A Five-Step Plan towards Growing the Role of Hydrogen in Belgium's Economy

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A Five-Step Plan towards Growing the Role of Hydrogen in Belgium's Economy

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INTRODUCTION

Hydrogen is emerging as a key lever for achieving the European Union's energy goals, including a reduction in greenhouse gas emissions by at least 55% by 2030, compared with 1990 levels, and reaching net zero by 2050. Initiatives, such as the Renewable Energy Directive (III) and Fit for 55, promote the development of a Hydrogen (H2) economy in Europe. Most recently, the European Commission's REPowerEU plan, announced with the aim of rapidly reducing Europe's dependence on Russian fossil fuels and accelerating the transition to green energy, set a target of 670 terawatt-hours (TWh) per annum (p.a.) of green H2 – from domestic production and imports – by 2030 for use in hard-to-decarbonize industries and transport sectors.

The Belgian government launched its Federal Hydrogen Strategy in 2021 to support the European Commission's goals and to prepare Belgium for the technological and economic challenges and opportunities arising from greater adoption of H2. The strategy is built around four pillars: Belgium as Europe's import hub for green H2 molecules, Belgian leadership in H2 technologies, the creation of a robust H2 market, and greater cooperation.

Given H2's potential for improving both carbon abatement within Europe and the region's energy security in the wake of the Ukraine war, the long lead times needed to develop the required infrastructure and ecosystems, and competition from other countries preparing similar moves (with over 30 countries globally having released official H2 strategies), the Belgian government is aiming to move ahead, concretize its vision for the role H2 can play in Belgium's economy, and put in place the building blocks for success.

This report is the result of a collaboration with representatives of the Cabinet of the Prime Minister, the Cabinet of the Federal Minister of Energy, and the State Secretary of Economic Recovery and Strategic Investments, intended to assess the country's current position and identify the next steps for Belgium to achieve its H2 ambitions.[1] In the process, we exchanged ideas with about 30 organizations and about 50 individuals from the private sector, regulatory bodies, public services, academia, research institutes, and selected sectoral federations. The report, which summarizes our analysis and conclusions,[2] is split into four main sections:

Sizing the H2 opportunity: Belgium will need to increase the supply of H2 molecules and H2 derivatives by 7-10 times by 2050 – and decarbonize these supplies – to meet the growth in domestic demand. As low-carbon H2 will be scarce and costly for at least the next decade, governments and industry need to be strategic in where to use it, prioritizing its use in areas where it can have a significant decarbonization impact and where other (more efficient) decarbonization paths do not exist or are not available. In the meantime, Belgium can expand its role as a natural gas transit hub to supply H2 molecules and/or H2 derivatives to adjacent markets such as Germany.

Concretizing the sourcing strategy: An effective strategy will need to take account of the multiple available technologies for producing H2, production locations, and transport pathways that include pipelines and shipping. The potential to produce low-carbon H2 from renewable energy through electrolysis in Northwest Europe is limited compared to total expected demand in the region. Consequently, Belgium must look towards other regions that are likely to have surplus renewable generation and H2. Multiple sourcing options exist, however, and companies and policy makers will need to choose carefully, avoiding single-party risk through diversified and carefully selected sourcing.

Developing a long-term vision for Belgium's industrial H2 policy: Because of the challenges of accessing and then importing competitively priced, decarbonized H2, Belgium should focus on executing an industrial policy bringing together the demand, supply and infrastructure opportunities and challenges, to create a view on the H2 molecules and H2 derivatives value chains end to end.

A five-step action plan for achieving the vision: Belgium's existing position as a natural gas transit hub with developed import and transit infrastructure, its geographical location close to major H2 demand centers, and its well-established technology base containing both OEMs and research institutions mean that the country starts from a position of strength. Nevertheless, coordinated action from the public and private sectors will be required to take a lead role in the H2 space. Our analysis suggests that policy makers and companies will need to act in five areas: unlock demand in priority applications; secure sufficient, stable, and competitive supplies; develop infrastructure; create a market and regulatory framework; and introduce effective enablers.

Belgium has an opportunity to become a European leader in H2 and to realize significant benefits. The growth in H2 usage would allow Belgium, and the wider European community via Belgium's enhanced position as a H2 hub, to decrease dependence on Russian oil and natural gas and enable governments and industries to decarbonize hard-to-abate areas of their economies. A strong and effective H2 strategy would also enable policy makers to protect Belgium's industrial base and unlock additional growth by attracting fresh investment and growing new technology leaders. In the following pages, we set out how this could be achieved.

1 When referring to H2 in this text, we refer to both H2 molecules and H2 derivatives unless specified otherwise.
2 BCG's support is provided on a pro bono basis.

SIZING THE H2 OPPORTUNITY

Hydrogen has been used in industrial processes for decades. Between 2000 and 2020, annual H2 consumption globally grew by a compound annual growth rate (CAGR) of 2%, and totals about 2,500 TWh p.a. today. Ammonia production accounts for about 45% of demand; refining for 25% of demand; methanol production for 15% of demand; with a large number of feedstock applications in other chemical processes accounting for the remaining 15%.

We expect H2 demand to grow significantly, due to the emergence of new applications. Low-carbon H2 molecules and low-carbon H2 derivatives such as green ammonia, methanol, e-kerosene, and synthetic methane are emerging as decarbonization levers for a wide range of applications in industry, transportation, power generation, and buildings. These include, for example, the use of low-carbon H2 in steel production, industrial heating for processes that require high temperatures, as well as fuel for (long-distance) shipping and aviation.

However, low-carbon H2 will be costly and in short supply for at least the next decade. Consequently, governments and industries need to take a strategic approach and prioritize its use in areas where it has the potential to have a significant decarbonization impact (Exhibit 1).

Exhibit 1: Hydrogen is an important decarbonization lever, with especially priority applications in industry and transport

Role of H2 or its derivatives	Industry	Transport	Power	Buildings
Important and necessary lever for decarbonization	*Main use today*: Feedstock in (petro-) chemicals and refining • Reducing agent in steelmaking	• Bunkering fuel for ocean shipping • Fuel for international aviation		
Possibly interesting lever for decarbonization	• Fuel for industrial heating (high-to-mid temperatures)	• Fuel for heavy-duty vehicles • Non-electrified (freight) rail vehicles • Short-distance shipping & aviation	• Long-term / seasonal electricity storage • Firm and back-up power generation	• Heating where HP / DH is challenging • Small back-up generators
Sub-optimal path for decarbonization	• Fuel for industrial heating (low-to-mid temperatures)	• Electrified and passenger rail • Light-duty vehicles and passenger cars • 2- and 3-wheelers		• Heating where HP / DH is feasible
Policy implications	*Prioritize H2's role as feedstock and for high temperature industrial heating*	*Assess case by case, fuel for ocean shipping and international aviation first*	*Assess different options going forward (incl. H2 turbines, ammonia)*	*Non-priority, be very selective in where to use H2 vs. alternatives*

Notes: HP = Heat pump; DH = District heating

Meeting domestic demand

Low-carbon H2 is a key lever for achieving decarbonization ambitions in the following four areas:

- Industrial applications including steel, chemicals and petrochemicals manufacturing, fossil fuels refining and processes requiring intense heat. The use of direct-reduced iron and electric arc furnaces (DRI-EAFs) is set to become the leading solution for decarbonizing steel making in Europe by 2050. DRI production facilities run on natural gas but will eventually use low-carbon H2. In Belgium, ArcelorMittal Ghent has already announced it aims to convert one of its two blast furnaces to a DRI-EAF by 2030. In chemicals, petrochemicals and refining value chains, companies are starting to substitute carbon-intensive H2 in feedstocks, made from fossil fuels, for lower-carbon H2 alternatives. They have also been observed to start producing low-carbon H2 derivatives, such as low-carbon methanol, ammonia, kerosene, and synthetic methane, with pilot projects for producing green methanol having been established in Belgium. Finally, low-carbon H2 is expected to be the main means for decarbonizing industrial processes requiring temperatures in excess of 500°C, but to play a minor role in industrial processes requiring lower temperatures. Industrial heating could represent 10-20 TWh of H2 demand by 2050 in Belgium, unless major breakthroughs in electrification for high-temperature processes take place.

- Low-carbon fuels for shipping, aviation, and heavy-duty transport. According to our forecasts, demand for low-carbon H2 for marine bunker and fuel for international aviation will reach at least 40 TWh p.a. nationally by 2050, potentially up to 75 TWh p.a. by 2050. Long-haul shipping is likely to be an especially important consumer of green ammonia and/or methanol in the future, representing the largest share of this demand. Road transportation, conversely, will primarily use electrification to reduce its emissions. However, selected heavy-duty transport use cases could still account for a small share of low-carbon H2 demand, but is not expected to be a main demand driver for H2 in Belgium.

- Reducing CO2 emissions in power generation. Whether in the form of low-carbon H2 molecules or H2 derivatives such as green ammonia, gas turbine OEMs and power generators have expressed the ambition to use low-carbon H2 with existing gas turbines (with low-carbon H2 typically representing a minor share of the feedstock) or new turbines over varying time horizons. As indicated in Exhibit 1, power generation is a less certain source of future low-carbon H2 demand vs. some of the applications mentioned in industry or transportation, but firm generation capacity will still be needed in some shape or form in 2050, which potentially could be H2-powered turbines, next to other forms of low-carbon dispatchable generators.

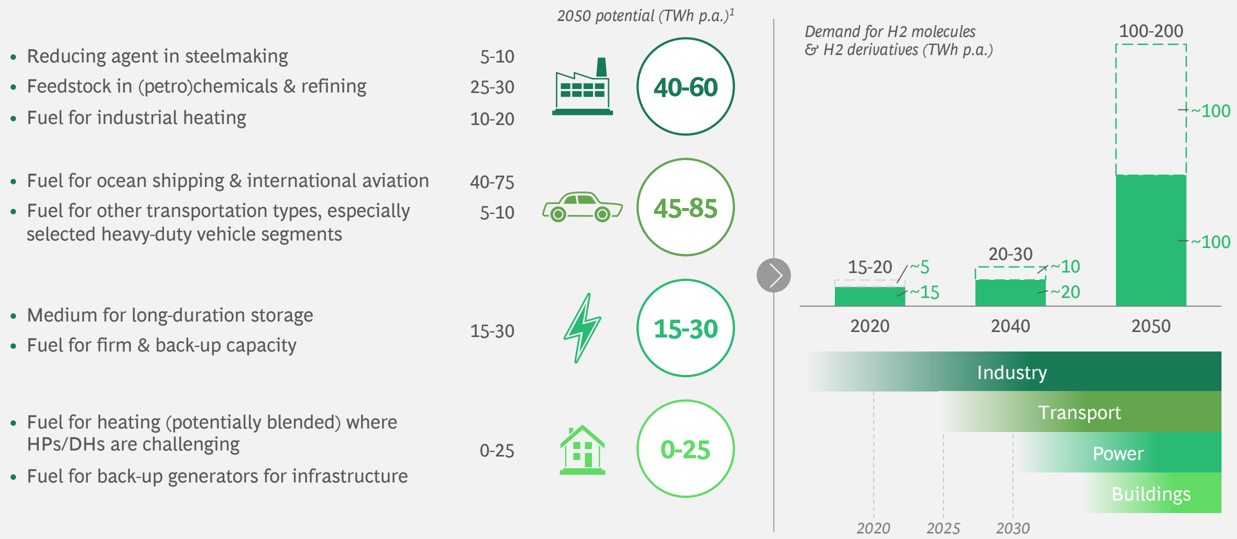
In addition, for example Germany recently announced its largest renewable energy expansion plan yet, with a clear role for H2-based power generation already pre-2030. The new renewable energy act contains auctions starting in 2023 with 400-1,000 MW p.a. H2-based electricity storage and power generation capacity.

- Lowering the environmental impact of heating. Despite an expected reduction in Belgium's absolute heating demand due to home renovations and improved insulation, and a large expected share for heat pumps in most areas, the remaining demand can be further decarbonized using either district heating, biofuels, or low-carbon H2. For the latter, boilers and other domestic heating equipment would need to be modified so that they can run on H2. In Belgium, several distribution system operators, for example Sibelga in Brussels, are looking into the need and requirements for this to materialize, but general consensus is that this should be treated as option-of-last-resort in case other, easier and/or more efficient, heating solutions are too challenging to implement.

Combining all end uses, the H2 challenge facing Belgian players over the next few decades is to both increase and decarbonize supply. We estimate that the supply of low-carbon H2 will need to increase by 7-10 times from today by 2050 to match the growth in domestic demand. According to our estimates, annual demand by mid-century will amount to between 100 and 200 TWh p.a. – up from 20-30 TWh p.a. in 2030 – with industry, ocean shipping, and international aviation representing the lion’s share at 70-80% of total demand in 2050 (see Exhibit 2).

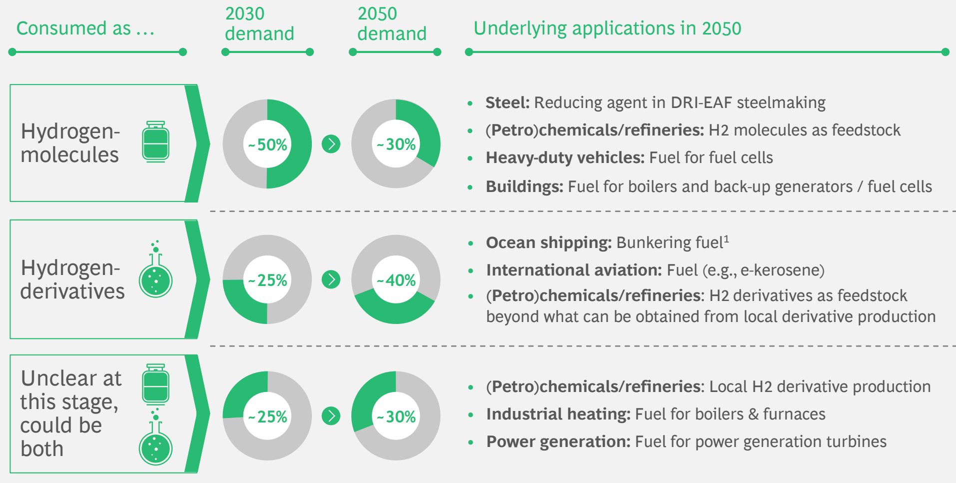
As mentioned, not all of this demand for low-carbon H2 will be demand for low-carbon H2 molecules themselves. Low-carbon H2 derivatives including green ammonia, sustainable methanol, and synthetic e-fuels could also play an important part (see Exhibit 3). We believe that derivatives will make up at least 40%, and potentially up to 70%, of demand by 2050. The potential role of derivatives has important implications for policy makers and companies as they consider future infrastructure requirements and the optimal pathways for importing H2.

Exhibit 2: Belgian's domestic hydrogen challenge is to increase supplies by 7-10 times by 2050, and decarbonize it



1. Rounded in blocks of 5TWh, assuming a constant industrial footprint vs. today; Source: BCG analysis

Exhibit 3: This is not all demand for H2 molecules, but part is demand for H2 derivatives



1. Long-term, the majority of H2-based bunkering fuels are expected to be H2 derivatives vs. H2 molecules; Source: BCG analysis

H2: Gas obtained through steam reforming of fossil fuels or electrolysis of water, can be transported in gaseous form in pipelines or liquified for shipping

Ammonia: Gas based on hydrogen and nitrogen, mostly used for fertilizer production and industrial applications, can be converted back to hydrogen

Methanol: Liquid obtained by the synthesis of hydrogen and CO2, mostly used to produce other chemicals

Synthetic fuels (synfuels): Liquid fuels obtained via synthesis of hydrogen and CO2, with substitution / blending applications in, e.g., aviation (e-kerosene)

10

Belgium's potential role as an H2 transit hub

Beyond supplying its own domestic market, Belgium is well positioned to extend its role as a transit hub from natural gas to H2, especially with regards to the German market. In 2019, about twice the amount of natural gas was imported in Belgium compared to what it needs for its domestic requirements, with the surplus directly being exported again, making it a genuine transit country for natural gas. It can build on its favorable geographical location, strong logistics and transport infrastructure, and neutral market position to become a thriving hub for H2 too.

- Favorable geographical location: Belgium is ideally located in Northwest Europe close to major H2 demand centers, particularly in Germany, and with access to the North Sea. Natural gas pipelines already connect the port of Zeebrugge and West Germany, a route which in the near future is expected to be strengthened and made capable of carrying H2. In addition, the Antwerp region contains Europe's biggest cluster of chemical companies and has strong commercial ties with West Germany.
- Strong logistics hub: The country boasts globally important ports that work closely together, as evidenced by the recent merger between Zeebrugge and Antwerp, the second-largest port in Europe. The liquified natural gas (LNG) terminal at Zeebrugge has the potential to expand in size, including adding a green ammonia terminal, and to repurpose existing equipment in preparation for H2 derivatives. Meanwhile, Antwerp already has an ammonia facility, with Fluxys recently having announced to look into further boosting capacity by adding an additional terminal. The same holds for existing methanol import capacity.
- Extensive gas infrastructure: Belgium is already the natural gas crossroads of Europe, with an extensive gas pipeline network and over 20 cross-border connections. In addition, with some 600 kilometers of H2 pipes already built, the country has the densest H2 network in the world to date.
- No competition from green imports: In contrast to its neighbors, Belgium has a limited appetite for producing green H2 locally using electrolysis at scale, in order to save scarce green electrons (from solar and wind generation) for the domestic power sector. This means it can be both a neutral and reliable import gateway for Northwest European companies and consumers outside Belgium over the long term.

The need for Belgium to act as a European H2 transit hub is evidenced by Germany's long-term H2 requirement. German demand for H2 today equals about 55 TWh p.a.. While different forecasts exist, a joint study by BCG and Bundesverband der Deutschen Industrie (Germany's Federation of Industries or BDI), "Klimapfade 2.0", estimates that Germany's annual H2 demand will reach about 100 TWh p.a. in 2030, with about 45% of demand for H2 molecules and 55% for H2 derivatives. By 2045, demand could be as high as 550 TWh p.a., with a similar split across H2 molecules and H2 derivatives.

Rising H2 demand is likely to emerge in Western Germany first, given that Nord Rhein Westfalen and Rhineland-Palatinate are largely industrial regions. We expect these two areas to face a supply gap that will require H2 imports from outside Germany. Since both regions border Belgium, the country is well-positioned to fill the gap.

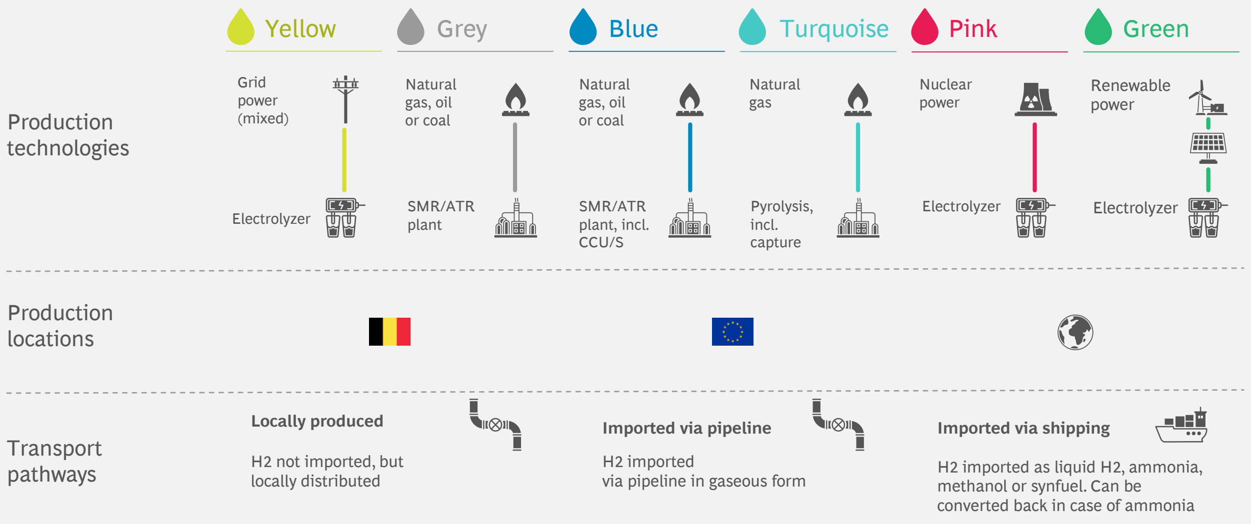
Nevertheless, Belgian companies and policy makers cannot afford to be complacent and lose the momentum. Over the next decade, West Germany can meet a limited volume of demand with low-carbon H2 produced domestically. But the bulk of supply will come through global shipping routes, through imports of H2 from offshore wind in Northwest Europe, and H2 imports via the north of Germany, the Netherlands, and Belgium. Pipeline-based supply from North Africa and the Iberia region in the south and from Eastern Europe are not expected to be feasible until after 2030-2040.

Assuming Belgium takes a proportionate share, the country could capture a sizeable West German transit demand of more than 10 TWh p.a. already by 2030. Towards 2050, however, German companies and consumers will have additional supply options to choose from. But by moving rapidly and building the necessary, scalable infrastructure, Belgium can position itself to play a central role in supplying West Germany over the long term.

CONCRETIZING THE SOURCING STRATEGY

To enable Belgium to develop a thriving H2 economy, its H2 sourcing strategy needs to encompass three elements: H2 production technologies, production locations, and transport pathways (Exhibit 4).

Exhibit 4: Hydrogen sourcing strategies need to encompass production technologies, locations, and transport pathways



Note: CCU/S = carbon capture & utilization or storage; SMR = steam methane reformer; ATR = autothermal reformer; Other potential transport paths such as rail & truck and toluene as H2 derivative for shipping are not considered

- Production technologies. Several methods exist to produce H2. They include production technologies that depend on fossil fuels (and produce grey, blue or turquoise H2) and technologies that rely on electricity (and produce green, pink, or yellow H2). CO2 emission levels and technological maturity vary from one to the next. Since Europe's goal is to achieve net-zero emissions, there is a strong regulatory push towards using green H2 in the long term, with other production methods – such as blue – seen as transition technologies by some while they can represent large volumes in the interim. At the same time, debate continues about the role of turquoise and pink production technologies over the long-term. Nevertheless, the European Union's cornerstone energy policies emphasise renewable energy-based (green) H2 production. REPowerEU, for example, aims to decarbonize a large part of 2030 consumption. It sets targets for 75% of energy consumption in industry and 5% in transportation to be met by Renewable Fuels of Non-Biological Origin (RFNBOs) by 2030, an increase from 50% and 2.6% respectively in the EU's Fit-for-55 policy package. While the exact definition of RFNBO is still being finalized, it mainly refers to renewable H2. For Belgium, this would mean that up to 15-20 TWh of H2 demand in 2030 would need to be met by H2 that qualifies for the RFNBO definition.

- Locations. In contrast to H2 production based on fossil fuels, as such Belgium's potential to produce green H2 locally is limited, since physical space to build additional capacity is limited and production of electricity for H2 will compete with electrification efforts. Along with neighbouring countries and regions, such as the Netherlands and Germany, it will need to import green H2 from other production sites across the globe. Next to the Middle East, many of the potential exporting countries are located in the global South, incl. South America, Africa, and Australia. Next to supplying Europe (and other major importers, for example Japan), clean H2 production could bring economic wealth to them as it has to oil and gas producers.
- Pathways. Belgian market players will need to choose from a range of transport pathways and whether to import H2 molecules or H2 derivatives, depending on their specific requirements. A pipeline, for example, is the cheapest option to transport H2 molecules in large volumes to a fixed location yet takes time to construct. It also creates opportunities to repurpose existing natural gas pipelines. Shipping H2 in the form of derivatives, on the other hand, provides flexibility around location and volumes and can relatively rapidly be deployed. However, the process of cracking ammonia to produce H2 molecules again after being shipped, remains costly and rather immature to date. So is the use of a LOHC (Liquid Organic Hydrogen Carrier), such as toluene. Over the longer term, the shipping of H2 molecules directly, through liquefaction and regasification, may become a viable transport pathway, but most experts foresee a future of shipping H2 derivatives, not one where H2 molecules are shipped directly.

Given the many potential sourcing options available, Belgian players need to consider what a good option looks like. Table stakes for good sourcing options include reliability of supply, ability to build the necessary infrastructure, ability to attract investments, and technology readiness. In contrast, potential differentiating factors among sourcing options that meet the table stakes include the emission intensity (quality), available quantity, cost, transport pathway, and appetite to team up with Belgian players.

Finally, as has been underlined by recent geopolitical events, European countries will need to diversify the sourcing of strategic resources, such as decarbonized H2, to lower risk and single-party dependence and to ensure a stable and competitive supply. By limiting the amount that a single source contributes to its total H2 imports, Belgium can help mitigate such risks, although this should rather be considered on the European level.

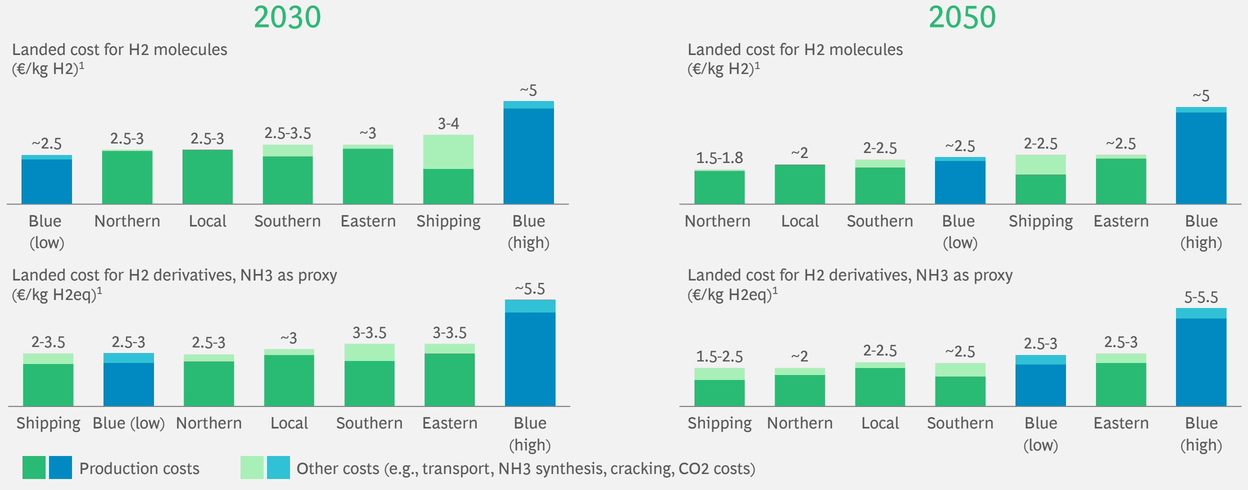
Bearing the above in mind, we believe Belgium's sourcing strategy should be based on achieving three objectives:

1. Secure access to sufficient volumes of H2 molecules and H2 derivatives to meet domestic demand and position Belgium as a transit hub for H2.
2. Ensure this access is as economically competitive as possible, especially compared with other regions with a similar industrial base.
3. Move to the cleanest production route for H2 molecules and H2 derivatives as quickly as possible, without compromising on the first two objectives.

Comparing the costs and availabilities of Belgium's sourcing pathways for H2

We have modelled the expected landed costs in Belgium by 2030 and 2050 for the different decarbonized H2 sourcing routes (molecules and derivatives), summarized in six archetypes, based on the characteristics set out in Appendix (Exhibit 5).

Exhibit 5: Cost estimates for Belgium's hydrogen sourcing pathways



1. Landed cost excl. storage cost & incl. cracking costs where applicable; Note: Given the large uncertainties on the gas price and CO2 cost in the current climate, we display two illustrative scenarios for Blue H2, in order to show the reader the resulting H2 and H2 derivative cost under certain gas price and CO2 cost assumptions. The first, "Blue (low)", assumes a CO2 cost of €50/tCO2 and a natural gas price of €25/MWh. The second, "Blue (high)", assumes a CO2 cost of €150/tCO2 and a natural gas price of €75/MWh.

Due to cost competitiveness and supply availability considerations, the number of potential routes for importing decarbonized H2 molecules will be limited by 2030. Pure economics will favor local production or piped imports of H2 molecules over transporting H2 derivatives by ship and cracking them into H2 molecules, given the extra cracking cost outweighs the benefits from premium renewable locations globally. As we said, however, Belgium's potential for local green H2 production is limited, and piped imports from locations with abundant renewable energy resources (e.g., Iberia, North Africa) will take time to materialize (the most feasible pipeline route by the 2030-2035 time horizon is likely to involve North Sea offshore wind). In addition, green electrons produced in Belgium will likely be used to decarbonize the power sector rather than H2 production.

On the other hand, for H2 derivatives, the option of importing via ship is the strongest contender around 2030 as this pathway provides access to the best locations for renewable energy whilst avoiding reconversion costs through cracking, providing competitive H2 derivatives like ammonia and methanol already in most cases today.

By 2030, imports by ship are thus likely to be Belgium's preferred option for sourcing H2 derivatives. However, the sourcing of H2 molecules will be more difficult. Beyond a small amount of local green H2 production, we see three non-mutually exclusive pathways (Exhibit 6).

Exhibit 6: Beyond little local green H2 production, three non-mutually exclusive paths to cover the 2030 demand for H2 molecules

Path 1
"Aggressive Northern Route"

Rapid build-up of multiple GWs of offshore wind dedicated to green H2 production for Belgium

- Only to be considered vs. direct use as electricity under certain conditions (e.g., distant from shore, in places where existing offshore gas infra can be leveraged)
- Reducing the need for blue H2 to meet targets, hence avoiding residual emissions & gas price exposure (blue H2 competitive vs. Northern Route at <€25-35/MWh)[1]
- Not needing the Shipping Route to deliver H2 molecules, hence avoiding higher green H2 costs (up to €0.5-1.5/kg more costly incl. cracking vs. piped green H2 imports)

Path 2
"Shipping and Cracking"

Ship H2 derivatives from overseas locations, and crack them back to H2 in Belgium

- If not sufficient H2 from the Northern Route can be made available in time
- Shipping Route only an option to meet demand for decarbonized H2 molecules if cracking technology matures vs. today and if this path proves to be more competitive vs. blue H2 (gas prices >€40-50/MWh)[1]
- Yet, expected to put pressure on the competitiveness of local industry given additional cost of up to €0.5-1.5/kg for the clean H2 molecules vs. piped green H2 imports

Path 3
"Blue as Transition"

Use blue H2 to close the gap for clean H2 molecules, imported or produced locally

- If not sufficient H2 from the Northern Route can be made available in time / at competitive prices, blue H2 to close the gap
- To be pursued to close the gap for clean H2 molecules if more competitive vs. shipping and cracking (gas prices <€40-50/MWh)[1]
- Imported via pipeline from nearby regions that later can switch to green H2 (e.g., Norway, UK)
- And/or produced locally if gas price risk can be mitigated, with assets set-up in such a way to limit stranded asset/lock-in risk

Part not yet decarbonized by 2030 to be met by remaining current gray H2 production facilities, to be fully phased-out between 2030 and 2050

1. Assuming CO2 prices of €50-150/ton

By 2050, additional pipeline options are expected to become available and will provide access to cost-competitive green H2 molecules from Northern, Southern, and (depending on geopolitical developments) Eastern routes. Due to constraints on space and renewable resources in Belgium, competitive, local green H2 production will remain limited. In addition, shipping could still be part of Belgium's sourcing mix for H2 molecules beyond H2 derivatives; for example, to diversify feedstocks and to provide access to distant overseas locations such as South America.

Based on these dynamics, we foresee three non-mutually exclusive pathways for Belgium to meet H2 molecule demand in 2050, beyond a small amount of local green H2 production (Exhibit 7).

Exhibit 7: Also for 2050, beyond little local green H2 capacity, three non-mutually exclusive paths to cover the demand for H2 molecules

Path 1
"Full Green – Pipeline only"

Use pipeline imports to meet demand for H2 molecules, shipping imports for H2 derivatives

- More pipeline import options become accessible with the development of an EU H2 backbone incl. major import corridors
- Next to the North (~closeby) and South (~low production cost), the East could play a diversification role, but is more expensive and volumes may not reach Belgium
- Given low costs of pipeline imports from renewable-rich regions, and net-zero ambitions, piped green imports preferred to meet H2 molecule demand (moving away from blue H2 and from cracking (potentially up to ~€0.5-1/kg H2 more costly vs. piped))

Path 2
"Full Green – Shipping and Cracking"

Next to bringing H2 derivatives, shipping as tool to diversify/hedge H2 molecules supply

- Expected to be less cost-competitive for H2 molecules vs. pipeline imports, yet can provide benefits by acting as tool to hedge and diversify
- Diversification tool: providing access to a broad set of locations / partners globally
- Hedging tool: hedging against non-(timely) development of a European H2 backbone incl. import corridors, and against a smaller set of potential suppliers via pipeline
- The challenge is the cost for local industry, given higher costs of potentially up to ~€0.5-1€/kg of green H2 vs. piped green H2 imports

Path 3
"Blue as Longer-Term Solution"

Use blue H2 to close the gap for clean H2 molecules, imported or produced locally

- Blue H2 could also be considered as alternative long-term hedge instead of the "shipping and cracking" path
- If more competitive vs. "shipping & cracking" (gas prices <€20-25/MWh)[1] or more tech-ready (CCU/S vs. cracking), and if accepted from a net-zero perspective towards 2050 (capture rate <100%)
- Blue H2 not likely to be a competitor for green pipeline imports, as long-term blue H2 only competitive at very low gas prices (<€10-15/MWh)[1] and would still result in remaining emissions (capture rate <100%)

1. Assuming CO2 prices of €50-150/ton

For H2 derivatives in 2050, shipping is expected to remain the supply route of choice, given it will provide access to the best locations for renewable energy whilst avoiding cracking costs. This would also allow scarce decarbonized (low- and zero-carbon) H2 molecules to serve the demand that really needs H2 molecules. Power plants, for example, can generate electricity using pure H2 or alter their gas turbines to use ammonia or methanol feedstock to allow pure H2 usage in other applications.

DEVELOPING A LONG-TERM VISION FOR BELGIUM'S INDUSTRIAL H2 POLICY

SEVEN TAKEAWAYS ABOUT BELGIUM'S LONG-TERM H2 SUPPLY AND DEMAND POSITION

1. Due to Belgium's limited ability to access large volumes of competitive decarbonized H2 molecules, Belgium should focus on maximizing the use of H2 derivatives in suitable applications.
2. By eventually focusing demand on just one or two H2 derivatives, Belgium can both benefit from greater diversity of supply and keep infrastructure needs simple. However, as a clear "winner" among H2 derivatives has yet to emerge, Belgium needs to keep flexibility in the short-term and remain open to a multi-derivative future.
3. H2 derivatives will primarily be imported by ship from more distant regions around the world that have abundant renewable resources and so are able to offer competitive products.
4. H2 molecules are more difficult to import in the short to medium term and should ideally be produced within Northwest Europe and be predominantly green in the medium term.
5. Blue hydrogen could play an important (transition) role, depending on developments in natural gas prices amongst other factors.
6. Cracking H2 derivatives to create H2 molecules will be of limited use in the long term given its relatively high expected cost (unless major cost breakthroughs emerge). However, cracking capacity can be valuable in providing additional flexibility, optionality, and diversification of supply – especially if Belgium is to become a H2 transit hub.
7. Belgium already has much of the necessary infrastructure to become a H2 molecule hub and is planning further investments, but its potential role as a H2 derivative hub requires further investigation.

Whatever combination of pathways is chosen, Belgium can initiate several no-regret sourcing actions and start to answer multiple open questions to help close the demand gap, especially for H2 molecules.

Exhibits 8a & 8b show a potential future vision for a Belgian industrial policy for both H2 molecules and H2 derivatives. To meet Belgium's domestic H2 demand and enable it to function as an effective transit hub, efforts will be required in several areas.

Exhibit 8a: A future vision for Belgium's policy for H2 molecules

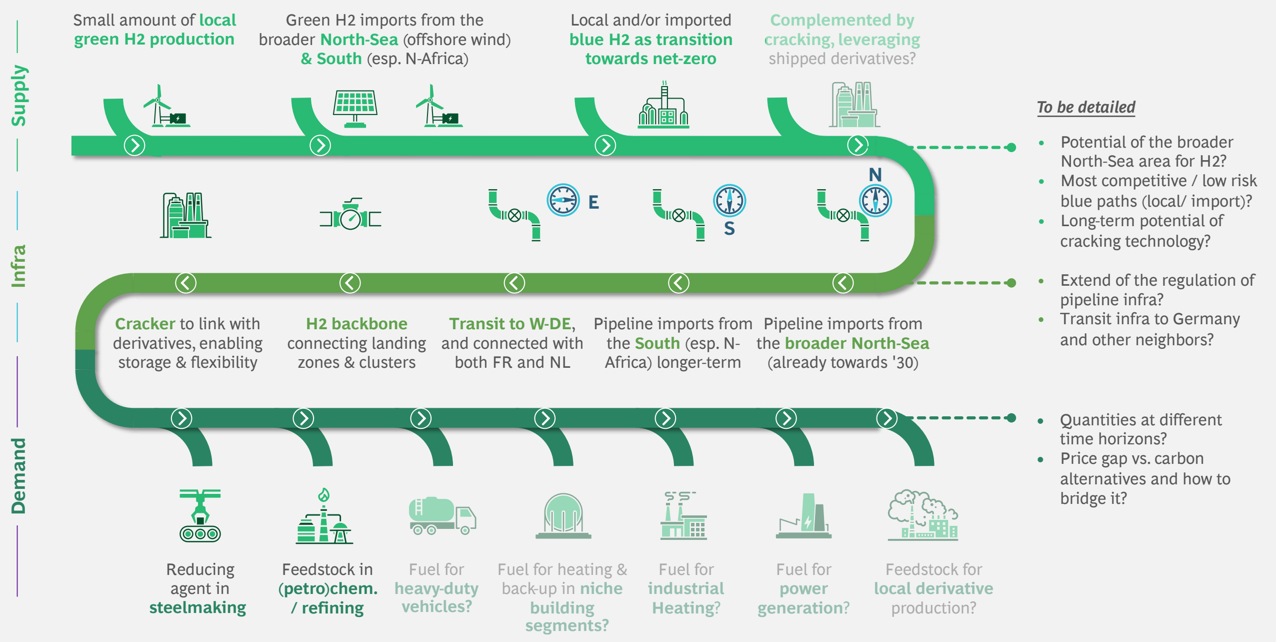
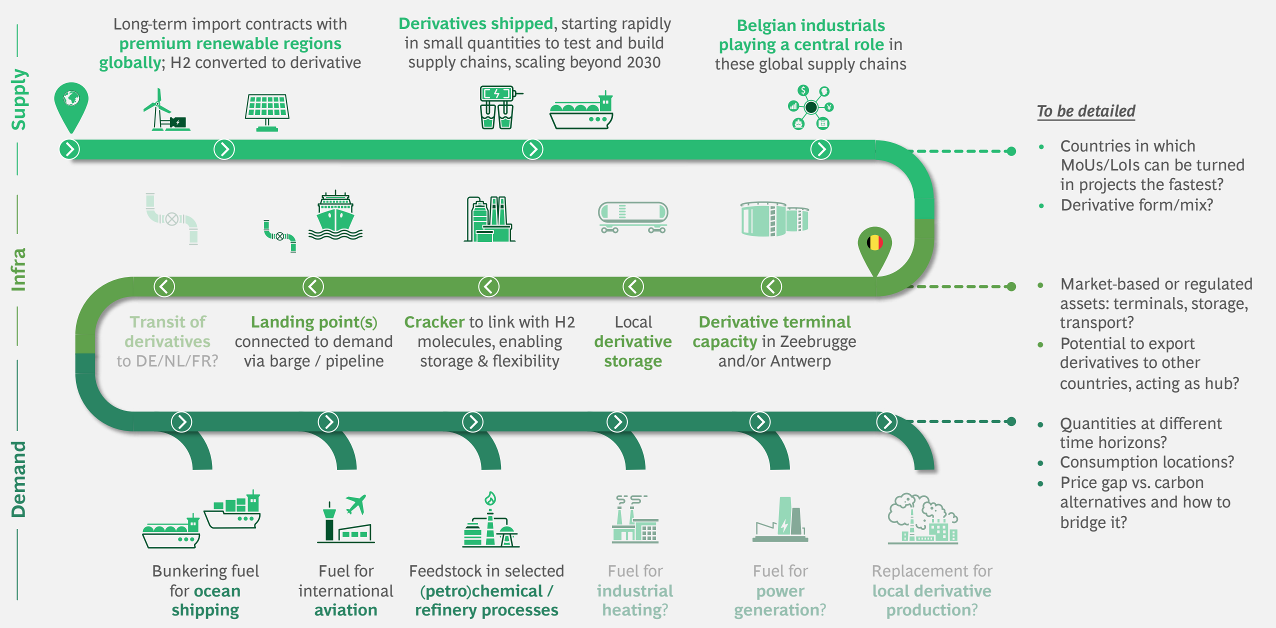


Exhibit 8b: A future vision for Belgium's policy for H2 derivatives

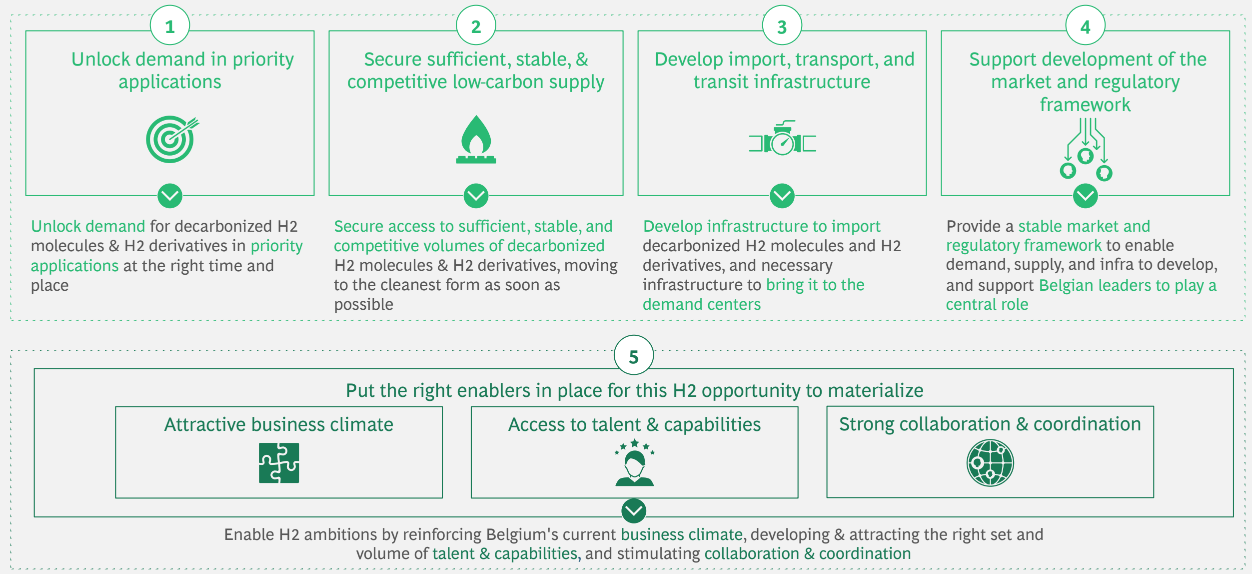


A FIVE-STEP ACTION PLAN FOR ACHIEVING THE VISION:

Belgium is in a strong position to turn this H2 vision into reality thanks to its proximity to major European demand centers, well-established logistics hubs and ports, existing natural gas transit infrastructure, strong industrial base, and potential role as a neutral import partner. But to focus on the right opportunities for H2 and its derivatives next to other important decarbonization actions to take (i.e., the further electrification of electricity grids, further development of electricity grids, carbon capture & utilization or storage, etc.), there must be a comprehensive and united approach across private and public sectors.

Leveraging its solid starting position, Belgium can take steps in five areas to pursue and realize its H2 ambitions: unlocking demand in priority applications, securing supply, developing infrastructure, supporting market & regulatory development, and putting the right enablers in place (Exhibit 9).

Exhibit 9: Leveraging its good starting position, Belgium can take steps along 5 areas to pursue and realize its H2 ambitions



Unlock demand for low-carbon H2 in priority applications

We have developed four recommendations to enable Belgium to unlock demand for decarbonized H2 molecules and H2 derivatives in priority applications at the optimal time:

1A Translate European decarbonization ambitions into national targets. Belgium should take a collaborative position, and set H2 and broader decarbonization targets that are ambitious but feasible, safeguarding the competitiveness of local Belgian industry.

1B Incentivize users to switch to low-carbon H2 for priority applications. In addition to creating greater awareness about low-carbon H2 in priority applications and asking industry to develop decarbonization paths (and centrally reviewing and supporting them), Belgium can concentrate incentives in these areas by de-averaging incentives (e.g., higher financial support or targets for industrial compared to other applications). Finally, a high European CO2 cost and carbon border adjustment mechanism will encourage companies to consume low-carbon H2.

1C Steer demand towards H2 derivatives where possible. For applications that are evaluating both H2 molecules and H2 derivatives and where importing by ship is a feasible and safe option, creating a dialogue between government and industrial companies that promotes transparency around Belgium's sourcing pathways and the limitations regarding the importing of H2 molecules can help steer demand towards H2 derivatives. As an example, potential financial support and targets should keep this in mind. In addition, the government needs to work with industry to understand what share of demand – and transit to neighbouring countries - could be derivatives and where this would be located.

1D Deepen engagement with Germany to concretize the need for transit capacity. Greater and continued interaction between German and Belgian policymakers and players can refine views on Germany's requirement for H2 that transits Belgium, and help to reliably quantify demand over time. By means of governmental or industrial guarantees or long-term contracts, infrastructure projects for transit can also be increasingly de-risked.

Secure sufficient, stable, and competitive low-carbon H2 supply

Five actions and investigations can support Belgium in securing access to sufficient, stable, and competitive volumes of decarbonized H2 molecules and H2 derivatives, and enable the country to switch to the cleanest form of H2 as soon as possible:

2A Be pragmatic in the short-term about technology preferences and don't exclude options that can reduce emissions and accelerate market development. Belgium's priority is to gain access to sufficient volumes of low-carbon H2. Ensuring that these volumes are secured as economically as possible, compared to countries and regions with a similar industrial base, is a no-regret action. Belgium's aim should be to move to the cleanest form of H2 molecules and H2 derivatives as quickly as possible, but without compromising on volumes and cost.

2B Take action to develop more offshore wind capacity in the North Sea region. Engaging with other countries bordering the North Sea to develop a masterplan that builds on the recent Esbjerg Declaration (by assigning areas for developing new offshore wind capacity, and deciding on the split between using green electrons for power or to convert water into H2 molecules based on distance to shore and re-usability of offshore gas infrastructure) and organizing project tenders with accelerated permitting will increase the volumes of green H2 supplied through the Northern Route.

2C Secure H2 derivatives supply from regions of the world with the best renewable resources. To meet demand, H2 will need to be imported in the form of H2 derivatives from these regions. Belgium should partner with counterparts from the best regions for renewables (such as Chile, Brazil, the Middle East, Namibia, South Africa, Australia) to make shipping a competitive import pathway for H2 derivatives, and turn MoUs (Memorandum of Understanding) and LoIs (Letter of Intent) with these regions into actual export projects.

2D Investigate possible pathways to competitive and low-risk blue H2. Engage with industry to understand the infrastructure requirements (including CO2 infrastructure) for developing local blue H2 production capacity. Also engage with Norway and the UK to understand their appetite for piping blue H2 molecules, as well as cost considerations and time horizons. Provided the risks can be managed effectively and blue H2 can be supplied at a competitive price, blue H2 has the potential for meeting part of Belgium's demand for H2 molecules.

2E Investigate the long-term potential of shipping for importing H2 molecules. By monitoring technology developments and supporting R&D and demonstration projects for cracking H2 derivatives, LOHC, and importing shipped, liquefied, H2 molecules, policy makers can ensure that alternative future pathways are included in Belgium's sourcing mix, in case a breakthrough materializes.

Develop import, transport, and transit infrastructure

Belgium can start to develop infrastructure to import, store, and transport H2 molecule and H2 derivatives to demand centers by taking the following five recommended steps:

3A Develop shipping routes and port infrastructure to meet H2 derivatives demand. To achieve its ambition to become a H2 transit hub, Belgium must take the first steps (such as allocating designated areas at ports and shipping routes) to develop new and scalable terminal and port infrastructure so that it can import decarbonized H2 derivatives. Policy makers will also need to work with industry to understand trade-offs between different ports and routes.

3B Develop a plan with North Sea Transmission System Operators (TSOs) to transport green H2 produced offshore using wind power to the coast. As part of this plan, North Sea TSOs will need to work with the offshore wind industry to understand trade-offs between power cable transmission (transporting green electrons from offshore wind for onshore green H2 production) versus transporting molecules by pipeline and explore what existing oil and gas infrastructure could be re-used for H2.

3C Become a driving force in developing a European H2 backbone. Building on the EHB initiative, Belgium should work with other countries, including for example Spain, France, Italy, Switzerland, and Germany, to drive the long-term development of the H2 backbone, including the creation of import corridors from the South, thereby helping to enable its vision to become a H2 hub.

3D Invest in transport infrastructure to meet domestic and transit demand for H2 molecules. Continuous engagement with H2 players, users, and infrastructure operators will be required to progress the roll-out of infrastructure to convey H2 molecules to demand centers and to support the de-risking of investments in domestic transport and transit infrastructure.

3E Invest in transport infrastructure to meet domestic and transit demand for H2 derivatives. In a similar way to what is being done for H2 molecules, Belgium should engage with stakeholders in the sector to understand their requirements for the supply, transportation, and transit of H2 derivatives, and support the de-risking of infrastructure investments for domestic and transit use.

Support the development of the market and regulatory development

By creating a stable regulatory and market environment, policy makers can support the development of H2 demand and supply, together with the necessary infrastructure, and enable Belgian industry to play a central role in the European H2 economy. They can do this by taking the following three actions:

4A Set up a local market and regulatory framework for H2 molecules and H2 derivatives. By acting quickly to roll out a regulatory framework, policy makers can strengthen Belgium's role in shaping the wider European H2 market. As a first step, however, a regulatory framework is needed for the transportation and transit of H2 molecules that balances having clear rules against keeping sufficient flexibility, not hindering the development of this nascent market. In addition, policy makers should confirm whether to also regulate derivative transport and transit, and terminal and storage capacity (and if so, what the implications are for existing capacities like the BASF terminal in Antwerp). Finally, the government has a role to play to create and support markets for trading H2 molecules and derivatives (e.g., building on the H2Global initiative, or hub systems for gas).

4B Coordinate internationally to embed and complement Belgium's market and regulatory framework. By supporting the development of European H2 regulation, as well as rules governing H2 imports from outside the European Union, and the creation of a Europe-wide certification system, policy makers can accelerate the development of a level playing field between Belgium and other countries.

4C Support Belgian industry so it can play a central role in the development of an international H2 value chain. Stimulating R&D and support for domestic industrial champions as well as Belgium's small amount of green H2 production will help the country to build up valuable expertise and further improve Belgium's market position internationally. This can take many forms beyond direct financial support, e.g., by supporting the establishment of multi-actor demo facilities and research labs, by helping local industry to be represented in international H2 forums, and by taking a structured approach in involving Belgian leaders in MoU and LoI set-ups.

Put the right enablers in place for this to materialize

The following three, more broader, recommendations will create the right enablers for Belgium to achieve its H2 vision:

5A **Build an attractive business climate.** By making fiscal and regulatory regimes predictable, stable, and simple, and helping industry decision makers to navigate the domestic political and regulatory environment, policy makers can support the development of H2 business initiatives and markets.

5B **Foster talent and workforce pools in the H2 space.** Pre-university orientation programs, workforce reskilling and upskilling programs, and measures that facilitate the exchange of talent within the Belgian H2 ecosystem are all important enablers that the government should take to support the domestic H2 industry.

5C **Foster collaboration and coordination between policy makers and industry - both domestically and internationally.** Continuing to forge supporting partnerships between export hubs and demand centers and creating platforms that bring together policy makers, industry, and societal stakeholders (such as a national H2 council) will help to facilitate Belgium's H2 vision. Belgium can accelerate such developments by, for example, continuing to help local industry to be represented in international H2 forums; supporting the establishment of multi-actor demonstration facilities and research labs; unlocking cross-border R&D collaborations with priority regions for trading H2; and ensuring close coordination at federal and regional levels.

APPENDIX
BELGIUM'S SOURCING PATHWAYS

Exhibit 10: Assumptions to calculate landed H2 and derivative costs for Belgium

Route	Local	Northern	Eastern	Southern	Shipping	Blue
H_2 quality						
Proxy countries & regions	Belgium	Netherlands UK	Romania Ukraine	Morocco Spain	Australia Chile Namibia Oman	Belgium Norway N. America Oman
Transport pathways	Local production	Pipeline	Pipeline	Pipeline	Shipping	Local production; Pipeline; Shipping

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