Energy Community

Study on the potential for implementation of hydrogen technologies and its utilisation in the Energy Community

Part III: Contracting Party assessment

Gas

ECA, E4tech

June 2021

This report was financed by the Energy Community.

Contributors

This report was prepared by:

Economic Consulting Associates Limited

41 Lonsdale Road, London NW6 6RA,
United Kingdom
tel: +44 20 7604 4546
fax: +44 20 7604 4547
www.eca-uk.com

E4tech

83 Victoria Street, London SW1H 0HW
United Kingdom
tel: +44 20 3008 6140
fax: +44 20 3008 6180
https://www.e4tech.com/

Contents

Tables and figures

Tables

Figures

Abbreviations and acronyms

ALKOGAP	Albania Kosovo* Pipeline
ALPEX	Albanian Power Exchange
CCGT	Combined cycle gas turbine
CfD	Contracts-for-difference
CHP	Combined heat and power
CP	Contracting Party
DSO	Distribution System Operator
EC	European Commission
FIT	Feed-in tariffs
GFEC	Gross final energy consumption
GHG	Greenhouse gas(es)
GMPA	Natural Gas Master Plan and Project Identification Plan (Albania)
GOGC	Georgian Oil and Gas Corporation
HPP	Hydro power plant
IAP	Ionian Adriatic Pipeline
LNG	Liquefied natural gas
MoESD	Ministry of Economy and Sustainable Development, Georgia
MOFTER	Ministry of Foreign Trade and Economic Relations, BA
NDC	Nationally Determined Contribution
NECP	National Energy and Climate Plan
NEEAP	National Energy Efficiency Action Plan
NGO	Non-governmental organisation
NREAP	National Renewable Energy Action Plan
PMI	Projects of Mutual Interest
R&D	Research and development
RES	Renewable energy sources
RGC	Regional Gas Company, Ukraine
SAEE	State Agency on Energy Efficiency, Ukraine
TANAP	Trans-Anatolian Natural Gas Pipeline
TAP	Trans-Adriatic Pipeline
VRE	Variable renewable energy

1 Introduction

This report is the third of three separate but related "foundation" reports under the *Study on the potential for implementation of hydrogen technologies and its utilisation in the Energy Community.* The key findings of these reports have been incorporated in a fourth streamlined *Synthesis Report* containing the main findings of the study and our ensuing recommendations.

The first report documented the current state of play *internationally* with regards to hydrogen, including its drivers, its potential role in the energy system and possible end use applications, as well as the policy mechanisms and strategies being employed worldwide to facilitate the introduction and / or scaling up of hydrogen.

The second report presented the results of *economic analysis* we undertook to guide which hydrogen technologies might have the greatest economic potential for the Contracting Parties (CPs).

This report contains a stocktake and *assessment of hydrogen developments and the readiness of each individual CP*. The report was prepared using information obtained in interviews that were conducted with various stakeholders in the CPs (see Annex A11) together with information and data from public sources.

This report is structured as follows:

- Section 2 describes the assessment framework we have employed to identify the state of readiness of, and the relative prospects of introducing or expanding hydrogen use in, the CPs;
- Section 3 contains the first part of the CP assessment, focusing on some key individual metrics for factors that could be conducive to promoting hydrogen adoption in the respective CPs; and
- Section 4 presents the second part of the CP assessment, by grouping the metrics into broader groupings and providing an overall comparative view of the CPs.

The report is supported by detailed individual CP profiles contained in Annexes A2 to A10, while Annex A1 describes the approach adopted for documenting the information contained in the CP profiles.

2 Assessment framework

Below we examine some key parameters that could help identify areas that are relatively advantageous in the CPs for producing and / or using hydrogen and / or that would require addressing or further investigation if hydrogen were to play a more significant role in the CPs' energy mix. This assessment is used together with the findings of our other two reports (the international review and economic analysis reports) to inform the development of recommended actions for the CPs and the Energy Community to progress the development of the hydrogen sector (contained in our Synthesis report).

The overriding conclusion of the individual assessments (see Annexes A2 to A10) is that most of the CPs have not yet thoroughly examined the potential for hydrogen in their respective economies. Hence, the institutional framework and other tools (policy, regulatory, financial) that are necessary for facilitating the introduction or expansion of hydrogen are not present. This is not surprising; although there has been much interest in recent months in the potential for hydrogen to contribute to worldwide decarbonisation efforts, only a relatively few countries have started progressing the policy framework to enable and support its deployment and scaling up – for example, France, Germany, the Netherlands, Portugal and Spain[1]. Even at the EU level, the hydrogen framework is only now starting to take shape.

Regarding the latter, we note that the evolving EU framework will (as with other elements of the *acquis* being adopted by the Energy Community CPs) become a major driver for the incorporation and expansion of hydrogen production and / or use in the CPs as the obligations stemming from the EU framework are rolled out at the Energy Community level. Already, there have been substantial developments in the EU; these include, for example, revisions to the Renewable Energy Directive (RED II) and the amended Energy Efficiency Directive. Moreover, the EU Hydrogen Strategy is expected to be translated into new legislative proposals including a common low carbon threshold / standard for the promotion of hydrogen production installations, comprehensive terminology and European-wide criteria for the certification of renewable and low carbon hydrogen (i.e. Guarantees of Origin), and a review of the legislative framework to design a competitive decarbonised gas market to be fit for renewable gases (i.e. the gas acquis reform). Given this momentum and policy drive, this report attempts to identify possible hydrogen focus areas for the CPs that can then be supported and reinforced within this broader policy agenda.

The comparative assessment framework we employ is summarised in Figure 1 overleaf. Our assessment approach seeks to identify a set of critical factors that could underpin the drive for greater hydrogen adoption and, subject to data limitations, identifies a set of metrics for each parameter to evaluate the respective status of the CPs. Specifically, and as demonstrated in the figure, the assessment concentrates on the following parameters:

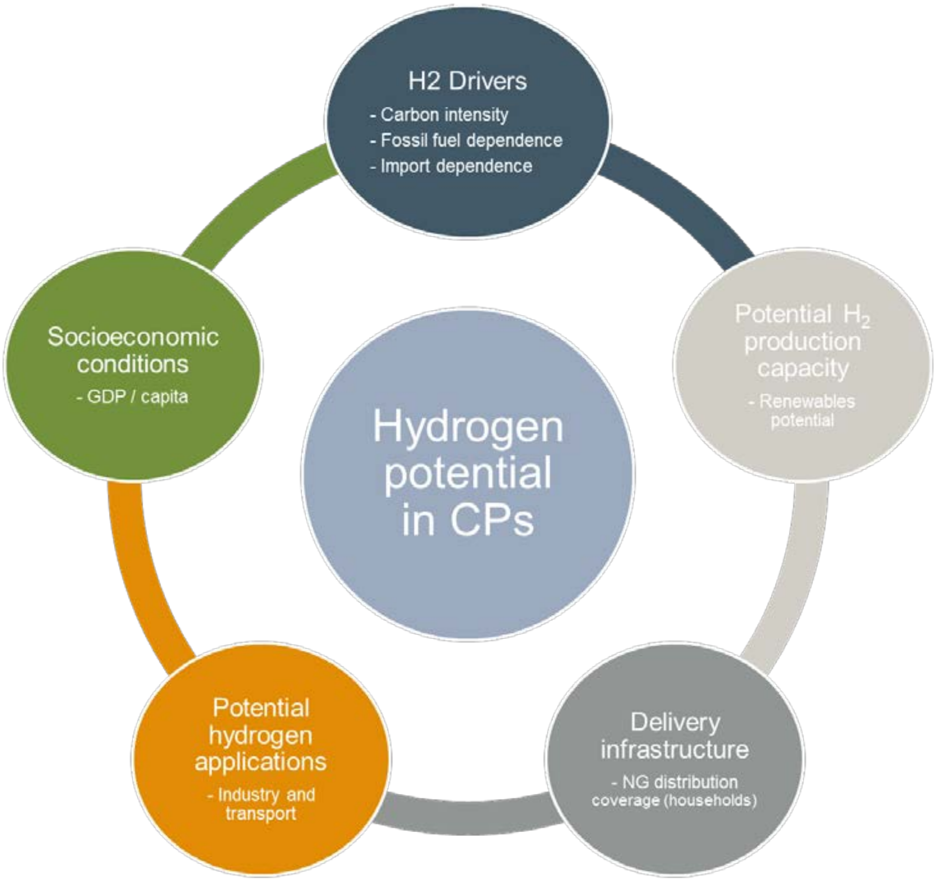
1. **Drivers for hydrogen** – the overwhelming imperative for adopting hydrogen and other forms of clean energy is the need to limit climate change and therefore carbon emissions, as well as improving air quality and limiting the associated health costs. Accordingly, we assume that the higher the carbon intensity and dependence on fossil fuels in a given CP, the greater will be the imperative to examine decarbonisation options, including hydrogen. A higher dependence on

[1] See our accompanying international review report for more details.

imported energy may also be an important driver for seeking energy supply alternatives, especially for many CPs dependent on single sources of supply.

2. **Potential hydrogen production capacity** – we focus on the technical potential for renewable energy production in the CPs as an indicator of this. This is because renewable energy sources (RES) continue to remain largely untapped in the CPs and the longer term benefits for the CPs are likely to come from coupling hydrogen with the power sector. Also, the EU is mostly promoting renewable hydrogen, although low carbon hydrogen is viewed as an interim solution[2]. The latter (i.e. low carbon hydrogen production) is also an important prospect, especially for Ukraine[3].

Figure 1 Comparative assessment framework



Source: ECA and E4tech

[2] We note that a considerable amount of water is also required to produce hydrogen with electrolysis. However, conventional means of energy production (e.g. electricity generation and oil refining) also use significant amounts of water so it is uncertain whether a shift to hydrogen would involve a net increase in water consumption or how large that would be. Our perception is that the water footprint of hydrogen production has not featured as a significant issue even in places where sources of freshwater are limited. We have therefore not included a metric for water availability. In any case, we also note that the CPs are generally ranked low to medium on conventional water stress or scarcity indices.

[3] From the information we have been able to ascertain, only Ukraine currently has a material level of hydrogen production (in oil refining), while Albania and Serbia also produce small volumes.

3. **Delivery infrastructure** – one of the key challenges for the scaling up of hydrogen is to connect producers with users and to minimise the costs of transportation. Given the expectation that natural gas pipelines will be the lowest cost option for delivering hydrogen to end users, we examine household gas connections as a proxy for potential and widely available distribution infrastructure for hydrogen in the CPs. This measure also “doubles up” as a measure of the potential for hydrogen to apply in the heating sector and for blending in gas networks.

4. **Potential hydrogen applications** – this criterion covers end use applications where hydrogen could be most effective or economically advantageous especially compared to low-carbon alternatives, namely industrial and transport applications. For the former, we employ a metric that collectively examines the importance of oil refining, ammonia production and steel making in CP economies. Refining and ammonia are existing demand sectors for hydrogen, while steel has high decarbonisation value (given its pervasiveness and high carbon footprint). In the case of transport, we focus on the relative economic importance of freight transportation for the CPs - hydrogen-fuelled heavy duty vehicles are expected to have comparative advantages over battery vehicles as discussed in our accompanying reports (the international review and economic analysis)[4].

5. **Socioeconomic conditions** – we use GDP per capita as a measure of the standard of living and economic wellbeing in the CPs. The rationale is that the higher this metric is, the greater is the likelihood that consumers would be able to adopt newer technologies and / or governments would have the capacity to support the development of the hydrogen economy. Put differently, even if the RES endowment of the CPs and the other factors enumerated above are favourable for the development of a hydrogen economy, this may still be hindered if funding for example is limited to bring hydrogen to scale.

In the sections below we first examine each of the individual assessment metrics and then group these by parameter to present a comparative view of the CPs.

[4] Note that the CPs are also required to include a certain percentage of RES in transport – see the CP annexes for more information.

3 Assessment by individual metric

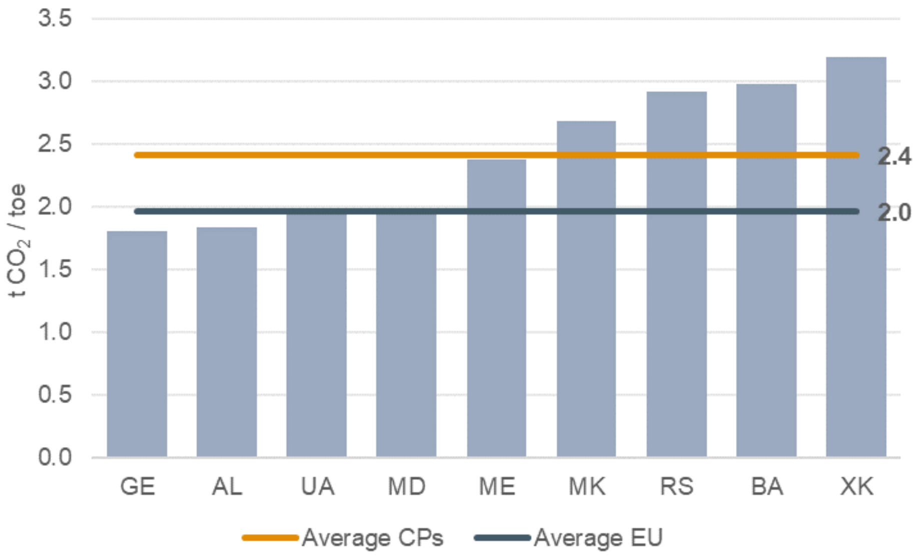
3.1 Drivers for hydrogen

3.1.1 Carbon intensity

Figure 2 below shows the carbon intensity of the CPs, expressed in tonnes of carbon dioxide emissions as a proportion of total primary energy supply in tonnes of oil equivalent (toe), compared to the average for the CPs as a whole and the average for the EU[5]. Key observations are:

- The carbon intensity of the CPs collectively is significantly higher than that of the EU, suggesting an even greater need and urgency to address decarbonisation goals;
- Of the CPs, Kosovo*, Bosnia and Herzegovina, Serbia and North Macedonia have the relatively higher carbon intensity, with all of them exceeding both the EU and CP average;
- Georgia and Albania have the lowest carbon intensity of the CP group owing to the significant contribution of hydropower (in both CPs) and natural gas (in Georgia, as Albania does not use natural gas yet), as opposed to coal, in their energy mix.

Figure 2 Carbon intensity (CO_2 emissions as a proportion of primary energy supply), 2018



Source: International Energy Agency

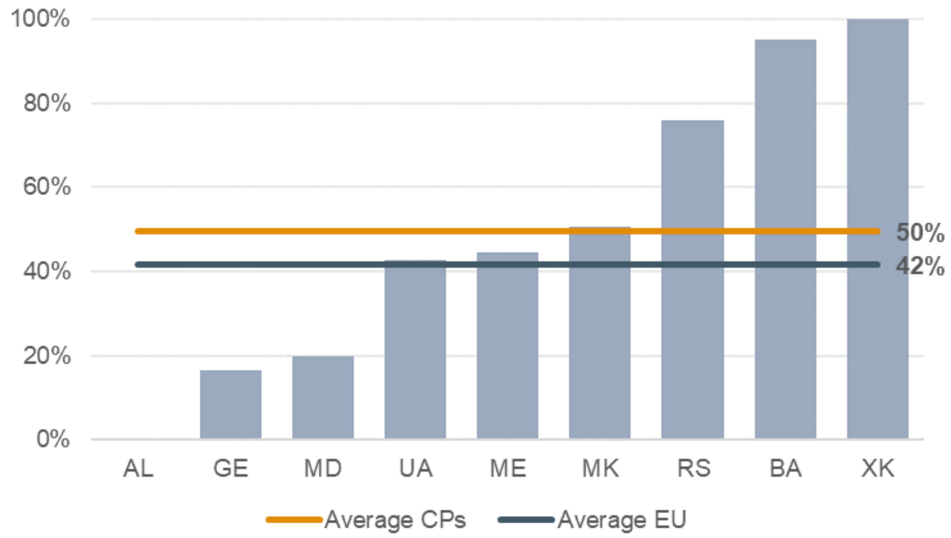
[5] The data is from 2018 and so the EU covers all Member States at the time, that is, it includes the United Kingdom.

3.1.2 Dependence on fossil fuels in electricity production

The relative dependence of the CPs on fossil fuels is shown in Figure 3 and Figure 4 below. The former shows the share of fossil fuels in the total inland electricity demand of each CP; the latter expresses fossil fuels as a share of power generation. Both graphs also contain the average for the CP group and the EU (including the UK). We note the following:

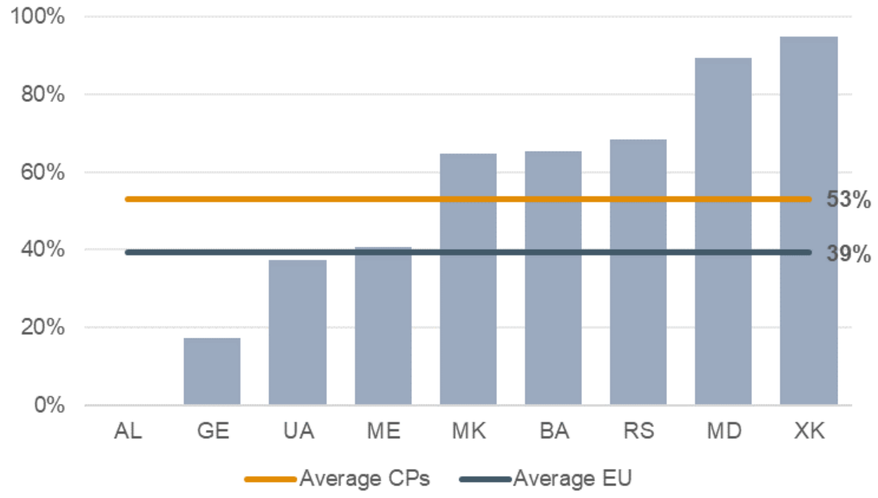
- Fossil fuels constitute a greater proportion of electricity demand in the CPs than the EU average, with the disparity being even greater in power generation;
- Consistent with the carbon intensity indicator, Kosovo*, Serbia, Bosnia and Herzegovina and North Macedonia are most dependent on fossil fuels, both as a total of electricity demand and in power generation;
- Moldova's reliance on fossil fuels is low overall, but it rates second highest in relation to its fossil fuel dependence in the power sector;
- Albania and Georgia have low fossil fuel dependence for the same reasons as those mentioned above for their low carbon intensity (i.e. greater reliance on hydropower for both CPs, and natural gas in Georgia);
- Ukraine and Montenegro sit somewhere between the two extremes with their fossil fuel dependence both in electricity demand overall and in power generation being broadly equivalent with the EU average.

Figure 3 Fossil fuel share in total inland electricity demand, 2018



Source: Eurostat

Figure 4 Fossil fuel share in power generation, 2018

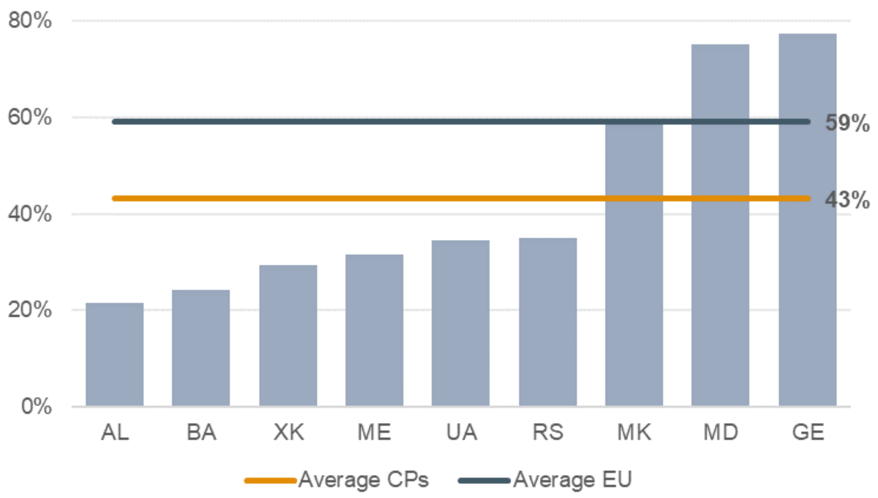


Source: Eurostat

3.1.3 Import dependence

Our final metric for the drivers parameter is the level of energy import dependence of total energy supply in the CPs[6]. On this measure (see Figure 5), the CPs are less import dependent than the EU on average. However, at the individual level, Moldova and Georgia are highly dependent on imports (they represent approximately three-quarters of total primary energy supply), given their reliance on piped natural gas from overseas. North Macedonia also has a large share of imports (~60%), while the remainder of the CPs have much lower shares ranging from about 20% to 35%.

Figure 5 Net energy imports (proportion of total energy supply), 2018



Source: Eurostat

[6] This is expressed as a proportion of Total Energy Supply as defined by Eurostat (so, includes transformed energy), which is broadly equal to primary production plus net imports plus the change in stocks plus international aviation.

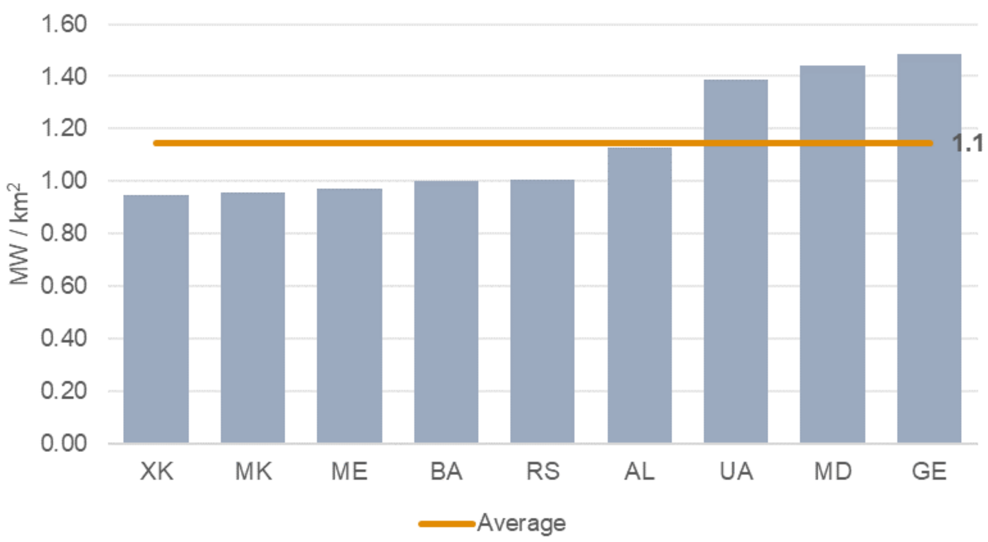
3.1.4 Potential renewable hydrogen production capacity

Renewable energy potential

The renewable energy *technical* potential for each of the CPs and versus the average for the group is shown in Figure 6. This potential has been measured as the estimated capacity in MW of solar, wind and small hydro, divided by the total surface area of each CP using data from the United Nations Development Programme (UNDP)[7]. We note that this is only theoretical potential and there are many factors that would determine economic viability, such as, location, system performance, and market and financing arrangements to name but a few. Hence, this metric should be treated with especial caution.

As shown in the figure, Georgia, Moldova and Ukraine have relatively higher potential for generation from RES (and by assumption hydrogen production capacity). Most of the other CPs are broadly equivalent and have a potential that is close to 1 MW / km^2, whereas Albania sits between the two groups and has a potential that is broadly commensurate with the average for the CP group.

Figure 6 Renewable energy technical potential (MW capacity per km^2 of country surface area)



Source: UNDP snapshots, 2014[8]

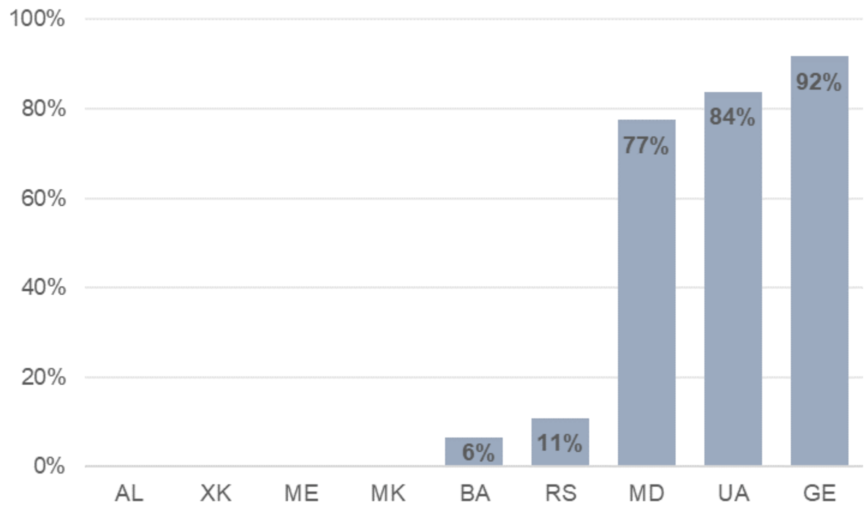
[7] We note that the data is somewhat dated (2014), but this was the only source we could identify that consistently reported on the technical potential of RES in all the CPs. For Serbia, we have relied on various sources and our own analysis, as the UNDP data seemed to us incorrect.
[8] https://www.eurasia.undp.org/content/rbec/en/home/library/environment_energy/renewable-energy-snapshots.html.

3.2 Delivery infrastructure

3.2.1 Gas distribution network coverage

The figure below shows the proportion of households connected to the CPs' gas distribution networks, where they exist. Albania, Kosovo* and Montenegro currently have no gas

Figure 7 Households connected to natural gas network (% of total)



Source: Various, including Energy Community Secretariat, CP statistical agencies.

distribution network. North Macedonia does have households connected to the distribution network, but they represent a negligible proportion of total households in the country. At the other end of the spectrum, Georgia, Ukraine and Moldova are all extensively gasified and therefore the vast majority of households are connected to the gas network. Finally, Serbia and Bosnia and Herzegovina have gas distribution networks in only parts of their territories and therefore the proportion of total households covered is small, while North Macedonia is also looking to expand the coverage of its currently limited distribution network[9].

3.3 Potential hydrogen applications

3.3.1 Industrial base

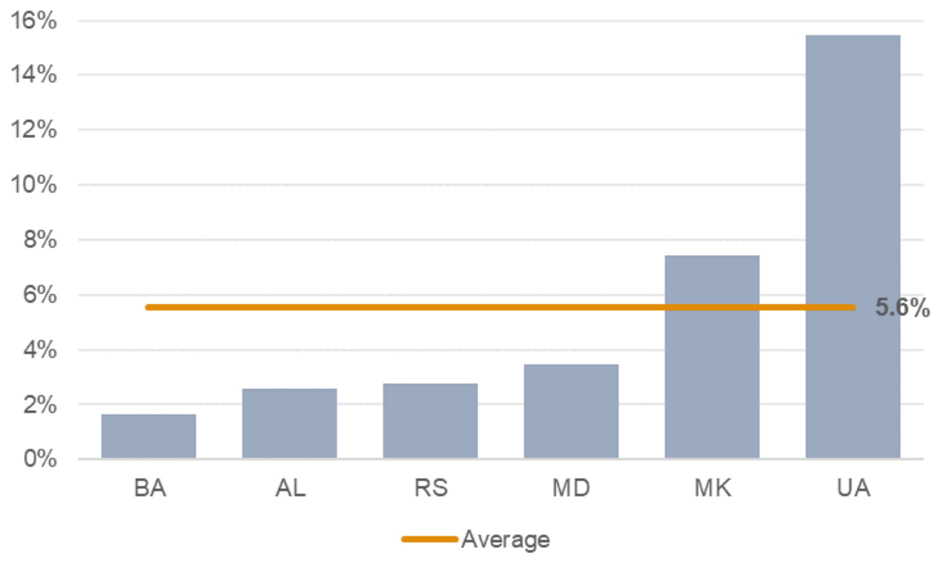
As mentioned above, our preferred measure for potential hydrogen applications in industry is the proportion of refining, ammonia production and steel making in overall economic production (GDP). We were unable to identify data at this level of granularity, given that industrial activity is typically reported according to broader groups of the statistical

[9] While these last-mentioned CPs are not ranked highly on the delivery infrastructure metric, this does not necessarily mean that there is not the prospect of using or blending hydrogen in those parts of the network that do exist (or are planned).

classification of economic activities in the European Community (or 'NACE'). Hence, for this reason we have used the following industrial classifications as a proxy for each application:

- Refining: C19 Manufacture of coke and refined petroleum products;
- Ammonia: C20 Manufacture of chemicals and chemical products; and
- Steel: C24 Manufacture of basic metals.

Figure 8 Share of key industrial applications in total output[10] (2018)



Source: CP statistical agencies. Albania 2017, North Macedonia 2012, Georgia, Kosovo* and Montenegro not available.

The resulting shares of industrial production in the three sectors as a percentage of total output are shown in Figure 8. We note that data for Georgia, Kosovo* and Montenegro were not available. As demonstrated in the graph, the three industrial sectors represent a very significant component of the economies of Ukraine (15.5%) and North Macedonia (7.4%). Although less significant, the shares for the other CPs are still a sizable proportion of economic activity, exceeding 2% in all cases except for Bosnia and Herzegovina.

3.3.2 Transport

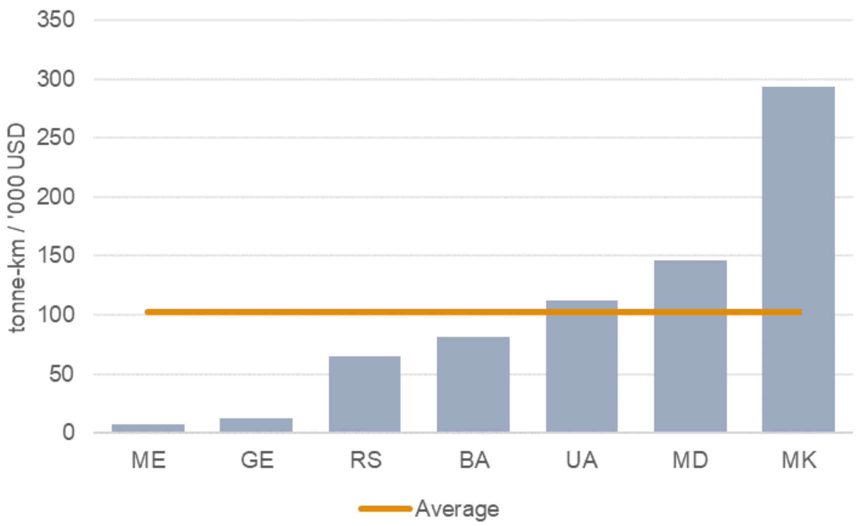
Figure 9 below shows the importance of freight transport as a share of total economic activity in all the CPs (except for Albania and Kosovo* where data were unavailable). Freight transport is expressed in tonne per kilometre, which corresponds to the transport of one tonne of freight by road over a distance of one kilometre. This serves as an indication of the overall level of freight transport activity as it considers both the amount of goods transported and the distance transported. To ensure comparability between CPs (given different geographical areas and

[10] Gross Value Added, although specification in CP statistical services also refers to total output and production volume.

lengths of road network) we express this measure as a proportion of their economic activity (GDP).

As shown in the figure, the importance of freight transportation is comparatively greater among the CPs in Ukraine, Moldova and North Macedonia. However, and despite not showing this in the graph, we note that based on data provided by the Transport Community, Serbia has the three busiest transport routes in the Western Balkans region (including a route through North Macedonia to the Greek border). Hence, when examining the relative economic attractiveness of hydrogen applications, it might be more meaningful in the case of transport to review large transit routes (rather than CP-focused transport metrics alone).

Figure 9 Road freight transport per unit of Gross National Income



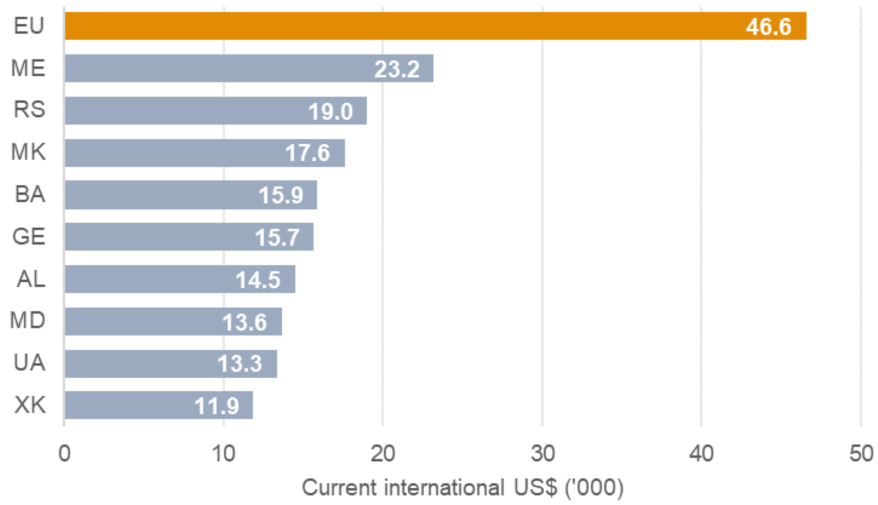
Source: World Bank, Road freight transport data for Albania and Kosovo* not available

3.4 Socioeconomic conditions

GDP per capita

The GDP per capita for each of the CPs compared to the EU average is shown in Figure 10 below. All CPs are considerably less wealthy compared to the EU average. This suggests that there might be constraints on the funding and investment necessary to facilitate the development of hydrogen and therefore external economic assistance is likely to be vital for the CPs.

Figure 10 GDP per capita in purchasing power parity terms, 2019



Source: World Bank

4 Comparative assessment of CPs

Below we provide a comparative assessment of the CPs based on the above metrics. For this purpose, we have:

- Grouped the metrics (where there is more than one) by parameter, that is, under the broad headings of hydrogen drivers, potential hydrogen capacity, delivery infrastructure, potential hydrogen applications and socioeconomic conditions;

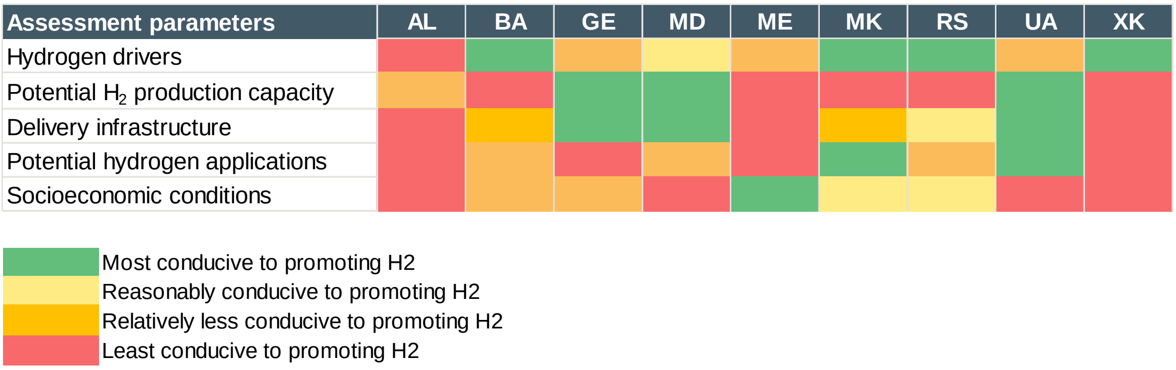
- We have normalised the metrics based on the minimum and maximum values for the CPs and then divided the CPs in quartiles along this range;

- We then ‘score’ the CPs for each factor based on the quartile they are in and using a scale of 1 to 4 – a lower score indicates that the CP is at the lower end of the range and conversely for the higher scores; hence, for example, a score of 4 against hydrogen drivers suggests that the CP has a high combined score for carbon intensity, fossil fuel dependence and energy import share, suggesting a potentially stronger imperative to pursue clean energy options like hydrogen;

- We present the results in the form of a heat map (see Figure 11) using graded colour coding from red through to orange, yellow and green with red representing the low end of the scoring spectrum and green the highest.

It should be noted that the assessment is indicative of the different parameters that could drive a policy shift in the CPs to hydrogen. Moreover, and importantly, the purpose of this evaluation is not to create a scorecard for the CPs, but to highlight areas where action might be needed and / or prioritised and to provide potential insights regarding the targeting of any required next steps for further promoting hydrogen in individual CPs.

Figure 11 Relative assessment of CP prospects of introducing hydrogen



Source: ECA and E4tech

Subject to the qualifications above, we make the following observations based on the heat map:

- None of the CPs scores unambiguously higher against the assessment parameters – each CP has its own relative “strengths” and “weaknesses” suggesting there is no “one size fits all” solution for the CPs and any policy prescriptions must be carefully targeted to the circumstances of the individual CPs. However, on this preliminary assessment, it appears the potential is relatively greater in Georgia, Moldova and Ukraine.

- Decarbonisation should be featuring as a priority for most CPs, that is, they score highly against the parameter ‘hydrogen drivers’ with the notable exception of Albania (given the predominance of hydropower).

- The theoretical potential for producing hydrogen from renewables appears to be medium to high in many CPs, with the greatest prospects seemingly being in Georgia, Moldova and Ukraine (although we stress again that this is highly indicative and certainly does not denote potential economic viability).

- Matching producers and users of hydrogen is likely to be the largest challenge for most of the CPs given the lack of existing infrastructure that can be repurposed for distributing hydrogen; the better prospects for this (and therefore also for blending and heating applications) are in those CPs with existing and extensive gas distribution networks, notably Georgia, Moldova and Ukraine and to a lesser degree, Serbia, Bosnia and Herzegovina and North Macedonia.

- Many of the CPs have a significant share in their total output of industrial applications and freight transportation, two broad areas where the prospects of using hydrogen are potentially the highest. This is particularly the case for Ukraine and North Macedonia[11].

- The relative economic development status of the CPs could act as a constraint on promoting hydrogen.

[11] We note that the picture is somewhat distorted as no data were available for both transportation and industry for Kosovo*. Industry data was also unavailable for Georgia and Montenegro, and transport data is missing for Albania.

Annexes

A1 Introduction to CP profiles

Annexes A2 to A10 contain profiles of the CPs, focusing on their current and prospective conditions in the energy sector, seen especially from the prism of the potential for the inclusion and / or expanded use of hydrogen. The information in these annexes is intended to serve as a self-contained summary of the CPs' energy status, but also forms the basis for the assessment discussed in the main body of this report.

The profiles are structured around the following sections for each CP:

- **Current situation overview** – this provides information about the CP's current status in the energy sector, including the composition of the energy supply, and the significance of energy imports in the energy balance, especially for electricity generation. This provides an indication of the significance of utilising a CP's renewable energy potential and / or developing hydrogen related applications to improve CP security of supply and reduce energy supply dependence on imports. This discussion is complemented by a presentation of the CPs' CO_2 intensity (CO_2 emissions / total primary energy supply) and the theoretical technical potential of wind, solar and small hydro power generation, as an indication of the capacity of a CP to decarbonise its electricity sector, while also creating possibilities for generating renewable hydrogen and / or utilising hydrogen in final energy uses. In addition to providing relevant energy data, this section includes a brief reference to the conditions in a CP's electricity and natural gas markets, on the presumption that competitive markets might be more conducive to, and / or would not distort, the underlying economics of hydrogen applications compared to other fuels. This section also includes information on energy consumption in the transport sector, as a potential area for hydrogen application. The information is mostly drawn from statistical publications, as well as relevant country reports.

- **Policy objectives and national goals / targets** – here we present each CP's current energy policy objectives, and national targets, as published in official Energy Strategies, National Energy and Climate Plans, other national planning documents, as well as their international decarbonisation commitments, as they may be available or relevant for each CP. The review focuses on identifying either hydrogen-specific policies, or policies and targets that may have an indirect relevance to hydrogen applications in the future.

- **Legislative and regulatory framework** – this examines the current legislative and regulatory framework governing the energy sector. The review focuses on provisions relevant to the introduction and use of hydrogen, as well as the regime governing natural gas transportation and use, the provisions supporting RES investment, and any provisions regarding carbon pricing.

- **Target sectors and infrastructure for end-use of hydrogen** – this section focuses on the existing conditions for developing hydrogen related infrastructure, and on the prospective demand for hydrogen in various end uses, which were examined in the economic analysis of the study. The section separately reviews the following:

- Available information regarding the production of hydrogen in the CP;
- The availability or plans for developing infrastructure, mainly in terms of natural gas interconnections and domestic transmission and distribution networks; and
- The potential for hydrogen utilisation in end uses in transport, industry, the power sector, and domestic and commercial sector heating.

- **Current projects and initiatives** – pilot or commercial scale projects entailing hydrogen applications, where available, are briefly presented here.

The information presented in the CP profiles is largely based on available published reports, studies, and official statistical sources. In addition, we aimed to have short, targeted interviews with CP representative authorities and other stakeholders with an interest or some activity relevant to hydrogen. We have included information gathered through these discussions in the various sections of the CP profiles. A list of stakeholders that agreed to be interviewed for this study is contained in Annex A11.

A2 Albania

A2.1 Current situation overview

The energy supply of Albania is made up of 49% oil and oil products, 31% hydropower, 12% biofuels, and 10% solid fossil fuels (i.e. coal), whereas natural gas and renewables (excluding hydro) make up 1% each.

Almost the entire domestic electricity supply is generated by hydropower. Although high dependence on hydropower may pose a potential long term security of supply risk, due to climate change, Albania does not face security of supply issues at present, as it is well interconnected, with three 400kV lines (plus one under construction), two 220kV lines, with 1,241 MW total maximum net transfer capacity for import and 4,137 MW nominal transmission capacity on all interconnectors.

There is a wholesale electricity market in place, but competition is limited, given public service obligations. In October 2020, the electricity TSOs of Albania and Kosovo* signed a shareholders' agreement to establish the Albanian Power Exchange, ALPEX. This is intended to enable day-ahead market coupling between the two CPs, planned for the second half of 2021, and expected to extend into the intraday markets thereafter, providing access to additional generation resources, especially for balancing during tight summer months.

Albania is the third largest producer of crude oil of all the CPs and a net exporter of crude oil, exporting a total of 64% of its domestic production volume. After accounting for stock changes, 33% of the total oil production volume is handled by Albania's refineries.

Although Albania has promising potential of solar and wind energy, these resources currently constitute a very small proportion of its energy supply.

There are significant ongoing developments towards developing gas pipeline interconnections with neighbouring countries and upgrading and expanding its limited domestic gas network. A key milestone was the recent commissioning of the Trans-Adriatic Pipeline (TAP) connecting Azerbaijan to Italy, which passes through Albania. TAP transported its first gas on 30 December 2020. A wholesale gas market has not been established yet.

Albania's transport sector is dominated by fossil-based energy sources, with oil products and natural gas accounting for 87% of final energy consumption in transport. A significant amount of biofuels does not have proven sustainability in line with Directive 2009/28/EC, which is mandatory for all CPs. Table 1 presents an overview of the current situation in Albania.

Table 1 Albania – current situation overview, 2018

Energy supply	ktoe	% of TES
Total energy supply (TES)	2,346	
Solid fossil fuels	223	10%
Natural gas	35	1%
Oil and oil products	1,147	49%
Hydropower	735	31%

Wind and solar	14	1%
Biofuel	271	12%
Nuclear	0	0%
Electricity	-79	-3%
Other	0	0%
Net imports	504	21%
Electricity	**GWh**	**% of TGEP**
Total gross electricity production (TGEP)	8,553	
Solid fossil fuels	0	0%
Natural gas	0	0%
Oil and petroleum products (excluding biofuel)	0	0%
Hydro	8,552	100%
Wind	0	0%
Solar photovoltaic	1	0%
Primary solid biofuels	0	0%
Nuclear heat	0	0%
Fossil fuels use in electricity production	0	0%
Inland electricity demand	7,595	
Fossil fuels use (% of inland electricity demand)		0%
CO_2 intensity	**t CO_2/toe**	
CO_2 emissions / Total primary energy supply	1.84	
Renewable energy technical potential	**MW**	**MW/km^2**
Solar	26,000	
Wind	2,000	
Small hydro	4,500	
Total solar, wind and small hydro potential	32,500	1.13
Economy	**Current international US$**	
GDP/capita, PPP (2019)	14,496	

Source: Eurostat, UNDP renewable energy snapshot, World Bank, ECA analysis. Terminology following Regulation EC 1099/2008 on energy statistics.

A2.2 Policy objectives and national goals / targets

In July 2018, the 'National Energy Strategy for the period 2018 – 2030' was approved by the Albanian Council of Ministers. The strategy aims to enhance energy security of supply mostly by utilising domestic, sustainable and competitive sources while establishing Albania as a regional energy hub and contributing to the development of a safer and more secure network in the region.

A large part of the Energy Strategy was the approval of the Natural Gas Master Plan and Project Identification Plan (GMPA)[12] which was finalised in 2016. Through its gas masterplan, Albania aims to develop its gas networks substantially and establish itself as an energy hub in the region. The first large milestone has been the successful operation of TAP in December 2020 connecting Azerbaijan to Italy and passing through Albania. The GMPA identifies and proposes gas network development projects in Albania while factoring in interconnected projects such as the completed TAP, the planned Ionian Adriatic Pipeline (IAP) and the planned Albania Kosovo* Pipeline (ALKOGAP). As part of the masterplan, storage sites are also being considered. The GMPA is focused on natural gas and makes no reference to hydrogen or hydrogen mixes.

There are also plans to use gas from TAP to produce more electricity domestically. New gas power plants are intended to help diversify supply and increase security of supply in the power sector. For example, the existing Vlorë, oil based power plant, which has never operated due to technical issues, is planned to be refurbished to burn gas and be connected to TAP. The government is also prioritising the development of the Skavica hydropower plant (210 MW), recognised as a project of strategic significance.

A workshop in February 2020 with the US Energy Department's Fossil Energy organisation explored the option of small scale liquefied natural gas (LNG) in Albania, including potential LNG terminals[13].

Albania's power transmission system is interconnected with Greece, Montenegro and Kosovo*. A new interconnector is under construction to North Macedonia which is part of the Projects of Energy Community Interest (PECI) with a planned commissioning year of 2023.

Albania has committed to an increase in renewable energy sources (RES) and a reduction of its greenhouse gas (GHG) emissions. In its revised National Renewable Energy Action Plan (NREAP) of 2018, it set a target to cover 42% of gross final energy consumption (GFEC) by RES in 2020, compared to a baseline of 31.2% in 2009. The following table breaks the NREAP RES target down further and reports each element against Albania's latest NREAP progress report.

Table 2 NREAP targets vs reported progress 2016 and 2017, Albania

Sector	2020 NREAP target (%)	Reported 2016 (%)	Reported 2017 (%)
Heating and cooling	9	9.2	8.7
Electricity	29	23.0	15.9
Transport	3[14]	2.0	2.0
Overall share of GFEC	42	34.2	26.6

Source: Revised NREAP 2018

Adhering to an increase in the RES share over the years has been challenging in Albania due to a rise in energy consumption but also because of the large share of hydropower and its

[12] Gas Master Plan for Albania and Project Identification Plan, *COWI IPF*, June 2016.
[13] https://www.energy.gov/fe/articles/small-scale-lng-deployment-central-and-eastern-europe-workshop.
[14] The transport target for 2020 should be 10%, in accordance with the obligation in the EnC Treaty, with which the revised NREAP is not in line.

variability between years. There are plans to accelerate RES uptake through utilisation of wind and solar energy. However, RES plans to increase solar and wind capacity by 2020 have not fully materialised.

Under the Paris Agreement, Albania committed to reduce its GHG emissions by 11.5% compared to the baseline scenario for the period 2016-2030 in its Intended Nationally Determined Contribution (NDC), i.e. an increase of 3.5% compared to 1990 levels. However, Albania is currently revising its NDC and will submit the updated contribution to the UNFCCC in 2021 ahead of the 26th Conference of Parties. Furthermore, it has yet to implement a national legal framework for the climate. Albania's integrated National Energy and Climate Plan (NECP) is currently being developed and an early draft has been shared with the EnC Secretariat for informal comments.

Albania is a signatory to the 10 November 2020 Sofia Declaration committing to work towards the 2050 target of a carbon-neutral continent together with the EU.

There are no hydrogen-related policies stated at the moment.

A2.3 Legislative and regulatory framework

A law was passed in 2017 converting the variable renewable energy (VRE) generation schemes from feed-in tariffs (FIT) to contracts-for-difference (CfD). The change applies to solar plants above 2 MW and wind plants more than 3 MW. Under CFDs, VRE generators sell electricity in the wholesale market and are guaranteed the reference price determined by the CfD auction for 15 years. Thus, the implementation of CFDs depends on the upcoming establishment of the day-ahead market.

Solar auctions of 100 MW and 70 MW were held in 2018 and 2020 respectively, however the contract for the 2018 auction has not been signed.

Current primary legislation does not forbid the use of hydrogen in the gas system. However, hydrogen-specific secondary legislation and technical standards required for its adoption have not been developed.

A2.4 Target sectors and infrastructure for end-use of hydrogen

A2.4.1 Production of hydrogen

There is no information on renewable or low carbon hydrogen production in Albania.

A2.4.2 Infrastructure

Albania's ongoing gasification plans provide a unique opportunity for the CP to set itself up for the future uptake of hydrogen in the CP and the region, provided the relevant economics are favourable.

Albgaz as the combined gas TSO and DSO is responsible for the operation, development and maintenance of Albania's gas transmission, distribution, storage and LNG infrastructure. It is in the early stages of developing its transmission and distribution network from the TAP exit points, with the city of Korçë (south-eastern Albania) planned to be connected by 2023.

Exploring possibilities for hydrogen production and/or use as part of this exercise has the potential to capture increased efficiencies; while feasibility studies and technical design are ongoing, this is an area Albgaz is interested in exploring further. This could include the exploration of blending hydrogen in the network as well as strategic injection sites of hydrogen, e.g. based on RES potential and the production of green hydrogen from electrolysers.

As part of Albania's gas expansion plans, domestic gas storage solutions are also being investigated. These could contribute to security of supply and provide a buffer to market price volatility. The area of Dumre (in Central Albania) is a possible location for gas storage facilities, using underground salt formations. The GMPA already identifies them as a potential storage option for gas, however in a future hydrogen economy they could be attractive for the potential storage of hydrogen or hydrogen blends. Albgaz has applied for certification regarding the development and operation of the Dumre underground storage site, for which a prefeasibility study is due in the summer of 2021.

A2.4.3 Hydrogen end-use potential

Actual hydrogen applications are limited as hydrogen has not been included in any strategic planning so far. Some prospective target sectors are identified below.

Transport

Freight and passenger transport by rail in Albania is among the lowest of all the CPs. Albania's road transport is predominantly reliant on fossil fuels, which account for 87% of final energy consumption in the sector. A recent Energy Community report on RES in the transport sector[15] recommends among its options a small 0.13% contribution of hydrogen to the 14% RES in transport target by 2030, to be further increased in the following years. It states that electric and hydrogen vehicles can make small contributions by 2030 and have a strong growth potential thereafter. The report recommends the uptake of hydrogen fuel cell-electric road vehicles (0.12% of target), the uptake of hydrogen fuel cell buses in urban areas and coaches (0.01% of target), and hydrogen in rail (0.01% of target). Road suggestions are for long distances and for large driving ranges in applications not suitable for battery-electric vehicles. Hydrogen rail suggestions are for non-electrified rail lines. Utilisation of hydrogen for long range road and rail applications would be subject to these being adopted and infrastructure established in a wider region covering other CPs through which Albania would be connected to EU hydrogen-fed transport networks.

[15] Modalities to foster use of renewable energy sources in the transport sector by the Energy Community Contracting Parties, *Energy Community*, December 2020.

Industry

Energy-intensive industry

As an indication of the potential use of hydrogen in the economy, current energy consumption in industry is considered. Approximately 50% of the energy consumed by Albania's industrial sector is derived from coal, by far the largest source of energy for the sector. The overwhelming majority (approximately 96%) of this is used by the non-metallic minerals industries, which is the largest energy-consuming industry in Albania. The top three industrial sectors by energy consumption are:

1. Non-metallic minerals (60%)
2. Food and tobacco (12%)
3. Iron and steel (6%).

Hydrogen favourable industry

Subject to available data, we also examine industrial end use applications where hydrogen could be most effective or economically advantageous especially compared to low-carbon alternatives, namely oil refining, ammonia production and steel making. As mentioned above, oil refining is significant in Albania. With a relatively large proportion of the domestic oil production being handled by Albania's refineries it could be valuable to align future hydrogen plans with refineries that currently produce or use hydrogen as part of their processes.

In terms of energy consumption, as already noted, iron and steel represents 6% of the total for all industry, while chemicals and petrochemicals (which includes ammonia production and oil refining) represents 3% of total industrial energy consumption. In terms of output and using the broader industrial classifications stated in section 3.3.1 of this report, these three sectors represent about 2.5% of the CP's GDP.

Other industry

Industry including cement, iron and aluminium smelting, currently using mainly electricity or oil, have expressed keen interest for connection to natural gas networks. Albgaz is assessing the feasibility of meeting this demand, considering the distance and concentration of these sites relative to the TAP exit point. In this context, consideration could also be given to whether, or under which conditions, possibilities for hydrogen production near the sites, and/or transport to the sites by road or rail, could make more economic sense than long distance gas networks.

Power generation

There are plans for use of natural gas for power generation in Albania, as gas is becoming available through TAP.

Domestic and commercial sector heating

Albania does not currently have gas supply infrastructure connected to residential properties and there is currently no natural gas use in commercial or public buildings. Energy consumption in households, of which heating energy will be a part during the winter months, is currently dominated by electricity, oil products and biomass. Albania's demographics are not favourable for the future development of gas distribution networks either, as noted in the GMPA. This is due to the relatively small number of inhabitants in many communities in Albania. In such cases, gasification (by developing traditional natural gas networks over long distances) of decentralised areas for a small number of customers may not be economically feasible. The Master Plan specifies how the TSO network should be developed, considering these restrictions. Decentralised hydrogen solutions and networks might provide economically and technically attractive options in such cases.

Table 3 below provides summarised statistics for potential hydrogen end-use sectors in Albania.

Table 3 Energy consumption metrics as of 2018 for potential hydrogen applications, Albania

Hydrogen application	Metric	Unit	
Industrial heat and feedstock	Final energy consumption in industry	ktoe	% of total
	Solid fossil fuels and natural gas	228	52%
	Fossil fuels	321	72%
Residential heat	Energy consumption for space heating	ktoe	%of total
	Solid fossil fuels	0	0%
	Natural gas	0	0%
	Oil and petroleum products	31	19%
	Renewables and biofuels	56	35%
	Electricity	73	46%
	Heat	0	0%
Commercial / public buildings heat	Total energy use	ktoe	% of total
	Solid fossil fuel	3	2%
	Natural gas	0	0%
	Oil and petroleum products	64	30%
	Renewables and biofuels	19	9%
	Electricity	129	60%
	Heat	0	0%
Transport	**Metric**	**Value**	**Units**
	Proportion of transport energy consumption from oil products or natural gas	86.6%	
	Road freight transport	No recent data available	Million tonne-km

Hydrogen application	Metric	Unit	
	Rail freight transport	42.9	Million tonne-km
	Passenger rail transport	2.0	Million passenger-km

Source: Eurostat

A2.5 Current projects and initiatives

No plans for pilot projects relating to hydrogen in Albania have been identified.

A2.6 Summary and conclusions

The focus of recent developments in Albania is on gasification through the utilisation of TAP and potentially IAP and ALKOGAP. Albania envisages becoming a future energy hub connecting East - West and South - North. With the recent operation of TAP, Albania intends to increase the role of gas in its domestic energy mix. In doing so, it is preparing the necessary gas legislation, resources, market, and infrastructure. However, no hydrogen considerations feature so far in current strategic or gasification plans.

With the increased interest in hydrogen in Europe, the region and globally, Albania finds itself in a potentially advantageous position. Albgaz is in the early stages of designing its gas transmission and distribution networks and if hydrogen is factored into those plans it could capitalise on being one of the few countries with a gas network which can accommodate hydrogen by design and making it a strategic enabler of the hydrogen economy in the area with significant potential in the short and longer term. Such an approach would have to extend beyond the existing gas network plans and integrate RES plans, storage plans and local hydrogen users (current and potential). The NECP under development seems an obvious instrument for including hydrogen in future plans and from there to materialise into the necessary enabling legislation and regulations.

Albania's current reliance and abundance of hydropower could be combined with RES to produce renewable hydrogen, provided the relevant economics are favourable. Further uptake of solar and wind would need to be accelerated from a relatively low starting point. In combination with the development of storage and the planned increase in interconnection capacity (in both gas and electricity) could set up Albania as a regional hydrogen hub, whilst simultaneously allowing it to meet its RES and emissions ambitions.

A3 Bosnia and Herzegovina

A3.1 Current situation overview

The energy supply of Bosnia and Herzegovina is dominated by solid fossil fuels, (i.e. locally sourced coal), accounting for 57%, followed by biofuels (16%), oil and oil products (23%). Natural gas accounts for a small proportion of the energy supply (3%), whereas RES supply is limited to mostly hydropower (7%) with other RES being negligible.

A deregulated wholesale electricity market is in place in the Federation of Bosnia and Herzegovina, whereas in Republika Srpska prices of generation are regulated. The creation of a day-ahead market is pending adoption of relevant legislation governing the whole territory of Bosnia and Herzegovina.

The wholesale gas market is regulated in the Federation of Bosnia and Herzegovina and deregulated in Republika Srpska, but a virtual trading point is not operational. Gas distribution is currently limited to a few urban areas.

Bosnia and Herzegovina has significant hydropower resources, which are already contributing to 35% of electricity production, or more, depending on the hydrology in a specific year. There is also significant wind energy potential, especially in the west and south-west of the CP, and a number of projects are under preparation.

The transport sector is almost entirely reliant on fossil fuels with most of the transportation being road transport.

Table 4 presents an overview of the current situation in Bosnia and Herzegovina.

Table 4 Bosnia and Herzegovina – current situation overview, 2018

Energy supply	ktoe	% of TES
Total energy supply (TES)	7,471	
Solid fossil fuels	4,230	57%
Natural gas	199	3%
Oil and oil products	1,683	23%
Hydropower	552	7%
Wind and solar	11	0%
Biofuel	1,191	16%
Nuclear	0	0%
Electricity	-396	-5%
Other	0	0%
Net imports	1,814	24%
Electricity	**GWh**	**% of TGEP**
Total gross electricity production (TGEP)	19,160	
Solid fossil fuels	12,437	65%

Natural gas	25	0%
Oil and petroleum products (excluding biofuel)	47	0%
Hydro	6,519	34%
Wind	103	1%
Solar photovoltaic	21	0%
Primary solid biofuels	1	0%
Nuclear heat	0	0%
Fossil fuels use in electricity production	12,509	65%
Inland electricity demand	13,169	
Fossil fuels use (% of inland electricity demand)		95%
CO_2 intensity	**t CO_2/toe**	
CO_2 emissions / Total primary energy supply	2.98	
Renewable energy technical potential	**MW**	**MW/km^2**
Solar	48,700	
Wind	2,000	
Small hydro	600	
Total solar, wind and small hydro potential	51,300	1.00
Economy	**Current international US$**	
GDP/capita, PPP (2019)	15,883	

Source: Eurostat, UNDP renewable energy snapshot, World Bank, ECA analysis. Terminology following Regulation EC 1099/2008 on energy statistics.

A3.2 Policy objectives and national goals / targets

In 2018, the Council of Ministers adopted the Framework Energy Strategy to 2035[16] in order to unlock further funding, improve markets and enable regulatory reform. The strategy makes no reference to hydrogen. The document mentions Bosnia and Herzegovina is *striving towards a true balance in the context of [the] "energy trilemma"*, although the framework appears to have locked in several coal power projects which could stall the transition to a decarbonised future.

The NDC target of Bosnia and Herzegovina is to reduce its emissions by 2% by 2030, compared to the business-as-usual scenario. This would mean 18% higher emissions compared to 1990. The NDC is currently being updated.

Almost all of Bosnia and Herzegovina's natural gas is imported through a single interconnector with Serbia, which is over 40 years old. There is an objective to diversify gas supply options, enhance reliability and improve security of supply. Bosnia and Herzegovina's Framework Energy Strategy to 2035[17] identifies three gas sources in order to diversify its gas supply, namely:

[16] Framework Energy Strategy of Bosnia And Herzegovina Until 2035, 2018.
[17] Framework Energy Strategy of Bosnia And Herzegovina Until 2035, 2018.

- LNG terminal in Croatia;
- The Caspian region through TAP, IAP and the Trans-Anatolian Natural Gas Pipeline (TANAP); and
- Russian gas through the extension of the current interconnection and the planned TurkStream pipeline.

Hydrogen is so far absent from Bosnia and Herzegovina's published strategic plans. There also appear to be limited hydrogen initiatives currently with no interest expressed by market participants in general. However, there appear to be intentions to include hydrogen in strategic planning, especially following the momentum gained from the announcement of the EU Hydrogen Strategy in the Eastern Neighbourhood. Moreover, the publication of the Energy Community report exploring the use of RES in transport[18] has triggered government interest in considering hydrogen as a means of improving the share of RES in the transport sector. MOFTER is open to including hydrogen in its future energy and decarbonisation plans and is exploring the future of hydrogen alongside global developments. Bosnia and Herzegovina's hydrogen strategy to 2025 is being developed but is in its very early stages. An unofficial draft of the first integrated NECP only lists existing policies and no future hydrogen-related measures.

The current economics of the hydrogen chain, along with the CP's economic priorities seem to limit the plans for development of relevant infrastructure to support hydrogen applications. Coal is domestically sourced and cheap and moving away from coal is difficult, bringing wider social and political challenges.

Following the suggestion in the recent Energy Community report for increasing RES in transport through hydrogen, the government intends to include it in its 2025 transport plan. In general, it is keen to improve the uptake of RES in transport and consider relevant options to that effect.

Bosnia and Herzegovina has committed to an increase in RES and a reduction of its GHG emissions. In its NREAP, it had set a target of 40% of GFEC to be provided from RES by 2020, factoring in a starting point of 34% in 2009. The following table breaks down the NREAP RES target further and reports each element against Bosnia and Herzegovina's latest NREAP progress report.

Table 5: NREAP targets vs reported progress 2016 and 2017, Bosnia and Herzegovina

Sector	2020 NREAP target (%)	Reported 2016 (%)	Reported 2017 (%)
Heating and cooling	52.4	53.9	54.1
Electricity	56.9	40.28	38.16
Transport	10	0.56	0.56
Overall share of GFEC	40	37.3	35.9

Source: NREAP and NREAP 2019 Progress Report

[18] Modalities to foster use of renewable energy sources in the transport sector by the Energy Community Contracting Parties, *Energy Community*, Dec 2020

For the heating and cooling and electricity sectors, Bosnia and Herzegovina had come a long way by 2017 to meeting its targets, however the overall share of GFEC in 2017 at 35.9% has not changed significantly from the 34% starting point in 2009.

The transport sector is dominated by fossil fuels which account for 99.6% of final energy use and almost all of the final energy consumption in the transportation sector applies to road transport, with rail transport accounting for less than 1%. Efforts to accelerate RES (wind and solar) uptake in the power sector by simplifying administrative procedures and introducing market-based support schemes are under way.

Despite the need for storage capacity, due to the relatively high share of households in natural gas consumption, there are currently no plans for storage development, primarily due to the low proportion of gas in the energy supply, which makes it economically unviable. Possibilities have been explored in the past to use gas storage in Serbia for Bosnia and Herzegovina's needs. There are prospects to explore storage solutions to provide security of supply in the future, however this has not been explored in depth.

Bosnia and Herzegovina is a signatory to the 10 November 2020 Sofia Declaration committing to work towards the 2050 target of a carbon-neutral continent together with the EU.

A3.3 Legislative and regulatory framework

So far, all electricity trading has been based on bilateral contracts. A new law, which would provide the legal basis for the implementation of an electricity market and market coupling with Croatia, Montenegro and Serbia, has been under development, but is not yet adopted.

The legal framework governing the gas sector in the whole territory of Bosnia and Herzegovina is missing. Republika Srpska has adopted a law at the entity level.

A3.4 Target sectors and infrastructure

A3.4.1 Production of hydrogen

There is no information on renewable or low carbon hydrogen production in Bosnia and Herzegovina.

Currently, solar and wind power production are minimal in Bosnia and Herzegovina, providing limited resources for renewable hydrogen production, although there is greater RES potential in the CP that could be harnessed.

A3.4.2 Infrastructure

Bosnia and Herzegovina's gas network and gasification plans are dependent on the planned cross-border projects. Gas distribution exists in certain urban centres and there are plans to develop the gas sector further, at transmission and distribution level. There are no plans to use current gas infrastructure for hydrogen mixes, and there have been no studies to support it.

Although there is an identified need for future storage solutions, there are currently no official plans for the storage of energy from RES, including in the form of hydrogen. There are old salt mines in the Tuzla region which could be theoretically used for gas storage, although this initiative has not been explored in depth. With the further development of gas networks, the mines might provide some storage, including for hydrogen.

A3.4.3 Hydrogen end-use potential

Actual hydrogen applications are limited as hydrogen has not been included in any strategic planning so far. Some prospective target sectors are identified below.

Transport

Energy consumption for transportation is currently almost exclusively fossil-based, with 99.6% of total consumption in the sector from oil products or natural gas. Almost all of the final energy consumption in the transportation sector applies to road transport, with rail transport accounting for less than 1% of the total for the sector. Bosnia and Herzegovina has a motorway network of 198 km in length, facilitating road freight volumes similar to those of Albania and Moldova. Bosnia and Herzegovina has over 1,000 km of rail network, which supports above average freight levels for the CPs (excluding Ukraine).

The Energy Community report on RES in the transport sector[19] recommends a small 0.08% contribution of hydrogen to the 9% RES in transport target by 2030[20], with higher uptake after 2030. The report recommends the uptake of hydrogen fuel cell-electric road vehicles and the uptake of hydrogen fuel cell buses in urban areas and coaches. Both suggestions are for long distances and for large driving ranges in applications not suitable for battery-electric vehicles.

Industry

Energy-intensive industry

As an indication of the potential use of hydrogen in the economy, current energy consumption in industry is considered. Coal and natural gas account for 28% of final energy consumption in the industrial sector, rising to 42% including oil, indicating a large scope for decarbonisation to which the use of hydrogen could contribute. The remainder of final energy consumption is mainly covered by electricity.

The top three industrial sectors by energy consumption are:

1. Non-ferrous metals (29%);
2. Iron and steel (25%);

[19] Modalities to foster use of renewable energy sources in the transport sector by the Energy Community Contracting Parties, *Energy Community*, Dec 2020

[20] The target is based on the recast Renewable Energy Directive (RED II), which ranges between 9% and 14% based on a calculation that considers fuels of biological and non-biological origin. Applying the calculation translates to an assumed 9% target for all CPs, except Albania where the target is assumed to be 14% (given the high quantities of crop-based biofuels consumed in Albania today).

3. Non-metallic minerals (13%).

There has been limited interest in Bosnia and Herzegovina so far from industry and other potential hydrogen users to invest in the hydrogen supply chain.

Hydrogen favourable industry

Subject to available data, we also examine industrial end use applications where hydrogen could be most effective or economically advantageous especially compared to low-carbon alternatives, namely oil refining, ammonia production and steel making. There are some refineries that currently use hydrogen, such as the Bosanski Brod refinery. As elsewhere, this sector could provide an option for expanded hydrogen use or production in future.

In terms of energy consumption, as already noted, iron and steel represents 25% of the total for all industry, while chemicals and petrochemicals (which includes ammonia production and oil refining) represents 2% of total industrial energy consumption. In terms of output and using the broader industrial classifications stated in section 3.3.1 of this report, these three sectors represent about 1.7% of the CP's GDP.

Power generation

Power generation is currently mainly based on coal and hydropower plants, including a 420 MW pumped storage plant.

Subject to the provisions of Directive 2001/80/EC on Large Combustion Plants and the provisions of the Directive 2010/75/EU on Industrial Emissions, three coal plants would not be allowed to operate by December 2023 or earlier.

A plan to construct a 380 MW CCGT unit in the region of Zenica was postponed due to gas supply uncertainty, and there are no other plans for development of gas fired power plants.

Based on current conditions and plans, the potential for use of hydrogen in power generation in Bosnia and Herzegovina seems rather low.

Domestic and commercial sector heating

Energy consumption for heating in households is dominated by wood biomass, with a smaller contribution by district heating, coal, and oil and gas. The commercial sector is mainly consuming electricity for all energy uses, followed by coal, and relatively similar shares of district heating, biomass, gas, and oil. The expansion of natural gas networks would improve the energy consumption mix in both sectors.

Table 6 provides summarised statistics for potential hydrogen end-use sectors in Bosnia and Herzegovina.

Table 6 Energy consumption metrics as of 2018 for potential hydrogen applications in Bosnia and Herzegovina

Hydrogen application	Metric	Unit	
Industrial heat and feedstock	Final energy consumption in industry	ktoe	% of total
	Solid fossil fuels and natural gas	240	28%
	Fossil fuels	360	42%
Residential heat	Energy consumption for space heating	ktoe	%of total
	Solid fossil fuels	76	6%
	Natural gas	25	2%
	Oil and petroleum products	23	2%
	Renewables and biofuels	1,032	82%
	Electricity	5	0%
	Heat	95	8%
Commercial / public buildings heat	Total energy use	ktoe	% of total
	Solid fossil fuel	49	14%
	Natural gas	23	7%
	Oil and petroleum products	21	6%
	Renewables and biofuels	27	8%
	Electricity	196	56%
	Heat	32	9%
Transport	**Metric**	**Value**	**Units**
	Proportion of transport energy consumption from oil products or natural gas	99.6%	
	Road freight transport	4,280	Million tonne-km
	Rail freight transport	1,275	Million tonne-km
	Passenger rail transport	55.5	Million passenger-km

Source: Eurostat

A3.5 Current projects and initiatives

There are currently no plans for pilot projects, as the concept of hydrogen as an energy carrier is new for Bosnia and Herzegovina.

A3.6 Summary and conclusions

Bosnia and Herzegovina is only just considering the introduction of hydrogen in national plans. There is also an urgent need for further development of legislation and regulations in the electricity and gas sectors, even before hydrogen can be considered more formally.

There is also still a heavy reliance on coal in the country. Although steering away from coal is difficult, Bosnia and Herzegovina will find it difficult to justify a future relying on coal, which is likely to set it on an opposite trajectory to the rest of the region, the EU and globally. The importance and reliance on coal can be seen by the significant subsidies that have been paid in recent years by the government towards coal powered generation and the new subsidies locked in by its Framework Energy Strategy to 2035. A just transition away from coal will need to be carefully planned and address economic, technical, social and political challenges.

The uptake of RES and the full use of the country's RES potential could be key to providing the resources for green hydrogen production. Further support such as the planned auctions in 2022 are able to unlock Bosnia and Herzegovina's RES potential. The development of the electricity market also has the potential to stimulate further RES uptake. Moreover, due to the lack of hydrogen in strategic plans there has been no consideration of hydrogen production from RES and its use, e.g. in chemical plants or refineries. Once carbon prices and incentives are in place, hydrogen solutions might be more likely to be pursued by industry.

Storage solutions will be a requirement into the future, given both Bosnia and Herzegovina's ambition to increase RES in its electricity mix and the planned further development of gas infrastructure, usage and interconnection. The government will have to carry out analysis on how to finance storage options and how to efficiently allocate investment across different sources, including hydrogen.

A4 Georgia

A4.1 Current situation overview

The energy supply of Georgia mainly comprises 42% natural gas, 26% oil and oil products, 18% hydropower, and 12% solid fossil fuels and biofuels. The total electricity generation in 2018 was 12.1TWh, with hydro accounting for 82% of the electricity generation mix[21]. The Enguri Hydro Power Plant (HPP) and Vardnili HPP are the two largest hydro generators in Georgia with a capacity of 1,300 MW and 220 MW respectively[22]. Electricity generation is highly concentrated, with the Enguri HPP producing 33% of total domestic electricity supply, followed by the Gardabani Thermal Power Plant (10%) and the Vartsikhe HPP (10%).

The wholesale electricity market is based on bilateral contracts, while day-ahead, balancing and ancillary services markets are to be launched by 1 July 2021. The Georgian Energy Exchange has been established and the organised markets are in their testing phase.

Georgia's power system is synchronised with Azerbaijan and Russia but is not yet directly interconnected with other CPs. The trade balance depends on the season, with the abundance of hydro power being available in the summer months and power imports from neighbouring countries taking place in the winter.

While the use of hydropower enables a low cost supply of clean energy, the seasonal pattern of hydro flows means that HPPs have to be combined with other sources of energy to guarantee security of supply throughout the year, leading to an increasing role for natural gas in Georgia's energy mix. The importance of gas as a fuel rose further with the construction of two combined cycle gas turbine (CCGT) power plants which increased power supply in the winter months.

Natural gas consumption was approximately 2.4 bcm in 2018[23] with households and power plants being the main consumers. Although the gasification percentage is high at approximately 80%, households in rural areas still rely heavily on biomass. Upstream activities are limited with low exploration levels and no oil refineries. The wholesale gas market is deregulated, based on long term bilateral contracts, however the market remains highly concentrated and illiquid.

The system integration of VRE sources, such as wind and solar, is minimal in Georgia. Favourable wind conditions tend to coincide with the availability of hydro, which, given the intermittency of renewable resources and the lack of large scale storage solutions, has staggered investment in wind farms. There is currently only 20 MW of operational wind capacity which will soon increase to 200 MW.

---

[21] International Energy Agency Policy Review for Georgia (2020), https://webstore.iea.org/download/direct/4021?fileName=Georgia_2020_Energy_Policy_Review.pdf.

[22] https://www.energy-community.org/dam/jcr:12607648-d848-4920-b560-82d648f95a39/ECS_Georgia_Report_082017.pdf.

[23] International Energy Agency Policy Review for Georgia (2020), https://webstore.iea.org/download/direct/4021?fileName=Georgia_2020_Energy_Policy_Review.pdf.

Table 7 presents an overview of the current situation in Georgia.

Table 7 Georgia – current situation overview, 2018

Energy supply	ktoe	% of TES
Total energy supply (TES)	4,852	
Solid fossil fuels	303	6%
Natural gas	2,045	42%
Oil and oil products	1,270	26%
Hydropower	855	18%
Wind and solar	10	0%
Biofuel	271	6%
Nuclear	0	0%
Electricity	79	2%
Other	18	0%
Net imports	3,752	77%
Electricity	**GWh**	**% of TGEP**
Total gross electricity production (TGEP)	12,149	
Solid fossil fuels	12	0%
Natural gas	2,103	17%
Oil and petroleum products (excluding biofuel)	0	0%
Hydro	9,949	82%
Wind	84	1%
Solar photovoltaic	0	0%
Primary solid biofuels	0	0%
Nuclear heat	0	0%
Fossil fuels use in electricity production	2,115	17%
Inland electricity demand	12,854	
Fossil fuels use (% of inland electricity demand)		16%
CO_2 intensity	**t CO_2/toe**	
CO_2 emissions / Total primary energy supply	1.81	
Renewable energy technical potential	**MW**	**MW/km^2**
Solar	96,900	
Wind	2,300	
Small hydro	4,500	
Total solar, wind and small hydro potential	103,700	1.49
Economy	**Current international US$**	
GDP/capita, PPP (2019)	15,656	

Source: Eurostat, UNDP renewable energy snapshot, World Bank, ECA analysis. Terminology following Regulation EC 1099/2008 on energy statistics.

A4.2 Policy objectives and national goals / targets

Energy market transformation is still under way and includes several components. The NREAP, adopted at the end of 2019, includes several measures designed to increase the share of renewables in the energy sector while the energy efficiency law is pending approval in Parliament. Due to Georgia's recent accession to the Energy Community, in accordance with the Accession Protocol, renewable energy targets for 2020 are not binding.

Under the Paris Agreement, Georgia committed to unconditionally reduce its GHG emissions by 15% below the business-as-usual scenario until 2030. This is equivalent to a reduction of 32% compared to 2019.

The current focus of Georgia's energy policy has been on energy efficiency and renewable energy and no provisions for hydrogen have been made so far. RES that are being considered include wind, solar and hydro. More HPPs are already being developed, but there have been delays in construction. Hydrogen has not really been considered as a serious addition to the energy mix. The earliest timeline for inclusion could potentially be after 2022, given the time needed for analysis and planning, and that will depend on whether hydrogen becomes economically viable, and whether the existing gas infrastructure can be adapted to carry a blend of natural gas and hydrogen (subject to relevant studies of the network operators). There are currently no tangible policy studies that would prepare Georgia for inclusion of hydrogen into the energy mix.

In a similar manner, carbon pricing has not been explored in Georgia, although the Georgian Oil and Gas Corporation (GOGC) has been collaborating with NGOs and there are some ongoing studies concerning carbon prices. The current focus of GOGC's decarbonisation strategy is limited to the modernisation of existing infrastructure and improving the efficiency of existing power plants. The company is committed to further increasing its involvement in natural gas developments, including the use of by-products.

The government has been investigating ways to increase the utilisation of Enguri HPP and other hydro resources. According to the Ministry of Economy and Sustainable Development (MoESD), pumped hydro storage and floating PV systems were amongst the technologies considered. According to the IEA Policy review[24], three companies were created to assist with the development of pumped hydro storage: the Enguri Pumped Storage Power Plant LLC, the Georgian Energy Development Fund JSC, and the Enguri HPP LLC; the prefeasibility studies are ongoing.

The Ministry indicated that it would like to investigate the impact of deploying the new technology on the labour market and the wider economy. Solutions that create new employment opportunities are likely to gain more government support.

The lack of supportive policy measures may further delay hydrogen deployment on a wider scale. There seems to be no clear policy direction regarding not only hydrogen, but also excess hydropower capacity and pumped storage, which is hindering private investment in hydro, and the potential for hydrogen alongside it. The lack of purchase pre-agreements with

[24] International Energy Agency Policy Review for Georgia (2020), https://webstore.iea.org/download/direct/4021?fileName=Georgia_2020_Energy_Policy_Review.pdf.

state owned companies is further discouraging investors from exploring the potential of hydrogen.

The NECP is under preparation. There are no hydrogen-related policies stated at the moment.

A4.3 Legislative and regulatory framework

In 2019, Georgia had 3,336 MW of renewable energy capacity, all of which except 24 MW was hydropower. While the conditions for development of hydro power plants are favourable, the dominance of hydro is also due to government support schemes and guaranteed power purchase agreements. The latest piece of legislation introduced feed-in-premiums of up to $0.015 per kWh for hydropower plants whose capacity exceeds 5 MW[25], to be received by the generator whenever the price of electricity is below $0.055 per kWh. No equivalent mechanism has been introduced for other renewables.

The newly adopted Law on Promoting the Production and Use of Energy from Renewable Sources has introduced a support scheme by providing priority access to the grid to renewable energy. Current hydropower producers are additionally supported with feed-in-tariffs and an exemption from balancing responsibilities. A technology-neutral net metering scheme has been in place since 2016 and has recently been expanded to include power suppliers between 100 kW and 500 kW.

The legislation allows the transportation of fuels other than natural gas in the gas networks; however, it does not mention hydrogen explicitly. According to the GOGC the law is expected to be developed further once hydrogen gains more traction. Current policies are focused on natural gas and its increasing role as the main fuel in Georgia. If hydrogen is proven viable on a commercial basis, Georgia is expected to follow international best practice with regard to institutional arrangements, following the lead of countries where the potential of hydrogen has been explored in more depth. No safety regulations related to the use of blended hydrogen have been developed yet.

Amendments to the existing legislation have previously been developed to allow for the use of biofuels and the introduction of hydrogen could follow a similar process. MoESD indicated that proposals to update regulation are more likely to be considered if they are based on tangible results (regarding the feasibility of using hydrogen).

A4.4 Target sectors and infrastructure for end-use of hydrogen

A4.4.1 Production of hydrogen

There is no information on renewable or low carbon hydrogen production in Georgia.

[25] https://www.euneighbours.eu/en/east/stay-informed/publications/energy-community-secretariats-annual-implementation-report-2020.

A4.4.2 Infrastructure

The focus of current infrastructure developments is on natural gas and the efficiency of the existing system. Parts of the network that have been modernised in recent years should be adequate to carry a blend of gas and hydrogen, however this has not been tested yet. The potential usage of storage facilities to store hydrogen has not been investigated either.

The gasification percentage is high at approximately 80%. The parts of the gas distribution network outside the capital, Tbilisi, and other major settlements tend to be more technically advanced as they were developed later. GOGC is the owner of the main pipeline system, and it signs lease agreements with the transportation company.

The development of storage capacity for gas is under way with the aim to meet Georgia's increasing demand. There is approximately a 20% difference between winter and summer demand for gas and underground storage would help maintain lower gas prices in the winter and improve security of supply. Feasibility studies for the development of a new natural gas storage facility have already been concluded. The engineering, procurement and construction phase is delayed due to the Covid-19 pandemic, however the timeline for conclusion of the project remains 2024-2025. The underground storage facility would be in a depleted oil field and its capacity is estimated at 280 bcm with approximately 5-7 million m^3/day injection and withdrawal rate. The storage facility has not been developed or tested for hydrogen storage, so its potential utilisation as part of a hydrogen strategy cannot be assessed at this point.

In terms of regional infrastructure, Georgia is strategically positioned on the route of the Southern Gas Corridor but is not directly interconnected with other CPs or the EU.

A4.4.3 Hydrogen end-use potential

Actual hydrogen applications are limited as hydrogen has not been included in any strategic planning so far. Some prospective target sectors are identified below.

Transport

Georgia's road transport sector is heavily reliant on imported fossil fuels, although its road network facilitates low levels of freight transport in comparison to other CPs.

Georgia's rail network is significantly electrified, with electricity accounting for 74% of energy used for rail transportation. It also accounts for the second highest level of rail freight transport of the Contracting Parties on a tonne-km basis.

Well positioned to serve the Caucasus region, Georgia also has key container ports on its Black Sea coastline, which handles nearly 65,000 TEU[26] of cargo a year.

However, the potential use of hydrogen as a fuel in transport, especially road freight and rail, depends heavily on the availability of infrastructure both in Georgia and in the neighbouring countries. Such prospects are currently unknown in the region. Hydrogen use for domestic

[26] TEU = Twenty-foot equivalent unit, data source: OECD (2020), Container transport (indicator). doi: 10.1787/26de63f3-en.

transport uses, e.g. public buses, may be an alternative option. The scale of the application would be the critical factor affecting feasibility in that case.

Industry

Energy-intensive industry

As an indication of the potential use of hydrogen in the economy, current energy consumption in industry is considered. Approximately 37% of the energy consumed by Georgia's industrial sector is derived from solid fossil fuels (mostly used in the non-metallic minerals industry), the largest single source of energy for the sector, followed closely by electricity (36%, mainly used in the iron and steel industry). The top three industrial sectors by energy consumption are:

1. Iron and steel (39%)
2. Non-metallic minerals (27%)
3. Construction (12%).

There are also export oriented fertiliser companies, which might be potential hydrogen users.

Hydrogen favourable industry

Subject to available data, we also examine industrial end use applications where hydrogen could be most effective or economically advantageous especially compared to low-carbon alternatives, namely oil refining, ammonia production and steel making.

In terms of energy consumption, as already noted, iron and steel represents a significant 39% of the total for all industry, while chemicals and petrochemicals (which includes ammonia production and oil refining) represents 4% of total industrial energy consumption.

Power generation

The potential usage of hydrogen as a fuel for CCGT power plants is also at the concept stage and would need to be investigated further. According to GOGC, the two CCGT power plants now in operation should be capable of using a blend of hydrogen and natural gas (with a maximum of 15% of hydrogen in the mix), but the efficiency rate would decrease by roughly 5%.

Domestic and commercial sector heating

Energy consumption for heating in households is dominated by natural gas and wood biomass, with a smaller contribution from electricity.

The commercial sector is mainly consuming electricity for all energy uses, followed by natural gas, and a minor share of biomass. Table 8 below provides summarised statistics for potential hydrogen end-use sectors in Georgia.

Table 8 Energy consumption metrics as of 2018 for key potential hydrogen applications, Georgia

Hydrogen application	Metric	Unit	
Industrial heat and feedstock	Final energy consumption in industry	ktoe	% of total
	Solid fossil fuels and natural gas	402	51%
	Fossil fuels	498	64%
Residential heat	Energy consumption for space heating	ktoe	%of total
	Solid fossil fuels	0	0%
	Natural gas	426	63%
	Oil and petroleum products		
	Renewables and biofuels	236	35%
	Electricity	14	2%
	Heat		
Commercial / public buildings heat	Total energy use	ktoe	% of total
	Solid fossil fuel	0	0%
	Natural gas	173	34%
	Oil and petroleum products	1	0%
	Renewables and biofuels	15	3%
	Electricity	325	63%
	Heat	0	0%
Transport	Metric	Value	Units
	Proportion of transport energy consumption from oil products or natural gas	97.7%	
	Road freight transport	702	Million tonne-km
	Rail freight transport	2,935	Million tonne-km
	Passenger rail transport	675	Million passenger-km

Source: Eurostat

A4.5 Current projects and initiatives

So far, relevant project considerations are driven by development donors and market participants with some limited involvement from policy makers. Most projects and initiatives have not gone beyond concept stage as investors are unwilling to provide substantial resources fearing that hydrogen will not prove commercially viable. Instead, a more passive approach has prevailed with market participants and policy makers closely following advancements in other countries.

Most initiatives are limited to concept stage discussions and conferences that debate hydrogen's potential utilisation opportunities in Georgia. An example of such an initiative is a suggestion explored by GOGC to construct a solar PV power plant that would be used to produce hydrogen. The mix of hydrogen and natural gas would then be used to fuel GOGC's thermal power plants through a pipeline. The study is a concept at a very preliminary stage and requires further work.

GOGC is also investigating the option of transporting a blend of hydrogen and gas using containers or trucks, if gas deposits turn out to be too small to justify constructing a pipeline. Associated infrastructure, such as filling stations would also need to be developed. All activities are currently at concept stage and the commercial viability of this project would need to be investigated further.

As recently announced, feasibility studies for an €11 billion renewable hydrogen generation project have been conducted. The project has a ten-year staged development profile and comprises a 3 GW hydrogen electrolysis plan along with related infrastructure and renewable energy generation facilities, reaching an annual hydrogen production of approximately 500 million kg.

There was one pilot project which included the use of hydrogen and natural gas for public buses. It was a short project driven by the municipalities and guided by the City Hall and MoESD and is concluded now, but the results and intentions are yet to be published. Municipal transport is often a good candidate for pilot projects as many cities in the region are signatories of the Covenant of Mayors, offering opportunities for collaboration.

No other pilot projects are currently under preparation. No projects or initiatives have explored the development of storage facilities for hydrogen so far. Any discussions are at a very preliminary stage and progress will depend on the economic viability of hydrogen.

A4.6 Summary and conclusions

Hydrogen could potentially provide a means to help achieve Georgia's decarbonisation targets using its domestic resources. The excess hydropower capacity during the summer months could be used to produce renewable hydrogen with electrolysis. The electricity required to produce hydrogen could be generated from other renewables such as wind and solar which tend to coincide with excess water capacity. Hydrogen could then be blended with natural gas and transported to end users or provide energy storage capacity. The technical and economic feasibility of such a scheme has not been examined yet. Another potential future direction is the utilisation of hydrogen to decarbonise sectors which have traditionally relied on fossil fuels, such as the transport sector.

Hydrogen is a potentially attractive future direction in Georgia for the following reasons:

- Georgia has some of the lowest electricity prices in the region and Europe. Therefore, the cost of electricity consumed by an electrolyser fed from the grid would be relatively low. Although electricity prices may not reflect full cost at this point, the availability of relatively low cost resources in Georgia may provide a relatively stable basis for development of hydrogen generation investment.

- Favourable location on the route of the gas pipeline between Azerbaijan and Turkey.

A5 Kosovo*

A5.1 Current situation overview

The energy supply of Kosovo* is dominated by solid fossil fuels (i.e. coal), accounting for 56% of total energy supply, followed by oil products (28%) and biofuels (15%). There is a small contribution from hydropower (1%), whereas the energy supply from other RES is negligible.

Coal is almost exclusively produced domestically (95% of total coal supply), and accounts for about 95% of the electricity generated in Kosovo*.

The wholesale electricity market of Kosovo* is deregulated, and a process is underway for market coupling with the day-ahead electricity market of Albania, the establishment of cross-border cooperation for balancing with Albania, and the operation of a joint power exchange company. The retail electricity market is still effectively regulated, despite formal opening for medium voltage customers.

The total RES installed capacity is 139 MW, of which 34 MW wind and 10 MW solar.

Kosovo* does not produce or import natural gas, but there are plans underway for the introduction of gas (see below).

Effectively, 100% of the energy consumed for transport - mainly road - is oil based.

Table 9 presents an overview of the current situation in Kosovo*.

Table 9 Kosovo* – current situation overview, 2018

Energy supply	ktoe	% of TES
Total energy supply (TES)	2,582	
Solid fossil fuels	1,434	56%
Natural gas	0	0%
Oil and oil products	731	28%
Hydropower	23	1%
Wind and solar	3	0%
Biofuel	377	15%
Nuclear	0	0%
Electricity	13	0%
Other	0	0%
Net imports	757	29%
Electricity	**GWh**	**% of TGEP**
Total gross electricity production (TGEP)	5,915	
Solid fossil fuels	5,601	95%
Natural gas	0	0%

Oil and petroleum products (excluding biofuel)	10	0%
Hydro	273	5%
Wind	30	1%
Solar photovoltaic	2	0%
Primary solid biofuels	0	0%
Nuclear heat	0	0%
Fossil fuels use in electricity production	5,611	95%
Inland electricity demand	5,529	
Fossil fuels use (% of inland electricity demand)		101%
CO_2 intensity	**t CO_2/toe**	
CO_2 emissions / Total primary energy supply	3.20	
Renewable energy technical potential	**MW**	**MW/km^2**
Solar	10,300	
Wind		
Small hydro		
Total solar, wind and small hydro potential	10,300	0.95
Economy	**Current international US$**	
GDP/capita, PPP (2019)	11,871	

Source: Eurostat, UNDP renewable energy snapshot, World Bank, ECA analysis. Terminology following Regulation EC 1099/2008 on energy statistics.

A5.2 Policy objectives and national goals / targets

There is no provision for hydrogen in the published energy plans of Kosovo* and no hydrogen-related initiatives were identified.

The energy objectives of Kosovo* are set by the Energy Strategy 2017-2026. The targets set by the strategy include, among others, preparation of conditions for the development of natural gas infrastructure and enhanced utilisation of RES.

The National Energy Efficiency Action Plan (NEEAP) and NREAP are drafted in line with the National Energy Strategy. The Strategy and the Plans make no reference to hydrogen. The NECP is now under preparation and is expected to set new GHG emission, energy efficiency, energy security and RES targets for 2030.

The following table presents the NREAP RES targets and shows each element against Kosovo*'s latest NREAP progress report. As shown in the table, Kosovo* has made no progress toward achieving the targets for transport and limited progress in the electricity sector. For heating and cooling, it has met its targets, which is due to the widespread use of biomass for heating.

Table 10 NREAP targets vs reported progress 2016 and 2017, Kosovo*

Sector	2020 NREAP target (%)	Reported 2016 (%)	Reported 2017 (%)
Heating and cooling	45.7	51.8	51.2
Electricity	25.6	4.3	3.2
Transport	10.0	0.0	0.0
Overall share of GFEC	29.5	24.6	23.6

Source: NREAP and 2017 Progress Report

Exploitation of the renewable energy potential in line with the strategic targets could benefit from the development of technical opportunities for optimisation of the operation of the electricity system, such as storage in renewable hydrogen, depending on the relevant economics. However, given the overall early stage in the underlying development of the energy system along that direction, the prospects for development of a hydrogen supply chain do not appear favourable at this stage.

Kosovo* is a signatory to the 10 November 2020 Sofia Declaration committing to work towards the 2050 target of a carbon-neutral continent together with the EU.

There are no hydrogen-related policies stated at this point.

A5.3 Legislative and regulatory framework

A support scheme based on administratively set FITs is currently in place for power generation projects using RES, with plans for adoption of a CfD regime. Power generators using RES enjoy non-discriminatory access to the electricity network, priority dispatch, and obligatory purchase of their production by the market operator. Only producers with a capacity equal to, or higher than, 500 kW are responsible for imbalances, and are charged for 25% of the respective costs.

Although a Law on Natural Gas with provisions for the transmission, distribution, supply, use and storage of natural gas, transposing Directive 2009/73/EC and Regulation 715/2009/EC, is in place, secondary legislation is yet to be developed. Natural gas codes will have to be developed once an independent gas TSO is established.

The Law does not include any provision for hydrogen, and only allows use of the networks for transmission and distribution of natural gas.

There are no hydrogen-related policies.

A5.4 Target sectors and infrastructure for end-use of hydrogen

A5.4.1 Production of hydrogen

There is no information on renewable or low carbon hydrogen production in Kosovo*.

A5.4.2 Infrastructure

There are plans for a gas pipeline interconnection between Kosovo* and North Macedonia and/or Albania. Based on a prefeasibility study completed in 2020, the interconnection with the Greek network through North Macedonia appears preferable and is being further evaluated through the Western Balkans Investment Framework. A gas masterplan will determine further steps regarding the gasification of Kosovo*, including options for small scale flexible power generation (in the order of 100 MW), and utilisation in the domestic and industrial sectors.

Plans to develop natural gas infrastructure could allow utilisation of the networks for transmission and distribution of hydrogen-blended gas, provided appropriate technical specifications are adopted in time.

A5.4.3 Hydrogen end-use potential

Transport

The transport sector of Kosovo* is effectively 100% carbon intensive, with virtually all transport sector energy supplied though oil product imports. Road transport accounts for over 99% of this energy use, with rail transport accounting for less than 1% of the sector total.

The Energy Community report on RES in the transport sector[27] recommends a small 0.109% contribution of hydrogen to the 9% RES in transport target by 2030, and a higher uptake in the following years. It states that electric and hydrogen vehicles can already make small contributions by 2030 and have a strong growth potential thereafter. The report recommends the uptake of hydrogen fuel cell-electric road vehicles and the uptake of hydrogen fuel cell buses in urban areas and coaches. Both suggestions are for long distances and for high driving ranges in applications not suitable for battery-electric vehicles.

Industry

There is a large nickel production plant in Kosovo*. Other large energy consumers in industry are in the non-metallic minerals, and the food and tobacco sectors. These plants are mainly using electricity and the possibilities for using hydrogen have not been considered at this point. No opportunities for using renewable hydrogen in refineries have been identified in Kosovo*.

[27] Modalities to foster use of renewable energy sources in the transport sector by the Energy Community Contracting Parties, *Energy Community*, December 2020.

Energy-intensive industry

As an indication of the potential use of hydrogen in the economy, current energy consumption in industry is considered. The top three industrial sectors by energy consumption are:

1. Non-metallic minerals (36%);
2. Iron and steel (20%);
3. Food, beverages and tobacco (18%).

Hydrogen favourable industry

Subject to available data, we also examine industrial end use applications where hydrogen could be most effective or economically advantageous especially compared to low-carbon alternatives, namely oil refining, ammonia production and steel making.

In terms of energy consumption, as already noted, iron and steel represents 20% of the total for all industry, while chemicals and petrochemicals (which includes ammonia production and oil refining) has negligible energy consumption as a proportion of the total.

Power generation

The contract for a new coal-fired power plant was terminated by the investor.

It is expected that the day-ahead market coupling and cross-border balancing cooperation, with Albania, in combination with plans for accelerated development of RES for power generation, and the introduction of natural gas in Kosovo*, might require the addition of a small gas fired power plant, in the order of 100 MW, to provide flexibility and contribute to security of supply. The possibilities will be reflected in the gas masterplan. Although this prospect may present opportunities for production and utilisation of renewable hydrogen (also considering the target for carbon neutrality by 2050 and possible application of carbon pricing), there have been no relevant studies or plans yet.

Currently, solar and wind power production are minimal providing limited resources for renewable hydrogen production, and their development so far is below expectations, signifying difficulty to reach the set targets.

There are currently no official plans for the storage of energy from RES, including in the form of hydrogen.

Domestic and commercial sector heating

Energy consumption for heating in households is dominated by wood biomass, with a smaller contribution from electricity. There are few households served by district heating networks.

The commercial sector is mainly consuming electricity and oil products for all energy uses.

Table 11 presents the characteristics of potential hydrogen applications areas in Kosovo*.

Table 11 Final energy consumption metrics as of 2018 for key potential hydrogen application areas in Kosovo*

Hydrogen application	Metric	Unit	
	Final energy consumption in industry	ktoe	% of total
Industrial heat and feedstock	Solid fossil fuels and natural gas	7	3%
	Fossil fuels	183	65%
	Energy consumption for space heating	ktoe	%of total
	Solid fossil fuels	5	1%
	Natural gas		
Residential heat	Oil and petroleum products		
	Renewables and biofuels	348	86%
	Electricity	42	10%
	Heat	10	2%
	Total energy use	ktoe	% of total
	Solid fossil fuel	8	5%
	Natural gas	0	0%
Commercial / public buildings heat	Oil and petroleum products	48	31%
	Renewables and biofuels	12	8%
	Electricity	81	53%
	Heat	5	3%
	Metric	**Value**	**Units**
	Proportion of transport energy consumption from oil products or natural gas	100%	
Transport	Road freight transport	n.a.	Million tonne-km
	Rail freight transport	n.a.	Million tonne-km
	Passenger rail transport	n.a.	Million passenger-km

Source: Eurostat

A5.5 Current projects and initiatives

No plans for hydrogen pilot projects in Kosovo* were identified.

A5.6 Summary and conclusions

There are no specific energy plans, involving hydrogen, in place in Kosovo*.

The development of a competitive electricity market in Kosovo* will be further supported by coupling with the Albanian market, and further development of interconnections. In addition, the planned connection of Kosovo* with natural gas networks would enhance security of supply and the development of the electricity market.

Given the overall early stage of development of the energy system, the prospects for development of a renewable hydrogen supply chain do not appear favourable at this stage in Kosovo*, but should be further assessed.

A6 Moldova

A6.1 Current situation overview

The energy supply of Moldova is significantly covered by imported energy, accounting for 75% of total energy supply. The share of different fuels in the energy supply is relatively even among oil and oil products (32%), natural gas (28%), and biofuels (mainly solid biomass - 27%), followed by electricity (10%). The heavy dependence on imports is illustrated by the fact that about 81% of inland demand for electricity is imported, while 89% of the electricity generated in Moldova is produced by imported natural gas.

Moldova is in the process of introducing effective competition to its electricity and natural gas wholesale and retail markets.

The electricity system of Moldova is synchronously interconnected with that of Ukraine, and there are plans for its asynchronous interconnection with the Romanian system by the end of 2024, which is expected to increase the opportunities for competition in the electricity market.

Although natural gas market rules have been adopted, they have not been implemented and the wholesale gas market is still illiquid, and monopolised. The incumbent company, Moldovagaz, is responsible for gas imports from Russia and exercises control over two gas transmission system operators.

Ninety-six per cent of the energy consumed for transport - mainly road - is oil based.

Table 12 presents an overview of the current situation in Moldova.

Table 12 Moldova – current situation overview, 2018

Energy supply	ktoe	% of TES
Total energy supply (TES)	2,947	
Solid fossil fuels	83	3%
Natural gas	820	28%
Oil and oil products	951	32%
Hydropower	4	0%
Wind and solar	2	0%
Biofuel	796	27%
Nuclear	0	0%
Electricity	301	10%
Other	-9	0%
Net imports	2,219	75%
Electricity	**GWh**	**% of TGEP**
Total gross electricity production (TGEP)	954	
Solid fossil fuels	0	0%

Natural gas	846	89%
Oil and petroleum products (excluding biofuel)	8	1%
Hydro	44	5%
Wind	23	2%
Solar photovoltaic	3	0%
Primary solid biofuels	0	0%
Nuclear heat	0	0%
Fossil fuels use in electricity production	854	90%
Inland electricity demand	4,322	
Fossil fuels use (% of inland electricity demand)		20%
CO_2 intensity	**t CO_2/toe**	
CO_2 emissions / Total primary energy supply	1.96	
Renewable energy technical potential	**MW**	**MW/km^2**
Solar	45,800	
Wind	2,700	
Small hydro	300	
Total solar, wind and small hydro potential	48,800	1.44
Economy	**Current international US$**	
GDP/capita, PPP (2019)	13,627	

Source: Eurostat, UNDP renewable energy snapshot, World Bank, ECA analysis. Terminology following Regulation EC 1099/2008 on energy statistics.

A6.2 Policy objectives and national goals / targets

Moldova's energy objectives are set by the National Energy Strategy 2030, which was drafted in 2013. Under the Paris Agreement, Moldova was the first CP to submit an updated NDC and has now committed to reduce its GHG emissions by 70% below the 1990 level by 2030.

The NEEAP and NREAP are drafted in line with the National Energy Strategy. The Strategy and the Plans make no reference to hydrogen. The NECP is now under preparation and will have to be aligned with the updated NDC.

In 2018, 27% of Moldova's GFEC was from RES, exceeding its overall NREAP target. As this mainly concerned the use of biomass in the domestic sector, there is still potential for increasing the RES contribution in power generation and transport. The following table breaks the NREAP RES target down further and reports each element against Moldova's latest NREAP progress report.

Table 13 NREAP targets vs reported progress 2016 and 2017, Moldova

Sector	2020 NREAP target (%)	Reported 2016 (%)	Reported 2017 (%)
Heating and cooling	27.2	45.5	46.1

Sector	2020 NREAP target (%)	Reported 2016 (%)	Reported 2017 (%)
Electricity	10	2.0	2.2
Transport	10	0.2	0.3
Overall share of GFEC	20	26.9	27.8

Source: NREAP and Moldova's NREAP 2017 Progress Report

A6.3 Legislative and regulatory framework

Although Moldova has considerable potential of solar and wind energy, these resources currently constitute a negligible proportion of its energy supply. The introduction of a net metering scheme resulted in applications of 1.5 MW PV capacity. There is also a feed-in tariff regime to support the development of renewable energy generation projects. Power generators using RES enjoy non-discriminatory access to the electricity network, priority dispatch, and obligatory purchase of their production by the central electricity supplier, which is also responsible for any imbalances.

A6.4 Target sectors and infrastructure for end-use of hydrogen

A6.4.1 Production of hydrogen

There is no information on renewable or low carbon hydrogen production in Moldova.

A6.4.2 Infrastructure

Gas distribution is well developed across Moldova, and there may be opportunities for introducing hydrogen in the networks, mixed with natural gas. However, the technical adequacy of the gas transmission and distribution networks to that effect remains to be tested and confirmed. In addition, apart from the interconnection with Ukraine, through which almost the whole volume of gas is imported to Moldova, a new gas pipeline interconnector with Romania has been built, through which Moldova aims to diversify its gas supply sources. The technical and economic possibilities to utilise these interconnections for transmission of hydrogen could be considered in coordination with neighbouring countries. Moreover, the government is considering the development of two potential underground gas storage sites, which may in principle be utilised as part of a strategic scheme including hydrogen development at national and regional level.

A6.4.3 Hydrogen end-use potential

Actual hydrogen applications are limited as hydrogen has not been included in any strategic planning so far. Some prospective target sectors are identified below.

Transport

A total of 95% of Moldova's transport sector energy consumption is supplied by oil product imports, the overwhelming majority of which is used for road transportation. Moldova's road network facilitates above average road freight levels for the CPs (excluding Ukraine). Moldova's rail infrastructure is not currently electrified with 100% of its energy demand provided by fossil fuels. Plans for rail electrification (which would reduce the possibilities for use of hydrogen) are not known at this point.

The Energy Community report into RES in the transport sector[28] recommends a small 0.024% contribution of hydrogen to the 9% RES in transport target by 2030, and a higher uptake in the following years. As for other CPs, the report recommends the uptake of hydrogen fuel cell-electric road vehicles and of hydrogen fuel cell buses in urban areas and coaches. Both suggestions are for long distances and for high driving ranges in applications not suitable for battery-electric vehicles.

Industry

Energy-intensive industry

Moldova's industrial sector is a large user of imported natural gas, which provides 28% of the industrial sector's energy demand. There is no iron or steel production in Moldova. Food production (42%) and non-metallic mineral (40%) industries are the largest energy consumers within Moldova's industrial sector.

There is no interest expressed so far from industry and other potential hydrogen users to invest in the hydrogen supply chain.

Hydrogen favourable industry

Subject to available data, we also examine industrial end use applications where hydrogen could be most effective or economically advantageous especially compared to low-carbon alternatives, namely oil refining, ammonia production and steel making.

In terms of energy consumption, chemicals and petrochemicals (which includes ammonia production and oil refining) represents 3% of total industrial energy consumption. In terms of output and using the broader industrial classifications stated in section 3.3.1 of this report, these sectors represent about 3.5% of the CP's GDP.

Power generation

Domestic power generation in Moldova is currently based on natural gas. The demand is mainly covered by imported electricity.

New planned capacity includes a 250 MW CCGT plant, and about 150 MW based on renewables.

---

[28] Modalities to foster use of renewable energy sources in the transport sector by the Energy Community Contracting Parties, *Energy Community*, December 2020.

Domestic and commercial sector heating

Gas transmission and distribution infrastructure currently supplies approximately 726,000 households. Moldovan cities are also significant users of biomass, which accounts for about 70% of residential energy consumption for space heating. Commercial and public buildings meet around 40% of their energy needs from electricity and 30% from natural gas. Table 14 provides some summarised statistics for potential hydrogen end-use sectors in Moldova.

Table 14 Final energy consumption metrics as of 2018 for key potential hydrogen application areas in Moldova

Hydrogen application	Metric	Unit	
Industrial heat and feedstock	Final energy consumption in industry	ktoe	% of total
	Solid fossil fuels and natural gas	94	38%
	Fossil fuels	134	54%
Residential heat	Energy consumption for space heating	ktoe	%of total
	Solid fossil fuels	29	3%
	Natural gas	150	16%
	Oil and petroleum products	0	0%
	Renewables and biofuels	661	70%
	Electricity	4	0%
	Heat	107	11%
Commercial / public buildings heat	Total energy use	ktoe	% of total
	Solid fossil fuel	19	7%
	Natural gas	86	31%
	Oil and petroleum products	1	0%
	Renewables and biofuels	12	5%
	Electricity	111	41%
	Heat	45	16%
Transport	**Metric**	**Value**	**Units**
	Proportion of transport energy consumption from oil products or natural gas	98.6%	
	Road freight transport	5,567	Million tonne-km
	Rail freight transport	940	Million tonne-km
	Passenger rail transport	74	Million passenger-km

Source: Eurostat

A6.5 Current projects and initiatives

No plans for hydrogen pilot projects in Moldova were identified.

There is currently no policy or strategic drive to incentivise interest in the hydrogen economy. In addition, the lack of competitive conditions in the electricity and natural gas sectors may not be conducive to new supply and innovation, while solar and wind production are minimal providing limited resources for renewable hydrogen production. Although there is an identified need for future storage solutions, there are currently no official plans for the storage of energy from RES, including in the form of hydrogen.

A6.6 Summary and conclusions

There are no specific energy plans, involving hydrogen, in place in Moldova.

There is an ongoing process for developing competitive electricity and natural gas markets, which would be further supported by the development of interconnections with the Romanian electricity and natural gas systems. In parallel, there is considerable technical potential for electricity generation from RES, and a supporting regime for relevant investment. There is, therefore ground for potential development of a renewable hydrogen supply chain that could contribute to optimisation of the electricity market.

The technical capacity of the gas networks to support such an opportunity would need to be assessed and verified.

Storage opportunities would be valuable in such a prospect, and the potential underground storage sites identified would need to be considered for development.

A7 Montenegro

A7.1 Current situation overview

Oil products and solid fossil fuels (i.e. coal) account for 68% of Montenegro's energy supply, followed by hydropower (17%), biofuels and waste (14%), and renewables (1%). Montenegro's electricity generation is based on hydropower plants and one lignite-fired power plant. An undersea cable between Montenegro and Italy with a capacity of 600 MW started operation at the end of 2019, increasing Montenegro's security of supply and trading opportunities. Hydropower accounts for 55% of the total gross electricity production in the CP, followed by coal (41%), and, notably, by wind (4%).

The energy market of Montenegro is still under development. Significant progress has been made in the electricity sector with the unbundling of the transmission and distribution systems. The wholesale market is fully deregulated and open to competition. The next stage of reforms involves the establishment of the day-ahead market and coupling mechanisms, but progress in this area has been delayed. Montenegro's transport sector is almost exclusively dependent on imported fossil fuels, which account for 100% of energy use in road transport. The rail sector is comparatively very small in terms of energy consumption and is overwhelmingly electrified.

Table 15 presents an overview of the current situation in Montenegro.

Table 15 Montenegro – current situation overview, 2018

Energy supply	ktoe	% of TES
Total energy supply (TES)	1,054	
Solid fossil fuels	361	34%
Natural gas	0	0%
Oil and oil products	366	35%
Hydropower	182	17%
Wind and solar	12	1%
Biofuel	151	14%
Nuclear	0	0%
Electricity	-17	-2%
Other	0	0%
Net imports	333	32%
Electricity	**GWh**	**% of TGEP**
Total gross electricity production (TGEP)	3,811	
Solid fossil fuels	1,555	41%
Natural gas	0	0%
Oil and petroleum products (excluding biofuel)	0	0%
Hydro	2,113	55%
Wind	143	4%

Solar photovoltaic	0	0%
Primary solid biofuels	0	0%
Nuclear heat	0	0%
Fossil fuels use in electricity production	1,555	41%
Inland electricity demand	3,481	
Fossil fuels use (% of inland electricity demand)		45%
CO_2 intensity	**t CO_2/toe**	
CO_2 emissions / Total primary energy supply	2.38	
Renewable energy technical potential	**MW**	**MW/km²**
Solar	12,800	
Wind	400	
Small hydro	200	
Total solar, wind and small hydro potential	13,400	0.97
Economy	**Current international US$**	
GDP/capita, PPP (2019)	23,189	

Source: Eurostat, UNDP renewable energy snapshot, World Bank, ECA analysis. Terminology following Regulation EC 1099/2008 on energy statistics.

A7.2 Policy objectives and national goals / targets

The NREAP, adopted at the end of 2014, set the target RES share at 33% of supply by 2020. The sectoral RES targets were set as:

- 51.4% in the electricity sector;
- 38.2% in the heating and cooling sector; and
- 10.2% in the transport sector.

Montenegro has already exceeded the 33% target, mostly as the result of biomass data revision. The last five years (2015-2020) saw a slight decline in the share of RES in the heating and cooling sector. The share of RES in the transport sector remains low.

Table 16: NREAP targets, Montenegro

Sector	2020 NREAP target (%)	Reported 2016 (%)	Reported 2017 (%)
Heating and cooling	38.2	35.0	36.1
Electricity	51.4	46.7	50.1
Transport	10.2	0.8	0.8
Overall share of GFEC	33.0	31.8	32.3

Source: NREAP

The Ministry of Economy is ultimately responsible for the implementation and monitoring of NREAP commitments and is assisted by the Energy Regulatory Agency, which is tasked with conducting independent annual reviews of the energy sector.

The NDC target of Montenegro is to reduce its emissions by 30% compared to the 1990 level, by 2030. The NECP and an update of the NDC are under development.

Montenegro is a signatory to the 10 November 2020 Sofia Declaration committing to work towards the 2050 target of a carbon-neutral continent together with the EU.

Hydrogen has not yet been considered in the energy plans of Montenegro. There is no publicly available information related to potential hydrogen initiatives.

A7.3 Legislative and regulatory framework

Although natural gas is not yet available in Montenegro, the regulatory framework for gas is under development. The legislative act for general conditions of gas supply was adopted in January 2020 while the tariff methodology for gas transmission and distribution is prepared and awaiting adoption. An equivalent document for LNG is in the final stage of development.

A set of policy measures aimed at increasing the penetration of renewables is in place, including feed-in-tariffs, applicable to all RES, a compulsory minimal share of RES in the total electricity supplied, issuance of guarantees of origin for energy produced from RES, and support measures at the final energy user level. There is no specific reference to hydrogen made in these measures.

Montenegro is the first CP to have applied carbon pricing, through regulation on activities emitting GHG, adopted in February 2020, specifying, among others, the operators participating in the emissions trading and determining the total amount and minimum price (24 €/tCO2) of the emission credits to be auctioned.

A7.4 Target sectors and infrastructure for end-use of hydrogen

A7.4.1 Production of hydrogen

There is no information on renewable or low carbon hydrogen production in Montenegro.

A7.4.2 Infrastructure

Montenegro is not connected to any existing gas systems and does not have a domestic gas network. Connection through the development of the IAP and/or an LNG terminal are potential future options. The lack of gas infrastructure that could potentially be adapted for the use of hydrogen means this avenue to introducing hydrogen is also not available at the moment, but this option could be considered when technical specifications of network development are considered in the future.

A7.4.3 Hydrogen end-use potential

Transport

The road transport sector of Montenegro is heavily reliant on imported fossil fuels, although its road network facilitates low levels of freight transport in comparison to other CPs. The relatively small rail network is significantly electrified. The potential use of hydrogen as a fuel in transport, especially road freight and rail, depends heavily on the availability of infrastructure both in Montenegro and in the neighbouring CPs, and the prospects for such use of hydrogen in Montenegro seem remote at this point.

Industry

Energy-intensive industry

Montenegro's industrial sector covers most of its energy requirements from electricity and oil products, which together account for 92% of the sector's final energy consumption. The top three industrial sectors by consumption are:

1. Non-ferrous metals (40%);
2. Food and tobacco (14%);
3. Wood and wood products (10%).

Among large industrial energy consumers, an aluminium smelter (KAP Uniprom) and a steel mill (Toscelik Niksic) already currently import LNG and/or CNG on trucks (notably, from Belgium where the closest available LNG truck filling facility is located). There has been no expression of interest on the potential use of hydrogen in these industries, but the fact that they are transporting LNG and CNG from afar, may mean that the possibility of sourcing locally or regionally produced hydrogen may be of interest to them. There has been discussion for the development of an LNG terminal in Montenegro[29].

Hydrogen favourable industry

Subject to available data, we also examine industrial end use applications where hydrogen could be most effective or economically advantageous especially compared to low-carbon alternatives, namely oil refining, ammonia production and steel making.

In terms of energy consumption, iron and steel represents 6% of the total for all industry, while chemicals and petrochemicals (which includes ammonia production and oil refining) represents 2% of total industrial energy consumption.

[29] https://seenews.com/news/us-companies-eye-lng-exports-to-europe-via-montenegros-bar-port-economy-min-688350.

Power generation

Pljevlja power plant is the only large scale thermal generator in Montenegro and was expected to reach the end of its life in 2020, following which its reconstruction and extension of lifetime until 2030 is planned. The potential of wind and solar energy is not fully utilised, with only 118 MW of wind and 2 MW of solar capacity in the mix. The NREAP makes no reference to the use of hydrogen in the sector.

Domestic and commercial sector heating

Energy consumption for heating in households is dominated by wood biomass, with a smaller contribution from electricity and district heating.

The commercial sector is mainly consuming electricity for all energy uses, followed by oil.

Table 17 provides summarised statistics for potential hydrogen end-use sectors in Montenegro.

Table 17 Final energy consumption metrics as of 2018 for key potential hydrogen application areas in Montenegro

Hydrogen application	Metric		Unit
Industrial heat and feedstock	Final energy consumption in industry	ktoe	% of total
	Solid fossil fuels and natural gas	3	2%
	Fossil fuels	64	47%
Residential heat	Energy consumption for space heating	Ktoe	%of total
	Solid fossil fuels	n.a	
	Natural gas	n.a	
	Oil and petroleum products	n.a	
	Renewables and biofuels	n.a	
	Electricity	n.a	
	Heat	n.a	
Commercial / public buildings heat	Total energy use	ktoe	% of total
	Solid fossil fuel	2	2%
	Natural gas	0	0%
	Oil and petroleum products	10	12%
	Renewables and biofuels	7	8%
	Electricity	69	78%
	Heat	0	0%
Transport	**Metric**	**Value**	**Units**
	Proportion of transport energy consumption from oil products or natural gas	99%	

Hydrogen application	Metric		Unit
	Road freight transport	103	Million tonne-km
	Rail freight transport	169	Million tonne-km
	Passenger rail transport	60	Million passenger-km

Source: Eurostat

A7.5 Current projects and initiatives

No plans for pilot hydrogen projects in Montenegro were identified.

A7.6 Summary and conclusions

Hydrogen has not been actively considered in existing energy plans and policies in Montenegro.

The implementation of renewable energy reforms is at an advanced stage, creating opportunities for production of renewable hydrogen. However, the lack of existing gas infrastructure that could be adapted to carry the mix of two fuels means that the deployment of hydrogen would have to be associated with large investment expenditures (or be applied at a localised level). Given the fact that the gas infrastructure development is yet to begin in Montenegro, there is an opportunity to consider both resources (natural gas and hydrogen) in a comprehensive way, being mindful of the fact that they may be used in a complementary way in the future.

A8 North Macedonia

A8.1 Current situation overview

The energy supply of North Macedonia is dominated by oil products and solid fossil fuels (coal), accounting for 38% and 33% of total energy supply, respectively. Natural gas and biofuels hold an equal share of 8% each, and hydropower 6%. Energy supply from RES is negligible.

North Macedonia is heavily dependent on energy imports. Apart from coal, which is produced locally, all other fossil-based fuels are imported. Net imports account for 59% of total energy supply.

More than half of the electricity generated in North Macedonia comes from coal, 32% from hydropower, 13% from natural gas, and 2% from wind.

North Macedonia has set up an organised wholesale electricity market, based on bilateral contracts, along with a competitive balancing market. The NECP includes actions to enable coupling with the Bulgarian electricity market by Q3 2021. To further enhance energy market integration and trading possibilities, there are plans for an electric interconnection with Albania, and gas pipeline interconnections with Greece, Kosovo* and Serbia.

A competitive wholesale natural gas market is yet to be developed in North Macedonia, mainly due to difficulties with setting up and certifying an unbundled transmission system operator. However, the gas regulatory infrastructure is in place, wholesale and end-user gas prices are deregulated, and all customers are eligible to choose supplier. At this point there is no trading point and gas is traded through bilateral contracts. The NECP includes plans for the further development of the gas transmission and distribution network.

Almost 100% of the energy consumed for transport - mainly road - is oil based.

Table 18 presents an overview of the current situation in North Macedonia.

Table 18 North Macedonia – current situation overview, 2018

Energy supply	ktoe	% of TES
Total energy supply (TES)	2,548	
Solid fossil fuels	838	33%
Natural gas	209	8%
Oil and oil products	970	38%
Hydropower	154	6%
Wind and solar	10	0%
Biofuel	198	8%
Nuclear	0	0%
Electricity	165	6%
Other	4	0%

Net imports	1,509	59%
Electricity	**GWh**	**% of TGEP**
Total gross electricity production (TGEP)	5,607	
Solid fossil fuels	2,848	51%
Natural gas	746	13%
Oil and petroleum products (excluding biofuel)	47	1%
Hydro	1,791	32%
Wind	97	2%
Solar photovoltaic	23	0%
Primary solid biofuels	0	0%
Nuclear heat	0	0%
Fossil fuels use in electricity production	3,642	65%
Inland electricity demand	7,202	
Fossil fuels use (% of inland electricity demand)		51%
CO_2 intensity	**t CO_2/toe**	
CO_2 emissions / Total primary energy supply	2.69	
Renewable energy technical potential	**MW**	**MW/km^2**
Solar	24,000	
Wind	400	
Small hydro	200	
Total solar, wind and small hydro potential	24,600	0.96
Economy	**Current international US$**	
GDP/capita, PPP (2019)	17,607	

Source: Eurostat, UNDP renewable energy snapshot, World Bank, ECA analysis. Terminology following Regulation EC 1099/2008 on energy statistics.

A8.2 Policy objectives and national goals / targets

North Macedonia's energy objectives are set by the Energy Development Strategy 2040, which was adopted in 2019. The strategy encompasses previous objectives and analysis included in the NEEAP and NREAP.

The strategy was the basis for the preparation of a draft NECP, which has been submitted to the Energy Community Secretariat for review and recommendations. The decarbonisation targets set by the NECP include a 66% reduction of GHG emissions, mainly through phasing out coal by 2030, as well as targets for agriculture, forest and other land use, and waste. An increase of GHG emissions in industrial processes and product use by 45% (because of an expected expansion of industrial activity) is also included. The draft NECP sets a target RES share in gross electricity production of 66% by 2030, which mainly comprises energy from hydro and small hydro power plants. The strategy and all plans make no reference to hydrogen.

Under the Paris Agreement, North Macedonia committed to reduce its GHG emissions by 30% compared to the baseline scenario for the period 2016-2030 in its intended NDC, i.e. an increase of 32% compared to 1990 levels.

North Macedonia is a signatory to the 10 November 2020 Sofia Declaration committing to work towards the 2050 target of a carbon-neutral continent together with the EU.

There is no provision for hydrogen in the published energy plans of North Macedonia.

The following table presents the NREAP RES targets in accordance with the revised NREAP issued in 2017.

Table 19: NREAP targets, North Macedonia

Sector	2020 NREAP target (%)	Reported 2016 (%)	Reported 2017 (%)
Heating and cooling	30.1	n/a	n/a
Electricity	26.8	n/a	n/a
Transport	10.0	n/a	n/a
Overall share of GFEC	23.9	n/a	n/a

Source: NREAP

A8.3 Legislative and regulatory framework

Subject to the Energy Law, RES based generation is supported through administratively set FIT and feed-in premiums determined by auction.

The draft NECP includes the plan for introduction of a carbon price[30] to accelerate the phasing out of conventional fuels, and attract investment in RES, in combination with the provision of FITs and feed-in premiums with auctions. The Plan also includes promotion of the “prosumer” concept, electrification of the heating and cooling sector using high efficiency heat pumps, district heating fuelled by combined heat and power (CHP) biomass, and increased penetration of biofuels in the transport sector.

The legislative and regulatory framework governing the gas sector is largely in place.

A8.4 Target sectors and infrastructure for end-use of hydrogen

A8.4.1 Production of hydrogen

There is no information on renewable or low carbon hydrogen production in North Macedonia.

[30] Which has been put in place.

A8.4.2 Infrastructure

Natural gas is imported from Russia through an interconnector with Bulgaria. There are plans for the construction of a gas pipeline interconnector with Greece which would diversify the gas supply sources and allow further utilisation of gas in the domestic economy. The interconnection is currently in the tendering phase and is planned to be constructed by 2024.

Along with the planned development of gas distribution in North Macedonia, there may be opportunities for introducing hydrogen in the networks, blended with natural gas. Moreover, NER JSC Skopje, which is undertaking the construction and development of the domestic gas pipeline system, and developing the gas pipeline interconnection with Greece, will be considering the technical and economic requirements for future proofing the interconnection and transmission pipeline for hydrogen and blends with natural gas. However, the technical adequacy of the *existing* gas transmission and distribution networks to accommodate hydrogen remains to be tested and confirmed. To allow use of the networks with hydrogen-blended gas the technical specifications of network extensions will need to be suitable for that purpose, therefore timely preparation of gas related secondary legislation and accompanying technical codes and specifications will be required. The network codes were due to be issued in March 2021. In addition, the technical and economic possibilities to utilise the existing gas pipeline interconnection with Bulgaria, as well as the planned new interconnections with Greece, Kosovo* and Serbia for transmission of hydrogen would also need to be considered, in coordination with neighbouring countries.

There are no gas storage or LNG terminals in operation, but a prefeasibility study for development of a gas storage site is under way. The Government of North Macedonia and relevant institutions are considering co-investing in the development of an LNG terminal in Greece, as North Macedonia has no access to the sea.

A8.4.3 Hydrogen end-use potential

Actual hydrogen applications are limited as hydrogen has not been included in any strategic planning so far. Some prospective target sectors are identified below.

Transport

North Macedonia's transport sector relies almost entirely on imported oil products, the overwhelming majority of which is used for road transport. North Macedonia's road network is slightly more extensive than that of some other CPs, with 287 km of motorways. This conveys among the highest volume of road freight of all the CPs except Ukraine. The rail network facilitates comparatively less freight transport, which is among the lowest of all CPs on a tonne-km basis.

The Energy Community report into RES in the transport sector[31] recommends a 0.095% contribution of hydrogen to the 9% RES in transport target by 2030, further increasing thereafter. It states that electric and hydrogen vehicles can already make small contributions by 2030 and have a strong growth potential thereafter. The report recommends the uptake of hydrogen fuel cell-electric road vehicles and the uptake of hydrogen fuel cell buses in urban

[31] Modalities to foster use of renewable energy sources in the transport sector by the Energy Community Contracting Parties, *Energy Community*, December 2020.

areas and coaches. Both suggestions are for long distances and for high driving ranges in applications not suitable for battery-electric vehicles.

Industry

Energy-intensive industry

North Macedonia's industrial sector satisfies 66% of its energy demand with fossil-based sources, with the largest contributions from oil products and coal. Electricity covers 32% of the final energy consumption. The top three industrial sectors by energy consumption are:

1. Iron and steel (44%);
2. Non-metallic minerals (24%);
3. Food and tobacco (9%).

An oil refinery is currently not in use.

There has been no expression of interest so far from industry and other potential hydrogen users to invest in the hydrogen supply chain. However, in studies of the Macedonian Academy of Sciences and Arts, use of hydrogen in industry is examined as an effective option for achieving NECP targets, considering that maximum efficiencies with the fuels currently used will have been reached by 2040, an unless natural gas is replaced emissions will continue to grow. The Academy is proposing that a hydrogen strategy be implemented, with specific measures to support gradual introduction of hydrogen during 2025-2030.

Hydrogen favourable industry

Subject to available data, we also examine industrial end use applications where hydrogen could be most effective or economically advantageous especially compared to low-carbon alternatives, namely oil refining, ammonia production and steel making.

In terms of energy consumption, as already noted, iron and steel represents a very significant 44% of the total for all industry, while chemicals and petrochemicals (which includes ammonia production and oil refining) represents 2% of total industrial energy consumption. In terms of output and using the broader industrial classifications stated in section 3.3.1 of this report, these three sectors represent about 7.4% of the CP's GDP.

Power generation

Along with interconnection of the gas network with Greece, there are considerations for conversion of a mothballed heavy oil-fired power plant to natural gas, as well as constructing new gas fired power plants.

As in other cases, the generation of renewable hydrogen could be a factor contributing to the increased contribution of RES in electricity generation and the optimisation of the electricity market. However, based on NECP provisions, the planned high penetration of RES in North Macedonia mainly concerns hydropower, and the development of wind and solar power generation is expected to be supported by the development of pumped hydro storage for balancing purposes (one plant is currently being tendered).

Only one 40 MW wind farm has been developed, and investor interest in wind power opportunities is currently low.

The Macedonian Academy of Sciences and Arts considers that the production of hydrogen would be an option for storage of surplus energy from solar PV plants, if installed capacity exceeded 1,000 MW.

Domestic and commercial sector heating

The use of natural gas in the residential sector is negligible, with household heating predominantly provided by fuelwood combustion or electricity. Natural gas is used for district heating, which is also used, particularly in Skopje[32], the capital city.

Natural gas use in commercial and public buildings is low, accounting for about 3% of the total energy consumption.

Table 20 presents the characteristics of potential hydrogen applications in North Macedonia.

Table 20 Final energy consumption metrics as of 2018 for key potential hydrogen application areas in North Macedonia

Hydrogen application	Metric	Unit	
Industrial heat and feedstock	Final energy consumption in industry	ktoe	% of total
	Solid fossil fuels and natural gas	148	36%
	Fossil fuels	272	66%
Residential heat	Energy consumption for space heating	ktoe	%of total
	Solid fossil fuels	1	0%
	Natural gas	0	0%
	Oil and petroleum products	5	2%
	Renewables and biofuels	175	60%
	Electricity	78	27%
	Heat	34	12%
Commercial / public buildings heat	Total energy use	ktoe	% of total
	Solid fossil fuel	1	0%
	Natural gas	6	3%
	Oil and petroleum products	58	27%
	Renewables and biofuels	5	3%
	Electricity	130	61%
	Heat	12	6%
Transport	**Metric**	**Value**	**Units**

32 https://www.euroheat.org/knowledge-hub/country-profiles/district-energy-north-macedonia/.

Hydrogen application	Metric	Unit	
	Proportion of transport energy consumption from oil products or natural gas	99.9%	
	Road freight transport	10,267	Million tonne-km
	Rail freight transport	350	Million tonne-km
	Passenger rail transport	62	Million passenger-km

Source: Eurostat

A8.5 Current projects and initiatives

No plans for pilot projects and other initiatives relating to hydrogen in North Macedonia have been identified.

A8.6 Summary and conclusions

There are no specific energy plans, involving hydrogen, in place in North Macedonia.

There is an ongoing process for developing competitive electricity and natural gas markets in the country, which would be further supported by the development of interconnections with the neighbouring electricity and natural gas systems. The technical potential for electricity generation from RES mainly concerns hydropower, and there is a supporting regime for relevant investment. Therefore, conditions for the potential development of a hydrogen economy remain nascent but should be further assessed.

A9 Serbia

A9.1 Current situation overview

The energy supply of Serbia is dominated by solid fossil fuels (coal), accounting for 49% of total energy supply, followed by oil (24%) and natural gas (14%). There is some contribution by biofuels and waste (7%), whereas RES energy supply is almost entirely hydropower (6%) with other RES being negligible. The majority of coal is made up of domestic production (lignite) which is used to supply coal-fired power stations. Most gas is supplied from Russia (~86% in 2018) and the rest domestically.

Although Serbia has transposed the Third Energy Package across electricity and gas, wholesale market arrangements are still being developed[33]. The electricity market is at a relatively mature state of development compared to the other CPs.

The gas market is less developed with the transposition of Connection Network Codes and REMIT pending. Moreover, unbundling of the TSO is incomplete, while access to gas entry points and market competition is limited.

Power generation is heavily dependent on solid fossil fuels (67% of total gross electricity production), while the remaining is mainly covered by hydropower (30%), and there is a small (2%) contribution by natural gas. The production from wind and solar power plants is negligible.

Table 21 presents an overview of the current situation in Serbia.

Table 21 Serbia – current situation overview, 2018

Energy supply	ktoe	% of TES
Total energy supply (TES)	15,388	
Solid fossil fuels	7,549	49%
Natural gas	2,132	14%
Oil and oil products	3,676	24%
Hydropower	915	6%
Wind and solar	14	0%
Biofuel	1,086	7%
Nuclear	0	0%
Electricity	10	0%
Other	6	0%
Net imports	5,385	35%
Electricity	**GWh**	**% of TGEP**
Total gross electricity production (TGEP)	37,426	
Solid fossil fuels	25,020	67%

[33] Annual Implementation Report, *Energy Community Secretariat*, November 2020.

Natural gas	596	2%
Oil and petroleum products (excluding biofuel)	52	0%
Hydro	11,393	30%
Wind	150	0%
Solar photovoltaic	13	0%
Primary solid biofuels	0	0%
Nuclear heat	0	0%
Fossil fuels use in electricity production	25,668	69%
Inland electricity demand	33,835	
Fossil fuels use (% of inland electricity demand)		76%
CO_2 intensity	**t CO_2/toe**	
CO_2 emissions / Total primary energy supply	2.92	
Renewable energy technical potential	**MW**	**MW/km^2**
Solar	84,000	
Wind	400	
Small hydro	4,500	
Total solar, wind and small hydro potential	88,900	1.01
Economy	**Current international US$**	
GDP/capita, PPP (2019)	19,013	

Source: Eurostat, UNDP renewable energy snapshot, World Bank, ECA analysis. Terminology following Regulation EC 1099/2008 on energy statistics.

A9.2 Policy objectives and national goals / targets

Serbia has committed to an increase in RES and a reduction of its GHG emissions. In its NREAP it had set a target of 27% of GFEC to be provided by RES by 2020.

The following table breaks the NREAP RES target down further and reports each element against Serbia's latest NREAP progress report[34]. The first integrated NECP draft has not yet been submitted but has the potential to act as a platform for hydrogen adoption, monitoring and progression.

Table 22: NREAP targets vs reported progress 2016 and 2017, Serbia

Sector	2020 NREAP target (%)	Reported 2016 (%)	Reported 2017 (%)
Heating and cooling	30	24.65	24.43
Electricity	36.6	29.15	28.71
Transport	10	1.23	1.18

[34] Progress Report on the Implementation of the National Renewable Energy Action Plan of the Republic of Serbia for 2016 and 2017, *The Republic of Serbia - The Ministry of Mining and Energy*.

Sector	2020 NREAP target (%)	Reported 2016 (%)	Reported 2017 (%)
Overall share of GFEC	27	20.98	20.60

Source: NREAP and Serbia's NREAP 2017 Progress Report

For the 'heating and cooling' and 'electricity' sectors Serbia had come a long way by 2017 to meet its targets.

For transport the transition has been harder with virtually all road transportation entirely reliant on fossil-based energy sources and a total of 75% of energy consumption in the rail sector provided by electricity. Progress has stagnated in recent years in meeting the 2020 targets, highlighting the increased effort required as the share of RES increases.

Serbia pledged to reduce its GHG emissions by 9.8% by 2030 compared to 1990 in its intended NDC under the Paris Agreement. The NDC is currently in the process of updating, however Serbia has not officially set up a national working group to prepare the NECP yet.

In 2016 the Ministry of Mining and Energy published the 'Energy Sector Development Strategy of the Republic of Serbia for the period to 2025 with projections to 2030'[35], which makes two references to hydrogen and its role in Serbia's future energy plans. Firstly, in the potential of a future market for hydrogen beyond the markets of electricity, natural gas, oil and petroleum products. Secondly, in the context of long term technology breakthroughs in the '*period up to the middle of this century'* where hydrogen is referenced along fuel cells, nuclear fusion and technologies that allow the use of 'clean coal'. Although the Strategy does not adopt specific policies or measures related to hydrogen development at this point, it identifies hydrogen as a potential field of activity, considering current technological progress and development work undertaken globally.

A large proportion of energy is coming from poor quality lignite, for which there is currently no viable replacement. Moving away from domestically sourced lignite brings its own economic, technical, social and political challenges. Therefore, the government's messaging is very sensitive about such plans and coal still features in the Energy Strategy to the detriment of other cleaner fuel sources.

More recently, a working group was established by the government in relation to energy policy out to 2025. It involves a variety of relevant stakeholders including from government, industry and academia. It is focused on RES, but hydrogen is not yet recognised as RES or a suitable technology for Serbia's future.

Serbia is a signatory to the 10 November 2020 Sofia Declaration committing to work towards the 2050 target of a carbon-neutral continent together with the EU.

A9.3 Legislative and regulatory framework

Support for implementation of investment in power generation through RES is provided through administratively set FIT, leading to installation of a total capacity of 511 MW, while an

[35] Adopted by the National Assembly in December 2015.

additional 300 MW is in development. A market-based support scheme is still not applied. Producers under this scheme are exempted from balancing responsibility.

Although the legislative framework governing natural gas is largely in place, the gas market remains foreclosed, as relevant third party access rules to the transmission system are not implemented. The Energy Community Network Codes are not transposed yet, however the recent amendments to the energy law set the legal background for transposition and implementation of the network codes. None of the three transmission system operators have been unbundled in line with the Third Energy Package.

A9.4 Target sectors and infrastructure for end-use of hydrogen

A9.4.1 Production of hydrogen

There is no information on renewable or low carbon hydrogen production in Serbia.

A9.4.2 Infrastructure

The gas transmission infrastructure in Serbia is relatively aged, with 77% of the transmission grid being more than 20 years old and 47% more than 30 years old. Gas was up until recently imported to Serbia through its interconnection with Hungary and is also transited to Bosnia and Herzegovina. After the commissioning of the new gas transit pipeline (Serbian Stream/New South Stream) the import of gas mainly happens via this pipeline, from Bulgaria, supplied from Russia. Planned interconnections to Bulgaria and North Macedonia are included in the 2020 list of projects of Energy Community interest (PECI), with the Bulgarian interconnector having been granted Connecting Europe Facility and Western Balkan Investment Framework funds.

The distribution network only supplies about 11% of households. The distribution networks are in good working condition, but there are no studies regarding their ability to accommodate mixes of hydrogen and natural gas.

Serbia has an underground gas storage site in operation, in Banatski Dvor, with a capacity of 0.45 bcm. A project is underway for expansion of its capacity to 0.7 bcm.

A9.4.3 Hydrogen end-use potential

Actual hydrogen applications are limited as hydrogen has not been included in any strategic planning so far. Some prospective target sectors are identified below. Although there are goals and an ambition for a low carbon future in Serbia, hydrogen is not considered a serious candidate at this point, and therefore receives little attention.

Transport

Serbia has a more extensive road network than most other CPs, with 963 km of motorways and over 45,000 km of non-motorway road, and the third highest share of total road freight transport among the CPs. Road transportation is virtually entirely reliant on fossil-based energy sources. A total of 75% of energy consumption in Serbia's rail sector is provided by electricity, demonstrating the significant level of electrification of this sector.

The Energy Community report on RES in the transport sector[36] recommends a 0.11% contribution of hydrogen to the 9% RES in transport target by 2030, further increasing thereafter. The report recommends the uptake of hydrogen fuel cell-electric road vehicles (0.09% of target), the uptake of hydrogen fuel cell buses in urban areas and coaches (0.01% of target), and hydrogen in rail (0.01% of target). Road suggestions are for long distances and for high driving ranges in applications not suitable for battery-electric vehicles. Hydrogen rail suggestions are for non-electrified rail lines.

Industry

Energy-intensive industry

Serbia's industrial sector is heavily dependent on fossil-based energy sources, with coal and gas accounting for 37% of consumption, and electricity (predominantly generated from coal) accounting for another 31% of consumption. The top four industrial sectors by energy consumption are:

1. Non-metallic minerals (20%);
2. Iron and steel (18%);
3. Food and tobacco (16%);
4. Chemicals and petrochemicals (16%).

Large oil companies with a significant market presence in Serbia have few incentives to explore hydrogen and have so far expressed little interest in non-oil related investments. Serbia has a substantial metal processing sector which could become a contributor for the production of hydrogen technology elements.

Hydrogen favourable industry

Subject to available data, we also examine industrial end use applications where hydrogen could be most effective or economically advantageous especially compared to low-carbon alternatives, namely oil refining, ammonia production and steel making.

In terms of energy consumption, as already noted, iron and steel represents 18% of the total for all industry, while chemicals and petrochemicals (which includes ammonia production and oil refining) represents 16% of total industrial energy consumption. In terms of output and using the broader industrial classifications stated in section 3.3.1 of this report, these three sectors represent about 2.8% of the CP's GDP.

[36] Modalities to foster use of renewable energy sources in the transport sector by the Energy Community Contracting Parties, *Energy Community*, December 2020.

Power generation

The Energy Strategy identifies several thermal power plants fuelled by lignite and gas as well as hydro power projects for future development. A 350 MW replacement lignite plant is expected prior to 2025, and 2,500 MW of lignite plants and 1,200 MW of gas CHP plants are identified as potential future projects. In addition, a total of 2,252 MW are identified as potential hydropower projects, of which 387 MW mini-hydro spread across 191 locations.

Domestic and commercial sector heating

Space heating in households is mainly covered by biomass (44%), followed by district heating (22%) and solid fossil fuels (13%). In the commercial sector, 50% of the energy needs is covered by electricity.

Serbia's gas transmission and distribution infrastructure serves around 280,000 customers, accounting for 22% of energy consumption in public and commercial buildings, and 10% of consumption for space heating in the residential sector.

Table 23 presents the characteristics of other potential hydrogen application areas in Serbia.

Table 23 Final energy consumption metrics as of 2018 for key potential hydrogen application areas in Serbia

Hydrogen application	Metric	Unit	
Industrial heat and feedstock	Final energy consumption in industry	ktoe	% of total
	Solid fossil fuels and natural gas	888	37%
	Fossil fuels	1,241	52%
Residential heat	Energy consumption for space heating	ktoe	%of total
	Solid fossil fuels	236	13%
	Natural gas	180	10%
	Oil and petroleum products	29	2%
	Renewables and biofuels	775	44%
	Electricity	141	8%
	Heat	394	22%
Commercial / public buildings heat	Total energy use	ktoe	% of total
	Solid fossil fuel	31	4%
	Natural gas	199	22%
	Oil and petroleum products	64	7%
	Renewables and biofuels	29	3%
	Electricity	446	50%
	Heat	121	14%
Transport	Metric	Value	Units

Hydrogen application	Metric	Unit	
	Proportion of transport energy consumption from oil products or natural gas	98.6%	
	Road freight transport	8,175	Million tonne-km
	Rail freight transport	2,861	Million tonne-km
	Passenger rail transport	285	Million passenger-km

Source: Eurostat

A9.5 Current projects and initiatives

No plans for hydrogen pilot projects in Serbia were identified.

Several mostly research related initiatives are ongoing, among which the development of solid state tanks for hydrogen, and apparatus for storage and compression of hydrogen for potential uses in transport[37].

The first call from industry to academia has been from a large industrial company that produces a significant amount of hydrogen as a by-product. They have enlisted academia to review possible solutions for wider use of the hydrogen that is being produced.

A9.6 Summary and conclusions

One of Serbia's largest challenges for developing hydrogen as an energy carrier will be its transition to cleaner electricity production. With Serbia's historical and current reliance on domestic lignite it is particularly difficult to transition to cleaner electricity production while dealing with the economic, technical, social and political challenges. Retrofitting current coal plants with cleaner alternatives, e.g. with CCS technologies, their conversion to biofuels or the planned phase-out of coal will be difficult and will need to be planned over many years. However, with other countries globally committing to decarbonisation, Serbia might not be able to afford a business-as-usual future especially with the introduction of carbon pricing, carbon trading and carbon border taxes.

Hydrogen has the potential to reduce Serbia's dependence on coal and reduce GHG emissions, in line with the recently adopted Green Agenda for the Western Balkans and can also provide increased security of supply by reducing reliance on imports of fuel such as natural gas and oil.

Currently there appear to be limited incentives for the production of hydrogen and therefore industry has expressed little interest. Clear direction and policies from the government have the power to alter this.

[37] References provided through an interview with "Hydrogen Storage Initiative".

A10 Ukraine

A10.1 Current situation overview

Ukraine's total energy supply is made up of solid fossil fuels (coal) (30%), natural gas (27%) and nuclear (24%). There is some contribution by oil and oil products (14%), plus biofuels and waste (3%), whereas RES supply is very limited with hydropower representing 1% of the total energy supply and other RES being negligible.

Nuclear energy accounts for 50% of gross electricity production, followed by coal (30%), hydropower (8%) and natural gas (7%). The contribution of wind and solar power in 2018 was negligible, but installed capacity is rising sharply, and had reached 5.5 GW of solar PV and 1.2 GW of wind in 2020.

The wholesale electricity market comprises forward bilateral, day-ahead, intraday, balancing, and ancillary services markets. However there is heavy regulatory intervention, including on prices of state owned generation companies, thus reducing competition.

A competitive wholesale gas market is in place, and a gas exchange is in the process of establishment.

RES based power generation has developed under a feed-in-tariff scheme which is now restructured, to require balance responsibility from generators above 1 MW, while an auction scheme will be applied for new investment.

Ukraine's transport sector energy consumption is dominated by fossil fuels, which account for 94% of final energy use. Ukraine's road transport system conveys similar road freight levels to the average across the EU. Road transport is entirely supported by fossil fuels. Ukraine's rail sector has a high share of electrification, with 83% of energy consumption in the sector provided by electricity.

Table 24 presents an overview of the current situation in Ukraine.

Table 24 Ukraine – current situation overview, 2018

Energy supply	ktoe	% of TES
Total energy supply (TES)	93,551	
Solid fossil fuels	27,957	30%
Natural gas	25,653	27%
Oil and oil products	13,272	14%
Hydropower	896	1%
Wind and solar	197	0%
Biofuel	3,223	3%
Nuclear	22,235	24%
Electricity	-522	-1%
Other	639	1%

Net imports	32,347	35%
Electricity	**GWh**	**% of TGEP**
Total gross electricity production (TGEP)	159,814	
Solid fossil fuels	47,720	30%
Natural gas	10,571	7%
Oil and petroleum products (excluding biofuel)	1,221	1%
Hydro	12,005	8%
Wind	1,188	1%
Solar photovoltaic	1,108	1%
Primary solid biofuels	125	0%
Nuclear heat	84,398	53%
Fossil fuels use in electricity production	59,511	37%
Inland electricity demand	139,451	
Fossil fuels use (% of inland electricity demand)		43%
CO_2 intensity	**t CO_2/toe**	
CO_2 emissions / Total primary energy supply	1.94	
Renewable energy technical potential	**MW**	**MW/km^2**
Solar	807,500	
Wind	26,800	
Small hydro	2,000	
Total solar, wind and small hydro potential	836,300	1.39
Economy	**Current international US$**	
GDP/capita, PPP (2019)	13,341	

Source: Eurostat, UNDP renewable energy snapshot, World Bank, ECA analysis. Terminology following Regulation EC 1099/2008 on energy statistics.

A10.2 Policy objectives and national goals / targets

The publication of the EU Hydrogen Strategy in July 2020 has triggered increased interest in hydrogen in Ukraine. The strategy, beyond suggesting that hydrogen is essential for reaching carbon neutrality by 2050, particularly refers to Ukraine as a priority partner, in conjunction with the Eastern Neighbourhood. It states that ‘Cooperation should range from research and innovation to regulatory policy, direct investments and undistorted and fair trade in hydrogen, its derivatives, and the associated technologies and services’[38]. It also states that a significant number of electrolysers could be installed in the Eastern and Southern Neighbourhood by 2030 ensuring a sustained cross-border trade of renewable hydrogen with the EU. In the strategy, the EC expressed its support for investments and energy cooperation (notably in

[38] European Commission, A hydrogen strategy for a climate-neutral Europe, COM(2020) 301 final, p.19.

renewable electricity and hydrogen) as well as the encouragement of the Western Balkans and Ukraine to participate in the Clean Hydrogen Alliance.

Hydrogen is mentioned in the Ukraine Energy Strategy for 2035.

A draft hydrogen roadmap was issued in March 2021[39] suggesting a detailed roadmap for introduction of hydrogen technologies and areas for further research to help Ukraine reach its decarbonisation goals. The roadmap spans across three phases, namely:

- First phase (2021-2023), focusing on the assessment of the Ukrainian economy for "green transition" and launch of the hydrogen economy;
- Second phase (2024-2026), including policy prioritisation, hydrogen market and supply chain development and demonstration, scale-up; and
- Third phase (2027-2029), putting together a smart portfolio of policies and strategic hydrogen project development, regulatory reform, and technological development.

The Ministry of Energy is working with the World Bank to draft ToR for the provision of consulting support for writing the Ukrainian Hydrogen Strategy, the focus of which will be on renewable hydrogen. The Ministry considers that the reduction in the production cost of renewable hydrogen is key for development of relevant investment and is anticipating such technological progress.

In addition, the Ministry of Energy intends to update the Energy Efficiency Strategy, considering that this is now two years' old and certain sections need a new, more modern approach.

Moreover, the Ministry is reviewing a first draft NECP which was scheduled to be finalised internally by end of March 2021 and then shared with other Ukrainian authorities for non-objection. The NECP will include renewable hydrogen, as well as production of hydrogen from nuclear power. It will also consider usage of existing assets, such as coal mines.

Under the Paris Agreement Ukraine has pledged to reduce its GHG emissions by 60% compared to 1990. An updated NDC has been prepared and is now in public consultation.

The Ukraine 2050 Low Emission Development Strategy, issued in 2017, included measures for implementation of hydrogen technologies targeted at GHG emission reduction, including development of hydrogen generation and promotion of use of hydrogen in road transport.

National Ukrainian goals of decarbonisation and further renewable energy deployment align well with a future that involves hydrogen, which is perceived by government as a medium to deliver on these goals.

The following table represents the NREAP RES target breakdown and reports each element against Ukraine's latest NREAP progress report[40].

[39] Draft Roadmap for production and use of hydrogen in Ukraine, March 2021, prepared for the Ministry of Energy of Ukraine, under the United Nations Economic Commission for Europe (UNECE) Regular Programme for Technical Cooperation (RPTC).
[40] Ukraine's Progress Report on The Promotion and Use of Energy from Renewable Sources in Ukraine in the years 2016-2017.

Table 25: NREAP targets vs reported progress 2016 and 2017, Ukraine

Sector	2020 NREAP target (%)	Reported 2016 (%)	Reported 2017 (%)
Heating and cooling	12.4	6.18	7.56
Electricity	11	7.91	8.65
Transport	10	2.1	2.44
Overall share of GFEC	11	5.83	6.66

Source: NREAP and Ukraine's NREAP 2017 Progress Report

A10.3 Legislative and regulatory framework

Ukraine's current direction is setting the foundations of transition to a phase where hydrogen technologies make sense from a technical, economic and sustainability perspective. Moreover, alignment with European standards to enable exports are also being explored by the gas TSO.

As in other CPs and most of the EU, a hydrogen-specific legal and regulatory framework has not been developed yet in Ukraine. Hydrogen has been used in various economic activities though, so laws and regulations on energy, energy networks, and transport govern various hydrogen-related applications. The development of an integrated legal and regulatory framework supporting the hydrogen development targets and policies is critical for the attraction of investment and smooth operation of the market.

If new gases are to enter the gas transmission and distribution networks, new policies around standards and security requirements will need to be defined. Industry is starting to request access to networks for the injection of biogas and biomethane, however, the lack of policy and legal frameworks is hindering progress. Hydrogen is likely to face similar issues. However, this appears to be on the agenda of the Ministry of Energy, the TSO, DSOs and industry, which are pressing and assisting with the development of the required standards.

Currently, hydrogen is not defined as an energy carrier making it very difficult for upcoming hydrogen projects to materialise as they seek to navigate themselves under disjointed regulations that were designed primarily for other applications.

DTEK, a Ukraine based group active in the energy sector, including power generation, coal and gas production, etc (see A11.9), is working with German partners on a 5 MW pilot hydrogen project, for the production of 150-550 tonnes of hydrogen annually, using electricity from wind and solar power generation, for use in industry and other applications.

Another missing element identified by stakeholders is the need for financial stimulus that would set industry into motion to advance the utilisation of hydrogen. This is considered important to create the demand for hydrogen including the environment that makes it competitive and profitable. The pilot projects underway are a good start for proof of concept, but it is felt that clear routes to market for clean hydrogen will need to be stimulated. An example cited by DTEK is the introduction of a carbon border tax that could incentivise renewable hydrogen production, usage and exports. It is noted that Ukraine has undertaken the responsibility under its Association Agreement to introduce ETS, which could support the development of low carbon solutions. The Carbon Border Adjustment Mechanism could also be utilised to provide incentives for development of hydrogen applications.

Financing for hydrogen projects has not been easy for Ukrainian companies. Funding is not easily accessible with several companies exploring potential partnerships with European counterparts in order to unlock financing options. The funding of hydrogen-related projects is currently being discussed by the government; however no funding is yet available.

Translating the findings from R&D projects into legal and regulatory frameworks and standards is very complicated. Engaging and coordinating all stakeholders in meaningful discussions has proven complex. Achieving this would be crucial, especially in setting the requirements and responsibilities for hydrogen injection into the existing gas networks. Individual R&D projects are useful; however their scope is limited. Without a fundamental national and regional strategy, the gradual adoption of hydrogen technologies is difficult.

There is a general lack of standards, safety regulations and clarity of responsibility in relation to hydrogen and its use in the current gas networks. This ambiguity applies to all new gases, such as biogas and biomethane, which may be injected in networks used for natural gas. This is a general phenomenon that needs to be addressed and will be particularly important with the increase in stakeholders aiming to gain access to and inject gases at different locations of gas pipeline networks. In Ukraine in particular, there is still much work needed to evaluate the gas network's readiness for hydrogen injection while maintaining safety and reliability.

A10.4 Target sectors and infrastructure for end-use of hydrogen

A10.4.1 Production of hydrogen

There is no information on renewable or low carbon hydrogen production in Ukraine.

A10.4.2 Infrastructure

As expressed in government plans, there is interest in utilising the current gas networks to accommodate hydrogen either as a blend with natural gas or with dedicated hydrogen pipelines. The gas transit contract for the transport of gas through Ukraine to European countries in 2020-2025 provides for lower gas flows compared to 2019, thus indicating decreased capacity utilisation, consequently an opportunity for this capacity to be used for the transport of cleaner gases, including hydrogen, domestically and to the rest of Europe. However, gas transmission network availability post 2025 remains uncertain. At a distribution level, retrofitted or dedicated pipelines would help meet the energy needs of decentralised areas and link current producers and consumers of hydrogen.

The gas TSO is examining the prospect of exporting hydrogen to the EU. Other utilities are conducting feasibility studies and trialling pilot projects while looking for stronger direction from government on regulatory frameworks, the development of technical requirements and safety measures, standardisation, and financing and cooperation opportunities (within Ukraine and externally).

With Ukraine's largest renewables potential being in the southern part of the CP, close to the Black Sea and the Dnieper river, export opportunities are currently limited to the existing gas network. Transmission and distribution networks will need to make best use of current network capability. It is important that this happens without disturbing existing supply while maintaining and upgrading networks to the necessary levels. A significant proportion of the distribution assets require repair or upgrading, especially if they are to accommodate other gases.

Ukraine has some of the largest underground storage sites in Europe. Some of them are currently being used for the storage of natural gas. This includes "left over" salt caverns, some of which are being used and others that are not. These storage sites could potentially be used to provide long term seasonal storage capabilities for Ukraine or serve as a transit hub for storage for European consumers. The technical suitability and required adaptation for storage of hydrogen blends would need to be studied.

A10.4.3 Hydrogen end-use potential

Actual hydrogen applications are limited as hydrogen has not been included in any strategic planning so far. Some prospective target sectors are identified below.

Transport

The Energy Community report on RES in the transport sector[41] recommends a 0.07% contribution of hydrogen to the 9% RES in transport target by 2030, further increasing thereafter. The report recommends the uptake of hydrogen fuel cell-electric road vehicles (0.05% of the target), the uptake of hydrogen fuel cell buses in urban areas and coaches (0.06% of the target), and hydrogen in rail (0.01% of the target). Road suggestions are for long distances and for high driving ranges in applications not suitable for battery-electric vehicles. Hydrogen rail suggestions are for non-electrified rail lines.

Industry

Ukraine has an established industry that either produces or uses hydrogen (e.g., steel industry, and production of ammonia and synthetic chemicals). These industries operate in isolation and no significant coordinated effort has been made to align with a common strategy for the use or production of hydrogen.

Changing energy requirements with regard to decarbonisation are becoming increasingly apparent to hydrogen-based or dependent industry, such as chemicals, and individual producers are looking to position themselves to be competitive in the future. This includes the decarbonisation of hydrogen production which would future-proof such industries, to avoid being directly or indirectly penalised.

Energy-intensive industry

Approximately half of industrial energy consumption in Ukraine is derived from fossil-based energy sources. Iron and steel accounts for approximately half of all industrial energy consumption. The top three industrial sectors by energy consumption are:

[41] Modalities to foster use of renewable energy sources in the transport sector by the Energy Community Contracting Parties, *Energy Community*, December 2020.

1. Iron and steel (52%);
2. Food and tobacco (9%);
3. Mining and quarrying (9%).

Hydrogen favourable industry

Subject to available data, we also examine industrial end use applications where hydrogen could be most effective or economically advantageous especially compared to low-carbon alternatives, namely oil refining, ammonia production and steel making.

In terms of energy consumption, as already noted, iron and steel represents a very significant 52% of the total for all industry, while chemicals and petrochemicals (which includes ammonia production and oil refining) represents 6% of total industrial energy consumption. In terms of output and using the broader industrial classifications stated in section 3.3.1 of this report, these three sectors represent about 15.5% of the CP's GDP.

Power generation

Considering the share of coal in Ukraine's power generation, hydrogen could contribute to decarbonising the sector, in line with relevant plans of the government. At this point there are no specific power generation projects identified in relation to hydrogen.

Domestic and commercial sector heating

Over 12 million end users are supplied with natural gas in Ukraine. Natural gas use accounts for over half of the total energy consumption for space heating in the residential sector and 18% of energy consumption in commercial and public buildings, comprising a significant potential domestic market for hydrogen.

Table 26 provides summarised statistics for potential hydrogen end-use sectors in Ukraine.

Table 26 Final energy consumption metrics as of 2018 for key potential hydrogen application areas in Ukraine

Hydrogen application	Metric	Unit	
Industrial heat and feedstock	Final energy consumption in industry	ktoe	% of total
	Solid fossil fuels and natural gas	6,156	37%
	Fossil fuels	6,597	40%
Residential heat	Energy consumption for space heating	ktoe	%of total
	Solid fossil fuels	245	3%
	Natural gas	5,083	57%
	Oil and petroleum products	8	0%
	Renewables and biofuels	1,761	20%
	Electricity	163	2%

Hydrogen application	Metric	Unit	
	Heat	1,614	18%
Commercial / public buildings heat	Total energy use	ktoe	% of total
	Solid fossil fuel	479	10%
	Natural gas	845	18%
	Oil and petroleum products	113	2%
	Renewables and biofuels	33	1%
	Electricity	1,731	37%
	Heat	1,491	32%
Transport	Metric	Value	Units
	Proportion of transport energy consumption from oil products or natural gas	93.7%	
	Road freight transport	64,953	Million tonne-km
	Rail freight transport	181,844	Million tonne-km
	Passenger rail transport	28,413	Million passenger-km

Source: Eurostat

A10.5 Current projects and initiatives

Hydrogen is seen as an enabler of the government's future energy ambitions of decarbonisation and security of supply through diversification. The applications that are being pursued unsurprisingly reflect Ukraine's characteristics and its perceived advantages and opportunities. Some of the current projects and initiatives are described below. This is not an exhaustive list and there are several companies which are pursuing hydrogen-related projects, especially in the production of "greener" hydrogen.

A10.5.1 Ukrainian members of the European Clean Hydrogen Alliance

A number of relevant stakeholders across industry, national and local public authorities, civil society and other sectors have joined the European Clean Hydrogen Alliance since its announcement in March 2020 as part of the new industrial strategy of Europe. It aims to enable the objectives of the European Green Deal and Europe's clean energy transition through an accelerated deployment of hydrogen technologies by 2030 and to support the EU target to reach carbon neutrality by 2050. Several Ukrainian institutions have joined the European Clean Hydrogen Alliance[42] in 2020, including:

- the gas TSO;

[42] https://ec.europa.eu/growth/industry/policy/european-clean-hydrogen-alliance_en.

- the Regional Gas Company;
- the National Technical University of Ukraine;
- the Centre for Energy Security of Ukraine; and
- the Ukraine Hydrogen Council.

By signing its declaration, committing to its shared vision and to contributing to its operational work, the Ukrainian members have access to and are collaborating with key stakeholders from the alliance. These include companies (such as other TSOs and DSOs), public authorities, research organisations, civil society organisations, financial institutions and other relevant organisations. Being part of the alliance positions Ukraine well in shaping the future of hydrogen in Ukraine and aligning it with Europe's strategy.

The Ukraine Hydrogen Council was established in 2019. As part of this, Naftogazbudinformatyka (NGBI) – an independent consulting institution for the oil and gas industry - has developed the roadmap for transportation of hydrogen using gas transmission and distribution pipes. The roadmap contains a set of proposed phases and milestones required to use hydrogen in Ukraine's networks through to 2030.

A10.5.2 Decentralised pilot projects and testing of hydrogen mixes in the gas distribution networks

The Regional Gas Company (RGC) brings together 20 distribution system operators (DSOs). They are looking into local decentralised pilot projects with testing taking place over the coming three to ten years (from December 2020), mostly decentralised storage solutions. They are not focusing on financial aspects for now, but on understanding the technical challenges to make the projects feasible including their cost models. They are aiming to address all key issues involving the distribution of hydrogen at a DSO level.

Furthermore, RGC has procured the services of NGBI which is leading a project whose goals are to:

- Assess what concentrations of hydrogen are feasible in the network including other gas equipment such as heating boilers, stoves, and meters; and
- Draw conclusions from this assessment about the possibilities of practical applications of different hydrogen mixes in the gas distribution networks.

The project started in 2019 and is planned to run until 2023. It is supported by a seven-member scientific group. They are testing different mixtures of hydrogen with natural gas across five regions with specially built test sites. Initial testing of 100% hydrogen has already been concluded with the results currently being analysed and publication expected early in 2021. The project will provide the necessary insights to realise the full potential of gas networks with hydrogen mixes from technical, legal and economic perspectives. It will also help set the required standards, safety regulations and responsibilities regarding injection of hydrogen into the gas distribution network.

The work conducted at distribution level will also have transferable learnings for the gas transmission network. Ukraine's gas TSO is looking to carry out similar testing on their network (see below). Although similar, there are differences between the two gas pipeline levels, such as step-up in pressure in transmission and the existence of compressor sites, which brings its own challenges when injecting hydrogen to the network.

A10.5.3 Investigation of different natural gas and hydrogen mixes in the transmission network

The Ukrainian gas TSO is looking to investigate the use of different mixes of natural gas and hydrogen in its gas transmission network. The project's scope is to examine all possible hydrogen mixtures in the transmission network including their effect on operability, reliability and safety in relation to all transmission network assets such as turbines, metering, pipelines and compressor stations. It is being conducted in partnership with the Ukrainian Science Institute.

The findings will allow an estimation of the percentage of hydrogen that can be safely and efficiently introduced to the network, but the possibility of operating isolated sections of the network with 100% hydrogen is also being explored. It is anticipated that the permissible level of hydrogen will vary in different parts of the current transmission network, due to various factors that are being examined, such as the age of network assets, their condition and the material of the assets.

It is expected that this work will provide a real picture of what can be done from a technical perspective and from there help set the national standards and also harmonise them with European standards. This work is conducted purely on a transmission level including potential interconnection and in partnership with possible producers and consumers.

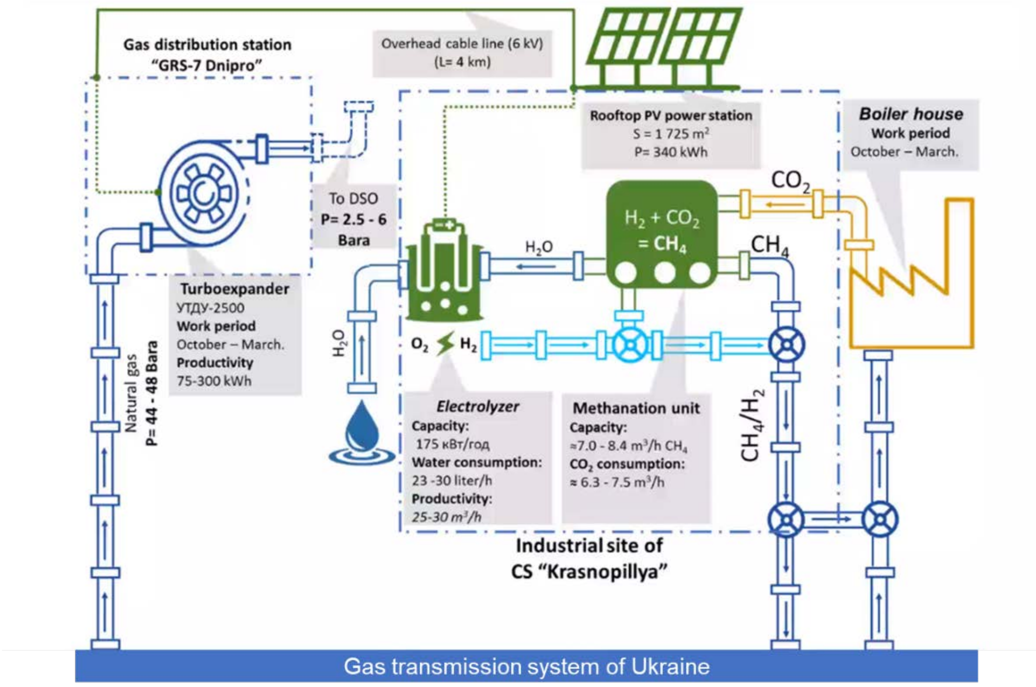
A10.5.4 Pilot project – H_2 & CH_4 technology on transmission network compressor station "Krasnopillya" (Gas TSO)

Ukraine's gas TSO is currently planning a pilot project on the transmission system. It is at a preliminary stage with feasibility assessment, design and the commencement of construction planned for 2021. The gas TSO is pursuing this project with European partners and looking to fund the project with grants from the European Clean Hydrogen Alliance.

The project will make use of a compressor site in an industrial area that is predicted to see its usage drop significantly in the coming years. It is a pure R&D project looking to enhance learning and demonstrate concepts. Future investigations will highlight strategic locations for optimised use of RES and networks with hydrogen technologies. It is looking to test several properties of a compressor site in relation to renewable energy production, the use of an electrolyser and a methanation reactor. The pilot project will examine how onsite electricity from renewables and the turboexpander (traditionally used to meet ancillary requirements) can be used to generate hydrogen from the electrolyser in conjunction with the methanation reactor that will take CO_2 from gas boilers used for water heating as an input. Hydrogen and methane are the products that get injected into the gas transmission network.

The project will help understand the production of hydrogen and synthetic methane in hybrid systems combined with the existing gas network.

Figure 12 TSO pilot project H_2 & CH_4 technology on compressor station (Krasnopillya)



Source: TSOUA

A10.5.5 Establishment of dedicated hydrogen project team by DTEK and membership of Hydrogen Europe

DTEK, one of the largest energy companies in Ukraine has recently shown increased interest in hydrogen. It is the first Ukrainian company to have joined Hydrogen Europe, the European association representing the interest of the hydrogen and fuel cell industry and its stakeholders. Moreover, in 2020 it established a dedicated project team to study the possibilities of using hydrogen in the Ukrainian economy. The team is currently conducting an in depth feasibility study of the use of hydrogen in the field of transport, energy and industry[43].

Hydrogen is seen as an opportunity by DTEK to help with its growing RES ambitions. DTEK is looking to make use of its wide range of utility involvement as well as connections with other large market players to position itself in advance of the hydrogen uptake, initially developing the domestic market to be hydrogen ready, especially with off-takers, to stimulate them in the use of renewable hydrogen. They are looking to choose meaningful small scale projects for testing and leverage on current facilities and systems for the transportation of hydrogen. Moreover, they are also exploring partnerships with EU companies with hydrogen prospects that would unlock further potential.

A10.5.6 RAG Austria exploring long term opportunities to receive Ukrainian hydrogen for storage in Austria and further transportation in the EU

RAG (Austria's largest storage facility operator) in a partnership with other European companies is pursuing a long term strategy including production of renewable hydrogen in

[43] https://dtek.com/en/media-center/press/dtek-is-the-first-in-ukraine-to-become-a-member-of-the-hydrogen-europe-association/.

Ukraine, along with transport and storage in its underground storage sites in Austria, for further use in the EU.

This plan is part of the company's intention to become a hydrogen storage hub in the EU, towards which they have carried out extensive research in the last 15 years on the storage of hydrogen and mixes of hydrogen. RAG considers Ukraine as a key candidate for producing and exporting hydrogen to Austria for storage due to its proximity, RES potential and gas infrastructure. It estimates that the annual volume of hydrogen energy that can be produced in Ukraine, transported via existing pipelines, and stored in Austria in existing and new storage sites, is in the order of 80 TWh.

Apart from electrolysis for the production of hydrogen, RAG is also very active in methane pyrolysis (splitting methane into hydrogen and carbon) and considers that this could provide Ukraine with another opportunity for hydrogen production, especially if the carbon is used for other uses, e.g. as a fertiliser.

RAG understands this is a long term expensive commitment that will require the involvement of many stakeholders across the EU and Ukraine including utilities and government. Development of the required regulatory framework in Ukraine as well as a coordinated framework for the transport of hydrogen across other countries, is critical for implementation of their plans. Given the current status of the needed regulatory and technical infrastructure, RAG aims to develop clean hydrogen production facilities in the western part of Ukraine, due to its proximity to the EU.

A10.5.7 Discovery of natural hydrogen in Ukraine

Scientists of the National Academy of Science in Ukraine have found natural hydrogen in the Rivne region and are encouraging the drilling of wells to explore its potential[44].

A10.5.8 Plans for wind farm with electrolyser for hydrogen production

In August 2020, the CEO of NBT, a Norwegian company already operating in Ukraine, in a meeting with the president of Ukraine referred to plans for an 800 MW wind farm in the region of Zaporizhia with 200 MW electrolyser capacity for the production of renewable hydrogen[45].

Also, an experimental solar power station with an electrolyser was developed in 2019 by Ukrainian scientists near Kiev for the production of green hydrogen.

A10.6 Summary and conclusions

Significant steps have been made in Ukraine to launch the transition to a hydrogen energy future mostly in the last two years. The EU hydrogen strategy and Ukraine's significant role in it have triggered a drive to a hydrogen future by all stakeholders. Although most of the developments are in their infancy, the momentum is growing. The hydrogen roadmap sets the

[44] https://kosatka.media/en/category/vozobnovlyaemaya-energia/news/ukrainskie-uchenye-na-rovenshchine-est-chistyy-vodorod.

[45] https://euea-energyagency.org/en/news/market-news/the-ceo-of-nbt-met-with-the-president-of-ukraine/.

foundations for developing clear and targeted goals, policies, regulations and legal requirements some of which are already underway.

At the same time, pilot projects and testing are being carried out by several stakeholders on gas networks; by current hydrogen users and producers; and private companies. These are testing various concepts and can provide the learning required to advance a hydrogen future in line with Ukraine's renewables and carbon reduction targets.

With Ukraine's largest renewables potential being in the southern part of the country, close to the Black Sea and the Dnieper river, export opportunities are currently limited to the existing gas network. As different gases aim to be injected at different locations of the network (at transmission and distribution level) responsibilities will expand and partially shift to DSOs and local participants. Raising collaboration between government bodies, the TSO, the DSOs and local participants would help unlock the full potential of the network as a hydrogen carrier. Unified responsibilities, standards and safety regulations would need to be implemented for the full potential of hydrogen to be realised.

Ukraine has additional drivers for decentralised distribution of new gases, including hydrogen. These include gasification of rural areas where the economics do not justify a traditional gas network connection; providing reliable supply to decentralised areas which are vulnerable to network outages; and enhanced security of supply to peripheral areas close to borders. For this potential to be realised, current distribution networks will need investments as many are in poor condition and continue to deteriorate. Future proofing these networks for the introduction of hydrogen and other gases would provide the necessary backbone for decentralised hydrogen solutions in the required regions of Ukraine.

Ukraine's renewables potential and its target to increase the share of energy from renewables to 25% makes the case for renewable hydrogen even stronger. Together with its large storage potential and existing gas infrastructure Ukraine could decarbonise its energy sector and position itself as a key enabler of the EU hydrogen strategy as a producer, storage provider and exporter of hydrogen.

Unlocking financing for hydrogen projects will be key moving forward. The EU has already identified Ukraine as a strategic partner in its hydrogen strategy. Pilot and testing projects such as the assessment of hydrogen mixes in distribution networks by RGC and NGBI are significant. Beyond the benefits for gas DSOs, the outcomes of these are proving useful for a wider audience across all stakeholders of Ukraine's transition to a hydrogen energy future. Similar projects including their funding will need to be encouraged for the successful adoption of hydrogen technologies.

A11 Interviewed stakeholders

A11.1 Albania

Albgaz

Albgaz Sh.a. is a joint stock company, 100% owned by the Albanian state, established and licensed as the natural gas transmission system operator and distribution system operator in the Republic of Albania.

https://albgaz.al/

A11.2 Bosnia and Herzegovina

The Ministry of Foreign Trade and Economic Relations (MOFTER)

The MOFTER is responsible for the following:

- foreign trade policy and customs tariff policy of Bosnia and Herzegovina (BA);
- development of contracts, agreements and other documents in the field of economic relations and trade with other countries;
- development of bilateral and multilateral agreements and other documents in regard to reconstruction of BA;
- relations with international organisations and institutions in the field of foreign trade and economic relations;
- designing and drafting strategic documents on macroeconomic relations;
- business environment, single economic space;
- development and promotion of entrepreneurship;
- control of turnover with goods and services under a special regime in the field of export and import;
- consumer protection;
- competition;
- coordination of international economic assistance to BA, except for the part regarding EU assistance; and
- Veterinary medicine.

The Ministry is also responsible for tasks and duties falling within the jurisdiction of the State of BA including defining policies and basic principles, coordinating activities and consolidating entity plans with those of international institutions in the following areas:

- Agriculture;
- Energy;
- Protection of environment and use of natural resources; and
- Tourism.

http://www.mvteo.gov.ba/Content/Read/nadleznosti

The State Electricity Regulatory Commission (SERC)

The State Electricity Regulatory Commission is an independent regulator in BA established in 2003 by the Parliamentary Assembly. The Act on Transmission of Electric Power, Regulator and System Operator of BA provided the legal basis for the establishment of the regulator.

SERC has regulatory responsibility over electricity transmission, transmission system operation and international trade. It additionally oversees electricity generation, distribution and supply in the Brčko District.

Specific activities include, but are not limited to:

- Issuance, revocation and monitoring of licences;
- Determination of tariff methodologies for transmission, ancillary services and Independent System Operator activities;
- Determination of tariff methodologies for distribution and supply of electricity in the Brčko District;
- Revision and approval of market rules and grid codes;
- Supervision of quality and safety standards for electricity transmission and ancillary services; and
- Approval of transmission investment plans.

https://erranet.org/member/serc-BA/

A11.3 Georgia

The MoESD

MoESD is responsible for the following energy-related activities:

- Approval of renewable energy projects including announcements of expressions of interest, review of prefeasibility and feasibility studies and preparation of the Memoranda of Understanding with developers, market operators and (if applicable) transmission licensees;
- Granting construction permits, supervision of projects and issuing commissioning certificates via the technical and construction supervision agency;
- Approval of Ten-Year Network Development Plan, electricity and natural gas forecasts; and
- Promotion of green economy initiatives, demand side management and energy efficiency measures that lead to a sustainable development of Georgia.

http://www.economy.ge/uploads/files/2017/energy/samoqmedo_gegma/nreap_v_3_eng_21022020.pdf

http://www.gse.com.ge/sw/static/file/TYNDP_GE-2020-2030_ENG.pdf

GOGC

GOGC is the national oil and gas company in Georgia, managed by the MoESD. GOGC is responsible for the production, supply and transportation of oil and natural gas, infrastructure development of the main pipeline system for oil and gas, and electricity generation and supply. GOGC owns and operates two power plants in Gardabani, which roughly contribute approximately 20% of Georgia's electricity generation. The company also represents state interests in Production Sharing Agreements.

In an agreement signed in September 2020, the EBRD agreed to provide technical assistance to explore green hydrogen potential in Georgia and the necessary infrastructure investments to supply blended hydrogen to end users. GOGC is one of the beneficiaries of this agreement.

https://www.gogc.ge/en/activities-overview

https://www.ebrd.com/news/2020/georgia-joins-the-race-to-produce-green-hydrogen.html

IBERIA capital

IBERIA capital is a family-run venture that has been operating in Georgia for three generations. IBERIA Capital is a developer of renewable energy projects and the largest developer of an upcoming windfarm in Georgia (300 MW).

https://capitaliberia.com/about-us

A11.4 Kosovo*

Energy Regulatory Office

The Energy Regulatory Office (ERO) was established in June 2004, with the promulgation by the Assembly of Kosovo* of the Law on Energy, the Law on Electricity and the Law on Energy Regulator.

The ERO is an independent body, which has the duty to regulate activities in the energy sector in Kosovo*, including electricity, district heating and gas, in accordance with the obligations arising from the Energy Community Treaty.

https://www.ero-ks.org/zrre/en/per-ne

A11.5 Moldova

No interviews were held with Moldovan stakeholders.

A11.6 Montenegro

Energy and Water Regulatory Agency of Montenegro

The Energy Regulatory Agency was established by the Parliament of Montenegro on 22 January 2004 in accordance with the Energy Law, as an autonomous, non-profit organisation, legally and functionally independent from the state authorities and energy undertakings.

The Agency is an independent regulatory authority with its jurisdiction spanning electricity, natural gas, oil and petroleum derivates and heating energy, as well as the regulation of prices for water supply and wastewater management.

The objectives of the Agency are to contribute, in cooperation with the competent bodies of the Energy Community and regulatory organisations of other Energy Community members, the promotion of competitive, efficient, safe and sustainable electricity and gas markets in Montenegro, the promotion of adequate conditions for the efficient and reliable functioning of the electricity and gas systems, as well as the development of competitive regional markets that function adequately within the Community.

http://regagen.co.me/site_en/public/index.php/index/artikli?id=177

A11.7 North Macedonia

Energy and Water Services Regulatory Commission (ERC)

The Energy and Water Services Regulatory Commission of the Republic of North Macedonia (ERC) is responsible for regulating and controlling the performance of energy activities in the fields of electricity, natural gas, district heating, oil, oil derivatives and transportation fuels, and also, for the establishment of the tariffs and prices of water services.

The competences of ERC are regulated by the Law on Energy, the Law on Water Services Prices, other by-laws, and the Statute and its Rulebook.

https://www.erc.org.mk/default_en.aspx#

MER JSC Skopje

MER JSC Skopje was established in 2010 for the purpose of constructing and developing the national gas pipeline system in the Republic of North Macedonia. It also undertakes various projects involving the construction of gas interconnections for the transmission of natural gas and connection with neighbouring countries and international transit gas pipelines.

http://212.13.72.91/en-US/ForUs/ZaMer

Macedonian University of Science and Arts

http://manu.edu.mk/

A11.8 Serbia

Hydrogen Storage Initiative

The aim of the Hydrogen Storage Initiative is the promotion of hydrogen storage materials research and the introduction of hydrogen and renewables in Serbian energy policy.

http://ives.edu.rs/index.html

A11.9 Ukraine

Ministry of Energy

http://mpe.kmu.gov.ua/

DTEK

DTEK's activities include:

- The production of coal and natural gas;
- The generation of electricity with solar, wind, and thermal power plants;
- The distribution and supply of electricity to households;
- The selling of energy resources in the Ukrainian and international wholesale markets;
- Offering customers products and services for the sustainable use of energy resources; and
- The development of a network of fast chargers (for car batteries).

In 2020 DTEK established a project team to study the possibilities of using hydrogen in the Ukrainian economy. The team is currently conducting an in depth feasibility study on the use of hydrogen in the fields of transport, energy and industry.

https://dtek.com/en/

Gas Transmission System Operator of Ukraine, Limited Liability Company

LLC Gas TSO of Ukraine is a natural monopoly that provides transportation of natural gas to the consumers in Ukraine and in countries of the European Union.

The company was established in 2019 to fulfil international obligations to the Energy Community to ensure the independence of the gas transmission system operator of Ukraine.

Starting from 1 January 2020, LLC Gas TSO of Ukraine is the certified operator of the gas transmission system of Ukraine and fully independent of vertically integrated undertakings.

The shareholder of LLC Gas TSO of Ukraine is JSC Mahistralni Gazoprovody Ukrainy, which is 100% owned by the Ministry of Finance of Ukraine.

https://tsoua.com/en/

Naftogazbudinformatyka (NGBI)

Naftogazbudinformatyka (NGBI) is a leading independent private consulting company within the oil and gas industry of Ukraine. It provides consultancy services including:

- Analytical services;
- The development of investment projects;
- Optimisation of corporate structures;

- Project management;
- Strategic management; and
- The development of regulatory, organisational and methodological frameworks.

It is also an unofficial adviser to the Ministry of Energy, the coal industry, and the National Joint Stock Company “Naftogaz Ukraine”. Moreover, it is one of the initiators and organisers of the Ukrainian Gas Forums.

RGC

The RGC is a service company that provides financial, legal, and technological consulting services. The RGC brings together 20 operators of gas distribution networks (DSOs) under the umbrella of a single brand, which serves eight million natural gas consumers through 250,000 km of gas pipelines.

The company was Ukraine’s first to join the EU Hydrogen Strategy and is implementing an R&D project to test gas network operation with hydrogen. The project will evaluate the specifics of using hydrogen and hydrogen gas mixtures in closed gas pipeline sections.

https://eba.com.ua/en/member/regionalna-gazova-kompaniya/

State Agency on Energy Efficiency and Energy Saving of Ukraine

State Agency on Energy Efficiency and Energy Saving of Ukraine (SAEE) is a central executive body, which is governed and coordinated by the Cabinet of Ministers of Ukraine and that implements state policy in:

- natural gas substitution; and
- projects on energy saving, RES and alternative fuels in Ukraine.

https://www.saee.gov.ua/

RAG Austria AG

RAG Austria AG is Austria’s largest gas storage company – making it the country’s biggest energy storage provider – and one of Europe’s leading gas storage facility operators. The company develops pioneering energy technologies that act as partners to renewables. Its portfolio of business activities also includes gas production, supply and trading, as well as the use of gas as a transport fuel.

https://www.rag-austria.at/en/index.html