



Report

Roland Berger

PARIS / FRANCE



How to capture value in the emerging hydrogen market

SUCCESSFUL GREEN H₂
BUSINESS MODELS

A window of opportunity

Leveraging green hydrogen market potential



Green hydrogen – hydrogen produced using renewable energy (REN) – is the key to decarbonizing sectors that cannot be electrified. This includes major industries such as petrochemicals, iron and steel, or fertilizers. The demand of these sectors and other potential offtakers gives green hydrogen enormous potential: the value pool arising from growth in the production of green hydrogen through 2030 is expected to be in the region of EUR 500 billion.

As with any new market, the value chain for green hydrogen projects is not yet fully structured. The various market players still have to carve out clear roles for themselves. Many are currently playing it safe, operating via consortia so as to share the risks. By the end of the decade, however, as the market matures and players gain more knowledge of the project risks and profit pools involved, we expect to see a convergence toward more traditional energy infrastructure project roles. In the majority of cases, participants will adopt either a pure player role or a technology provider role, or choose a full solution provider model in which all roles are covered by a single group or conglomerate.

For companies already active in the hydrogen market or considering entering it from adjacent and other related sectors, choosing the right role and business model is critical. Players must take several factors into consideration, such as what their existing skills are, which archetype of hydrogen project (mobility vs. industry vs. utility scale), what geographical region they plan to operate in and how good they are at forming partnerships. No one-size-fits-all solution exists; rather, different segments of the hydrogen market will require different business models.

Companies currently have a window of opportunity to shape the industry and build a leading role for themselves. This window will likely close in the second half of the decade. Accordingly, players should act now to ensure their position in the market and lay claim to a major share of the potential profits.

CONTENTS

| | | |
|--|---|----|
| 1/ STRONG MARKET MOMENTUM | — | 4 |
| Europe is in the lead | | |
| 2/ A POORLY STRUCTURED VALUE CHAIN | — | 8 |
| First business models are emerging | | |
| 3/ WHO STANDS TO BENEFIT? | — | 9 |
| Project developers, solution providers and technology providers | | |
| 4/ CAPTURING VALUE | — | 12 |
| Choosing the right business model | | |

1/

Strong market momentum

Europe is in the lead

Green hydrogen or "green H₂" – hydrogen produced by using renewable or low-carbon sources of energy to split water into its components via electrolysis – is currently enjoying strong market momentum. Governments around the world have set themselves decarbonization goals and are increasingly striving for energy independence. Many countries have developed national strategies, and Europe in particular has set itself ambitious targets for introducing green hydrogen. Indeed, in the period to 2030 Europe is likely to be the most dynamic region for the technology, with many small-scale and mid-scale projects clustered in "hydrogen valleys" and utility-scale projects located in areas with access to abundant solar or wind power. → A

The market for green hydrogen is likely to develop in two phases. Initially, it will grow on the back of incentives offered by government. Beyond 2030, the market will likely become self-sustaining, with Europe both an importer of green hydrogen and a major demand and production center.

The unique value of green hydrogen is that it can be used to decarbonize sectors that cannot be electrified, such as petrochemicals, iron and steel, or fertilizers. For this reason, global green hydrogen production is expected to grow massively in the coming years, the value pool arising from this ramp-up amounting to around EUR 500 billion by 2030.

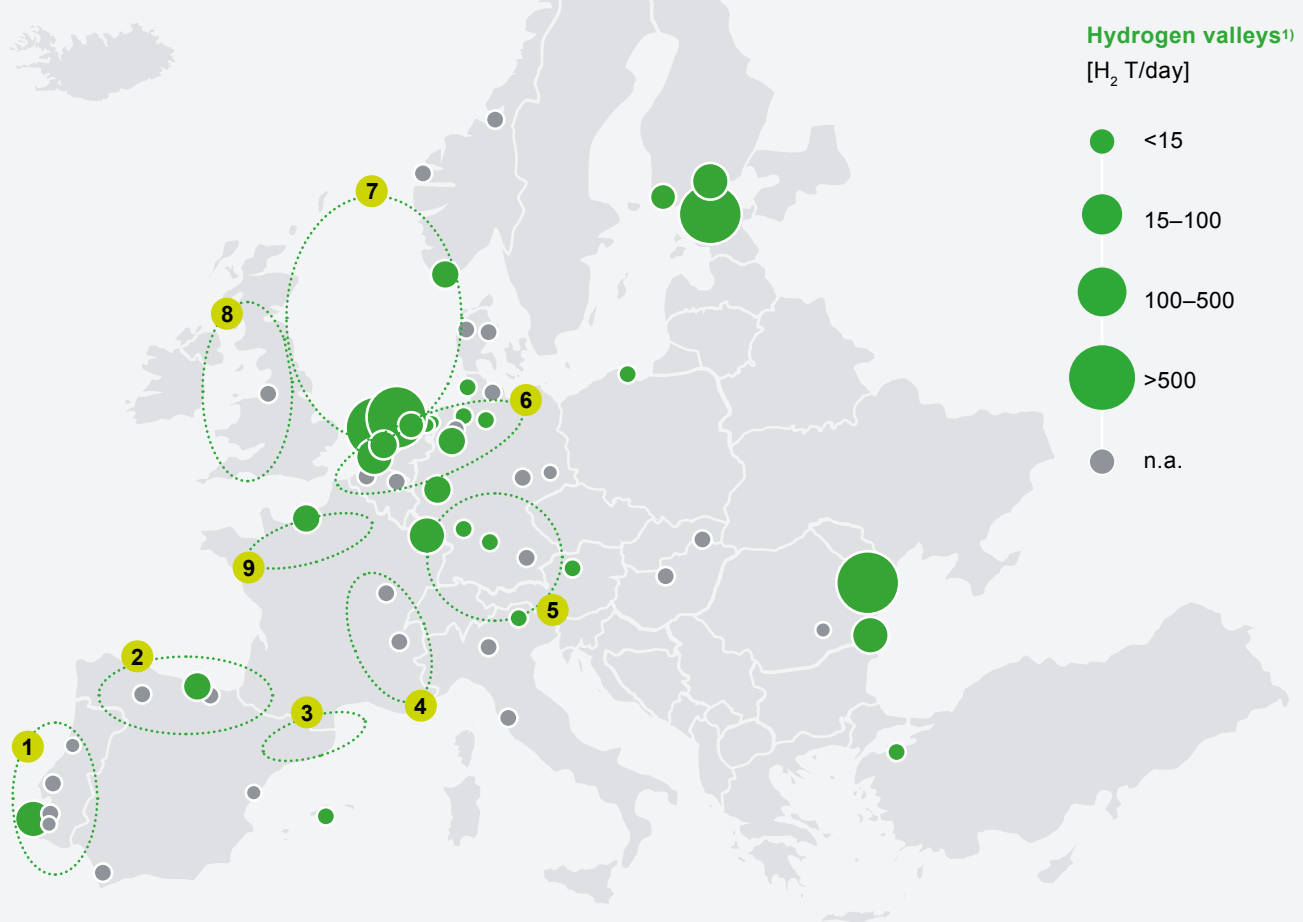
The market for green hydrogen is likely to develop in two phases. Initially, in the five years between 2025 and 2030, the market will grow on the back of incentives offered by

governments, especially in the European Union, the United States and Asia, combined with declining costs. The market for green hydrogen began with small-scale technological demonstration projects, with less than 1 MW electrolyzers. Now, it is developing in the direction of multiple, large-scale green hydrogen production, with double-digit or even triple-digit MW electrolyzers.

Beyond 2030, the market will likely become self-sustaining. It will be driven by growing hydrogen supply routes between countries where the cost of producing hydrogen is low and demand areas, with Europe becoming both an importer of green hydrogen and a major demand and production center in global hydrogen supply chains. The main users of green hydrogen are expected to be

A / Centers of production

Location of major green hydrogen projects in Europe, 2030



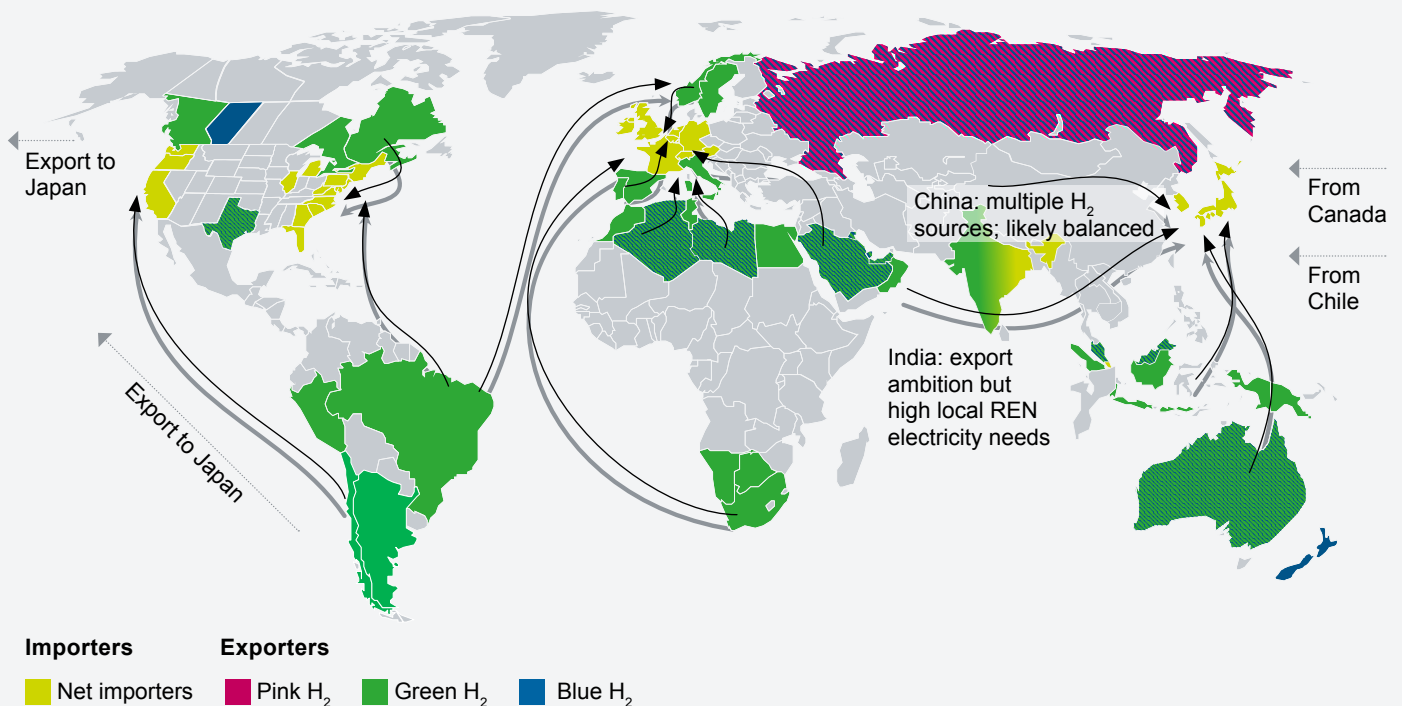
- 1 **South of Portugal** e.g. Sines industrial hub
- 2 **Bay of Biscay** e.g. HyDeal, Basque Hydrogen Corridor, Green Crane
- 3 **Southwest of France** e.g. H2V Bassin de Lacq, Qair Port-la-Nouvelle
- 4 **Rhone Valley** e.g. Zero Emission Valley, Regional Hydrogen Roadmap, Masshylvia
- 5 **South of Germany** e.g. HyBayern, H2 Rivers
- 6 **North of Germany** e.g. HyWays for Future, NDRL, eFarm
- 7 **North Sea rim** e.g. Europe's Hydrogen Hub, HEAVENN (Netherlands), HyNet North West (UK), HyBalance (Denmark)
- 8 **United Kingdom** e.g. BIG HIT
- 9 **Normandy (France)** e.g. Normand'Hy

Around 10 key H₂ ecosystems in Europe, encompassing hydrogen valleys¹⁾ and other H₂ projects

¹⁾ Clean Hydrogen Partnership and Mission Innovation, recollection of 79 most advanced an integrated H2 projects around the globe, including 59 in Europe
 Source: Hydrogen Valleys H2V, Roland Berger

B / International trade routes

Expected hydrogen flows after 2030



Source: IEA, European Commission, EEA, ACEA, Colliers, Savills, desk research, Roland Berger

oil and gas companies (for their refining processes), chemicals companies (for use as feedstock), steel companies (for reducing iron) and producers of synthetic fuels, such as ammonia for shipping and eSAF for aviation. → B

According to our understanding of the market, green hydrogen projects will fall into three groups or project archetypes. The first are **utility-scale, export-oriented mega-projects** (1 GW to multi-GW, onshore or offshore). These are regional or international projects producing low-cost green hydrogen, NH₃, MeOH, and so on, for export. Typically, they will be located next to sources of renewable energy. Projects will mainly be led by private developers or the state.

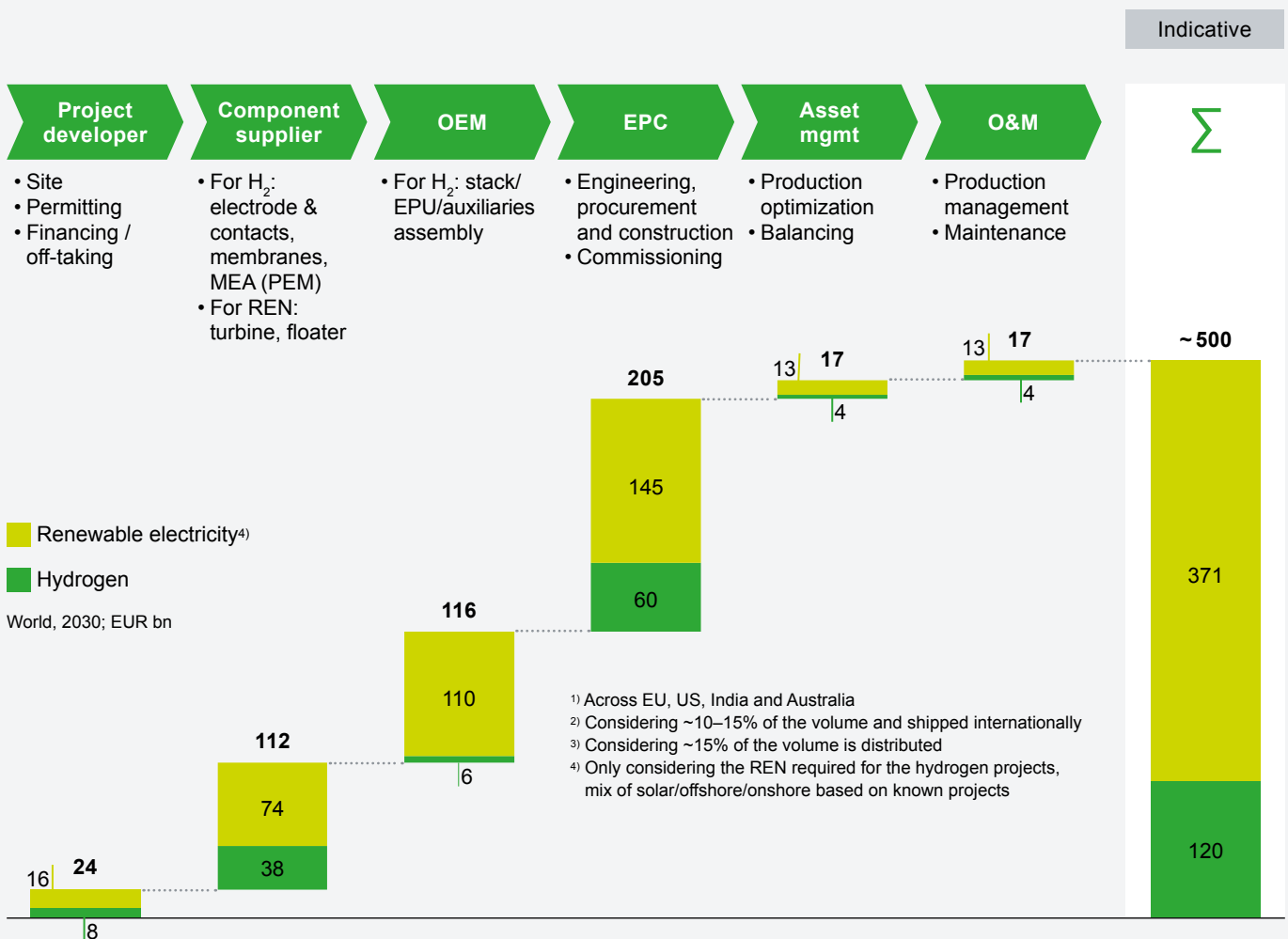
The second type of green hydrogen project will be **mid-scale industrial projects** (10 MW to 1 GW), in which hydrogen is produced close to where demand for it exists, that is, in the vicinity of large industrial consumers, and is seamlessly integrated into their production processes. Projects on this scale require a good supply of renewable electricity, available whenever the need for it arises. Projects will mainly be led by off-takers (that is, entities that buy a contractually agreed portion of the green hydrogen produced), sometimes in partnership with energy companies.

Third, we have **small-scale projects focused on mobility and decentralized heat and power systems (< 50MW)**. These systems will mainly replace diesel generators or remote hydrogen refueling stations (HRS). Like mid-scale industrial projects, this type of project will require a good supply of renewable electricity, available whenever it is needed.

The business opportunities across the whole value chain for green hydrogen production projects – from project development to operation and maintenance (O&M) – are huge: the total value added pool for the hydrogen part of projects is expected to be as high as EUR 120 billion by 2030, and the value added pool for the renewables part (that is, the electricity used to produce the green hydrogen) up to EUR 371 billion. Europe will account for 40%, whereas the rest of the world account for the remaining 60%. → C

C / Where does the value lie?

Global green hydrogen value added pool^{1) 2) 3) 4)} along the value chain, 2030



Source: Roland Berger model

2/

A poorly structured value chain

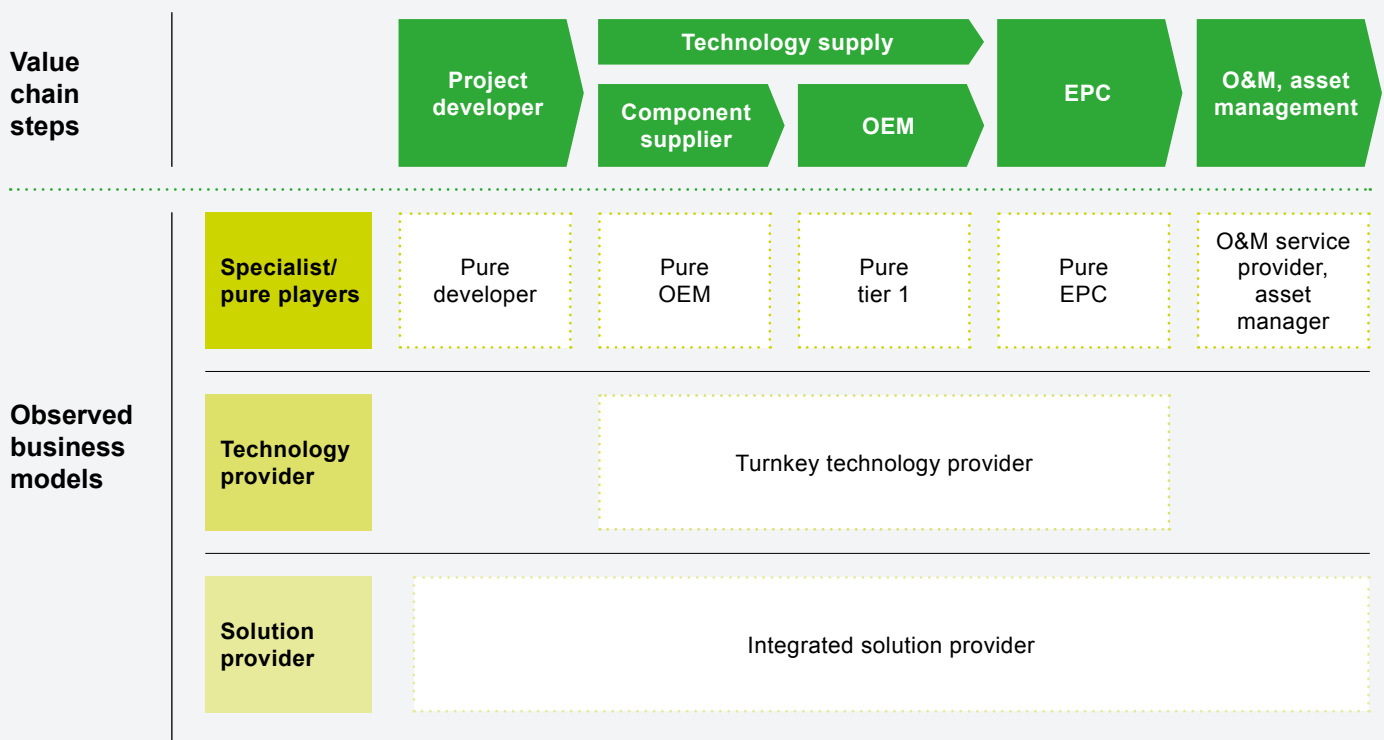
First business models are emerging

Green hydrogen projects require the involvement of various market players. Each of these players traditionally fulfills one or several roles, namely project development, research and development (R&D), financing, original equipment manufacturing, engineering procurement and construction (EPC), operation and maintenance (O&M), and asset management. In addition, the producers of the renewable energy used to feed the electrolyzer, and the offtakers of the hydrogen, also often play a key role in green hydrogen projects. Access to renewable energy is critical, as it is responsible for 70%–80% of the production costs. At the same time, the producers of the green hydrogen need to secure their offtakers in advance, as otherwise the investments are too risky and cannot be financed.

Given the enormous value-added pool for green hydrogen, one might expect the roles of different players in the industry to be well established already. But, in fact, green hydrogen is still in search of a winning business model. Standard structures are not yet in place and various project setups currently coexist.

D / Who's doing what?

Current business models in green hydrogen production projects



Source: Roland Berger

Thus, players often participate in green hydrogen projects as part of a consortium, to gain experience while sharing the risk with others. At present, they tend to act in line with their historical role – for example, OEMs manufacture the necessary equipment for green hydrogen production projects, EPC companies provide the required engineering, procurement and construction services for the project, and so on. However, as the market matures and companies understand the projects' risks and profit pools better, we believe that players will adapt their business models so as to capture more value. → D

3/

Who stands to benefit?

Project developers, solution providers and technology providers

Over time, business models for green hydrogen projects are likely to evolve. We expect to see them converging in the direction of the traditional roles observed in energy infrastructure projects. This is because green hydrogen projects require large capital investment and involve a high level of risk. As the underlying structure and client preferences are similar to those of the overall energy market, the same dynamic is likely to emerge in green hydrogen projects as is already seen elsewhere.

Three models currently compete. First, we see players such as developers, OEMs or EPC companies acting as pure players. This model is widespread and often espoused by Europe-based companies. Second, we find players taking the role of technology providers, combining both technology (OEM) and installation (EPC) roles. This model occurs in all regions, and is particularly favored by US players. Third, we see **solution providers**, with all roles covered by a group or a conglomerate. This model is typical of Asian players.

Going forward, it is not self-evident where the value will lie and which business model or positioning will be the most profitable. Here, it is worthwhile looking at other industries. In solar energy production, for example, Europe-based players specializing in the manufacture of photovoltaic cells were all ultimately outpaced by Asian players; in this case, more value was to be found in the role of developer than in the role of OEM or solution provider. Similarly, in the production of electrolyzers, we currently observe a strong move upstream by the main OEMs, toward the production of electrodes; this has become a core capability that players must master in order to be able to guarantee the performance and lifetime of the electrolyzer.

The examples above show how difficult it is to anticipate where the true value will lie in the future. Will it be in integration and project development across the whole value chain, as in the case of photovoltaic cells? Or could it lie in being a small but crucial player with a technological advantage, as in the case of electrolyzers?

E / Scale and location

Four project types

| | | Pure player (specialist role) | Technology provider (partial integration) | Solution provider (full integration) |
|----------------------|---------------------|--|---|---|
| Mid-scale industrial | Onsite | Not relevant (offtaker wants hydrogen, and not to be involved in the technology) | Highly relevant | Relevance depends on the industry (some industrial players/offtakers are likely to develop the hydrogen project themselves, others won't) |
| | Shared ¹ | Not relevant (offtaker wants hydrogen, and not to be involved in the technology) | Moderate relevance – a developer is needed to federate the various offtakers | Highly relevant |
| Utility-scale | Onshore | Relevant | Relevant | Usually not relevant – size and risk level may prevent single players from getting involved |
| | Offshore | Highly relevant, within a consortium, each player being specialized in offshore work (e.g. PEM techno, marine EPC) | Relevant, especially in order to avoid having additional risks linked to an immature integration of EPC/OEM | Usually not relevant – size and risk level may prevent single players from getting involved |

¹ Consumers in one region using the same producer. This model is interesting for mid-sized companies that want to share the cost burden. But is also advantageous for producers, as it reduces their client dependency and thus their investment risk.

Source: Roland Berger

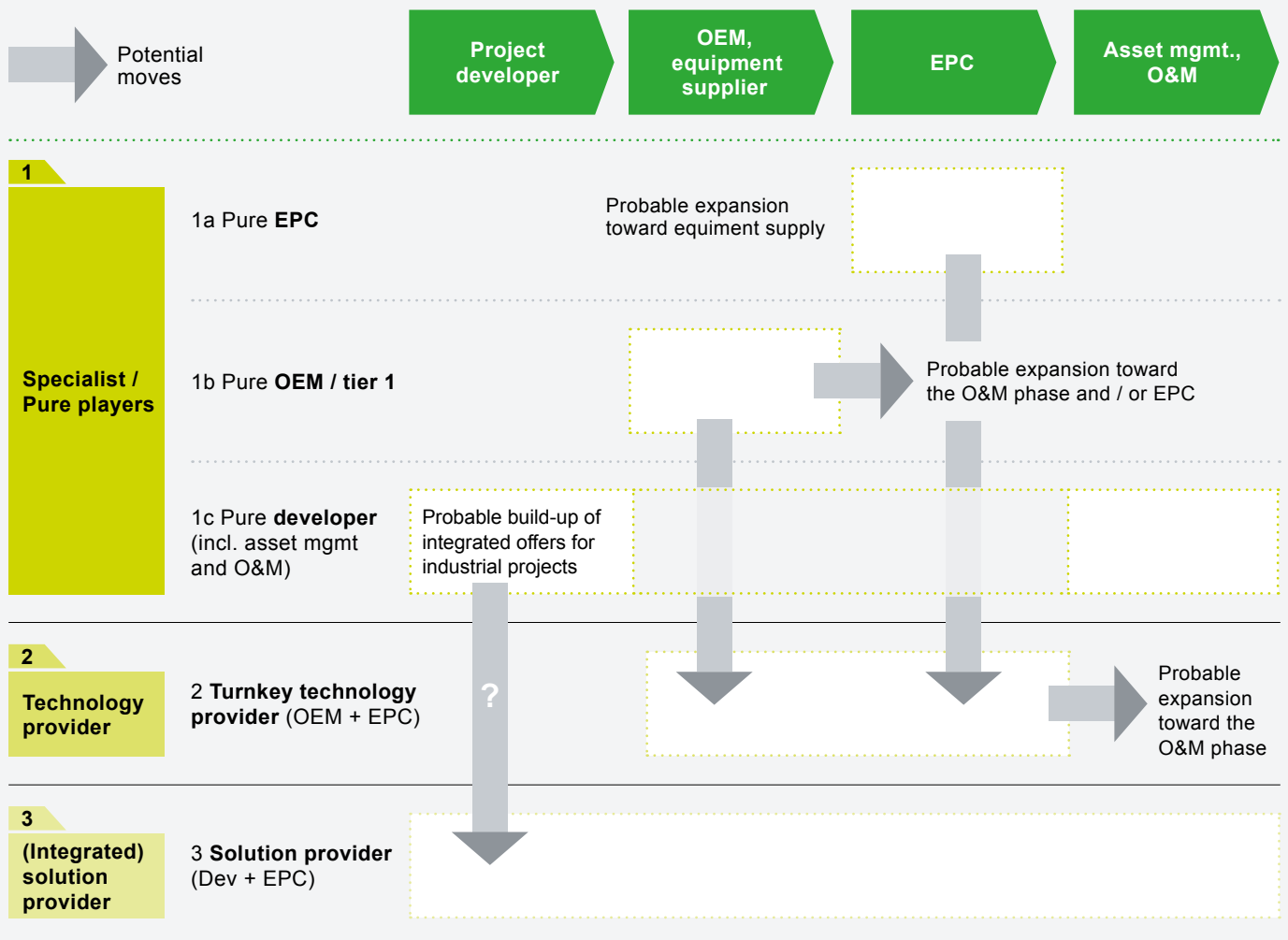
Green hydrogen projects are complex. The hydrogen production system needs to reconcile constraints on both its inputs (intermittent supply of renewable energy, quality of water, access to water, space constraints) and outputs (flows and volumes of hydrogen depend on offtakers). Many factors are therefore critical for the business model: access to renewable energy, willingness of offtakers to be involved in the hydrogen/gas technology, expected consolidation and competition in electrolyzer manufacturing, the pace of innovation and cost decline in hydrogen transportation and storage, and the type of industrial process. Based on our analysis, we identify four different types – or "archetypes" – of green hydrogen production projects. Each type requires a different business model. The projects types are as follows: mid-scale industrial projects (< 200 MW electrolyzer) with "captive" onsite hydrogen production, mid-scale industrial projects (< 200 MW electrolyzer) with shared hydrogen production, onshore utility-scale projects (> 200 MW electrolyzer), and offshore utility-scale projects (> 200 MW electrolyzer). → E

The roles played by different players in the green hydrogen world are set to change. As the technology matures, subsidies decline and the market becomes more firmly established, the value of pure OEM, i.e. assembly of stacks, will decrease, as stack will become increasingly commoditized. But integration with the renewable production, and within industrial sites, will become critical. Hence the ability to provide the complete equipment + EPC part on a turnkey basis within an industrial site will gain value – as we describe on the next page. → F

The role of **developers** will be key, in that they are the ones who will identify the right locations for hydrogen production, close to sufficient sources of renewable energy. They will also play a vital role as aggregators of the needs and volumes of various hydrogen offtakers located nearby. At the same time, developers of renewable power plants and energy players will have a clear competitive edge, as they stand at the origins of the hydrogen production system. Most likely, they will either develop renewable power plants wholly or partially dedicated to hydrogen production or they will provide the power purchasing agreements (or PPAs, a specific type of offtaking contract) for hydrogen projects.

Solution providers – players with integrated business models – will also benefit as the preferred partners for shared production between industrial sites, or for single-site projects with industry players who do not want to be involved in the hydrogen value chain but simply buy it by the ton, like any other raw material.

F / As the H2 market & techno. mature and players have a better knowledge of projects risks and profit pools, players are expected to adapt their business model along the value chain to capture more value



Source: Roland Berger

Finally, the role of **technology providers** will expand, particularly in both industrial and utility-scale projects, where integrating all the different technological pieces will be important to reduce the risk associated with the interface between OEMs and EPC companies. Technology providers will also be a suitable choice for multi-site industrial projects where the offtaker is the developer and asset manager, for example petrochemical plants and fertilizer producers.

At the same time, offtakers will be able to choose between having a hydrogen production facility on site or using mutualized equipment. Most offtakers, we believe, will not want to be involved in the hydrogen and gas technology and will therefore favor integrated solutions.

4/

Capturing value

Choosing the right business model

How can players guarantee themselves a share of the EUR 500 billion green hydrogen added value pool that is expected to emerge by 2030? We believe that firms currently have a window of opportunity to shape the industry structure. This window should remain open until the end of the decade, but taking the lead now will allow players to secure a major role for themselves in the industry and a sizeable share of the future profit pool.

Companies that are already active in the green hydrogen industry or thinking of entering it need to ensure that they choose the right business model. By this, we mean the business model that is right for them: There is no one-size-fits-all solution. When choosing a business model, we recommend that companies ask themselves the following critical questions:

- What capabilities do we already have that are relevant for the hydrogen supply chain, gas supply chain or project development in general? For example, know-how in renewables or gas, experience delivering large-scale projects, knowledge of specific offtaker processes
- What pilot projects in green hydrogen have we carried out and how successful were they?
- Which project archetype and which geographical areas do we want to target? What resources do we have in these areas, and how well do we understand the markets?
- What is our dominant business model at present? For example, are we asset-light or asset-heavy? Are we a service provider?
- How willing and able are we to form partnerships with players that are positioned differently, so we can together cover several links of the value chain?

Answering these questions will help you identify which business model fits your situation best – and enable you to profit from a market that is set to grow massively over the coming decade and beyond.

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Trying to decide which business model is right for your business?

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