen Infrastructure Partners along with leading danish agriculture and shipping companies

Source: IEA, IEEFA Analysis

Ammonia as an Energy Carrier

'More than 85% of export-oriented low-carbon hydrogen projects plan to ship ammonia, not H2'

Green NH3 is emerging as the hydrogen carrier of choice, but it's not without its challenges, writes Noel Tomnay, global head of hydrogen consulting at energy analyst Wood Mackenzie

- Ammonia has a better volumetric energy density than hydrogen (less space required to store equivalent energy content)
- Both can be stored in liquid form, hydrogen requires cryogenic tanks maintained at -253°C, while ammonia requires less cooling and can be stored at about -33°C
- Sophisticated cooling equipment and mitigation hazards make hydrogen more expensive to transport, whereas ammonia is liquid at ambient conditions, requiring lower storage volumes

Source: Wood Mackenzie

India’s green hydrogen policy

The government identifies green ammonia as the top use case for green hydrogen and hence the stated incentives are for green hydrogen as well as green ammonia projects in the policy

- Single-window clearance system
- Allotment of land in renewable energy parks
- Priority access to the inter-state transmission network
- Waiver of inter-state transmission charges for 25 years
- 30-day energy banking policy and other measures
- Open access procurement within 15 days

Readiness for transition: challenges and possible solutions

- **Creation of demand**

  Second Phase of the green hydrogen/green ammonia policy to include off-take related incentives such as green hydrogen consumption obligation (GHCO) for various industries

- **Financing**

  In May 2021, ARENA topped up its ongoing funding for commercialising green hydrogen projects by AU$100m (US$72.3m) for three projects with 10MW electrolysers – The Indian Renewable Energy Development Agency (IREDA) could look to play a similar role in the proliferation of green hydrogen projects by supporting pilot projects and eventually to commercial scale-up

- **CO2 requirement for Urea**

  An external carbon source is required for Urea production — When urea is produced using natural gas, CO2 is recovered from the reformation process and recycled for urea production. However, for a switch to green ammonia, an additional CO2 source would be required

  TERI recommends adding additional electrolyser capacity to existing natural gas plants in the short to medium term, to expand the capacity. The resulting CO2 should be used or sold for other industrial usages, for instance, carbonated beverages. In future, these plants could be switched to using biomass

Take-away

- Green ammonia is the most viable of all applications in the green hydrogen economy. The projected growth in fertiliser demand in India will further intensify subsidy and import dependence in the sector, unless it is switched to a cleaner and domestically produced feedstock
- Green ammonia could significantly help the government in reducing the trillion rupees subsidy bill from the fertiliser sector
- In the long term, it also has the potential to reverse India's dependence on imports for its energy needs. Green ammonia either as a chemical feedstock or even as an energy carrier is an avenue for creating export capabilities
- Locally manufactured electrolysers and solar modules will eliminate import dependence, create jobs and investment opportunities and accelerate the energy transition in a wholesome manner.

Thank You!