SLOVAKIA

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

FCH
FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

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
(Ref. FCH / OP / Contract 234)
fch-ju@fch.europa.eu

Prepared by

Trinomics

ludwig bölkow systemtechnik

Graphic Design:
Ático, estudio gráfico® - aticoestudio.com

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.

SLOVAKIA

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

Onshore Wind
220- 620 MW
550 - 1 540 GWh/a

Solar Photovoltaic
110 - 310 MW
100 - 290 GWh/a

Electrolysers
140 - 390 MW
410 - 1 140 GWh_{H2}/a

POWER
0,3 - 3 GWh/a

TRANSPORT
24 - 98 GWh/a

BUILDINGS
21 - 210 GWh/a

INDUSTRY
363 - 829 GWh/a

0 - 60
Buses

15 - 31
Refuelling Stations

0 - 1 000
Trucks

8 000 - 15 900
Cars

140 - 1 430 GWh/a
Electricity Produced

2- 19 GWh/a
into Synthetic Fuels

980- 4 280
Micro-CHP units
in buildings

1 - 12
Commercial-scale
CHP installations

0 - 53 kt/a
of Steel

0 - 2.1 kt/a
of Aromatics

0 - 78 t/a
of Olefins

0 - 24.2 kt_N/a
of Ammonia

360 - 440 GWh_{H2}/a
in Refineries

59 - 160
m EUR/a

Value Added
in the domestic economy

Value Added as Share of Annual Costs

New Jobs
1 290 - 3 610

Emissions avoided
0.1 - 0.4 Mt CO_2/a

EXECUTIVE SUMMARY

Slovakia's commitment for hydrogen deployment according to its NECP

According to its NECP, Slovakia considers the "use of decarbonised gases and hydrogen" as a way to "ensure environmental sustainability". Slovakia considers hydrogen as a "very promising fuel" and a good option (also regarding air quality) to replace natural gas on the one hand and fossil fuels in the transport sector on the other hand.

According to its NECP, Slovakia estimates that by 2030 around 1% of its RES target for the transport sector will be covered by the direct use of hydrogen (2 ktoe hydrogen out of a total of 229 ktoe renewable fuels). By 2040, this share could be multiplied by more than 20. Slovakia addresses the entire value chain from generation, over underground storage, delivery infrastructure to end uses mainly in the transport sector and the industry.

A National Hydrogen Strategy is expected to be approved in 2021. Slovakia is involved in the Zero Emission Urban Delivery @ Rainbow UnHycorn[1] potential IPCEI project, but was not involved in the HyLaw[2] project, and could possibly use the same approach and carry out a similar assessment to identify its own national barriers to the deployment of hydrogen. The Slovak National Hydrogen Association[3] is a key partner to provide support to identify and address these barriers.
Slovakia's NECP includes a specific objective for the use of hydrogen in the transport sector, but it does not comprise a global objective for the production of hydrogen, or for other end-uses. Slovakia announces that it will promote the use of renewable hydrogen in the transport sector and the deployment of the required infrastructure, but concrete measures are not mentioned in its NECP.

The scenario assessment shows substantial potential benefits of hydrogen deployment in Slovakia 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 Slovakia, a very limited development of hydrogen demand is assumed in the considered scenarios in **transport**, in particular for passenger cars and also in aviation (through hydrogen-based liquid fuels or PtL) and inland navigation[4].

The development of low-carbon hydrogen demand is also assumed in the scenarios in **industry**, in particular in refining and ammonia production. 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 green 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, 330 to 900 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 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, Slovakia estimates an installed capacity in 2030 of 0.5 GW in wind and 1.2 GW in solar PV, generating about 2.3 TWh of variable renewable electricity in 2030. The technical potential for renewable electricity production in Slovakia seems however significantly higher[5]. Building additional renewable electricity capacity dedicated for hydrogen production thus could be a feasible scenario.

Estimated socio-economic and environmental impacts

The annual costs to produce green hydrogen (including the cost of dedicated renewable electricity sources), to develop the transport infrastructure (or adapt the existing one) and end-user applications would in the considered scenarios reach respectively 60 and 170 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[6], the Slovak GHG emissions should be reduced by 12 Mt CO_2 in 2030, compared to 2015. In the scenarios considered, the deployment of hydrogen could contribute 0.1 – 0.4 Mt CO_2 to this goal, which is equivalent to 1% - 3% of the required emission reduction.

[1] *https://static1.squarespace.com/static/5d3f0387728026000121b2a2/t/5d9b5ee7f5229f74dc24aa73/1570463472420/Rainbow+Unicorn+poster_print.pdf*
[2] *https://www.hylaw.eu/*
[3] *https://hydrogeneurope.eu/member/slovak-national-hydrogen-association-nvas*
[4] *Detailed assumptions are available in the methodology annex of the report, that can be consulted via the following link : http://trinomics.eu/project/opportunities-for-hydrogen-in-necps.*
[5] *The technical potential for renewable electricity production is based on the study commissioned by DG ENER Impact of the use of the biomethane and hydrogen potential on trans-European infrastructure (Trinomics, LBST, E3M; 2019).*
[6] *EC, 2019. Technical Note on Results of the EUCO3232.5 scenario on Member States. Available at https://ec.europa.eu/energy/sites/ener/files/technical_note_on_the_euco3232_final_14062019.pdf*

HYDROGEN IN THE NECP OF SLOVAKIA

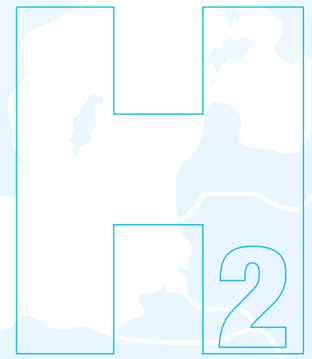
According to Slovakia's NECP, biomethane and hydrogen are promising fuels, enabling energy storage is one of their major advantages. Hydrogen generation for new end-uses (mainly transport) is expected to be 100% renewable, and renewable hydrogen would also partially replace the use of fossil-based hydrogen in industry by 2030. Slovakia will promote the production of renewable or low-carbon hydrogen (hydrogen whose carbon footprint is 60% lower -by capturing and using or storing the CO_2 - compared to hydrogen production via natural gas reforming without CCUS).

According to its NECP, Slovakia estimates that by 2030 a contribution of around 1% of its RES target for the transport sector could be provided by the direct use of hydrogen (2 ktoe hydrogen out of a total of 229 ktoe renewable fuels). By 2040, this share could be multiplied by more than 20. To facilitate the use of renewable fuels in the transport sector, Slovakia will support the deployment of alternative fuel infrastructure, including the installation of Hydrogen Refuelling Stations.

The replacement of natural gas by biomass in households is considered problematic for air quality reasons, hindering compliance with EU legislation. Slovakia considers the injection of biomethane and decarbonised hydrogen into the existing natural gas infrastructure as a key alternative to ensure environmental sustainability, in the long term.

Slovakia has several suitable geological structures that are used or can be used as underground storage facilities for natural gas. The storage of hydrogen is also considered in this context (possibly in the form of a mixture with natural gas). The deployment of production and storage of hydrogen is considered by the Slovak authorities to have the potential to accelerate the use of variable renewable energy sources, by providing flexibility to the system and long-term storage.

Since January 2015, Slovakia applies a reduced taxation regime for hybrid, CNG and hydrogen motor vehicles (Act No 361/2014).



OPPORTUNITY ASSESSMENT

Hydrogen production potential & its role in energy system flexibility

The technical variable renewable electricity production potential is almost two times higher than the expected electricity demand in 2030 in Slovakia, which, according to the assessment, creates a moderate opportunity to use this renewable electricity potential to produce hydrogen via electrolysis. According to the NECP, Slovakia would by 2030only use 4% of its technical potential in renewable electricity generation, so there is a great margin for building up dedicated capacities to produce renewable hydrogen.
The existence of nuclear power generation capacity in Slovakia 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.

The opportunity to use power-to-hydrogen technology as a flexibility provider in Slovakia is limited. The Slovak energy system is expected to have by 2030 low additional flexibility needs (among others due to a significant pumped hydro storage capacity) as the expected installed capacity of variable renewable electricity generation is substantially lower than the forecasted average load in 2030.

With respect to the production of low-carbon hydrogen via steam reforming of natural gas combined with CCUS, the short term potential is rather limited. Even though there are plans in place to use CCUS technologies by 2030, there is only limited indication of progress towards effectively building up these capacities.

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	Readiness for CO_2 storage
				based on NECP	
63	178%	2.26	4%	47%	Low

Slovakia has limited readiness for wide-scale deployment of CCS. Although there are some plans to utilize this technology, there are no concrete indications that this potential will effectively be used.

Energy infrastructure

Slovakia considers using its existing methane infrastructure for hydrogen transport and distribution, by blending hydrogen in the public natural gas grid, probably in the short (2025-2030) and medium term (2030-2040). Slovakia could also potentially assess converting (part of) its network to hydrogen in the long term (>2040). As less than half of the distribution network is made of polyethylene, the technical feasibility and cost to make it suitable for large hydrogen volumes should be further assessed.

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)
42%	0.6	0	YES
MS range 16%-99%			

According to its NECP, Slovakia has several suitable geological structures that are used or can be used as underground storage facilities for natural gas.

Slovakia considers storing hydrogen in these structures, possibly blended with methane. However, further assessment should be conducted to evaluate the feasibility.

Current and potential gas & hydrogen demand

In Slovakia, the opportunities relating to hydrogen demand occur most strongly in industry and the built environment. In industry, existing hydrogen use as a feedstock exists, but is limited. Therefore, hydrogen deployment will likely primarily 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, where direct and indirect use of natural gas is a very dominant application for heat generation, hydrogen can be deployed in order to decarbonise the gas supply. In Slovakia's transport sector, the largest opportunities for hydrogen relate to its deployment in road transport, where it can play a role in the decarbonisation of trucks, buses and vans. Additionally, together with electrification, hydrogen can be deployed to replace fossil fuel use in the passenger car sector.

Opportunities for hydrogen demand in industry

Slovakia seems to have 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, there is an opportunity for the deployment of renewable or low-carbon hydrogen to replace the use of fossil-derived hydrogen. Next to this, natural gas accounts for a quarter of the industrial energy demand in Slovakia and this natural gas can be replaced relatively easily with renewable hydrogen. Furthermore, more than half of the energy demand in industry is used to generate heat for high-temperature processes. This represents a substantial opportunity for the deployment of hydrogen as it 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 Slovak refineries in total captive hydrogen production by refineries in the EU28	Share of Slovakia 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)
SK	3%	2%	5%	25%	52%
EU	MS range 0%-16%	MS range 0%-26%	MS range 0%-30%	Average 32% MS range 0%-43%	Average 38% MS range 9%-60%

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

In Slovakia, natural gas accounts for almost half of the final energy demand in households and services and for over 60% of the demand for heating. This means that there is a large opportunity for the deployment of hydrogen in the built environment as it is one of the ways in which the gas supply can be decarbonised. Besides natural gas, district heating is the most important source of heating in Slovak households and the services sector. These district heating plants are predominantly fuelled with fossil fuels (mostly natural gas). Here, hydrogen is also one of the options to decarbonise the fuel use.

	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)
SK	49%	82%	1%
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

In Slovakia's transport sector, road transport seems to be the only sector with significant opportunities for the deployment of hydrogen. Almost half of the energy use in this sector is consumed by trucks, buses and light commercial vehicles (e.g. vans). Since electrification of this segment of the road transport sector remains challenging, there is a significant opportunity for hydrogen to decarbonise this part of Slovak road transport. Furthermore, hydrogen could also play a role in the decarbonisation of the aviation sector, which currently accounts for only 1% of the energy demand in the Slovak transport sector. However, given the expected economic growth in Slovakia in the coming decades, the energy demand in aviation is expected to grow steeply. Although international aviation is currently not yet covered by European or international climate legislation, EU countries with high international aviation activity need to make a collective effort to support the decarbonisation of this 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
SK	46% (11 932 GWh)	0% (0 GWh)	0.0% (0 GWh)	0.0% (0 GWh)	1% (469 GWh)	94% (27 774 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

The assessment shows that Slovakia is just starting to set specific targets in the transport sector for the deployment and use of hydrogen. Slovakia's NECP does acknowledge the importance of hydrogen, mainly in the transport sector and as a way to decarbonise the gas supply, as a long-term option. However, Slovakia does not address transport sub-sectors and does not address specific end-users (e.g. passenger cars, trucks, vans, trains, aviation, navigation, …).
Taking into account its objective by 2030, it becomes relevant for Slovakia to address all regulatory and non-regulatory barriers for the generation, the transmission/distribution, the storage and the end-use of renewable hydrogen, preferably in coordination with the neighbouring countries and taking into account the initiatives and policies at EU level.
In the meantime, Slovakia could provide support for dedicated hydrogen related research and facilitate the implementation of pilot and demonstration projects in the areas of sector coupling, delivery and storage infrastructures and acquisition of hydrogen-driven vehicles, which can contribute to paving the way for the use of renewable or low-carbon hydrogen as a means to achieve deep decarbonisation.

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

The non-ETS GHG emission reduction target for 2030 would be achieved with the policies and measures included in the NECP. The NECP does however not indicate whether potential additional policies would be cost-efficient and effective (e.g. in the building and transport sectors).
Slovakia could consider hydrogen as an option to strengthen its ways to decarbonise the building and transport sectors.

Positive environment

Existence of (active) hydrogen national association

Positive environment ✓

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

In its NECP, Slovakia recalls that natural gas is considered as a "transition fuel" and that it should progressively be substituted by the use of decarbonised gases and hydrogen as fuels in the long run. Slovakia supports European research related to hydrogen.
There is currently no dedicated hydrogen roadmap. The Slovak National Hydrogen Association[7] could provide valuable input to support the authorities in preparing such a hydrogen roadmap or strategy.

Positive environment ✓

[7] *https://hydrogeneurope.eu/member/slovak-national-hydrogen-association-nvas*

Current and planned hydrogen refuelling infrastructure for the transport sector

Alternative fuels infrastructure directive (2014/94/EU)

Hydrogen is included in the Slovak National Policy Framework (or NPF set in the context of the alternative fuel infrastructure directive (2014/94/EU)) which comprises specific targets for hydrogen-driven vehicles.

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	N.A	SK
	Total 156	Average 1 677 543	EU

Existence of (investment on) hydrogen-related projects

The revision of the Slovak National Policy Framework (or NPF set in the context of the alternative fuel infrastructure directive (2014/94/EU)) does include hydrogen as an alternative fuel.

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	0.0	NO	0	SK

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

Positive environment

✖

There are no specific national carbon taxes or fiscal rules in Slovakia that would encourage the use of renewable or low-carbon hydrogen. But there is a dedicated vehicle taxation regime for hybrid, CNG and hydrogen-driven vehicles.

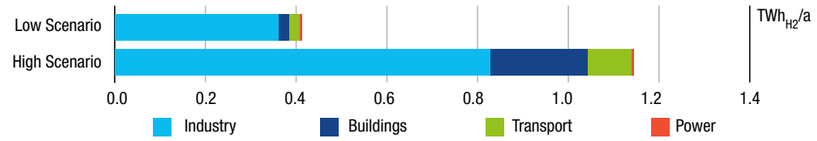
Fossil energy import bill

Like many EU Member States, Slovakia 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 could contribute to reducing the import dependence and bill.

Import bill for natural gas as share of national Gross Value Added	Import bill for all fossil fuels
1.5%	**3.7%**
Average: **0.6%** MS range: 0% - 1.5%	Average: **2%** MS range: 0% - 7%

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

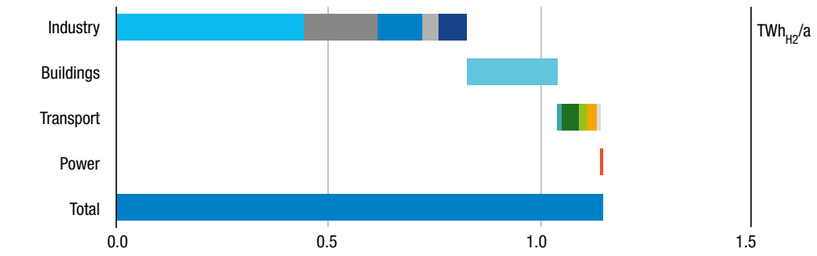
Hydrogen demand in the year 2030 has been estimated in a low and a high scenario covering the range of uncertainty. Today, conventional hydrogen mainly used in industry is produced from fossil fuels (e.g. through steam methane reforming) or is a by-product from other chemical processes. Both scenarios 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).



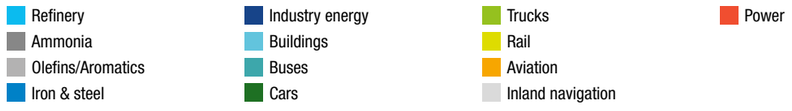
Low scenario

In the low scenario, renewable hydrogen accounts for 0.3% of final total energy demand (i.e. 0.4 out of 123 TWh/a) or 1.2% of final gas demand (35 TWh/a) according to EUCO3232.5.

High scenario



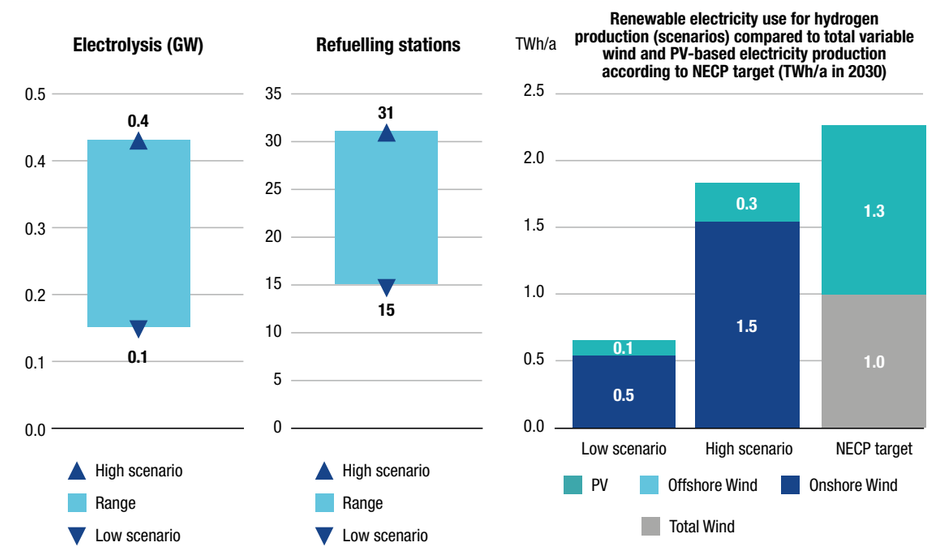
In the high scenario, renewable hydrogen accounts for 0.9% of final total energy demand (i.e. 1.1 out of 123 TWh/a) or 3.3% of final gas demand (35 TWh/a) according to EUCO3232.5.



Hydrogen generation, infrastructure and end users in Slovakia 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 1.2% of the overall technical renewable power potential in the low scenario and for 3.3% in the high scenario.

End users

End user	Unit	Low scenario	High scenario
Passenger cars	Nº	8 000	15 900
Buses	Nº	0	60
Lorries	Nº	0	900
Heavy duty vehicles	Nº	0	100
Trains	Nº	0	0
Substituted fuel in aviation	GWh/a	2	16
Substituted fuel in navigation	GWh/a	0.3	2.9
Micro CHP	Nº	980	4 280
Large CHP	Nº	1	12
Iron&Steel	% of prod.	0%	1%
Methanol	% of prod.	0%	0%
Ammonia	% of prod.	0%	5%

According to the estimations, the hydrogen refuelling station network will by 2030 encompass between 20-30 stations for 8 000-17 000 fuel cell vehicles on the road. [8]

In addition, the analysis estimates substitutions of up to 1% of the conventional steel production by renewable hydrogen-based steelmaking.

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

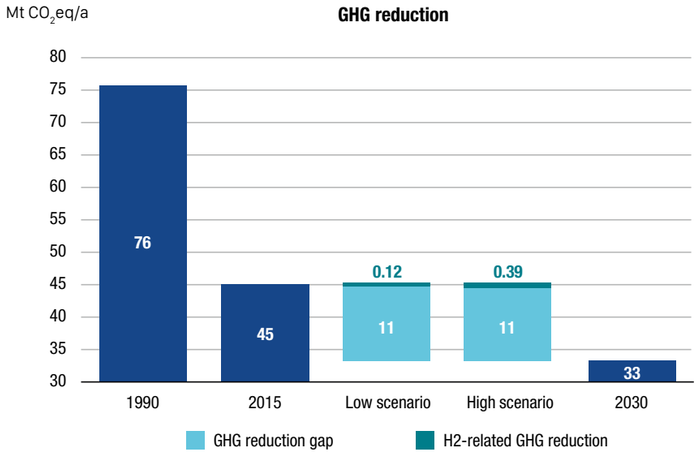
Finally, the introduction of 980-4 290 stationary fuel cells for combined power and heat production is estimated.

[8] *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 Slovakia 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.

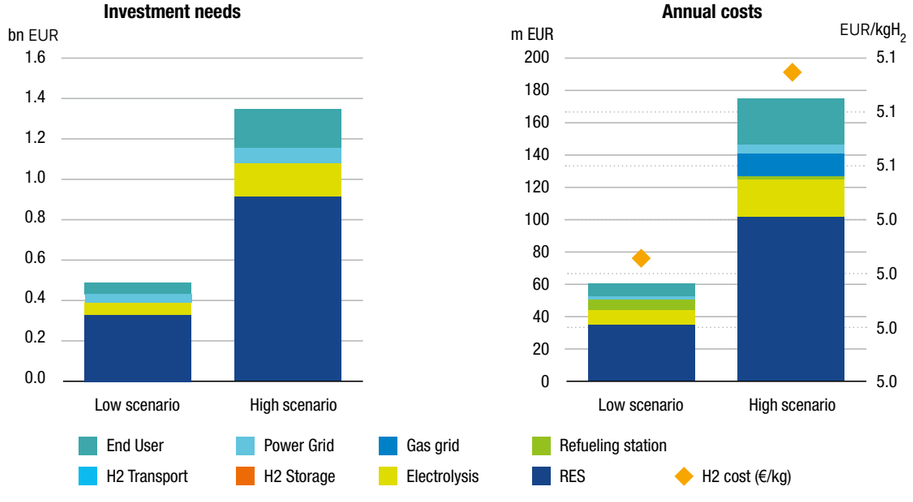
Environmental impact



An additional GHG emission reduction of 0.1-0.4 Mt CO_2 is estimated in 2030 corresponding to 1.1%-3.3% 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 0.5-1.3 billion EUR until 2030, while annual expenditure would amount to 60-170 million EUR (including end user appliances as well as power and gas grids).

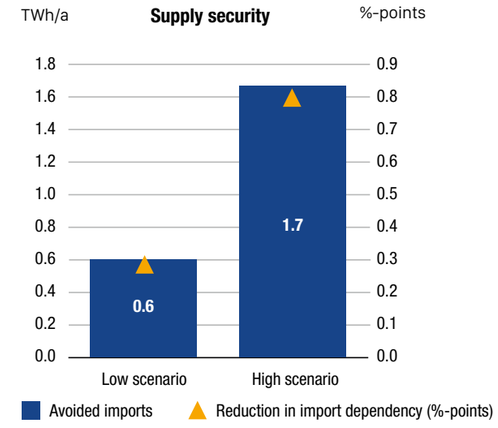


Impact on security of supply, jobs and economy in Slovakia by 2030

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

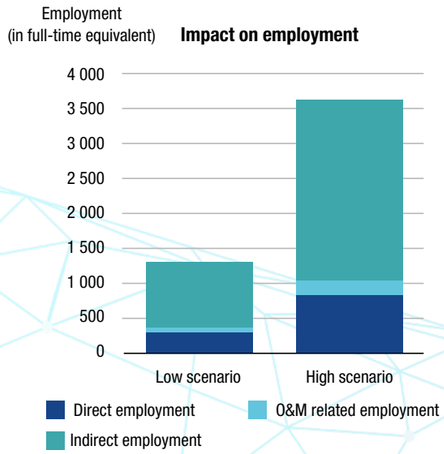
Deployment of renewable hydrogen would lead to 0.6-1.7 TWh/a of avoided imports, and thus reduce import dependency by 0.3-0.8% (in volume terms) in 2030, depending on the scenario.

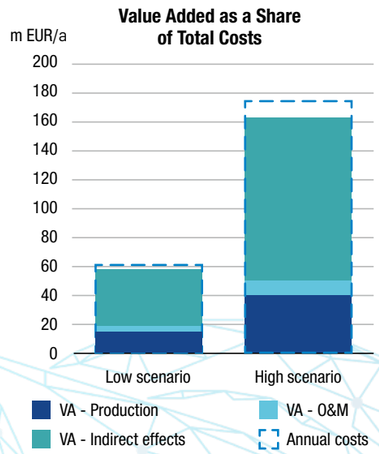


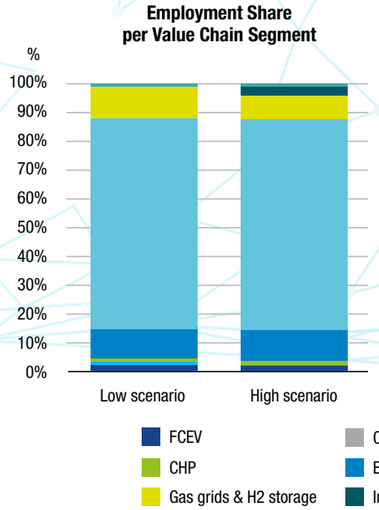
Impact on employment and value added

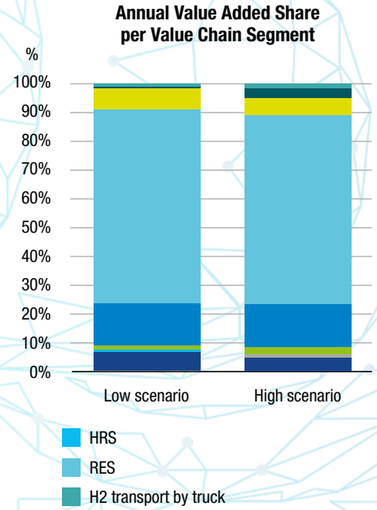
This analysis shows that in the years 2020-2030 around 20 million EUR can be retained annually in the domestic economy as value added in the low scenario, and over 50 million EUR in the high scenario (value added is defined here as sum of wages for employees, margins for companies and taxes). If the indirect effects induced by the investment in and operation of hydrogen technologies are also taken into account, around 60 million EUR (low scenario) and over 160 million EUR (high scenario) of value added can be created in the Slovak 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 by building and operating hydrogen transport networks and storage facilities.

The hydrogen-related expenditures in 2020-2030 are estimated to generate employment of 360 – 1 000 direct jobs (in production and operations & maintenance) and contribute to a further 920 – 2 600 indirectly related jobs, depending on the scenario. Most of these jobs are expected to be created in the by building and operating renewable electricity sources, electrolysers and hydrogen transport infrastructure.









SLOVAKIA

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

FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING

2