

FRANCE

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



2

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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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Energy Technologies in the National Energy & Climate Plans  
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# FRANCE

Main results and impacts of hydrogen deployment in France by 2030 in the two scenarios modelled in the present study

**Onshore Wind**  
2 010 - 9 230 MW  
5 280 - 24 270 GWh/a

**Offshore Wind**  
30 - 140 MW  
130 - 580 GWh/a

**Solar Photovoltaic**  
1 300 - 6 060 MW  
1 390 - 6 380 GWh/a

**Electrolysers**  
1 150 - 5 290 MW  
4 260 - 19 590 GWh<sub>H<sub>2</sub></sub>/a

**POWER**  
14 - 137 GWh/a

**TRANSPORT**  
2 703 - 7 818 GWh/a

**BUILDINGS**  
578 - 5 780 GWh/a

**INDUSTRY**  
969 - 5 850 GWh/a

6 - 59 GWh/a  
Electricity Produced

1 200 - 2 410 Buses  
60 - 181 Trains  
635 - 1 113 Refuelling Stations  
45 970 - 91 940 Trucks  
351 700 - 703 400 Cars  
202 - 1 917 GWh/a into Synthetic Fuels

770 - 1 330 GWh<sub>H<sub>2</sub></sub>/a in Refineries

0 - 320 kt/a of Steel

26 540 - 115 460 Micro-CHP units in buildings

0 - 13.7 kt/a of Aromatics

30 - 290 Commercial-scale CHP installations

0 - 82.2 kt/a of Olefins

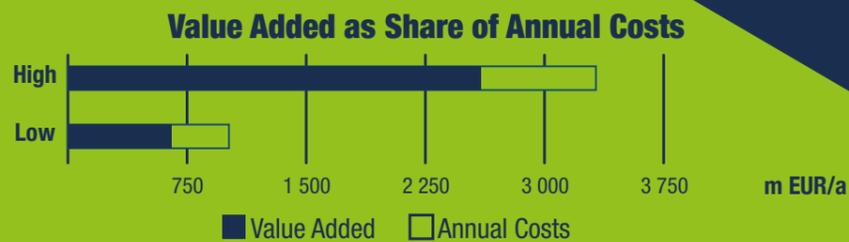
0 - 710 t/a of Methanol

0 - 54.0 kt/a of Ammonia

670 - 2 680 m EUR/a | **Value Added** in the domestic economy

**New Jobs**  
10 380 - 33 650

**Emissions avoided**  
1.9 - 6.2 Mt CO<sub>2</sub>/a



# EXECUTIVE SUMMARY

## France's commitment for hydrogen deployment according to its NECP

The French “hydrogen deployment plan for the energy transition”<sup>1</sup> aims to “support innovation and promote the first ‘decarbonised hydrogen’ industrial deployment projects, to prepare the role of hydrogen as a pillar of the energy transition”. In its NECP and its hydrogen plan, which is an annex to the Multiannual Energy Programming 2019-2028 (PPE2<sup>2</sup>), France is committed to have by 2028 20 000 - 50 000 light duty and 800 - 2 000 heavy duty fuel cell vehicles, as well as 400 - 1 000 hydrogen refuelling stations. Further, the switch of 20 to 40% of fossil-based hydrogen in industry to hydrogen produced in electrolyzers using low carbon electricity is foreseen by 2028. New regulatory and market measures are announced to pave the way for ‘decarbonised hydrogen’ in the industrial, transport and gas sectors addressing the entire value chain covering generation, storage, transport, distribution and end-use.

France is in a favourable starting position for hydrogen deployment given its active national hydrogen association<sup>3</sup>, its clear vision on hydrogen deployment as set in its Hydrogen Plan, its current investments in hydrogen research and in pilot & demonstration projects, its existing hydrogen infrastructure, its robust players in hydrogen and fuel cells from both industry (AirLiquide, Michelin, McPhy, etc.) and research/academia (CEA, CNRS), its various flagship projects like the deployment of professional vehicle fleets (e.g. taxis in Paris<sup>4</sup>) or the deployment of hydrogen mobility in the Auvergne-Rhône-Alpes region<sup>5</sup>. France is currently involved in the Green Octopus and Zero-emission Urban Delivery @ Rainbow UnHycorn<sup>6</sup> potential IPCEI projects<sup>7</sup>, and was also involved in the HyLaw<sup>8</sup> project, that identified and assessed major regulatory barriers, in view of prioritizing measures to address them. The French participation in Mission Innovation, especially in Innovation Challenge no 8 on renewable and low-carbon hydrogen<sup>9</sup>, will support France to accelerate the development of a global hydrogen market by identifying and overcoming the key technology barriers.

The French NECP does not include hydrogen production targets.

## The scenario assessment shows substantial potential benefits of hydrogen deployment in France 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 France, a significant development of hydrogen demand is assumed in the considered scenarios in **transport**, especially for passenger cars, trucks, buses and trains, and to a more limited extent in aviation (through hydrogen-based liquid fuels or Ptl) and navigation<sup>10</sup>. A significant development of hydrogen demand is also assumed in the 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, 3.4 to 15.4 GW of dedicated renewable electricity sources 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 draft NECP, France estimates the production of 153 TWh of variable renewable electricity in 2030<sup>11</sup>. The technical potential for renewable electricity production in France seems however significantly higher<sup>12</sup>. 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 960 and 3 260 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<sup>13</sup>, the French GHG emissions should be reduced by 144 Mt CO<sub>2</sub> in 2030, compared to 2015. In the scenarios considered, the deployment of hydrogen could contribute 1.9 – 6.2 Mt CO<sub>2</sub> to this goal, which is equivalent to 1.3% - 4.3% of the required emission reduction.

<sup>1</sup> [https://www.ecologique-solidaire.gouv.fr/sites/default/files/Plan\\_deploiement\\_hydrogene.pdf](https://www.ecologique-solidaire.gouv.fr/sites/default/files/Plan_deploiement_hydrogene.pdf)

<sup>2</sup> Programmation Pluriannuelle de l'énergie

<sup>3</sup> <https://www.afhypac.org/>

<sup>4</sup> With the objectives to operate 600 taxis in 2030, <https://hype.taxi/>

<sup>5</sup> <https://www.hyvolution-event.com/fr/hyway>

<sup>6</sup> [https://static1.squarespace.com/static/5d3f0387728026000121b2a2/t/5d9b5ee7f5229f74dc24aa73/1570463472420/Rainbow+Unicorn+poster\\_print.pdf](https://static1.squarespace.com/static/5d3f0387728026000121b2a2/t/5d9b5ee7f5229f74dc24aa73/1570463472420/Rainbow+Unicorn+poster_print.pdf)

<sup>7</sup> <https://www.hydrogen4climateaction.eu/projects>

<sup>8</sup> <https://www.hylaw.eu/sites/default/files/2018-10/National%20Policy%20Paper%20-%20Denmark%20%28EN%29.pdf>

<sup>9</sup> <http://mission-innovation.net/our-work/innovation-challenges/renewable-and-clean-hydrogen/>

<sup>10</sup> 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>.

<sup>11</sup> The higher values from the two options mentioned in the draft NECP were used for this comparison.

<sup>12</sup> 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).

<sup>13</sup> 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](https://ec.europa.eu/energy/sites/ener/files/technical_note_on_the_euco3232_final_14062019.pdf)

# HYDROGEN IN THE NECP OF FRANCE

According to its NECP, France is committed to have by 2028 20 000 - 50 000 light duty and 800 - 2 000 heavy duty fuel cell vehicles, as well as 400 - 1 000 hydrogen refuelling stations, and to replace 20 to 40% of fossil-based hydrogen in industry by hydrogen produced in electrolyzers using low carbon electricity.

The French “hydrogen deployment plan for the energy transition”<sup>14</sup>, launched in 2018, aims to “support innovation and promote the first ‘decarbonised hydrogen’ industrial deployment projects in France, to prepare the role of hydrogen as pillar of the energy transition”. This hydrogen plan is part of the French Multiannual Energy Programming which covers the 2019-2028 period.

The National Industry Council (CNI<sup>15</sup>) provides advice to decision makers regarding industrial trends and is considered as an important pillar of the industry policy in France. It is since 2018 specifically focusing on storage and hydrogen, which illustrates the importance of hydrogen in the French industry policy agenda.<sup>16</sup>

The hydrogen plan announces new regulatory and market measures to pave the way for ‘decarbonised hydrogen’ in the industrial, transport and gas sectors addressing the entire value chain including generation, storage, transport, distribution and end-use. The deployment of hydrogen is planned to be integrated within the energy system, e.g. taking into account its complementarities with battery storage. The plan is phasing the deployment of hydrogen production with electrolyzers first using electricity from the existing electricity generation park and then progressively shifting to more variable renewable sources. It is also phasing the deployment and adaptation of the infrastructure, and the development of hydrogen end-use across the different sectors.

According to its NECP, France considers the current decade as a preparation period for a massive deployment of hydrogen as of 2030. France will first focus on decarbonising existing industrial uses of hydrogen, like in the refinery, iron and steel, ammonia, plastics, and glass sectors.

France considers different ways to produce low carbon hydrogen: with electrolyzers using nuclear or renewable electricity or through steam methane reforming using fossil fuels coupled with CCS.

According to its NECP, France considers hydrogen produced from electricity as a long-term solution to integrate an increasing share of renewable electricity into the system, by providing the required flexibility to balance the system. It is also recognised as a promising solution for seasonal storage. France foresees to use its geological salt cavern formations to store hydrogen generated from Power-to-Gas installations. The gas infrastructure will in France continue to play an important role to ensure security of energy supply and provide flexibility to the electricity system via short-term storage of energy; it will also facilitate the integration of renewable electricity through power-to-gas, and enable the development, transport and storage of renewable gases.

According to its NECP, France plans to further analyse the impact of blending hydrogen into the natural gas infrastructure on the network and the different types of end-users, in order to establish appropriate technical and regulatory specifications to facilitate the direct injection of hydrogen.

The Clean Mobility Development Strategy foresees to deploy alternative fuel infrastructure, including the installation of hydrogen refuelling stations and delivery equipment in ports. The deployment of this infrastructure will be organised following the logic of “captive fleets”, prioritising the installation of infrastructure in areas with demand pulled by large fleets. The hydrogen plan aims at deploying territorial ecosystems, starting with professional fleets. France will focus on the deployment of fuel cell vehicles (light and heavy duty), and on the use of hydrogen in the navigation, rail and aviation sectors.

The French NECP mentions only a limited number of the measures foreseen in the hydrogen plan, such as:

- Implementing a support scheme with a budget of 100 million EUR (through tendering for hydrogen mobility and low carbon electrolyzers projects);
- Maintaining the tax advantages for the acquisition of hydrogen driven vehicles;
- Simplifying the regulatory framework for the use of hydrogen for vessels.

According to the French NECP, R&D is a key pillar to ensure the competitiveness of hydrogen in the medium and long term, by improving the applications and technologies, in particular the efficiency of electrolyzers, storage material, etc. through pilot and demonstration projects.



<sup>14</sup> [https://www.ecologique-solidaire.gouv.fr/sites/default/files/Plan\\_deploiement\\_hydrogene.pdf](https://www.ecologique-solidaire.gouv.fr/sites/default/files/Plan_deploiement_hydrogene.pdf)

<sup>15</sup> <https://www.conseil-national-industrie.gouv.fr/>

<sup>16</sup> <https://www.economie.gouv.fr/files/files/PDF/2018/dp-cni-221118.pdf>

# OPPORTUNITY ASSESSMENT

## Hydrogen production potential & its role in energy system flexibility

Since the technical potential of variable renewable electricity production in France is more than five times higher than its expected electricity demand in 2030, there is a great opportunity to use this renewable electricity potential to produce hydrogen via electrolysis. According to its draft NECP, France would by 2030 use up to 6% of its technical potential in renewable electricity generation, so there is a great margin for building up additional dedicated renewable electricity sources for hydrogen production.

The existence of nuclear power generation capacity in France 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.

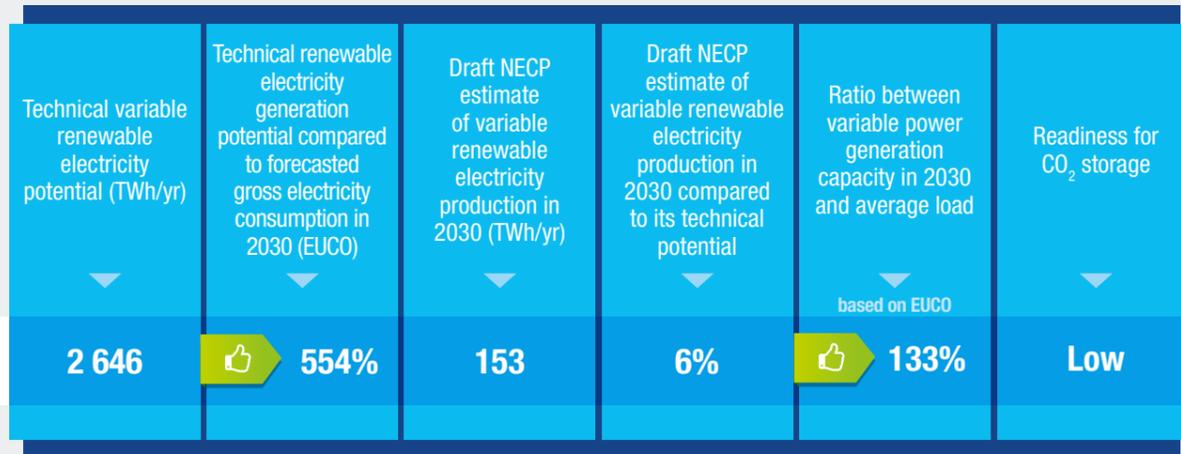
There is also an opportunity to use power-to-hydrogen production and storage facilities as a flexibility provider for the energy system. Even though the flexibility needs are in France relatively limited when compared to electricity demand, the absolute volume of needed flexibility will still be quite high and create opportunities for various flexibility providers, including hydrogen installations, although part of the flexibility needs can also be covered by the interconnection capacity with other markets – which is quite high, especially when compared to the expected installed variable renewable power generation capacity in 2030.



## Energy infrastructure

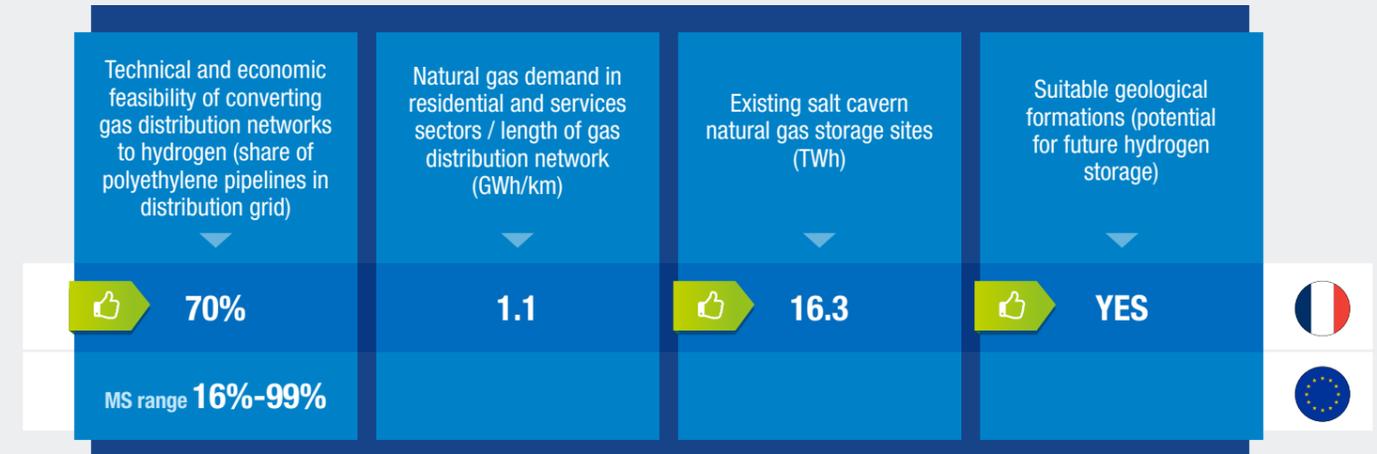
France considers using its existing methane infrastructure for hydrogen transport and distribution, by blending hydrogen in the public grid. France can also consider converting (part of) its network to hydrogen in the long term (>2040). As the share of polyethylene in the distribution network is relatively high, it could be converted to hydrogen at relatively low cost. However,

conversion of the networks to dedicated hydrogen pipelines would be a longer-term consideration. In the short and medium term, the production of hydrogen will still be rather low and it could hence be blended with methane in the existing grid, without the need for physical adjustments to the transport and end-use infrastructure.



France has limited readiness for wide-scale deployment of CCS. Even though France hosts one of the few existing large-scale CO<sub>2</sub> capture & utilization

facilities, there are only limited signs of progress towards wide-scale utilization of CO<sub>2</sub> storage.



There is an important salt cavern natural gas storage capacity in France, that could be used for hydrogen storage. France has also large underground salt layers that could provide additional gas storage opportunities (in the two main mountainous regions and in the

extreme East part of the country). The availability of suitable formations to develop storage sites for seasonal hydrogen storage represents an opportunity for France and offers it a competitive advantage compared to other Member States.



## Current and potential gas & hydrogen demand

In France, there is a considerable potential for the deployment of hydrogen across sectors. In industry, the deployment of renewable or low-carbon hydrogen in ammonia production and refineries can help to reduce the GHG emissions associated with existing fossil-based hydrogen use. More generally, hydrogen deployment can contribute to the decarbonisation of the gas supply in industry and act as a low-emission solution for the provision of high-temperature process heat. In the built environment, hydrogen provides the

opportunity to replace the existing natural gas use, thereby significantly reducing the GHG emissions in this sector. Lastly, there are opportunities to deploy hydrogen for a range of applications in the transport sector. Together with electrification, hydrogen is one of the promising solutions for the decarbonisation of road and rail transport. On the medium to long term, hydrogen and derived fuels can also be used to decarbonise shipping and aviation.



### Opportunities for hydrogen demand in industry

In France, the opportunities for the deployment of hydrogen in industry are considerable. First of all, French industry has a substantial market share in Europe's ammonia production and refinery capacity. These industries already consume fossil-based hydrogen, which could be replaced by renewable or low-carbon hydrogen. Next to this, gas accounts for almost two fifths of the industrial energy mix and the deployment of decarbonised hydrogen is one of the ways to decarbonise the gas supply. Furthermore, a large

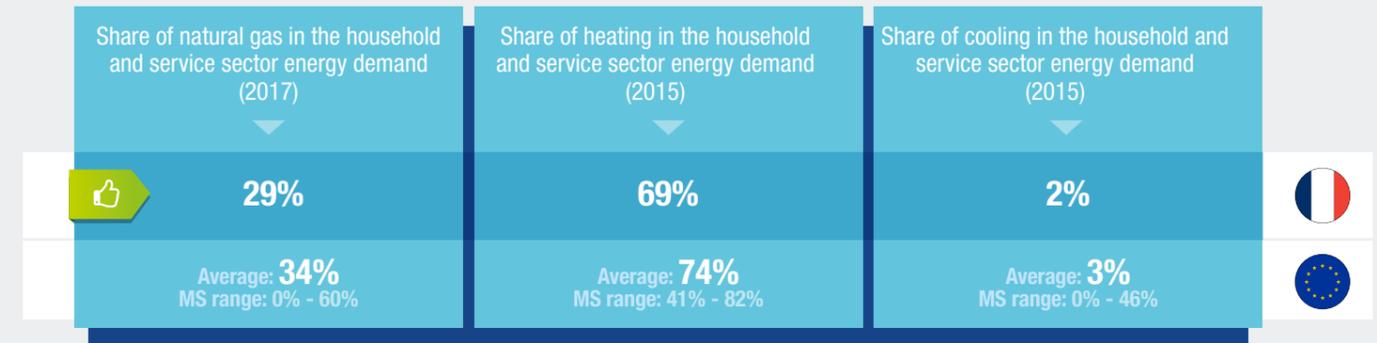
share (36%) of the industrial energy consumption in France is used for the generation of high-temperature process heat. Hydrogen is one of the low-emission energy carriers that is well-suited for the generation of high-temperature heat. Lastly, the French steel sector, which is responsible for 11% of the primary steel production in the EU can be decarbonised through the switch from conventional fossil-based steelmaking processes to a process where direct reduction iron is produced using hydrogen.



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

In the built environment of France, natural gas accounts for almost 30% of the final energy demand and almost 40% of the heating demand. Therefore, hydrogen could play a substantial role in the decarbonisation of heating in the French residential and service sectors. Furthermore, around 17% of the heating demand in France is still supplied by oil-fired boilers. Together with electrification, hydrogen can be one of the solutions

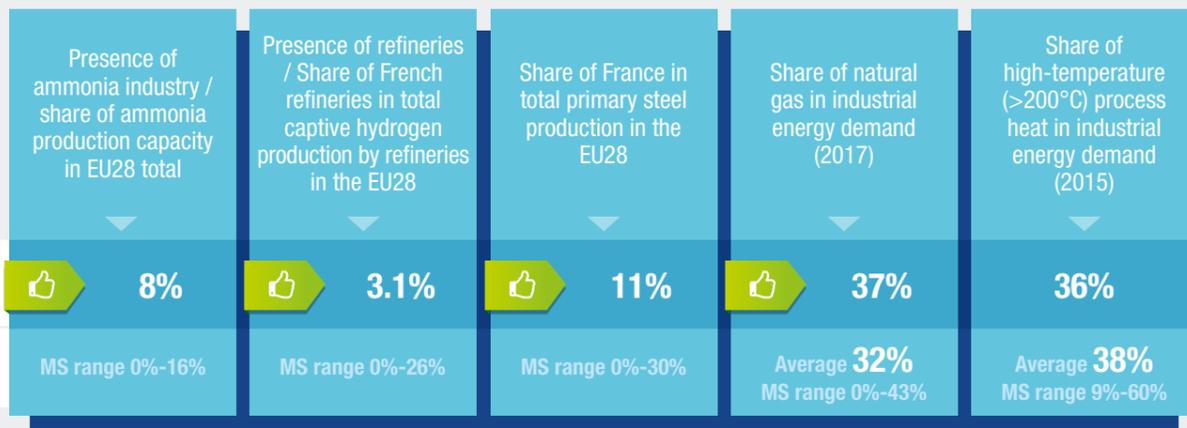
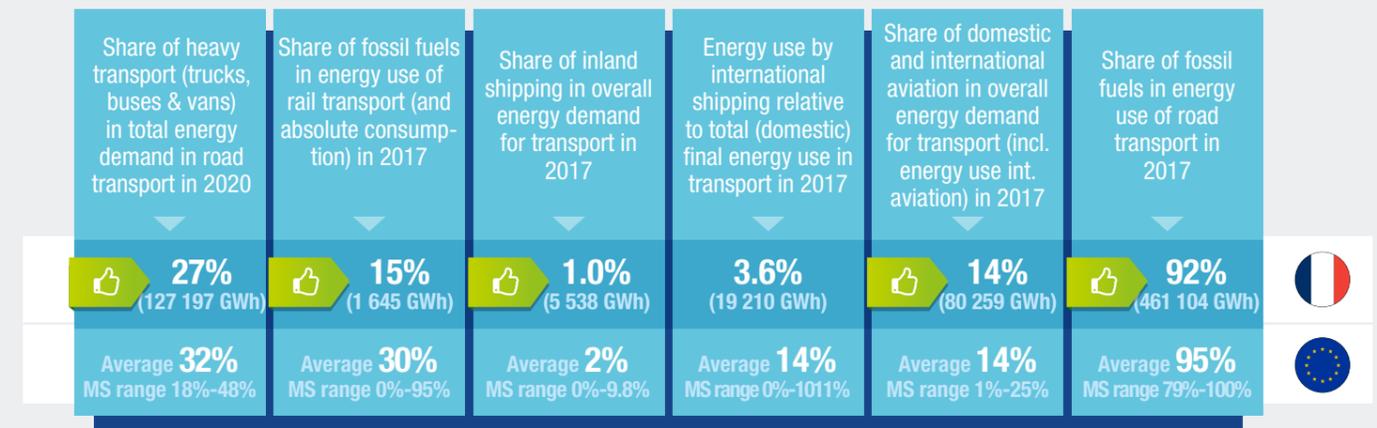
to decarbonise this part of the heat supply in the built environment. Cooling still accounts for a relatively minor share of the final energy demand in the built environment in France, but this share is expected to grow in the future. In some cases, hydrogen-based technologies can also be deployed as a low carbon solution for cooling.



### Opportunities for hydrogen demand in transport

Like in most EU countries, the transport sector in France holds significant opportunities for the deployment of hydrogen. First of all, hydrogen can play a role in the decarbonisation of road transport, especially for light commercial vehicles (vans) and heavy-duty vehicles. In its hydrogen roadmap, France has already included some specific targets relating to the use of hydrogen in road transport. In the light-duty vehicle segment there should be around 5000 hydrogen vehicles on the road by 2023, growing to 20 000-50 000 in 2028. For heavy-duty transport, the aim is to have 200 hydrogen vehicles on the road by 2023 and between 2000 and 8000 in 2028. Although the largest part of the French

rail sector is electrified, diesel still accounts for 14% of the sector's energy use, which amounts to a total of 1645 GWh. Next to electrification, hydrogen is one of the solutions for replacing these diesel trains with a low-emission alternative. The French rail operator SNCF already made a first step in this direction by ordering 15 hydrogen trains. Although the shipping sector does not have a large share in the total energy use in the French transport sector, it is a sector that is relatively hard to decarbonise, and hydrogen and derived fuels can provide a solution. On the medium to long run, hydrogen and derived fuels can also be deployed to decarbonise the aviation sector.





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

The assessment shows that France is in a favourable position for the deployment of low carbon hydrogen in the current decade and beyond, also thanks to its research and innovation community and industry which are tackling the challenges of this early stage technology.

Furthermore, France has launched in 2018 its hydrogen plan which will provide an integral strategy for the deployment of hydrogen and its implications for the different parts of the energy system and demand sectors.

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

In its “hydrogen deployment plan for the energy transition”<sup>17</sup>, France provides a comprehensive framework to support hydrogen. It comprises several objectives to enhance the deployment of hydrogen through power-to-gas and enable hydrogen use in transport (for example, by installing 400 to 1 000 refuelling stations by 2028). It also includes several measures to stimulate hydrogen deployment: support for the development of hydrogen (up to €100 million); guarantees of origin for decarbonised hydrogen production; financial incentives for the purchase of hydrogen vehicles; standardisation of co-financing models for ecosystem deployment projects; simplification and harmonisation of licensing and certification procedures for refuelling infrastructure.

France’s hydrogen plan also considers the use of hydrogen for low-carbon heating and cooling in buildings as one of the eight innovation challenges.

Positive environment

✓

<sup>17</sup> [https://www.ecologique-solidaire.gouv.fr/sites/default/files/Plan\\_deploiement\\_hydrogene.pdf](https://www.ecologique-solidaire.gouv.fr/sites/default/files/Plan_deploiement_hydrogene.pdf)

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

Complying with its 2030 non-ETS target (trajectory to reach carbon neutrality by 2050) would require the implementation of additional policies that keep emissions within the carbon budgets proposed in the National Low-Carbon Strategy. These additional policies are not yet clearly defined. With existing policies and measures only, France would fall short of its 2030 non-ETS target by 11 percentage points. Notwithstanding ambitious objectives for the transport and building sectors, specific policies need to be further defined. Therefore, higher hydrogen objectives could be one of the additional measures to be considered for these targeted sectors.

Positive environment

✓

**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)		
In its National Policy Framework (or NPF set in the context of the alternative fuel infrastructure directive (2014/94/EU)), France has committed to promote the deployment of hydrogen refuelling infrastructure and to fund projects in this field. The French NPF comprises several hydrogen related measures, of which the great majority is already implemented.		
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	33	1 600 299
	Total 156	Average 1 677 543

Existence of (investment on) hydrogen-related projects			
There were in 2019 33 hydrogen refuelling stations in operation in France, which is the first step in the construction of hydrogen corridors (which implies strong regional coordination). The French R&D budget for hydrogen is among the highest in the EU, showing the commitment to strongly invest in research and innovation in this versatile technology. There are at present at least 7 hydrogen projects in operation.			
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	33.1	YES	7

Positive environment

Existence of national tax incentives (CO<sub>2</sub> pricing mechanisms & car taxation)

France has set up a CO<sub>2</sub> pricing mechanism in 2014 and has introduced carbon related taxation for vehicles, which are key to support the progressive shift to low carbon vehicles (including on hydrogen).



Fossil energy import bill

Like many EU Member States, France 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, heating and transport applications will contribute to reducing the energy import dependence and bill.

Import bill for natural gas as share of national Gross Value Added

0.4%

Average: 0.6%  
MS range: 0% - 1.5%

Import bill for all fossil fuels

1.9%

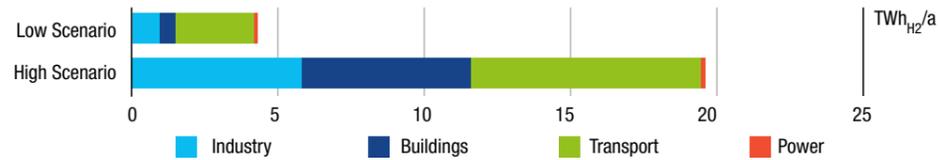
Average: 2%  
MS range: 0% - 7%



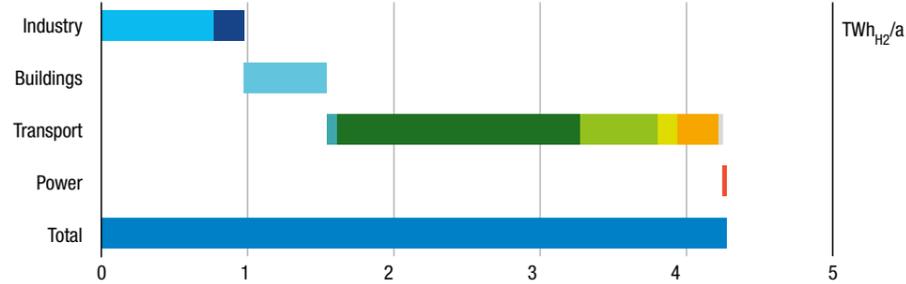
# SCENARIO ASSESSMENT

## Estimated renewable/low carbon hydrogen demand for France 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).

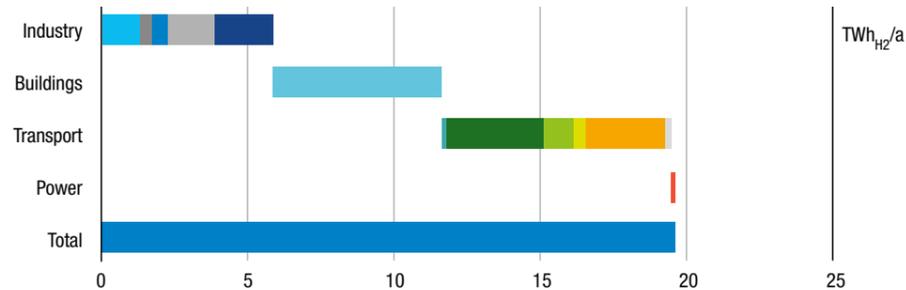


### Low scenario



In the low scenario, renewable hydrogen accounts for 0.3% of final total energy demand (i.e. 4.3 out of 1459 TWh/a) or 1.7% of final gas demand (255 TWh/a) according to EUCO3232.5.

### High scenario



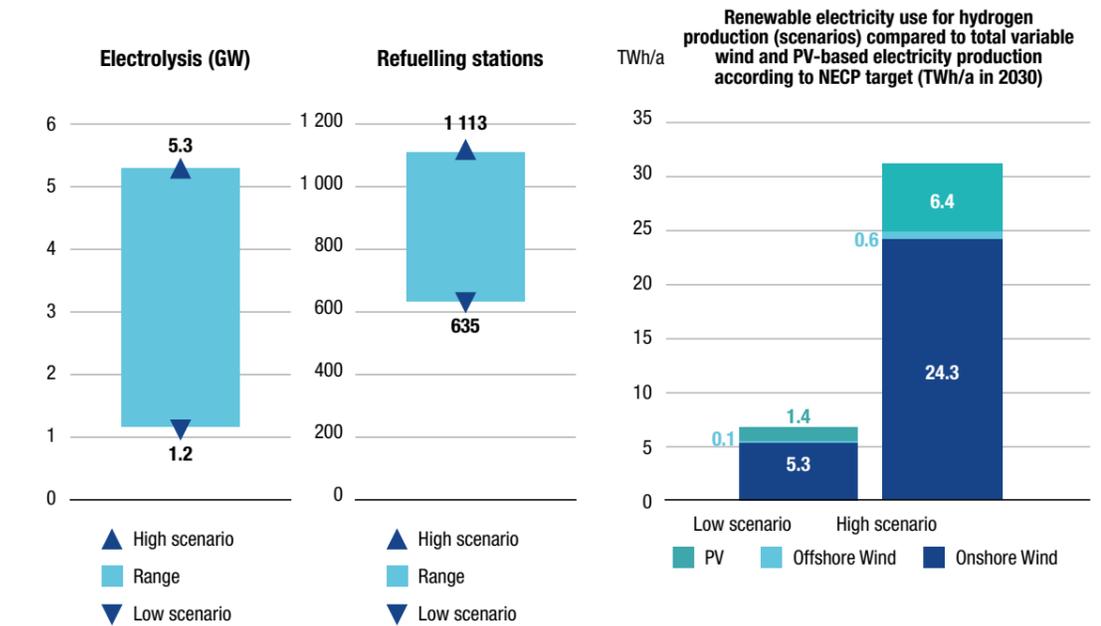
In the high scenario, renewable hydrogen accounts for 1.3% of final total energy demand (i.e. 19.6 out of 1 459 TWh/a) or 7.7% of final gas demand (255 TWh/a) according to EUCO3232.5.



## Hydrogen generation, infrastructure and end users in France 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 0.4% of the overall technical renewable power potential in the low scenario and for 1.7% in the high scenario.

### End users

End user	Unit	Low scenario	High scenario
Passenger cars	N°	351 700	703 400
Buses	N°	1 200	2 410
Lorries	N°	44 600	89 200
Heavy duty vehicles	N°	1 370	2 740
Trains	N°	60	181
Substituted fuel in aviation	GWh/a	187	1 780
Substituted fuel in navigation	GWh/a	14.4	137.2
Micro CHP	N°	26 540	115 460
Large CHP	N°	30	290
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 640-1 100 stations for 399 000-798 000 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.

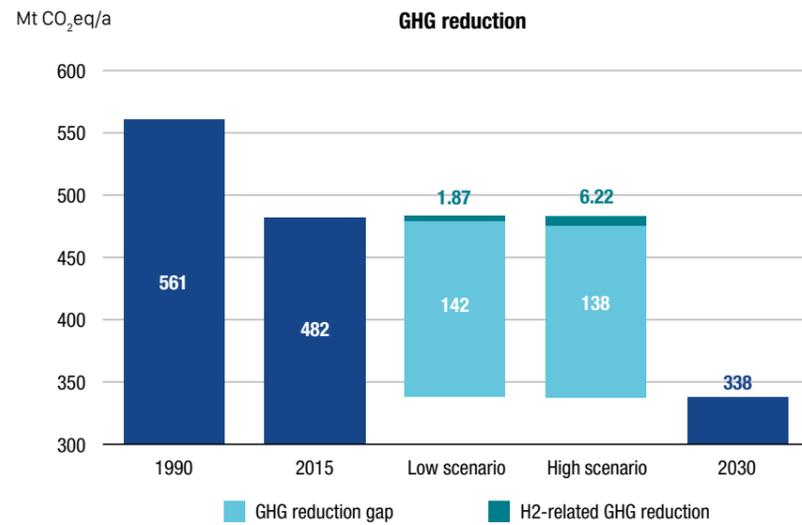
Further use of renewable hydrogen is foreseen in methanol production (up to 5%) and in ammonia production (up to 5%).

Finally, the introduction of 26 570-115 750 stationary fuel cells for combined power and heat production is estimated.

# Environmental and financial impact in France 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.

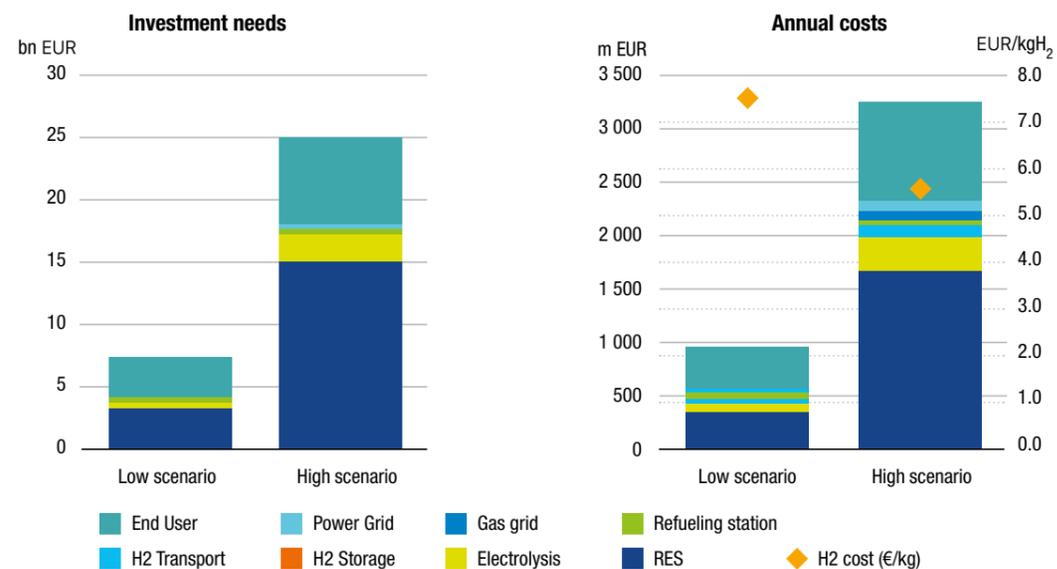
## Environmental impact



An additional GHG emission reduction of 1.9-6.2 Mt CO<sub>2</sub> is estimated in 2030 corresponding to 1.3%-4.3% 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 7.3-25.1 billion EUR until 2030, while annual expenditure would amount to 960-3 260 million EUR (including end user appliances as well as power and gas grids).

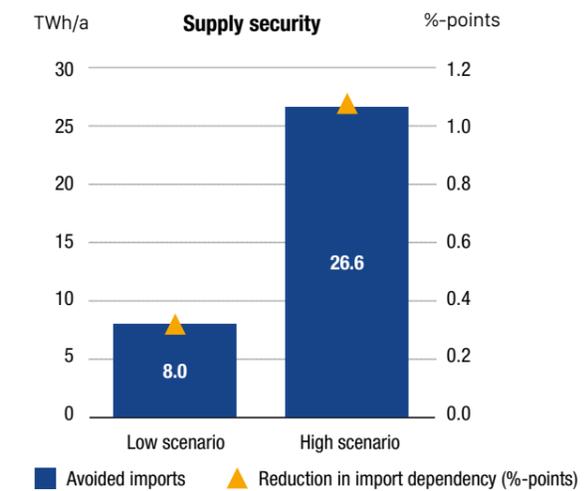


# Impact on security of supply, jobs and economy in France by 2030

Hydrogen contributes to the 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 8.0-26.6 TWh/a of avoided imports, and thus reduce import dependency by 0.3-1.1% (in volume terms) in 2030, depending on the scenario.



## Impact on employment and value added

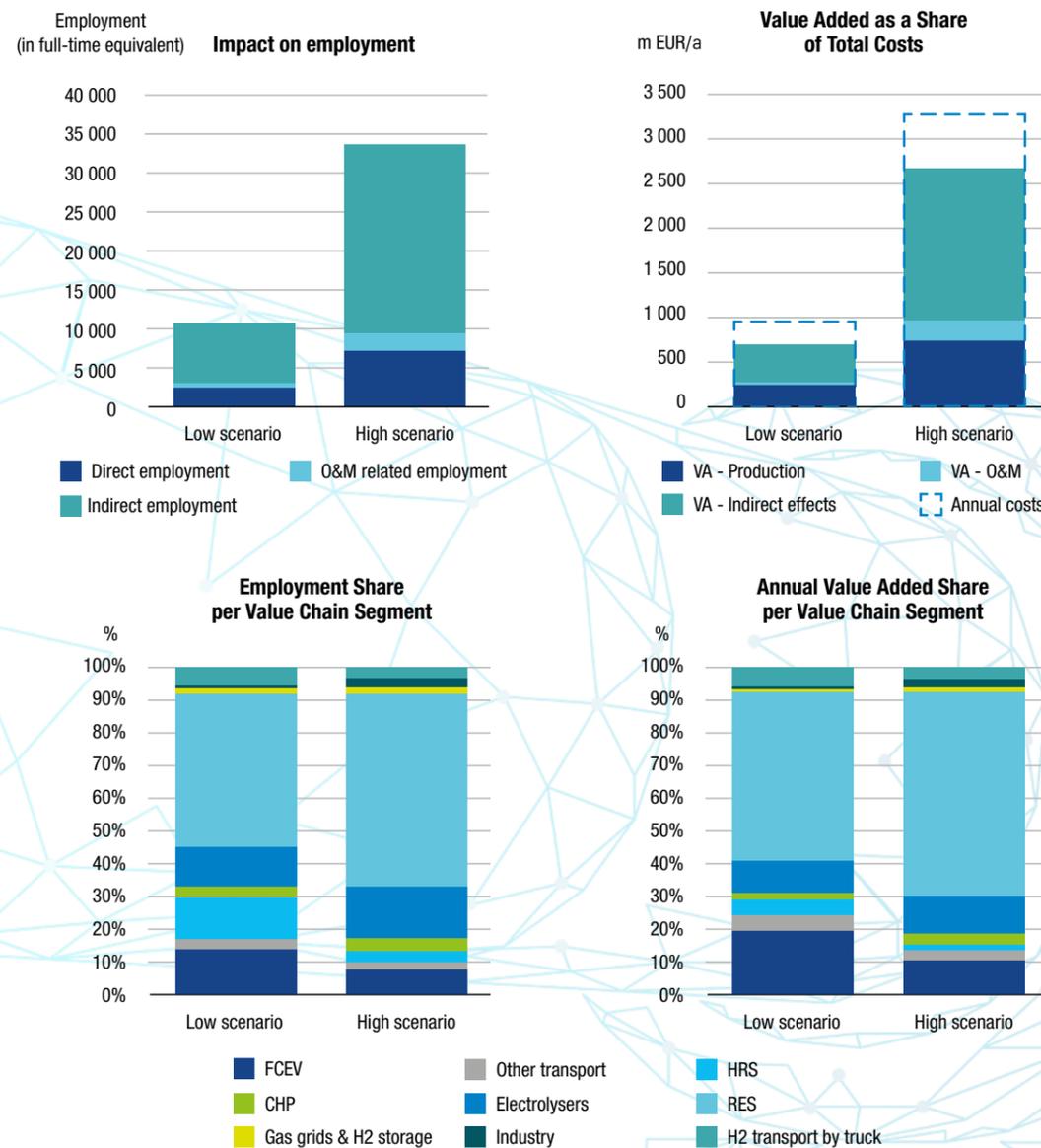
This analysis shows that in the years 2020-2030 around 275 million EUR can be retained annually in the domestic economy as value added in the low scenario, and almost 990 million EUR in the high scenario (value added is defined here as sum of wages for employees, margins for companies and taxes). If the indirect effects induced by the investment in and operation of hydrogen technologies are also taken into account, around 670 million EUR (low scenario) and over 2 680 million EUR (high scenario) of value added can be created in the French 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 and operating dedicated renewable electricity sources and electrolysers for hydrogen production and in the automotive industry.

The hydrogen-related expenditures in 2020-2030 are estimated to generate employment of 2 620 – 9 400 direct jobs (in production and operations & maintenance) and contribute to a further 7 760 – 24 200 indirectly related jobs, depending on the scenario. Most of these jobs are expected to be created by building and operating dedicated renewable electricity sources and electrolysers for hydrogen production, in the automotive industry and by building and operating hydrogen refuelling stations.



FRANCE

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





**FUEL CELLS AND HYDROGEN**  
JOINT UNDERTAKING



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