



CLIMATE ENERGY FINANCE

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H2 2 ZERO Summit

International  
Perspectives: The role of  
hydrogen in the global  
energy system

3 May 2022

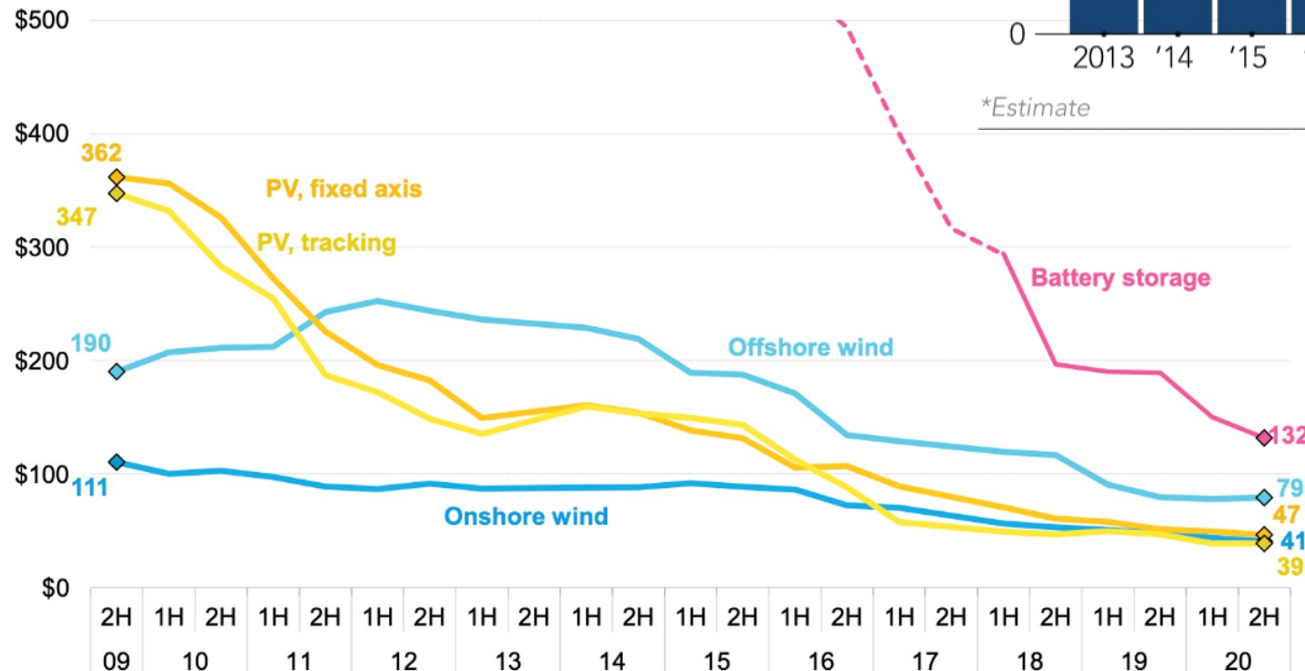
# Agenda

- The global energy transition is accelerating, driven by the convergence of factors:
  1. Technology-Driven Deflation in Renewables
  2. Global Policy Developments in Decarbonisation
  3. CO<sub>2</sub> Pricing (& CBAM)
  4. Global Finance Zero Emissions Pledges – US\$130 trillion
  5. The Climate Science
- Green hydrogen technologies are scaling, rapidly
- The global policy & corporate focus is extreme
  1. UK
  2. India
  3. Australia / Germany (FFI / E.ON)
  4. Industry-Transport-Power convergence e.g. Steel

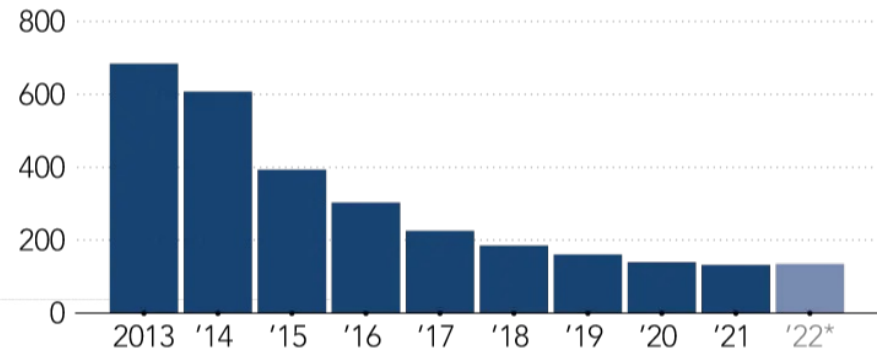
# 1. Technology-Driven Deflation

## Ongoing Renewable Energy and Battery Deflation

LCOE (\$/MWh, 2019 real)



**Battery pack costs were falling over the past decade**  
(Price per kilowatt hour, in dollars)



\*Estimate

Source: Bloomberg NEF

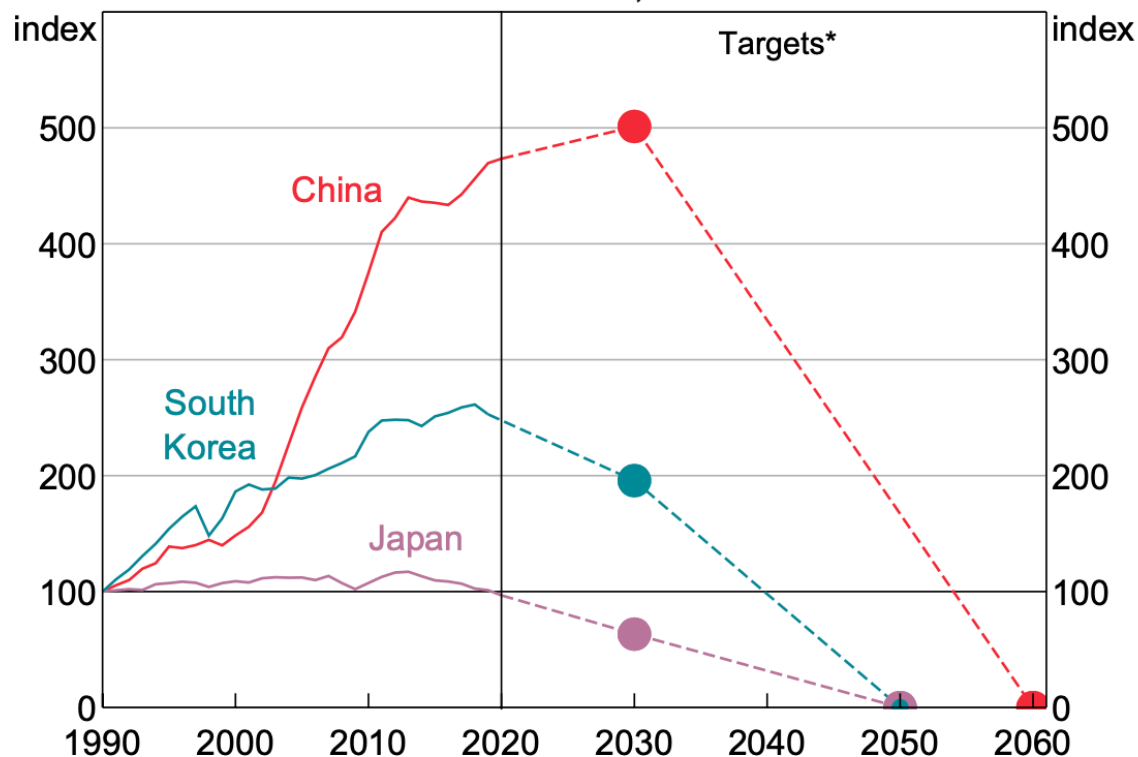
November 2020 saw a 1,070MW solar tender awarded in India at just Rs2.00/kWh (an LCOE <US\$20/MWh) down 18% yoy.

August 2020 saw a 700MW solar tender awarded in Portugal at US\$13.15/MWh (down 24% yoy).

## 2. Global Policy Developments

### Carbon Dioxide Emissions

Selected economies, 1990 = 100



India NZE  
by 2070

\* Bubbles show targets; dashed lines show indicative paths to achieve them; Japan and South Korea's greenhouse gas targets are shown in terms of carbon dioxide; China's 2030 target is authors' estimate based on carbon intensity target for 2030 and authorities' desire for GDP growth to 2035

Sources: CEIC Data; International Energy Agency; RBA

### 3. Emissions – CO<sub>2</sub> Prices are Rocketing Up

#### The Five-Year EU ETS Pricing (€/t)



# 4. Global Finance Zero Emissions Pledges

## UN Net Zero Finance Alliance 1.5°C

New Financial Alliance for Net Zero Emissions Launches



PRESS RELEASE ISSUED ON BEHALF OF THE COP25 and COP26 CLIMATE CHAMPIONS

*Industry-led and UN-convened Net Zero Banking Alliance also announced today, co-launched by the UNEP Finance Initiative and the Financial Services Taskforce of the Sustainable Markets Initiative*

- The Glasgow Financial Alliance for Net Zero (GFANZ), chaired by Mark Carney, UN Special Envoy on Climate Action and Finance, brings together over 160 firms (together responsible for assets in excess of \$70 trillion<sup>1</sup>) from the leading net zero initiatives across the financial system to accelerate the transition to net zero emissions by 2050 at the latest.
- All GFANZ member alliances must be accredited by the UN Race to Zero campaign. They must use science-based guidelines to reach net zero emissions, cover all emission scopes, include 2030 interim target setting, and commit to transparent reporting and accounting in line with the UN Race to Zero criteria.
- 43 banks from 23 countries (with assets of \$28.5 trillion) form the Net-Zero Banking Alliance (NZBA) today – which joins GFANZ – with its members committing to align operational and attributable emissions from their portfolios with pathways to net-zero by 2050 or sooner.

**US\$130 trillion by Nov 2021  
(+90% in 6 months)**

### A Tectonic Shift Accelerates

In January of last year, I wrote that climate risk is investment risk. I said then that as markets started to price climate risk into the value of securities, it would spark a fundamental reallocation of capital. Then the pandemic took hold – and in March, the conventional wisdom was the crisis would divert attention from climate. **But just the opposite took place, and the reallocation of capital accelerated even faster than I anticipated.**

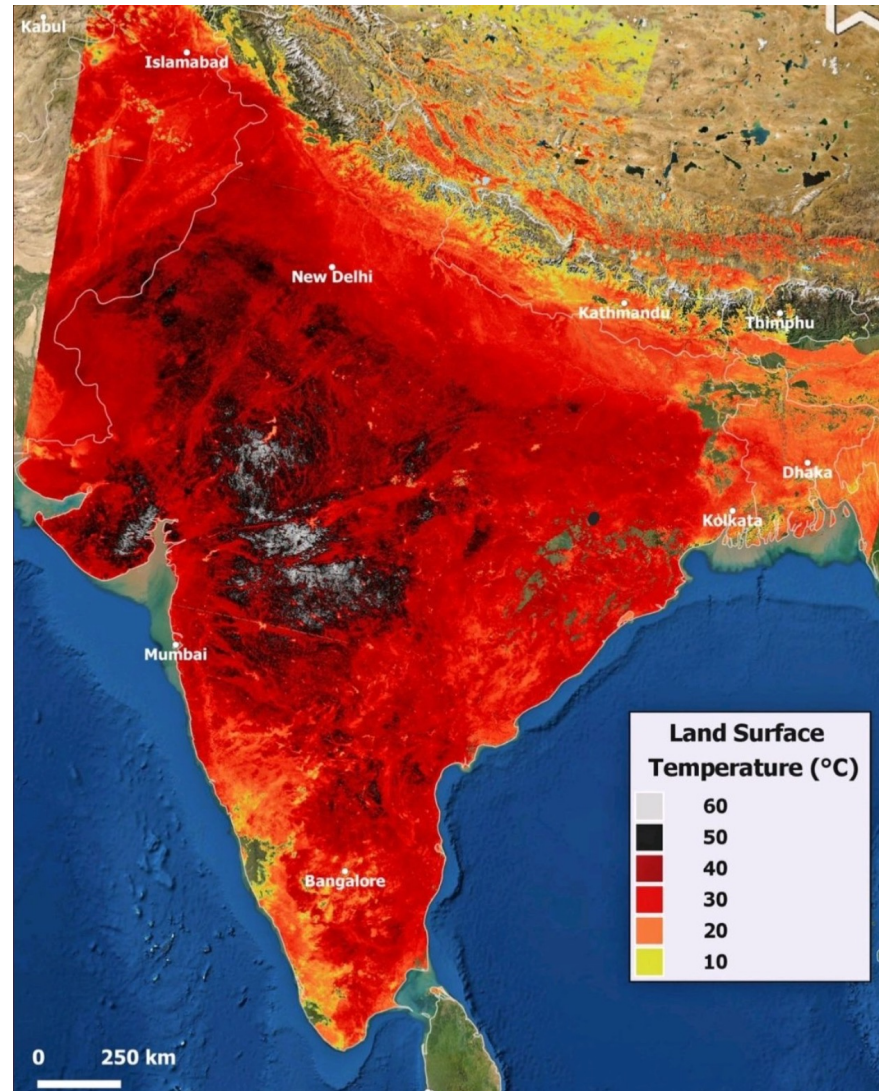
From January through November 2020, investors in mutual funds and ETFs invested \$288 billion globally in sustainable assets, a 96% increase over the whole of 2019.<sup>1</sup> I believe that this is the beginning of a **long but rapidly accelerating transition** – one that will unfold over many years and reshape asset prices of every type. **We know that climate risk is investment risk. But we also believe the climate transition presents a historic investment opportunity.**

BlackRock (AuM US\$10 trillion)  
[Larry Fink 2021 CEO Letter](#)



## 5. The Climate Science

There is no economy on an unliveable planet



# The Scaling Up of Hydrogen

## Electrolyser Manufacturing: Scaling Up 10-fold



**ITM Power Bessemer Park | 1GW pa Capacity Electrolyser Factory**

Measure	Atlas Way	Bessemer	Change
Production capacity	100MW	1GW+	10x
Effective capacity	<30MW	1GW+	30x
Test Zone	0.5MW (outside)	5MW ATEX (inside)	10x

**Double capacity (1 to 2GW/year)**

### Alkaline electrolyzers

Notodden/Herøya, Norway



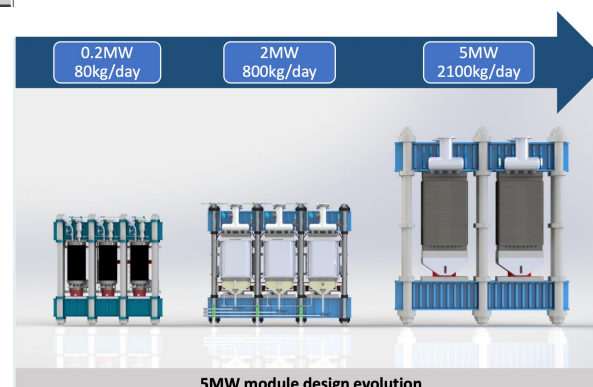
Test production in new line **Q2'21**,  
start of ramp-up Q3'21

Systems delivered: **800+**

Production capacity:

**40 MW/year → 500 MW/year (~2 GW/year)**

History: **90 years**

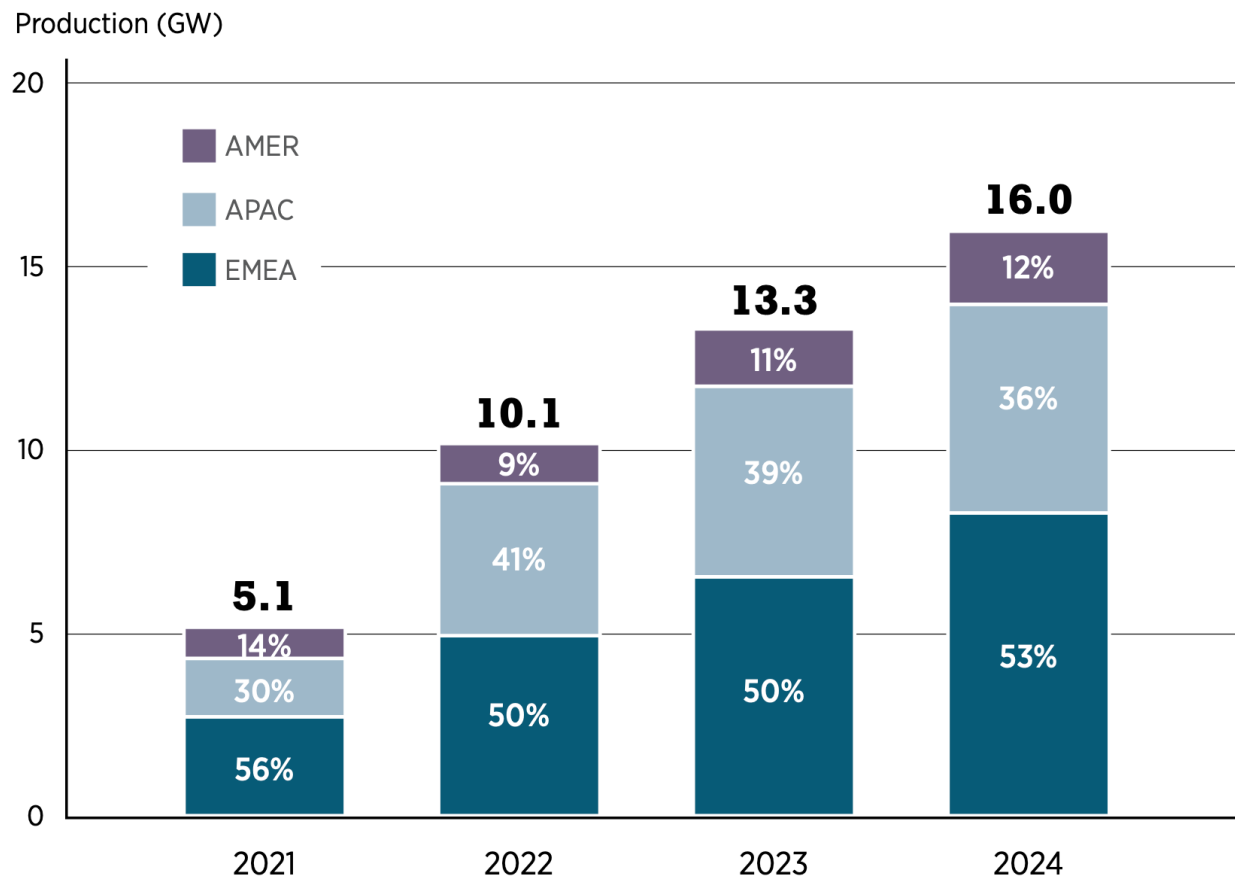




# The Scaling Up of Hydrogen

## Electrolyser Projects: Scaling Up

The IEA reports only 70MW of electrolyzers were installed in 2020, double the record set in 2019.

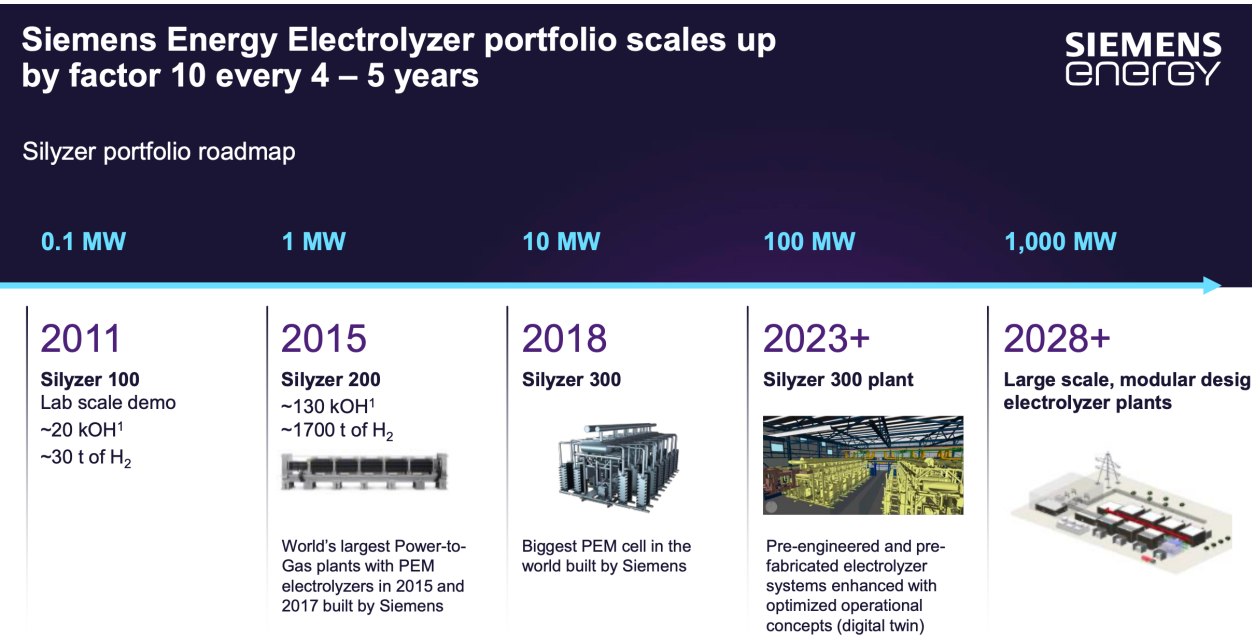


Source: BloombergNEF (2021b).

Note: AMER = Americas; APAC = Asia-Pacific; EMEA = Europe, the Middle East and Africa.

# The Scaling Up of Hydrogen

## Electrolyzer Facilities, Scaling Up



Feb'2020: Japan commissioned a 10MW facility, the world's largest.

Jan'2021: Air Liquide in Canada commissioned the world's first 20MW capacity PEM unit, doubling in just one year.

Jan'2021: Vattenfall/MHI/Shell announced a 100MW PEM unit in Hamburg for commissioning in 2025.

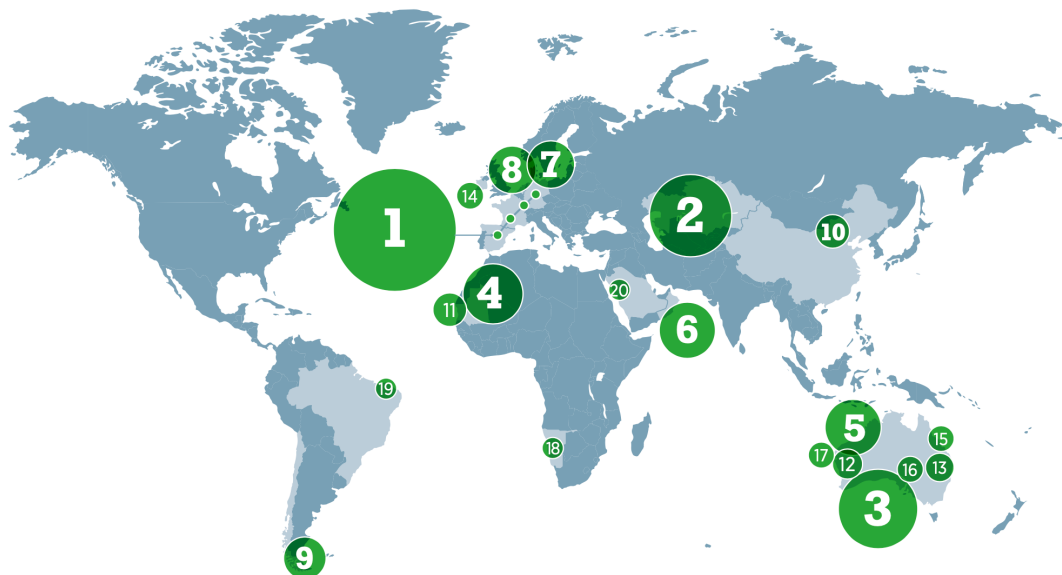
Jan'2022: thyssenkrupp & Shell announced a 200MW unit in Rotterdam, commissioning by 2024/5.

Meridian / Contact Energy proposing a 600MW facility for ~2025/26.

# The Scaling Up of Hydrogen

## Electrolyzer Projects, Scaling Up

**Figure 4.6** The world's 20 largest announced giga-scale green hydrogen projects



- |    |   |                |
|----|---|----------------|
| 1  | <b>HyDeal Ambition (67GW)</b>                                   | Western Europe |
| 2  | <b>Unnamed (30GW)</b>   | Kazakhstan     |
| 3  | <b>Western Green Energy Hub (28GW)</b>                          | Australia      |
| 4  | <b>AMAN (16GW)<sup>a</sup></b>                                  | Mauritania     |
| 5  | <b>Asian Renewable Energy Hub (14GW)</b>                        | Australia      |
| 6  | <b>Oman Green Energy Hub (14GW)<sup>a</sup></b>                 | Oman           |
| 7  | <b>AquaVentus (10GW)</b>  | Germany        |
| 8  | <b>NorthH2 (10GW)</b>   | Netherlands    |
| 9  | <b>H2 Magallanes (8GW)</b>                                      | Chile          |
| 10 | <b>Beijing Jingneng (5GW)</b>                                   | China          |
| 11 | <b>Project Nour (5GW)<sup>a</sup></b>                           | Mauritania     |
| 12 | <b>HyEnergy Zero Carbon Hydrogen (4GW)<sup>a</sup></b>          | Australia      |
| 13 | <b>Pacific solar Hydrogen (3.6GW)</b>                           | Australia      |
| 14 | <b>Green Marlin (3.2GW)</b>                                     | Ireland        |
| 15 | <b>H2-Hub Gladstone (3GW)</b>                                   | Australia      |
| 16 | <b>Moolawatana Renewable Hydrogen Project (3GW)<sup>a</sup></b> | Australia      |
| 17 | <b>Murchison Renewable Hydrogen Project (3GW)</b>               | Australia      |
| 18 | <b>Unnamed (3GW)</b>  | Namibia        |
| 19 | <b>Base One (2GW)<sup>a</sup></b>                               | Brazil         |
| 20 | <b>Helios green Fuels Project (2GW)</b>                         | Saudi Arabia   |

Note: Size refers to electrolyser capacity. Information based on announced plans.

Source: IRENA, Hydrogen Economy Hints at New Global Power Dynamics, 15 January 2022:

<https://www.irena.org/newsroom/pressreleases/2022/Jan/Hydrogen-Economy-Hints-at-New-Global-Power-Dynamics>


# The Scaling Up of Hydrogen

## Global Finance is Moving

### Opportunistic GH2 capital raisings in 4Q2020/2021 provide Scaling Up

#### PLUG POWER'S \$2B+ CAPITAL RAISE MARKS THE LARGEST BOUGHT DEAL IN THE CLEANTECH SECTOR

02/09/21

 Download this Press Release

Ideally Positions the Company to Accelerate Global Growth Strategy

LATHAM, N.Y., Feb. 09, 2021 (GLOBE NEWSWIRE) -- [Plug Power Inc.](#) (NASDAQ: PLUG), a leading provider of hydrogen engines and fueling solutions enabling e-mobility, today announced the completion of its previously announced upsized offering of 32,200,000 shares, which includes the underwriters option to purchase an additional 4,200,000 of its common stock. The shares were sold at a price to the public of \$65 per share with net proceeds in excess of \$2B. This transaction signifies the largest bought deal in the cleantech sector. This offering represents the third largest follow-on primary block trade with Morgan Stanley as a sole bookrunner in any market sector historically. Proceeds from this transaction, and final closing of the partnership with SK Group, will bring the total cash balance to over \$5B. This liquidity positions Plug Power to execute and accelerate its green hydrogen and overall growth strategy.

Plug raised US\$2bn at  
US\$65/share in Feb'2021

ITM Power raised £250m at  
£4/share in Oct'2021



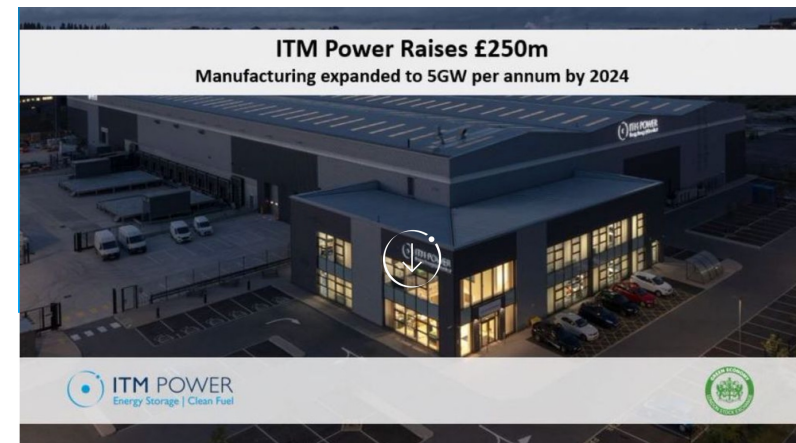
OSE-FILING

10 November, 2020 – Oslo, Norway

### Nel ASA: Share capital increase registered

(Oslo, 10 November 2020) Reference is made to the stock exchange announcement on 6 November 2020 regarding the issuance of shares in Nel ASA. The share capital increase pertaining to the issuance of the 354,000 new shares has now been registered with the Norwegian Register of Business Enterprises. The Company's new registered share capital is 281,559,497.60, divided into 1,407,797,488 shares, each with a par value of NOK 0.20.

After several capital raises,  
Nel has US\$330m cash as at  
Sept'2021



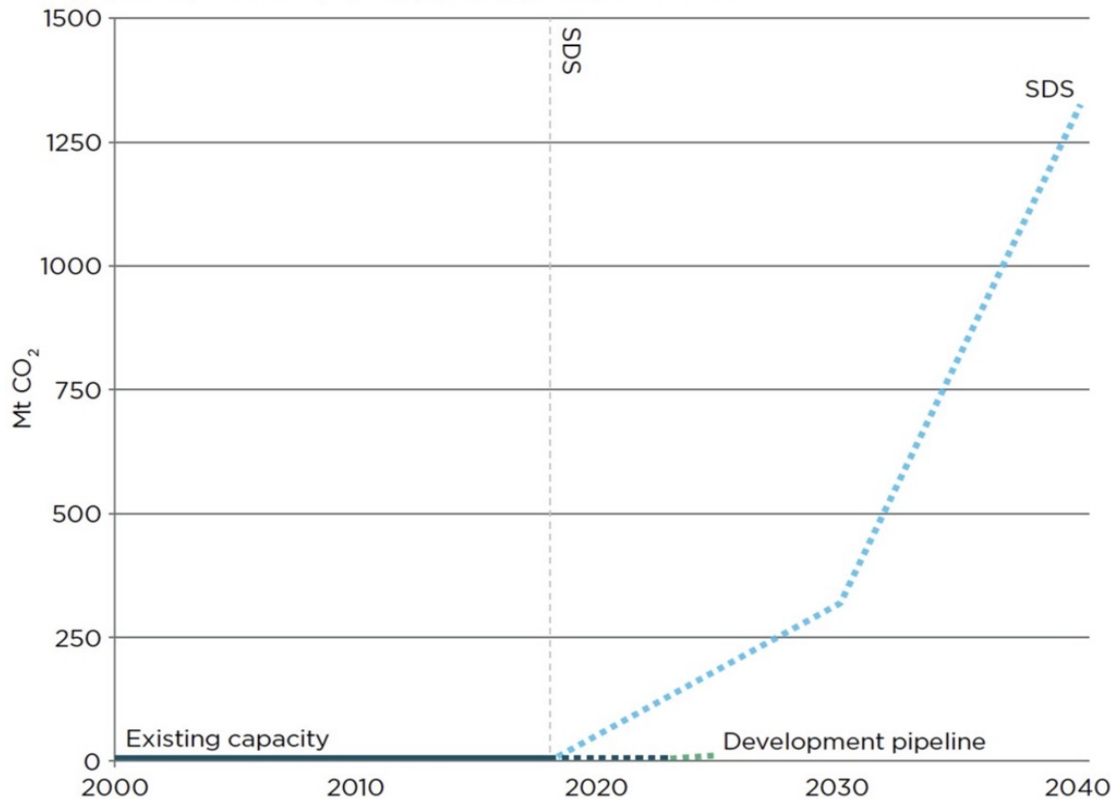
On 14 October 2021, ITM Power plc (AIM: ITM), the energy storage and clean fuel company, announced the launch of a placing (the "Placing") by way of an accelerated bookbuild (the "Launch Announcement") by Investec Bank plc ("Investec") and Merrill Lynch International ("BofA Securities"). The Placing has now closed.



# Blue vs Green Hydrogen

“Blue Hydrogen” Requires a High CO<sub>2</sub> Price & for CCS to be Proven

Figure 3: Large-scale CO<sub>2</sub> capture projects in power generation, SDS projections vs. actual development pipeline, 2000-2040



Source: IEA: [Exploring Clean Energy pathways: The role of CO<sub>2</sub> storage](#). July 2019

CCS is very different to CCUS-EOR; there is no viably operating commercial scale CCS in the power sector.

## Carbon Capture Suffers a Huge Setback as Kemper Plant Suspends Work

It's the latest U.S. government-supported boondoggle around CCS.

KATIE FEHRENBACHER | JUNE 29, 2017



Carbon Capture Suffers a Huge Setback as Kemper Plant Suspends Work

**US\$7.5bn Kemper facility demolished October 2021**



# UK: A Doubling to 10GW H2 by 2030

Hydrogen investor roadmap: £1bn debt & grant funding

## Sample of potential hydrogen projects across the UK

### Scotland

1. Fife Hydrogen Hub
2. Acorn Hydrogen
3. BEIS & Ofgem: H100 Heat Trial
4. CNES
5. EMEC
6. ERM (Dolphyn)
7. ERM (Salamander)
8. H2 Green
9. Hy2GO
10. Cromarty Firth Green Hydrogen
11. Repsol Sinopec
12. Scottish Power (Whitelee)
13. Shetlands Island Council
14. Octopus Hydrogen
15. Kittybrewster HRS
16. Aberdeen Hydrogen Hub
17. BayoTech

### North West England

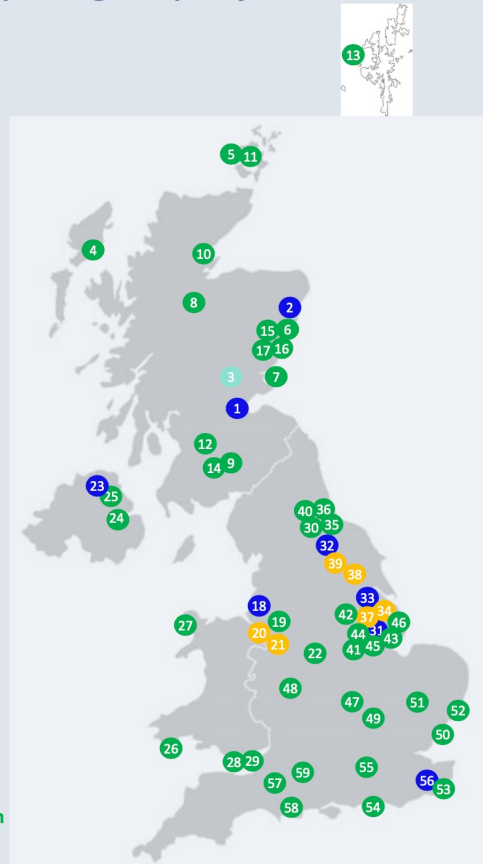
18. Hynet: HPP
19. Trafford Green /Carlton Power
20. Hynet: Phase 2 & 3 pipeline (Cadent)
21. Hynet: Salt Cavern Storage (INOVYN)
22. Octopus Hydrogen

### Northern Ireland

23. Skuunag
24. GenComm/Belfast Met
25. NI Water

### Wales

26. RWE Pembroke
27. Mentor Mon
28. Octopus Hydrogen
29. Protium Magor



### North East England

30. BP: CCUS enabled hydrogen and green hydrogen
31. Uniper Humber Hub
32. H2NorthEast
33. H2 to Humber Saltend
34. Aldbrough storage (SSE)
35. Protium
36. EDF Tees Green
37. ECC pipeline (Nat Grid Ventures)
38. Project Union (Nat Grid Gas)
39. East Coast Hydrogen (NGN)
40. Tees Valley Transport Hub
41. Octopus Hydrogen
42. Anonymized
43. Project Mayflower

### East England

50. Sizewell
51. Octopus Hydrogen
52. Lowestoft Port

### South East England

53. Ryze
54. Shoreham Port Green Hydrogen Production
55. Viridor
56. Acorn: Project Cavendish

### South West England

57. Bristol Airport
58. Canford Renewable Energy
59. Octopus Hydrogen

### Yorkshire & Humber

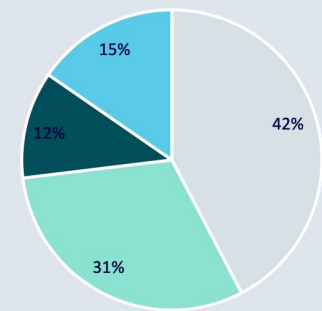
44. Yorkshire Energy Park
45. Oyster Project
46. Gigastack

### East & West Midlands

47. Tyseley Energy Park
48. Shropshire Council
49. Octopus Hydrogen /MIRA Technology Park

- CCUS enabled projects
- Electrolytic projects
- Storage & Distribution

Electrolytic end use (indicative)



Note: Includes plans and proposals for projects that are in the public domain. Many more projects are under development in all parts of the UK. Total UK pipeline estimated up to 20GW as of April 2022. Location of projects on this map is approximate.

□ Mobility (Road, NRMM, Aviation, Maritime) □ Industry ■ Power ■ Heat

Source: UK Government 8 April 2022:

<https://www.gov.uk/government/publications/hydrogen-investor-roadmap-leading-the-way-to-net-zero>

# India: A Doubling to 10GW H2 by 2030

Energy Minister RK Singh considering a mandatory purchase obligation for 10% GH2 on fertiliser, refineries & steel in initial years.

## Mukesh Ambani sees green hydrogen costs coming down to \$1 per kg in 10 yrs

Ambani noted that the PM had set a goal to reach 450GW of renewable energy capacity by 2030

### Topics

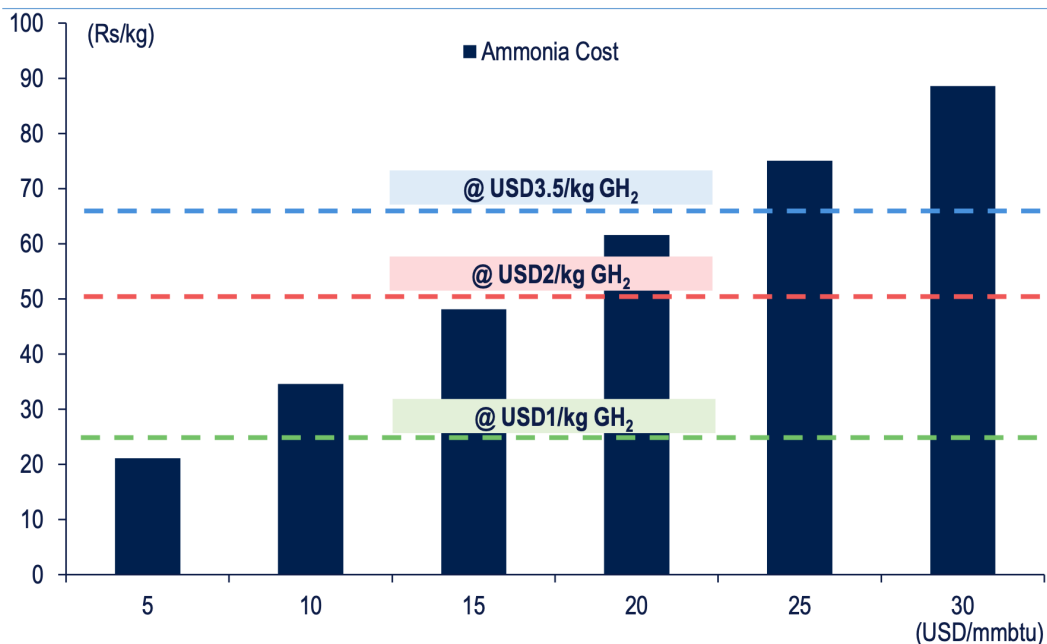
Reliance Industries | Climate Change | Mukesh Ambani

BS Reporter | New Delhi

Last Updated at September 4, 2021 02:20 IST

Mukesh Ambani, Chairman and Managing Director of [Reliance Industries](#) (RIL), on Friday said India can be the first country to bring down the cost of green [hydrogen](#) to \$1 per kg within a decade, reiterating the company's push towards alternate energy.

Figure 17: Green Ammonia viable at currently elevated global gas prices



Source: Yara, Investec Securities estimates

# Germany/Oz: A Landmark MoU

## ‘Freedom energy’: Forrest offers hydrogen to Russia-dependent Germany

[Hans van Leeuwen](#) Mar 30, 2022 – Australian Financial Review



*[E.ON](#) COO Patrick Lammers signs the H2 deal with Fortescue's Andrew Forrest*

5Mtpa GH2 is 28Mtpa  
of ammonia worth  
A\$30bn annually.

Mining magnate Andrew Forrest has offered a major slice of Fortescue's planned future supply of GH2 to Germany, branding it "freedom energy" that will help Europe's largest economy cut its dependency on Russian gas. Mr Forrest signed a memo with Germany-based [E.ON](#), one of Europe's largest energy network operators, to underpin a potential future supply of up to 5 Mtpa of hydrogen from renewable sources by 2030.

"We all know there is so much which we cannot yet fully answer. But as people of honour, we will be able to solve it simply through the agreement of our word. We trust each other, the corporations trust each other, and emphatically and most importantly, our two countries trust each other. They're based on the principle of democracy – the absolute, unadulterated necessity of human freedom." "On both sides, it will be like a duck swimming," he said. The two firms' executives would be "really calm", but "underneath, our organisations will be going like crazy because for us it's a \$50bn expenditure".

According to Fortescue, a 5-Mtpa supply of green hydrogen by 2030 would account for one-third of Germany's calorific energy imports from Russia.



# Industry-Energy Convergence: Green Steel

SSAB / Vattenfall / LKAB HYBRIT £3.56bn Investment plan



Regulatory press releases

## SSAB plans a new Nordic production system and to bring forward the green transition

JANUARY 28, 2022 7:15 CET

5 MIN RE/

SSAB's Board has taken a policy decision to fundamentally transform Nordic strip production and accelerate the company's green transition. The decision was taken against the background of strongly growing demand for fossil-free steel. The plan is to replace the existing system with new mini-mill technology, which will result in a broader product program and improved cost position. The ambition is to largely eliminate carbon dioxide emissions around 2030, 15 years earlier than previously announced. However, to achieve this ambition, the necessary infrastructure, access to fossil-free electricity in particular, must be in place in time.

Source: SSAB Sweden, 28 January 2022:

<https://www.ssab.com/en/news/2022/01/ssab-plans-a-new-nordic-production-system-and-to-bring-forward-the-green-transition>