Santander Private Banking

Green hydrogen: fuelling a sustainable future

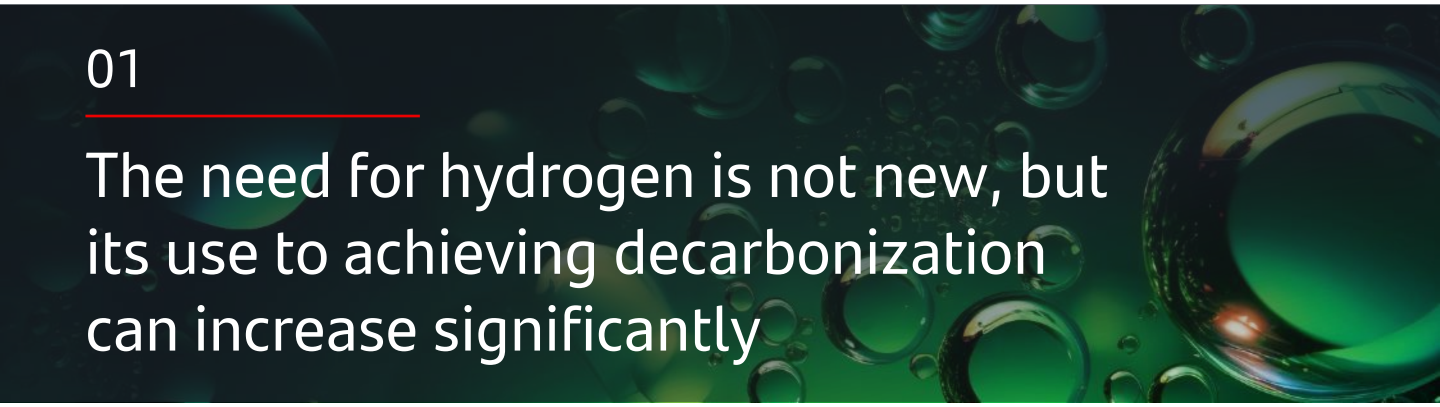
> “I believe that water will one day be employed as fuel, that hydrogen and oxygen, which constitute it, used singly or together, will furnish an inexhaustible source of heat and light of an intensity of which coal is not capable”
>
> Jules Verne

Hydrogen is the most abundant and simplest chemical element on the planet; it is present in 75% of matter. Humanity has been using it as a raw material in the chemical and metallurgical industries for over 100 years. Additionally, it is light, can be stored and does not, in itself, generate emissions, so it is a perfect candidate for a sustainable fuel[1].

Hydrogen cannot be obtained directly from nature; it needs to be manufactured. The process used determines whether this fuel is clean. When produced from renewable energy sources, hydrogen is one of the fuels of the future.

According to S&P Research, green hydrogen is one of the top ten cleantech trends in 2024, and it is becoming a key part of net zero plans to decarbonizing hard-to-abate sectors. It also offers major opportunities for historically energy-dependent countries[2,3] . It can increase developing countries' overall resilience while driving the creation of a diversified and knowledge-based economy[4].

There is unprecedented momentum around the world to fulfil hydrogen's longstanding potential as a clean energy solution. However, it is important to understand all the challenges that this technology faces and how they are being tackled [5].



01

The need for hydrogen is not new, but its use to achieving decarbonization can increase significantly

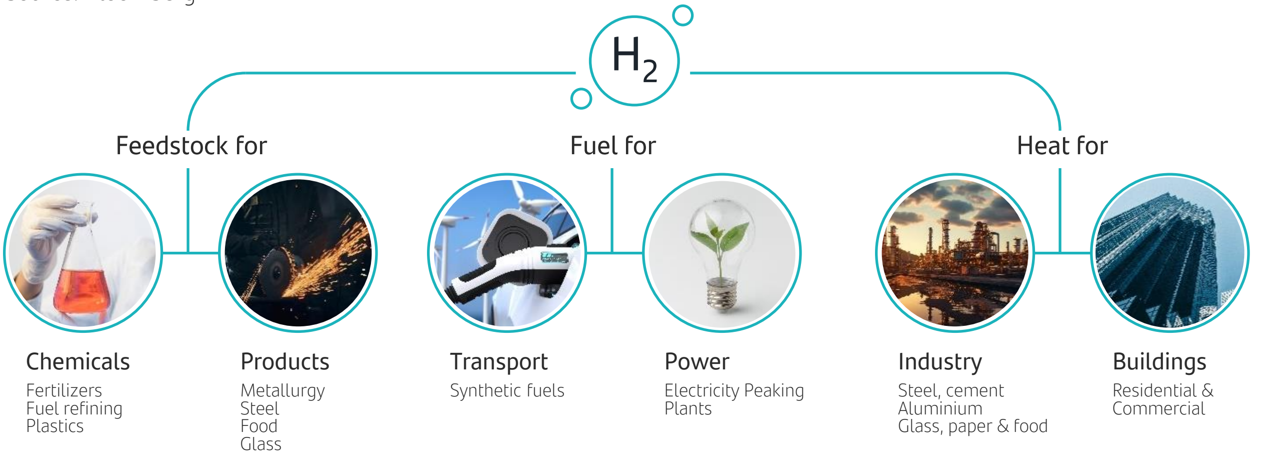
Hydrogen has **traditionally been used as an input across carbon intensive industries** that are more difficult to decarbonize, the so-called hard-to-abate sectors. The top four industrial uses of hydrogen are oil refining, ammonia production for fertilizers, methanol production for synthetic fibers for clothing, etc and iron ore refining for steel production.

In addition, hydrogen can power an electric vehicle's drivetrain through a fuel cell when converted into electricity. Finally, the combustion of hydrogen can provide high-quality, low-carbon heat for industrial applications (e.g., melting, gasification, drying, or catalysing chemical reactions) and buildings (e.g. hydrogen boilers [9]).

Figure 1.

Current and future uses of Hydrogen

Source: BloombergNEF



An industrial input[1,7,9]

Hydrogen is used for several carbon-intensive industrial processes as a feedstock for chemicals and refining.

A fuel

Hydrogen can serve as fuels for internal combustion engines [8].

A heat source

Hydrogen can replace solid, liquid and gaseous fuels in heavy industries and provide a low-carbon alternative to gas to heating buildings.

02

The benefits of green hydrogen

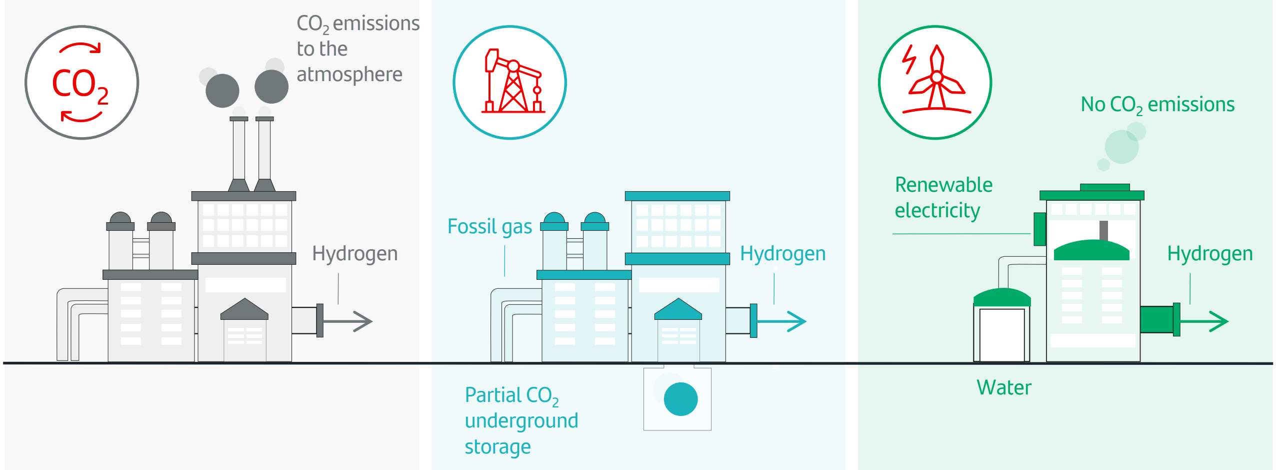
Hydrogen is not a primary energy source; rather, it is an **energy vector,** which means that **it requires a chemical process to be produced**[2]. Non-renewable hydrogen is extracted from fossil gas, a process that releases CO2 emissions while green hydrogen is extracted from water using renewable energy in the process[3].

Figure 2.

Types of hydrogen, based on the manufacturing process

Source: The Guardian

From grey to green: how is hydrogen produced



Grey hydrogen
Hydrogen is extracted from fossil gas releasing CO_2 into the atmosphere.

Blue hydrogen
Hydrogen is extracted from fossil gas, and a part of the CO_2 emissions (60-65%[6]) are trapped and stored underground permanently.

Green hydrogen
Hydrogen is extracted from water using renewable electricity and releasing oxygen into the air.

Green hydrogen...

Is a clean fuel

Green hydrogen is obtained from water through **electrolysis,** using an electrical current to break a water molecule into oxygen and hydrogen. This process is powered by renewable energies such as wind or solar. Through a fuel cell, hydrogen binds again with oxygen from the air, producing electricity. There are zero CO_2 emissions and the **only by-product of this process is water**[1].

Is storable and transportable

Hydrogen presents a clear advantage to renewable energy[5] as it can be liquified, compressed, stored alongside other materials or in underground caves[13,17]. Compressed hydrogen tanks are lighter and easier to handle than lithium batteries.

Is efficient in combustion and charging time

Hydrogen-powered fuel cells can achieve more than twice the efficiency of conventional combustion technologies[10]. Additionally, refuelling time is c.5 minutes for a passenger vehicle, and c.15 minutes for a bus, much shorter than electric vehicles[14].

Fosters energy independence

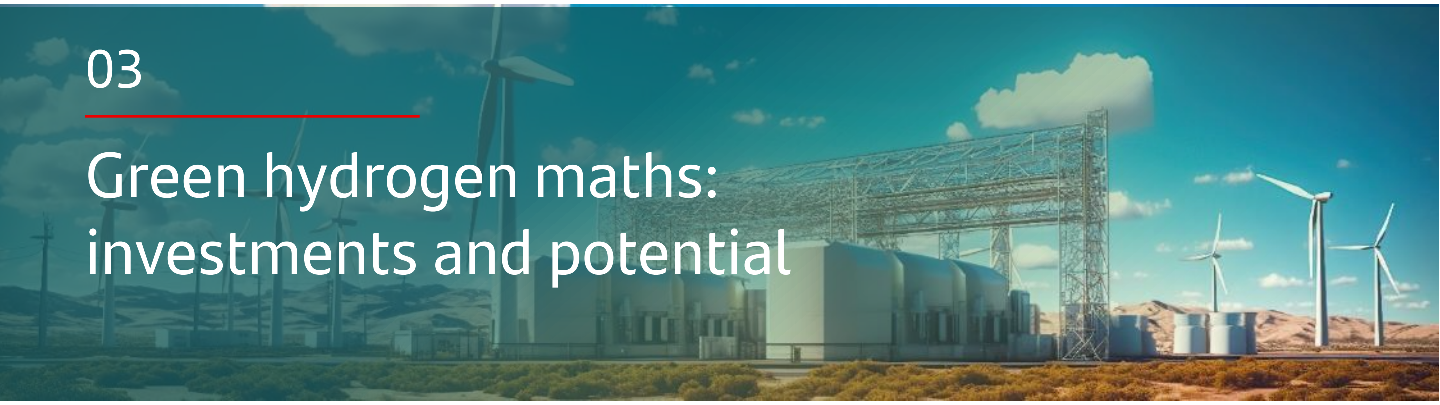
Countries with an optimal combination of abundant renewable resources, space for solar or wind farms, and access to water[15] could reduce their energy dependency.

Could be a game changer for developing countries

In developing countries, the production of steel, cement and chemicals products is expected to continue increasing and putting pressure on emissions reduction[15].

Requires no trade-off

Compared to alternatives like biofuels, hydrogen does not require a trade-off [15,16] with agriculture.



03

Green hydrogen maths: investments and potential

3.1. The investments

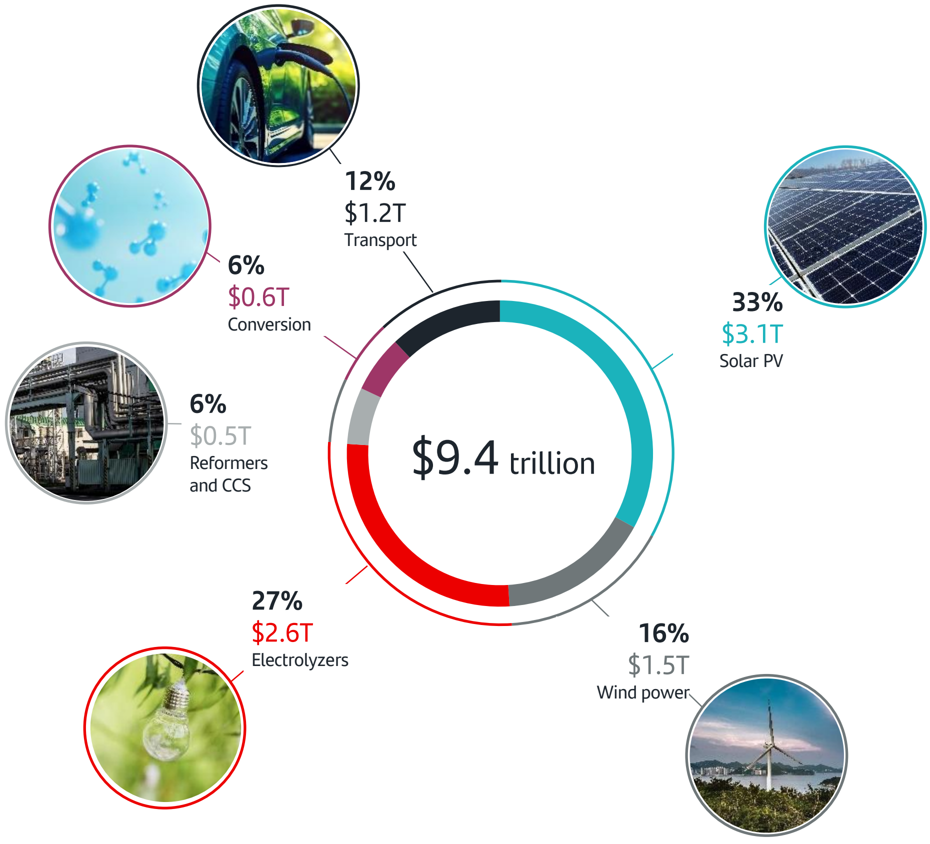
The hydrogen value chain will require **USD 9.4 trillion in total of investments through 2050**, USD 3.1 trillion of which in developing economies[17], mainly for technology development and renewable energy.

Figure 3

Cumulative investments in the hydrogen value chain

(USD trillion through 2050)

Source: Deloitte. CCS refers to carbon capture and storage



3.1. The investments

Investments are key to overcoming the following challenges

Production costs

According to the latest forecasts, the price per kilo of green hydrogen has been reduced to a quarter of what had been estimated four years ago[12] .

Still, green hydrogen is more expensive to produce than grey hydrogen. Falling renewable energy prices have opened a new window of opportunity. Solar electricity is 10 times cheaper than it was a decade ago and wind energy costs have more than halved[1]. This trend is expected to continue driven by clean energy technology investments[19].

Efficiency

Large electrolysis equipment is still in the test phase, and electrolysis costs are almost 95% higher than in 2020 due to increases in balance of plant, operation and maintenance of all subsystems and equipment[19]. In addition, green hydrogen plants for industrial purposes must be built next to the final consumption location to avoid energy losses[20]. The efficiency of hydrogen production, storage, and conversion technologies needs to improve to maximize the benefits of using hydrogen as an energy vector.

Infrastructure[21]

Building hydrogen refuelling stations for fuel cell vehicles, expanding hydrogen storage and transportation networks, integrating hydrogen into existing energy systems, etc is key to scale green hydrogen.

Existing gas infrastructure could be refurbished for hydrogen.

3.2. Growing potential

Demand growth

By 2050, total global demand for hydrogen may be 4 to 6 times the current levels[22]

From

c. 1 Mt

(million metric tons) of green hydrogen supply out of 100Mt[17, 22] total current production.

To

c. 500 Mt

of green hydrogen supply mainly for industrial and transportation sectors. An additional c.100 Mt of blue hydrogen is also projected[17] driven by improved economics, demand from Asia and a mature project pipeline.

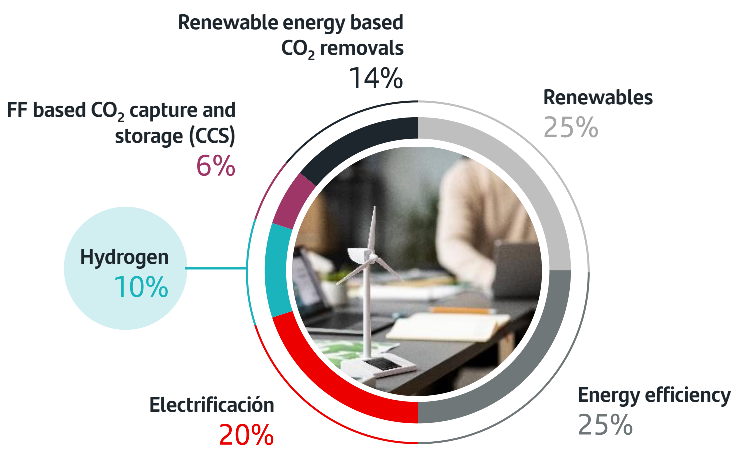
The breakeven

The cost of hydrogen installations could decrease 40 to 80%, which coupled with lower renewable energy prices, could drive green hydrogen to profitability by 2030[1].

Figure 4

2050 Reduced emissions scenario by technology

Source: IRENA. CCS refers to carbon capture and storage



The solution

In 1.5ºC scenario clean hydrogen could represent c.10% of the needed emissions reduction by 2050[22]

3.3. About regulation[27]

- A growing number of countries and companies are engaged in intense competition for leadership in clean hydrogen technologies.
- In 2017, just one country (Japan) had a national hydrogen strategy.
- Today, more than 30 countries have developed or are preparing hydrogen strategies, indicating growing interest in developing hydrogen value chains.
- Supportive policies will be needed to meet targets and achieve the necessary installed capacity by 2050[27].

Figure 5

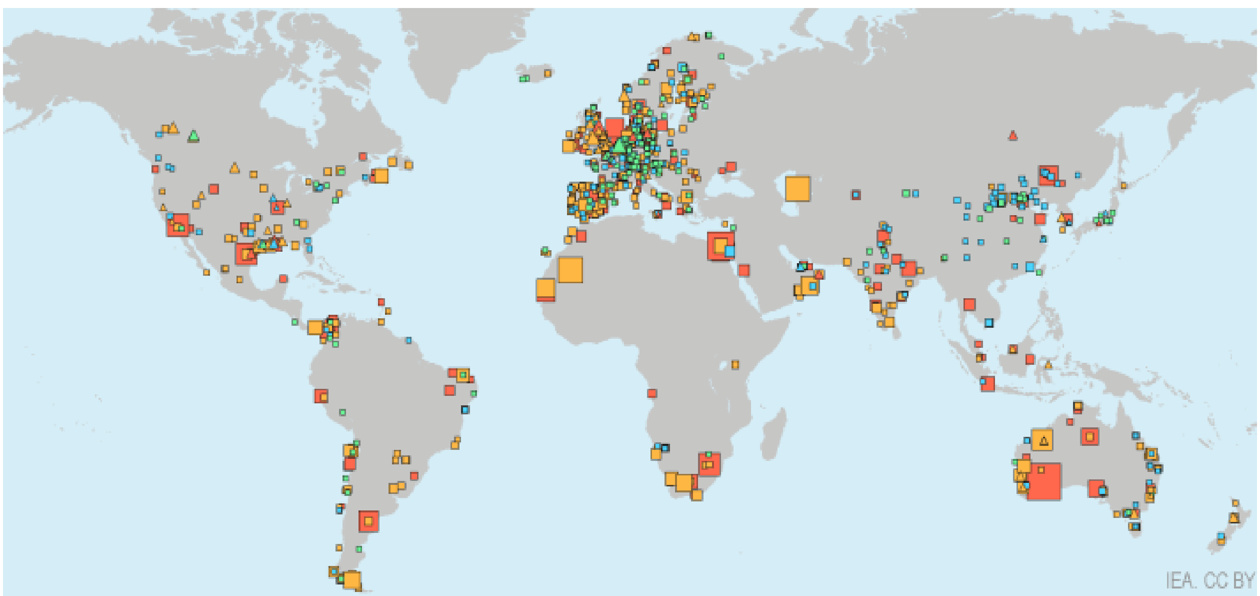
Low emission hydrogen projects in the pipeline

Source: IEA Hydrogen Projects database

CCUS projects
- Early stage
- Feasibility study
- FID/under construction
- Operational

Electorlyser projects
- Early stage
- Feasibility study
- FID/under construction
- Operational

Capacity (Kt H_2/year)
50
150
250
500
1 000
5 000
15 000



Plans by geography

Investment in hydrogen tripled YoY in 2023[23] globally. Over 1,000 green hydrogen project proposals[24] have already been announced, of which 75% will be in full or partial development by 2030.

Europe[25]
The EU aims to produce 10 Mt of green hydrogen and import an additional 10 Mt by 2030, as it is considered a major contributor to reduce dependence on imports of Russian fossil fuel. Despite Europe's leading position on announced volumes, the maturity of the project funnel is low with only 5% committed volumes. In 2022, hydrogen accounted for less than 2% of Europe's energy consumption with 96% of it produced from natural gas.

Japan[12]
Because of its limited domestic scope to generate renewable energy, the country has signed an agreement to import hydrogen from Australia in large quantities.

Brazil[24]
Has launched several initiatives with the goal of becoming a competitive producer by 2030 and consolidate several hydrogen hubs by 2035. Additionally, the EU will invest EUR 2 billion in Brazil to develop green hydrogen projects.

N. America and China[24]
Despite low announced volumes, China has the highest commitments, about 40% of the total announced supply in China is already committed while in North America, the share drops to 20%. The low announced volumes in China could be due to fewer companies announcing their plans or different public support schemes. In North America, more than 70% of the announced volumes is low-carbon hydrogen (blue), mainly driven by the tax credits received for CO_2 capture and storage boosted by the IRA.

04

Case study

Decarbonizing highly polluting industries: green steel[28]

H^2 Green Steel, headquartered in Stockholm, was founded in 2020 and aims to build a **large-scale green steel production facility using a combination of renewable electricity and green hydrogen, thus eliminating almost all the CO_2 emissions from the conventional steelmaking process.** The project consists of a 700 MW capacity alkaline and proton exchange membrane (PEM) electrolyzer, a direct reduced iron (DRI) plant, a steel melt shop to combine the DRI with steel scrap and downstream production lines to produce 2.5 Mt of finished steel products per year with a second-phase capacity expansion already planned.

The business model

Producing steel based on green hydrogen is currently more expensive than producing it via conventional coal-based blast furnace. As a result, the business model relies on **demand from first-mover customers willing to pay a premium.**

Access to cheap, stable renewable electricity throughout the day and the year is the main prerequisite for the H_2 Green Steel project. Building an energy-intensive plant near Sweden's large hydropower resources avoids the need for massive investments from the grid operator.

Going forward, the production costs of conventional polluting methods are expected to rise significantly, negatively affected by the carbon border adjustment mechanism (CBAM) and high EU ETS (emissions trading system)[29] prices, as every ton of steel produced using conventional processes emits c. 2 tons of CO_2.

06

Conclusions

Green hydrogen could represent **10% on the expected mix of renewable energy technologies** facing the emissions reduction required to **reach Net Zero by 2050**, posing a **promising alternative for several hard-to-abate industries** that can use it as an energy vector, including power generation, transport, feedstock and heating.

It is estimated that total **USD 9.4 trillion investments are needed until 2050** for its development. It could reach profitability by 2030 with production increasing significantly from then onwards.

The main existing **challenges are electrolyzers technology, efficiency and infrastructure**. A **specific policy** development **could be a catalyst** for this sector.

Green hydrogen can be **transported and stored.** It could be a **game changer for countries with high renewable energy resources**. Additionally, it can play an important role in ensuring **countries´ energy independence,** eliminating reliance on conventional fuel producers and can be key in developing countries and isolated areas.

Sources:

1 Acciona

2 Business Norway

3 IMF

4 United nations industrial development organization

5 World Economic forum

6 Iberdrola

7 UNIDO

8 Airbus

9 Columbia

10 US Department of energy

11 The guardian

12 The Economist impact

13 Spectra

14 Hydrogen refuelling solutions

15 IRENA

16 World bank

17 Deloitte

18 The economist impact

19 S&P Global

20 100% RE

21 Linkedin articles

22 IRENA

23 BloombergNEF

24 Hydrogen council and McKinsey

25 European commission

26 Enagas

27 IRENA

28 OECD

29 European commission

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