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Opportunities for **Hydrogen Energy Technologies** Considering the National Energy & Climate Plans

H2

FCH

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

Contract details
Fuel Cells and Hydrogen 2 Joint Undertaking (FCH 2 JU)
Study on Opportunities arising from the inclusion of Hydrogen
Energy Technologies in the National Energy & Climate Plans
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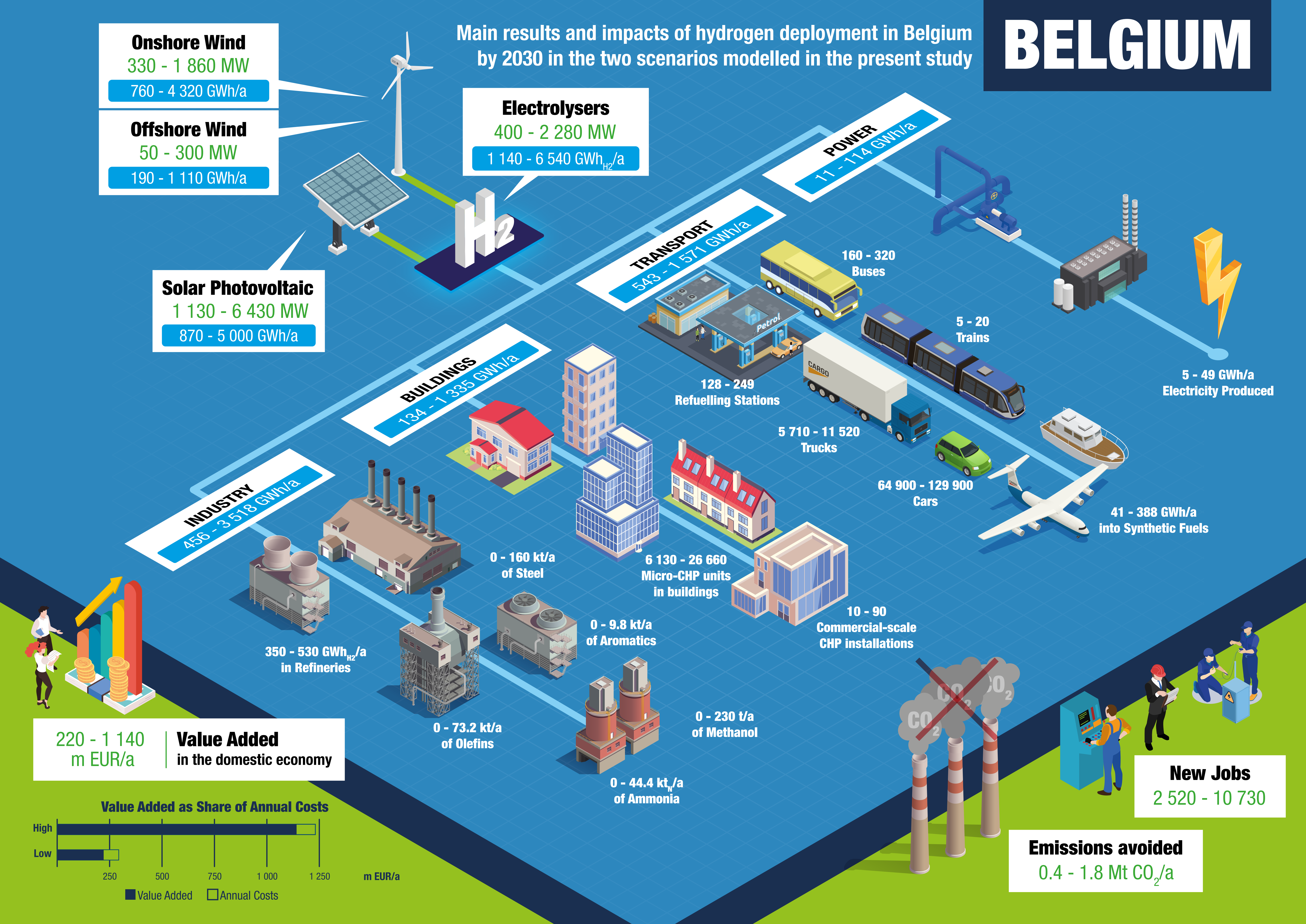
Introduction

The **Fuel Cells and Hydrogen Joint Undertaking** (FCH JU), in close cooperation with the **European Commission - DG Energy**, has commissioned a study on the "Role of Hydrogen in the National Energy and Climate Plans". This study is being conducted by the consultancies **Trinomics and LBST**.

This fiche represents one of the outputs of the study; it comprises two major parts:
- Analysis of **national opportunities for hydrogen deployment**, based on the national hydrogen production and demand potential, the gas infrastructure and the enabling environment. In this context, the role of hydrogen in the current National Energy and Climate Plan is in particular analysed.
- Assessment of **national economic, environmental and technical impacts of hydrogen deployment** under a high and a low scenario.

This information is expected to provide useful information to EU Member States that are considering to include renewable or low-carbon hydrogen deployment in their decarbonisation policies or roadmaps.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Main results and impacts of hydrogen deployment in Belgium
by 2030 in the two scenarios modelled in the present study
Onshore Wind
330 - 1 860 MW
760 - 4 320 GWh/a
Offshore Wind
50 - 300 MW
190 - 1 110 GWh/a
Solar Photovoltaic
1 130 - 6 430 MW
870 - 5 000 GWh/a
Electrolysers
400 - 2 280 MW
1 140 - 6 540 GWh_{H2}/a
H_2
POWER
11 - 114 GWh/a
TRANSPORT
543 - 1 571 GWh/a
BUILDINGS
134 - 1 335 GWh/a
INDUSTRY
456 - 3 518 GWh/a
160 - 320
Buses
5 - 20
Trains
128 - 249
Refuelling Stations
Petrol
CARGO
5 710 - 11 520
Trucks
64 900 - 129 900
Cars
41 - 388 GWh/a
into Synthetic Fuels
5 - 49 GWh/a
Electricity Produced
0 - 160 kt/a
of Steel
6 130 - 26 660
Micro-CHP units
in buildings
10 - 90
Commercial-scale
CHP installations
350 - 530 GWh_{H2}/a
in Refineries
0 - 9.8 kt/a
of Aromatics
0 - 73.2 kt/a
of Olefins
0 - 230 t/a
of Methanol
0 - 44.4 kt_N/a
of Ammonia
CO_2
220 - 1 140
m EUR/a
Value Added
in the domestic economy
Value Added as Share of Annual Costs
High
Low
250
500
750
1 000
1 250
m EUR/a
Value Added
Annual Costs
New Jobs
2 520 - 10 730
Emissions avoided
0.4 - 1.8 Mt CO_2/a

EXECUTIVE SUMMARY

Belgium's commitment for hydrogen deployment according to its NECP

According to its NECP, Belgium has the intention to start deploying renewable and low-carbon hydrogen technologies, as shown in the NECP stating for instance that "Flanders has the ambition to become a European leader in hydrogen technologies". Both the federal and regional authorities recognize the importance of hydrogen in a decarbonized economy, as an enabler for the deployment of renewable electricity production, a reliable option for energy storage, an alternative to decarbonize fossil fuels' use, and a solution to reduce GHG emissions in energy end-use sectors difficult to decarbonize.

The NECP announces new federal and regional regulatory and financial measures to stimulate the deployment of renewable hydrogen in the industrial, building and transport sectors. Next to renewable hydrogen, Flanders also supports the deployment of CCUS installations (carbon capture and utilisation or storage), that could be combined with fossil fuel-based hydrogen produced by steam methane reforming (SMR), in order to provide a carbon-neutral fuel. Belgian companies are also considering importing renewable or low-carbon hydrogen in the future, probably anticipating a limited domestic production potential.

Current developments show that Belgium could effectively join the leading countries in Europe for the deployment of renewable or low-carbon hydrogen, given the interest expressed by several local energy and industrial companies, the different concrete initiatives and first investments (e.g. hydrogen refuelling stations, transport and delivery infrastructure with the IPCEI Green Octopus project[1], hydrogen city buses[2] and heavy duty vehicles). Belgium was also involved in the HyLaw[3] project, that identified and assessed major regulatory barriers in view of prioritizing measures to address them.

According to the NECP, Wallonia has fixed a concrete target for the transport sector where 1% of the passenger cars would be hydrogen driven by 2030. In Flanders, 50% of all new light vehicles would be zero emission (including hydrogen) in 2030. There are in the NECP no other strategies mentioned nor further targets for the production or consumption of hydrogen.

Sector associations in Flanders and Wallonia have set up roadmaps that could serve as basis for the authorities to develop mid-term policy strategies and measures. Overall, Belgium is committed to invest in hydrogen related research, to implement pilot and demonstration projects and to further deploy refuelling stations.

[1] https://www.hydrogen4climateaction.eu/projects
[2] https://www.waterstofnet.eu/nl/toepassingen/openbaar-vervoer/5-bussen-in-antwerpen-highvlocity
[3] https://www.hylaw.eu/

The scenario assessment shows substantial potential benefits of hydrogen deployment in Belgium by 2030

Hydrogen demand

Two (high and low) scenarios of hydrogen demand in 2020-2030 were developed, based on different levels of ambition linked to the national context. The resulting values are summarised in the scheme in the previous page. For Belgium, a significant development of hydrogen demand is assumed in transport, especially for passenger cars and buses, trucks and to a more limited extent in aviation (through hydrogen-based liquid fuels or PtL) and navigation[4]. A significant development of hydrogen demand is also assumed in the considered scenarios in industry. Some industries use fossil-based hydrogen as feedstock or reducing agent, which could be replaced by renewable hydrogen. Switching high temperature heat processes fuels to renewable hydrogen could represent another important potential use in the considered scenarios.

In the building sector, hydrogen can replace part of the current use of natural gas and can be distributed via existing gas grids through admixture to natural gas. The building sector is expected to have in the Low scenario a limited demand of hydrogen by 2030 but would have a stronger demand in the High scenario.

The scenarios assume only a marginal use of hydrogen for electricity generation by 2030, mainly in combined heat and power installations.

Hydrogen production

To cover the estimated hydrogen demand from new uses and from substitution of fossil-based hydrogen, 1.5 to 8.6 GW of dedicated renewable electricity capacity would have to be installed to produce green hydrogen via electrolysis. While "surplus" electricity might be available in times of high renewable electricity production, the main share will have to be covered by dedicated sources. In the two scenarios, part of the 2030 hydrogen demand would still be covered by fossil-based hydrogen produced via steam-methane reforming of fossil fuels.

In its NECP, Belgium estimates an installed capacity in 2030 of 6.5 GW in wind and 6.9 GW in solar PV, generating about 15 TWh of variable renewable electricity in 2030. The technical potential for renewable electricity production in Belgium seems however significantly higher[5]. Building additional renewable electricity capacity dedicated for hydrogen production thus could be a feasible scenario.

Estimated socio-economic and environmental impacts

The annual costs to produce green hydrogen (including the cost of dedicated renewable electricity sources), to develop the transport infrastructure (or adapt the existing one) and end-user applications would in the considered scenarios reach respectively 270 and 1 200 million EUR. These activities will generate value added in the domestic economy, amongst others by creating jobs in manufacturing, construction and operation of hydrogen technologies and will contribute to greenhouse gas emission reductions. This is in particular important in hard-to-decarbonize industries. According to the European EUCO3232.5 scenario[6], the Belgian GHG emissions should be reduced by 33 Mt CO_2 in 2030, compared to 2015. In the scenarios considered, the deployment of hydrogen could contribute 0.4 – 1.8 Mt CO_2 to this goal, which is equivalent to 1% - 6% of the required emission reduction.

[4] *Detailed assumptions are available in the methodology annex of the report, that can be consulted via the following link : http://trinomics.eu/project/opportunities-for-hydrogen-in-necps.*
[5] *The technical potential for renewable electricity production is based on the study commissioned by DG ENER Impact of the use of the biomethane and hydrogen potential on trans-European infrastructure (Trinomics, LBST, E3M; 2019).*
[6] *EC, 2019. Technical Note on Results of the EUCO3232.5 scenario on Member States. Available at https://ec.europa.eu/energy/sites/ener/files/technical_note_on_the_euco3232_final_14062019.pdf*

HYDROGEN IN THE BELGIAN NECP

Belgium recognises renewable and low-carbon hydrogen as an essential energy carrier in the energy transition: it allows to decarbonize market segments which have few other suitable alternatives and provides the electricity system with a flexible solution facilitating the development of variable renewable energy sources.

Flanders aims to "green" its hydrogen production and supply, but it also considers producing and use "blue" hydrogen.

Wallonia has mentioned in the NECP that 1% of its passenger cars should be hydrogen driven by 2030, and that hydrogen could become an alternative fuel to decarbonise heavy logistic vehicles. To enable this shift to hydrogen, 10 hydrogen refuelling stations would be required by 2025 and 20 by 2030. From 2020, Wallonia aims to invest in the energy transition by, among others, making its bus fleet more sustainable (purchase of buses on hydrogen, electricity or hybrid) with a dedicated budget of 4.5 million EUR.

In Flanders, hydrogen is considered as an alternative energy carrier for transport. In order to stimulate the development of a network of hydrogen refuelling stations, implementing a support scheme is considered. Flanders has opted to switch to alternative fuels (electricity and hydrogen) for the public transport buses (De Lijn). Since 2019, purchasing procedures allow only zero-emission public buses. The Flemish authorities are also making resources available to support the use of hydrogen for trucks. By 2030, Flanders aims to reach 50% of all new light vehicles with zero emission.

The federal authorities' purchasing procedures will advantage zero or low-emission vehicles acquisition.

The possibility of using hydrogen driven trains on non-electrified railway lines will be studied in 2020.

The NECP refers to the potential use of renewable or low-carbon hydrogen and synthetic fuels to decarbonise industrial processes. Renewable electricity can directly be used in industrial heat production processes, or indirectly after conversion to hydrogen or synthetic methane.

In Wallonia, a significant fuel switch to electricity, renewable heat, synthetic gases (including hydrogen methanation) and hydrogen in industry will be pursued.

The gas transmission grid operator Fluxys is studying the infrastructure adaptations that would be needed to transport hydrogen the natural gas transport network.

Storing energy in the form of hydrogen or synthetic fuels offers an alternative to cover longer periods of time.

In Flanders, the existence of maritime ports and pipelines offers opportunities to develop hydrogen as a low-carbon energy carrier. In this context, Flanders is also committed to supporting CCS and CCU initiatives.

A revision of the fiscal system is also considered, both for gas (to take into account its carbon content) and for infrastructure (like refuelling stations).

The NECP also refers to the potential of hydrogen technologies to convert 'excess' renewable electricity into hydrogen or other vectors (e.g. Power-to-gas, power-to-industry concepts, power-to-mobility), and suggest developing a roadmap and launching pilot projects.

Both Wallonia and Flanders intend to adopt a strategic approach, supporting the industrial deployment of innovation results by participating in IPCEIs (Important Projects of Common European Interest) on hydrogen (Green Octopus project[7], Silver Frog[8], White Dragon[9], Zero Emission Urban Delivery @ Rainbow Unhycorn[10]). In this context, renewable fuels, hydrogen and syngas mentioned in the Walloon Regional Policy Declaration of September 2019 will be the focus in RD&I initiatives.

At the supra-national level, the Pentalateral Energy Forum addresses the impact of the implementation of flexibility options, including the role of demand response, PtX and hydrogen as well as the role of storage and electro-mobility, and analyses specific electricity-related barriers to sector coupling. In view of increasing the potential use of hydrogen from renewable sources, the participating countries explore possible common approaches to guarantees of origin, cross-border infrastructure, respective roles of TSOs and DSOs and hydrogen blending standards, and the future role of hydrogen in general.

[7] https://www.hydrogen4climateaction.eu/projects
[8] https://static1.squarespace.com/static/5d3f0387728026000121b2a2/t/5d9c79b467e52303370991bd/1570535868733/Silver+Frog.pdf
[9] https://static1.squarespace.com/static/5d3f0387728026000121b2a2/t/5da472e9ff3f1e0b334d5e3b/1571058415654/White+Dragon+poster.pdf
[10] https://static1.squarespace.com/static/5d3f0387728026000121b2a2/t/5d9b5ee7f5229f74dc24aa73/1570463472420/Rainbow+Unicorn+poster_print.pdf

OPPORTUNITY ASSESSMENT

Hydrogen production potential & its role in energy system flexibility

The domestic technical potential for variable renewable electricity production is lower than the expected electricity demand in 2030 (only 42%). Thus, according to the indicators, the incentive to utilize 'excess' renewable electricity generation capacity to produce hydrogen via electrolysis seems rather limited. The existence of nuclear power generation capacity in Belgium may represent a specific opportunity for deploying hydrogen; as the variable cost of nuclear power plants is very low, they could be used at full load while converting 'excessive' output into hydrogen. This approach would also enhance the load factor of power-to-hydrogen installations and improve their economic feasibility.

Regarding the flexibility needs for the electricity system, there is only a moderate opportunity to develop hydrogen production as a flexibility provider, since Belgium has substantial storage capacity (mainly pumped-storage hydroelectricity), flexible production capacity and demand response potential, that can cover its flexibility needs until 2030. The geographical position of Belgium - proximity to offshore wind production centres in the North Sea and to large energy markets in France and Germany - offers however an opportunity to develop domestic hydrogen production capacities that can be locally used and would benefit from cross-border trade.

	Technical variable renewable electricity potential (TWh/yr)	Technical renewable electricity generation potential compared to forecasted gross electricity consumption in 2030 (EUCO)	NECP estimate of variable renewable electricity production in 2030 (TWh/yr)	NECP estimate of variable renewable electricity production in 2030 compared to its technical potential	Ratio between variable power generation capacity in 2030 and average load (based on EUCO)	Readiness for CO_2 storage
Belgium	38	42%[10]	15.33	40%	173%	Low

Belgium has limited readiness for wide-scale deployment of CCS. Belgium has no suitable sites for CO_2 storage on its territory but could have access to the storage potential in the Netherlands.

[10] The NECP figure is not available

Energy infrastructure

Belgium can consider using its existing methane infrastructure for hydrogen transport and distribution, by blending hydrogen in the public grid in the short and medium term and potentially converting (part of) its network to hydrogen in the long term. As the share of polyethylene in the distribution network is relatively high, it could be converted to hydrogen at relatively low cost. However, conversion of the distribution networks to dedicated hydrogen pipelines would be a longer-term consideration, as the hydrogen production volumes are expected to be relatively low until 2030. In the short and medium term, hydrogen could hence be blended with methane in the existing grid, without the need for physical adjustments to the transport and end-use infrastructure.

	Technical and economic feasibility of converting gas distribution networks to hydrogen (share of polyethylene pipelines in distribution grid)	Natural gas demand in residential and services sectors / length of gas distribution network (GWh/km)	Existing salt cavern natural gas storage sites (TWh)	Suitable geological formations (potential for future hydrogen storage)
Belgium	72%	0.8	0	NO
EU	MS range 16%-99%			

To date, there are no natural gas storage sites in Belgium that would be suitable for hydrogen storage (salt caverns), nor underground salt layers that could provide storage opportunities for hydrogen

Current and potential gas & hydrogen demand

Hydrogen represents a significant opportunity for Belgium to decarbonise its energy mix. Natural gas accounts for a significant share of the country's energy supply, which is also reflected in the extensive transport and distribution infrastructure in the country. As this infrastructure as well as the related end-use equipment are already in place, hydrogen can be deployed relatively easily, at first through admixture with natural gas, which allows it to make a contribution to decarbonisation of Belgium's energy mix on the short and medium term. Next to this, Belgium has also a strong presence of industry and hosts several industrial enterprises that already use hydrogen. Replacing this fossil-based hydrogen by decarbonised hydrogen, represents an opportunity for reducing industrial GHG emissions on the short and medium term. Furthermore, hydrogen can replace natural gas use in industry and replace coal as a reducing agent in the steelmaking process. Further, the harbour of Antwerp can continue to lead by example, using hydrogen as a key building block for the decarbonisation of shipping. Lastly, there is significant potential for the deployment of hydrogen in road transport, especially for the decarbonisation of heavy-duty road freight.

Opportunities for hydrogen demand in industry

Belgium has a significant potential for hydrogen use in industry, for example in ammonia production, refineries, primary steel production and for the generation of process heat. Belgium has fertiliser industry, where methane-derived hydrogen is already used for methane production. Furthermore, fossil energy-based hydrogen is being used in Belgium's refineries in Antwerp. In both cases, the current fossil-based hydrogen use represents a strong opportunity as this could be a steppingstone for switching towards low-carbon or renewable hydrogen. Further, natural gas has an important share in Belgium's industry, accounting for 38% of the final energy mix, so hydrogen could play an important role in the decarbonisation of this part of the industrial energy demand. Especially for the generation of high-temperature process heat, which accounts for 40% of Belgium's industrial heat demand hydrogen is one of the few suitable decarbonisation options. A primary steel plant, located in Ghent, currently produces steel using a blast furnace. This carbon-intensive process could be replaced with an alternative hydrogen-based Direct Reduction Iron process.

	Presence of ammonia industry / share of ammonia production capacity in EU28 total	Presence of refineries / Share of Belgian refineries in total captive hydrogen production by refineries in the EU28	Share of Belgium in total primary steel production in the EU28	Share of natural gas in industrial energy demand (2017)	Share of high-temperature (>200°C) process heat in industrial energy demand (2015)
Belgium	5%	2%	6%	38%	40%
EU	MS range 0%-16%	MS range 0%-26%	MS range 0%-30%	Average 32% MS range 0%-43%	Average 38% MS range 9%-60%

Opportunities for hydrogen demand for heating and cooling in the built environment

In Belgium's built environment, natural gas accounts for two-fifths of the heating demand. Therefore, renewable and low-carbon hydrogen could play a substantial role in the decarbonisation of heating in Belgium's built environment.

	Share of natural gas in the household and service sector energy demand (2017)	Share of heating in the household and service sector energy demand (2015)	Share of cooling in the household and service sector energy demand (2015)
Belgium	40%	76%	2%
EU	Average: 34% MS range: 0% - 60%	Average: 74% MS range: 41% - 82%	Average: 3% MS range: 0% - 46%

Opportunities for hydrogen demand in transport

The port of Antwerp, which is the second largest harbour in Europe, plays an important role in the energy bunkering of ships. The (international) shipping sector consumes an equivalent of 85% of the domestic (final) energy use in Belgium's transport sector. Although international shipping is not yet covered by European or international climate legislation, EU countries with large shipping activities need to make a collective effort to support the decarbonisation of this sector. Hydrogen and derivatives thereof, are amongst the few solutions for (near) full decarbonisation of energy use in shipping on the long term. The harbour of Antwerp is already leading by example, through the introduction of a hydrogen-powered towing vessel. This could set the stage for broader roll-out of hydrogen in shipping, as a fuel for international shipping as well as for inland navigation.

Like most EU countries, Belgium has a large potential for hydrogen use in road transport. Almost half of the energy demand in Belgium's road transport is consumed by heavy-duty trucks, buses and vans, so there is a significant opportunity for the deployment of hydrogen to decarbonise this segment of road transport in Belgium. Finally, while Belgium's railway system is largely electrified, diesel trains still account for 14% of the energy consumption in the rail sector. Together with electrification, hydrogen trains are a solution to decarbonise this fossil fuel dependent segment of the rail sector. On the medium to long run, hydrogen and derived fuels can also be deployed to decarbonise the aviation sector.

	Share of heavy transport (trucks, buses & vans) in total energy demand in road transport in 2020	Share of fossil fuels in energy use of rail transport (and absolute consumption) in 2017	Share of inland shipping in overall energy demand for transport in 2017	Energy use by international shipping relative to total (domestic) final energy use in transport in 2017	Share of domestic and international aviation in overall energy demand for transport (incl. energy use int. aviation) in 2017	Share of fossil fuels in energy use of road transport in 2017
Belgium	48% (45 694 GWh)	14% (252 GWh)	1.7% (1 707 GWh)	85% (87 070 GWh)	9% (20 098 GWh)	94% (93 429 GWh)
EU	Average 32% MS range 18%-48%	Average 30% MS range 0%-95%	Average 2% MS range 0%-10%	Average 14% MS range 0%-1011%	Average 14% MS range 1%-25%	Average 95% MS range 79%-100%

Enabling environment: national hydrogen policies and plans, projects and industry

Belgium has expressed the ambition to become a European leader in the deployment of hydrogen, as shown in the NECP. Belgium considers hydrogen as a key technology in the transition, increasing the flexibility of its energy system, enabling the deployment of renewable electricity production, storing energy on the long-term, decarbonizing fossil fuels and gases and allowing for carbon reduction in difficult-to-decarbonise sectors. Flanders and Wallonia have set hydrogen-related objectives regarding the public transportation, car fleet and refuelling stations. Belgium is considering the development of pilot projects and assessing the feasibility of deploying hydrogen related infrastructure. As such, Belgium has a positive enabling environment for the development of hydrogen.

Existence of (or concrete plans for) national hydrogen roadmaps or strategies

Positive environment: ✗

Despite the political commitments, there is currently no coordinated strategy or approach to address hydrogen across the country. There are several regional initiatives and plans, but further coordination between the competent entities at federal and regional level might be useful to agree on a scalable roadmap for the deployment of hydrogen considering the relevant applications in all sectors, including the building, power, industry, and transport sectors. Regional and federal authorities could use the existing hydrogen industrial roadmaps (in Flanders and Wallonia) as a basis for elaborating policy strategies and measures.

GHG mitigation gap in non-ETS sectors (need for additional GHG reduction measures)

Positive environment: ✗

The NECP does not provide a concrete target to reduce the non-ETS GHG emissions, preventing to identify a potential gap with the Effort Sharing Regulation (ESR) contribution of Belgium (as there is no agreement on the emission reduction share between the entities and on the EU methodology to calculate the GHG emissions, Belgium has no overall target in this regard).

Existence of (active) hydrogen national association

Positive environment: ✓

Current and planned hydrogen refuelling infrastructure for the transport sector

Alternative fuels infrastructure directive (2014/94/EU)

The Belgian National Policy Framework (or NPF set in the context of the alternative fuel infrastructure directive (2014/94/EU)) contains a comprehensive list of measures, most already implemented. Belgium is actively involved in coordinating and collaborating with the Benelux countries as regards alternative fuels infrastructure. These activities might also positively affect hydrogen deployment.

Inclusion of hydrogen in national plans for the deployment of alternative fuels infrastructure (2014/94/EU)	Existence of hydrogen refuelling stations (2019)	which is equivalent to 1 refuelling station per … cars
YES	3	1 928 482

Existence of (investment on) hydrogen-related projects

There are several hydrogen-related ongoing activities in Belgium which pave the way for further developments. The country invests in hydrogen-related research and experiments with power-to-gas, power-to-industry and power-to mobility projects. The deployment of 19 publicly accessible hydrogen refuelling stations is planned, in addition to the three existing ones.

Existing R&D and pilot projects directly related to hydrogen	RD&D annual expenditure on hydrogen & fuel cells (m EUR) (average 2013-2017)	Activities and projects in industry to use hydrogen as feedstock	Number of power-to-gas projects (existing and planned)
YES	1.6	YES	2

Positive environment

Existence of national tax incentives (CO_2 pricing mechanisms & car taxation)

All political entities (3 regions and federal state) have implemented carbon related taxation for vehicles, which may be an incentive to deploy hydrogen-based transport alternatives. But there is currently no carbon pricing mechanism that would give a signal to low-carbon alternative solutions.

Fossil energy import bill

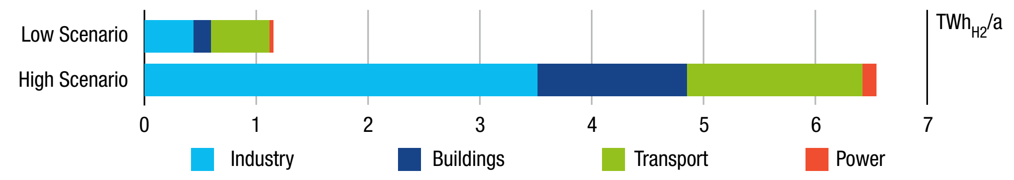
Like many EU Member States, Belgium is strongly dependent on imports for its natural gas as well as its oil consumption. Switching from imported fossil fuel to nationally produced hydrogen for industrial processes and heating applications and facilitating the use of hydrogen in the transport sector will contribute to reducing the energy import dependence.

	Import bill for natural gas as share of national Gross Value Added	Import bill for all fossil fuels
Belgium	0.8%	2.5%
EU	Average: 0.6% MS range: 0% - 1.5%	Average: 2% MS range: 0% - 7%

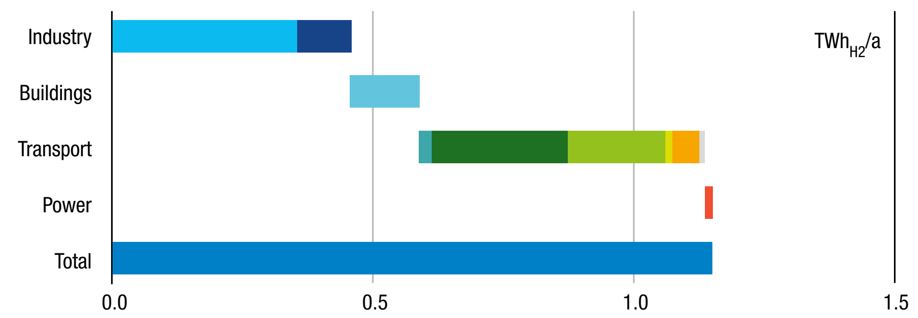
SCENARIO ASSESSMENT

Estimated renewable/low carbon hydrogen demand for Belgium by 2030

Hydrogen demand in the year 2030 has been estimated in a low and a high scenario covering the range of uncertainty. Today, conventional hydrogen mainly used in industry is produced from fossil fuels (e.g. through steam methane reforming) or is a by-product from other chemical processes. Both scenarios assume that in 2030 renewable hydrogen will be provided to partially substitute current conventional production and to cover additional demand (e.g. from transport sector).

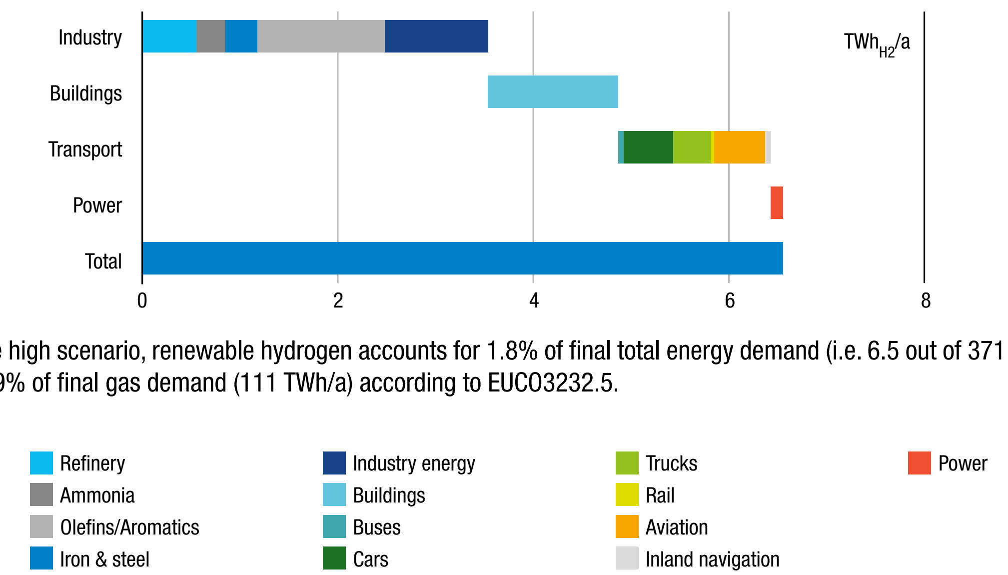


Low scenario



In the low scenario, renewable hydrogen accounts for 0.3% of final total energy demand (i.e. 1.1 out of 371 TWh/a) or 1.0% of final gas demand (111 TWh/a) according to EUCO3232.5.

High scenario

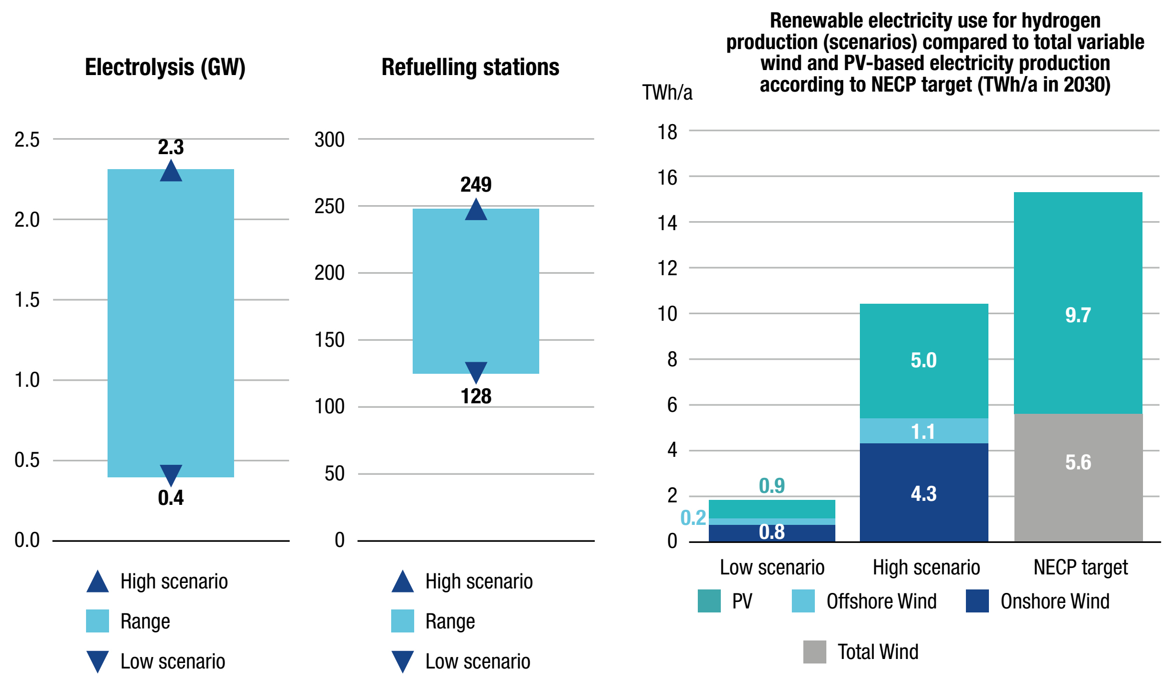


In the high scenario, renewable hydrogen accounts for 1.8% of final total energy demand (i.e. 6.5 out of 371 TWh/a) or 5.9% of final gas demand (111 TWh/a) according to EUCO3232.5.

Hydrogen generation, infrastructure and end users in Belgium by 2030

The analysis of renewable hydrogen generation, infrastructure and end use is based on the demand estimates presented above. Renewable hydrogen is generated from variable renewable power using electrolysis. The analysis covers only national hydrogen production to satisfy domestic demand and does not take into account any cross-border trade of hydrogen (i.e. hydrogen imports and exports are not included in this analysis).

Renewable hydrogen generation and infrastructure



The required renewable power production accounts for 4.9% of the overall technical renewable power potential in the low scenario and for 27.8% in the high scenario.

End users

End user	Unit	Low scenario	High scenario
Passenger cars	Nº	64 900	129 900
Buses	Nº	160	320
Lorries	Nº	5 400	10 900
Heavy duty vehicles	Nº	310	620
Trains	Nº	5	21
Substituted fuel in aviation	GWh/a	36	342
Substituted fuel in navigation	GWh/a	4.9	46.4
Micro CHP	Nº	6 130	26 660
Large CHP	Nº	10	90
Iron&Steel	% of prod.	0%	2%
Methanol	% of prod.	0%	5%
Ammonia	% of prod.	0%	5%

According to the estimations, the hydrogen refuelling station network will by 2030 encompass between 130-250 stations for 71 000-142 000 fuel cell vehicles on the road.

In addition, the analysis estimates substitution of up to 2% of the conventional steel production by renewable hydrogen-based steelmaking.

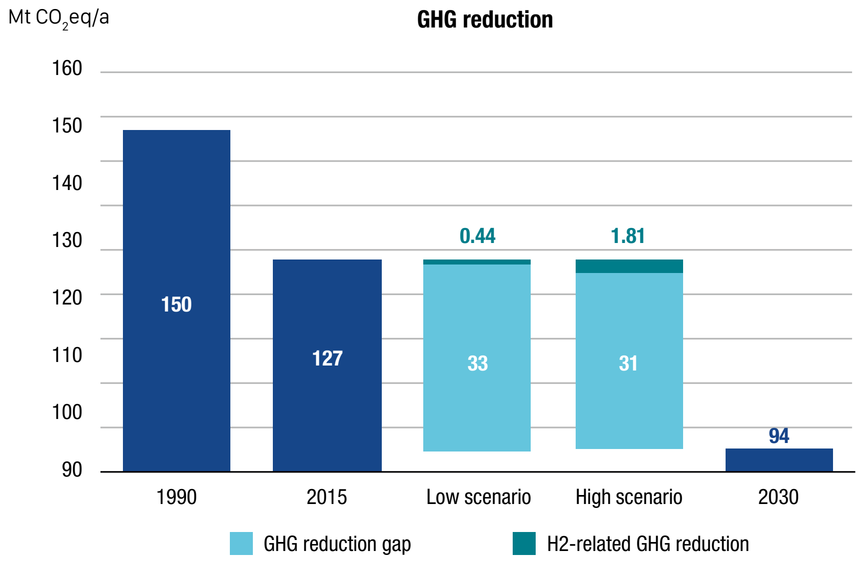
Further use of renewable hydrogen is foreseen in methanol production (up to 5%) and in ammonia production (up to 5%).

Finally, the introduction of 6140-26750 stationary fuel cells for combined power and heat production is estimated.

Environmental and financial impact in Belgium by 2030

Greenhouse gas (GHG) emission reductions were calculated by estimating the fuels replaced by hydrogen, and their respective greenhouse gas footprint. Comparing these to the 2030 GHG reduction targets results in the contribution of hydrogen to achieving these targets.

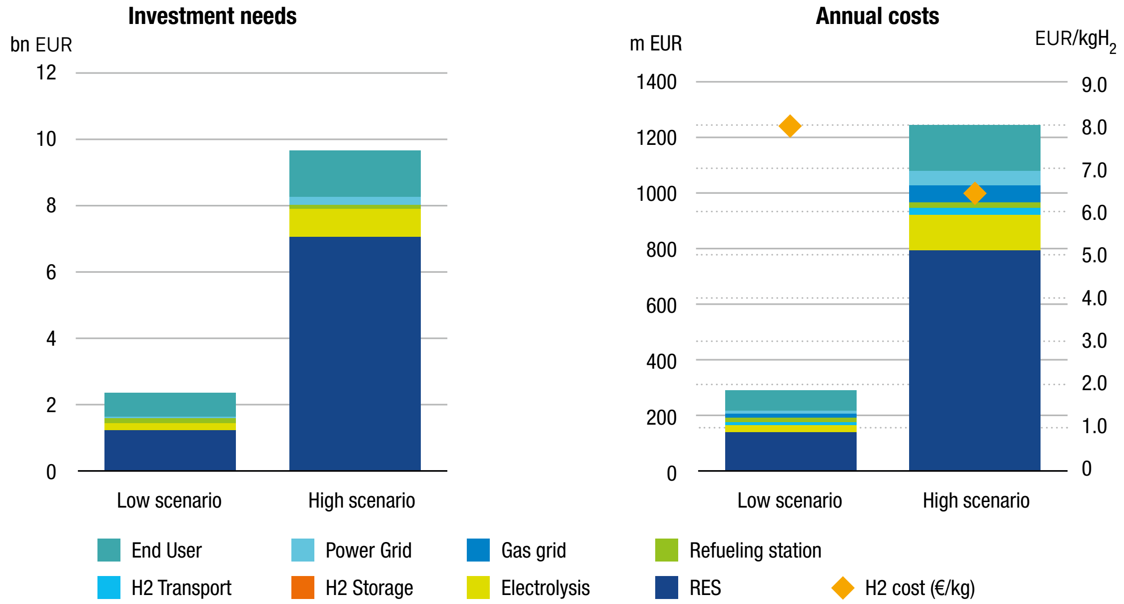
Environmental impact



An additional GHG emission reduction of 0.4-1.8 Mt CO_2 is estimated in 2030 corresponding to 1.3%-5.4% of the overall GHG emission reduction gap towards 2030 target (based on EUCO3232.5).

Financial impact

The financial scenario assessment includes investments (CAPEX) until 2030 and operating expenses (OPEX) per year in 2030. Cumulative investments in hydrogen technologies are estimated at 2.1-9.6 billion EUR until 2030, while annual expenditure would amount to 270-1240 million EUR (including end user appliances as well as power and gas grids).

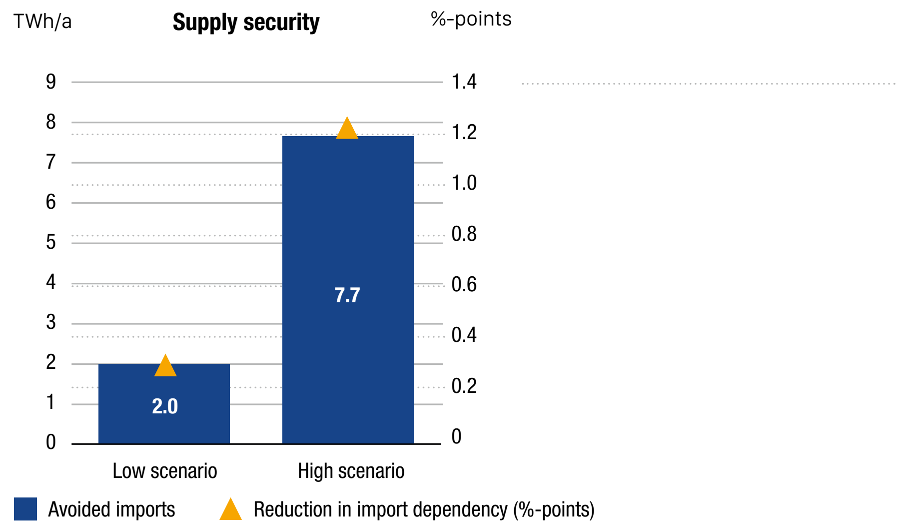


Impact on security of supply, jobs and economy in Belgium by 2030

Hydrogen contributes to the security of energy supply security objective by reducing fossil energy import dependence and enhances energy supply diversification by facilitating deployment of renewable energy sources. This is assessed by estimating imported fossil fuels that will be replaced by hydrogen based on domestic renewable sources.

Security of energy supply

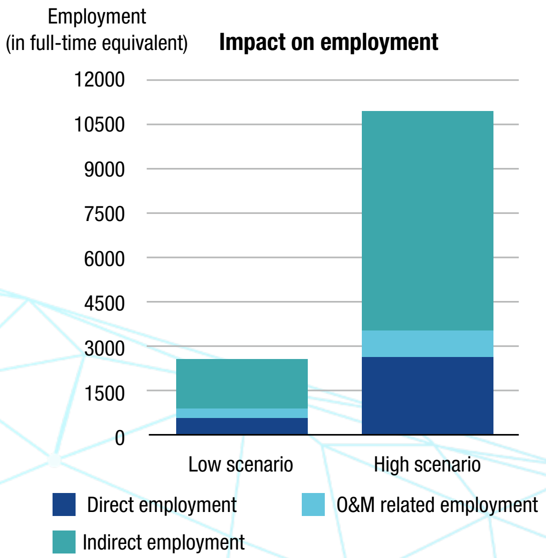
Deployment of renewable hydrogen would lead to 2.0-7.7 TWh/a of avoided imports, and thus reduce import dependency by 0.3-1.2% (in volume terms) in 2030, depending on the scenario.

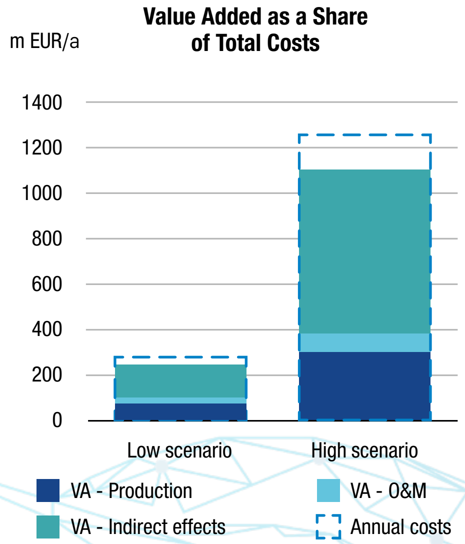


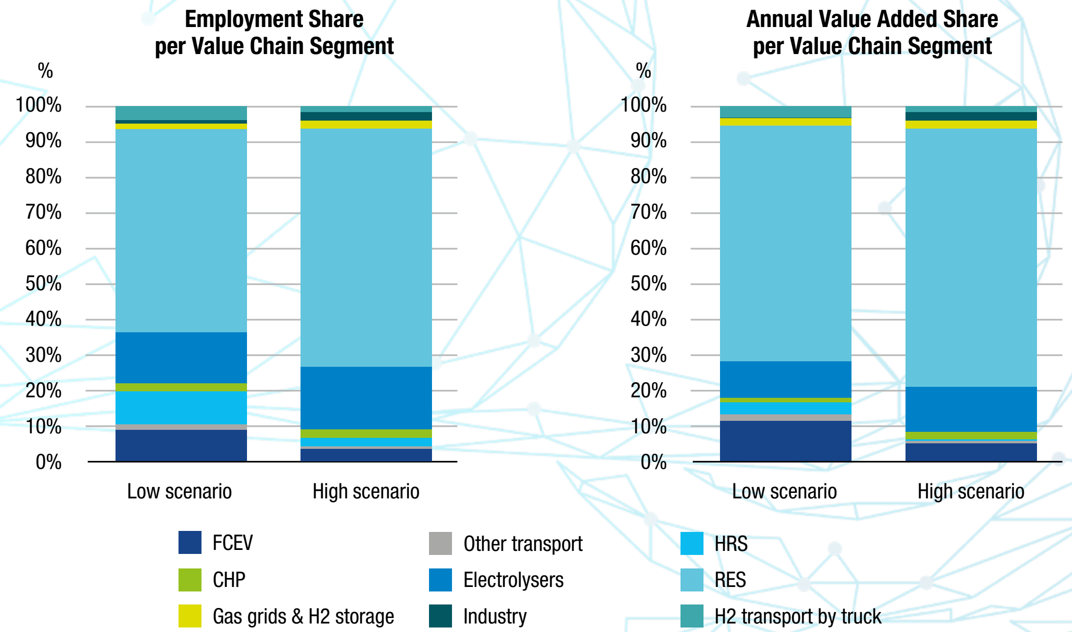
Impact on employment and value added

This analysis shows that in the years 2020-2030 90 million EUR can be retained annually in the domestic economy as value added in the low scenario, and 400 million EUR in the high scenario (value added is defined here as sum of wages for employees, margins for companies and taxes). If the indirect effects induced by the investment in and operation of hydrogen technologies are taken into account, around 200 million EUR (low scenario) and more than 1 140 million EUR (high scenario) of value added can be created in the Belgian economy annually, which is almost equivalent to the amount of annual investment needed. Most of this value added is expected to be created by building dedicated renewable electricity sources and electrolysers for hydrogen production.

The hydrogen-related expenditures in 2020-2030 are estimated to generate employment of 700 - 3400 direct jobs (in production and operations & maintenance), and indirectly contribute to the creation of further employment of 1800 – 7300 indirectly related jobs, depending on the scenario. Most of these jobs are expected to be created by the production of renewable electricity and electrolysers.







BELGIUM

Opportunities arising from the inclusion
of **Hydrogen Energy Technologies**
in the National Energy & Climate Plans

FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING