BULGARIA

# 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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# 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.

# BULGARIA

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

**Onshore Wind**
450 - 800 MW
1 080 - 1 920 GWh/a

**Offshore Wind**
2 - 3 MW
6 - 11 GWh/a

**Solar Photovoltaic**
160 - 280 MW
170 - 310 GWh/a

**Electrolysers**
270 - 480 MW
790 - 1 400 $GWh_{H2}/a$

$H_2$

**POWER**
1 - 8 GWh/a

360 - 3 600 $MWh_{H2}/a$
Electricity Produced

**TRANSPORT**
106 - 325 GWh/a

80 - 160
Buses

1 - 3
Trains

42 - 84
Refuelling Stations

2 930 - 5 750
Trucks

20 100 - 40 200
Cars

10 - 92 GWh/a
into Synthetic Fuels

**BUILDINGS**
6 - 65 GWh/a

300 - 1 290
Micro-CHP units
in buildings

4 - 35
Commercial-scale
CHP installations

**INDUSTRY**
678 - 1 006 GWh/a

670 - 790 $GWh_{H2}/a$
in Refineries

0 - 1.7 kt/a
of Olefins

0 - 16.2 $kt_N/a$
of Ammonia

110 - 190
m EUR/a

**Value Added**
in the domestic economy

**Value Added as Share of Annual Costs**


**New Jobs**
3 350 - 6 000

**Emissions avoided**
0.3 - 0.4 Mt $CO_2/a$

# EXECUTIVE SUMMARY

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

According to its NECP, Bulgaria intends to enable the integration of hydrogen in its energy and mobility systems. It expects by 2030 an annual final hydrogen consumption of 32GWh in the transport sector, which will be facilitated by the planned deployment of hydrogen refuelling stations. The hydrogen will be produced with electrolysers using renewable electricity.

According to Bulgaria's NECP, the role of hydrogen in its energy and transport systems is expected to slowly uptake by 2030. Bulgaria's Minister of Economy launched the process to prepare a new Innovation Strategy for Smart Specialisation 2021-2027, with the aim to further explore the deployment of electrochemical sources such as hydrogen and fuel cell technologies.

Bulgaria has an enabling environment to address the deployment of renewable hydrogen mainly in the transport sector, given at least one important pilot project announced, its commitment to deploy hydrogen refuelling stations, its involvement in the Green Hydrogen @ Blue Danube[1] and the H2Go[2] IPCEI potential projects. Bulgaria was also involved in the HyLaw[3] project, that identified and assessed major regulatory barriers, in view of prioritizing measures to address them.

[1] *https://static1.squarespace.com/static/5d3f0387728026000121b2a2/t/5d9b5e81e73c03421d1dd837/1570463369453/Green+HH2+Blue+Danube+poster_print.pdf*
[2] *https://static1.squarespace.com/static/5d3f0387728026000121b2a2/t/5d9b82e03ef63205cf33e4a4/1570472681940/H2Go.pdf*
[3] *https://www.hylaw.eu/sites/default/files/2018-10/National%20Policy%20Paper%20-%20Denmark%20%28EN%29.pdf*



## The scenario assessment shows substantial potential benefits of hydrogen deployment in Bulgaria 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 Bulgaria, a moderate development of hydrogen demand is assumed in transport, especially for passenger cars, buses and trucks, and to a more limited extent in aviation (through hydrogen-based liquid fuels or PtL) and navigation[4]. A limited development of hydrogen demand is also assumed in the considered scenarios in industry, especially in refining and in the ammonia and olefins industries. 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 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, 0.6 to 1.1 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, Bulgaria estimates an installed capacity in 2030 of 0.95 GW in wind and 3.2 GW in solar PV, generating about 6.7 TWh of variable renewable electricity in 2030. The technical potential for renewable electricity production in Bulgaria 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 130 and 230 million EUR. These activities will generate value added in the domestic economy, amongst others by creating jobs in manufacturing, construction and operation of hydrogen technologies and will contribute to greenhouse gas emission reductions. This is in particular important in hard-to-decarbonize industries. According to the European EUCO3232.5 scenario[6], the Bulgarian GHG emissions should be reduced by 18 Mt $CO_2$ in 2030, compared to 2015. In the scenarios considered, the deployment of hydrogen could contribute 0.3 – 0.4 Mt $CO_2$ to this goal, which is equivalent to 1% - 2% of the required emission reduction.

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

# HYDROGEN IN THE NECP OF BULGARIA

Bulgaria's Minister of Economy launched the process to prepare a new Innovation Strategy for Smart Specialisation 2021-2027. The previous Innovation Strategy for smart specialisation 2014-2020 did focus on the development of clean technologies, among which hydrogen-based applications. With this new Strategy, Bulgaria will further explore the deployment of electrochemical sources such as hydrogen and fuel cell technologies.

A number of national energy and climate research programmes (e.g. "Low carbon energy for transport and households — EPU" and "Protection of the environment and reducing the risk of adverse events and natural disasters") have already addressed the storage and conversion of renewable electricity and the deployment of hydrogen technologies.

Bulgaria intends to diversify its sources of renewable energy for transport, with the deployment of electrical vehicles and the introduction of advanced biofuels and hydrogen. The NECP comprises the 2030 concrete target of a renewable electricity-based hydrogen consumption of 32GWh in the transport sector.

The switch to alternative fuel vehicles will lead to significant infrastructure changes. To ensure the access to alternative fuels for a large public, Bulgaria plans to adapt its existing infrastructure and deploy hydrogen refuelling stations.

Bulgaria will take concrete actions to stimulate the production of hydrogen with renewable-based electricity (through power-to-X). Bulgaria's 'excess' supply of electricity generated from solar and wind power would be used for the production of hydrogen. Bulgaria expects around 47 GWh of renewable electricity to be dedicated to produce renewable hydrogen by 2030.

To reach its renewable hydrogen target, Bulgaria expects total investments of around 3,45 million EUR.

A pilot project for hydrogen production with a total installed capacity of 20 MW is planned. On the basis of this project, the further development of hydrogen capacities beyond 2030 will be analysed.

# OPPORTUNITY ASSESSMENT

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

The technical potential of variable renewable electricity in Bulgaria is five times higher than its forecasted electricity demand in 2030. The 'surplus' electricity production potential could efficiently be utilized by developing hydrogen production plants with electrolysers using renewable electricity. This option would especially be relevant since the country has comparatively low interconnection capacities to other EU Member States and therefore less possibilities to export its potential electricity production surpluses. According to the NECP, Bulgaria would by 2030 only use 4% of its technical potential in renewable electricity generation, so there is a great margin for building up dedicated renewable electricity sources for hydrogen production.

The existence of nuclear power generation capacity in Bulgaria 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 forecasted increase in developing variable renewable electricity generation will also translate in higher demand for flexibility services, which creates an opportunity for hydrogen development as flexibility provider. These hydrogen installations would however have to compete in the flexibility market with pumped-storage hydroelectricity, which has in Bulgaria a significant installed capacity compared to the average load.

| 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 |
|---|---|---|---|---|---|
| 169 | 494% | 6.7 | 4% | based on NECP 120% | Low |

Bulgaria 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

Bulgaria could assess the possibility to start injecting limited hydrogen volumes into its natural gas transport and distribution infrastructure. If in the medium or long term, the hydrogen production would substantially increase, conversion of (part of) its methane network or construction of new dedicated pipelines for hydrogen transport and distribution can be considered.

| 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) |
|---|---|---|---|
| Not available<br>MS range 16%-99% | 0.4 | 0 | YES |

There are no existing salt cavern gas storage sites in Bulgaria that could be used for hydrogen storage. However, there is a Palaeozoic salt deposit in the eastern region. Bulgaria could explore whether these salt formations might be suitable for hydrogen storage, for the period beyond 2030.


# Current and potential gas & hydrogen demand

The opportunities for hydrogen use in Bulgaria seem to lie primarily in industry and in the transport sector. When it comes to the use of hydrogen to decarbonise heating demand in the residential and services sector, the potential seems to be relatively limited, especially before 2030.

## Opportunities for hydrogen demand in industry

Bulgaria seems to have significant potential for hydrogen use in industry. Bulgaria hosts industries that already utilise fossil-based hydrogen, namely ammonia industry and refineries. Furthermore, natural gas has currently an important role in Bulgaria's industry, accounting for 34% of the final energy mix, so hydrogen could contribute to the decarbonisation of this part of the industrial energy demand. Lastly, a significant share of the industrial energy demand is related to the generation of high-temperature heat. Hydrogen is one of the few solutions that can be deployed to decarbonise this part of the energy demand in industry.

| | Presence of ammonia industry / share of ammonia production capacity in EU28 total | Presence of refineries / Share of Bulgarian refineries in total captive hydrogen production by refineries in the EU28 | Share of Bulgaria 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) |
|---|---|---|---|---|---|
| BG | 3% | 4% | 0% | 34% | 28% |
| EU | MS range 0%-16% | MS range 0%-26% | MS range 0%-30% | Average 32%<br>MS range 0%-43% | Average 38%<br>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 Bulgaria is limited, as natural gas has a very low share in the energy mix of these sectors. On the long term, hydrogen might play a role in the decarbonisation of the remaining fossil-based heat supply such as oil-fired boilers, supplied either through new dedicated hydrogen grids or through other means of distribution (e.g. transport by truck).

| | 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) |
|---|---|---|---|
| BG | 5% | 64% | 2% |
| EU | Average: 34%<br>MS range: 0% - 60% | Average: 74%<br>MS range: 41% - 82% | Average: 3%<br>MS range: 0% - 46% |

## Opportunities for hydrogen demand in transport

Like all EU countries, Bulgaria has a strong opportunity for the use of hydrogen in road transport. Additionally, Bulgaria's rail sector is still dependent on fossil fuels for one third of its energy use. Hydrogen is one of the solutions to decarbonise this sector, by replacing the existing diesel trains. The domestic shipping sector represents a relatively low share of Bulgaria's energy use in transport. However, in order to achieve deep emission reductions in the long term, decarbonisation of the energy use in the domestic shipping sector will be needed as well. Lastly, in the long-term hydrogen and derived fuels can be deployed to decarbonise the international shipping sector as well as aviation.

| | 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 |
|---|---|---|---|---|---|---|
| BG | 38% (11 269 GWh) | 34% (158 GWh) | 0% (0 GWh) | 2.4% (931 GWh) | 7% (2 768 GWh) | 94% (33 976 GWh) |
| EU | Average 32%<br>MS range 18%-48% | Average 30%<br>MS range 0%-95% | Average 2%<br>MS range 0%-10% | Average 14%<br>MS range 0%-1011% | Average 14%<br>MS range 1%-25% | Average 95%<br>MS range 79%-100% |


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

The assessment shows that Bulgaria has included hydrogen in its NECP considering mobility applications and infrastructure, renewable-based hydrogen generation and R&D aspects. Bulgaria has not yet addressed hydrogen in its NPF.

An overarching hydrogen roadmap has not yet been developed; such a comprehensive roadmap would support the country in mainstreaming hydrogen within the energy system to tackle the decarbonisation challenges in all sectors. The Innovation Strategy for Smart Specialisation could be considered as an interesting basis to mainstream hydrogen in all sectors.

The existing national association for hydrogen could provide support in structuring the preparation of such roadmap, which should preferably be adopted in coordination with the neighbouring countries and take into account the relevant initiatives and policies at EU level.

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

Positive environment

Only R&I

Bulgaria's authorities could use the Innovation Strategy for Smart Specialisation which includes hydrogen as a basis for elaborating a complete renewable hydrogen roadmap.

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

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)

Bulgaria's National Policy Framework (or NPF set in the context of the alternative fuel infrastructure directive (2014/94/EU)) states that the deployment of hydrogen vehicles will be facilitated by the availability of refuelling points. At present, Bulgaria has a relatively dense network of CNG refuelling points in parts of the country and the NPF foresees that this infrastructure will further be extended to cover the whole Bulgarian territory. The choice made for CNG infrastructure will affect the possibility (and the need) to deploy hydrogen refuelling infrastructure in the future. However, as the use of CNG for transport results in carbon dioxide emissions, it might be appropriate to switch in the long term to a renewable or low-carbon fuel, such as hydrogen, in order to reach carbon neutrality by 2050.

| 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** | **0** | **Not applicable** | |
| | Total **156** | Average **1 677 543** | |

## 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)**

There are no specific national carbon taxes or fiscal rules that would encourage the use of renewable or low-carbon hydrogen.

Positive environment

✖

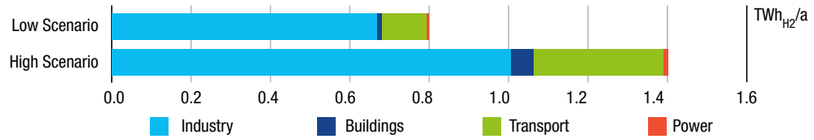
## Fossil energy import bill

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

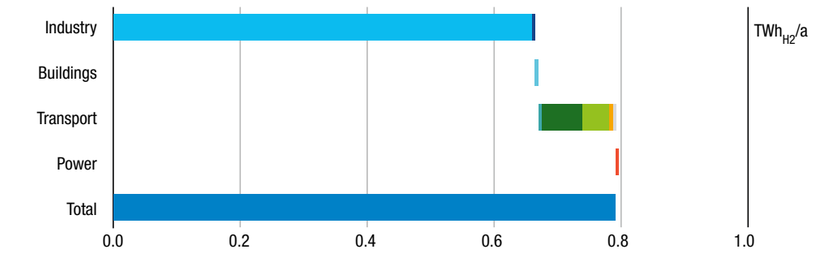
| | Import bill for natural gas as share of national Gross Value Added | Import bill for all fossil fuels |
|---|---|---|
| | **1.2%** | **3.5%** |
| | Average: **0.6%**<br>MS range: 0% - 1.5% | Average: **2%**<br>MS range: 0% - 7% |

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

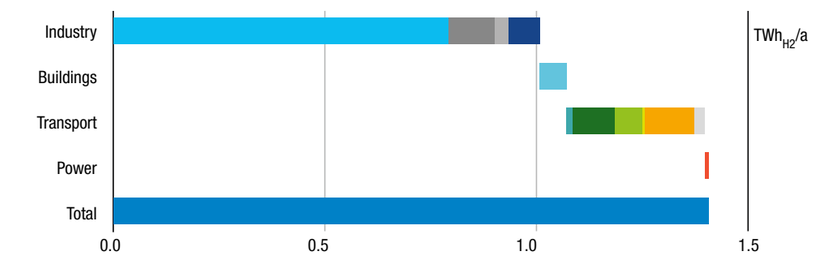



## Low scenario

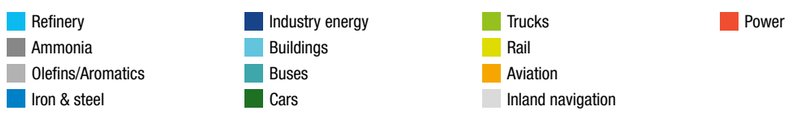



In the low scenario, renewable hydrogen accounts for 0.8% of final total energy demand (i.e. 0.8 out of 100 TWh/a) or 7.9% of final gas demand (10 TWh/a) according to EUCO3232.5.

## High scenario




In the high scenario, renewable hydrogen accounts for 1.4% of final total energy demand (i.e. 1.4 out of 100 TWh/a) or 13.9% of final gas demand (10 TWh/a) according to EUCO3232.5.

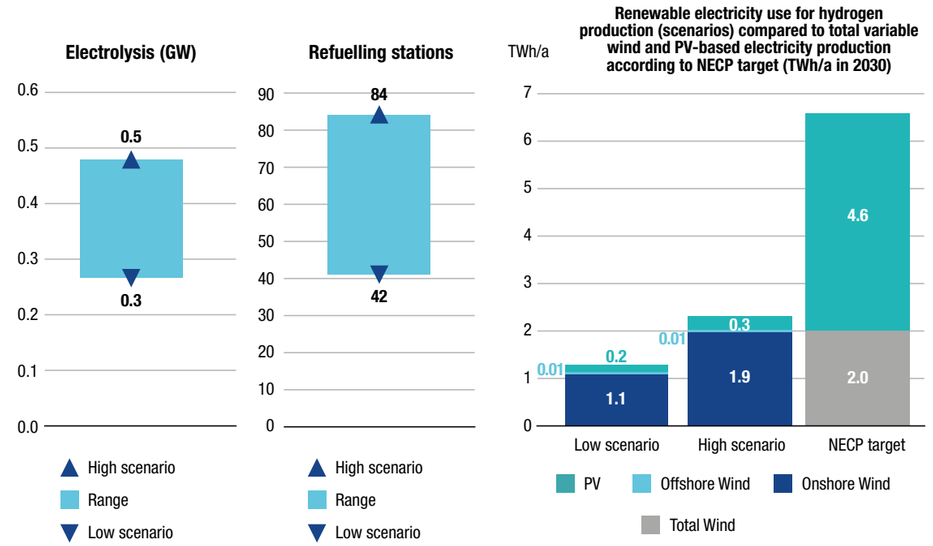





# Hydrogen generation, infrastructure and end users in Bulgaria by 2030

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 2.2% in the high scenario.

## End users

| End user | Unit | Low scenario | High scenario |
|---|---|---|---|
| Passenger cars | Nº | 20 100 | 40 200 |
| Buses | Nº | 80 | 160 |
| Lorries | Nº | 2 600 | 5 100 |
| Heavy duty vehicles | Nº | 330 | 650 |
| Trains | Nº | 1 | 3 |
| Substituted fuel in aviation | GWh/a | 8 | 77 |
| Substituted fuel in navigation | GWh/a | 1.6 | 15.0 |
| Micro CHP | Nº | 300 | 1 290 |
| Large CHP | Nº | 4 | 35 |
| 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 40-80 stations for 23 000-46 000 fuel cell vehicles on the road.

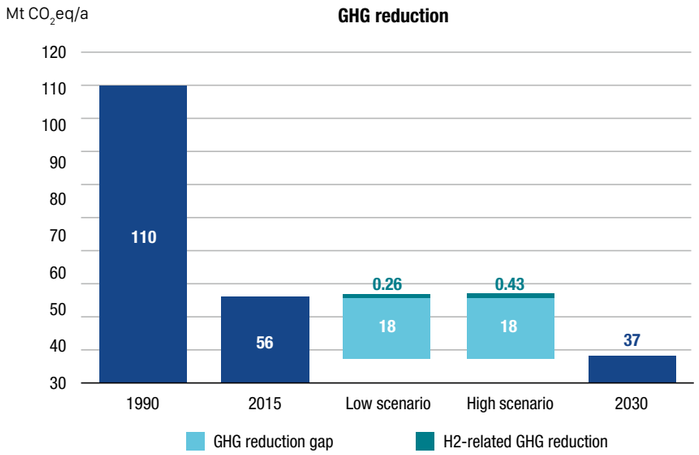
Further use of renewable hydrogen is foreseen in ammonia production (up to 5%).

Finally, the introduction of 300-1330 stationary fuel cells for combined power and heat production is estimated.

# Environmental and financial impact in Bulgaria 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.

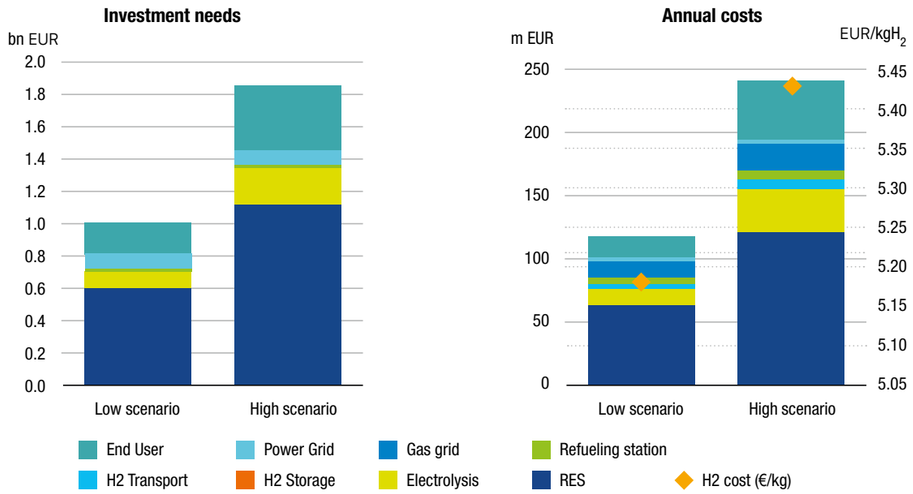
## Environmental impact




An additional GHG emission reduction of 0.3-0.4 Mt $CO_2$ is estimated in 2030 corresponding to 1.4%-2.4% of the overall GHG emission reduction gap towards 2030 target (based on EUCO3232.5).

## Financial impact

The financial scenario assessment includes investments (CAPEX) until 2030 and operating expenses (OPEX) per year in 2030. Cumulative investments in hydrogen technologies are estimated at 1.0-1.8 billion EUR until 2030, while annual expenditure would amount to 130-230 million EUR (including end user appliances as well as power and gas grids).

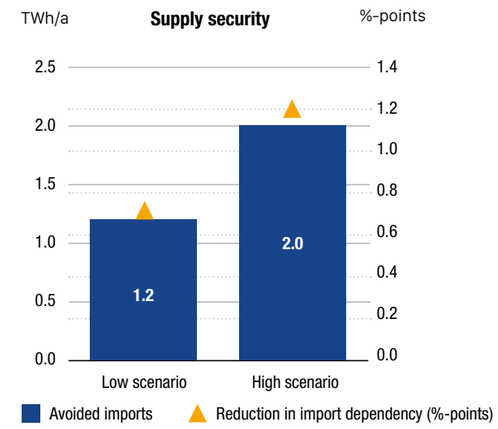



# Impact on security of supply, jobs and economy in Bulgaria by 2030

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

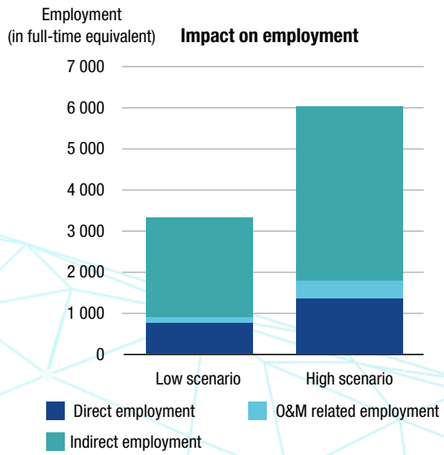
Deployment of renewable hydrogen would lead to 1.2-2.0 TWh/a of avoided imports, and thus reduce import dependency by 0.7-1.2% (in volume terms) in 2030, depending on the scenario.

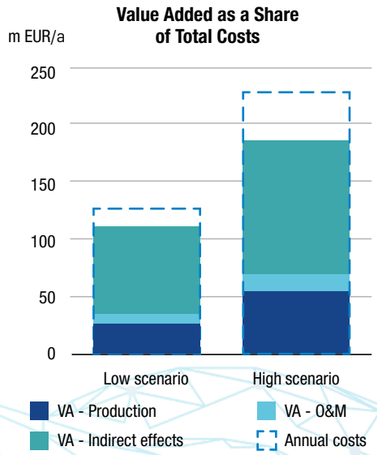


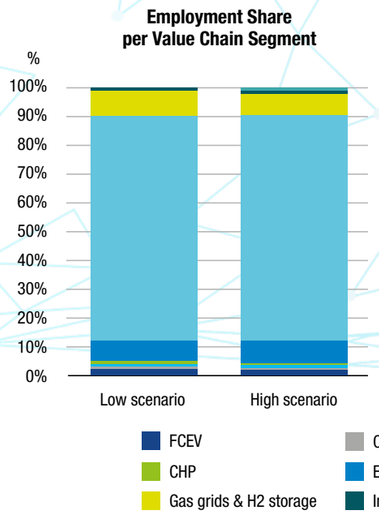

## Impact on employment and value added

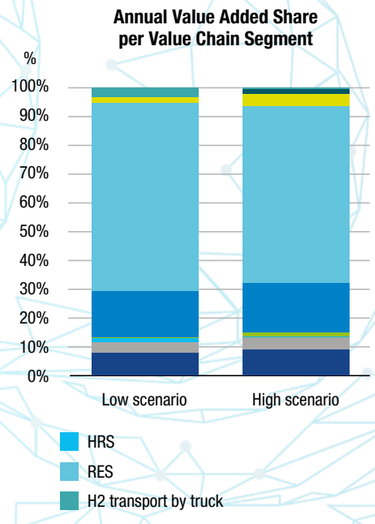
This analysis shows that in the years 2020-2030 around 40 million EUR can be retained annually in the domestic economy as value added in the low scenario, and over 60 million EUR in the high scenario (value added is defined here as sum of wages for employees, margins for companies and taxes). If the indirect effects induced by the investment in and operation of hydrogen technologies are also taken into account, around 110 million EUR (low scenario) and over 190 million EUR (high scenario) of value added can be created in the Bulgarian economy annually, which is almost equivalent to the amount of annual investment needed. Most of this value added is expected to be created by building dedicated renewable electricity sources and electrolysers for hydrogen production, and in automotive industry.

The hydrogen-related expenditures in 2020-2030 expenditures are estimated to generate employment of 1 000 – 1 700 direct jobs (in production and operations & maintenance) and contribute to a further 2 400 – 4 300 indirectly related jobs, depending on the scenario. Most of these jobs are expected to be created in the and by building and operating renewable electricity sources, hydrogen transport infrastructure and electrolysers.






Bulgaria

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

FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING

# 2