GREECE

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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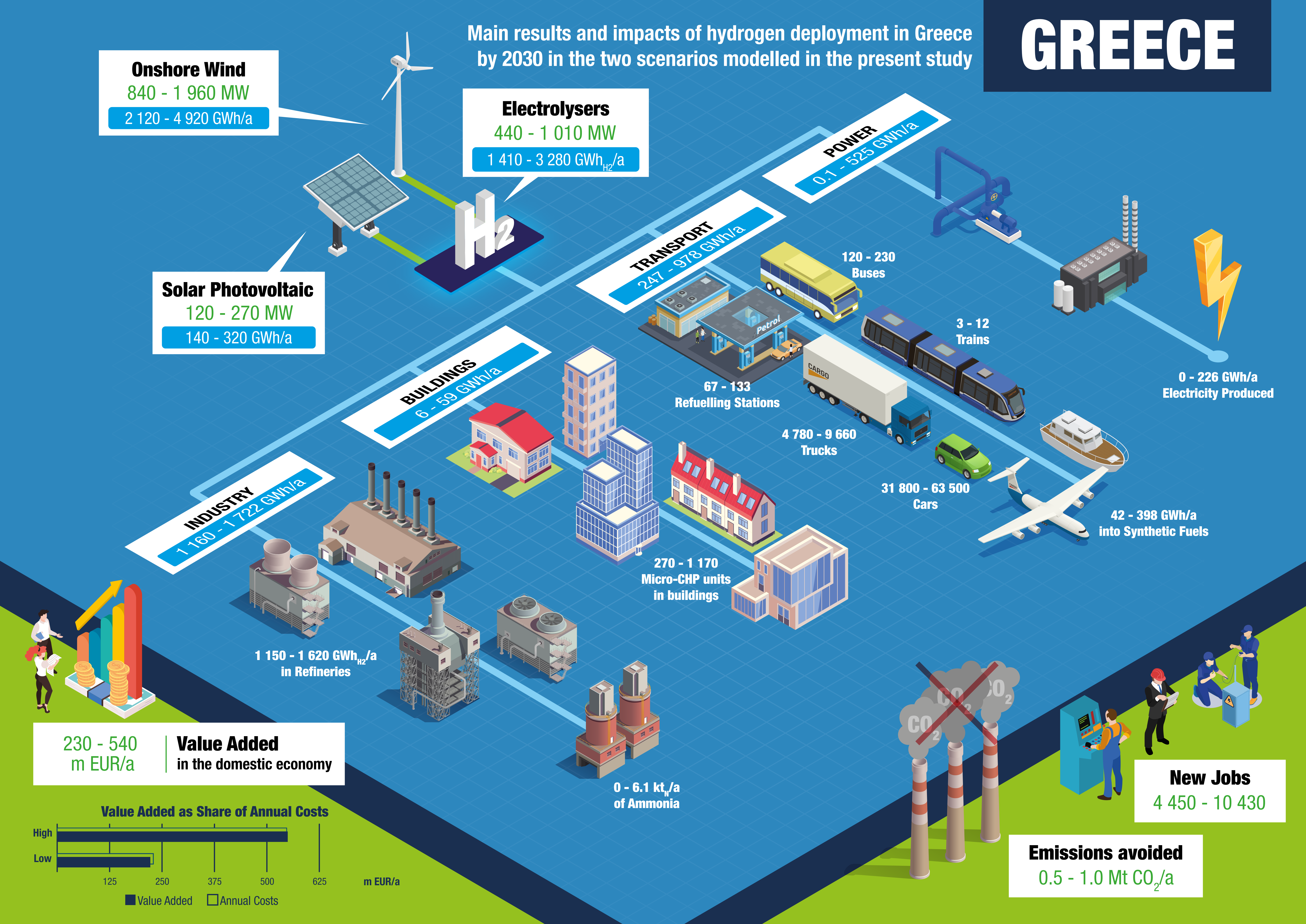
Table of content

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.


GREECE
Main results and impacts of hydrogen deployment in Greece by 2030 in the two scenarios modelled in the present study
Onshore Wind
840 - 1 960 MW
2 120 - 4 920 GWh/a
Electrolysers
440 - 1 010 MW
1 410 - 3 280 GWh_{H2}/a
Solar Photovoltaic
120 - 270 MW
140 - 320 GWh/a
POWER
0.1 - 525 GWh/a
TRANSPORT
247 - 978 GWh/a
BUILDINGS
6 - 59 GWh/a
INDUSTRY
1 160 - 1 722 GWh/a
120 - 230
Buses
3 - 12
Trains
67 - 133
Refuelling Stations
4 780 - 9 660
Trucks
31 800 - 63 500
Cars
0 - 226 GWh/a
Electricity Produced
42 - 398 GWh/a
into Synthetic Fuels
270 - 1 170
Micro-CHP units
in buildings
1 150 - 1 620 GWh_{H2}/a
in Refineries
0 - 6.1 kt_N/a
of Ammonia
230 - 540
m EUR/a
Value Added
in the domestic economy
Value Added as Share of Annual Costs
High
Low
125
250
375
500
625
m EUR/a
Value Added
Annual Costs
New Jobs
4 450 - 10 430
Emissions avoided
0.5 - 1.0 Mt CO_2/a

EXECUTIVE SUMMARY

Greece’s commitment for hydrogen deployment according to its NECP

According to its NECP, Greece’s approach to develop hydrogen as low-carbon solution comprises the following pillars: hydrogen production from renewable electricity; hydrogen use to decarbonize the transport sector (mainly shipping); long term hydrogen storage for power generation; use of existing gas infrastructure for hydrogen transport; stimulate hydrogen related RD&I. As stated in its NECP, *“Hydrogen is a future solution, although it is currently at an early stage of development. It is noted that Greece has a significant track record in scientific investigation and research in the field of hydrogen production from RES”*.

Greece is in a positive starting position given its scientific knowledge and economic activity, its potential to further deploy renewable electricity production, the involvement of some regions and cities[1] in deploying hydrogen projects and initiatives, and its activity in the maritime sector. Greece is involved in the White Dragon[2] IPCEI project, but was not involved in the HyLaw project, and could possibly carry out a similar assessment to identify and address its national barriers to the deployment of hydrogen.

Greece considers hydrogen as a longer-term option. Its NECP provides neither concrete hydrogen targets, nor hydrogen specific policies and measures.

The scenario assessment shows substantial potential benefits of hydrogen deployment in Greece 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 Greece, a limited development of hydrogen demand is assumed in **transport**, especially for passenger cars, buses, trucks, and also, through hydrogen-based liquid fuels or PtL, in aviation and navigation[3]. A limited development of hydrogen demand is also assumed in the considered scenarios in **industry**, especially in refining, and in the high scenario in ammonia industry as well. These 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 a very limited demand of hydrogen by 2030.

The scenarios assume that Greece will be one of the early adopters of using hydrogen for power generation, although the produced electricity volumes will be still limited by 2030.

Hydrogen production

To cover the estimated hydrogen demand from new uses and from substitution of fossil-based hydrogen, 1 to 2.2 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, Greece estimates an installed capacity in 2030 of 7.05 GW in wind and 7.73 GW in solar PV, generating over 29 TWh of renewable electricity in 2030. The technical potential for renewable electricity production in Greece seems however significantly higher[4]. 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 230 and 540 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, such as refining. According to the European EUCO3232.5 scenario[5], the Greek GHG emissions should be reduced by 45 Mt CO_2 in 2030, compared to 2015. In the scenarios considered, the deployment of hydrogen could contribute 0.5 – 1 Mt CO_2 to this goal, which is equivalent to 1% - 2% of the required emission reduction.

[1] *https://ec.europa.eu/energy/sites/ener/files/documents/3-0_fchju_biebuyck.pdf*
[2] *https://static1.squarespace.com/static/5d3f0387728026000121b2a2/t/5da472e9ff3f1e0b334d5e3b/1571058415654/White+Dragon+poster.pdf*
[3] *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*
[4] *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).*
[5] *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 GREEK NECP

Greece considers hydrogen as a future solution, although at an early stage of development. Greece is already active in scientific investigation and research in the production of hydrogen from RES.

Greece has an important scientific potential to monitor and participate in projects focusing on using hydrogen as a fuel in the shipping sector, in targeted areas/applications (e.g. barges at terminals or hydrogen-electric ferries). A prominent example is an initiative to construct and operate a hydrogen/electric ferry. As the use of hydrogen for seagoing vessels results in a significant reduction of the useful capacity of ships and requires a complex and rather expensive investment, this is still a challenge that is expected to be addressed by the research community, possibly in cooperation with and support from the domestic maritime industry.

Innovative RES technologies that can contribute to the further exploitation of the domestic renewable energy potential will be considered and promoted mainly in the form of pilot applications: production of hydrogen from RES is one of the applications that will be further analysed. The policies and measures to promote research and innovation, and especially the development of integrated local and regional energy systems, include support for innovative actions relating to electric vehicles and their charging strategies, while the emphasis will be on renewable hydrogen. In view of the deployment of advanced liquid and gaseous biofuels, the production of renewable hydrogen from water electrolysis and RES electricity will be promoted.

There is also an interest in storing hydrogen produced via electrolysers; in this concept electricity and gas systems would be coupled. The first electrolysis systems are expected to operate by 2030, allowing the power generation sector to be coupled to the hydrogen production sector, with a view to storing energy. Accordingly, the development of RES fuels (particularly hydrogen) for large-scale energy storage is estimated to remain limited up to the year 2030 but is expected to grow in the longer term.

An objective mentioned in the NECP is a higher and more efficient coupling of the energy supply and consumption sectors, with an emphasis on maximising the use of RES. The possibility of injecting hydrogen or synthetic methane produced from RES into the natural gas grid is an example of sector coupling. To this end, the sustainability and efficiency of such a scheme will be assessed and measures and policies will be taken where appropriate.

According to its NECP, Greece considers the system of Guarantees of Origin for biogas and hydrogen as an appropriate measure to stimulate the use of renewable gases.

OPPORTUNITY ASSESSMENT

Hydrogen production potential & its role in energy system flexibility

The Greek technical potential of variable renewable electricity generation is more than ten times higher than its forecasted electricity demand in 2030. The expected variable renewable electricity capacity in 2030 is also substantially higher than the average load in the same year. Based on these projections, there is a strong opportunity to use potential surpluses in renewable electricity generation to produce hydrogen, especially given that the electricity interconnection level with neighbouring countries is expected to remain limited, compared to the overall renewable electricity production capacity. According to the NECP, Greece would in 2030 use only 4% of its technical potential in variable renewable electricity generation, so there is also a great margin for building up dedicated renewable electricity plants for hydrogen production via electrolysis.

Increasing deployment of variable renewable electricity generation also means that the system flexibility needs are forecasted to be significant. This constitutes an important opportunity for Greece to use power-to-hydrogen installations and hydrogen storage as a system flexibility provider.

	Technical variable renewable electricity potential (TWh/yr)	Technical renewable electricity generation potential compared to forecasted gross electricity consumption in 2030 (NECP)	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 NECP)	Readiness for CO_2 storage
Greece	720	1 276%	29.28	4%	271%	Low

Greece has limited readiness for wide-scale deployment of CCS. Although it has potentially suitable sites for CO_2 storage and there are plans to use CCS technologies by 2030, the practical feasibility of such activities has not been extensively studied yet.

Energy infrastructure

Greece can consider using its existing methane infrastructure for hydrogen transport and distribution, by blending hydrogen in the public grid in the short (2025-2030) and medium term (2030-2040) and potentially converting (part of) its network for dedicated hydrogen use in the long term (>2040). As most of the distribution network is made up of polyethylene, it could be converted to hydrogen at relatively low cost. However, conversion of the network to dedicated hydrogen pipelines would be a longer-term consideration, as the hydrogen production volumes are expected to remain 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, distribution 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)
Greece	77%	1.0	0	NO
EU	MS range 16%-99%			

To date, there are no salt cavern natural gas storage sites in Greece that could be used for hydrogen, nor underground salt layers that could provide suitable storage opportunities for hydrogen.

Current and potential gas & hydrogen demand

The indicators show there is a large opportunity for the use of hydrogen and derived fuels in the effort to decarbonise the transport sector, which is still heavily dependent on fossil fuels. Especially in rail and road transport, there seems to be substantial room for the deployment of hydrogen as a decarbonisation solution. Additionally, there is also significant potential for the deployment of hydrogen and derived fuels to decarbonise domestic and international shipping. Next to its role in the transport sector, there are also opportunities for the deployment of hydrogen in industry. There, hydrogen can be used to replace existing use of fossil-derived hydrogen, decarbonise the gas supply and act as an energy carrier for the generation of high-temperature process heat.

Opportunities for hydrogen demand in industry

The indicators show that Greece has significant potential for hydrogen use in industry. First of all, the country has ammonia industry and refineries, both of which currently use fossil-derived hydrogen. Although the production capacities of these facilities are relatively low, they represent an opportunity for the deployment of renewable or low carbon hydrogen to replace the current use of fossil-derived hydrogen. Next to this, natural gas, which accounts for one fifth of the industrial energy demand in Greece, can be replaced relatively easily with renewable or low-carbon hydrogen as a decarbonisation solution. Furthermore, 32% of the energy demand in industry is used to generate heat for high-temperature processes. Hydrogen is one of the low-emission energy carriers that is well-suited for the generation of high-temperature heat.

	Presence of ammonia industry / share of ammonia production capacity in EU28 total	Presence of refineries / Share of Greek refineries in total captive hydrogen production by refineries in the EU28	Share of Greece 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)
Greece	1%	3%	0%	21%	32%
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

The opportunity for using hydrogen for heating in the residential and services sectors in Greece is rather limited, as natural gas has a low share in the energy mix of these sectors (only 8%). In Greece, demand for heating accounts for three quarters of the energy use in the built environment and this heat is primarily generated by oil-fired boilers, electric boilers or the combustion of biomass. Decarbonised hydrogen can be used to replace the current use of natural gas in the built environment and on the long term, hydrogen might also replace oil for heating. This would require either investments in new dedicated hydrogen grids or the hydrogen could be supplied through other distribution means (e.g. transport by truck). Given the limited use of gas, the latter is more likely. Furthermore, there is a significant demand for cooling in Greece, which is nowadays primarily satisfied with electric air conditioning. In the future, hydrogen-based cooling technologies might also play a role in satisfying the (increasing) demand for cooling.

	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)
Greece	8%	57%	13%
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

Like most EU countries, Greece has a large potential for hydrogen use in road transport. Around a third of the energy use in this sector is consumed by trucks, buses and light commercial vehicles (e.g. vans). Since electrification of utility vehicles remains challenging, there is a significant opportunity for hydrogen to decarbonise this part of road transport in Greece. Next to this, diesel trains account for over 70% of the energy use in the Greek rail sector. A switch to hydrogen trains is one of the solutions that can help to reduce the GHG emissions from rail transport. Furthermore, hydrogen could also play a role in the decarbonisation of the energy mix in the shipping sector. Due to the large number of islands, domestic shipping accounts for almost 10% of the total transport demand (which is the highest share in the EU), so in order to fully decarbonise the transport sector in Greece, a switch to low-carbon fuels in the shipping sector is essential. Hydrogen and derived fuels are amongst the most feasible solutions to decarbonise this sector. On the medium to long term, these energy carriers can also be used to decarbonise the fuel used by international ships, which consume an equivalent of almost 40% of the total energy use for domestic transport in the country and for the decarbonisation of 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
Greece	34% (22 027 GWh)	72% (462 GWh)	10% (6 630 GWh)	37% (24 821 GWh)	13% (18 104 GWh)	97% (56 132 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

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Greece is in a positive starting position given its scientific knowledge and economic activity, its potential to further deploy renewable electricity production, the involvement of some regions and cities[6] in deploying hydrogen projects and initiatives, and its activity in the maritime sector. Greece is involved in the White Dragon[7] IPCEI project, but was not involved in the HyLaw project, and could possibly carry out a similar assessment to identify and address its national barriers to the deployment of hydrogen.

Greece considers hydrogen as a longer-term option. Its NECP provides neither concrete hydrogen targets, nor hydrogen specific policies or measures. The assessment shows that Greece has not set up yet a comprehensive framework for the deployment and use of hydrogen but is demonstrating an interest and considering hydrogen as a future solution. Greece's NECP does not fix any objective to produce or use hydrogen, though it does show interest in electricity-to-hydrogen conversion, in storage applications, in using hydrogen in the transport sector and in using its natural gas infrastructure for hydrogen transport. Greece could leverage efforts taken by cities and regions setting up hydrogen initiatives. Greece could also consider setting up a national association for hydrogen to provide support in structuring the preparation of a specific roadmap for hydrogen. In the meantime, it would be appropriate that Greece takes further steps to launch, where appropriate, pilot and demonstration projects, which can contribute to paving the way for the use of renewable or low-carbon hydrogen as a means to achieve deep decarbonisation.

[6] https://ec.europa.eu/energy/sites/ener/files/documents/3-0_fchju_biebuyck.pdf
[7] https://static1.squarespace.com/static/5d3f0387728026000121b2a2/t/5da472e9ff3f1e0b334d5e3b/1571058415654/White+Dragon+poster.pdf

	Positive environment
Existence of (or concrete plans for) national hydrogen roadmaps or strategies	Limited
GHG mitigation gap in non-ETS sectors (need for additional GHG reduction measures)	✕
Existence of (active) hydrogen national association	✕

Current and planned hydrogen refuelling infrastructure for the transport sector

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
NO	0	Not applicable

Existence of (investment on) hydrogen-related projects

A few ongoing projects are in place, including a pilot unit for renewable hydrogen production which comprises a wind park (CRES in Kerata), an electrolyser and a hydrogen filling station[8] (EC funded RES2H2 project[9]). Greece will host the 4th International Workshop on Degradation Issues of Fuel Cells and Electrolysers[10] (date to be defined).

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	0.0	NO	0

[8] http://www.cres.gr/kape/present/labs/hydro_1_uk.htm
[9] https://www.res2h2.com/
[10] https://hydrogeneurope.eu/events/4th-international-workshop-degradation-issues-fuel-cells-and-electrolysers

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

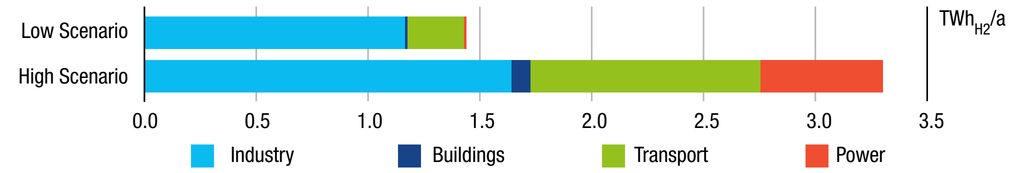
Fossil energy import bill

Like many EU Member States, Greece 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.

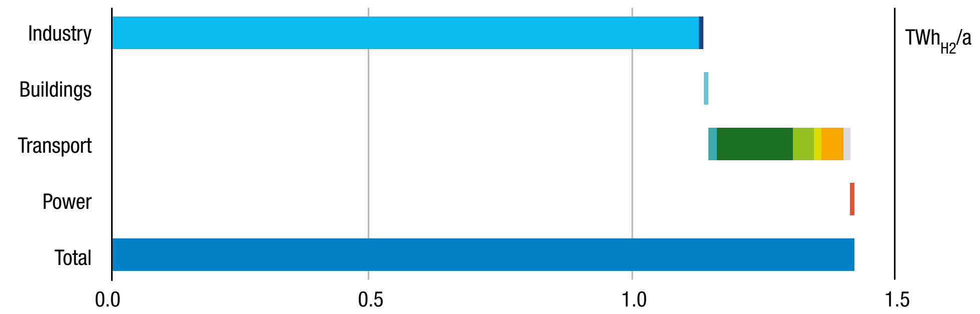
	Import bill for natural gas as share of national Gross Value Added	Import bill for all fossil fuels
Greece	0.6%	2.0%
EU	Average: 0.6% MS range: 0% - 1.5%	Average: 2% MS range: 0% - 7%

SCENARIO ASSESSMENT
Estimated renewable/low carbon hydrogen demand for Greece 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).

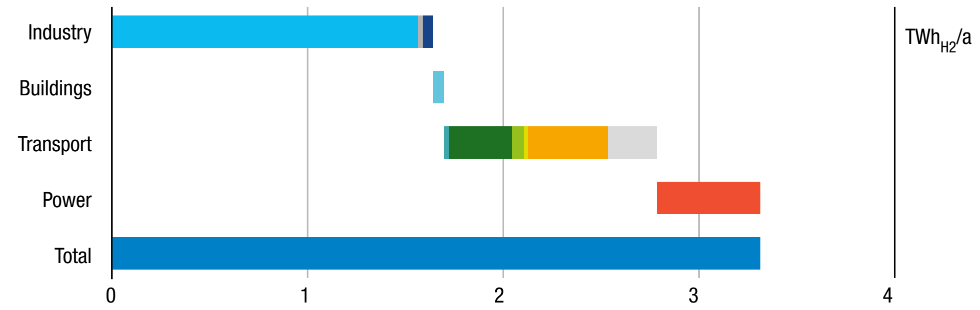


Low scenario



In the low scenario, renewable hydrogen accounts for 0.9% of final total energy demand (i.e. 1.4 out of 163 TWh/a) or 10.2% of final gas demand (14 TWh/a) according to EUCO3232.5.

High scenario



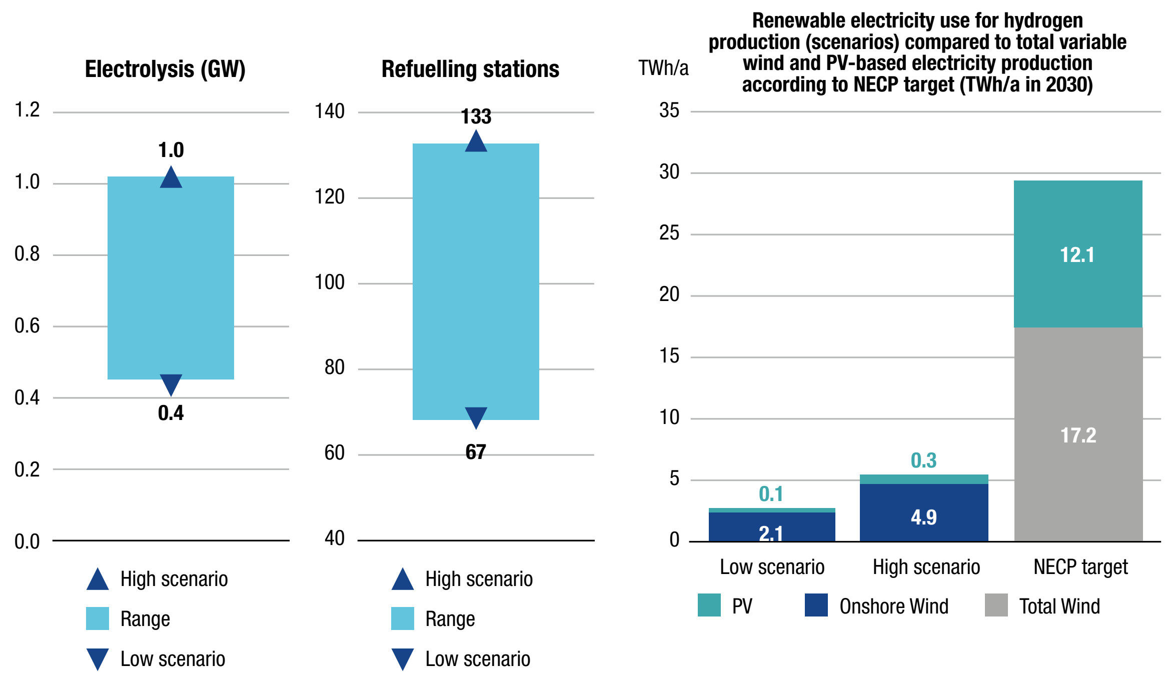
In the high scenario, renewable hydrogen accounts for 2.0% of final total energy demand (i.e. 3.3 out of 163 TWh/a) or 23.7% of final gas demand (14 TWh/a) according to EUCO3232.5.

Refinery
Ammonia
Methanol
Iron & steel
Industry energy
Buildings
Buses
Cars
Trucks
Rail
Aviation
Inland navigation
Power

Hydrogen generation, infrastructure and end users in Greece 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 0.5% of the overall technical renewable power potential in the low scenario and for 1.2% in the high scenario.

End users

End user	Unit	Low scenario	High scenario
Passenger cars	Nº	31 800	63 500
Buses	Nº	120	230
Lorries	Nº	4 700	9 500
Heavy duty vehicles	Nº	80	160
Trains	Nº	3	12
Substituted fuel in aviation	GWh/a	27	254
Substituted fuel in navigation	GWh/a	15.1	143.6
Micro CHP	Nº	270	1 170
Large CHP	Nº	0	0
Iron&Steel	% of prod.	0%	0%
Methanol	% of prod.	0%	0%
Ammonia	% of prod.	0%	5%

According to the estimations, the hydrogen refuelling station network will by 2030 encompass between 70-130 stations for 37 000-73 000 fuel cell vehicles on the road.

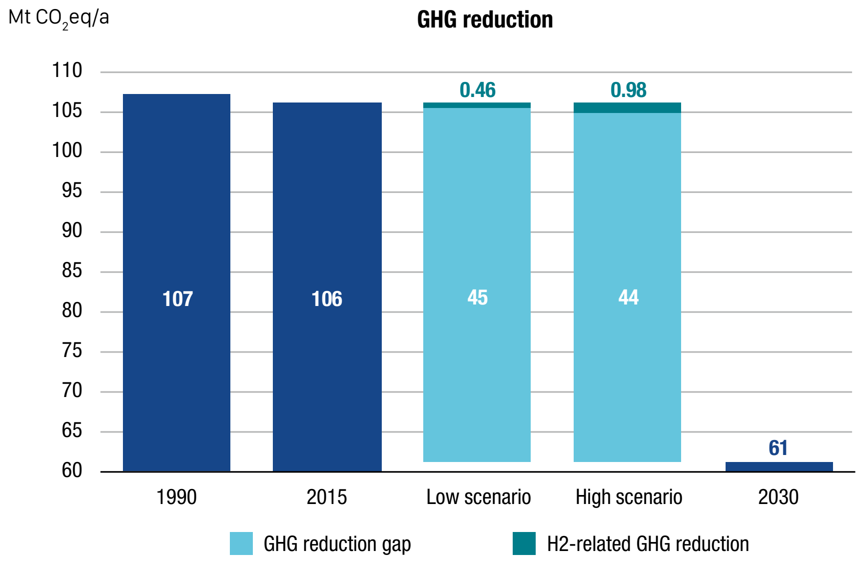
Further use of renewable hydrogen is foreseen in ammonia production (up to 5%)

Finally, the introduction of 270-1170 stationary fuel cells for combined power and heat production is estimated.

Environmental and financial impact in Greece 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.

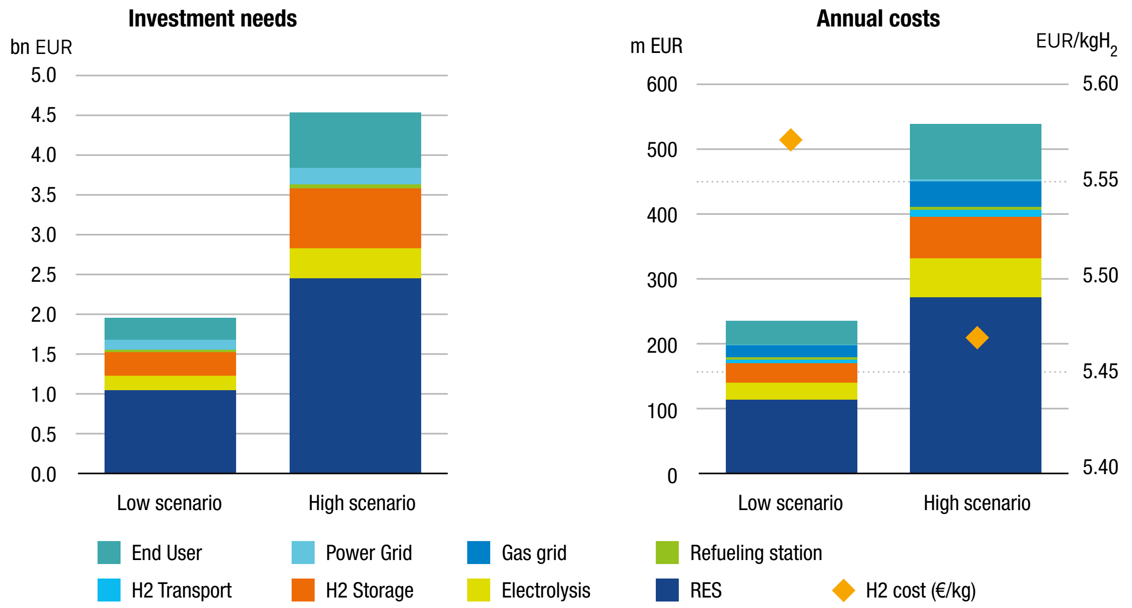
Environmental impact



An additional GHG emission reduction of 0.5-1.0 Mt CO_2 is estimated in 2030 corresponding to 1.0%-2.2% 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 2.0-4.5 billion EUR until 2030, while annual expenditure would amount to 230-540 million EUR (including end user appliances as well as power and gas grids).

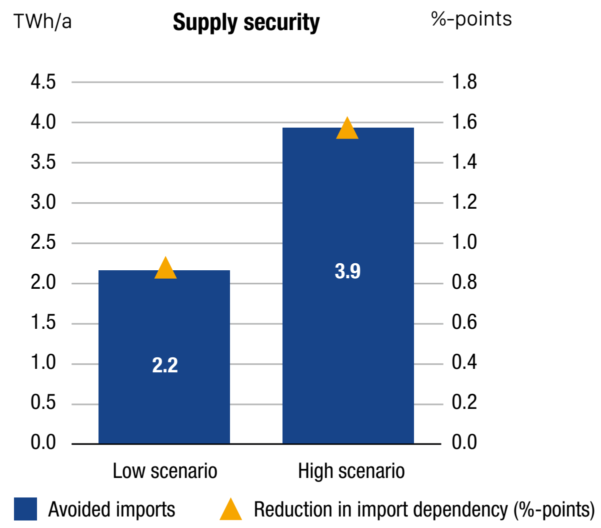


Impact on security of supply, jobs and economy in Greece by 2030

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

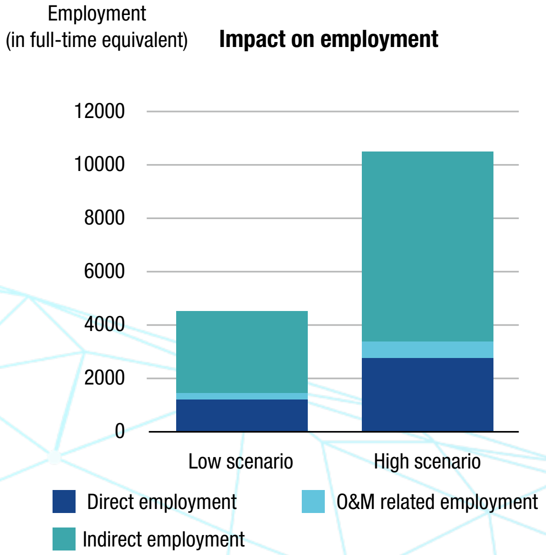
Deployment of renewable hydrogen would lead to 2.2-3.9 TWh/a of avoided imports, and thus reduce import dependency by 0.9-1.6% (in volume terms) in 2030, depending on the scenario.

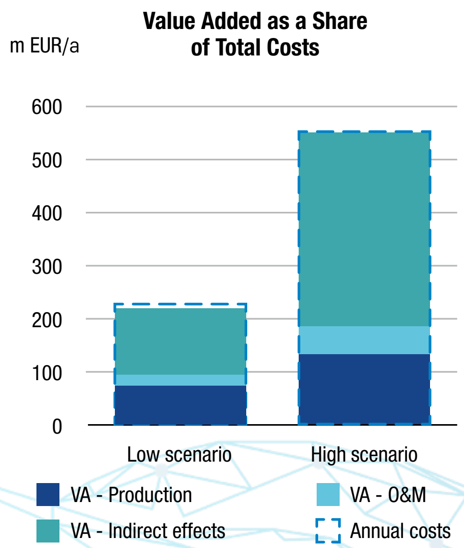


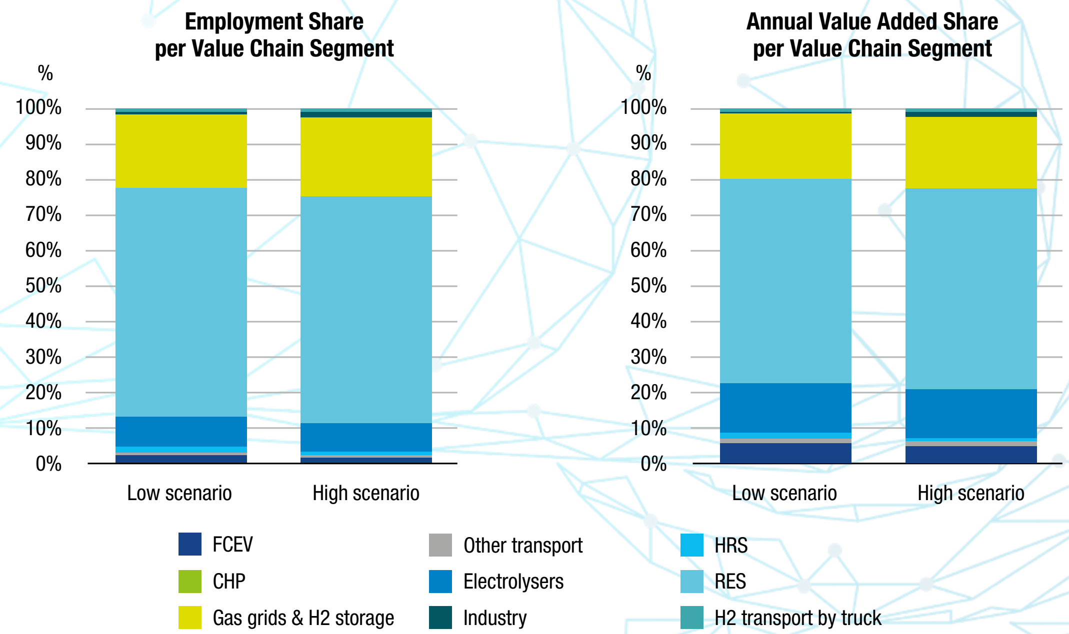
Impact on employment and value added

This analysis shows that in the years 2020-2030 more than 80 million EUR can be retained annually in the domestic economy as value added in the low scenario, and around 90 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 230 million EUR (low scenario) and almost 540 million EUR (high scenario) of value added can be created in the Greek economy annually, which is equivalent to the amount of annual investment needed. Most of this value added is expected to be created by building-up and operating dedicated renewable energy sources and electrolysers for renewable hydrogen production, and by building hydrogen storage capacities.

The hydrogen-related expenditures in 2020-2030 are estimated to generate employment of 1 450 – 3 400 direct jobs (in production and operations & maintenance), and contribute to a further 3 00 – 7 000 indirectly related jobs, depending on the scenario. Most of these jobs are expected to be created by building-up and operating dedicated renewable energy sources and electrolysers for renewable hydrogen production, and by building hydrogen storage capacities.







GREECE

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

FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING