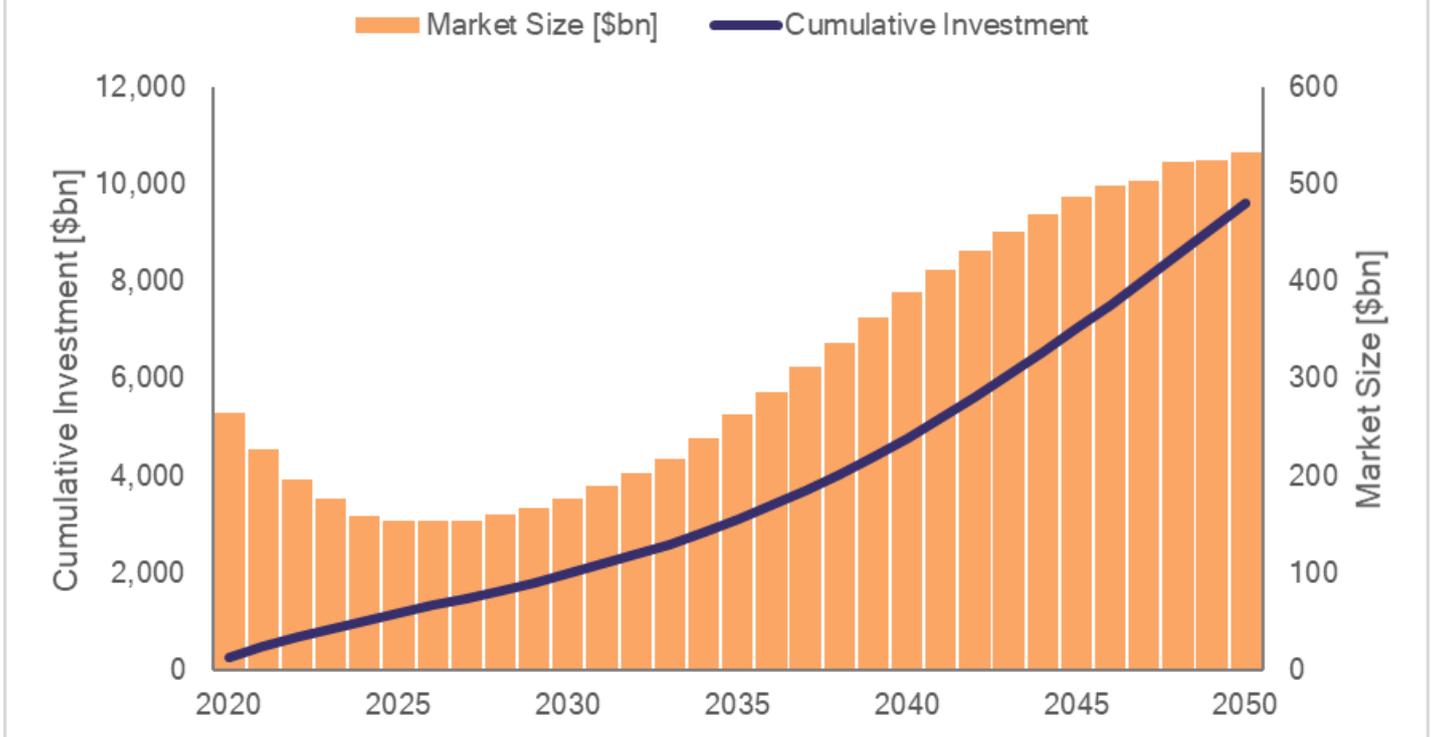


Hydrogen to clean up energy with \$10 trillion spend

Rethink Energy forecast to 2050 - by industry, with pricing model

Hydrogen Market Size and Spend 2020-2050



Companies mentioned in this report: ACWA Power, Airbus, Air Liquide, Air Products, AME, Ansaldo Energia, BigH2, BMW, Bosch, Coradia, Citroen, Costain, CWP Global, Cummins, Decarbit, EnacpCo, Enapter, Enegas, Enel, EnerTech, Equinor, Esoro, EUTurbines, Fertiberia, Fortescue Metals Group, Foton, Frontrunner, FuelPositive, Gasunie, GE Power, Green Hydrogen Systems, GRHYD, H100, H2-Share, H2Global, H2HoWi, H2Pro, Haldor Topsoe, HeidelbergCement, Hero Future Energies, HyDeal Ambition, HyDeploy, Hy4Heat, Hyundai, Iberdrola, IEA, InterContinental Energy, International Maritime Organization, ITM Power, John Cockerill, Kenworth, Kyoto University, Macquarie, MAN Energy, McPhy, Mercedes, Mitsubishi Hitachi Power Systems, Nel, NEOM, Nikola, Nouryon, Omani Oil, Orsted, OQ, Ohmium, Plug Power, Proton Technologies, Peugeot, Reliance Industries, Stanford University, Standard Hydrogen, Shell Aviation, Siemens, Sinopec, Sinotruck, SkyNRG, SNAM, Svevind, Tesla, Thyssenkrupp, Toyota, Vauxhall, Vestas, Ways2H, Western Green Energy Hub, ZeroAvia

Lead analyst: Harry Morgan
January 2022

“Rethink has a commitment to forecasting markets that others shy away from – those on the verge of radical transformation”

RETHINK
TECHNOLOGY
RESEARCH

<https://rethinkresearch.biz>



CONTENTS

	Page
Table of Contents	2
Table of Figures	3
Introduction	4
Market Activity	7
Cost of H2 and why green has to win	10
Blue Hydrogen	11
Pink Hydrogen	13
Worth Noting Technologies	14
Demand	15
Oil Refining	16
Ammonia	17
Transport	19
Road Transport	21
In the Air	26
Hydrogen offers simpler, less efficient decarbonized heat	28
Industry	32
Cement	34
Hydrogen has plenty of opportunities ahead of the power sector	35
Methodology	38
Contacts	43
About Rethink Technology Research	44

GRAPHS AND TABLES

	Page
Hydrogen market size and spend to 2050	4
Hydrogen demand by sector to 2050	5
Green Hydrogen demand by Country	5
Electrolyzer capacity to 2050	6
Electricity demand for H2 production	6
Cost breakdown of Green hydrogen to 2050	9
Cost breakdown of Blue hydrogen to 2050	11
Cost breakdown of Grey hydrogen to 2050	13
Global average hydrogen price by production type to 2050	14
Hydrogen demand in existing feedstocks by production type to 2050	15
Hydrogen demand oil refineries to 2050	16
Hydrogen demand in Ammonia production to 2050	17
Hydrogen demand in Maritime Sector to 2050	20
Hydrogen demand in passenger vehicles to 2050	22
Hydrogen demand in Light Commercial Vehicles to 2050	24
Hydrogen demand in Heavy Duty Transport to 2050	25
Hydrogen demand in Rail Transport	26
Hydrogen demand in Aviation	28
Hydrogen demand in Heating	29
Hydrogen ready boiler Bosch	29
Hydrogen demand in Steel making	33
Hydrogen demand in Cement making	34
Gross to net renewable generation in power grids	36
Hydrogen demand in power sector	36
Gas turbines that are designed to use hydrogen	37

Introduction

As investment continues to be ploughed into clean technology, in hope of a green recovery to Covid-19, green hydrogen has become *the* technology that will fill the gap between renewable energy and net zero emissions. Global pipelines for projects and electrolyzer production facilities have seen four-figure growth, despite criticisms from industry laggards who claim to have seen this all before.

But with the promised economies of scale of this production buildout, as well as a plummeting cost of renewables, and a rising cost of carbon, green hydrogen – produced using renewable energy – is set to become cost-competitive with existing fossil-fuel-based hydrogen **in just two years** – far before any other analyst groups have previously forecast.

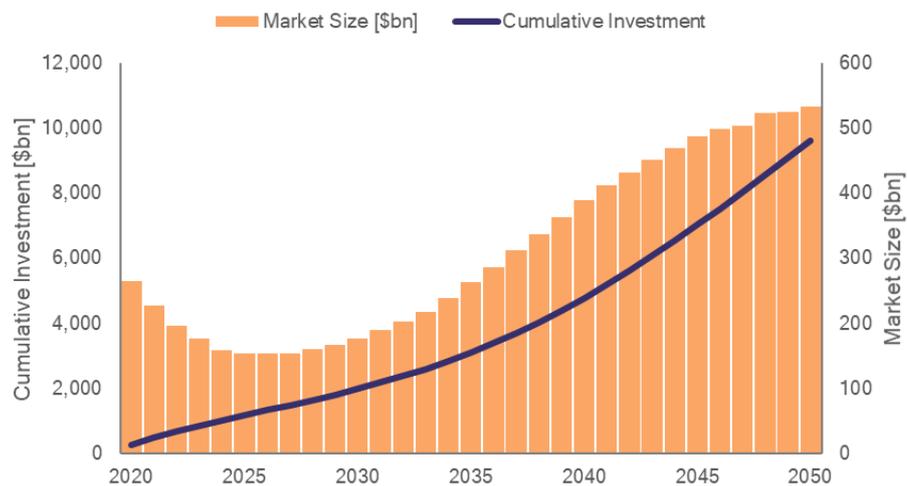
This will see a violent shakedown of industries that have plodded on with a business-as-usual approach to decarbonization, without innovation.

While these laggards continue to push CCUS (carbon capture) approaches or complain about a ‘chicken-and-egg’ problem for hydrogen demand, the companies making the zero-regret investments in green hydrogen now will dominate the hydrogen supply for existing ammonia and oil refining sectors by 2035, with an overall demand of 73 million tons by 2050, although by then there will be scant requirement from oil.

In transport, green hydrogen will provide heavy transport the opportunity for close to continuous operation. Despite minimal penetration in the passenger vehicle space – at just 2.4% of on-the-road cars by 2050 – the economics of fleet-based transport will see penetration hit 22% for light commercial vehicles and 95% for heavy-duty trucking, with an overall hydrogen demand of 47 million tons per year across the world’s roads.

In the seas, ammonia will be used as a carrier for hydrogen in 74% of ships by 2050, with the first ships being made available as soon as this year.

Hydrogen Market Size and Spend 2020-2050

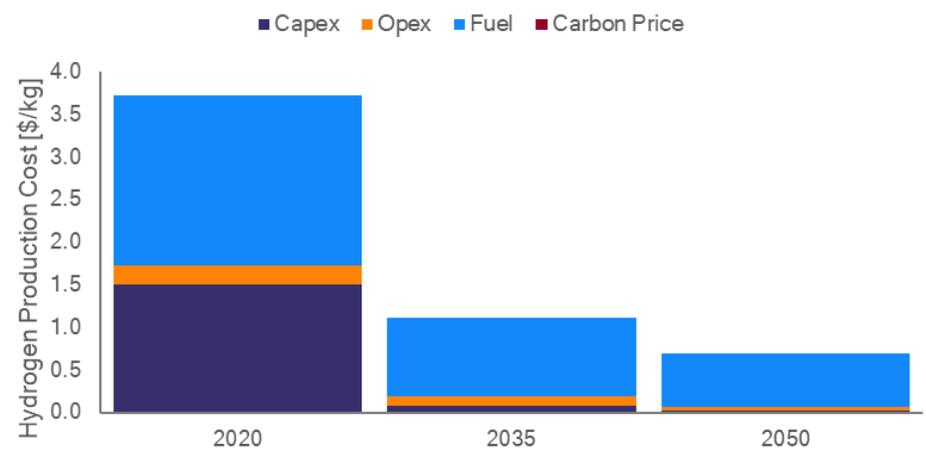


Whether its Proton Exchange Membrane (PEM), Anion Exchange Membrane (AEM), or Solid Oxide (SOE) electrolyzers, the physical activity in the electrolyzer manufacturing space is evidence that hydrogen is more than the ‘hype’ that many naysayers have touted.

Whichever technology wins is not as important as the competitive environment and momentous R&D effort that will see the cost of electrolyzers plummet over the coming decade. In fact, with each having distinct advantages (PEM in large scale projects, AEM in distributed systems, and SOE in industrial settings with waste heat availability), all three technologies are likely to play some part in long-term decarbonization.

Since ITM Power announced the first Gigafactory for electrolyzers back in July 2019, and commissioned it in January last year, subsequent plans have been announced for more than 35 GW of annual production capacity at gigafactories alone.

Cost breakdown of Green hydrogen to 2050



Cummins, Nel, John Cockerill, Haldor Topsoe, Reliance Industries, Ohmium, Plug Power, Green Hydrogen Systems, Thyssenkrupp, Enapter, and Hero Future Energies, are now among those likely to be producing more than 1 GW of electrolyzer units per year, with many reaching this mark within the next two years.

At the rate at which these facilities are being announced, the global production capacity is likely to be well in excess of 100 GW by 2030, which is more than enough to satisfy existing government or corporate targets.

If electrolyzer manufacturers can match the learning rate of the solar sector, units will fall in cost by 23% every time the installed capacity doubles from the current total of just 300 MW – less than 1% of total production. Even without any sudden disruptions in technology – of which several are almost certain – the learning rate for electrolyzer units we calculate to be 14%. The economies of scale that it will bring will see the capital cost of electrolyzer units fall by over 85% from around \$1,400 per kW to \$340 per kW by 2030.



Methodology for our reports

This report is one of the many reports which makes up our Annual Primary Electricity forecast for 2022. It takes our existing forecasts for Green Steel, Trucks, Trains and Buses, Passenger cars and Home Heating and Power Generation and calculates how much hydrogen would need to be created to support each of those efforts individually. To this we have added forecasts we have touched on in the past but never stated specifically, such as Cement production, Oil Refining, Ammonia production, Shipping fuels and Aviation use of hydrogen and clarified our forecasts and used these to add to the hydrogen total.

As we often say, forecasting is NOT rocket science, it is just dogged hard work to process the type of calculations you could do for yourself, if you had the time, using a combination of available public numbers (for instance country by country power generation by fuel source), key governmental promises, tempered by how close those particular governments have met their aims in the past, and our own projections based on the current rate of uptake of technologies and the likely uptake as pricing falls.

In each case we have had extensive interviews with industry executives, both those who support a particular technology and those who are unsure of its effectiveness, as well as technology providers, who often confidentially reveal their cost and pricing projections into the future. We would like to thank anyone who has been interviewed for any part of this report.

Putting this all together into a series of industry by industry forecasts and projecting the doubling points of Hydrogen (when the market place size doubles), has given us the final key ingredient of being able to calculate the learning curve on the production of green hydrogen and the price implications. If you take that with the falling prices of renewable electricity, already calculated in our prior reports on wind and solar, you reach the inescapable conclusion that the hydrogen industry is up and running, it has boundless enthusiasm and funding, and many driven people are hell-bent on owning a piece of the rising global supply chain for hydrogen. This time it is not going to fail or be railroaded.

We hope you enjoy our first comprehensive report on that global hydrogen effort.

Who should buy this report?

Understanding the fledgling hydrogen market is vital for anyone in a multitude of industries, including Oil Refining, Ammonia production, Heavy Duty Transport, Road Transport, Aviation, home heating, and cement production. This forecast is also relevant to organizations investing in any area of the energy market such as renewable energy developers, existing oil suppliers, investors, traders, energy equipment manufacturers, grid-scale energy storage, government regulators, lobbying firms and strategic decision makers and even the power sector.

For **\$4,600** we will give you and everyone in your company access to this report and every report, webinar and podcast we produce in the next 12 months, as well as from the last 12. We will also throw in an annual subscription to our Weekly Energy Analysis.

Rethink Energy: Taking a different view of the energy transition

Rethink Energy is a series of “breakthrough” forecasts and webinars which show the true rate at which the Energy Transition is happening.

Rethink Energy believes it is the only forecaster that can see quite clearly how the energy markets are like a circle of dominoes – push one and they all fall over. It is very different forecasting a market that is on the edge of a precipice, compared to one which is on a flat hilltop.

“Hydrogen to clean up energy with \$10 trillion spend”. [Buy it here.](#)

Previous forecasts include;

- Tesla versus ExxonMobil – who’s right?
- Warming and Cooling - double whammy for the grid
- Last Chance Saloon for Gen 3 CSP
- Renewables set to unlock \$2.2 trillion Green Steel Monster
- Look Back in Anger – A simplified global energy model
- Perovskites poised to disrupt solar supply chains everywhere
- Wind accelerates past nuclear, hydro in post Covid power markets
- What a difference a day makes; Biden win triggers solar acceleration
- Europe goes all in on hydrogen for the transport economy
- Energy through the looking glass | What stock markets look like on the other side of the energy transition
- USA flying start triggers rush for Energy Storage leadership

RETHINK ENERGY'S MAIN CONTRIBUTORS

Peter White - **Principal Analyst**

peter@rethinkresearch.biz

+44 (0)7734 - 037414

Harry Morgan - **Senior Analyst (author of this report)**

harry@rethinkresearch.biz

Andries Wantenaar - **Junior Analyst**

andries@rethinkresearch.biz

RETHINK LEADERSHIP

Peter White - **CEO and Co-founder**

peter@rethinkresearch.biz

+44 (0) 7734 037414

Caroline Gabriel - **Research Director**

caroline@rethinkresearch.biz

+44 (0)207 450 1230

www.rethinkresearch.biz

About Rethink Technology Research

Rethink is a thought leader in quadruple play, renewable energy, and 5G wireless. It offers consulting, advisory services, research papers, webinars, plus three weekly research services; Wireless Watch, a major influence among wireless operators and equipment makers; Faultline, which tracks disruption in the video ecosystem, and OTT video, Rethink Energy, which monitors progress and technologies as well as investment opportunities in the ever-changing energy landscape.



"Forecasting technology markets, whether they are growing or shrinking."

Need more information?

Simon Thompson (*Publisher*)

simon@rethinkresearch.biz

+44 (0) 7765 342918

Bristol & Exeter House
Lower Approach Road
Temple Meads
Bristol
BS1 6QS
United Kingdom

Tel. +44 (0) 1280 820560
Tel. +44 (0) 7765 342918

www.rethinkresearch.biz

Published January 2022

