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# The role of hydropower in selected South-Eastern European countries

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www.e3-consult.at



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# Executive summary

The SEE region has the largest remaining unexploited hydropower potential in Europe. However, the development of untapped hydropower potentials in South-Eastern European countries has caused growing environmental concerns, since many of the effected river stretches are considered to be of high ecological value. Nevertheless, the number of awarded concessions has been rapidly increasing in the last few years and today a few thousand new hydropower plants are in the pipeline in the whole SEE region. On the other hand despite a promising potential alternative renewable energy sources have yet experienced only in a few SEE countries an emerging trend, i.e. most SEE countries put the focus of its energy policy still on hydropower rather than on wind, solar and biomass. In this context, EuroNatur and RiverWatch commissioned e3 consult with a study on the future role of hydropower in seven selected SEE countries, namely Albania, Bosnia and Herzegovina, Bulgaria, the Former Yugoslav Republic of Macedonia, Greece, Montenegro, and Serbia. The results of the study are summarized in the following:

### Hydropower serves 21% of the electricity demand in the region

The seven SEE countries currently have an installed hydropower capacity of 12.5 GW with an electricity generation of about 34 TWh/a. The average share of hydropower in the yearly electricity consumption is about 21%. However, due to fluctuating hydropower supply the contribution of hydropower to the demand varied between 16 and 25% in the years 2011-2017. On a country level the average share of hydropower in demand ranged between 10% in Greece and 88% in Albania.

### One third of technical and half of economic hydropower potential yet exploited

The remaining available hydropower potentials add up to total economic potential of 12.8 GW (37 TWh/a) and a total technical potential of 25.2 GW (65 TWh/a), respectively. The countries with the highest remaining potentials are Albania, Bosnia and Herzegovina and Greece.

### NREAP targets for hydropower will most likely be missed

Between 2010 and 2017 about 1.7 GW of additional hydropower capacities were put into operation, however another 1.4 GW would be required to meet the combined 2020 NREAP targets for hydropower of the seven SEE countries.

### Identified projects would double annual electricity output from hydropower

EuroNatur and RiverWatch identified almost 2,400 hydropower projects with an estimated total capacity of 12.2 GW and an annual generation of some 36 TWh/a in the seven countries. About 92% of the projects are small hydropower plants below 10 MW and two third are even below 1 MW. With about 840 projects more than one third of the projects are located in Serbia, however almost 90% of this projects are below 1 MW. From an economic perspective the strong focus of most countries on very small hydropower is not immediately apparent because very small hydropower projects are typically less economically attractive.

### 8 % of the projects ecologically feasible according to EuroNatur and RiverWatch classification

EuroNatur and RiverWatch applied an ecological evaluation to the hydropower projects to classify the feasibility of the projects from EuroNatur/RiverWatch perspective. As a result 92% of the projects and 96% of the total project capacity, respectively, are located in exclusion zones as defined by EuroNatur/RiverWatch.

### Potentials of wind, solar PV and biomass exceed remaining hydropower potentials by far

In total, the seven countries covered in this study have an economic potential of wind, solar PV and biomass of about 240 TWh/a. This potential does not only significantly exceed the remaining economic hydropower potential of 37 TWh/a but also exceeds the current electricity demand of all countries that is not yet covered by renewable by a factor of 2. However, the promising potentials of wind, solar PV and biomass have yet not been reflected in the energy policy of most of the seven SEE countries. Only Bulgaria and especially Greece have already experienced an emerging trend towards alternative renewable energy sources.

### Wind, solar PV and biomass diversify the country's renewable portfolios

Even if hydropower is still the most economically viable renewable energy technology in the SEE region wind onshore and solar PV have already reached a competitive cost level. Hence, alternative renewable energy sources could in principle substitute ecologically sensitive hydropower projects without major economic disadvantages. Furthermore, a greater consideration of wind, solar PV and biomass in the country's renewable and generation portfolios, respectively, would better diversify the portfolios and make them less vulnerable to unavoidable seasonal and yearly fluctuations of electricity generation from hydropower and potential impacts of climate change on the availability of hydropower plants, respectively.

### An overall assessment of hydropower projects is recommended

However, the assessment of hydropower projects should not only be based on ecological but also on energy economic related aspects to consider the interaction of hydropower projects with the electricity system. For example, hydropower plants that are combined with a reservoir can provide flexible generation and ancillary services. It is expected that flexibility in a power system will considerably gain importance in the future, if the share of volatile generation from wind and solar increases. Hence, a more differentiated classification of hydropower projects is recommended that would allow a transparent and equal consideration of energy economic and environmental aspect.

# 1 Introduction

In contrast to other European regions the South-Eastern European (SEE) countries and especially the Western Balkans still represents a significant portion of untapped hydropower potential [1]. Hence, efforts to further exploit hydropower potentials in SEE have been strengthen by project developers and governments, since the expansion of hydropower is considered to serve the expected growing demand and to replace old and inefficient thermal power plants but also to deliver a substantial contribution for the implementation of renewable energy targets. As a consequence, the number of awarded concessions has been rapidly increasing in the last the few years and today about 2,800 new hydropower plants are in the pipeline in the whole SEE region. [2]

However, the expansion of hydropower has caused increasing environmental concerns because the industries' appetite for new hydropower capacities also affects river stretches with a high ecological value and hence, potentially threatens the ecosystem of the rivers in terms of e.g. hydromorphology and biodiversity. For example, a recently published study by Fluvius concluded that 37% of the planned projects in the SEE region are in protected areas. [3] Consequently, the conflicting interests between energy industry and nature conversation needs in SEE have already been put on the agenda of the European Union. For example, the EU-funded project *Regional Strategy for Sustainable Hydropower in the Western Balkans* [4] aims to define how the region's hydropower potential could be developed in a way that e.g. energy generation, flood protection and ecological concerns are well balanced. However, the focus of the project was put on a "full exploitation of hydropower potentials in a sustainable way" rather than the question if a (untouched) river stretch should be excluded for any use of hydropower from an environmental perspective. Additionally, the assessments mainly considered large hydropower projects with an electrical output above 10 MW and did not include the large amount of small hydropower projects in the SEE region. Against this background e3 consult was commissioned by EuroNatur/RiverWatch to carry out a study on the future role of hydropower that includes a project specific evaluation of the ecological feasibility of hydropower projects in seven selected SEE countries (cf. Fig. 1).

**Fig. 1: South-Eastern European countries covered in this study**


* The former Yugoslav Republic of Macedonia

Based on an overview of the existing generation mix this study analyses the overall perspectives of hydropower in the covered SEE countries. Furthermore the study provides an assessment of the impact of the ecological classification of hydropower projects by EuroNatur/RiverWatch on the further development of hydropower in the seven SEE countries and gives an overview about the potentials of other renewable technologies to verify if ecologically unattractive projects could in principle be substituted by wind, solar and/or biomass.

# 2 Existing electricity generation system

This chapter contains a brief summary of the electricity generation systems of the seven SEE countries covered in this report, i.e. Albania, Bosnia and Herzegovina, Bulgaria, the Former Yugoslav Republic of Macedonia (FYR Macedonia), Greece, Montenegro, and Serbia. After a high level overview of the main characteristics of all seven countries individual country profiles provide a more detailed picture of the country specific generation and demand structure in the years 2011 to 2017.

In order to have a consistent data basis all presented data are – if available – taken from various ENTSO-E publications [5] even if ENTSO-E data can differ from other data sources. However, data inconsistency amongst different sources is a general issue and not only related to SEE countries.

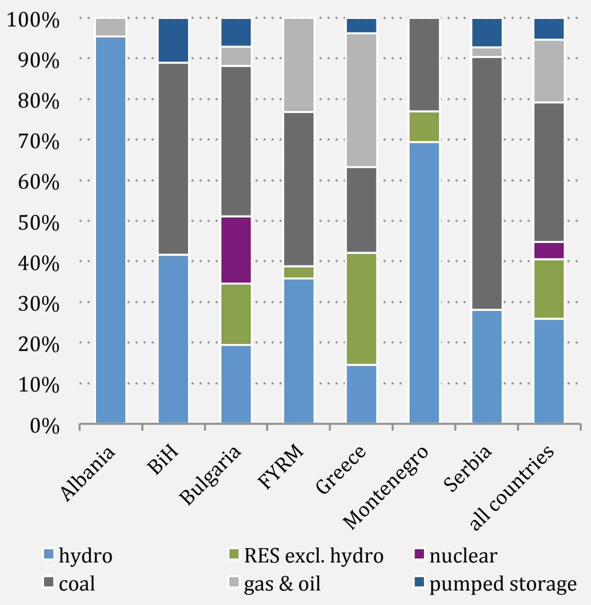
## 2.1 SEE region at a glance

With an installed generation capacity of 48 GW and an annual electricity consumption of 156 TWh Albania, Bosnia-Herzegovina, Bulgaria, the Former Yugoslav Republic of Macedonia, Greece, Montenegro and Serbia represent about 4.2% of the total installed capacity (1,150 GW) as well the total electricity consumption (3,700 TWh) in the ENTSO-E system in 2017. In comparison, the installed hydropower capacity (including pumped storage) in the seven countries of 15 GW account for 6.4% of the total ENTSO-E[1] hydropower capacity of 235 GW. However, the national generation mix differs widely between the individual countries as shown in Fig. 2.

The share of hydropower capacities (excl. pumped storage) in the national power plant portfolios has a wide range between 95% in Albania and 15% in Greece. Besides hydropower the main domestic source of electricity generation in the region is coal (mainly lignite) – only Greece and Bulgaria have a considerable share of non-hydro renewables so far and Bulgaria is the only country with nuclear capacities.

As a consequence of the yearly fluctuating hydropower conditions the annual load coverage of hydropower varies strongly amongst the countries. For example, Albania shows a share of renewable hydropower generation (i.e. excl. pumped storage) in the years 2011-2017 between 57 and 100%, Montenegro between 28 and 59% and Greece between 8 and 12%.

**Fig. 2: Installed generation capacity by technology and country 2017**




Source: ENTSO-E; IHA and AEA for Albania

Electricity demand in the South-East European region exhibited between 2000 and 2008 a relatively strong growth rate. However, the impact of the recession on the demand was significant and the pre-

[1] European Network of Transmission System Operators for Electricity (https://www.entsoe.eu/)

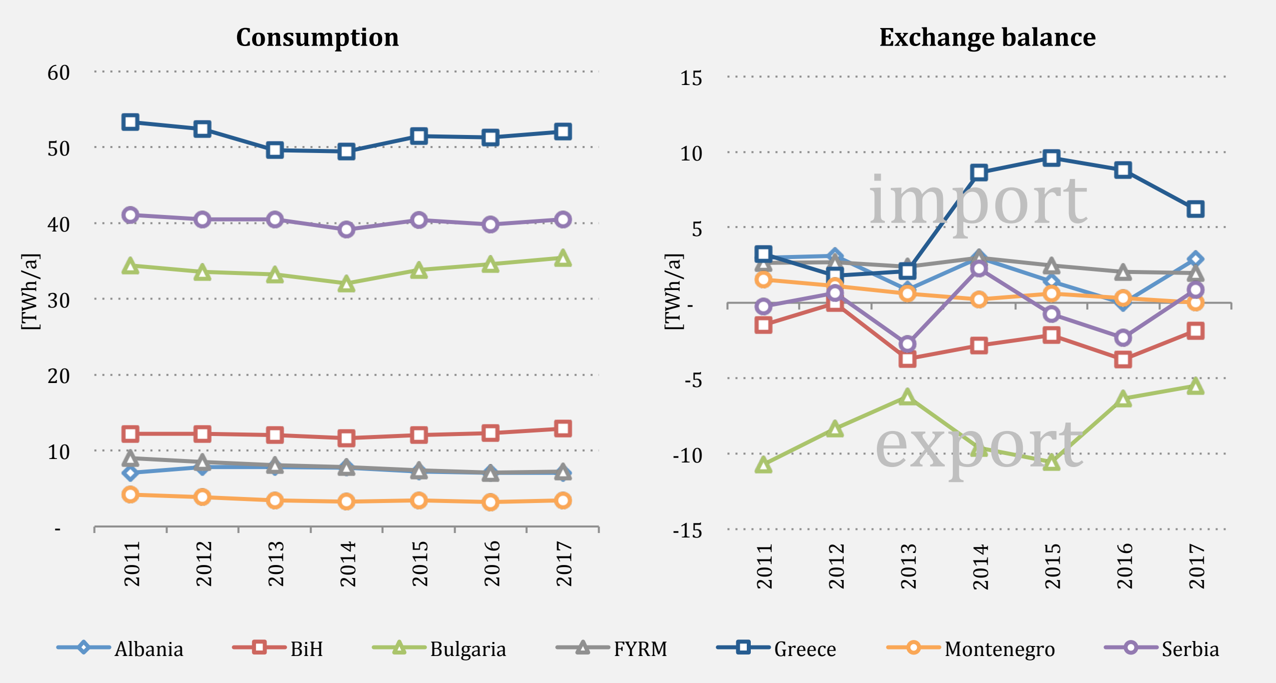
viously expected growth rates for current years have yet not been seen in market trends.

Hence, the electricity consumption of the seven South-Eastern European countries in 2017 was roughly at or even below the level of 2011 (Fig. 3, left chart). Greece is by far the largest consumer with an electricity demand of about 52 TWh/a followed by Serbia (40 TWh/a) and Bulgaria (34 TWh). The lower boundary of the bandwidth of electricity consumption marks Montenegro with an annual demand of some 3 TWh/a in 2017.

Despite the relatively slow growth rate of demand in the recent years most of the seven countries depend on electricity imports – at least in periods with low water levels in rivers and reservoirs, respectively, and therefore a low electricity production from hydropower. Hence, some countries have been import-dependent to a very high degree in the past years, including FYR Macedonia with on average 31%, Albania with 27% and Montenegro with 22% of its total consumption. Only Bulgaria and Bosnia and Herzegovina were net exporting countries in all of the past 7 years (Fig. 3, right chart).

Historically the electricity grid of former Yugoslavia was interconnected and synchronized with the European grid. In 1991 the grid in the region was split into two separately operating synchronous zones, which were reconnected to the Central European system in 2004. Additionally, the interconnection capacity has been increased in the South-Eastern European region, i.e. major barriers to the creation of a regional electricity market and a supra-national dispatch optimization have been removed. Hence, national import dependency for smaller countries is at least from the perspective of security of supply not as critical as it may has been the case in previous years. This is especially true against the background of an almost balanced electricity exchange of the seven SEE countries with neighbouring regions.

**Fig. 3: Consumption and exchange balance 2011 – 2017**




Source: ENTSO-E (for Greece data refer to interconnected system)

## 2.2 Country profiles

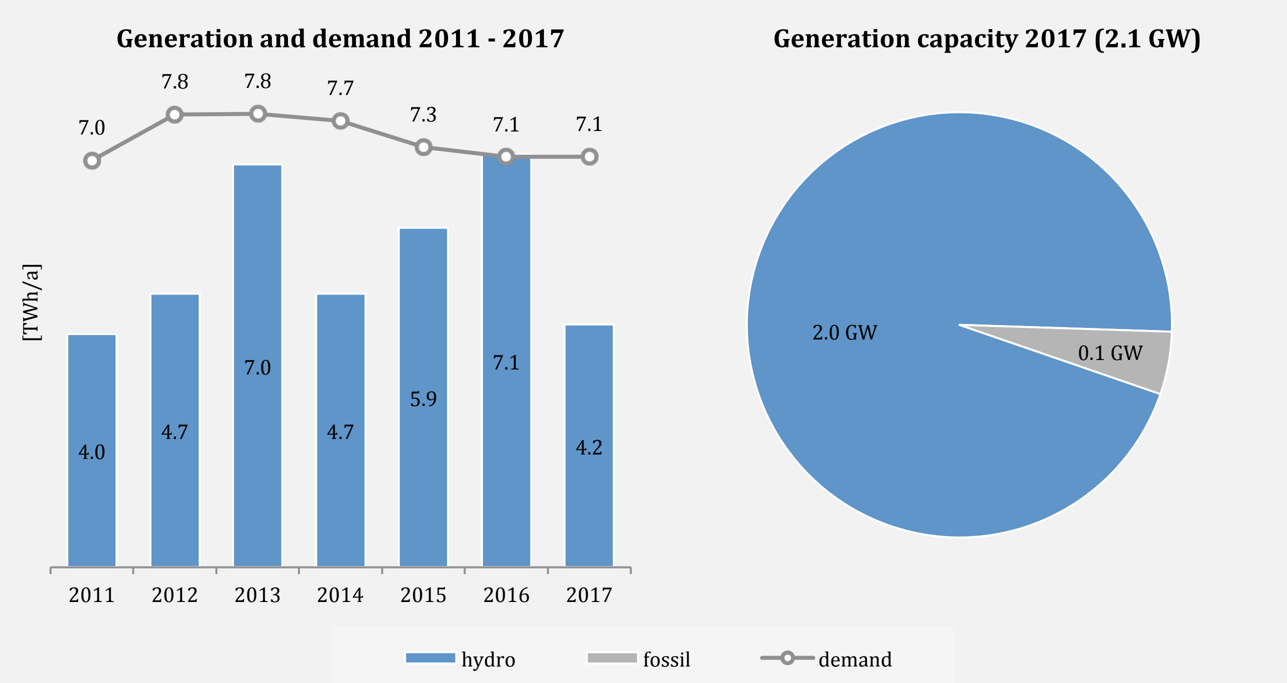
### 2.2.1 Albania

Since 1996 Albanian is synchronized with the ENTSO-E system and in 2017 the transmission system operator OST became a member of ENTSO-E. The country's domestic generation is almost entirely dependent on hydropower – in 2017 the total installed capacity reached about 2,100 MW from which 100 MW was thermal. Besides hydropower no other renewable technology has yet been installed even if the Ministry of Infrastructure and Energy launched the selection process for the development and construction of the largest solar PV plant in the region with an installed capacity of 50 MW [6]. Though, as the only oil-fired power plant has been out of operation the share of renewables in total electricity generation is still 100%.

Even if the total installed hydropower generation capacity has been increased in the last 6 years by about 500 MW Albania is highly import-dependent, particularly in drought years. Depending on the available water supply hydropower production can vary significantly – the capacity factor (defined as annual generation divided by installed capacity and 8,760 hours) of the years 2011-2017 shows a range between 24% (2017) and 48% (2013), which equals to annual full load hours of 2,100 h/a and 4,200 h/a, respectively. Hence, Albania has been a considerable net importer of electricity from neighbouring countries and in years with severe drought – as for example in 2017 – security of supply is still a challenge.

The annual electricity consumption was about 7.1 TWh in 2017 and peak load demand was 1.4 GW. However, the Albanian power sector has been suffering from comparatively high losses due to an inefficient transmission and distribution grid but mainly due to non-technical losses from power thefts and non-collections. Hence, to address these issues the government has launched energy sector reforms, which could be one reason for the noticeable decrease in electricity consumption in the last few years.

**Fig. 4: Key figures electricity generation and demand Albania 2011 – 2017**




Source: EIA, ANA, AEA, IHA

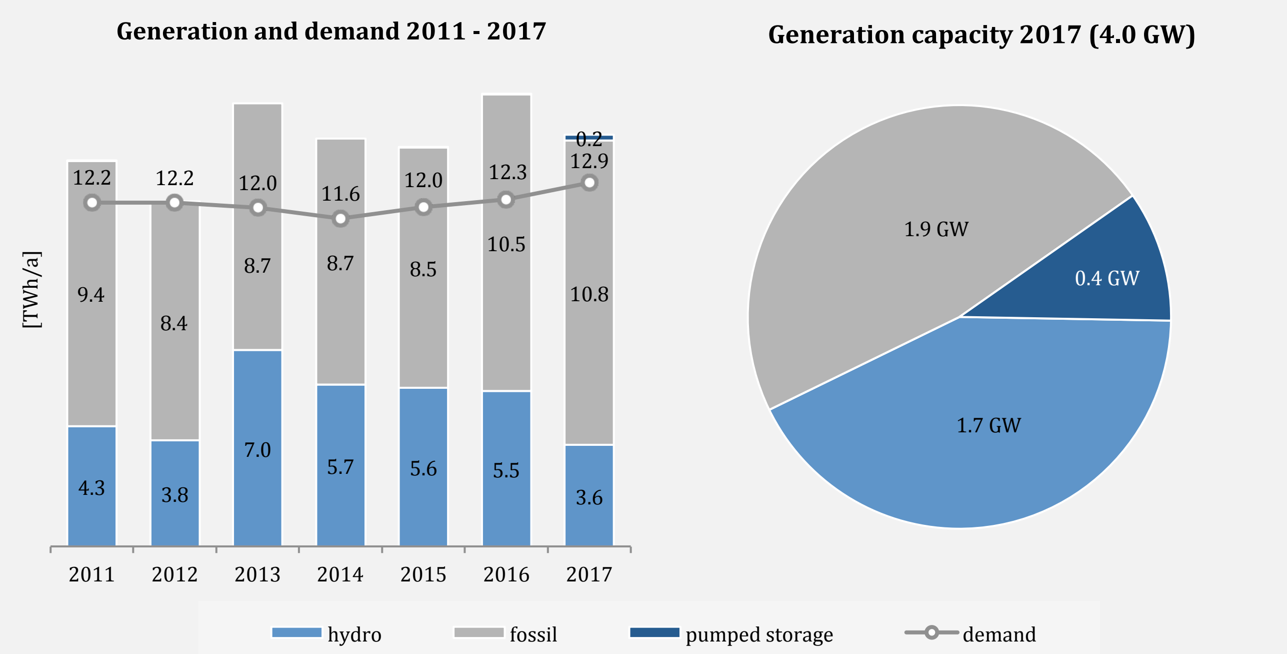
### 2.2.2 Bosnia and Herzegovina

Bosnia and Herzegovina has a total installed generation capacity of 4.0 GW (2017), of which 1.9 GW lignite and 2.1 GW hydropower incl. pumped storage. Until 2017 no other renewable energy sources but hydropower have provided a contribution to the national generation mix. However, in 2018 the country's first wind farm with 22 turbines and an installed capacity of 50.6 MW was commissioned in Mesihovina [7] and the first utility-scale tender for a 65 MW PV plant in Ljubinje was announced [8]. Hydropower capacity has been increased by about 130 MW in last 6 years and in 2016 some 300 MW of lignite were newly commissioned – the latter increased the output from lignite power plants by 2 TWh to 10.5 TWh in 2016 and 10.8 TWh in 2017. Consequently, the share of renewables in total electricity generation dropped in 2016 on a year-to-year basis from 40% to 34%. Due to an exceptional drought the share of renewables in total generation further plunged in 2017 to 24%.

Despite the strong dependency on hydropower Bosnia and Herzegovina is the only power exporter in the Western Balkans. However, hydro conditions have been affecting the actual import-export balance in recent years. Depending on the water supply hydropower production can vary significantly – in the past 7 years between 3.6 TWh in 2017 (25% capacity factor or 2,200 full load hours) and 7.0 TWh in 2013 (50% capacity factor or 4,400 full load hours). Bosnia and Herzegovina also has substantial hydro pumped storage capacities but according to ENTSO-E statistics [5] the pumped storage plants have only been operated for a few hours in the past years.

Power consumption has not been significantly changed in last few years and was at 12.9 TWh with a peak load of some 2,240 MW in 2017. Generally, the annual demand has been mostly moved by economic and weather events. Power consumption growth was negative in 2012 and 2013 during warm years, and weak economic growth. Even if the consumption is expected to increase in the future the potentially possible closure of Aluminij d.d. Mostar could cause a significant drop in the national power consumption.

**Fig. 5: Key figures electricity generation and demand Bosnia and Herzegovina 2011 – 2017**




Source: ENTSO-E

### 2.2.3 Bulgaria

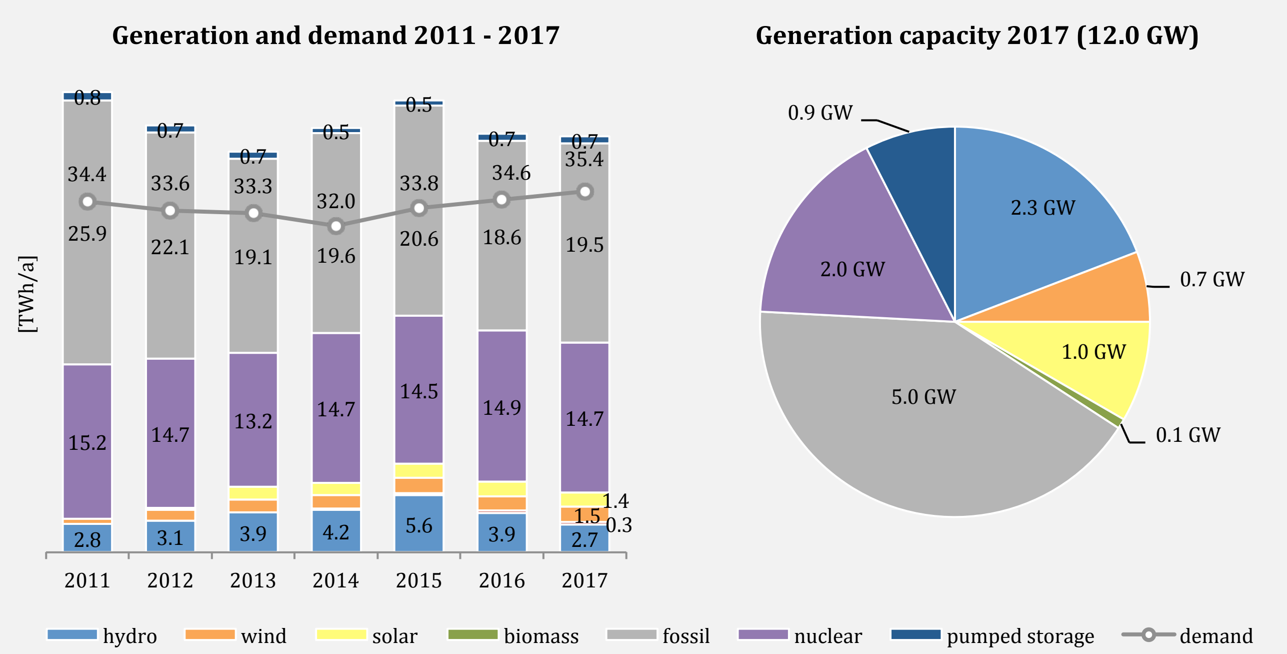
Bulgaria has a total installed generation capacity of 12.0 GW (2017), including 4.5 GW lignite and hard coal, 2.0 GW nuclear, 0.6 GW natural gas, 3.2 GW hydropower incl. pumped storage and 1.8 GW other renewables. Hence, the generation mix depends primarily on domestic coal and nuclear, i.e. Bulgaria is the only SEE country considered in this study that operates a nuclear power station. The country also have substantial hydro (storage) capacities and unlike most other SEE countries already considerable wind and solar capacity installed due to a successful five-year implementation of feed-in tariffs. Nevertheless, the share of renewables in total electricity generation is still comparatively low and reached about 14% in 2017.

Hydropower has shown a relatively slow growth rate in the past 6 years with a net addition of only some 50 MW. Capacity growth in the upcoming years is expected to come mostly from "new" renewables and gas to substitute old an efficient fossil fired thermal plants. Even if Bulgaria has pursued plans to build new nuclear plants for years, it is unlikely that these projects will finally be accomplished.

Depending on the available water supply hydropower production can vary significantly. For example the range of the capacity factor in the years 2011-2017 was between 13% (2017) and 20% (2015), which equals to full load hours of 1,200 h/a and 2,400 h/a, respectively. However, since the contribution of hydropower to the total annual electricity generation is relatively small – on average 11% in the years 2011-2017 – and the generation portfolio is well diversified security of supply is generally not affected from the availability of hydropower capacities.

In 2017 Bulgaria's annual electricity consumption was about 35.4 TWh and peak load demand was 7.7 GW. Hence, Bulgaria is well-supplied with power compared with demand and is a strong regional power exporter.

**Fig. 6: Key figures electricity generation and demand Bulgaria 2011 – 2017**




Source: ENTSO-E

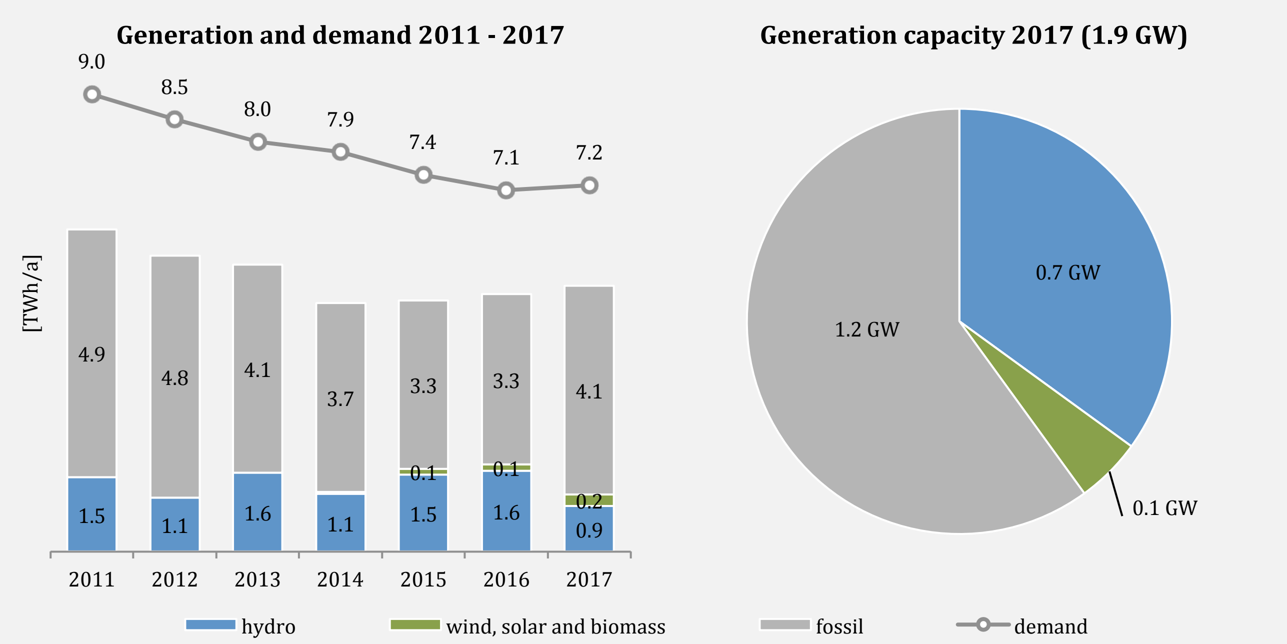
### 2.2.4 The former Yugoslav Republic of Macedonia

The former Yugoslav Republic of Macedonia (FYROM) has a total installed generation capacity of 1.9 GW (2017), of which 0.7 GW lignite, 0.4 GW natural gas and oil, 0.7 GW hydropower and 0.1 GW wind and solar. Whereas lignite capacities have been significantly decommissioned in the past years, gas fired CHP (combined heat and power) capacities have been added to the generation system. Also the installed generation capacity of hydropower has increased by some 170 MW in last 6 years. Hence, the share of renewables in total electricity generation went up to 34% in 2016 from about 20% at the beginning of the decade. However, in 2017 the share of renewables dropped to 22% due to the exceptional drought and low electricity generation from hydropower.

Based on ENTSO-E statistics total power consumption has significantly and constantly decreased in last few years and was at 7.2 TWh with a peak load of some 1.5 GW in 2017. Beside the collapse of the energy-intensive industry a major reason for such an extraordinary reduction of the electricity demand was probably the reduction of non-technical losses from power thefts and non-collections in the distribution grid. Hence, the constantly decreasing national electricity consumption of the past few years will probably be turned into a growth trend in the future.

Despite the strong reduction of the national consumption FYROM is still highly depend on electricity imports. In 2017 about 27% of the consumed electricity was imported from neighbouring countries. In drought years import dependency has even been higher – hydropower production showed a capacity factor between 15% (2017) and 35% (2013), which equals to full load hours of 1,300 and 3,100 h/a, respectively.

**Fig. 7: Key figures electricity generation and demand FYR Macedonia 2011 - 2017**




Source: ENTSO-E

### 2.2.5 Greece

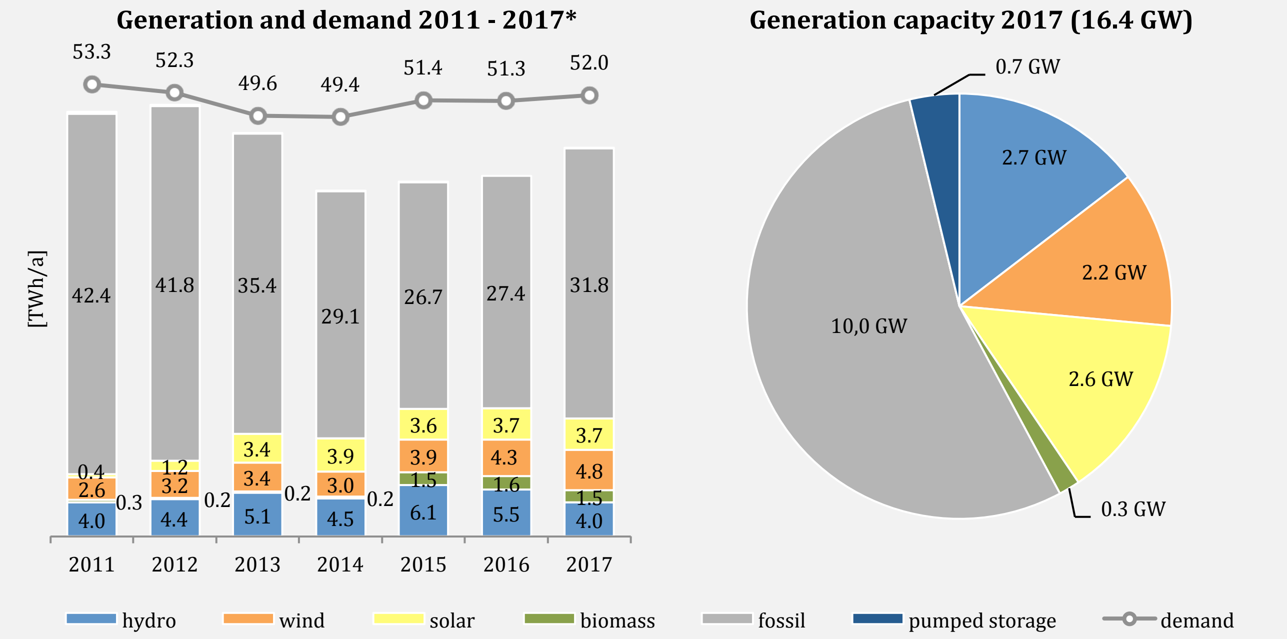
According to ENTSO-E data Greece had a total installed capacity of 16.4 GW at the end of 2017 including 3.9 GW lignite, 4.3 GW natural gas, 3.4 GW hydropower incl. pumped storage and 4.8 GW other renewables. Additionally, about 2.2 GW of generation capacity is installed at the non-interconnected islands (NIIs), which are mainly supplied from diesel-driven generators'. Besides Bulgaria, Greece is the only SEE country covered in this study with a substantial portfolio of "new" renewable energies. Wind, solar and biomass represent a generation capacity of 5.1 GW (incl. NIIs) at the end of 2017 and have already exceeded hydropower capacities. However, in 2017 the growth rate of "new" renewables significantly slowed down mainly due to a delay in the adoption of the new support policy. In contrast to the strong growth rates of "new" renewables hydropower capacity additions in the past 6 years amount to only some 170 MW.

Peak demand in the interconnected Greek electricity system was 9.6 GW in 2017 and the total electricity generation amounted to 45.8 TWh with a share of renewables of about 30%. In comparison the renewable energy share in the electricity mix of the NIIs was about 22%, corresponding to a production of 1.0 TWh and an installed capacity of about 500 MW.

As in other SEE countries the contribution of hydropower to the national generation mix varies significantly over the years. The bandwidth of the hydropower capacity factor was between 17% (2017) and 27% (2015) and of the full load hours between 1,500 h/a and 2,400 h/a, respectively.

Greece has been a net importer of electricity for several years but in 2014 imports sharply increased to about 18% of annual consumption due to a significant decrease of electricity production from domestic lignite. However, despite environmental concerns and a relatively cost-intensive mining industry Greece decided to invest in new lignite power stations, i.e. the negative exchange balance will likely be reduced in the upcoming years.

**Fig. 8: Key figures electricity generation and demand Greece 2011 - 2017**




Source: ENTSO-E, HEDNO (*without non-interconnected islands)

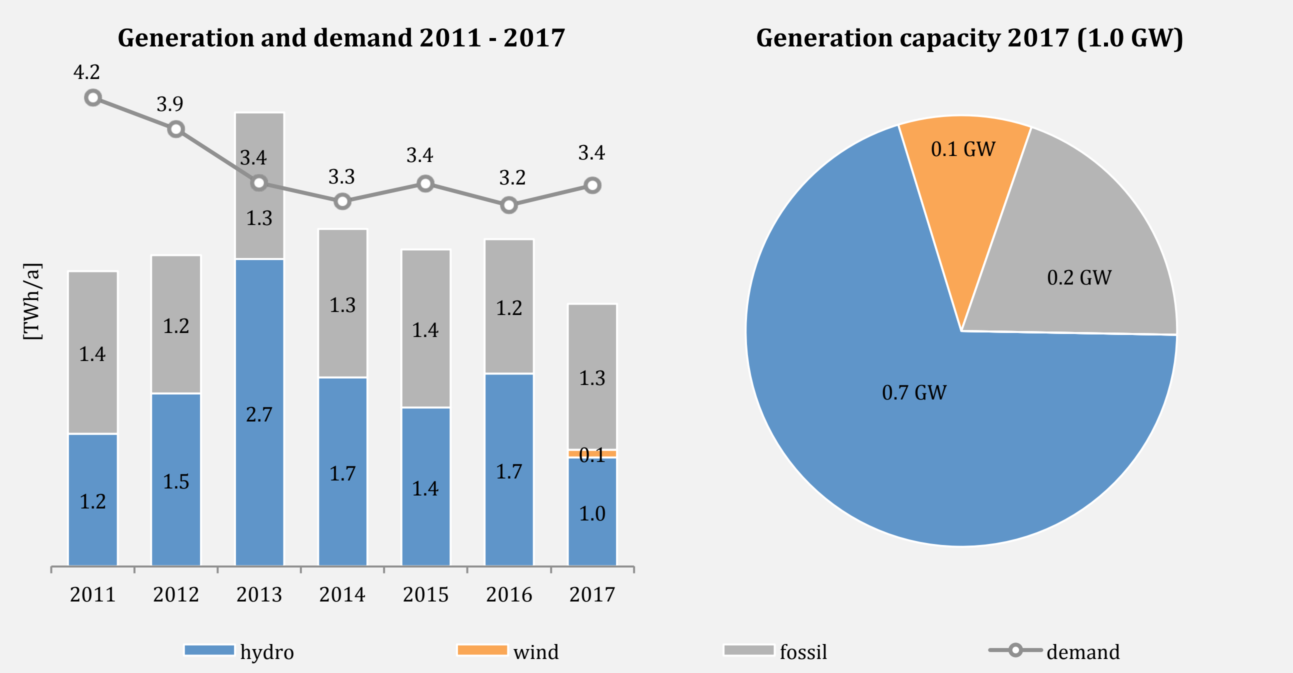
### 2.2.6 Montenegro

Montenegro has a total installed generation capacity of 1.0 GW (2017), of which 0.2 GW lignite, 0.7 GW hydropower and 0.1 GW wind. In the last few years no major fossil and hydropower capacity additions have taken place. However, in 2017 the country's first wind farm with 26 turbines and an installed capacity of 72 MW was commissioned in Krnovo and in 2018 a 1 GW undersea cable between Montenegro and Italy will be completed that will probably affect the utilization of Montenegro's thermal power plants.

Based on ENTSO-E statistics total power consumption was at 3.4 TWh with a peak load of some 0.7 GW in 2017. Similar to other Western Balkan countries the collapse of the energy-intensive industry as well as the reduction of non-technical losses from power thefts and non-collections in the distribution grid has considerably decreased electricity consumption in last few years. However, it can be expected that this trend will probably be turned into a growth of demand in the future. Parallel to the decreasing demand the share of renewables in total electricity generation has increased in the last years and was 59% in 2016. However, in 2017 the renewables share dropped to 43% due to the extraordinary low precipitation in the Balkan region.

Despite the reduction of the national consumption Montenegro is still depending on electricity imports. In 2017 about 33% of the consumed electricity was imported from neighbouring countries. Only in years with a very high production from hydropower Montenegro has been a net exporter of electricity, e.g. in 2013. Generally, hydropower production had a capacity factor in the years 2011-2017 between 17% (2017) and 47% (2013) that equals to full load hours of 1,500 and 4,200 h/a, respectively.

**Fig. 9: Key figures electricity generation and demand Montenegro 2011 - 2017**




Source: ENTSO-E (demand 2013 based on CGES)

### 2.2.7 Serbia

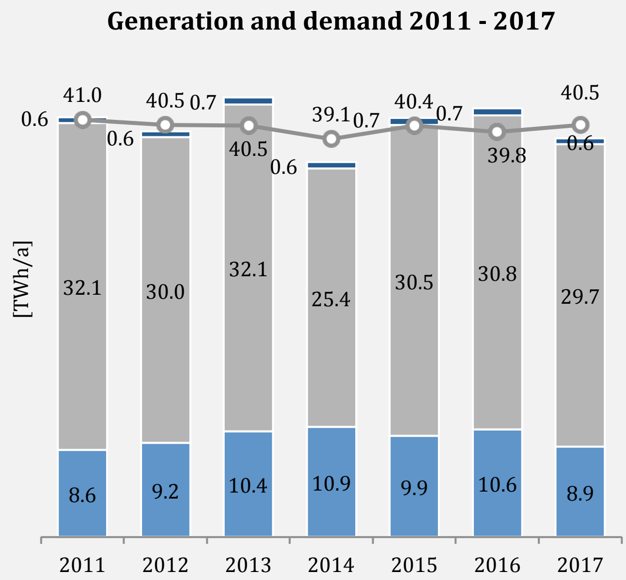
Serbia has a total installed generation capacity of 8.5 GW (2017), including 5.3 GW lignite, 0.2 GW natural gas and 3.0 GW hydropower incl. pumped storage. So far no notable wind, solar and biomass capacities have been installed. Hence, the share of renewables in total electricity generation is still solely determined by hydropower and reached about 23% in 2017. However, in 2018 the construction of a number of wind farms with a total capacity of 266 MW has been announced (Alibunar with 42 MW, Čibuk 1 with 158 MW and Kostolac with 66 MW) [9], [10].

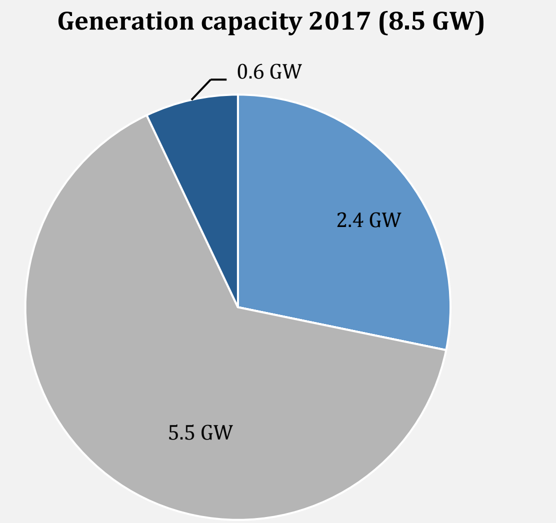
Hydropower has shown a relatively slow growth rate in the past 6 years with a net addition of some 130 MW. Despite growing concerns about environmental aspects and climate change capacity growth in the upcoming years is expected to come from domestic lignite. However, old and inefficient lignite power plants will be decommissioned in parallel and also the construction of "new" renewables is planned for the upcoming years.

Since run-of river plants at large rivers with comparatively smaller annual fluctuations of the water supply (e.g. Danube) dominate Serbia's hydropower production the contribution of hydropower to the national generation mix shows a significant lower annual variation compared to other SEE countries. The range of the capacity factor in the years 2011 to 2017 was between 43% (2017) and 52% (2014), which equals to full load hours of 3,700 h/a and 4,600 h/a, respectively.

In 2017 Serbia's annual electricity consumption was about 40.5 TWh and peak load demand was 7.4 GW. Besides Bulgaria and Bosnia and Herzegovina Serbia is the only SEE country covered in this study, which has had a balanced or positive power exchange with neighbours in the past. Only in 2014, when heavy floods negatively impacted lignite generation Serbia was a net importer of electricity.

**Fig. 10: Key figures electricity generation and demand Serbia 2011 – 2017**




Source: ENTSO-E

# 3 Perspectives for further development of hydropower

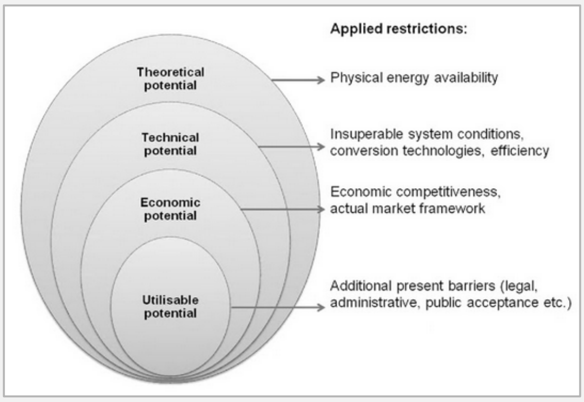
With an installed capacity of about 12.5 GW and a standard capacity of about 34 TWh/a hydropower represents today about 25% of the capacity and generation mix of the seven SEE countries covered in this study. All seven countries still have considerable potentials for major hydropower capacity additions, which are consequently also reflected in the country specific renewables targets. However, except the 2020 renewable energy targets as included in the countries' National Renewable Energy Action Plans (NREAP) no consistent long-term targets for the expansion of different renewable energy technologies and therefore also hydropower in SEE have been communicated so far. Hence, beside a quantitative summary of the hydropower potentials in the seven SEE countries in this chapter the national medium-term targets for the expansion of hydropower can only be provided based on national NREAP targets.

## 3.1 Technical and economic hydropower potentials

As already mentioned, it is estimated that only about one third of the technical hydropower potential of the SEE region has already been exploited so far. However, due to e.g. economic and environmental restrictions typically only a certain share of the technical hydropower potential can finally be utilized, i.e. the technical potential can only give a first indication about the remaining hydropower potentials in the SEE region. Generally, besides the technical potential it can additionally be differentiated between the theoretical, economic and utilizable potential of renewable energies as for example shown in Fig. 11 (cf. e.g. [12], [13]).

- **Theoretical potential:** From a physical perspective theoretically useable amount of energy within a limited region and over a specific time period (e.g. potential energy of drainage in river stretches of a certain country). The theoretical potential has no practical relevance but is typically used to calculate other potentials.
- **Technical potential:** Defined as the part of the theoretical potential that is available if technical restrictions are taken into account, such as efficiencies and conversion losses. Other technical restrictions can be e.g. the availability of a grid connection, the accessibility of a location to build a power plant or the daily/seasonal demand for energy.

**Fig. 11: Definition of different renewable potentials and applied restrictions**




Source: Hermann [13]

- **Economic potential:** Is the part of the technical potential that can be economically utilized under the current or the expected future market framework. The economic potential of renewable technologies is strongly determined by the cost structure of conventional technologies that are used for the comparison with the cost structure of renewables. Hence, the economic potential is a function of the underlying assumptions of e.g. fuel and carbon emission costs, investment and maintenance costs and costs of financing.

- **Utilisable potential:** Is the share of the economic potential that is accessible if not only technical and economic but also other restrictions are taken into account (e.g. legal and regulatory barriers, environmental restrictions). The utilisable potential is normally smaller than the economic potential but subsidies for renewable energies can boost the utilisable potential even beyond the economic potential.

For its recently issued report "Cost-Competitive Renewable Power Generation: Potential across South-East Europe" [11] the International Renewable Energy Agency (IRENA) collected and published the latest publicly available information on hydropower potentials in SEE on a country level. Besides the technical potential the IRENA report also includes the so-called cost-competitive (i.e. economic) potential to consider the fact that only a portion of the technical potential can – from an economic point of view – effectively be implemented. IRENA defines the cost-competitive renewable energy potential as the potential that is cost-competitive with new hard coal, natural gas and lignite fired power plants. However, the IRENA report explicitly mentions that environmental aspects were not taken into account to derive the cost-competitive hydropower potentials and stated "the real implementable renewable potentials might be lower, due to increasing environmental protection requirements".

The IRENA report includes all seven SEE countries covered in this study except Greece. Hence, for Greece the technical and economic hydropower potential is derived from other publications (cf. [17] and [18]). Additionally, the technical hydropower potentials as included in the IRENA report are verified with other publications and – if justifiable – adopted.[2] Fig. 12 depicts the technical and additional economic potentials of hydropower capacities (left) and generation (right) in the seven SEE countries as well as the respective numbers for the year 2017. The countries represent a hydropower portfolio of 12.5 GW installed capacities with an average annual generation of about 33.6 TWh/a[3]. In total the technical potential amounts to some 36 GW and 99 TWh/a, respectively, i.e. the technical potential is about three times above the actual usage. The total economic potential is estimated to be 25 GW and 71.0 TWh/a, respectively, i.e. one third less than the technical potential but still 100% above the current usage. Hence, the additional cost-competitive potential is about 13 GW and 37.4 TWh/a. However, the individual countries have different deployment rates of their hydropower potentials, which is discussed in the following in more details.

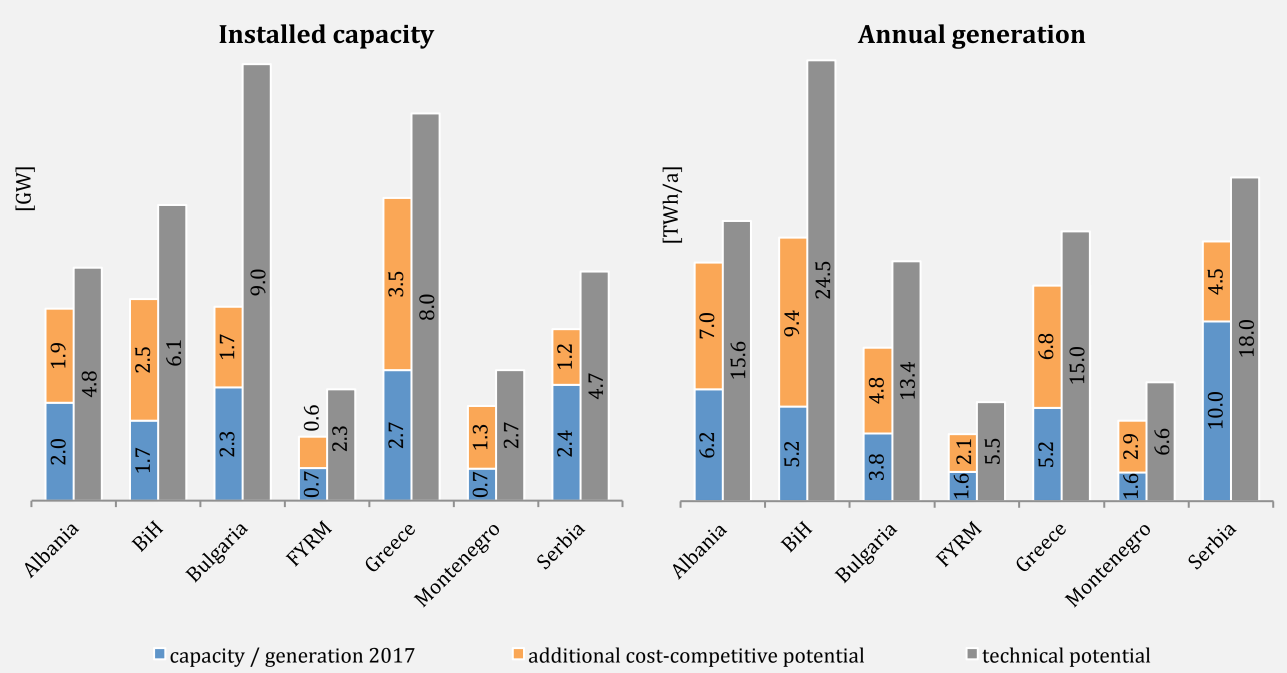
- **Albania** has a technical hydropower potential of 4.8 GW (15.6 TWh/a) and an economic potential of 3.9 GW (13.2 TWh/a). Based on the installed hydropower capacity of 2.0 GW (6.2 TWh/a) in 2017 an additional cost-competitive potential of 1.9 GW (7.0 TWh/a) can be derived. Hence, Albania has yet exploited about 40% of its technical and 50% of its economic potential, respectively.

- **Bosnia and Herzegovina** has a technical hydropower potential of 6.1 GW (24.5 TWh/a) and an economic potential of 4.2 GW (14.6 TWh/a). Based on the installed hydropower capacity of 1.7 GW (5.2 TWh/a) in 2017 an additional cost-competitive potential of 2.5 GW (9.4 TWh/a) can be derived. Hence, Bosnia and Herzegovina has yet exploited about 25% of its technical and 40% of its economic potential, respectively.

[2] Note that hydropower potentials as included in publications of the EU-funded project *Regional Strategy for Sustainable Hydropower in the Western* Balkans (cf. [14]) only consider potentials of large hydropower (except for FYROM and partially Montenegro). I.e. besides possible general difference in the definition of the technical hydropower potential the published numbers cannot directly be compared.

[3] Calculated on the basis of installed capacities 2017 and average full load hours of the years 2011 to 2017, i.e. numbers differ from actual generation in the year 2017.

**Fig. 12: Hydropower capacity and generation in 2017 as well as additional economic and technical hydropower potential**




Source: Source: ENTSO-E; AEA, IRENA, IHA, Government of Macedonia

- **Bulgaria** has a technical hydropower potential of 9.0 GW (13.4 TWh/a) and an economic potential of 4.0 GW (8.6 TWh/a). Based on the installed hydropower capacity of 2.3 GW (3.8 TWh/a) in 2017 an additional cost-competitive potential of 1.7 GW (4.8 TWh/a) can be derived. Hence, Bulgaria has yet exploited about 25% of its technical and 60% of its economic potential, respectively.
- **FYR Macedonia** has a technical hydropower potential of 1.6 GW (4.0 TWh/a) and an economic potential of 1.3 GW (3.7 TWh/a) according to the IRENA report "Cost-Competitive Renewable Power Generation: Potential across South-East Europe" [11]. However, in its background report No. 1 "Past, present and future role of hydropower" the project *Regional Strategy for Sustainable Hydropower in the Western* Balkans [14] showed a technical potential of about 9.8 TWh/a and also the officially stated technical potential of 5.5 TWh/a [15], [16] is above the number in the IRENA report. Hence, in the following a technical potential of 5.5 TWh/a and 2.3 GW, respectively, is assumed for FYR Macedonia. Based on the installed hydropower capacity of 0.7 GW (1.6 TWh/a) in 2017 the additional cost-competitive potential amounts to 0.6 GW (2.1 TWh/a). Hence, FYR Macedonia has yet exploited about 30% of its technical and about 50% of its economic potential, respectively.
- **Greece** has a technical hydropower potential of 8.0 GW (15.0 TWh/a) [17] and an economic potential of 6.3 GW (12.0 TWh/a) [18]. Based on the installed hydropower capacity of 2.7 GW (5.2 TWh/a) in 2017 an additional cost-competitive potential of 3.5 GW (6.8 TWh/a) can be derived. Hence, Greece has yet exploited about 35% of its technical and 45% of its economic potential, respectively.
- **Montenegro** has a technical hydropower potential of 2.04 GW (5.0 TWh/a) and an economic potential of 1.96 GW (4.5 TWh/a) according to the

IRENA report “Cost-Competitive Renewable Power Generation: Potential across South-East Europe” [11]. However, even without having considered small hydropower to a full extend the *Regional Strategy for Sustainable Hydropower in the Western* Balkans [14] showed a considerable higher technical potential of about 6.6 TWh/a. Hence, in the following a technical potential of 6.6 TWh/a (2.7 GW) is considered for Montenegro. Based on the installed hydropower capacity of 0.7 GW (1.6 TWh/a) in 2017 an additional cost-competitive potential of 1.3 GW (2.9 TWh/a) can be derived. Hence, Montenegro has yet exploited about 25% of its technical and 35% of its economic potential, respectively.

- **Serbia** has a technical hydropower potential of 4.7 GW (18.0 TWh/a) and an economic potential of 3.6 GW (14.5 TWh/a). Based on the installed hydropower capacity of 2.4 GW (10.0 TWh/a) in 2017 an additional cost-competitive potential of 1.2 GW (4.5 TWh/a) can be derived. Hence, Serbia has yet exploited about 50% of its technical and 70% of its economic potential, respectively.

## 3.2 2020 NREAP targets

In 2006, Albania, Bosnia and Herzegovina, FYR Macedonia, Montenegro and Serbia ratified the Treaty on establishing the Energy Community (EnC). As part of their obligations under the EnC the Western Balkan countries have committed themselves to increase the overall share of renewable energies – from country to country between 25% and 40% by 2020. In 2012 the Western Balkan countries also adopted the EU Renewable Energy Directive with binding renewable energy targets for 2020 and the obligation to submit a NREAP to further detail renewable energy targets. However, no long-term targets for renewable energies in general and/or hydropower in particular have been defined yet, i.e. the NREAPs provide the only consistent targets for the expansion of hydropower in the seven SEE countries covered in this study. Table 1 shows for each country (a) the NREAP targets for the expansion of hydropower (excl. pumped storage), (b) the installed hydropower capacity 2010, (c) the installed hydropower capacity 2017, (d) the capacity additions from 2010 to 2017 and (e) the remaining capacity gap to achieve NREAP targets for 2020.

**Table 1: NREAP 2020 targets for hydropower and installed hydropower capacity in MW**

| | NREAP target 2020 | Installed capacity 2010 | Installed capacity 2017 | Capacity additions 2010 - 2017 | Remaining capacity gap NREAP targets |
|---|---|---|---|---|---|
| Albania | 2,320 | 1,500 | 2,020 | 520 | 300 |
| BiH | 2,210 | 1,530 | 1,660 | 130 | 550 |
| Bulgaria | 2,420 | 2,120 | 2,340 | 220 | 80 |
| FYROM | 750 | 500 | 680 | 180 | 70 |
| Greece | 2,950 | 2,520 | 2,700 | 180 | 250 |
| Montenegro | 830 | 640 | 660 | 20 | 170 |
| Serbia | 2,660 | 2,220 | 2,380 | 160 | 280 |
| Total | 14,140 | 11,030 | 12,440 | 1,410 | 1,700 |

Source: ENTSO-E, AEA, NREAPs of countries

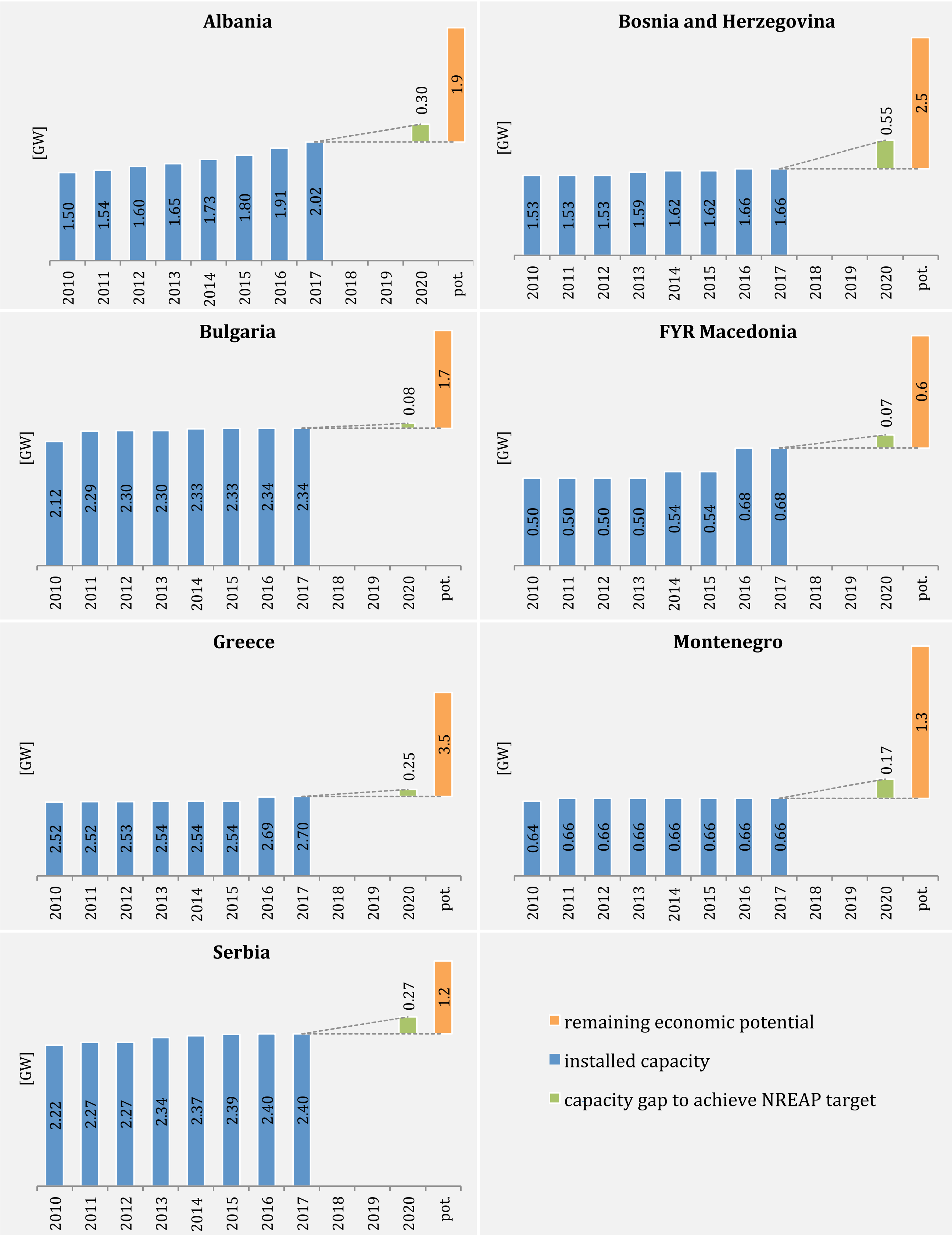
In addition, Fig. 13 provides an overview of the installed hydropower development between 2010 and 2017 and the additional capacity that would be required to achieve the 2020 NREAP targets. Fig. 13 also includes the remaining cost-competitive potentials.

All seven NREAPs sum up to an envisaged hydropower net capacity addition of about 3.1 GW between 2010 and 2020, which corresponds to a capacity increase of 28% compared to 2010. In total some 1.4 GW have already been implemented, i.e. an additional 1.7 GW of hydropower capacities would be required to meet overall NREAP targets. However, there are large differences between the individual countries in the progress of hydropower deployment.

If growth rates of the years 2010-2017 are taken into account Albania, Bulgaria and FYR Macedonia will likely meet their hydropower targets for 2020, while Greece and Serbia will need additional efforts if they want to reach their hydro specific 2020 NREAP targets. In contrast Bosnia and Herzegovina as well as Montenegro will hardly be able to meet their NREAP targets for hydropower. In the following a brief country specific summary about the extent to which objectives are being achieved is provided.

- **Albania's** NREAP defines a capacity target for hydropower of 2.32 GW by 2020 or an increase of 55% (0.82 GW) compared to 2010. Two third of the target has already been achieved by 2017, hence Albania is on a promising way to meet its 2020 targets for hydropower.
- **Bosnia and Herzegovina** has a 2020 NREAP target for hydropower excl. pump storage of 2.21 GW, i.e. an increase of 44% (0.68 GW) compared to 2010 would be required. However, only 0.13 GW of new hydropower capacity has been added in the past few years, which makes it very unlikely that Bosnia and Herzegovina will accomplish its 2020 objectives.
- **Bulgaria** defined a 2.42 GW NREAP target for hydropower in 2020, which corresponds to an increase of 14 (0.30 GW) compared to 2010. Between 2010 and 2017 already some 0.22 GW of new hydropower capacities were built, i.e. Bulgaria will probably meet its hydropower targets.
- **FYR Macedonia** included a hydropower target of 709 MW for 2020 in its NREAP. However, it seems that the NREAP confused 2019 and 2020 targets for hydropower >10 MW, since the official numbers for 2020 would lead to a decline of about 20 MW hydropower capacity from 2019 to 2020. Therefore, it can be assumed that the NREAP numbers for large hydropower in the years 2019 and 2020 are interchanged, i.e. the correct 2020 NREAP target for hydropower should probably be 750 and not 709 MW. Hence, compared to 2010 FYR Macedonia targets a hydropower capacity addition of 50% (0.25 GW) until 2020 of which 0.18 GW have already been implemented.
- **Greece** aims to achieve 2.95 GW of installed hydropower capacity by 2020, which corresponds to an increase of 17 (0.43 GW) compared to 2010. However, hydropower expansion has been implemented too slow so far (+0.18 GW between 2010 and 2017), which will make it difficult for Greece to meet its NREAP 2020 hydropower targets.
- **Montenegro** has a 2020 hydropower target in its NREAP of 0.83 GW. This represents an increase of 30% (0.19 GW) compared to 2010. However, between 2010 and 2017 only some 0.02 GW of new hydropower capacity was commissioned, i.e. Montenegro will likely miss its 2020 target for hydropower.
- **Serbia** defined a hydropower target of 2.66 GW in its NREAP for 2020, which corresponds to an increase of 20% (0.44 GW) compared to 2010. However, hydropower expansion at a level of the past growth rate of the past years (0.16 GW between 2010 and 2017) would not be sufficient to meet Serbia's NREAP targets for hydropower in 2020.

**Fig. 13: Hydropower capacity development 2010 - 2017, NREAP 2020 target and economic potential**




Source: IRENA, ENTSO-E, NREAPs of countries

## 3.3 Hydropower project pipeline

South-Eastern European countries and especially the Western Balkans still represent a significant portion of untapped hydropower potentials. Efforts to further exploit these potentials have been strengthened in recent years and hence, a few thousand new hydropower plants are in the project pipeline in the SEE region. EuroNatur and RiverWatch have been closely monitoring and reporting hydropower expansion activities in SEE countries[4] and provided an updated list of hydropower projects for the seven SEE countries covered in this study [19].

The EuroNatur/RiverWatch project list includes the name of the project, the affected river, the planned installed capacity (allocated to one of the four size categories 0.1-1 MW, 1-10 MW, 10-50 MW and >50 MW) and the project feasibility as result of an ecological classification by EuroNatur/RiverWatch (i.e. located in exclusion or non exclusion zones from EuroNatur/RiverWatch perspective). The EuroNatur/RiverWatch list considers in total 2,354 hydropower projects for the seven SEE countries. However, since sole pumped storage projects are not considered in this study three pumped storage projects are excluded for the further analysis. Hence, 2,351 projects from the EuroNatur/RiverWatch list remain relevant. Table 2 provides a country specific overview about the number of projects allocated to each size category.

With 842 projects more than one third of the considered projects are located in Serbia. Greece, Bulgaria and Bosnia and Herzegovina with a pipeline of each between 300 and 400 projects are already lagging behind Serbia but still have a considerable number of projects. Albania follows this group of countries with 252 projects. FYR Macedonia with 154 projects and Montenegro with 92 projects complete the seven SEE countries.

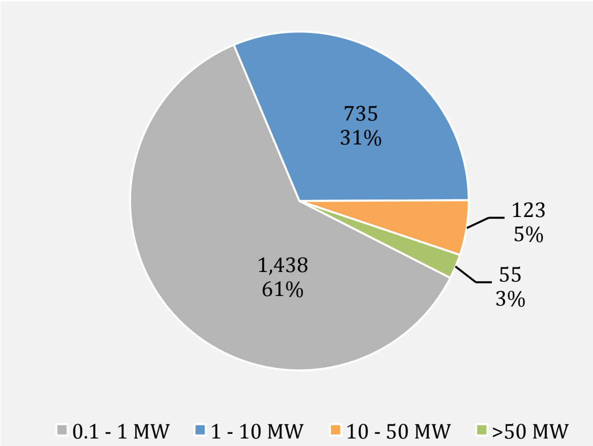
**Table 2: Hydropower projects covered by EuroNatur/RiverWatch project list**

| | 0.1 MW - 1 MW | 1 MW - 10 MW | 10 MW - 50 MW | > 50 MW | all projects |
|---|---|---|---|---|---|
| Albania | 112 | 106 | 24 | 10 | 252 |
| BiH | 84 | 159 | 49 | 13 | 305 |
| Bulgaria | 212 | 112 | 2 | 6 | 332 |
| FYROM | 88 | 48 | 13 | 5 | 154 |
| Greece | 226 | 142 | 6 | 0 | 374 |
| Montenegro | 13 | 58 | 11 | 10 | 92 |
| Serbia | 703 | 110 | 18 | 11 | 842 |
| Total | 1,438 | 735 | 123 | 55 | 2,351 |

Source: EuroNatur/RiverWatch

About 92% of all considered projects are small hydropower plants below 10 MW and two third are even below 1 MW. Therefore large hydropower plants (i.e. above 10 MW) only contribute 8% or 173 projects to the overall project list. Fig. 14 shows the number of hydropower projects allocated to the four size categories for all seven SEE countries.

**Fig. 14: Hydropower projects per size category EuroNatur/RiverWatch project list**




Source: EuroNatur/RiverWatch

[4] e.g.. https://riverwatch.eu/de/balkanrivers/map

However, even if the number of small and especially very small hydropower plants is very high they may only have a limited contribution to the overall installed capacity and annual generation, respectively. Since the EuroNatur/RiverWatch list does only provide the size category but no specific data about the installed capacity and annual generation (so called standard capacity) of the projects these data are estimated according to the following approach:

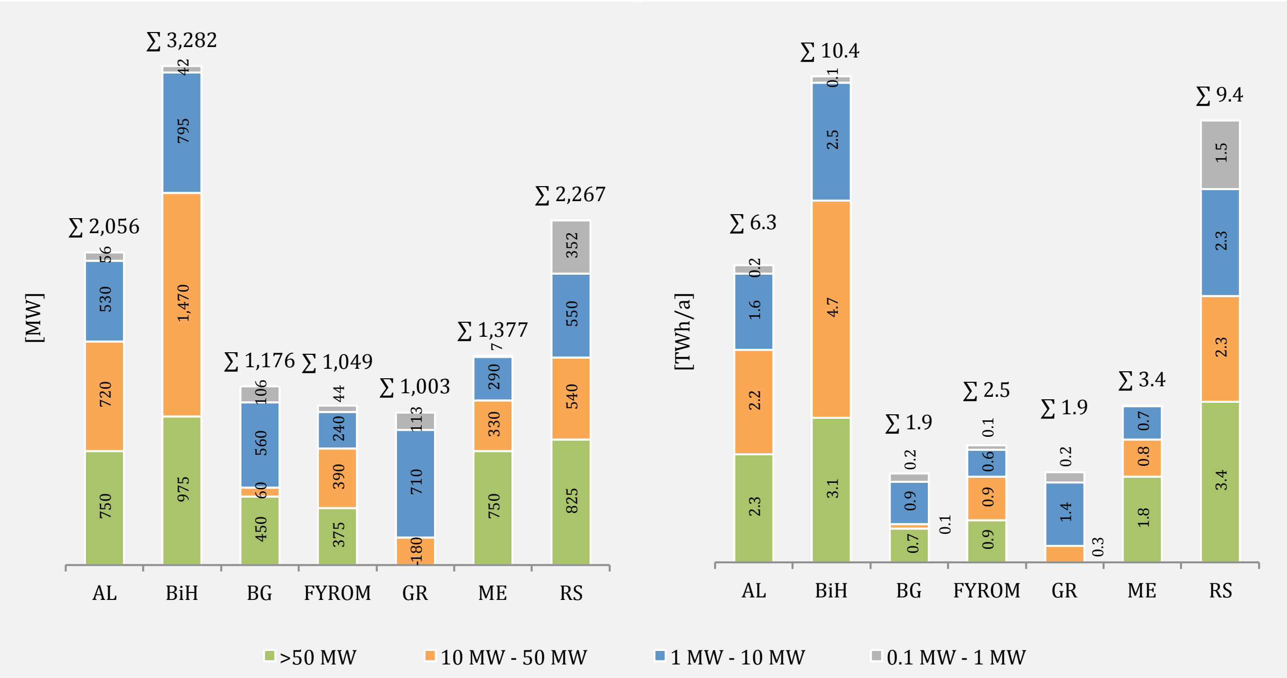
– The installed hydropower capacity is assumed to be 0.5 MW for projects allocated to the category 0.1-1 MW, 5 MW for projects of the category 1-10 MW, 30 MW for projects of the category 10-50 MW and 75 MW for projects of the category above 50 MW.

– The annual generation is calculated from the estimated capacity and the average country specific full load hours of hydropower plants of the years 2011-2017.

For an individual project this approach potentially delivers a deviation from the actual capacity and generation, respectively. However, this study is not focused on the evaluation of individual projects but rather on the assessment of country specific project portfolios, for which this approach certainly provides sufficient accuracy.

In total the EuroNatur/RiverWatch list comprises hydropower projects with some 12.2 GW of installed capacity and 35.9 TWh/a of annual generation. Fig. 15 provides a more detailed breakdown of project capacities and generation between countries as well as size categories. Projects in Bosnia and Herzegovina, Serbia and Albania contribute together 62% of the capacity and 73% of the generation, respectively. The reason for the noticeable higher share in the projects' total generation is because average full load hours in the three countries have been significantly above full load hours in Bulgaria, Greece, FYR Macedonia and Montenegro, i.e. one MW of newly installed hydropower capacity would potentially produce more MWh per year in this three countries.

**Fig. 15: Capacity (left) and annual generation (right) of hydropower project portfolios EuroNatur/RiverWatch project list**



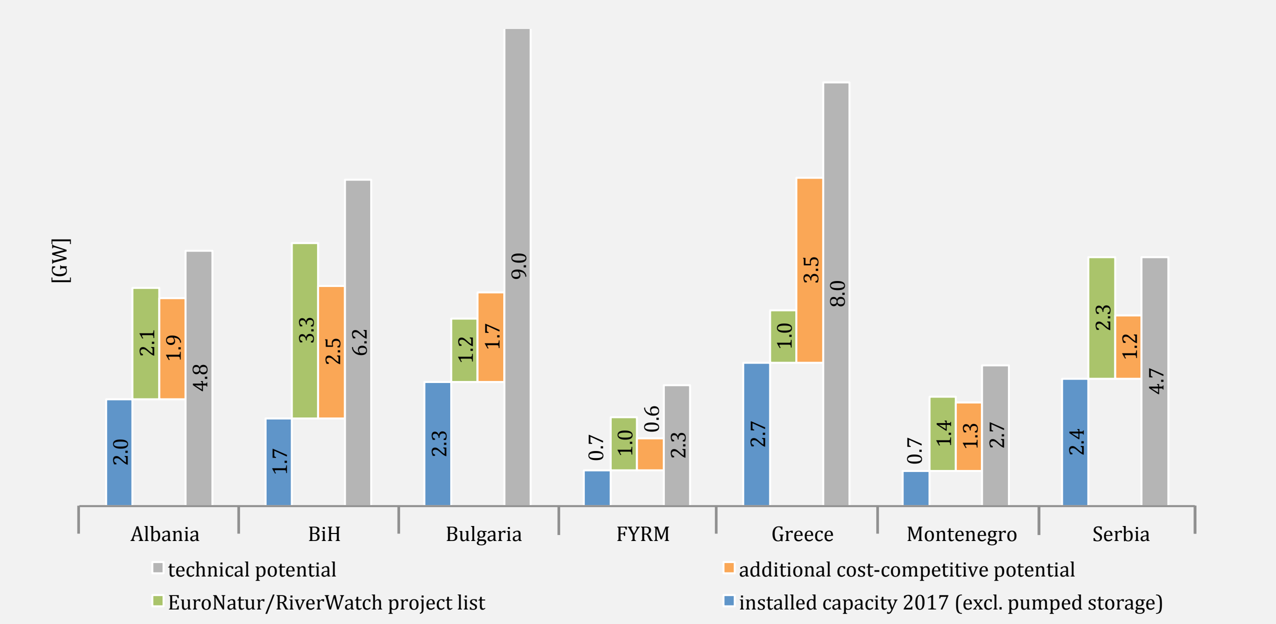

Source: EuroNatur/RiverWatch

With regard to size categories it is especially noticeable that large hydropower plants provide 2/3 of the capacity and generation, respectively. Small hydropower, which represents 92% of the projects, delivers 1/3 of the capacity and generation, i.e. the number of plant and contribution to the electricity system of large and small hydropower are exactly opposite to each other.

Compared to the already installed capacity of 12.5 GW (excl. pumped storage) and the average generation of about 34 TWh/a the announced projects would double the use of hydropower in the seven SEE countries. However, the ratio between the already installed capacities and capacities based on EuroNatur/RiverWatch project list differs widely among countries and in most countries the cumulated capacity of all projects even exceeds economic hydropower potentials. This is shown in Fig. 16 that compares on a country-by-country level the total capacity of the projects to the already installed capacity as well as the additional cost-competitive or economic and the technical potential.

- **Albania:** Projects sum up to an installed capacity of 2.1 GW and an annual generation of 6.3 TWh/a, respectively, i.e. they would double today's hydropower capacities. Even if this number is slightly above the additional cost-competitive potential of 1.9 GW, the project pipeline plausibly reflects from an energy economic point of view Albania's options for the expansion of hydropower.
- **Bosnia and Herzegovina:** The project pipeline of 3.3 GW (10.4 TWh/a) would triple the country's actual hydropower generation. However, the cumulated capacity of all projects exceeds the economic potential by about 30%. Hence, it seems that economic aspects have not been sufficiently considered in all projects yet, i.e. it can be expected that a number of projects will not be pursued unless e.g. additional subsidies compensate the economic unattractiveness of these projects.

**Fig. 16: Capacity of hydropower projects EuroNatur/RiverWatch list compared to installed capacity 2017, additional cost-competitive and technical potential**




Source: EuroNatur/RiverWatch, IRENA, IHA

- **Bulgaria:** Projects considered by EuroNatur/RiverWatch account for a capacity of 1.2 GW and an annual generation of 1.9 TWh/a, respectively, i.e. they would increase the use of hydropower by about 50%. Taking the economic potential of 1.7 GW into account the project pipeline plausibly reflects Bulgaria's options to further expand the use of hydropower.

- **FYR Macedonia:** The project pipeline of 1.0 GW (2.5 TWh/a) would not only increase the country's use of hydropower by about 140% but would also exceed the economic potential, which is about 0.6 GW. However, the country has an additional available technical potential of 1.6 GW, i.e. the site conditions would in principle allow the implementation of the announced projects if economic boundary conditions were reasonable.

- **Greece:** The projects would deliver a capacity of 1.0 GW (1.9 TWh/a) and correspond to about one third of the currently installed capacity. Since the project pipeline is well below the additional economic potential of 3.5 GW, the pipeline is inline with the fundamental possibilities to expand the use of hydropower in Greece from an energy economic perspective.

- **Montenegro:** The country's project pipeline of 1.4 GW (3.4 TWh/a) would not only double the use of hydropower but also slightly exceed the economic potential of 1.3 GW. However, with a remaining technical potential of some 2.0 GW the implementation of the already announces projects would in principle be possible even if the project pipeline seems to be quite ambitious.

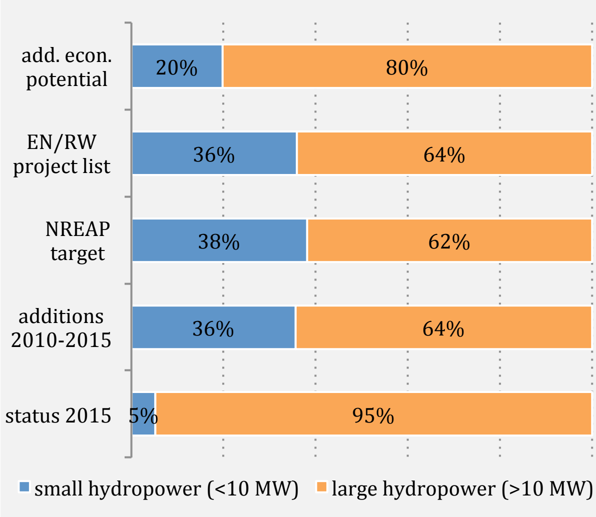
- **Serbia:** With a project pipeline of 2.3 GW (9.4 TWh/a) Serbia would almost double its use of hydropower. However, the announced projects would not only exceed the economic potential of 1.2 GW by far but would also require the full exploitation of the technical potential. This seems to be rather ambitious.

## 3.4 A glance at small hydropower

While large hydropower (i.e. installed capacity above 10 MW) is a well-established technology in the SEE region, small hydropower (<10 MW) has emerged only in the last few years. Hence, large hydropower still represents 95% of the installed hydropower capacities in the seven SEE countries that are covered in this study. In contrast, small hydropower represents 92% of the number of projects of the EuroNatur/RiverWatch list and 1/3 of the capacity and annual generation, respectively. This mismatch between the number and quantitative contribution of projects is even larger for (very) small hydropower projects below 1 MW, which represent 61% of the number of projects in the seven SEE countries but only provide 6% of the capacity and annual generation.

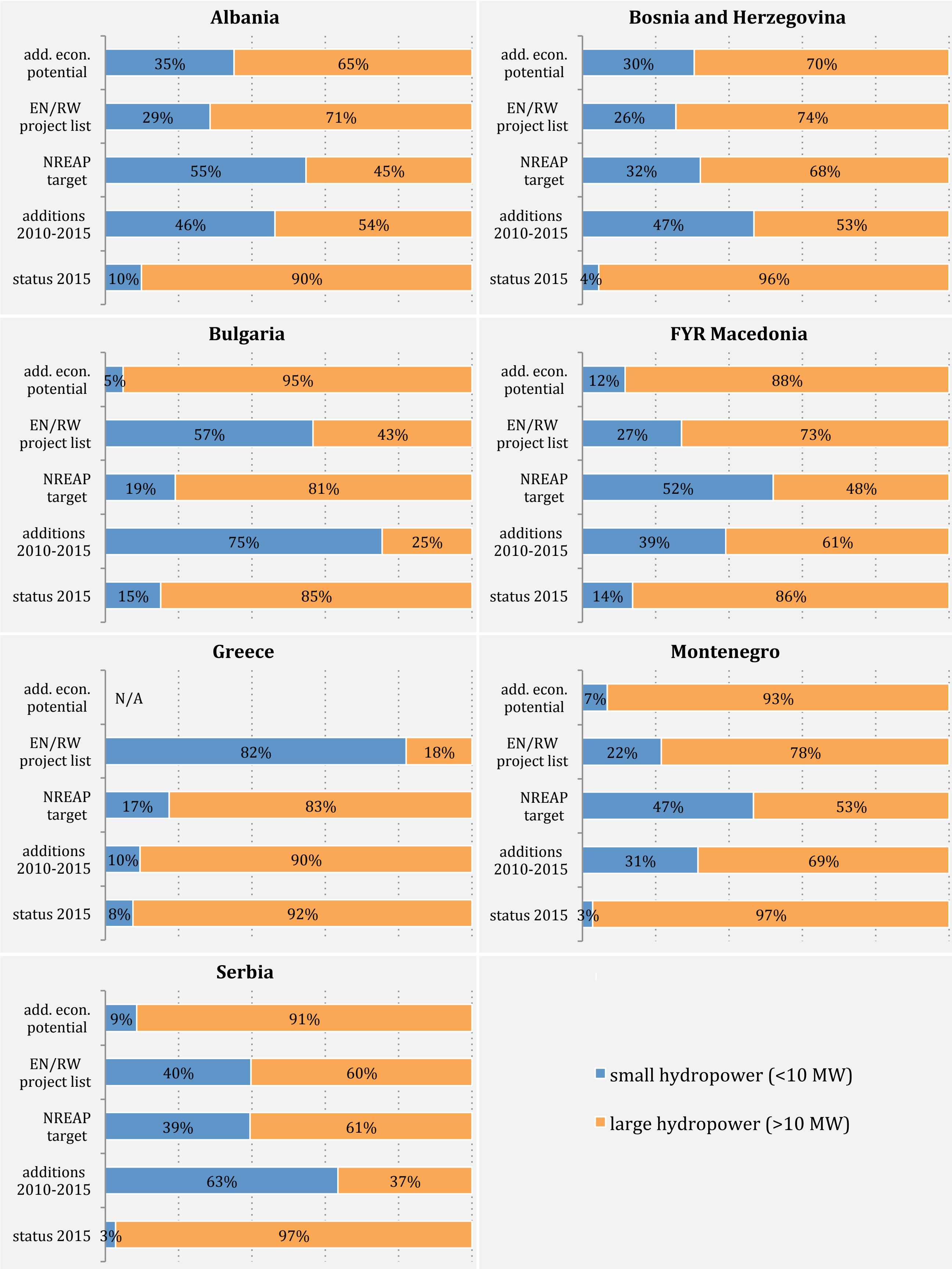
Fig. 17 gives an overview of the share of small and large hydropower for all seven SEE countries for (a) the existing hydropower plants, (b) the capacity additions between 2010 and 2015, (c) the NREAP targets, (d) the EuroNatur/RiverWatch (EN/RW) project list and (e) the additional economic or cost-competitive potential – a country specific analysis is provided in Fig. 18.

**Fig. 17: Share of small and large hydropower in installed capacity in all seven SEE countries**




Source: IRENA, ENTSO-E, NREAPs of countries, EuroNatur/RiverWatch

**Fig. 18: Share of small and large hydropower in installed capacity**




Source: IRENA, ENTSO-E, NREAPs of countries, EuroNatur/RiverWatch

In 2015 only 5% of the installed hydropower capacity in the seven SEE countries was provided by small hydropower. However, the NREAP targets of all seven SEE countries have put a strong focus on small hydropower, 38% of the total 3.1 GW hydropower targets between 2010 and 2020 is allocated to small hydropower. The NREAP targets are already reflected in the capacity additions between 2010 and 2015, where small hydropower contributed about 36% to the total new hydropower capacities of 1.1 GW. By chance, this is the same percentage of the share of small hydropower as it can be derived for the actual project portfolio from the EuroNatur/RiverWatch list. Though, on country level significant differences can be identified with regard to the development of small hydropower:

– NREAP 2020 targets for small hydropower are between 17% (Greece) and 55% (Albania) of the total national hydropower capacity targets.

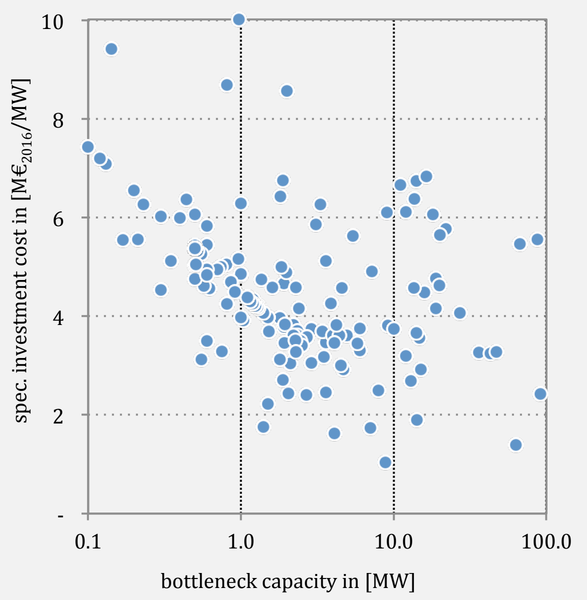
– In the EuroNatur/RiverWatch project list the share of small hydropower ranges between 22% in Montenegro and 82% in Greece.

– The share of small hydropower in capacity additions of the years 2010-2015 varies between 10% in Greece and 75% in Bulgaria.

However, the relatively strong focus of the countries' hydropower strategies on small hydropower is not necessarily reflected in the economic potentials. For example, the IRENA report about cost-competitive renewables potential across South-East Europe shows on average a 20% share of small hydropower in the total economic hydropower potentials [11][5]. On a country level this share ranges between 5% in Bulgaria and 35% in Albania, i.e. from an economic perspective small hydropower seems to be overrepresented in most of the seven SEE country's renewables strategies.

The comparatively low share of small hydropower in the economic potentials is quite comprehensible because specific investment costs of small hydropower plants are in general higher than specific investment costs of large(er) hydropower plants. Since there are no consistent numbers for the investment costs of hydropower plants in SEE countries available the following Fig. 19 shows as an example the results of an economic analysis that was conducted for 159 Austrian run-of river power plants and projects, respectively, in the year 2016 [20].

**Fig. 19: Specific investment costs of run-of river power plants in Austria**




Source: e3 consult

The 159 hydropower plants considered in the analysis had been either put in operation since 2009 or were under construction and in an advanced planning stage, respectively. The study showed that the capacity weighted average of the investment costs was 4.0 Million Euros per MW. Although the results didn't show a clear correlation between installed capacity and specific investment cost the study concluded that small hydropower plants below 2 MW typically have the highest specific investment costs, whereas the most attractive hydropower plants in Austria were in the range between about 5 and

[5] W/o Greece, which is not considered in the IRENA report.

10 MW. Even if these results cannot be directly transferred to the seven SEE countries, they provide at least a strong indication that very small hydropower plants are from an economic perspective the least favourable hydropower option. Hence, very small hydropower plants would require more subsidies per MW and MWh, respectively, to provide potential investors a viable business case.

However, beside possible economic issues small hydropower plants may also have disadvantages in terms of grid connection compared to large hydropower. For example, the final report of the study *Regional Strategy for Sustainable Hydropower in the Western Balkans* [21] stated "[…] the capacity of the distribution networks in the region is insufficient to facilitate growing demand for connection of new small HPPs and distributed generation in general". On the other hand the study also concluded: "The capacity of the transmission grid, if observed from the regional level, seems to be sufficient to facilitate any additional major planned HPP development projects." Hence, at least for the foreseeable future the grid connection of additional large hydropower capacities seem easier to implement than the grid connection of the same capacities from small hydropower.

# 4 Feasibility of hydropower projects according to EuroNatur/River-Watch criteria

The efforts of most countries to further exploit the remaining hydropower potentials is impressively shown in the EuroNatur/RiverWatch project list with a total number of 2,351 projects (excl. pumped-storage) for the seven SEE countries considered in this study. However, the expansion of hydropower has also caused increasing environmental concerns because new hydropower plants primarily affect river stretches with a high ecological value. Hence, EuroNatur/RiverWatch applied an ecological evaluation to 2,351 hydropower projects to classify the feasibility of the projects from EuroNatur/RiverWatch perspective located in exclusion or non-exclusion zones. Based on the ecological classification of projects this chapter assesses the effects of the EuroNatur/RiverWatch classification on the further development of hydropower in the seven SEE countries. Additionally, it is evaluated if other renewable energy sources, such as wind and solar PV, would be able to substitute “exclusion” projects.

## 4.1 Ecological classification of hydropower projects

EuroNatur/RiverWatch provided a classification of all projects considered in its project list either as located in an exclusion zone or in a non-exclusion zone [19], i.e. the assessment reflects EuroNatur/RiverWatch’s perspective of the ecological feasibility of a project. Table 3 provides this differentiation between projects in “non-exclusion” and “exclusion” zones of the EuroNatur/RiverWatch project list.

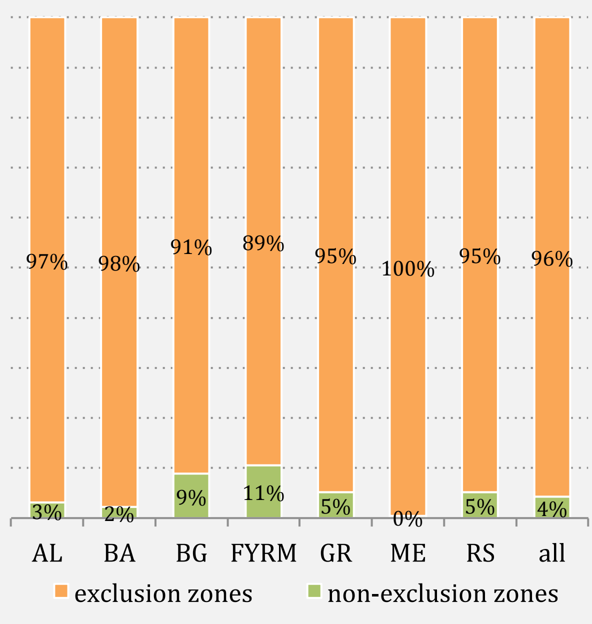
In total 198 or 8.5% of the projects are classified as “non-excluded”, i.e. could be ecologically feasible according to the criteria applied by EuroNatur/RiverWatch. However, since only 7 large hydropower projects are classified as ecologically feasible a mere of 4% or 531 MW of the installed capacity of all projects (12,210 MW) is allocated to projects in non-exclusion zones. This is also shown in Fig. 20 that presents the share of “exclusion” and “non-exclusion” projects in the total installed capacity of the projects on a country as well as an overall region level. As a result the capacity of projects that are located in non-exclusion zones range between almost 0% in Montenegro, where only two small hydropower projects are classified as feasible, and 11% in FYR Macedonia.

**Table 3: Number of hydropower projects classified in “exclusion” and “non-exclusion” by EuroNatur/RiverWatch**

| Country | EuroNatur classification | 0.1 MW - 1 MW | 1 MW - 10 MW | 10 MW - 50 MW | > 50 MW | all projects | | |
|---|---|---|---|---|---|---|---|---|
| | | [-] | [-] | [-] | [-] | [-] | [MW] | [TWh/a] |
| AL | non-excl. | 9 | 0 | 2 | 0 | 11 | 65 | 0.2 |
| | excl. | 103 | 106 | 22 | 10 | 241 | 1,992 | 6.1 |
| BiH | non-excl. | 8 | 2 | 2 | 0 | 12 | 74 | 0.2 |
| | excl. | 76 | 157 | 47 | 13 | 293 | 3,208 | 1.2 |
| BG | non-excl. | 30 | 18 | 0 | 0 | 48 | 105 | 0.2 |
| | excl. | 182 | 94 | 2 | 6 | 284 | 1,071 | 1.7 |
| FYROM | non-excl. | 12 | 0 | 1 | 1 | 14 | 111 | 0.3 |
| | excl. | 76 | 48 | 12 | 4 | 140 | 938 | 2.2 |
| GR | non-excl. | 15 | 9 | 0 | 0 | 24 | 53 | 0.1 |
| | excl. | 211 | 133 | 6 | 0 | 350 | 951 | 1.8 |
| ME | non-excl. | 1 | 1 | 0 | 0 | 2 | 6 | 0.0 |
| | excl. | 12 | 57 | 11 | 10 | 90 | 1,371 | 3.3 |
| RS | non-excl. | 76 | 10 | 1 | 0 | 87 | 118 | 0.5 |
| | excl. | 627 | 100 | 17 | 11 | 755 | 2,149 | 9.0 |
| Total | non-excl. | 151 | 40 | 6 | 1 | 198 | 531 | 1.5 |
| | excl. | 1,287 | 695 | 117 | 54 | 2,153 | 11,679 | 34.4 |

Source: EuroNatur/RiverWatch

**Fig. 20: Share of projects in exclusion and non-exclusion zones in total capacity of EuroNatur/RiverWatch project list**



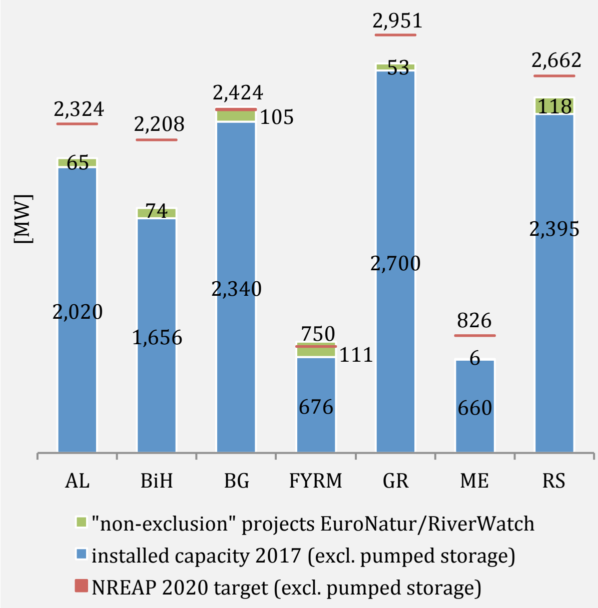

Source: EuroNatur/RiverWatch

## 4.2 Effects on overall hydropower development

Potentially feasible projects in EuroNatur/RiverWatch non-exclusion zones represent in total a capacity of 531 MW and an annual generation of 1.5 TWh/a for all seven SEE countries. Compared to the output of the existing fleet of hydropower plants this would correspond to an increase in capacity and generation, respectively, of about 4%. Hence, without considering any refurbishment measures or capacity increases in existing hydropower plants the EuroNatur/RiverWatch assessment of the ecological feasibility of hydropower projects would de facto stop any further development of hydropower in the seven SEE countries.

As a consequence, most of the seven countries would not be able to meet their NREAP hydropower targets – not to mention any hydropower target beyond 2020. Only in Bulgaria and FYR Macedonia sufficient projects in non-exclusion zones would be available that 2020 NREAP targets for hydropower could theoretically be met. This is shown in Fig. 21 that depicts the installed hydropower capacity in the year 2017, the capacity of "non-exclusion" projects and the hydropower targets for 2020 as derived from the national NREAPs. One can clearly see that feasible projects would only provide very limited new hydropower capacities to the already installed capacities in the seven SEE countries and for most countries a significant gap between NREAP target and the feasible project pipeline would remain.

**Fig. 21: Installed hydropower capacity 2017, capacity additions EuroNatur/RiverWatch project list and NREAP targets**



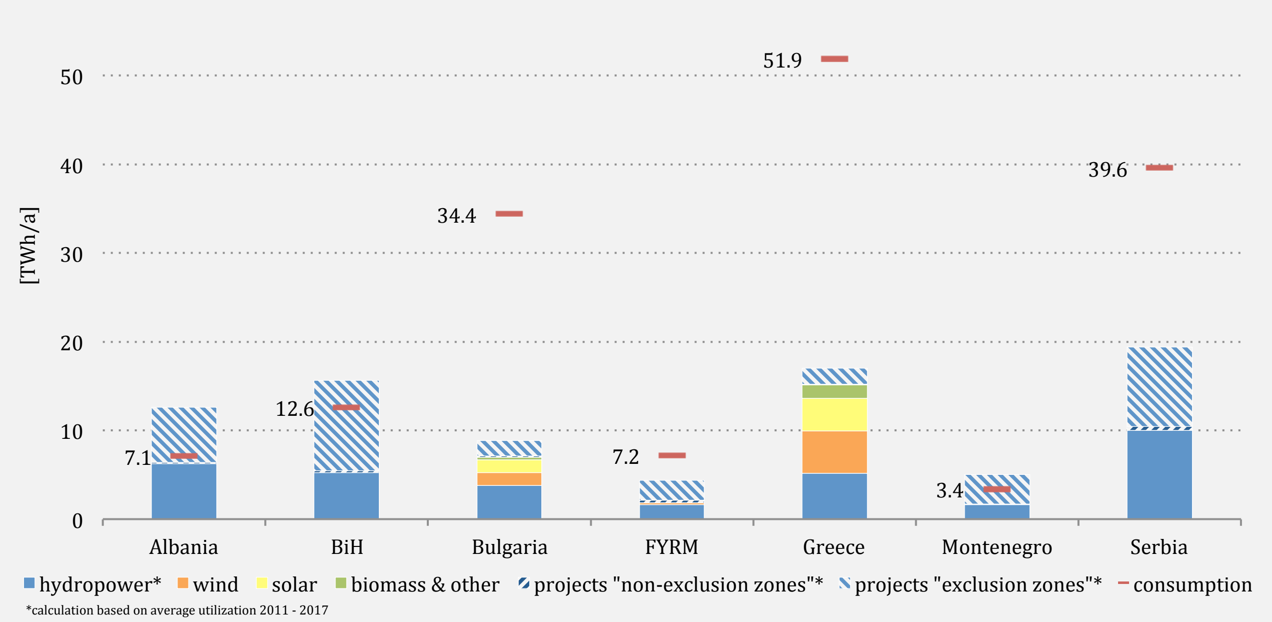

Source: ENTSO-E, EuroNatur/RiverWatch, NREAPs of countries

However, even if hydropower plays the most important role in the short-term renewable energy targets in all of the seven countries except Bulgaria and Greece hydropower will not be enough to put the SEE region on track towards a low-carbon electricity system. In the last seven years the share of hydropower in the total electricity consumption of the seven SEE countries was in a range between 16% and 25%. Even if an implementation of all projects from the EuroNatur/RiverWatch list would double the share of hydropower in the seven SEE countries other renewable energy sources would still need to provide the majority of green electricity if the electricity sector were decarbonized. At national level there are certainly some differences, i.e. in Albania, Bosnia and Herzegovina and Montenegro the potential additional generation of the projects would allow at least on an average annual basis a 100% supply of the countries with electricity from hydropower.

In contrast, for Bulgaria, FYR Macedonia, Greece and Serbia the listed projects would only provide a limited contribution to close the gap between a supply with electricity from mainly renewable energies and the consumption. In Fig. 22 this situation is shown for the seven SEE countries by means of the generation from renewable energies and the electricity consumption in 2017. Additionally, the potential generation from "non-exclusion" and "exclusion" projects according to the EuroNatur/RiverWatch project list is represented in Fig. 22 (note that the bar of projects located in non-exclusion zones is comparatively narrow for most countries and therefore difficult to see). However, it should be noted that the seasonal and yearly fluctuations of electricity generation from hydropower would in most cases require other technologies and/or a strongly interconnected power system to provide sufficient reserve capacity and complementary generation, respectively, in case of low water levels. This means that a generation portfolio that only relies on a single technology (i.e. hydropower without major seasonal storage as for example in Norway) could not be considered as a robust generation portfolio from a security of supply perspective. Therefore the expansion of wind, solar PV and biomass in the SEE region may not only be considered as "the second best renewable option" in the case of limited remaining hydropower potentials but as a reasonable contribution to a robust low-carbon generation portfolio.

Consequently, a smaller than generally anticipated expansion of hydropower would not necessarily have a negative impact on the development of a generation portfolio based on renewable energies. However, the development of a robust low-carbon portfolio that equally considers environmental, economic and security of supply aspects would require a more detailed analysis. The existing stock of hydropower plants in the SEE region provides in any case a very good starting position for such a diversified portfolio.

**Fig. 22: Electricity generation from renewables and share of renewable energies in total electricity consumption 2017 as well as annual generation of projects in exclusion and non-exclusion zones**




Source: ENTSO-E; EIA, AKOB and AEA for Albania, EuroNatur/RiverWatch

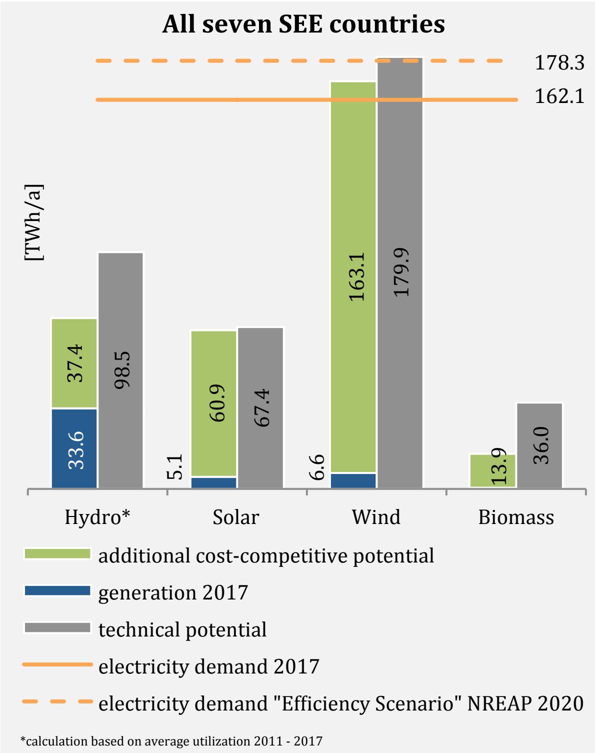
## 4.3 Alternative renewable energy sources

The EuroNatur/RiverWatch classification of hydropower projects would de facto mean the end for the further expansion of the use of hydropower in the SEE region. Hence, other alternative renewable energy sources, namely wind, solar PV and biomass, would need to substitute the not realized hydropower generation if renewable targets remained unchanged. However, for such a shift from hydropower to other renewable energy sources their potentials would need to be enough to provide the additionally required capacities.

In this context it can again be referred to the IRENA report on cost-competitive renewables potential across South-East Europe. Even if renewables potentials may differ between individual publications the IRENA report provides at least a consistent set of economic and technical potentials of hydropower, wind, solar PV, biomass and geothermal for all countries covered in this study except Greece [11]. Correspondingly, economic or additional cost-competitive potentials of wind, solar and biomass for Greece were derived from other sources ([22] and [23]). Furthermore the IRENA report defines different scenarios to assess the cost-competitive or economic potentials to consider uncertainties about today's and future capital costs as well as expected investment cost reduction of renewables in the future. Except for hydropower, the report provides a bandwidth of economic potentials for the years 2016, 2030 and 2050. However, for simplicity a conservative approach was applied, i.e. in the following only the average of the bandwidth of the cost-competitive potentials in the year 2030 is taken into account. Hence, it can be expected that in a long-term perspective (>2030) the economic potentials of especially wind and solar PV will be higher.[6]

Fig. 23 depicts the additional cost-competitive and technical potential for hydropower, wind, solar PV and biomass for all seven SEE countries – Fig. 24 provides the same information on a country level. Additionally, the electricity generation and demand in 2017 as well as the projected demand in 2020 ("efficiency scenario" from the country's NREAP[7]) are shown in both figures as a benchmark. Please note that for Greece no up-to-date technical potentials of wind, solar and biomass are available. Hence, for a complete picture of all seven countries as shown in Fig. 23 it is assumed that the technical potentials of wind, solar and biomass approximately correspond to the economic potentials.

**Fig. 23: Generation from renewables, electricity demand and potentials of renewable energy sources for all seven SEE countries**




Source: IRENA, ENTSO-E, Dii, NREAPs of countries

[6] For a general definition of renewable potentials please refer to section 3.1Technical and economic hydropower potentials.

[7] The NREAPs consider two scenarios for the development of the energy demand - the "reference scenario" and "efficiency scenario". The "reference scenario" takes the energy efficiency and energy saving measures into account that have already been implemented before 2009 (i.e. business as usual). In contrast, the "efficiency scenario" considers additional measures to be adopted after 2009 in order to improve the energy efficiency.

**Fig. 24: Country specific generation from renewables, electricity demand and potentials of renewable energy sources**


Source: IRENA, ENTSO-E, Dii, NREAPs of countries

- **Albania:** The already installed hydropower capacities with an average output of 6.2 TWh/a can serve about 90% of the country's actual electricity demand, i.e. the remaining economic hydropower potentials of 7.0 TWh/a would not only allow Albania to serve its demand growth with additional hydropower capacities but also to become a net exporter of electricity. However, the strong fluctuations of annual hydropower generation in the past years have proven the vulnerability of a power system that only relies on one technology. Hence, even without a consideration of ecological aspects for an expansion of hydropower – as for example proposed by EuroNatur/RiverWatch – a much stronger focus on other technologies is highly recommended from an energy economic point of view in order to diversify Albania's generation portfolio. Since the country has considerable solar, wind and biomass potentials of in total almost 20 TWh/a Albania could perfectly diversify its existing hydropower portfolio with other renewable technologies and hence, maintain its position as the only country with a carbon free power generation fleet in the SEE region. However, the attractive potentials of other renewable energy sources have yet neither been reflected in the installed generation capacity nor in the country's renewable targets. Albania's NREAP only considers 40 MW of non-hydro renewables of which none has been implemented so far. Though, the Ministry of Infrastructure and Energy recently launched the selection process for the development and construction of the largest solar PV plant in the region with an installed capacity of 50 MW [6].
- **Bosnia and Herzegovina:** Hydropower covers currently about 40% of the country's electricity demand of 12.6 TWh/a and the economic hydropower potential of 9.4 TWh/a would in principle provide the remaining 60% of the actual electricity demand plus an additional potential for a demand growth of about 15%. However, due to the unavoidable seasonal and yearly fluctuations such a "full supply" with electricity from hydropower would only be possible on an annual basis if water supply were on or above average. Hence, from a portfolio perspective additional hydropower capacities without storage options (i.e. reservoirs) may only deliver a limited contribution to the country's security of supply. Since Bosnia and Herzegovina has not only considerable hydropower but also a combined solar, wind and biomass potential of about 30 TWh/a the power generation of projects that are located in exclusion zones as defined by EuroNatur/RiverWatch (1.2 TWh/a) could in principle be substituted by other renewable technologies. This would not only allow that the overall renewable targets are met even without any major hydropower additions but would also further diversify the existing generation portfolio. However, even if the attractive potentials of other renewable energy sources are to some extend included in the country's NREAP targets the actual expansion of renewable energies in the electricity sector is still solely focused on hydropower, since only a small portion of no non-hydro renewables has been implemented so far.
- **Bulgaria:** With an average annual generation of 3.8 TWh/a hydropower provides about 10% of the electricity demand of 34.4 TWh/a. Even if the country still has a considerable remaining economic potential of 4.8 TWh/a hydropower alone would by far not be able to accomplish an energy transition in Bulgaria. Hence, the country has already experienced an emerging trend towards solar PV, wind and biomass with a combined generation of 3.2 TWh/a in 2017. Furthermore, the available additional potentials of these technologies are very promising (>50 TWh/a), i.e. the country's renewable targets could in principle be

achieved if hydropower projects that are situated in EuroNatur/RiverWatch exclusion zones (1.7 TWh/a) were not implemented.

- **FYR Macedonia:** With an average output of 1.6 TWh the installed hydropower capacities provide about 20% of the actual electricity demand of 7.2 TWh/a. Even if the remaining economic potential of 2.1 TWh/a would in principle increase the share of hydropower in the domestic demand to about 50% a significant expansion of other renewable energy sources would be required in the long run to further decarbonize the country's generation system. The economic potential of wind and solar of together about 8 TWh/a is in principle sufficient to deliver the required additional renewable generation for a fossil free electricity system in FYR Macedonia. However, it would be challenging if wind and solar additionally had to substitute EuroNatur/RiverWatch's "exclusion" projects of 2.2 TWh/a. This would especially be the case if demand increased as assumed in the FYR Macedonia's NREAP scenarios. However, the country's expectation for electricity demand growth seems to be quite progressive, i.e. the country should in principle be able to achieve a carbon free generation based on domestic renewable energy sources.

- **Greece:** Hydropower provides currently 5.2 TWh/a or about 10% of the overall Greek electricity demand of some 58 TWh/a (interconnected system and NIIs )[8]. Even if Greece has a considerable additional economic hydropower potential of 6.8 TWh/a, the country will strongly depend on other renewable sources to provide the required contribution to the EU energy and climate targets. Though, Greece has already experienced a remarkable trend towards solar PV, wind and to some extend biomass. The so-called new renewables currently deliver an annual generation of about 8.8 TWh/a and thus already significantly more than hydropower. However, the remaining potentials of domestic renewable energy sources of about 50 TWh/a would only allow a complete substitution of fossil generation if the further demand growth can be limited. In this context the possible contribution of hydropower projects that are located in EuroNatur/RiverWatch exclusion zones (1.8 TWh/a) would be rather limited.

- **Montenegro:** Hydropower covers currently about 50% of the country's electricity demand of 3.4 TWh/a. Montenegro has a remaining economic hydropower potential of 2.9 TWh/a that would allow in principle the full coverage of the actual demand and in addition a demand growth of about 30%. However, as already discussed for Albania and Bosnia and Herzegovina the unavoidable seasonal and yearly fluctuations of water levels in the rivers would only allow a full supply based hydropower on an annual basis and not throughout the whole year. Hence, from a portfolio perspective additional hydropower capacities without storage options (i.e. reservoirs) may only deliver a limited contribution to the country's security of supply. Since Montenegro has not only a considerable hydropower but also a combined solar, wind and biomass potential of about 7 TWh/a sufficient non-hydro resources are in principle available to significantly increase the share of renewable energies in the Montenegrin electricity system and hence, to diversify the generation portfolio. Furthermore wind and solar potentials would in principle allow the substitution of hydropower projects that are located in EuroNatur/RiverWatch exclusion zones (3.3 TWh/a). Montenegro has already started to exploit its wind potentials but will likely not meet its NREAP targets for non-hydro renewa-

[8] ENTSO-E publishes data for the interconnected Greek electricity system but does not cover the non-interconnected islands (NIIs). The electricity demand of the interconnected system in 2017 was about 52 TWh/a [5] and of NIIs in 2016 about 5,6 TWh/a [24].

bles of about 0.5 TWh/a (90 MW) in 2020. Hence, the attractive potentials of wind and solar could be put even more in the focus of the country's energy policy.

- **Serbia:** With an average annual generation of 10.0 TWh/a hydropower provides about 25% of the electricity demand of 39.6 TWh/a. Even if the country still has some attractive economic potentials of 4.5 TWh/a, hydropower would by far not be able to accomplish an energy transition in Serbia. However, wind, solar and biomass have in total an economic potential of 60 TWh/a, i.e. in principle it would be possible to fully decarbonize the country's power sector with domestic renewable energy sources. In this context wind, solar and biomass potentials would also be sufficient to compensate the potential generation of 2.1 TWh/a of those hydropower projects that are located in exclusion zones as defined by EuroNatur/RiverWatch. However, the required development of non-hydro renewables has just been started, even if Serbia's NREAP targets would foresee an expansion of wind, solar and biomass to almost 2.0 TWh/a (650 MW) by 2020.

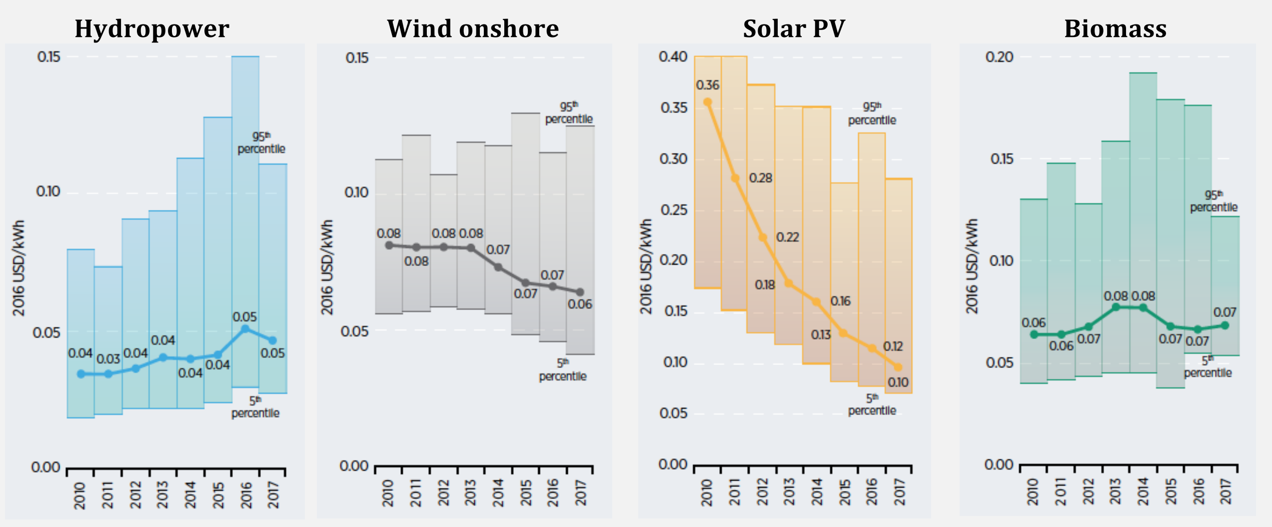
In total, the seven countries covered in this study have a technical potential of wind, solar PV and biomass of almost 300 TWh/a and an economic potential of about 240 TWh/a. This potential does not only significantly exceed the remaining economic hydropower potential of 37 TWh/a but also exceeds the current electricity demand of all countries that is not yet covered by renewable by a factor of 2. Hence, the region would in principle have sufficient non-hydro renewable potentials for a sustainable transformation of the electricity sector. Though, non-hydro renewables have only been playing in Bulgaria and Greece a relevant role so far. The other five SEE countries are either not on track with their non-hydro NREAP targets or have even not adequately considered wind, solar and biomass in their energy policies so far.

It is notable that the power sector in the Western Balkan countries has been suffering not only from comparatively high **grid losses** due to an inefficient transmission and distribution grid but mainly due to non-technical losses from power thefts and non-collections (e.g. [25]). Hence, to address these issues the governments has launched energy sector reforms, which have already significantly reduced technical and commercial grid losses in the Western Balkan. However, compared to other European countries losses are still high and additional measures will need to be implemented to further increase the sector's efficiency and hence reduce the need to exploit the still available but limited hydropower potentials.

However, besides the question of sufficient potentials a stronger shift of energy policies from hydropower to other renewable energy technologies would also have to be evaluated in terms of its effects on e.g. security of supply, grid integration and the overall costs of energy transition. Especially **security of supply** can become a major issue if seasonal fluctuations of hydropower and the relatively large year-to-year differences of hydropower's capacity factor (i.e. full load hours) threaten a 24/7 electricity supply. Additional hydropower capacities without storage options (i.e. reservoirs) may only deliver a limited contribution to the country's security of supply, if the generation pattern does not significantly differ from the existing power plants (which is typically not the case). Hence, a stronger focus on alternative renewable technologies would not only relief some pressure from so far untouched river stretches but would also diversify the regions generation portfolio and hence, make it less vulnerable to e.g. seasonal and yearly fluctuations of water runoffs. Such considerations will most likely be of high importance in the context of **climate change** adaption strategies, since climate change may have a severe effect on the runoffs and therefore electricity generation from hydropower in the Balkan region (cf. e.g. [26], [27]).

With regard to economics of hydropower compared to alternative renewable technologies the IRENA report on cost-competitive renewables potential across South-East Europe concluded that hydropower is still the most economically viable renewable energy technology in the region [11], i.e. wind, solar and biomass would still have some competitive disadvantages. However, non-hydro technologies have seen a tremendous and partly even unexpected cost reduction in the past few years and have already achieved or will probably achieve soon cost competitiveness with hydropower and fossil fuels, respectively. For example, in its report "Renewable Power Generation Costs in 2017" [28] IRENA provided a global perspective on the cost development of different renewable energy technologies and showed that especially wind onshore and solar PV have had significant cost reductions in the recent years (cf. Fig. 25). Today average LCOEs of wind onshore are already in the range of hydropower and also LCOEs of solar PV will soon catch up with hydropower if the trend continuous. In this context it should be mentioned that large-scale solar PV plants that have been brought to European markets in 2018 have already shown cost structures significantly below the average IRENA numbers for wind and solar PV. For example tenders for PV in 2018 resulted in an average auction price of 4.33 €ct/kWh in Germany [29] and 5.82 ct/kWh in France [30], respectively.

**Fig. 25: Global weighted average levelized cost of electricity (LCOE) 2010-2017**




Source: IRENA [28]

# 5 Conclusion

The seven SEE countries covered in this study have already an installed hydropower capacity of 12.5 GW with an average electricity generation of about 34 TWh/a. In addition, pumped storage power plants with a total capacity of 2.6 GW are installed in Bosnia and Herzegovina, Bulgaria, Greece and Serbia. The remaining available hydropower potentials add up to total economic potential of 12.8 GW (37 TWh/a) and a total technical potential of 25,2 GW (65 TWh/a), respectively. Between 2010 and 2017 about 1.7 GW of additional hydropower capacities were put into operation, however another 1.4 GW would be required to meet the combined 2020 NREAP targets of the seven countries.

Though, in all of the countries a large number of hydropower projects have been announced that would not only easily deliver the missing capacities to achieve NREAP targets but would almost double the already installed hydropower capacities. EuroNatur/RiverWatch identified almost 2.400 hydropower projects with an estimated total capacity of 12.2 GW and an annual generation of some 36 TWh/a in the seven SEE countries.

The untouched river stretches do not only offer attractive potentials from energy economic but also from nature conversation perspective. Based on a set of own criteria EuroNatur/RiverWatch applied an ecological feasibility assessment of the hydropower projects and classified 92% of the projects or 96% of the total project capacity as located in exclusion zones. This means that the further development of hydropower in the SEE countries would de facto be limited to the refurbishment and upgrade of existing hydropower power plants but hardly any new hydropower station would be built.

Other renewable energy sources, namely wind, solar PV and biomass, provide a huge technical potential of almost 300 TWh/a, i.e. almost twice as high as the current electricity demand of the seven countries. Hence, wind, solar PV and biomass could deliver enough opportunities to accomplish the country's NREAP targets and to transform the country's electricity sectors into a post-carbon world in the long-term. Wind, solar PV and biomass could not only close the gap between hydropower and demand but also substitute projects that are located in EuroNatur/RiverWatch exclusion zones. Additionally, a stronger focus on alternative renewable technologies would make the country's generation portfolios less vulnerable to seasonal and yearly fluctuations of water runoffs, which may significantly increase in the future due to the impact of climate change on the precipitation in the region.

However, it must also be taken into account that a complete stop of all new hydropower projects does not only seem to be rather unlikely but would also neglects the potential contribution of hydropower to the management of the electricity system. Hydropower can provide technology immanent advantages to the electricity system; especially if hydropower plants are combined with a reservoir they can provide flexible generation and ancillary services. It is expected that flexibility in a power system will considerably gain importance in the future, if the share of volatile generation from wind and solar increases. In this context hydropower offers the possibility to balance wind and solar with electricity from renewable energy sources, i.e. without any additional flexibility options such as pumped storage, batteries, power-to-gas or load management. Hence, a more differentiated classification of hydropower projects is recommended that would allow a transparent and equal consideration of energy economic and environmental aspects.

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# 7 Abbreviations

| | |
|---|---|
| AEA | Albania Energy Association |
| AL | Albania |
| ANA | Albanian Nuclear Agency |
| BG | Bulgaria |
| BiH | Bosnia and Herzegovina |
| CGES | Crnogorski Elektrtroprenosni Sistem AD |
| EIA | US Energy Information Agency |
| EnC | Energy Community |
| ENTSO-E | European Network of Transmission System Operators for Electricity |
| EU | European Union |
| FYROM | The former Yugoslav Republic of Macedonia |
| GR | Greece |
| GW | Gigawatt |
| GWh | Gigawatt hour |
| HEDNO | Hellenic Electricity Distribution Network Operator |
| HPP | Hydropower plant |
| IHA | International Hydropower Association |
| IRENA | International Renewable Energy Agency |
| LCOE | Levelized cost of electricity |
| ME | Montenegro |
| MWh | Megawatt hour |
| NIIs | Non-interconnected islands |
| NREAP | National Renewable Energy Action Plan |
| PV | Photovoltaic |
| RS | Serbia |
| SEE | South-Eastern European |
| TSO | Transmission system operator |
| TW | Terawatt |
| TWh | Terawatt hour |
| USD | US Dollar |