CYPRUS

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

2

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.

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

Onshore Wind
7 - 50 MW
20 - 160 GWh/a

Solar Photovoltaic
8 - 56 MW
11 - 80 GWh/a

Electrolysers
7 - 51 MW
21 - 150 GWh_{H2}/a

TRANSPORT
20 - 146 GWh/a

0 - 10
Buses

3 - 6
Refuelling Stations

1 500 - 3 000
Cars

0 - 300
Trucks

9 - 86 GWh/a
into Synthetic Fuels

BUILDINGS
0.02 - 0.18 GWh/a

1 - 4
Micro-CHP units
in buildings

INDUSTRY
0.4 - 4 GWh/a

0.4 - 4 GWh/a
Industrial energy demand

5 - 31
m EUR/a

Value Added
in the domestic economy

Value Added as Share of Annual Costs

New Jobs
100 - 600

Emissions avoided
7 - 34 kt CO_2/a

EXECUTIVE SUMMARY

Cyprus's commitment for hydrogen deployment according to its NECP

Cyprus is not explicitly considering hydrogen deployment in its NECP for the period from 2021 to 2030.

However, already in 2009, hydrogen was recognised by the Cyprus University of Technology for its advantages across sectors, in terms of reduction of imported oil dependency, reduction of carbon dioxide emissions, improvement of the local air quality and the environment in general. The most sustainable path to produce hydrogen in Cyprus would be by exploiting the solar potential of the island which is more than large enough to cover its whole energy needs[1].

Cyprus is at present neither involved in IPCEI projects, nor in projects under the EU funding programmes (FP7, H2020) related to hydrogen.

The scenario assessment shows substantial potential benefits of hydrogen deployment in Cyprus 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 Cyprus, only limited development of hydrogen demand in transport is assumed in the considered scenarios, in particular use of hydrogen-based liquid fuels in aviation[2]. A very limited use of hydrogen is assumed also for industrial energy production and for CHP applications in buildings in the considered scenarios.

[1] https://www.researchgate.net/publication/264898340_The_introduction_of_Hydrogen_Economy_in_Cyprus
[2] 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/

Hydrogen production

To cover the estimated hydrogen demand from new uses and from substitution of fossil-based hydrogen, 15 to 100 MW 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 of hydrogen demand will have to be covered by dedicated sources.

In its NECP, Cyprus estimates a production of about 1.5 TWh of renewable electricity in 2030. The technical potential for renewable electricity production in Cyprus seems however significantly higher. Building additional renewable capacity dedicated for hydrogen production could thus 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 5 and 28 million EUR. These activities will generate value added in the domestic economy, amongst others by job creation in manufacturing, construction and operation of hydrogen technologies and will also contribute to greenhouse gas emission reductions. According to the European EUCO3232.5 scenario[3], the Cypriot GHG emissions should be reduced by 2 Mt CO_2 in 2030, compared to 2015. In the scenarios considered, the deployment of hydrogen could contribute 7 – 34 kt CO_2 to this goal, which is equivalent to 0.5% - 2% of the required emission reduction.

[3] 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 NECP OF CYPRUS

Cyprus is not explicitly considering hydrogen deployment in its NECP for the period from 2021 to 2030. According to its NECP, Cyprus would by 2050 become an exporter of electricity, mainly produced from solar energy, while gas would be used for backup purposes and for security of energy supply. Emerging technologies based on hydrogen are in the NECP not considered, even not in the 2050 scenario.

In its NECP, Cyprus has set targets for the use of alternative fuels for its different fleets of vehicles (passenger cars, buses, trucks), but there is no specific target for hydrogen vehicles.

OPPORTUNITY ASSESSMENT

Hydrogen production potential & its role in energy system flexibility

Cyprus has a large technical renewable electricity generation potential, exceeding considerably its expected overall electricity demand in 2030. This potential could be better exploited if renewable electricity plants would be coupled with electrolysers producing renewable hydrogen. The opportunity to locally deploy renewable energy sources is very high as Cyprus still relies on imported petroleum products for its electricity production. According to the NECP, Cyprus would only use 4% of its technical potential in variable renewable electricity generation by 2030, so there is a great margin for building up dedicated renewable electricity plants in view of hydrogen production via electrolysis.

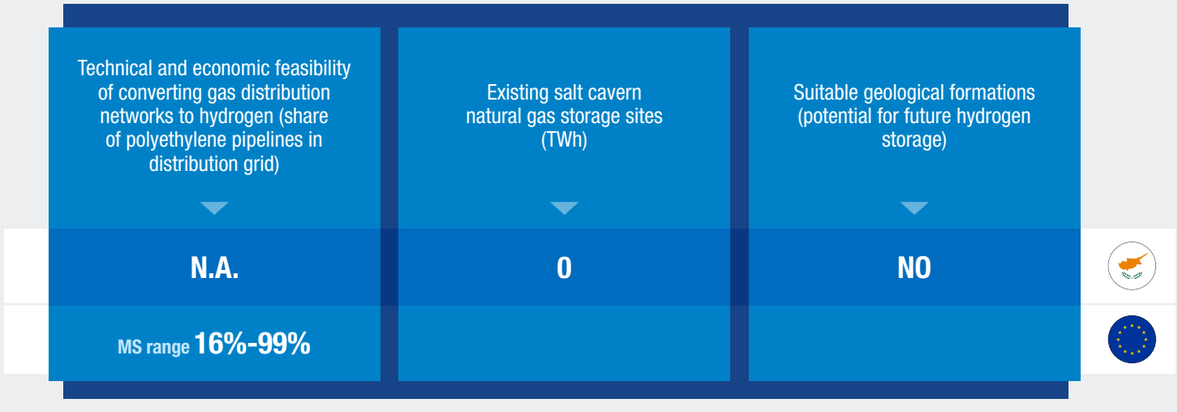
As Cyprus has an isolated energy network with no possibility of addressing potential electricity supply shortages or surpluses by imports or exports, there is a significant need for flexibility in the national energy system. Therefore, investing in renewable hydrogen production and storage processes as a flexibility provider to balance energy demand and supply at any moment, represents an important opportunity for Cyprus.

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

Energy infrastructure

There is in Cyprus no potential for using existing methane infrastructure to transport or distribute hydrogen, as there is no natural gas network. However, in view of enhancing energy supply security and market competition, Cyprus plans to diversify its energy sources by importing natural gas via LNG infrastructure[3] and by using domestic energy resources like biomethane. It also intends to further increase its renewable energy penetration, improve the conditions for demand response via network modernisation and regulatory changes, fully implement a competitive electricity market, and interconnect its currently isolated electricity system. There are currently no concrete plans for hydrogen infrastructure transport or distribution.

On the short and medium term, Cyprus could consider transporting hydrogen by road, similar to LNG transport, given the limited expected production volumes.



There are neither salt cavern natural gas storage sites nor underground salt layers that could provide suitable storage opportunities for hydrogen in Cyprus.

[3] *https://www.euractiv.com/section/climate-environment/news/eus-new-list-of-energy-projects-includes-32-gas-facilities/*

Current and potential gas & hydrogen demand

In Cyprus, opportunities for the deployment of renewable and low-carbon hydrogen are expected mostly beyond 2030. This is due to the fact that Cyprus cannot build on an existing gas infrastructure for transport and end-use and has a relatively low energy demand for industry and for heating in the built environment. However, on the medium and long term, hydrogen could be utilised to decarbonise heavy road transport, the shipping sector and the supply of high-temperature process heat in industry.

Opportunities for hydrogen demand in industry

The level of opportunity for hydrogen use in industry seems limited as there is currently no natural gas use in Cyprus. This means that all the required infrastructure would still need to be built, limiting the attractiveness of hydrogen as a solution to decarbonise industry on the short to medium term.

Presence of ammonia industry / share of ammonia production capacity in EU28 total	Presence of refineries / Share of Cypriot refineries in total captive hydrogen production by refineries in the EU28	Share of Cyprus 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)
0%	0%	0%	0%	46%
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 Cyprus, the opportunities for using hydrogen for heating/cooling in the built environment on the short term seem also limited. Cyprus has no natural gas in its energy mix and, next to that, demand for space heating is limited. Space cooling on the other hand, is an important energy end-use in the built environment, accounting for almost half of the final energy demand. Hot water demand is, to a large extent, covered by solar heaters (and is thus already decarbonised); whereas space heating needs are predominantly covered with a combination of electric and oil-fired boilers and cooling demand with electric air conditioners. Given the relatively low demand for space heating in Cyprus, electrification is likely a suitable option to replace oil-fired boilers, but hydrogen-based alternatives (e.g. reversible systems producing electricity and heating/cooling) might become competitive alternatives, in particular for the services sector.

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)
0%	49%	46%
Average: 34% MS range: 0% - 60%	Average: 74% MS range: 41% - 82%	Average: 3% MS range: 0% - 46%

Opportunities for hydrogen demand in transport

In the transport sector in Cyprus, there is mainly an opportunity for the deployment of hydrogen in the shipping sector. Energy use for international shipping is equivalent to 37% of the country's domestic energy demand in transport. Hydrogen is one of the few technical options to decarbonise this strongly fossil fuel-dependent sector. As in other countries, road transport in Cyprus is also heavily reliant on fossil fuels. Electrification of this sector is an attractive decarbonisation strategy for Cyprus, as the travelling distances on the island are rather limited. However, for some specific applications, like trucks and buses, hydrogen could from a technical, economic and environmental perspective be a suitable alternative to electrification. 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
25% (1 907 GWh)	No fossil-dependent rail transport (0 GWh)	0% (0 GWh)	37% (2 946 GWh)	25% (3 665 GWh)	99% (7 769 GWh)
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

The assessment shows that Cyprus has not yet started to set up a comprehensive framework for the deployment and use of hydrogen. There are in the NECP or other publicly available documents from Cyprus no concrete figures, policies or measures planned for the deployment or use of hydrogen. There is also no specific agenda in the frame of hydrogen R&D in Cyprus. Taking into account its high potential for variable electricity generation and its lack of electricity interconnection capacity, Cyprus could assess the potential contribution of deploying hydrogen in the frame of security of energy supply and to address the challenge of balancing electricity supply and demand in a system with a high share of variable renewable energy. Having a clear and integrated energy strategy and roadmap including hydrogen could in particular support the large-scale deployment of renewable energies and the decarbonisation of the energy system.

There is currently no national association for hydrogen to provide support in structuring the preparation of such roadmap.

In the meantime, Cyprus could participate in international and EU hydrogen research projects and launch its own research initiatives where adequate, as well as start assessing the potential of power-to-hydrogen and the use of hydrogen in its economy, given its specific situation as an energy island.

Existence of (or concrete plans for) national hydrogen roadmaps or strategies — Positive environment: Limited

Cyprus has no national hydrogen roadmap or strategy

GHG mitigation gap in non-ETS sectors (need for additional GHG reduction measures) — Positive environment ✓

Cypriot GHG emissions are expected to decrease by 20.9% in 2030, while the country's target according to the Effort Sharing Regulation foresees by 2030 an emission reduction of 24% compared to 2005. Additional measures under examination to achieve the reduction target of 24% are, among others a green tax reform and a higher penetration of vehicles and buses with low or zero emissions based on the effects of the proposed tax reform. It could be an opportunity for Cyprus to consider in this context also the decarbonisation potential offered by hydrogen deployment, in particular in the transport sector.

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)

Besides electric mobility, alternative fuels such as hydrogen are only briefly mentioned in the Cyprus National Policy Framework (or NPF set in the context of the alternative fuel infrastructure directive (2014/94/EU)).

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

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)
NO	0	NO	0

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

Positive environment

Cyprus has a carbon related taxation for vehicles that incentivizes low carbon transport technologies. Given the lack of hydrogen refuelling stations in Cyprus, this measure has no impact yet on the use of hydrogen for transport purposes.
The measures included in the NECP are not sufficient for reaching the non-ETS GHG emission reduction target of 24% by 2030, as required according to the Effort Sharing Regulation. In order to reach this target, Cyprus is considering implementing a gradually increasing carbon tax on all non-ETS sectors.

Fossil energy import bill

Switching from imported fossil fuel to nationally produced decarbonised hydrogen for industrial processes, heating/cooling applications and transport purposes would contribute to reducing the oil import dependence and import bill of Cyprus. This option could be considered in a coordinated way taking into account other envisaged measures such as the deployment of LNG infrastructure, in order to avoid overlapping infrastructures and to ensure optimal energy sector coupling.

	Import bill for natural gas as share of national Gross Value Added	Import bill for all fossil fuels
	No NG imported	**4.6%**
	Average: **0.6%** MS range: 0% - 1.5%	Average: **2%** MS range: 0% - 7%

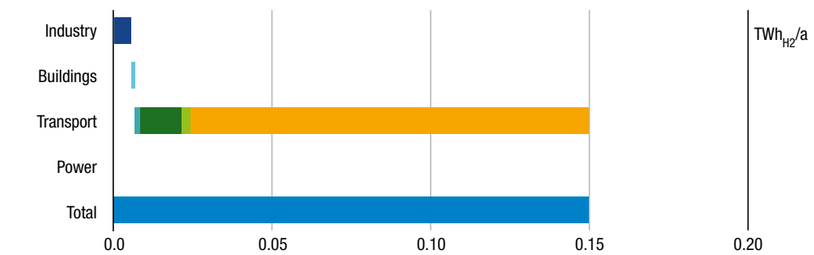
SCENARIO ASSESSMENT
Estimated renewable/low carbon hydrogen demand for Cyprus by 2030

Hydrogen demand in the year 2030 has been estimated in a low and a high scenario covering the range of uncertainty. Both scenarios assume that in 2030 renewable hydrogen will be provided to cover additional demand (e.g. from transport sector).

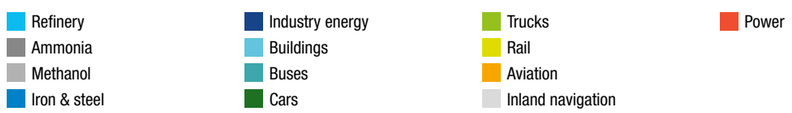
Low scenario

In the low scenario, renewable hydrogen accounts for 0.1% of final total energy demand (i.e. 0.02 out of 19 TWh/a) or 44.6% of final gas demand (0.05 TWh/a) according to EUCO3232.5.

High scenario



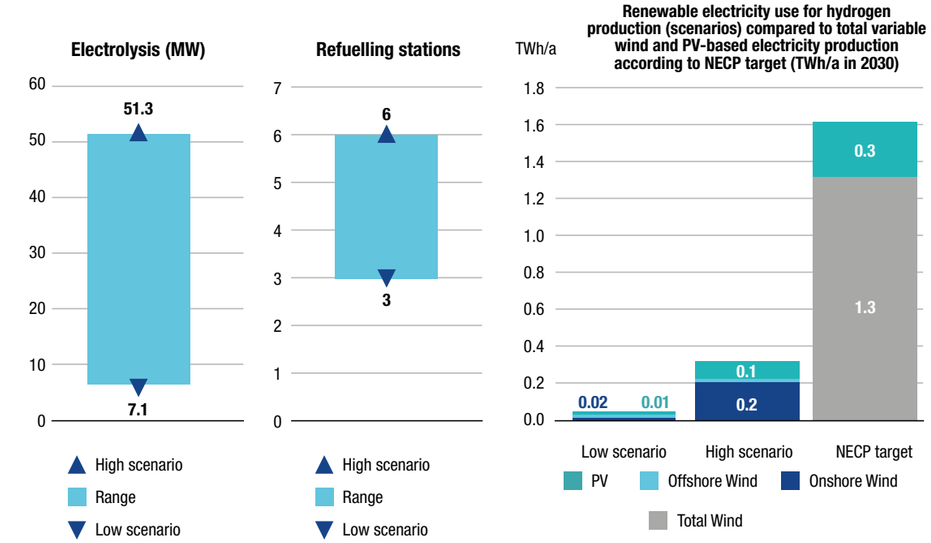
In the high scenario, renewable hydrogen accounts for 0.8% of final total energy demand (i.e. 0.1 out of 19 TWh/a) and exceeds final gas demand (0.05 TWh/a) according to EUCO3232.5 by factor of 3.



Hydrogen generation, infrastructure and end users in Cyprus 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 0.6% of the overall technical renewable power potential in the low scenario and for 4.0% in the high scenario.

End users

End user	Unit	Low scenario	High scenario
Passenger cars	Nº	1 500	3 000
Buses	Nº	0	10
Lorries	Nº	0	300
Heavy duty vehicles	Nº	0	5
Trains	Nº	0	0
Substituted fuel in aviation	GWh/a	9	86
Substituted fuel in navigation	GWh/a	0	0
Micro CHP	Nº	1	4
Large CHP	Nº	0	0
Iron&Steel	% of prod.	0%	0%
Methanol	% of prod.	0%	0%
Ammonia	% of prod.	0%	0%

According to the estimations, the hydrogen refuelling station network will by 2030 encompass between 3-6 stations for 1 500-3 000 fuel cell vehicles on the road[4].

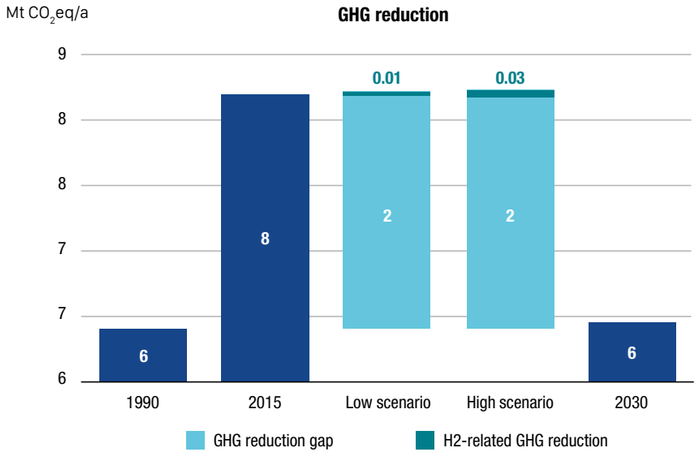
Finally, the introduction of 1-4 stationary fuel cells for combined power and heat production is estimated.

[4] *In order to ensure a minimum coverage of the country with hydrogen refuelling stations, more stations may be necessary for supplying hydrogen to the vehicle fleet.*

Environmental and financial impact in Cyprus 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.

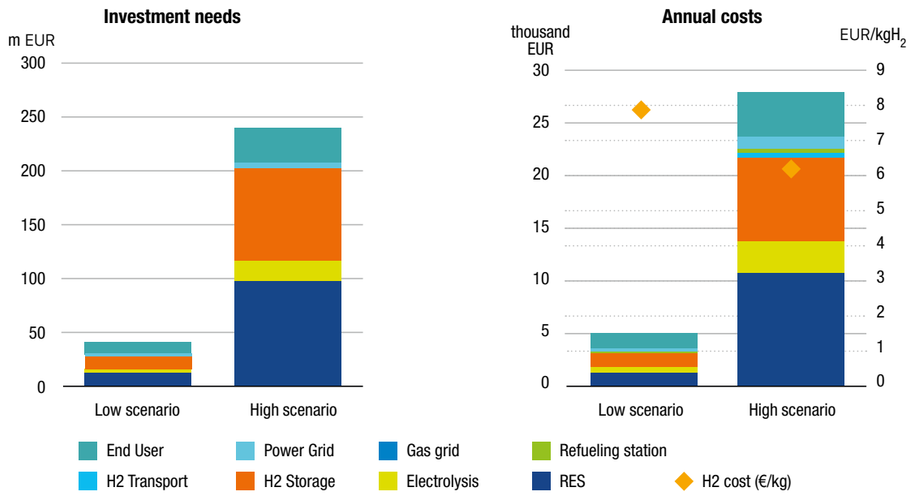
Environmental impact



An additional GHG emission reduction of 10-30 kt CO_2 is estimated in 2030 corresponding to 0.4%-1.9% 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 40-240 million EUR until 2030, while annual expenditure would amount to 5-30 million EUR (including end user appliances as well as power and gas grids).

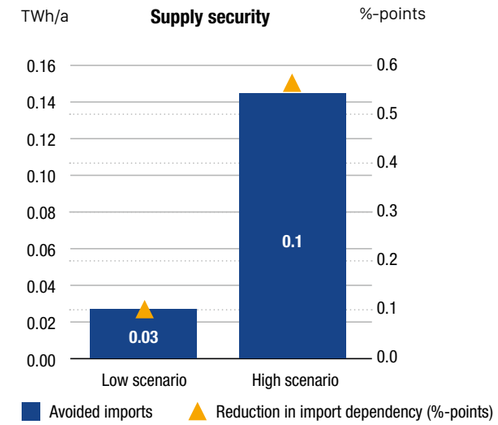


Impact on security of supply, jobs and economy in Cyprus by 2030

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

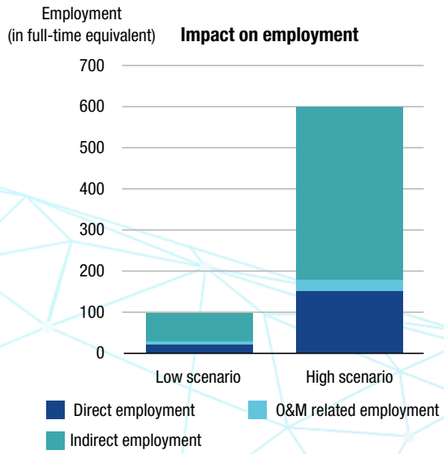
Deployment of renewable hydrogen would lead to 0.03-0.14 TWh/a of avoided imports, and thus reduce import dependency by 0.1-0.6% (in volume terms) in 2030, depending on the scenario.

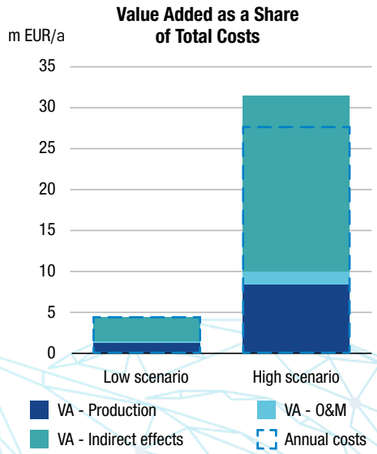


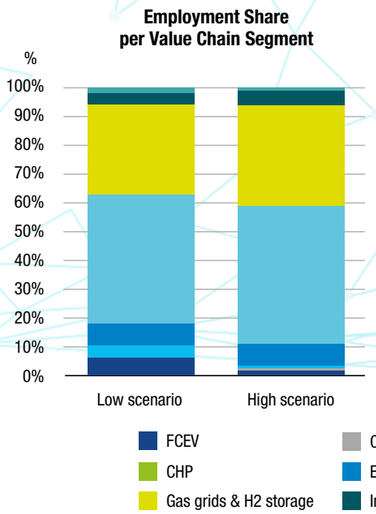
Impact on employment and value added

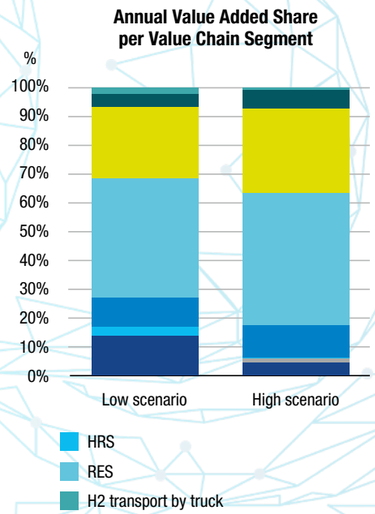
This analysis shows that in the years 2020-2030 almost 2 million EUR can be retained annually in the domestic economy as value added in the low scenario, and over 10 million EUR in the high scenario (value added is defined here as sum of wages for employees, margins for companies and taxes). If the indirect effects induced by the investment in and operation of hydrogen technologies are also taken into account, around 5 million EUR (low scenario) and over 31 million EUR (high scenario) of value added can be created in the Cypriot economy annually, which is equivalent, or even higher in the high scenario, than the amount of annual investment needed. Most of this value added is expected to be created by building dedicated renewable electricity sources and by building-up electrolysis and hydrogen storage capacity.

The hydrogen-related expenditures in 2020-2030 are estimated to generate employment of 30 - 200 direct jobs (in production and operations & maintenance) and contribute to a further 70 - 400 indirectly related jobs, depending on the scenario. Most of these jobs are expected in the production of renewable electricity, electrolysers and hydrogen storage. In the low scenario, a more significant job creation is expected to occur in relation to fuel cell electric vehicles.









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

FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING

2