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COST-COMPETITIVE RENEWABLE POWER GENERATION:

Potential across South East Europe

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The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future and serves as the principal platform for international co-operation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity.

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COST-COMPETITIVE RENEWABLE POWER GENERATION:

Potential across South East Europe

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FOREWORD

South East Europe is at a pivotal moment in deciding on the optimal strategy for achieving a future with reduced carbon emissions and clean, sustainable power sources to drive future economic growth.

The broad region – encompassing the newest European Union (EU) member states and others in the EU-led Energy Community – has adopted near-term renewable energy targets for 2020. It also aims to align itself with the EU commitment to achieve at least 27% share of renewables in energy consumption by 2030.

Renewable energy development is still at an early stage in South East Europe. Apart from the large hydropower capacity, mostly constructed several decades ago, renewables have just started to take off in a few countries. Yet significant resource endowments, combined with falling technology costs and newfound cost-competitiveness, mean that an energy system powered by renewables is closer at hand than ever.

Much of the region's vast untapped renewable energy potential could already be cost-competitive for power generation today. By 2030, almost all of it will be exploitable in a cost-effective manner. In particular, South East European policy makers need to look more closely at wind and solar photovoltaic power as over 98 GW of wind energy and 5.2 GW of solar PV could be deployed today in a cost-competitive manner. These are viable power supply options that could play an increasingly prominent role in the region's power systems.

This study – undertaken by the International Renewable Energy Agency in collaboration with regional experts – combines detailed mapping of resource potential from the Global Atlas for Renewable Energy with real project cost data collected through the IRENA Renewable Costing Alliance. As governments set new targets, formulate long-term strategies and increase the ambition of national renewable energy plans, we hope the results and findings will provide useful guidance for future decision-making.

The region already possesses solid foundations to attract large-scale investment in renewables, but more needs to be done to ensure a successful energy transition, such as strengthening enabling policies as well as regulatory and institutional conditions, and providing strong support schemes for renewables. IRENA stands ready to assist the Energy Community and governments across South East Europe in efforts to accelerate their development of renewables.

Adnan Z. Amin
Director-General
International Renewable Energy Agency

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ABBREVIATIONS

ANRE	National Agency for Energy Regulation
AU	Area unit
BiH/FBiH	Federation of Bosnia and Herzegovina
BiH/RS	Republika Srpska
CCGT	Combined-cycle gas turbine
CF	Crowdfunding
CHP	Combined heat and power
CPs	Contracting Parties to the Energy Community Treaty
DSO	Distribution system operator
EnC	Energy Community
EU	European Union
FIP	Feed-in premium
FIT	Feed-in tariff
GDP	Gross domestic product
GFEC	Gross final energy consumption
HPP	Hydropower plant
IRENA	International Renewable Energy Agency
IRR	Internal rate of return
LCOE	Levelised cost of electricity
MV	Medium voltage
NGO	Nongovernmental organisation
NPV	Net present value
NREAP	National Renewable Energy Action Plan
O&M	Operation and maintenance
PPA	Power purchase agreement
P-PPA	Preliminary power purchase agreement
PV	Photovolatics
RES	Renewable energy sources
REScoop	Renewable energy co-operative
RET	Renewable energy technology
SEE	South East Europe
SHPP	Small hydropower plant
TPP	Thermal power plant
TSO	Transmission system operator
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
WACC	Weighted average cost of capital

OVERVIEW OF SOUTH EAST EUROPE

Contracting Parties of the Energy Community: Albania, Bosnia and Herzegovina, Kosovo,[1] Montenegro, Republic of Moldova, Serbia, the former Yugoslav Republic of Macedonia and Ukraine.

Members of the European Union: Bulgaria, Croatia, Romania and Slovenia.

1 All references to Kosovo in this publication should be understood to be in the context of United Nations Security Council Resolution 1244 (1999).

Figure: South East Europe: Area covered in this report

Table: Overview of South East Europe

Country	Total population	Population density [population/km²]	Total area [km²]	GDP [billion USD]	GDP per capita [USD]
Albania	2,889,167	105	28,750	11,456.6	11,305.4
Bosnia and Herzegovina	3,810,416	74	51,210	15,995.4	10,509.7
Bulgaria	7,177,991	66	111,000	48,953.0	17,511.8
Croatia	4,224,404	75	56,590	48,732.0	21,880.5
Kosovo	1,797,151	165	10,887	6,385.9	9,712.0
Montenegro	622,388	46	13,810	3,992.6	15,485.8
Republic of Moldova	3,554,150	124	33,850	6,551.2	5,038.5
Romania	19,832,389	86	238,390	177,954.5	21,403.1
Serbia	7,098,247	81	88,360	36,513.0	13,481.9
Slovenia	2,063,768	102	20,270	42,747.0	31,122.4
The former Yugoslav Republic of Macedonia	2,078,453	82	25,710	10,086.0	13,907.9
Ukraine	45,198,200	78	603,550	90,615.0	7,915.9

Source: World Bank (2015).

EXECUTIVE SUMMARY

Over the past decade, renewable energy has been developing rapidly. Since 2011, in the global power sector alone, renewables have accounted for more than half of all capacity additions. Increasing deployment and technological innovation have led to sharp cost reductions and improved cost-competitiveness for solar photovoltaic (PV) and wind, in particular. Solar PV module costs have fallen as much as 80%, while wind turbine prices have fallen by almost a third since 2009. Yet, in South East Europe (SEE) this trend of accelerated uptake of renewables has been observed only to a limited extent.[1]

The region's power sector comprises over 118 gigawatts (GW) of installed capacity, out of which renewables accounted for 36 GW in 2015. Hydropower accounts for 75% of this renewable capacity, however, with most of it constructed several decades ago. At the same time, energy systems vary significantly across the region in terms of the energy resource base, indigenous energy production vs. energy import dependency, and energy supply mix. For example, while Albania relies almost entirely on hydropower for its power generation, Kosovo[2] relies predominantly on lignite, and other countries have a mix of hydro- and fossil fuel-based power generation. **Bulgaria, Romania and Ukraine are the only countries in the region that already have significant solar PV and wind energy capacity,** with this totalling some 7.8 GW in 2015.

Yet, in recent years, with improved economics and a better understanding of renewable energy technologies (RETs), non-hydro options have been taken more seriously in SEE. In addition, the results of this report clearly indicate that **solar PV and wind energy are today already viable options** for the region.

In designing new, long-term energy strategies, policy makers are also realising the need to replace old power plants and addressing rising electricity consumption in most countries around the region. Therefore, a comprehensive and reliable analysis of the cost-competitive potential of various RET options needs to be fed into the upcoming planning process for renewable energy strategies, stretching up to 2030 and beyond. Existing national renewable energy development plans may also need to be revised.

Renewable energy targets for 2020 have been introduced throughout the SEE, and National Renewable Energy Action Plans (NREAPs) have been developed to achieve the required penetration level per the targets set. Most of these plans, however, face challenges in implementation unless the current policy and regulatory frameworks are strengthened. In addition, in line with recent developments in the European Union (EU), new commitments up to 2030 are expected.

Meanwhile, SEE possesses vast technical renewable energy potential – equal to some **740 GW.** The region's wind energy (532 GW) and solar PV (120 GW) potential is largely untapped, as illustrated by IRENA's suitability mapping of the region. This analysis revealed that **126.9 GW**[3] of the overall renewable energy potential could be implemented in a cost-competitive way today.[4] This is almost equal to 17% of the identified technical renewable energy potential. It is also **15 times higher** than the 8.2 GW planned total capacity addition required by the NREAPs from now until 2020. The additional cost-competitive potential could be even higher – above 290 GW if low-cost capital is available.

1 *For the purpose of this report, SEE is defined to include: Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Kosovo, Montenegro, Republic of Moldova, Romania, Serbia, Slovenia, the Former Yugoslav Republic of Macedonia and Ukraine.*

2 *All references to Kosovo in this publication should be understood to be in the context of United Nations Security Council Resolution 1244 (1999).*

3 *Based on medium cost of capital scenario for all RETs, with the exception of hydro: 8% for Bulgaria, Croatia, Romania and Slovenia; 10% for Albania, Bosnia and Herzegovina, Kosovo, Montenegro, Republic of Moldova, Serbia, and the former Yugoslav Republic of Macedonia; 16% for Ukraine. For hydro, as proven technology, 7.5% has been used for all countries except Ukraine, where 10% has been assumed.*

4 *Renewable energy potential is deemed cost-competitive only if the LCOE of its generation is within the ranges of electricity cost produced by the fossil fuel supply options. As an upper threshold of cost-competitiveness, the generation cost of the most efficient gas-fired combined-cycle gas turbine (CCGT) with the lowest LCOE equal to EUR 90/MWh has been assumed.*

Hydropower, including both small and large applications, is still the **most economically viable RET** in the region, given the abundant resources and many years of experience. Although over 27 GW of hydro capacity is already installed, an **additional 18 GW** out of a technical potential of 61 GW, **at an average Levelised Cost of Electricity (LCOE) of EUR 56/megawatt hour (MWh)** could be deployed in a cost-effective manner today.[5]

Wind energy is the most abundant resource in the region, with an overall **technical potential amounting to over 532 GW**. This compares to only 4.9 GW installed in the region at the end of 2015, with most of this in Bulgaria, Romania and Ukraine. Over 18% of this potential, or 98 GW, could be additionally deployed today in a cost-effective manner. This would generate electricity at an **average LCOE of EUR 82/MWh** based on the medium cost of capital scenario. At most suitable locations, characterised by good resource availability and proximity to the grid, LCOE can go below **EUR 50/MWh,** with the highest cost-competitive potential in Bulgaria, Republic of Moldova, Romania and Ukraine. Even in the high cost of capital scenario (higher by two percentage points) close to 33 GW of additional capacity could be identified as cost-competitive, while in the low cost of capital scenario (lower by two percentage points) this potential equals 231 GW. This demonstrates the high influence of the level of cost of capital on the attractiveness of potential investments in this sector.

Out of 120 GW of technical potential, **solar PV** could provide an additional **5.2 GW** of cost-competitive renewable energy capacity **at an average LCOE of EUR 88/MWh** in the medium cost of capital scenario. This is despite the fact that only 3.5 GW had been installed in the region by the end of 2015. This potential, however, equals 32.4 GW, if low-cost capital is available. The dramatic decline in technology costs and the satisfactory irradiation levels in the region – which range from 1120 to 1730 kWh/m2/year – make solar PV a viable supply option. At most suitable locations, LCOEs can go as low as **EUR 70/MWh** with the highest cost-effective potential in Albania, Bulgaria, Croatia and Romania.

The additional cost-competitive **biomass potential** in the region amounts to **up to 4.7 GW**, with an average LCOE slightly below EUR 72/MWh in the medium cost of capital scenario. Landfill gas plants are considered an attractive option throughout SEE, while cost-competitiveness in solid biomass[6] is likely to be achieved outside of the EU in the low cost of capital scenario only, in which case the additional cost-competitive potential equals 9.7 GW.

The **geothermal energy potential** of the region is primarily characterised by a relatively low-enthalpy resource base, which is more appropriate for non-power applications. Binary plants that allow cooler geothermal reservoirs to be used for electricity generation are the only feasible option, which offer a potential of up to **690 megawatts (MW)** at an average LCOE of **EUR 86/MWh** in the medium cost of capital scenario. This renewable could be deployed mainly in Romania and, to a lesser extent, in Bulgaria, Croatia and Slovenia. In the rest of SEE, the geothermal electricity potential is often marginal and uncertain.

As for the projections for 2030 and 2050, with the expected further decline in technology costs, as well as the expected lower cost of capital in the mid- to long-term, the **cost-competitive wind and solar PV potential of the region** is expected to further grow to more than **650 GW by 2030. This means that almost the entire technical potential of those technologies will be cost-effectively exploitable.** Given its size and potential, Ukraine can develop the largest part of this cost-competitive capacity, with an additional 70 GW of solar PV and 320 GW of wind. The high shares of renewables in the power sectors, however, can be also achieved in other parts of SEE.

5 The real implementable renewables potential may be lower, due to increasing environmental protection requirements. This is also becoming particularly relevant to the EU accession countries. The environmental impact of hydropower plants can be significant and has not been considered in this study.

6 Biomass co-firing, which is a low-cost option and is already being applied to a certain extent in the SEE region, is not considered in this study.

The sensitivity analysis conducted for different levels of **cost of capital** revealed this as one of the determining factors significantly influencing the cost-competitiveness of a technology option; therefore, lower figures could render additional renewable capacities accessible. Strengthened enabling policy, regulatory and institutional conditions, and strong support schemes for renewables, among other measures, could improve the risk perception of the region. These would give positive signals to investors in the non-EU part of the region, in particular. The major identified barriers include: the absence of a long-term strong and stable renewable energy policy environment in the region; inadequately designed Power Purchase Agreements (PPAs) that do not meet investor requirements; high administrative barriers, adding to transaction costs for businesses; and a lack of sufficiently attractive and consistent renewable energy support systems. In addition, several technical challenges exist, such as grid limitations and insufficient experience with the grid integration of variable renewables.

The region has, however, already stepped up its efforts to improve the investment framework and tackle the major challenges hindering a more accelerated renewables deployment. At the same time, the region is taking steps to introduce more market-based support schemes, moving from feed-in-tariffs (FITs), largely implemented in the region, to feed-in-premium (FIP) systems (in Albania and Croatia, for example). Due to limited competition in the energy markets and the early stage of renewable energy development, there are, however, concerns about the auction scheme being a suitable model.

In line with the long-term energy transition and decarbonisation objectives of the EU and Energy Community (EnC), deployment of renewables offers a number of socio-economic benefits beyond cost effectiveness, including job creation; the development of local manufacturing capacity; the avoidance of health and environmental costs; and the addressing of climate change. Yet, while these benefits provide additional arguments for an accelerated uptake of renewables, they were not systematically assessed in this report.

1 INTRODUCTION

1.1 Objective of the study

The International Renewable Energy Agency (IRENA) has undertaken a project on cost-competitive renewable energy in South East Europe (SEE). The aim of the project was to carry out a systematic assessment of the overall electricity potential of the region, including all renewable energy options – i.e., hydropower, wind, solar photovoltaic (PV), geothermal and biomass resources. In particular, the project's goal is to fill the data gap in the region regarding the potential and costs for developing solar PV and wind options.

The results of this study shall firstly provide concrete input for the decision-making process in SEE for the implementation and prospective updating of the National Renewable Energy Action Plans (NREAPs). They will also help in developing a cost-effective pathway and creating long-term energy development strategies up to 2030 and beyond in the SEE region.

The study also presents investment frameworks for renewables, including the latest developments gathered through stakeholder interviews. It also highlights the policy and regulatory barriers impeding more accelerated deployment of these resources. This is complemented by a discussion of emerging financing models and a capacity-building needs assessment for solar PV. This has been done as adequate skills are of importance in enabling the tapping of the vast potential of this renewable energy technology (RET) – one of the most promising in the region.

The geographical coverage of the report includes all the Contracting Parties (CPs) to the Energy Community (EnC) Treaty, namely: Albania, Bosnia and Herzegovina, Kosovo,[7] Montenegro, Republic of Moldova, Serbia, the former Yugoslav Republic of Macedonia and Ukraine; as well as four members of the European Union (EU), namely: Bulgaria, Croatia, Romania and Slovenia. Therefore, the study allows a direct comparison of the lessons learned in EU-member SEE countries with the EnC CPs.

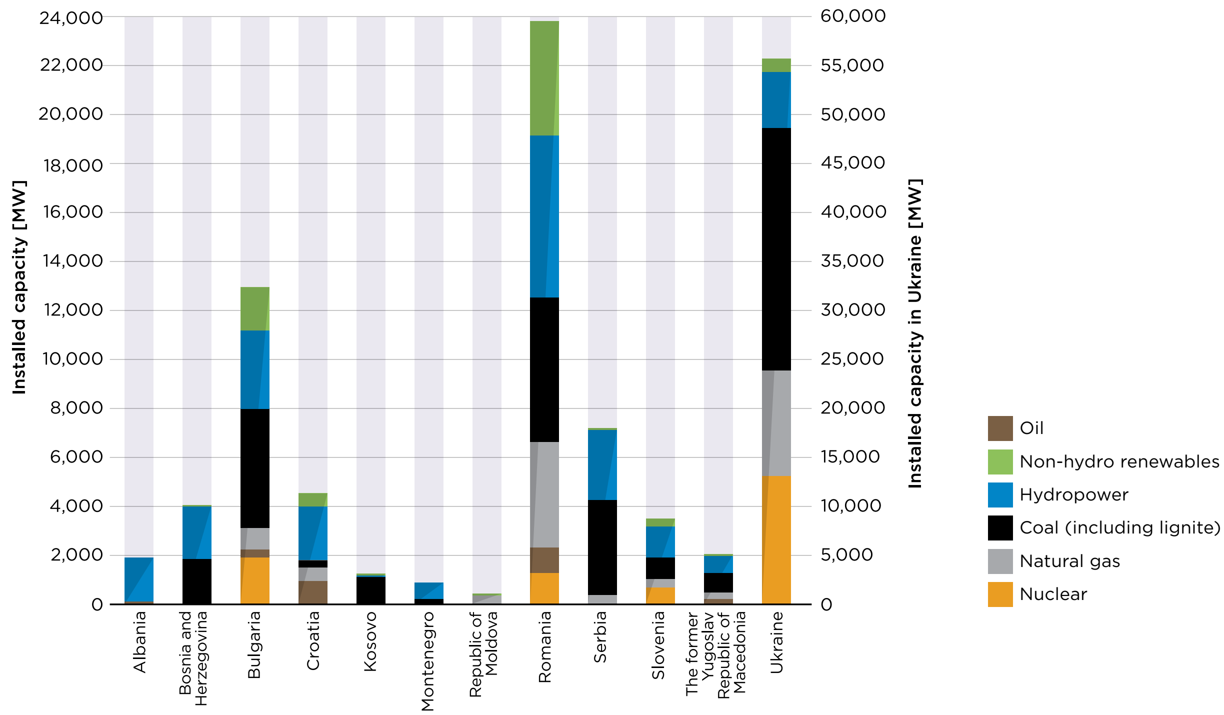
7 All references to Kosovo in this publication should be understood to be in the context of United Nations Security Council Resolution 1244 (1999).

1.2 Current status of energy and renewables in the region

The energy systems of SEE have a total installed power capacity of 118 gigawatts (GW) and annual electricity consumption of 334 terawatt hours (TWh). These systems vary significantly across the region, however, in terms of the energy resource base, indigenous energy production vs. energy import dependency, and energy supply mix. For example, while Albania relies for its power generation almost entirely on hydropower, Kosovo relies predominantly on lignite, while other countries have a mix of hydro- and fossil fuel-based power generation. Bulgaria, Romania and Ukraine are the only countries that already have significant solar PV and wind energy capacity installed, amounting to some 7.8 GW (Figure 1.1 and Figure 1.2).

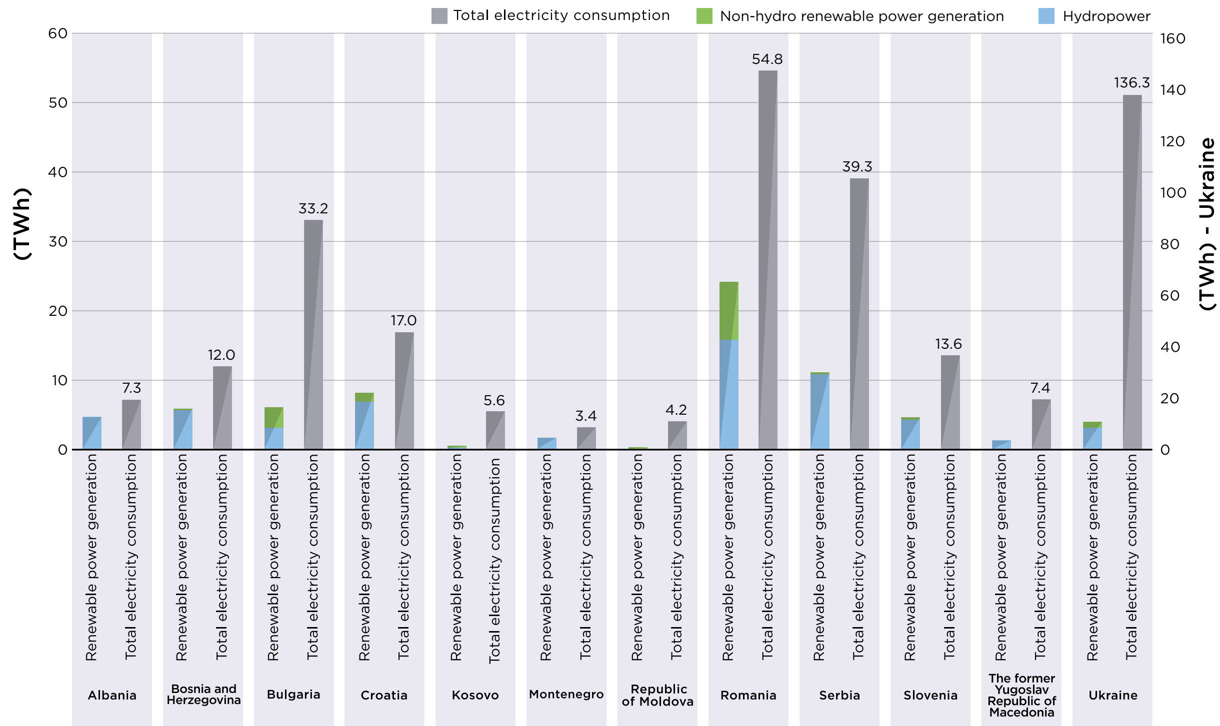
The key elements of the energy infrastructure (e.g., major thermal and hydropower plants) were built in the 1960s and 1970s (IEA, 2008). This concentration in age, combined with inadequate maintenance in the 1990s, is now creating serious technical and policy challenges. As a consequence, there is an urgent need for widespread rehabilitation and replacement of this infrastructure (IEA, 2008; Lazzaroli, 2011). At the same time, electricity consumption is expected to increase in most of the SEE countries, as can be observed in the NREAPs. This leads to an inevitable discussion on future energy mixes in the region.

Figure 1.1: Power systems of SEE in 2015[8]



Based on Energy Community, GlobalData and IRENA data

Figure 1.2: Renewable power generation and total electricity consumption in SEE in 2015[9]



Based on Energy Community, ENTSO-E and Eurostat

8 Due to its magnitude, installed capacity for Ukraine is shown on the secondary axis.

9 Due to its magnitude, TWh for Ukraine is shown on the secondary axis

The SEE region has significant renewable energy potential (see Chapter 3). So far, though, the focus in discussion and planning has been largely on hydropower, as well as on biomass in the heating sector. It has been less so on the emerging options, such as wind or solar PV, due to insufficient understanding of the RETs, coupled with concerns over electricity price rises (Figure 1.3).

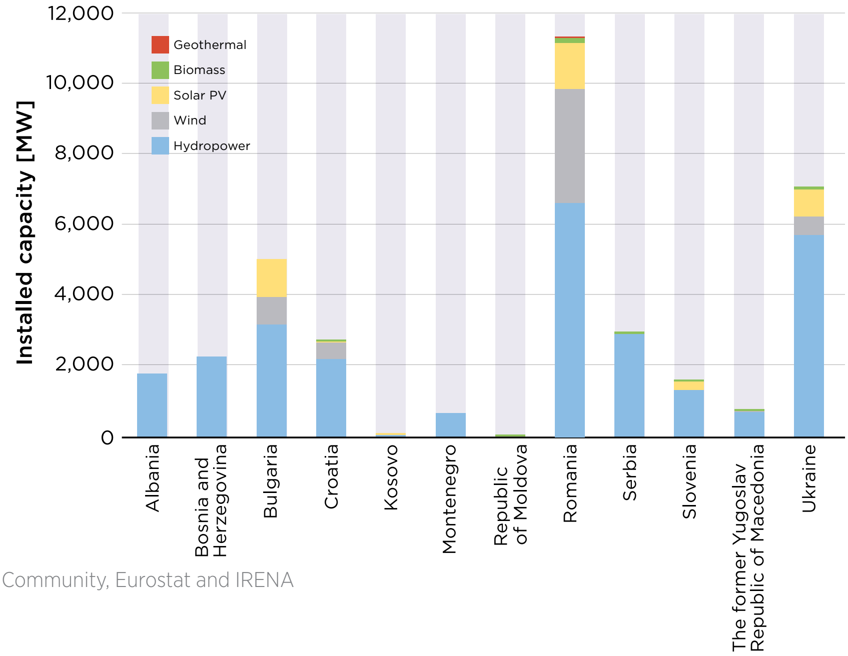
By 2015, a total of 36 GW of renewable energy capacity had been installed in the power sector of the region, more than 75% of which is accounted for by hydropower (Figure 1.4).

While large hydro[10] is a well-established technology in the SEE region, small hydropower plants (SHPPs) have emerged only in the last few years. Small hydro is considered a success, particularly in Bosnia and Herzegovina, Montenegro, and the former Yugoslav Republic of Macedonia. The success of smaller plants is due to their advantages compared to the large plants – namely higher cost efficiency, lower public opposition, easier permitting procedures, reduced financing issues (access to capital, the need for high-cost loans) and a lower risk perception for hydro in general by investors, compared to new RETs.[11]

10 Large hydro is defined as capacity above 10 MW, and small hydro is below or equal to this threshold.

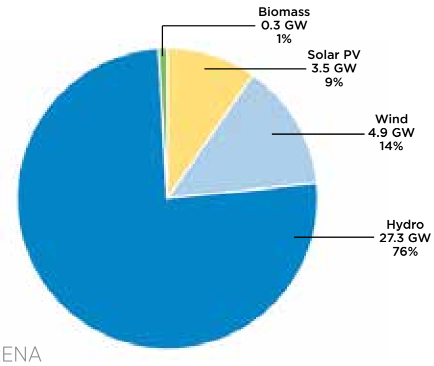
11 It shall be noted, however, that SHPPs face difficulty in attracting foreign investors and financing from multilateral development banks.

Figure 1.3: Renewable energy capacity in the power sectors of SEE in 2015



Based on Energy Community, Eurostat and IRENA

Figure 1.4: Shares of renewable energy power capacity in the SEE region in 2015 (36 GW)



Based on Energy Community, Eurostat and IRENA

The region has also experienced an emerging trend towards solar PV and wind. This occurred, however, only in the **EU SEE countries**, as deployment of renewables has been a part of the EU's energy policy since before the adoption of the Renewable Energy Directive (RES Directive)[12] in 2009. These EU SEE countries had submitted their NREAPs by 2010 and achievement of their targets was legally sanctioned under EU law. In Bulgaria, Slovenia and Romania, a favourable support system and decreasing technology costs led to an investment boom in solar energy in the years 2010-14. In Bulgaria, for instance, more than 1 GW of solar PV capacity had been installed by 2012, which is three times more than the amount foreseen by 2020 in the country's NREAP. Wind energy also developed successfully in Bulgaria and Romania. However, some of these countries experienced drastic, sometimes retroactive, changes to the legal basis of their support schemes in later years, causing investors to withdraw. Investors reported a spillover of the resulting uncertainties from these countries to the entire SEE region.

In 2012, the RES Directive was also adopted by the **Contracting Parties of the EnC**, who introduced binding renewable energy targets for 2020 and committed to submission of their NREAPs. This was an impulse to start development of non-hydro renewable technologies in the power sector. The progress of renewable energy deployment, however, has been slower than expected and many EnC CPs will have difficulties reaching their 2020 NREAP targets (Veum et al., 2015).

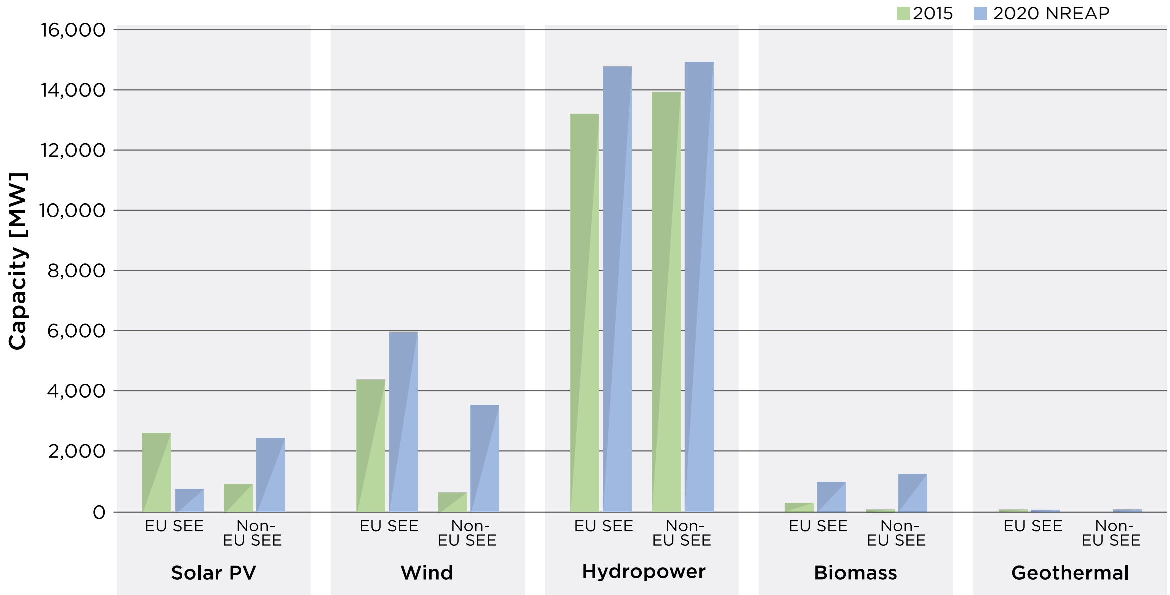
Despite the efforts to improve the legislative and regulatory frameworks, the actual implementation of renewable energy has been rather slow. As a result, there is still a significant gap in the region between today's level of renewables deployment and the one planned for 2020, both in the EU and non-EU area (Table 1.1 and Figure 1.5). Solar PV constitutes the only exception to this picture, as by 2015, its development levels in Bulgaria and Romania had already exceeded the goals for 2020, by 729 megawatts (MW) and 1 041 MW, respectively.

Table 1.1: Current and planned renewable energy deployment levels in the power sector

Technology	Capacity [MW] - 2015	Capacity [MW] – 2020 NREAP	Achievement of 2020 NREAP planned level - in 2015 (%)
Solar PV	**3,479**	**3,171**	**109.7%**
EU SEE	2,617	754	347.1%
Non-EU SEE	862	2,417	35.7%
Wind	**4,925**	**9,498**	**51.9%**
EU SEE	4,371	5,946	73.6%
Non-EU SEE	554	3,552	15.6%
Hydropower	**27,306**	**29,862**	**91.4%**
EU SEE	13,325	14,827	89.9%
Non-EU SEE	13,981	15,035	93.0%
Biomass	**337**	**2,171**	**15.5%**
EU SEE	273	979	27.9%
Non-EU SEE	64	1,192	5.4%
Geothermal	**0.1**	**31**	**0.3%**
EU SEE	0.1	10	1.00%
Non-EU SEE	0	21	0.00%
Total	**36,047**	**44,241**	**81.5%**
EU SEE	20,586	22,516	91.4%
Non-EU SEE	15,461	21,725	71.2%

12 Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC.

Figure 1.5: Current and planned renewable energy deployment levels in the power sector



Based on Energy Community, Eurostat, IRENA and NREAPs

In **non-EU SEE** in particular, **solar PV** has previously received limited political acceptance, due to concerns over rising retail electricity prices. This is still a major issue. In most cases, the quotas for solar PV plants up to 2020 are very small (e.g., 5 MW in Kosovo, 12 MW in Serbia and 16.2 MW in Bosnia and Herzegovina). Due to declining technology costs, however, there is developing interest in increasing solar PV quotas. For example, Albania's NREAP, adopted in 2016, set the highest PV expansion target of any West Balkan country (30 MW), while other countries are also discussing an increase in the quota.

Wind energy expansion has also seen limited success in the non-EU SEE, due to lack of bankable Power Purchase Agreements (PPAs) in, for example, the Federation of Bosnia and Herzegovina, Kosovo and Serbia. Other barriers, specified in the report below, have also impeded success. In Serbia, for example, there were 800 MW of projects with preliminary PPAs that had been waiting for a new PPA model. This was eventually adopted in June 2016. Despite the existing challenges, however, several hundred megawatts of wind projects may be eventually implemented in the region over the next few years.

The **market structures** in the non-EU SEE also contribute to the limited expansion of renewables. In most of the area, there is still no open electricity market. Concepts such as power exchange, unbundled transmission and generation ownership, regulated third-party access, and sufficient competition on supply and demand side have often been unknown. An important step towards a regional electricity market, however, was the Memorandum of Understanding signed in April 2016 between six West Balkan countries on regional electricity market development and the establishment of a framework for future collaboration.

In non-EU SEE, retail electricity prices are regulated tariffs, which are in many cases kept artificially low through subsidies provided to the incumbent state-owned utilities. The revenues based on the regulated prices often cannot support the maintenance of the existing plants, the financing of new generation capacity, or the upgrades of transmission network infrastructure needed to accommodate an increased share of variable renewable generation (Tuerk et al., 2013a). While the liberalisation of the energy market may be of high importance in order to attract investors, the current systems are difficult to change in a short timeframe. In particular, electricity prices reflecting actual generation costs may cause major social problems, if they are not combined with compensation mechanisms for the poorer parts of the population.

1.3 Future developments in the region

Detrimental to the EU decarbonisation pathways and implementation of the Paris Agreement, a significant **expansion of new coal** and lignite plants of up to 6 GW is planned in the Western Balkans, as well as 990 MW in Ukraine (EndCoal, 2016). Those plants would still be operating by 2050 and therefore threaten countries' ability to comply with EU long-term decarbonisation and other environmental objectives (Tuerk et al., 2013b). An expansion of conventional capacities, including gas and coal-based power plants, is seen by many countries as the only means to guarantee energy security at reasonable costs. In addition, domestic lignite and coal is available at very cheap prices, and electricity production from these sources is publicly accepted, as it creates local jobs. While some of the non-EU SEE countries are well connected to gas pipelines importing gas from the Russian Federation, others, such as Albania, are only in the process of connecting to international gas corridors. Others still, such as Bosnia and Herzegovina, have the infrastructure for gas supply limited to specific areas only.

Several recent developments at the EU level will have implications for the **expansion of renewables** in the SEE region.

In October 2014, the European Council adopted the EU's 2030 Climate and Energy framework. This introduces a renewable energy target of **27% at the EU level by 2030**, but no longer foresees national binding renewable energy source targets. The EU goal is meant to be fulfilled through contributions of the member states, guided by the need to collectively deliver the said 27% – without preventing countries from setting their own more ambitious national targets. A new renewables directive that will define specific mechanisms for how to reach the target is currently under development. This is also likely to be adopted under the Energy Community framework.

Another development at the EU level that will be increasingly reflected in the SEE region is the move towards more **market-based support schemes**. The new EU state aid guidelines adopted in 2014 provide for the gradual introduction of competitive bidding processes in allocating public support, while offering member states flexibility to take account of their national circumstances. The rules foresee the gradual replacement of the feed-in-tariffs (FITs) by feed-in premiums (FIPs), which expose renewable energy technologies (RETs) to market signals and the introduction of auctioning mechanisms. In some of the SEE countries, there is already a trend towards moving from the current FIT to FIP systems. This is occurring in Albania and Croatia, while in the Republic of Moldova an auctioning system has recently been introduced. SEE is, however, a region with limited competition in the energy market and at an early stage of renewable energy development, so there are concerns about whether an auction scheme is a suitable model. Therefore, most countries intend to keep FIT systems in the next few years, as these guarantee predictable revenues for investors.

Finally, a proposal for a **new EU electricity market directive** was published in November 2016. The new market design is supposed to promote decentralised structures, allowing innovative companies with new business models to emerge and compete in the electricity market. A prospective, longer-term adoption of the new market directive will pose significant challenges to many CPs that are characterised by monopolistic and centralised structures. The directive may, however, create a framework for new financing models that could accelerate renewables expansion in the region.

2 OVERVIEW OF METHODOLOGY FOR ASSESSMENT OF THE COST-COMPETITIVENESS OF RENEWABLES

This chapter contains a brief overview of the methodology used for analysis of cost-competitive renewable energy potential. A more detailed description is provided in the appendices, while the general cost assumptions are included in Table 2.1. For wind and solar PV, the study focuses only on utility scale grid-connected installations. This is because they are considered to be the most cost-effective solutions, while their Levelised Cost of Electricity (LCOE) is assumed to be lower than that of residential-scale plants (IRENA, 2015).[13]

13 A study on rooftop-PV potential would provide interesting insights for potential uptake of prosumers in the region.

2.1 Assessment of resource potential

The assessment of solar PV and wind power potential in SEE has been based on the data on solar irradiation and wind resources in the most suitable areas within the region. The data was provided by **IRENA's Global Atlas for Renewable Energy**, via a map on investment opportunities in SEE and a suitability analysis,[14] as presented in Chapter 3. Six dimensions were taken into account to identify these areas: resource intensity; distance to power grids; population density; land cover; topography and altitude; as well as protected areas (IRENA 2016a). The assessment was tailored to account only for those areas with a suitability score of 60% and above. This information was coupled with the associated average distance from the transmission network and fed into an algorithm designed to calculate the respective solar PV and wind resource potential. The resource potential datasets used have a spatial resolution of 3 km for solar irradiation and 1 km for wind. For the other renewable technologies, information on potentials has been extracted from the national energy strategies (NREAPs) or academic and feasibility studies, as well as complemented and validated by energy experts.

14 The following datasets have been used: DTU Global Wind Atlas (wind), Vaisala's Global Solar Dataset (solar PV), Open Street Map® (grid distance), the LandScan 2014 Global Population Database (Population density), Shuttle Radar Topography Mission (SRTM) and SRTM Water Body Dataset (slope %), Global Land Cover 2000 (land cover), the World Database on Protected Areas (protected areas). For a full description please refer to IRENA 2016a.

2.2 Cost assumptions for RETs

Table 2.1 presents an overview of the general cost assumptions used to calculate the LCOE[15] of RETs. Since these figures are region specific, the table provides a comparison with IRENA's Renewable Cost Database containing worldwide data from around 9 000 medium- to large-scale renewable energy projects. More detailed information is included in the appendices.

15 The LCOE estimates in this study are based on several assumptions and are primarily provided for comparison between different technologies. Further country-specific factors shall be taken into account to design relevant policies, including real cost of capital, capital costs of the technology available to the developer and actual capacity factors.

Table 2.1 General cost assumptions for renewable technologies in 2016

Technology	Total installed costs		Operations & Maintenance (O&M)	
	Assumptions in the report [EUR/kW]	IRENA Renewable Cost Database[1] [EUR/kW][2]	Assumptions in the report [EUR/year/kW]	IRENA Renewable Cost Database [EUR/kW/year]
Solar PV	1,231 – 1,403	1,150 – 3,310	12.5 – 15.1	8 - 23
Wind	1,451 – 1,836	1,230 – 2,560[3]	35.6 – 47.1	30 - 60
Hydropower[4]	482 – 8,000	440 – 7,040	40	18 - 55
Biomass[5]	1,935 – 6,723.5	1,716 – 6,160	71.5 – 162.5	2.1 – 20% of total investment/year
Geothermal (binary)	6,470 – 7,470	4,400 – 8,800	145	100[6]

[1] For plants commissioned in 2014/2015.

[2] EUR 1 = USD 1.12.

[3] Excluding projects in China and India.

[4] More detailed information for small and large hydropower projects is included in Section 7.3.1.

[5] More detailed information for biomass projects is included in Section 7.3.2.

[6] For the projects in active geothermal areas. The costs are expected to be higher for projects implemented in low temperature reservoirs (in the case of SEE), but no detailed data are available.

Based on Held et al. (2014), IRENA (2015 and 2016d) and Sigfússon and Uihlein (2015)

2.3 Determining cost-competitive potential

To determine the cost-competitive renewable energy potential, the cost of generation has been compared to the fossil fuel supply options being considered in the region by policy makers, namely: coal, gas and lignite. The LCOE levels of the fossil fuel plants were proposed by Held et al. in the project REScost (Held et al., 2014), which provides a European perspective. Renewable energy potentials are deemed cost-competitive in this report only if the LCOEs of their generation are within the ranges of cost electricity produced by the fossil fuel supply options. As the study assumes a conservative approach, as an upper threshold of cost-competitiveness, a generation cost of the most efficient Combined Cycle Gas Turbine (CCGT), with the lowest LCOE equal to EUR 90/MWh (including the CO_2 price),[16] has been assumed. This also enables the authors to take into account the decline in fuel prices (in our case, natural gas) that we are observing today.

During the second half of 2015, those prices saw significant declines globally. The fuel cost assumptions in Held et al. (2014) were fixed before much of this decline and therefore may be high, relative to expectations at the time of publication. For the LCOE calculation, however, an average fuel price over the lifetime of the project is relevant. In addition, fuel prices represent only part of the variable costs, as the total costs also include fixed costs (e.g., investment costs) and other variable costs (e.g., Operations and Maintenance [O&M] costs). Furthermore, any prospective power plants could not become operational before 2020.

From a governmental perspective, the air pollution and climate change externalities related to fossil fuels should be taken into account when making investment decisions (IRENA, 2016e). Therefore, the study provides the **benchmark for fossil fuel plants with and without a CO_2 price**, accounting for a potential CO_2 market price change. The LCOEs without the assumed CO_2 emission prices were calculated based on the LCOE values of Held et al. (2014) by subtracting the price of carbon emissions multiplied by the appropriate carbon factor (VGB PowerTech, 2015). The values are shown in Table 2.2, where the carbon factor and the LCOE values for the fossil fuel supply options considered are shown separately, with and without the CO_2 price.

Compared to prices in 2016, the LCOE in the future scenarios has been shown as rising. This is due to the assumption that while the cost of these mature technologies will remain steady, the prices of CO_2 emissions and fuels are expected to rise (Table 2.2).

Table 2.2: LCOE levels for fossil fuel supply options

	Carbon factor (tCO_2/MWh_{th})	2016		2030		2050	
		With CO_2 (EUR/MWh)	Without CO_2 (EUR/MWh)	With CO_2 (EUR/MWh)	Without CO_2 (EUR/MWh)	With CO_2 (EUR/MWh)	Without CO_2 (EUR/MWh)
Lignite	0.404	51 - 68	47 - 64	72- 93	58 -79	100 - 129	60 - 89
Coal	0.339	68 - 83	65 - 80	91 - 110	79 - 98	110 - 150	76 - 116
CCGT	0.202	90	88	107	100	127	107

Based on: Held et al. (2014). [1]

1 *The cost of capital assumed for non-renewable energy technology was taken from the literature (Held et al., 2014) for the purpose of providing a baseline for the renewable energy source scenarios. In Held et al. (2014), a standard default interest rate, based on a Weighted Average Costs of Capital (WACC) of 7.5%, is used for fossil fuels, up to 2050.*

Table 2.3: Price levels of CO_2 emissions

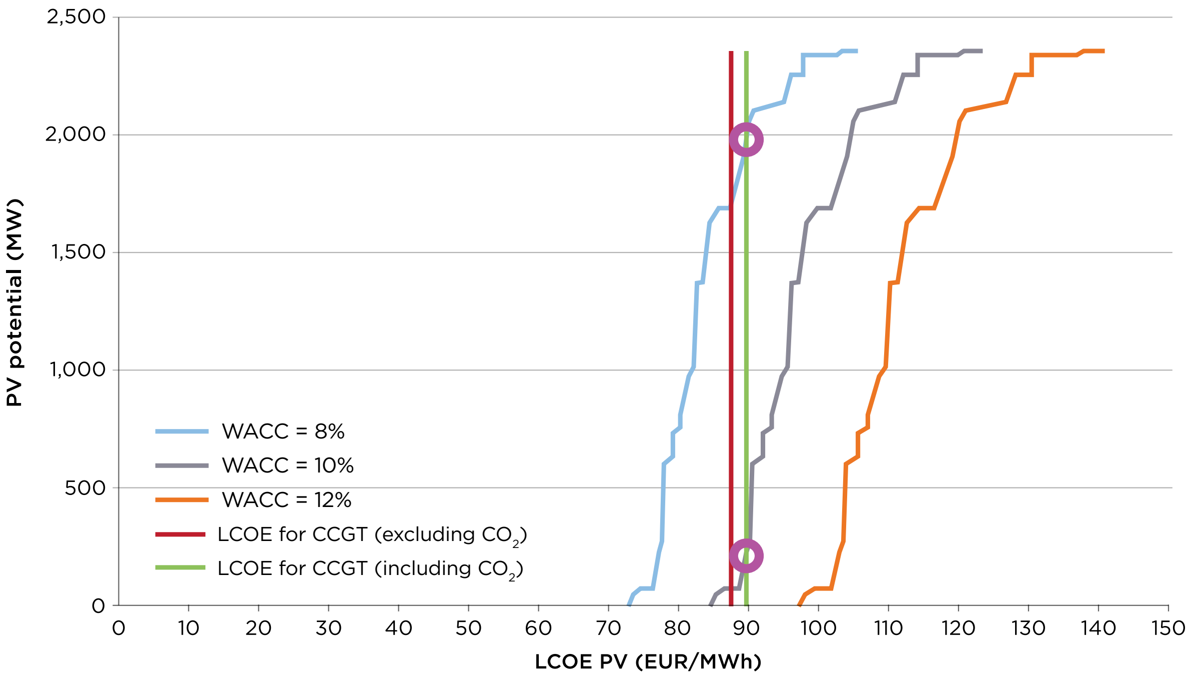
Year	2016	2030	2050
CO_2 price (EUR/t)	10	35	100

Source: European Commission (2014a and 2014b).

16 *Higher values for CCGT in Europe are proposed by the International Energy Agency and Nuclear Energy Agency, Projected Costs of Generating Electricity (2015) and Bloomberg New Energy Finance (2015), Levelised cost of electricity analysis for H2 2015.*

Figure 2.1 shows the conceptual presentation used in the study of the cumulative technical renewable energy potential (in this case solar PV) as a function of the PV LCOE compared to the LCOE of the most cost-effective CCGT natural gas-fired power plants. The LCOE values of fossil generation are shown as two vertical lines (green for those with CO_2 included, red for those without). The LCOE of the selected renewable energy source (wind or solar PV) is shown in three curves. These are distinguished by the cost of capital scenario, with the lowest Weighted Average Cost of Capital (WACC) towards the left, the highest towards the right (see also Table 2.4). Each LCOE curve is sorted by suitability, with the most suitable renewable energy resources having the lowest LCOE and the least suitable the highest LCOE. Where renewable LCOE lines lie to the left of the vertical lines, renewable technologies are more economical than fossil fuel generation.

Figure 2.1: Example of a marginal LCOE potential curve for solar PV in Albania



As an example, in the medium cost of capital scenario (the grey LCOE line), the cost-competitive solar PV potential for Albania would be some 150 MW (see circle at the bottom where grey and vertical green line cross). In the low cost of capital scenario (blue LCOE line), the potential is close to 2,000 MW (upper circle). When cost-competitive potentials are given in the following, they are compared to CCGT with the CO_2 price (green vertical line) and -- if not stated otherwise -- for the medium cost of capital scenario.

2.4 Scenarios

For each time horizon (2016, 2030 and 2050), three scenarios have been developed. These vary in terms of the level of cost of capital represented by WACC, as presented in the Table 2.4.[17] The different WACC levels were used to show the level of sensitivity regarding the LCOEs and cost-competitive potentials. They do not fully represent the range of WACCs in the market, with these depending on technology and country, the type of investor, or whether a preferential loan has been granted, as well as overall economic conditions. If state-owned utilities invest, the risk profile is often lower than for Independent Power Producers. Moreover, preferential loans by international financial institutions are granted for most renewable electricity projects in non-EU SEE countries (except for large hydro), effectively reducing their WACCs.

In the SEE region, investments are considered more costly than in other, EU member countries. The biggest increase of WACCs in the SEE region, compared to other countries, comes from the risk factor, which is considerably higher.[18] The WACC for renewable power generation (with the exception of well-established hydropower) in those SEE countries belonging to the EU was assumed to be within 6-10%, with the medium level at 8%. In 2016, the WACC of the EnC CPs is within 8-12%, with the medium level set at 10%. In Ukraine, the WACC was set within the 14-18% range. In the 2030 and 2050 scenarios, the WACC of the entire region has converged on the EU values, based on the assumption that the CPs will by then have carried out successful policy and regulatory reforms, leading to a lower cost of capital.

For hydro, as a proven technology, however, 7.5% was used for the entire SEE region, except Ukraine, for which 10% has been assumed (the medium cost of capital scenario).

17 The WACC is calculated as the average of the after-tax cost of a company's various capital sources.

18 The reasons for the higher risk factor are discussed in Chapter 5.

Table 2.4: Scenarios for 2016, 2030 and 2050

Cost of capital scenarios	WACC (%)								
	Low			Medium			High		
	2016	2030	2050	2016	2030	2050	2016	2030	2050
EU SEE	6	6	6	8	8	8	10	10	10
Non-EU SEE	8	6	6	10	8	8	12	10	10
Ukraine	14	6	6	16	8	8	18	10	10

3 RENEWABLE ENERGY POTENTIAL IN SEE

3.1 Technical potential

At around 740 GW, the SEE region possesses a vast technical renewable energy potential. This is particularly so for wind (532 GW) and solar PV (120 GW). Both of these are also largely untapped (Figure 3.1).

There are, however, substantial differences across the region in terms of the availability of suitable locations for large-scale renewable energy investments. Variables include resource intensity, population density and topography (Figure 3.2 and Figure 3.3). While, for example, almost the entire area of the Republic of Moldova, or Ukraine, offers interesting renewable energy locations, only a few attractive spots have been identified in Slovenia, with these mainly in the country's north east.

Figure 3.1 Technical renewable energy potential in SEE

(Due to its magnitude, the potential for Ukraine is shown in the secondary axis).

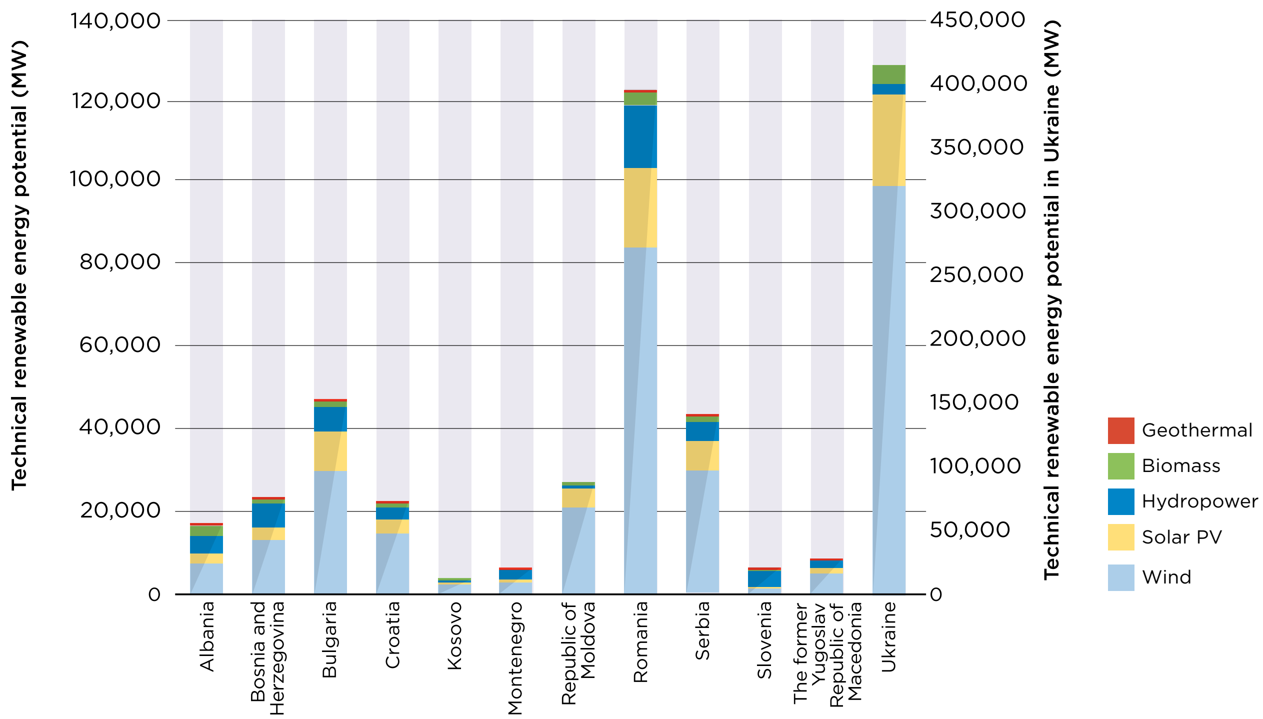
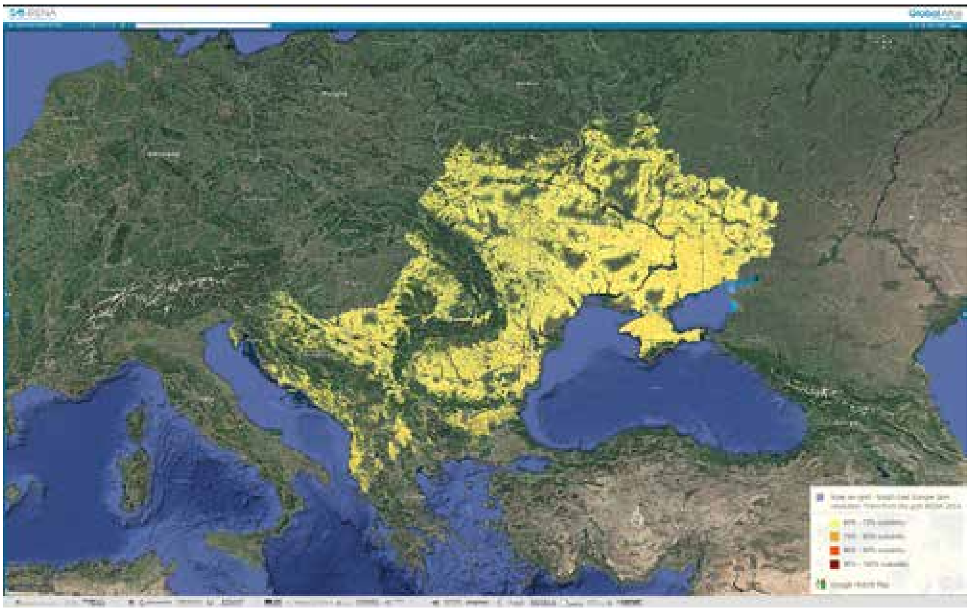
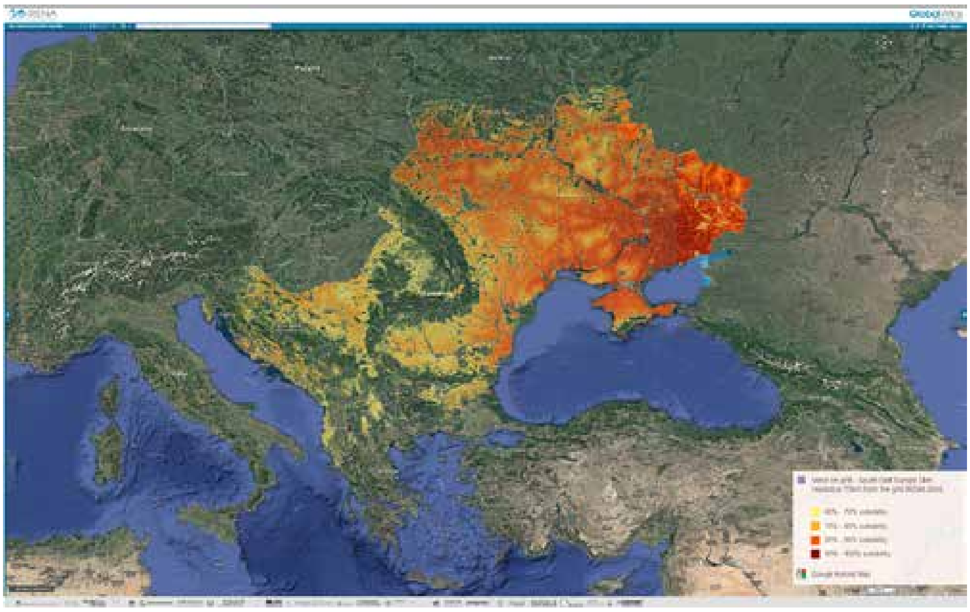


Figure 3.2: Suitable locations for solar PV investments in SEE



Source: IRENA, Global Atlas; map data: Vaisala Global Solar Dataset (2016); base map: Google (2016). Available at: http://irena.masdar.ac.ae/?map=2411.

Figure 3.3: Suitable locations for wind investments in SEE



Source: IRENA, Global Atlas; map data: DTU Global Wind Atlas (2016); base map: Google (2016). Available at: http://irena.masdar.ac.ae/?map=2411.

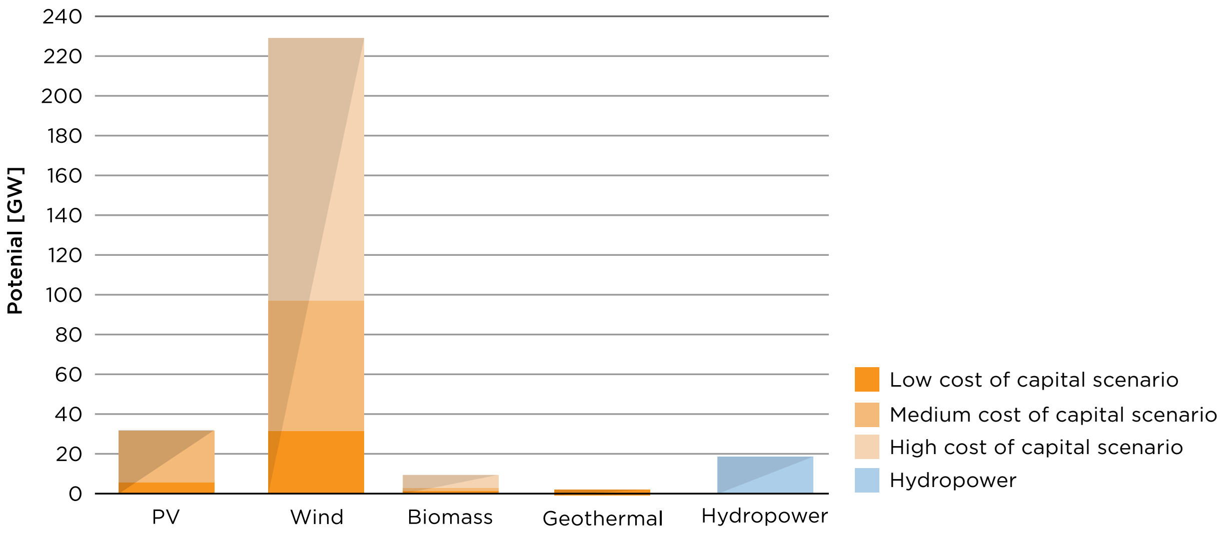
3.2 Additional cost-competitive renewable energy potential in 2016

By 2015, 36.2 GW of renewables had been installed in the power sector of SEE. Out of this, hydro represented more than 75% (Table 1.1). This capacity was assumed to have been deployed in the most suitable locations, and therefore has been deducted from the cost-competitive potential values identified in the study, to determine **additional cost-competitive potential**.

The study reveals that in the medium cost of capital scenario, an **additional 126.9 GW** can be implemented today in a cost-effective way. This is equal to 17% of the identified technical potential (Figure 3.4) and 15 times higher than the 8.2 GW of additional total capacity planned up to 2020, as required by the NREAPs (Table 1.1). The additional cost-competitive potential could be even higher – up to 292.7 GW, if low-cost capital is available.[19]

19 This number equals 52.8 GW in the high cost of capital scenario.

Figure 3.4: Cumulative additional cost-competitive renewable power potential for SEE in 2016 (292.7 GW)



The differences among countries are shown in Figure 3.5. More detailed figures for the additional cost-competitive potentials are included in Table 3.1, with an average LCOE of their deployment in all three scenarios. In Figure 3.6, particular focus is given to the medium cost of capital scenario. The differences depend, among others, on the size of territory, its topography and the development of transmission lines.

Figure 3.5 Additional cost-competitive potential in 2016: Overview of SEE

(Due to its magnitude, the potential for Ukraine is shown in the secondary axis).

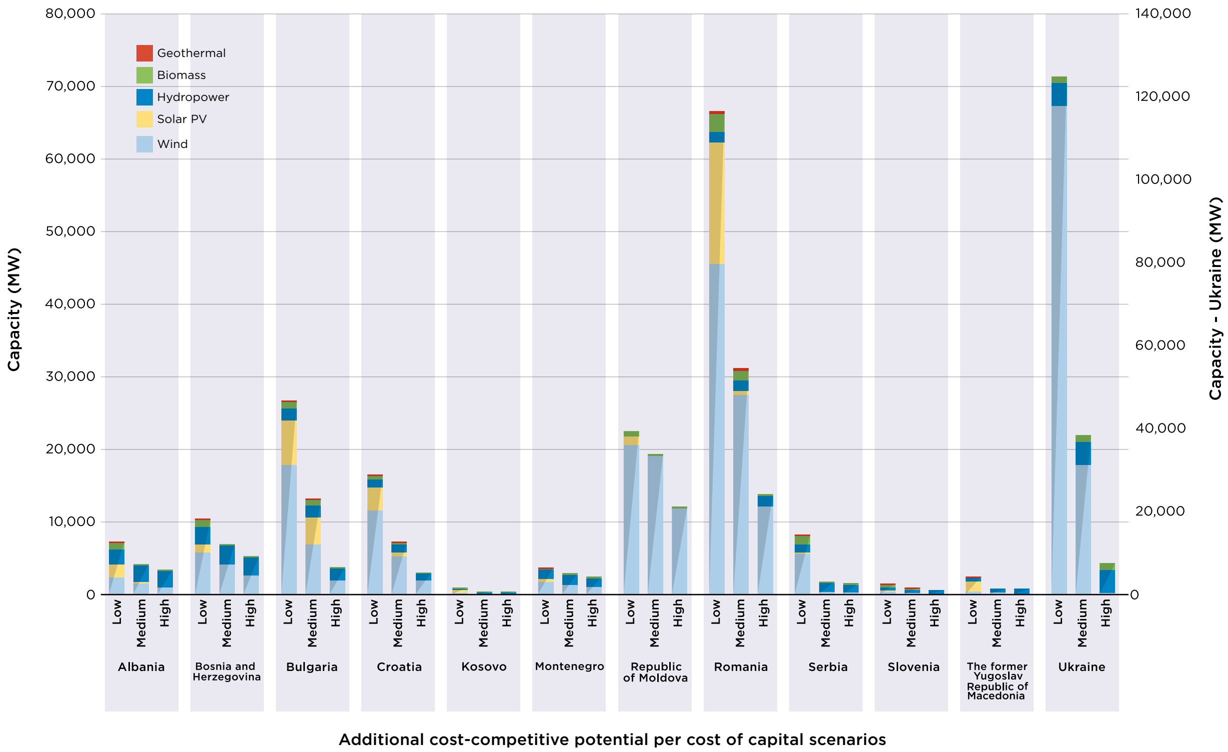
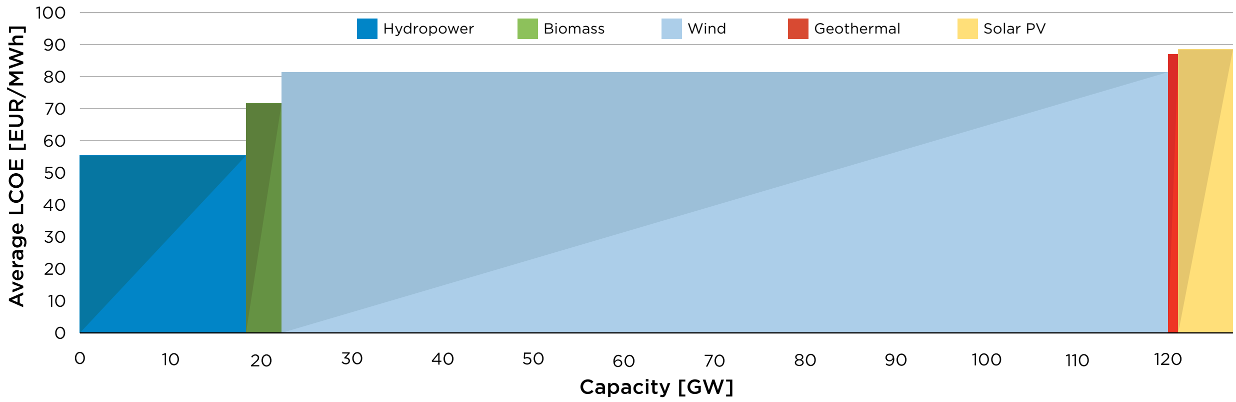


*Table 3.1: Additional cost-competitive renewable energy potential in SEE**

Technology	Low cost of capital scenario			Medium cost of capital scenario			High cost of capital scenario		
	Capacity [GW]	Average LCOE [EUR/MWh]	Generation [GWh]	Capacity [GW]	Average LCOE [EUR/MWh]	Generation [GWh]	Capacity [GW]	Average LCOE [EUR/MWh]	Generation [GWh]
Solar PV	32.36	81.79	45,137	5,23	88.23	7,600	0	0	0
Wind	231.74	79.84	595,517	98.15	82.18	257,154	32.56	84.71	85,421
Hydropower	18.12	56.07	52,860	18.12	56.07	52,860	18.12	56.07	52,860
Biomass	9.74	73.64	55,933	4.70	71.63	25,962	2.16	71.28	12,840
Geothermal	0.72	74.73	5,100	0.69	86.48	4,890	0	0	0
Total	292.67	-	755,052	126.89	-	348,971	52.84	-	152,484

**It is assumed that up to 2015, all the renewable energy capacity was installed in the most suitable locations, and therefore it has been deducted from the identified cost-competitive potential values to determine additional cost-competitive potential.*

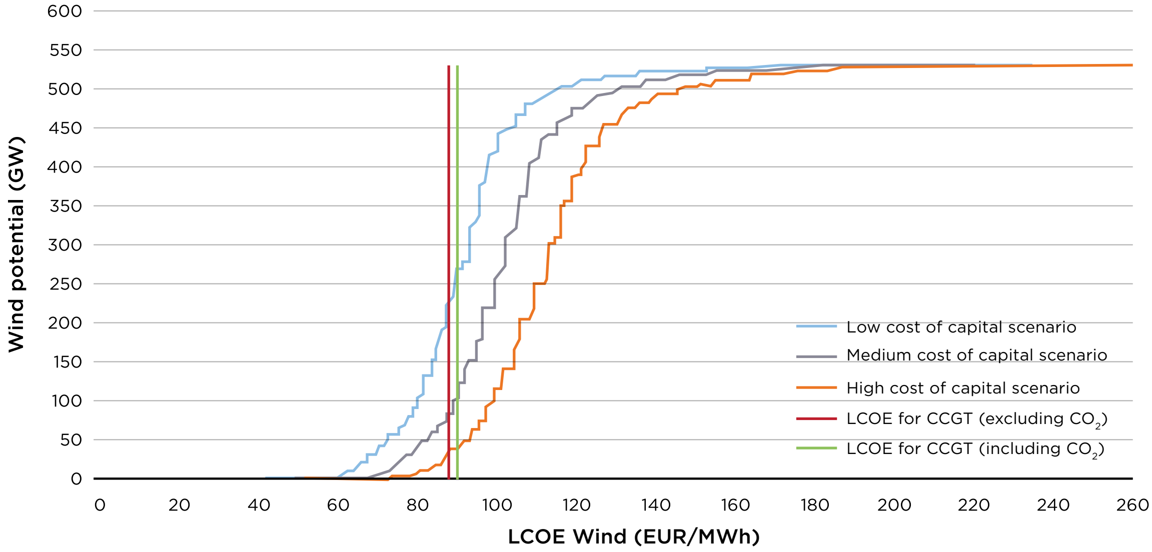
Figure 3.6: Additional cost-competitive renewable energy potential in SEE (medium cost of capital scenario)



Hydropower, including both small and large applications, is still the most economically viable RET in the region, given the abundant resources and many years of experience in this regard. Although over 27 GW of capacity is already installed in this sector, an additional 18 GW, out of 61 GW of technical potential, could be deployed in a cost-effective manner, with an **average LCOE of EUR 56/MWh**, in almost all of the countries in the region. The cost of capital is assumed not to change in the different scenarios given that it is mature technology in the region (Figure 3.6 and Table 3.1). Increasing nature conservation requirements may, however, reduce this potential in practice.

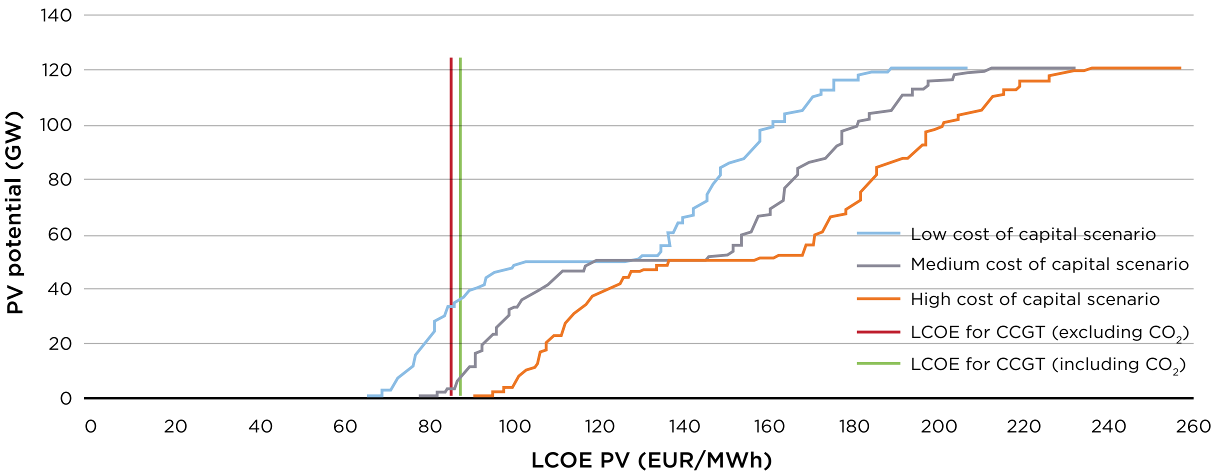
Wind energy is the most abundant resource in the region, with an overall technical potential more than four times higher than that of solar PV. Wind potential amounts to over 532 GW, compared to only 4.9 GW installed in the region by the end of 2015. Over 18% of this potential, equalling 98 GW, could be additionally deployed today in a cost-effective manner to generate electricity **at an average LCOE of EUR 82/MWh**, based on the medium cost of capital scenario. At most suitable locations – characterised by good resource availability and proximity to the grid – LCOE can go **below EUR 50/MWh**, with the highest cost-competitive potential in Bulgaria, Republic of Moldova, Romania and Ukraine. Even in the high cost of capital scenario (higher by two percentage points), close to 33 GW of additional capacity could be identified as cost-competitive, while in the low cost of capital scenario (lower by two percentage points), this potential equals 231 GW. This demonstrates the high influence of the level of cost of capital on the attractiveness of potential investments in the sector (Figure 3.7).

Figure 3.7 Cost-competitive wind potential in SEE in 2016



In the medium cost of capital scenario, **solar PV** could provide an additional 5.2 GW of cost-competitive renewable energy capacity, out of 120 GW of full technical potential. This is despite the fact that only 3.5 GW had been installed in the region by the end of 2015. This potential, however, rises to 32.4 GW if low-cost capital is available. The dramatic decline in technology costs and the satisfactory irradiation levels in the region, which range from 1 120 to 1 730 kWh/m2/year, make solar PV a viable supply option. The average LCOE for this potential is **EUR 81.8/MWh** in the low cost of capital scenario. At the most suitable locations, characterised by good resource availability and proximity to the grid, LCOE can go as low as EUR 70/MWh (Figure 3.8) with the highest cost-competitive potential in Albania, Bulgaria, Croatia and Romania. The vast PV potential of Ukraine cannot be tapped today in a cost-effective way due to the more expensive cost of capital. This explains the "step" in Figure 3.8 where the potential above 49 GW – which represents the total PV potential in SEE without Ukraine – has far higher LCOEs.

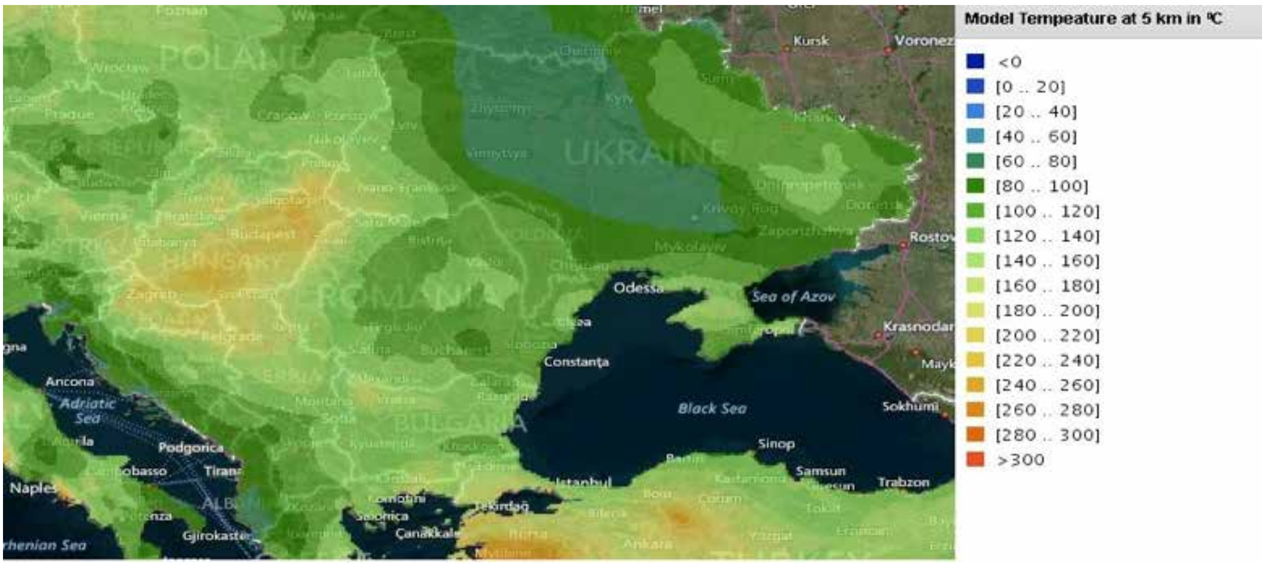
Figure 3.8 Cost-competitive solar PV potential in SEE in 2016



The technical biomass electricity potential in the region is 25.8 GW, while the cost-competitive potential amounts to **4.7 GW**. This is with an average LCOE slightly below **EUR 72/MWh** in the medium cost of capital scenario. The largest share of the technical biomass potential is in Ukraine, where most of the biomass technologies are not cost-effective, given the high cost of capital. Landfill gas plants are considered an attractive option throughout SEE, while cost-competitiveness in solid biomass is achieved outside of the EU only in the low cost of capital scenario (the LCOEs drop below the threshold to EUR 88/MWh). In this, the additional cost-competitive potential equals 9.7 GW. This highlights the importance of capital costs and the fact that a lot of potential may be just at the verge of becoming cost-competitive. Admittedly, the analysis was undertaken based on standard values, so due to high variations and uncertainties for biomass data in particular, individual cases may turn out to deviate from the analysis. For instance, prices for biomass, as well as transport costs, may vary significantly.

The **geothermal** energy potential of the region is primarily characterised by a relatively low-enthalpy resource base, which is more appropriate for non-power applications. Only binary plants, which allow cooler geothermal reservoirs to be used for electricity generation, are considered feasible options for generating electricity, which offers a potential of up to **690 MW**, with an average LCOE of EUR 86/MWh in the medium cost of capital scenario. This potential could be deployed mainly in Bulgaria, Romania and to a lesser extent in Croatia and Slovenia, while in the rest of SEE, the geothermal electricity potential is often marginal and uncertain.

Figure 3.9: Modelled temperature at 5 km depth in Europe



Source: Modified from GeoELEC (2016), Graphical Information System, www.thermogis.nl/geoelec/ThermoGIS_GEOELEC.html

3.3 The future additional cost-competitive potential of solar PV and wind

As for the projections for 2030 and 2050, with a further decline in technology costs, as well as an expected lower cost of capital in the mid- to long-term, the cost-competitive wind and solar PV potential of the region is expected to further grow to more than 650 GW by 2030, as can be seen in Figure 3.10 and Figure 3.11. This means that almost the entire technical potential for those technologies can be cost-effectively explored by 2030. Due to its size, Ukraine is the country that can develop the greater part of this cost-competitive capacity, with an addition of 70 GW of solar PV and 320 GW of wind. More detailed results are presented in Section 4.

Figure 3.10: Cost-competitive solar PV potential in SEE in 2030

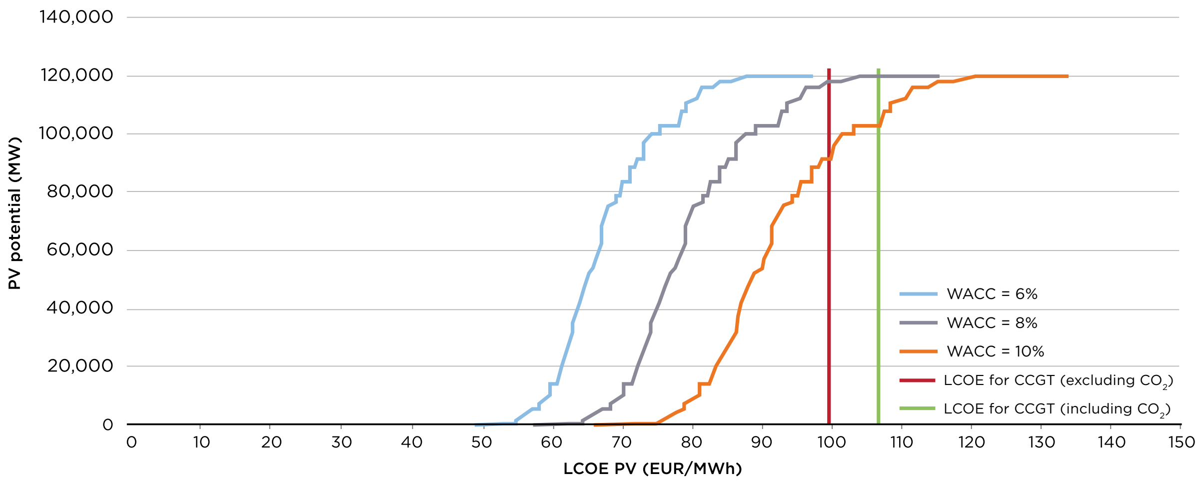
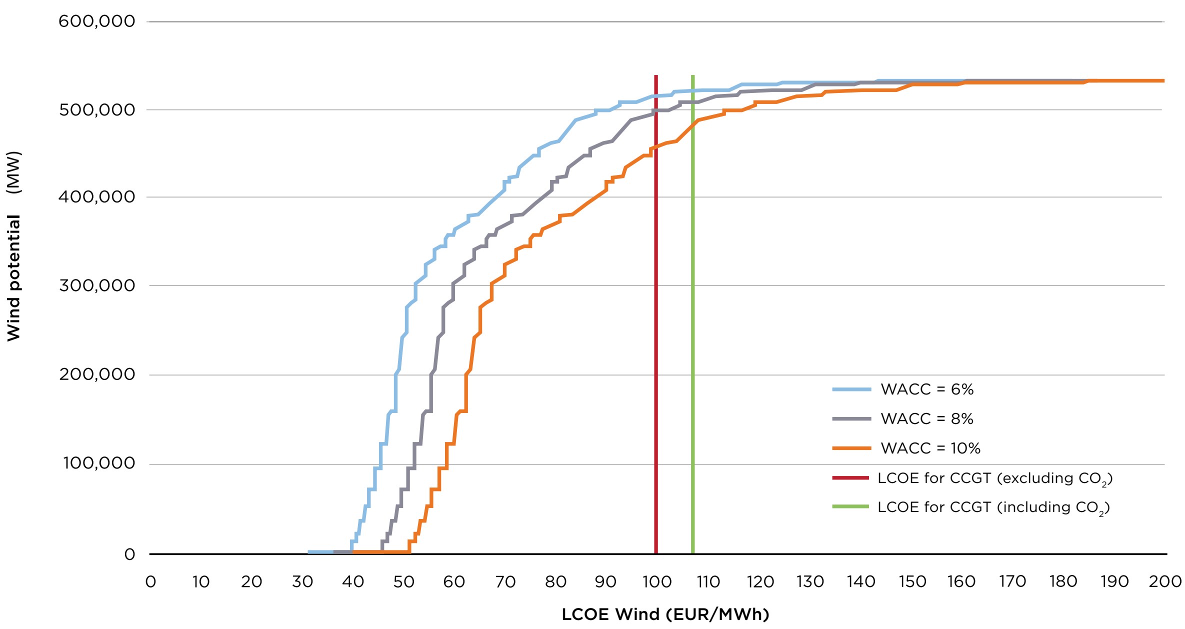


Figure 3.11: Cost-competitive wind potential in SEE in 2030



4 DETAILED ANALYSIS

This chapter presents the status and potential of renewable energy, including the latest developments in the investment frameworks for renewables, in each of the SEE EU member states and CPs of the EnC, gathered through stakeholder interviews. It also identifies barriers, as they are of crucial importance for prospective investors in the region. Furthermore, an illustration of the progress towards achievement of the 2020 renewable energy targets is provided.

It is assumed that all the renewable energy capacity installed up to 2015 was installed at the most suitable locations, and therefore, this has been deducted from the identified cost-competitive potential values in determining **additional cost-competitive potential** today, as well as in 2030 and 2050.

The data for the years 2009 and 2020 (and 2005 in some cases) comes from the NREAPs, while the latest available capacity data for 2015 stems from the 2016 Implementation Report of the EnC, as well as from Eurostat and IRENA.[20] Comparison of LCOEs for different technologies is also included. While the LCOEs of wind and solar PV are based on models (see Appendices 7.1 and 7.2), data for the other technologies was collected bottom-up. Assumptions on technology choice were made for biomass and geothermal energy (see Appendix 7.3), while the hydro LCOEs are based on a survey of planned plants. There could, however, be plants with LCOEs outside the range presented in the study.

20 The latest available data for generation are for 2014. To create a consistent set of data for 2015, a conversion factor, MW to GWh, from the year 2014 has been applied to the 2015 power capacities of the region.

4.1 Albania

Current status

The electricity supply in Albania is almost exclusively based on hydropower, with three large hydropower plants (HPPs) on the Drin River producing 88% of the country's total electricity generation capacity (Tuerk et al., 2013b). Electricity consumption has risen slightly in recent years and this trend is expected to continue, according to the NREAP. In 2014, the share of renewables in the Gross Final Energy Consumption (GFEC) amounted to 33.1%. Yet, without an improved support scheme, the country is not expected to meet its 2020 target of 38%. At the end of 2015, there was no on-grid solar PV and wind electricity generation in Albania.

So far, Albania has not had a FIT for wind or PV, but in 2007, the country initiated a support policy for SHHPs and awarded hundreds of concession rights. Out of 501 concessions, however, only 84 plants are in the construction phase and 307 (with a total capacity of 1 127 MW) are still in the project development phase (Deloitte, 2015). Many concessions are said to have been given in a non-transparent way and to companies without any experience in the field. In addition, instead of developing the projects for which they obtained concessions, concession holders often traded those concession rights on the market (Simaku, 2016). The lack of expertise of many licensed companies led them to make economically unviable investments or to start construction without due technical and financial support (REC, 2015).

Another major issue that limits renewable energy expansion is that of technical and non-technical losses (illegal electricity usage and theft). This was reduced significantly in 2015, a move that has improved conditions substantially for new investments in the energy sector (Simaku, 2016; REC, 2015).

Table 4.1: Renewable energy deployment in Albania

Renewable energy shares [%] in	2009	2014	2020 (NREAP)
Gross final energy consumption (GFEC)	31.2	33.1	38
Electricity consumption	83	60	100

Based on Energy Community, Eurostat and NREAP

Cost-competitive renewable energy potential

Albania has large, additional cost-competitive hydro potential of more than 2 GW. This is available on rivers such as the Drin or Vjosa, but also on many smaller rivers. Due to the very good solar resource and relatively satisfactory wind speeds (3.3-9.6 m/s), there is high, untapped potential for the deployment of solar PV (up to 1.9 GW) and wind (987-2 153 MW). These renewables can already be considered viable alternatives in designing actions aimed at achieving the 2020 and other future renewable energy targets (Figure 4.1 and Figure 4.2). Due to the low temperatures of available geothermal reservoirs, however, geothermal power generation is unlikely. As shown in Table 4.2, hydropower, wind and solar PV potential significantly exceeds the deployment levels by 2020 envisaged in the NREAP.

Hydropower is still considered the cheapest renewable energy option in Albania (Figure 4.3). In the most suitable locations, however, wind and solar PV power plants could already generate electricity with LCOEs of less than EUR 50/MWh for wind and slightly above EUR 70/MWh for solar (Figure 4.1 and Figure 4.2).

Figure 4.1: Cost-competitive solar PV potential in Albania in 2016

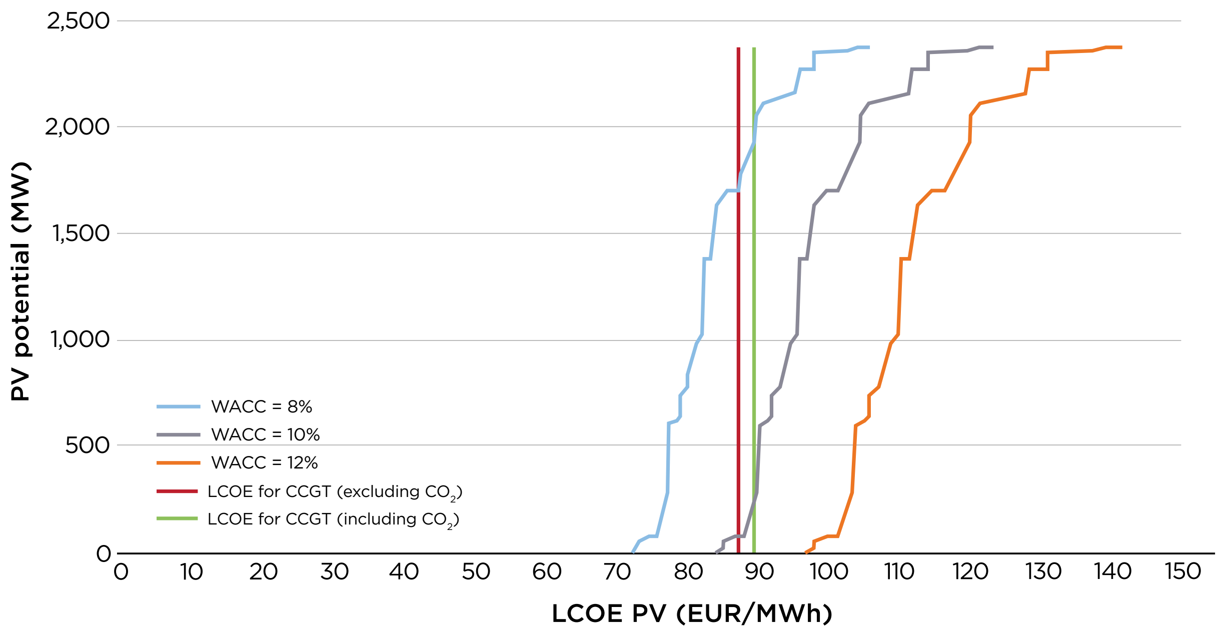


Figure 4.2: Cost-competitive wind potential in Albania in 2016

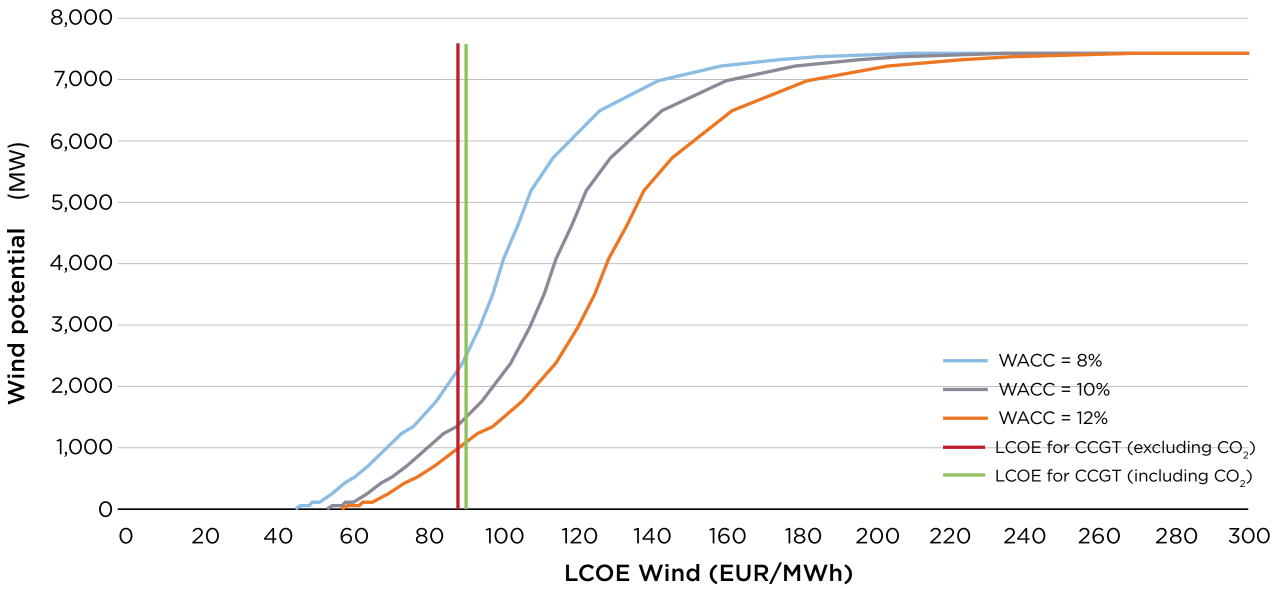


Figure 4.3: LCOE ranges and weighted averages of renewable energy technologies in Albania (medium cost of capital)

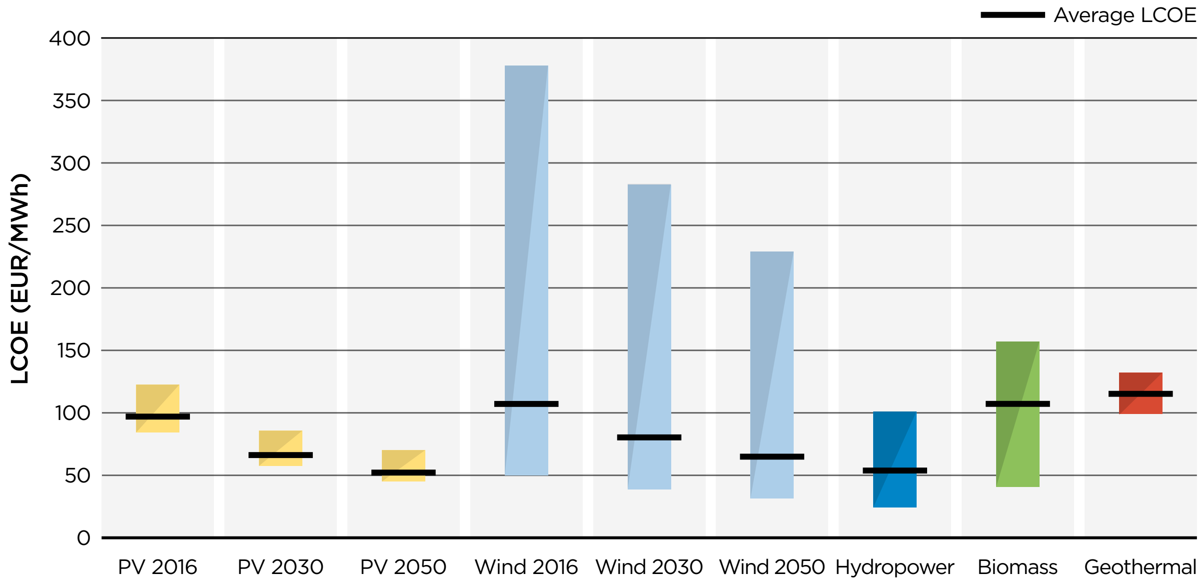


Table 4.2 Potential for renewable-based electricity in Albania

Technologies	2009	2015		2020 (NREAP)	Additional cost-competitive potential			Technical potential	
	MW	MW	GWh	MW	MW		GWh	MW	GWh
Solar PV	0.0	0.0	0.0	50.0	**2016**	**0.0 - 1,917.6**	0.0 – 3,001.1	2,378.2	3,706.3
					2030	**2,378.2**	3,706.3		
					2050	**2,378.2**	3,706.3		
Wind	0.0	0.0	0.0	30.0	**2016**	**986.7 - 2,152.8**	2,885.7 – 5,397.3	7,483.1	13,653.9
					2030	**5,209.5 – 6,989.7**	10,672.8 – 13,160.4		
					2050	**7,238.1 – 7,414.1**	13,437.3 – 13,604.6		
Hydro	1,488.0	1,797.0	4,916.2	2,324.0		**2,169.0**	7,033.7	4,813.0	15,572.0
≤ 10 MW	28.0	177.0	484.2	490.0		**761.0**	2,082.3	938.0	3,572.0
> 10 MW	1,460.0	1,620.0	4,432.0	1,834.0		**1,408.0**	4,980.8	3,875.0	12,000.0
Pumping	n.a	0.0	0.0	n.a		**n.a**	0.0	n.a	n.a
Biomass	0.0	0.0	0.0	5.0		**83.3-788.0**	504.0 – 4,989.0	1,832.0	11,195.0
Biogas	0.0	0.0	0.0	0.0		**83.3-125.0**	504.0 – 756.0	416.6	2,520.0
Solid Biomass	0.0	0.0	0.0	5.0		**0.0 - 663.0**	0.0 – 4,233.0	663.0	4,233.0
Biowaste	0.0	0.0	0.0	0.0		**0.0**	0.0	755.1	4,442.0
Geothermal el.	0.0	0.0	0.0	0.0		**0.0 - 1.4**	0.0 – 10.0	1.4	10.0
Total	1,488.0	1,797.0	4,916.2	2,409.0	**2016**	**3,239.0 – 7,028.8**	10,423.4 – 20,431.1	16,507.7	44,137.2

Note: The lower values of the ranges of the additional cost-competitive potential represent the high cost of capital scenario, while the upper values represent the low cost of capital scenario.

Based on Energy Community and NREAP

Investment framework for renewable energy

Albania lacks a comprehensive and supportive regulatory framework for the deployment of renewable energy sources other than hydropower. Importers and manufacturers of solar thermal equipment, however, are entitled to benefit from tax exemptions. A support policy for SHPPs introduced in 2007 had, however, a negative impact on the financial balance of a state-owned utility, Korporata Elekroenergjitike Shquiptare, which was obliged to buy all the generation output of private SHPPs at a preferential, fixed FIT. In 2012-2013, the losses amounted to EUR 32 million and were eventually covered by budget taxes (Zavalani, 2016). To tackle this economically unsustainable practice, a new formula to calculate the FIT for electricity from SHPPs has been proposed that would reduce the purchase price by approximately 30% (Frieden et al., 2015).

The 2013 Law on Renewable Energy provides a limited incentive to develop non-hydro sources, but new legislation is currently being developed. Continuing discussions indicate that FIP tariffs will be introduced for small hydro, wind and solar PV installations, but only for the capacity necessary to reach the national, 2020 renewable energy target (30 MW of wind and 50 MW of solar PV). The current FIT for small hydro systems will be maintained, however, for smaller installations, with a capacity of less than 2 MW (Kamberi, 2016). The allocation of FIP tariffs shall be determined via a competitive, non-discriminatory bidding process (auctioning). Installations above 10 MW will be excluded from any support. The new law is also supposed to introduce a framework for the development of a net metering system. Yet low and regulated retail energy prices of EUR 0.07/kWh (REC, 2015) provide only a limited incentive for self-consumption schemes such as net metering.

The Renewable Energy Directive has not been implemented to a full extent yet and still lags behind, reportedly due to insufficient administrative capacity. This also significantly hinders proper monitoring of operating conditions and the environmental impact of all SHPPs. Furthermore, limited capacity in the transmission and distribution systems impedes the provision of priority access for renewable energy to the grid, as stipulated in the Law on Renewable Energy (REC, 2015). As a result, until now only state-owned HPPs and private SHPPs under the FIT system have been able to dispatch electricity to the grid.

Institutional capacities have improved recently, due to the establishment of the National Licensing Centre, which aims to operate as a one-stop-shop for shortening procedures and increasing the transparency of the licensing process. There are still several administrative steps, however, which have not been integrated into the centre yet and which still require the involvement of different institutions, such as obtaining energy production and construction permits. Further financial support for renewable and energy efficiency projects is also expected to be provided by the National Energy Efficiency Fund that has been set up, but is not yet operational.

4.2 Bosnia and Herzegovina

Current status

Bosnia and Herzegovina consists of two entities: the Federation of Bosnia and Herzegovina (BiH/FBiH), and the Republika Srpska (BiH/RS). In both, electricity is almost equally generated by coal-fired and large-hydropower plants, while recently, there has been a growing interest in the deployment of SHPPs. Meanwhile, as of 2015, only a small amount of non-hydro renewable capacity had been deployed.

While electricity consumption was stable in recent years, it is expected to be higher by 2020. Therefore, the country plans to significantly expand its fossil fuel electricity generation. Yet, according to the energy balance published by Eurostat, in 2014, Bosnia and Herzegovina achieved a 42.3% share of energy from renewable sources, thus overachieving a 40% target for 2020. This was due to a revision of biomass data (Energy Community, 2016), as previously, a share of only 34.9% for renewable energy had been assumed, for 2013.

Wind and solar PV have been gaining more interest, recently. High FITs for solar PV (up to EUR 277/MWh for micro systems) in the BiH/FBiH have resulted in more applications than the foreseen quotas.

Approximately 35 MW of small projects are registered as “in construction” while 7 MW have been already constructed in BiH/FBiH. In addition, in the BiH/RS, 2.12 MW of solar PV have currently obtained a preliminary PPA and 3.46 MW a final PPA (RERS, 2016b)

By the end of 2015, only 0.3 MW of wind power had been constructed in BiH/FBiH (Operator for renewable energy sources and efficient co-generation, 2016). A 50 MW wind park in BiH/FBiH near Mostar is, however, being developed and the construction is to be finalised in 2016. Furthermore, in BiH/RS two 50 MW wind parks are being planned, one by a private investor, the other by the state-owned utility, which is currently negotiating a loan with KfW Developmnent Bank. The latter park aims to reserve the corresponding production under the FIT quote (Muratovic, 2016). As the official registries indicate, another 600 MW of wind energy projects in BiH/FBiH are in the early stages of development. Most of these projects, however, were registered between 2011 and 2013 (Operator for renewable energy sources and efficient co-generation, 2016), and there has been no progress on their construction since then. One of the reasons is a FIT level that is considered insufficient (EUR 75/MWh).

Table 4.3: Renewable energy deployment in Bosnia and Herzegovina

Renewable energy shares [%] in	2009	2014	2020 (NREAP)
Gross final energy consumption (GFEC)	34	42.3	40
Electricity consumption	50.3	47	56.9

Based on Energy Community, Eurostat and NREAP

Cost-competitive renewable energy potential

Apart from hydropower, Bosnia and Herzegovina has large additional cost-competitive potential in terms of solar PV (up to 1 GW) and wind (2.5-5.9 GW). This is, however, highly influenced by the cost of available capital (Figure 4.4 and Figure 4.5). There is also significant availability of biomass, which is, however, planned to be mainly used for heating purposes. Moreover, the northern part of the BiH/RS has a substantial geothermal potential that cannot be deployed to generate cost-effective geothermal electricity due to its relatively low temperature.

Hydropower is still the cheapest renewable energy option in Bosnia and Herzegovina (Figure 4.6). There are, however, many locations where wind could be deployed at relatively low cost, below EUR 50/MWh.

Figure 4.4: Cost-competitive solar PV potential in Bosnia and Herzegovina in 2016

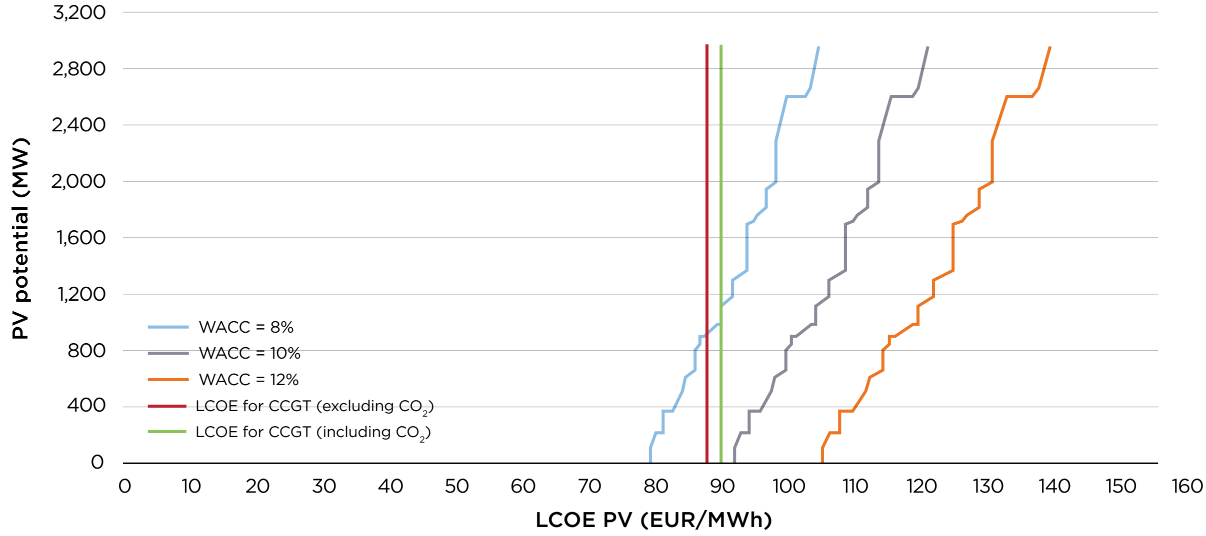


Figure 4.5: Cost-competitive wind potential in Bosnia and Herzegovina in 2016

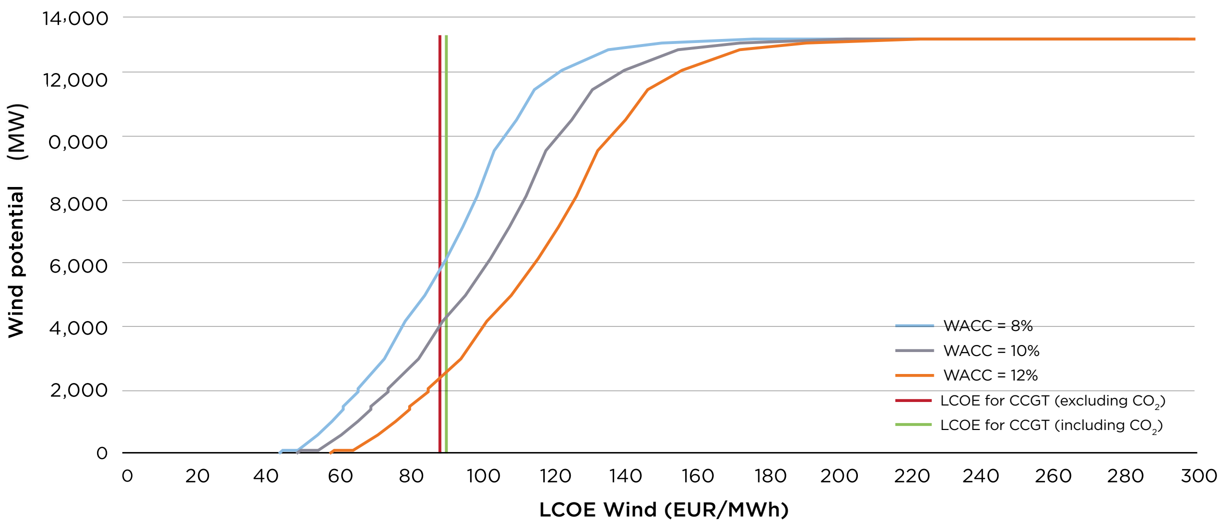


Figure 4.6: LCOE ranges and weighted averages of renewable energy technologies in Bosnia and Herzegovina (medium cost of capital)

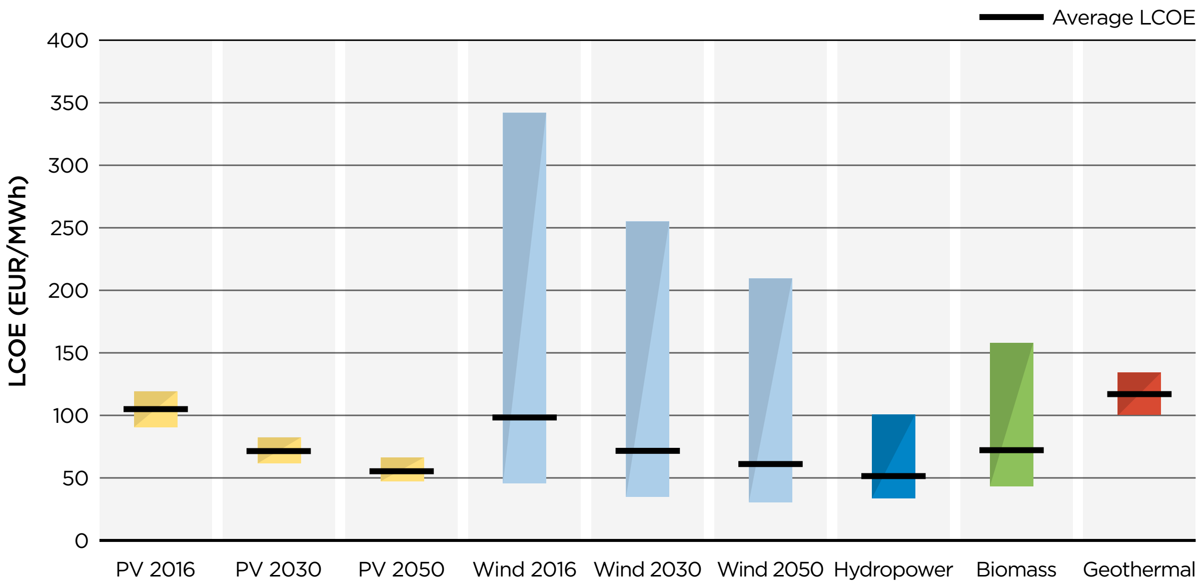


Table 4.4: Potential for renewable-based electricity in Bosnia and Herzegovina

Technologies	2009	2015		2020 (NREAP)	Additional cost-competitive potential			Technical potential	
	MW	MW	GWh	MW		MW	GWh	MW	GWh
Solar PV	0.0	8.2	8.9	16.2	**2016**	**0.0 – 993.5**	0.0 – 1,477.2	2,963.7	4,135.2
					2030	**2,955.5**	4,126.2		
					2050	**2,955.5**	4,126.2		
Wind	0.0	0.3	n.a	330.0	**2016**	**2,556.2 – 5,861.3**	7,476.4 – 14,654.9	13,141.1	26,335.9
					2030	**10,618.8 – 12,809.6**	22,892.7 – 26,000.0		
					2050	**12,982.1 – 13,102.8**	26,192.7 – 26,308.0		
Hydro	2,006.0	2,150.0	5,806.4	2,700		**2,510.0**	9,399.6	6,110.0	24,498.0
≤ 10 MW	28.2	95.5	257.9	251.4		**764.5**	3,108.9	860.0	3,498.0
> 10 MW	1,978.0	2,054.5	5,548.5	2,448.8		**1,745.5**	6,285.2	5,250.0	21,000.0
Pumping	440.0	420.0	0.0	492.0		**n.a**	n.a	n.a	n.a
Biomass	0.3	1.0	0.0	35.7		**29.0 – 857.0**	180.0 – 5,470.0	983.0	6,220.0
Biogas	0.3	1.0	0.0	16.5		**29.0-44.0**	180.0 – 270.0	150.0	900.0
Solid Biomass	0.0	0.0	0.0	19.2		**0.0 - 813.0**	0.0 – 5,200.0	813.0	5,200.0
Biowaste	0.0	0.0	0.0	0.0		**0.0**	0.0	20.0	120.0
Geothermal el.	0.0	0.0	0.0	0.0		**0.0 - 7.1**	0.0 – 50.0	7.1	50.0
Total	2,006.3	2,159.5	5,815.3	3,081.9	**2016**	**5,095.2 – 10,228.9**	17,056.0 – 31,051.7	23,204.9	61,239.1

Note: The lower values of the ranges of the additional cost-competitive potential represent the high cost of capital scenario, while the upper values represent the low cost of capital scenario.

Based on Energy Community and NREAP

Investment framework for renewable energy

In the BiH/FBiH, BiH/RS and the Brčko district, there are three, state-owned electricity utilities without harmonised goals and plans. In addition, the procedures for obtaining all the necessary permits have not been unified and streamlined, making the duration of administrative processes hard to predict. Even small projects can take up to a year to obtain all their permits, depending on the entity. Large-scale projects face even more obstacles, since all the municipal, federal and national levels (and cantonal in BiH/FBiH) are involved (Harbas, 2016). Foreign investors find these frameworks too complex and risky, and therefore most investments are conducted by the state-owned utilities (Harbas, 2016).

The support system in Bosnia and Herzegovina includes a FIT in BiH/FBiH as well as a combination of a FIT and FIP in BiH/RS. All technologies are supported, but there are significant differences between the entities with regard to capacity thresholds (the quota for solar PV by 2020 is 12 MW in BiH/FBiH and 5 MW in BiH/RS), the level of tariffs and the duration of support (12 years in BiH/FBiH and 15 years in BiH/RS). There is, however, on-going discussion over prospective changes for PV, so that increased interest in this technology is better reflected, along with decreasing prices, since the FIT/FIP tariffs in Bosnia and Herzegovina are the highest in the region.

PPAs in Bosnia and Herzegovina are reported to be not reliable enough to secure bank loans, which applies especially to large-scale projects. In BiH/FBiH a project first receives a preliminary right for the FIT (as an option for the investor) and, once it is constructed, a final PPA. However, in the preliminary right, a time frame to grant a final PPA is not assumed or defined, even after submission of all the required documents by the investor. Obtaining the final PPA is very time consuming and costly and exposes the investors to a large risk. In the case of SHPPs, less uncertainty is reported (Schwarz, 2016). According to the stakeholders, additional problems can also arise due to frequent changes in the legal frameworks.

Net metering has only been introduced in BiH/RS by the 2013 Law on Renewable Energy Sources and Efficient Co-generation. A two-way meter is allowed for installations up to 50 kW and a producer is entitled to consume electricity produced on site. Any surplus is not the subject of any remuneration. Due to tax concerns raised by the tax authority of BiH/RS, however, any new development of net metering in the entity has been temporarily halted (Muratovic, 2016). In addition, electricity prices are relatively low in Bosnia and Herzegovina, which means that net metering investments have a long payback time.

4.3 Bulgaria

Current status

Imports cover more than 70% of Bulgaria's gross energy demand. This dependency on imported natural gas and crude oil has a traditional single origin – the Russian Federation. In addition, the country relies entirely on Russian imports for its nuclear fuel (Government of Bulgaria, 2011)[21]. Against this background, however, Bulgaria has made significant steps in diversifying its energy system and expanding its use of renewables.

The country's electricity consumption more than doubled between 2005 and 2014, but is expected to stabilise by 2020. Bulgaria has already achieved its 2020 overall renewable energy target of 16%, primarily because of a higher than expected expansion of renewables in the heating and cooling sector. An important solar PV and wind boom also contributed to this. As a result, and in the interest of reducing renewable energy support costs and stabilising household electricity prices, Bulgaria now grants almost no support to renewables.

21 Eurostat, however, considers nuclear energy as indigenous energy source.

The largest solar PV capacity increase took place between 2011 and 2012, when high support levels were available. Some 843 MW were installed during this short timeframe (BPVA, 2016). This investment hype was caused by decreasing technology costs and an initially generous and non-capped FIT. Regarding wind energy, Bulgaria was equally perceived as a highly attractive, emerging market, due to a generous FIT system. As a result, by 2014, 700 MW of wind generation had been installed.

These developments, however, revealed problems in the inadequately designed and subsidised energy market, which led to a raising of electricity prices. An increase of 14% caused public resistance, ultimately leading to the resignation of the government (Toshkin, 2016). The strong limitation of support for renewables has led to a standstill over investments since 2012.

Table 4.5: Renewable energy source deployment in Bulgaria

Renewable energy shares [%] in	2009	2014	2020 (NREAP)
Gross final energy consumption (GFEC)	9.4	18	16
Electricity consumption	8.4	18.9	20.8

Based on Energy Community, Eurostat and NREAP

Cost-competitive renewable energy potential

Bulgaria already has significant additional cost-competitive renewable energy potential, in particular in the wind sector (up to 18 GW). Solar PV could provide slightly over 6 GW of capacity, which is six times today's already tapped potential (Figure 4.7 and Figure 4.8). Moreover, biomass (up to 1 GW) and hydro (1.6 GW) are also considered interesting investment options.

Hydropower is still the cheapest renewable energy option in Bulgaria, but the average LCOE is higher than in other SEE countries. While wind is already attractive, with LCOEs below EUR 60/MWh in the most suitable locations (Figure 4.9), solar PV can be deployed today at a cost slightly above EUR 70/MWh in the low cost of capital scenario.

Figure 4.7: Cost-competitive solar PV potential in Bulgaria in 2016

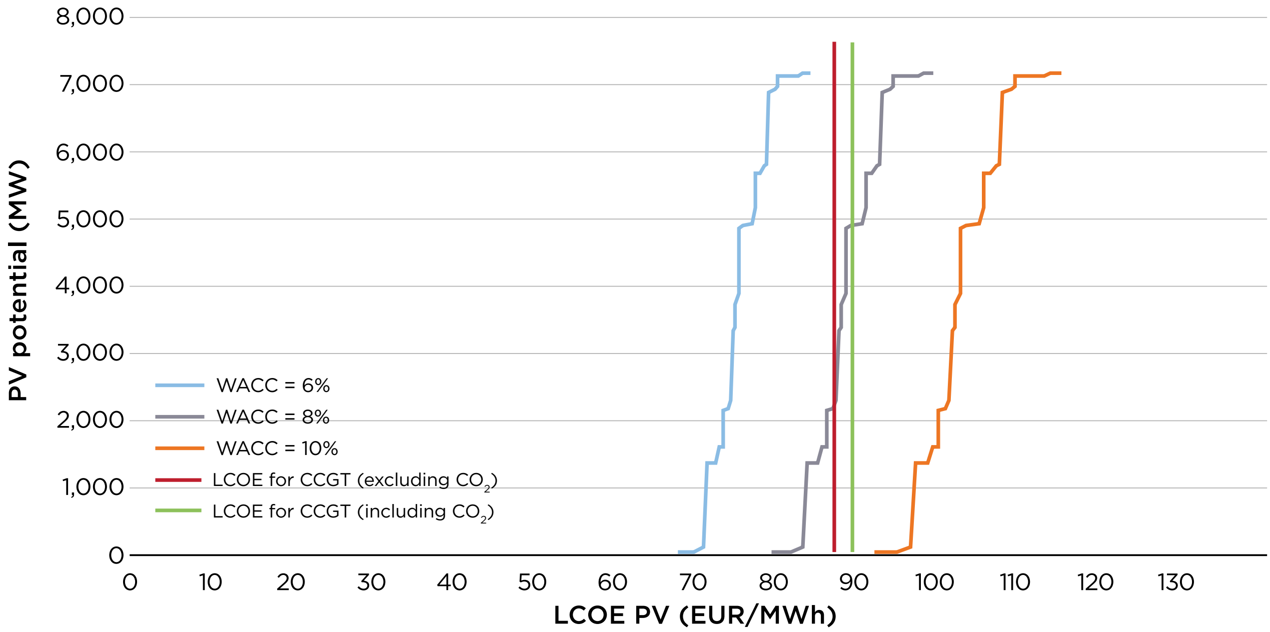


Figure 4.8: Cost-competitive wind potential in Bulgaria in 2016

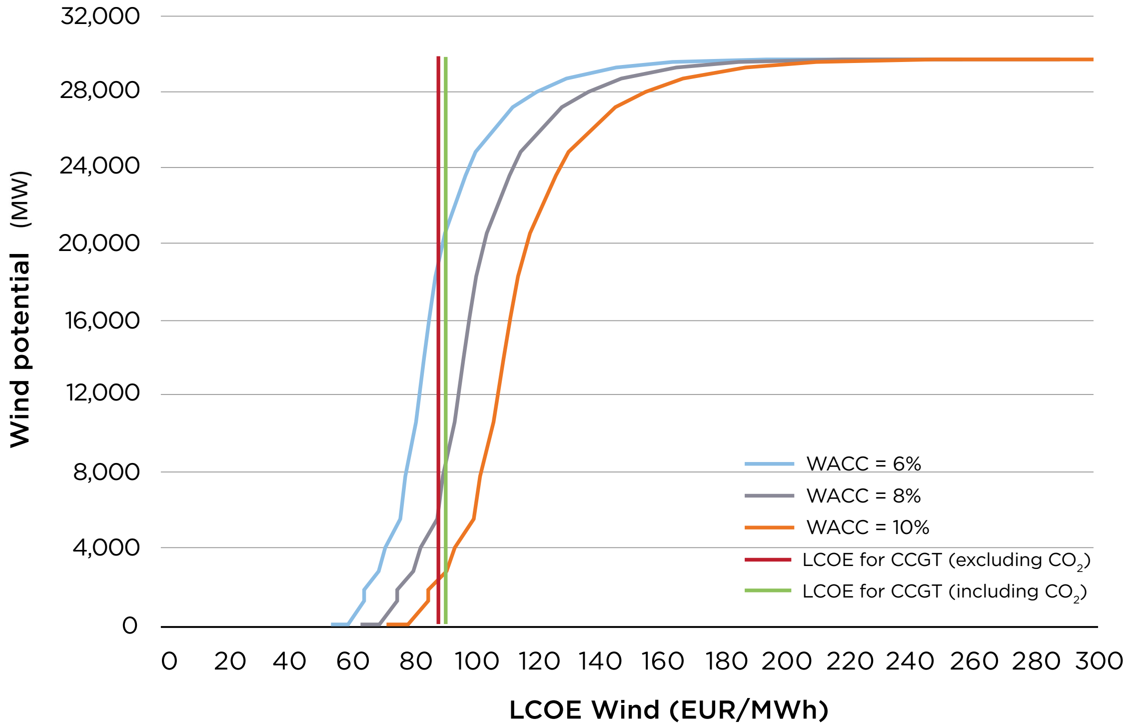


Figure 4.9: LCOE ranges and weighted averages of renewable energy technologies in Bulgaria (medium cost of capital)

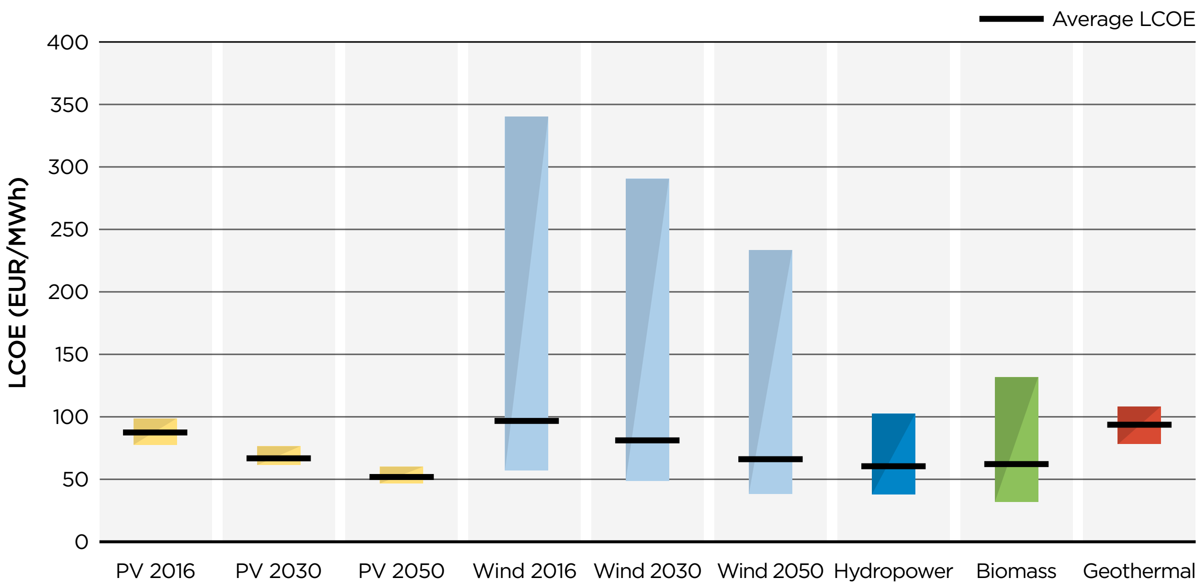


Table 4.6: Potential for renewable-based electricity in Bulgaria

Technologies	2009	2015		2020 (NREAP)	Additional cost-competitive potential			Technical potential	
	MW	MW	GWh	MW		MW	GWh	MW	GWh
Solar PV	0.0	1,032.0	1,260.3	303.0	2016	0 – 6,097.0	7,129,0	7,129.0	10,129.7
					2030	6,097.0	8,869.4		
					2050	6,097.0	8,869.4		
Wind	8.0	700.0	1,301.0	1,440.0	2016	1,818.5 – 17,985.2	29,804.6	29,804.6	52,851.4
					2030	22,829.0 – 27,227.8	43,254.9 – 49,522.6		
					2050	28,211.0 – 28,976.9	50,689.6 – 51,456.0		
Hydro	2,915.0	3,221.6	3,421.3	3,288.0		1,661.4	4,751.0	9,022.0	13,353.0
≤ 10 MW	199.0	333.6	796.3	322.0		81.4	385.0	731.0	1,745.0
> 10 MW	1,852.0	1,875.0	2,625.0	2,102.0		1,580.0	4,366.0	8,291.0	11,608.0
Pumping	864.0	864.0 (pure) 149.0 (mixed)	0.0	864.0		n.a	n.a	n.a	n.a
Biomass	0.0	40.0	201.0	158.0		64.0 – 1,056.0	338.0 – 5,799.0	1,193.0	6,290.0
Biogas	0.0	10.0	62.0	65.0		64.0 -360.0	338.0 – 1,938.0	370.0	2,000.0
Solid Biomass	0.0	30.0	139.0	93.0		0.0 – 696.0	0.0 – 3,861.0	726.0	4,000.0
Biowaste	0.0	0.0	0.0	0.0		0.0	0.0	97.0	290.0
Geothermal el.	0.0	0.0	0.0	0.0		0.0 – 200.0	0.0 – 1,400.0	200.0	1,400.0
Total (2016)	2,923.0	4,993.6	6,183.3	5,189.0	2016	3,543.9 – 26,999.6	9,791.2 – 56,140.7	47,348.6	84,024.1

Note: The lower values of the ranges of the additional cost-competitive potential represent the high cost of capital scenario, while the upper values represent the low cost of capital scenario.

Based on Energy Community and NREAP

Investment framework for renewable energy

After a period with an attractive support system in place, for wind and solar PV in particular, major amendments to the legal framework were introduced after 2011. These included a reduction in the support period for solar PV (from 25 to 20 years) and wind (from 15 to 12 years). In addition, an applicable tariff is fixed on the date on which a plant is put into operation. This has had a significant impact on investors, as the level of FIT granted for new installations is to be reviewed once a year, decreasing the level of long-term certainty. Moreover, some of the adjustments retroactively affected the effective PPAs (BPVA, 2016). As a consequence, investments in wind power stopped in 2011, while solar PV has become increasingly unattractive.

From September 2012 to June 2013, the owners of all renewable energy power plants commissioned between 2010 and 2012 were required to pay a grid access fee. Depending on the commissioning date, the equivalent of up to 39% of the FIT had to be paid to the grid operators for nine months, leading to further investment uncertainty. Furthermore, in 2014, a fee of 20% of the monthly revenue, and a limitation of the production hours for which the preferential price could be received, were imposed on wind and solar PV energy producers. Eventually, the 20% fee was declared illegal, but no compensation has been provided to renewable electricity producers, according to the Bulgarian Photovoltaic Association (BPVA, 2016).

After 2015, the government limited support to biomass and small-scale installations of up to 30 kW on buildings, only (IEA/IRENA, 2016). In particular, the early achievement of the 2020 renewables target, and the aim to reduce household energy prices, led to this broad phase-out of renewable energy support. In addition, an energy security fund was established into which all electricity producers and electricity traders have to pay 5% of their income. In the future, the fund is expected to compensate renewable energy producers for the difference between the market price and the preferential price. With a fund board consisting of representatives of conventional and renewable producers as well as three ministries (Finance, Environment and Energy), the government is trying to ensure a high level of transparency in spending these resources.

Currently only one off-taker, the state National Electricity Company (NEK), is present, and the electricity price is regulated at slightly below generation costs (Bulgaria has the second-lowest electricity price in the EU). There are, however, several moves being made towards liberalisation of the energy market, including the launch of the Power Exchange in January 2016.

4.4 Croatia

Current status

Electricity in Croatia is almost equally generated from gas, coal and oil-based thermal sources and large hydropower plants. About 2.2 GW of hydropower and 1.8 GW of thermal power plants are currently installed. The contribution of other renewable energy sources (in particular wind) has become visible in the last few years, so that the country has already achieved its 2020 target. Croatia, as with most of the Western Balkan countries, suffers from a high energy-import dependency because of the depletion of its own oil and gas reserves (Tuerk et al., 2013a). In recent years, an increase in imports of electrical energy, petroleum products and natural gas has occurred, while from 2005 to 2015, electricity demand increased significantly and is expected to rise still further.

With the new Law on Renewable Energy and High-efficient Co-generation (adopted in January 2016), the pre-existing feed-in system was abandoned, except for plants of up to 30 kW. A transition to a premium support scheme was also introduced. The development of solar PV under FIT support was stopped at 52 MW and hundreds of megawatts of projects were cancelled. Some 42 MW out of this 52 MW are currently installed and operational, while 10 MW are still in construction. Solar PV for self-consumption in industry is, however, developing without FIT support due to a 40% investment subsidy, which leads to a payback period of less than eight years.

Table 4.7: Renewable energy source deployment in Croatia

Renewable energy shares [%] in	2009	2014	2020 (NREAP)
Gross final energy consumption (GFEC)	12.8	27.9	20
Electricity consumption	33.3	45.3	39

Based on Energy Community, Eurostat and NREAP

Cost-competitive renewable energy potential

Today, Croatia has significant additional cost-competitive wind potential, ranging from 1.9-11.8 GW depending on the cost of capital (Figure 4.11). Solar PV could provide up to 3.2 GW in the low cost of capital scenario (Figure 4.10). There is also room for further development of hydro and, to a lesser extent, biomass and geothermal.

Hydropower potential in Croatia has a wide cost range. Its deployment could also be relatively expensive compared to other SEE countries, as many rivers are already used for power generation (Figure 4.12). While wind is already attractive, with LCOEs below EUR 50/MWh in the most suitable locations (Figure 4.11), solar PV power plants can generate electricity with an LCOE as low as EUR 70/MWh (Figure 4.10) in the low cost of capital scenario.

Figure 4.10: Cost-competitive solar PV potential in Croatia in 2016

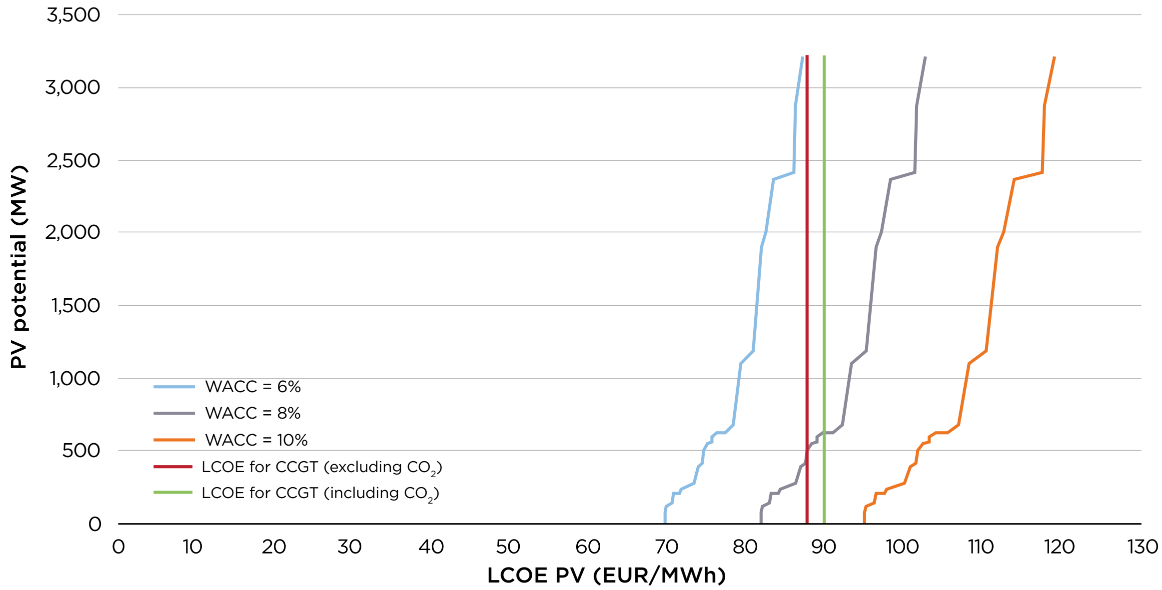


Figure 4.11: Cost-competitive wind potential in Croatia in 2016

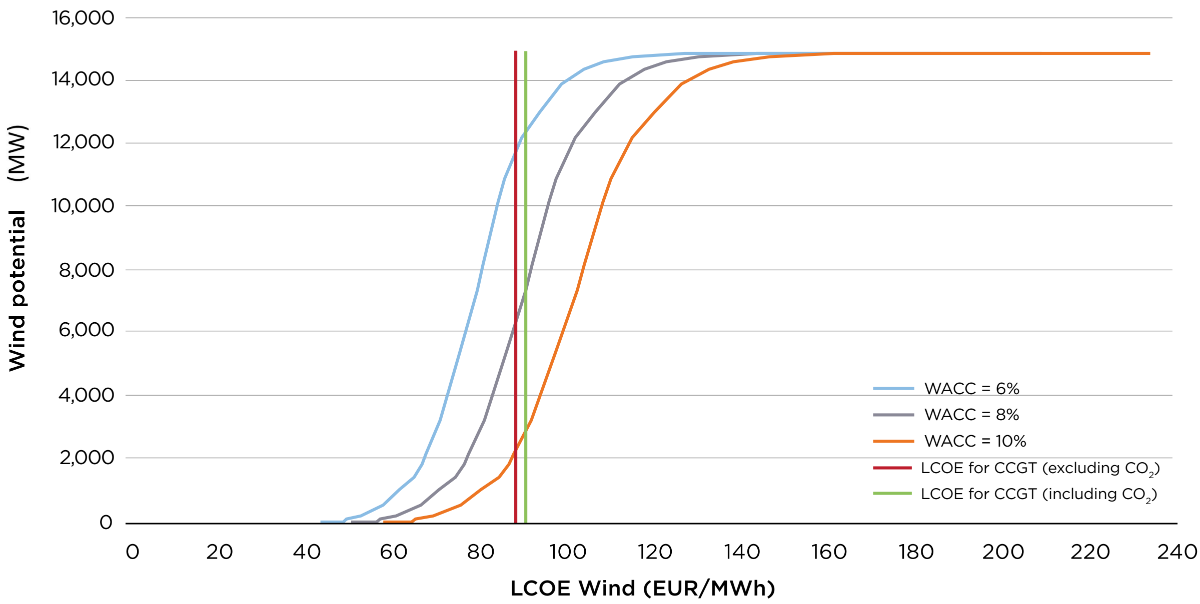


Figure 4.12: LCOE ranges and weighted averages of renewable energy technologies in Croatia (medium cost of capital)

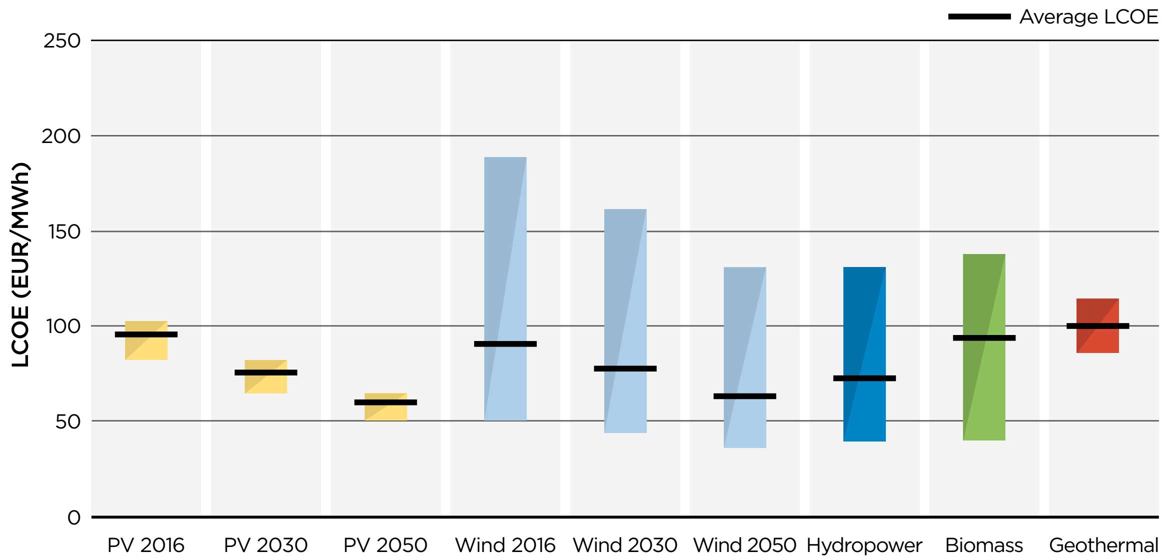


Table 4.8: Potential for renewable-based electricity in Croatia

Technologies	2009	2015		2020 (NREAP)	Additional cost-competitive potential			Technical potential	
	MW	MW	GWh	MW		MW	GWh	MW	GWh
Solar PV	6.0	44.0	46.7	52.0	**2016**	**0 – 3,173.6**	0 - 4,309.1	3,217.6	4,355.8
					2030	**3,173.6**	4,309.1		
					2050	**3,173.6**	4,309.1		
Wind	0.0	422.7	835.4	400.0	**2016**	**1,812.9 – 11,669.6**	4,788.3 – 24,101.4	14,807.4	29,152.8
					2030	**12,549.3 – 14,298.5**	25,570.2– 28,220.0		
					2050	**14,357.1 – 14,384.7**	28,289.4 – 28,317.3		
Hydro	2,082.7	2,195.0	7,020.4	2,456.0		**989.0**	2,527.9	3,316.0	9,400.0
≤ 10 MW	26.7	32.0	96.3	100.0		**n.a**	n.a	281.0	900.0
> 10 MW	2,056.0	2,163.0	6,925.7	2,356.0		**989.0**	2,533.0	3,035.0	8,500.0
Pumping	n.a	293.0	0.0	n.a		**n.a**	n.a	n.a	n.a
Biomass	2.0	51.0	350.6	125.0		**25.8 – 542.0**	151.9 – 3,379.2	930.0	5,743.0
Biogas	0.0	26.4	188.1	40.0		**25.8 – 234.6**	151.9 – 1,511.9	261.0	1,700.0
Solid Biomass	2.0	24.6	153.8	85.0		**0.0 – 307.4**	0.0 – 1,867.3	332.0	2,021.0
Biowaste	0.0	n.a	0.0	n.a		**0.0**	0.0	337.0	2,022.0
Geothermal el.	0.0	0.0	0.0	10.0		**0.0 – 64.0**	0.0 – 450.0	64.0	450.0
Total (2016)	2,090.7	2,712.7	8,253.1	3,043.0	**2016**	**2,834.5 – 16,438.2**	7,468.1 – 34,767.6	22,335.0	49,101.6

Note: The lower values of the ranges of the additional cost-competitive potential represent the high cost of capital scenario, while the upper values represent the low cost of capital scenario.

Based on Energy Community and NREAP

Investment framework for renewable energy

The 2016 Law on Renewable Energy and High-efficient Co-generation introduced several major changes to the support scheme in Croatia, including:

- a FIP to be allocated through an auctioning system and for a predefined quota (maximum cumulative capacity to receive support) for each technology
- a FIT to be maintained for plants of up to 30 kW and allocated through an auctioning system and predefined quota for each technology
- a net metering scheme for prosumers of installations of up to 500 kW, with the calculation of production/consumption on a monthly basis.

Many administrative barriers reported in Croatia are not related to the energy policy framework, but to the construction and environmental legal framework. For example, there is a lack of clear criteria and procedures for construction on state-owned land, which affects not only renewable energy power plants, but all investments. Furthermore, a methodology for calculating the balancing of energy costs is yet to be developed. In addition, to improve investors' confidence, rules for secondary/auxiliary services that clearly determine the necessary costs and division of responsibilities are yet to be designed (Rešćec, 2016).

In the past, the allocation of FIT support was perceived as non-transparent, and trust in the institutions was compromised, with many lawsuits filed (HROTE 2015). The 12 MW quota expansion for solar PV in 2014, for example, was exhausted within a few minutes of opening on a first-come-first-served basis, with 72 MW of solar PV projects rejected, casting doubt over the transparency of the selection process. On the other hand, the PPA for existing projects in the FIT scheme was perceived to be low risk, with generally no complaints from investors. A PPA is signed for 14 years, and existing renewables projects have a preferential producer status that guarantees them priority access to the grid. In addition, the tariff is adjusted for inflation every year.

Regarding net metering, initial calculations indicate that it is not economically viable for private house owners if no additional subsidies are provided. This is due to a large (around 50%) share of non-energy costs. These include grid costs and fees in the electricity price that are not netted and must be fully paid for every kilowatt-hour taken from the grid. In addition, excess energy produced and dispatched to the grid is not fully taken into account but reduced by a factor of 90%. There are energy suppliers, however, that are willing to implement the scheme on a 1:1 basis. In addition, the billing period is one month, which further reduces the economic viability of the scheme, because seasonal variations cannot be compensated. The National Environmental Protection and Energy Efficiency Fund, which already supports industrial and commercial sectors, is expected to grant individuals subsidies for equipment purchase. However, even if this subsidy is equally available for households, it is not sufficient to make household installations economically viable.

4.5 Kosovo*

Current status

Around 98% of Kosovo's electricity is supplied by two lignite power plants (1 171 MW in total). In addition, power is generated by two large and several small HPPs, as well as being imported. Electricity consumption was stable between 2009 and 2014 but is expected to rise by 2020. By the end of 2015, only a marginal amount of solar PV and wind had been deployed. By far the largest share of renewables is based on biomass heating. One additional large HPP (HPP Zhur, 305 MW) is planned, but whether it will be constructed in the near future remains unclear. As a pump storage plant, it could provide an efficient tool to balance the variability of renewables. Kosovo has a 25% binding renewable energy target by 2020 as well as a voluntary target of 29.47%.

Given the developments in Kosovo to date, the deployment levels by 2020 envisaged in the NREAP are expected to be achieved only for SHPPs. If policies are not revised, the development of solar PV and wind will proceed at a much slower pace than anticipated. There are seven wind energy applications in the permitting process with an overall installed capacity of 170 MW. However, whether these are profitable and feasible to implement is questionable, given a range of significant barriers described in this chapter.

Table 4.9: Renewable energy deployment in Kosovo

Renewable energy shares [%] in	2009	2014	2020 (NREAP)
Gross final energy consumption (GFEC)	18.9	19.8	25
Electricity consumption	2.3	2.8	14

Based on Energy Community, Eurostat and NREAP

Cost-competitive renewable energy potential

There is already significant additional cost-competitive solar PV potential (up to 436 MW) that could substantially contribute to Kosovo's energy mix. The large-scale hydro potential mainly consists of the planned Zhur power plant (305 MW), which, however, is relatively expensive. The cost-competitive hydro potential can be provided by SHPPs alone. Kosovo also has significant wind potential, but only a fraction of this is deemed cost-effective due to the mountainous character of the country and wind speeds ranging from only 4-6 m/s in most of the identified suitable areas (Figure 4.14).

The average LCOEs of hydro are rather low, as SHPPs can be implemented in Kosovo at relatively low cost compared to other SEE countries (Figure 4.15). Wind power plants can generate electricity with LCOEs slightly above EUR 60/MWh (Figure 4.14), while solar PV potential could be deployed with an LCOE above EUR 80/MWh in the most suitable locations (Figure 4.13).

**All references to Kosovo in this publication should be understood tbe in the context of United Nations Security Council Resolution 1244 (1999).*

Figure 4.13: Cost-competitive solar PV potential in Kosovo in 2016

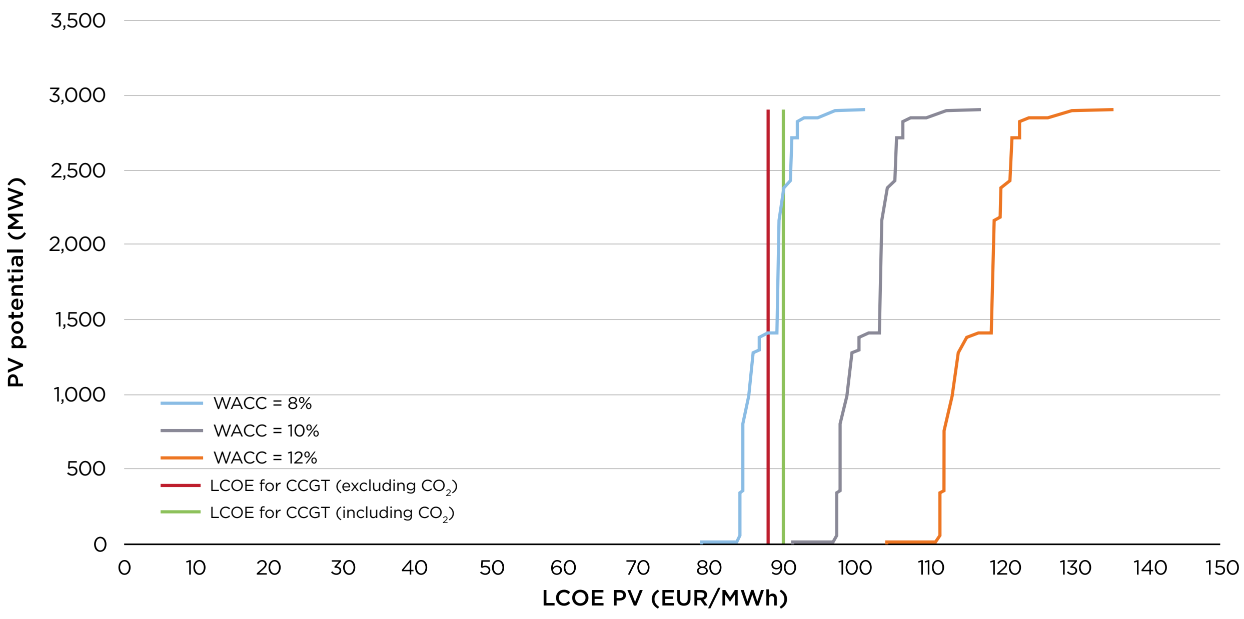


Figure 4.14: Cost-competitive wind potential in Kosovo in 2016

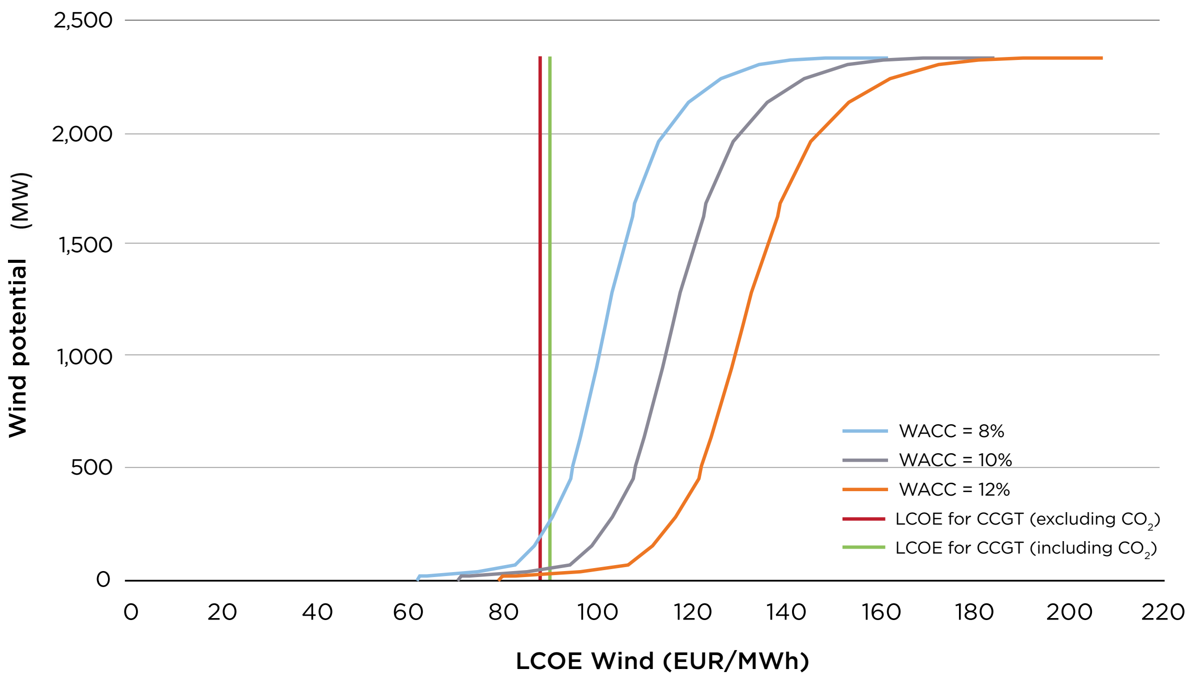


Figure 4.15: LCOE ranges and weighted averages of renewable energy technologies in Kosovo (medium cost of capital)

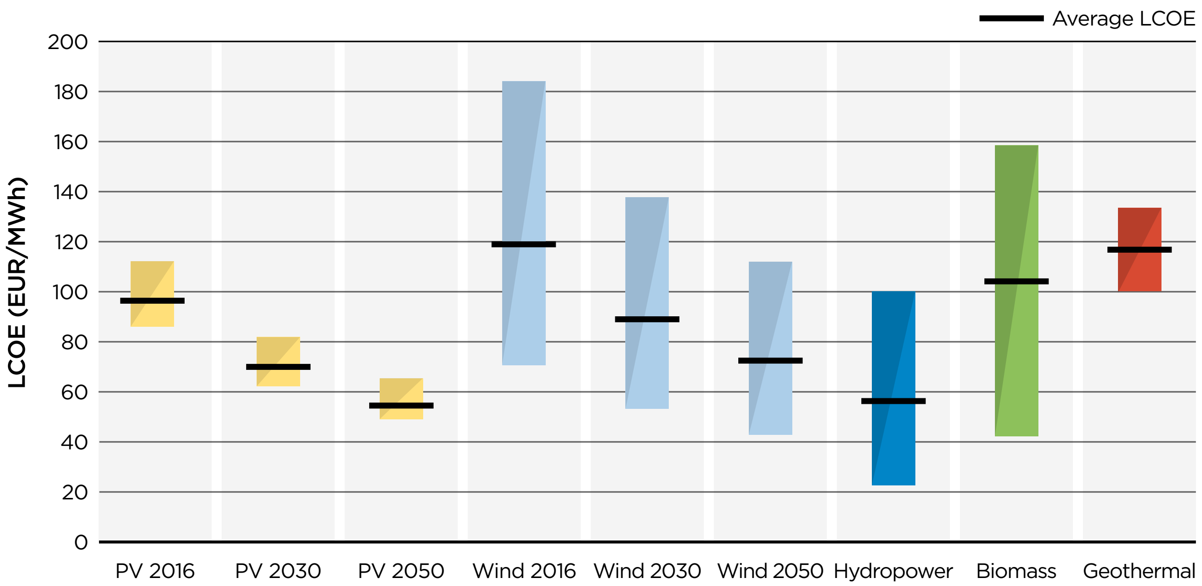


Table 4.10: Potential for renewable-based electricity in Kosovo

Technologies	2009	2015		2020 (NREAP)	Additional cost-competitive potential			Technical potential	
	MW	MW	GWh	MW	MW		GWh	MW	GWh
Solar PV	0.0	0.1	0.0	5.0	**2016**	**0 – 436.2**	0– 627.7	581.3	834.5
					2030	**581.2**	834.5		
					2050	**581.2**	834.5		
Wind	0.0	1.4	0.4	62.2	**2016**	**12.5 – 133.2**	36.2 – 286.6	2,328.8	3,849.5
					2030	**1,671.9 - 2,313.6**	2,909.6 – 3,833.5		
					2050	**2,327.4**	3,849.1		
Hydro	45.8	49.4	166.5	447.8		**137.4**	640.6	494.8	1,348.0
≤ 10 MW	10.8	17.4	58.6	107.8		**137.4**	640.6	144.8	720.0
> 10 MW	35.0	32.0	107.9	340.0		**0.0**	0.0	350.0	528.0
Pumping	n.a	n.a	n.a	n.a		**n.a**	n.a	350.0	528.0
Biomass	0.0	0.0	0.0	5.0		**14.0 - 36.0**	84.2 – 240.3	115.0	715.0
Biogas	0.0	0.0	0.0	5.0		**14.0 - 21.0**	84.2 - 126.3	70.0	421.0
Solid Biomass	0.0	0.0	0.0	0.0		**0.0 – 15.0**	0.0 – 114.0	15.0	114.0
Biowaste	0.0	0.0	0.0	0.0		**0.0**	0.0	30.0	180.0
Geothermal el.	0.0	0.0	0.0	0.0		**0.0**	0.0	n.a	n.a
Total (2016)	45.8	50.9	166.9	520.0	**2016**	**163.9 – 742.8**	761.0 – 1,795.2	3,519.9	6,747.0

Note: The lower values of the ranges of the additional cost-competitive potential represent the high cost of capital scenario, while the upper values represent the low cost of capital scenario.

Based on Energy Community and NREAP

Investment framework for renewable energy

The current support scheme for renewables in Kosovo includes a FIT for SHPPs of up to 10 MW, biomass, biogas, wind and solar PV. As of May 2016, the Energy Regulatory Office had fixed solar and wind FITs for 12-year terms (Kittner et al., 2016), while other RETs were able to benefit from FITs for 10-year terms. For solar PV, however, a capacity cap of 10 MW remained.

Due to higher capital investments for additional infrastructure needs (such as access roads to hilltops) and unattractive capital costs, the FIT for wind (EUR 85/MWh) provides a payback period of 12-13 years, according to investors. The previous support period of ten years was considered insufficient and made investment in wind energy economically unattractive and risky. In addition, a 10% tariff on imported wind turbines is being applied, although there has been discussion regarding abandoning this tax (Schneeberger, 2016). Solar PV panels, in contrast, are exempt from this import tariff (Azemi, 2016).

The investment framework in Kosovo is characterised by long administrative procedures. Obtaining all the necessary permits typically takes between one and two years. This process requires engagement with up to eight institutions, each with 10-15 criteria that have to be fulfilled (Sfishta, 2016). In 2016, the United States Agency for International Development (USAID) launched an initiative to create a one-stop-shop for renewables, aiming to address these issues. The institution that was established, however, does not seem to have an executive or legal role, but rather is intended to serve as an information desk (Sfishta, 2016).

Previous controversies over granting a final PPA have caused uncertainty among stakeholders. A 1.35 MW wind park near Prishtina International Airport has been in operation since 2010, according to official registries, but disputes surrounded its commissioning because old wind turbines were installed (Azemi, 2016). Since the legal regulations were not precise enough in this regard, a final project PPA was denied after construction, and several years were needed to reach an agreement with an investor to sell electricity under a lower support level (Azemi, 2016).

The recent amendments to the PPA authorisation process, however, enable investors to sign the final PPA at the moment of receiving the preliminary authorisation, guaranteeing at the same time the applicable FIT (Veum et al., 2015). This significantly decreases the risk when securing financing. At the same time, however, the transmission grid is considered to be insufficiently developed, making it hard to connect projects that are distant from the main lines. Investors are also responsible for bearing the connection costs (Azemi, 2016).

4.6 Montenegro

Current status

Montenegro's electricity generation is mainly provided by hydropower (658 MW), with Piva and Perućica the HPPs playing the most important roles. There is also a coal-based thermal power plant (TPP) at Pljevlja (218.5 MW).

Montenegro recently retrospectively changed its statistical record on solid biomass consumption in the heating and cooling sector. This has had a significant impact on data concerning previous overall renewable energy consumption. In 2014, for example, the country reported a 44.9% share of renewables in GFEC, thus overachieving its 33% target for 2020. With the revised data, however, Montenegro had already exceeded its renewables target by 2009, a year that constituted a baseline in the process of setting up the original 33% target (Energy Community, 2016). In order to clarify the situation, in March 2016, the government introduced a moratorium until the end of 2016 on new concessions to build renewable energy power plants.

Montenegro is a country where small hydro is considered a success, with over 18 MW installed by 2015. There are also two wind power plants in the development phase, including Krnovo (72 MW) and Možura (46 MW), for which concessions and PPAs have already been signed. They are expected to be commissioned in early 2017 and in 2018, respectively. These two power plants will most likely be the only ones to be built in Montenegro before 2020, although the NREAP (2013) envisions an expansion to 150 MW by that date.

Table 4.11: Renewable energy deployment in Montenegro

Renewable energy shares [%] in	2009	2014	2020 (NREAP)
Gross final energy consumption (GFEC)	26.3	44.9	33
Electricity consumption	44.4	53.4	51.4

Based on Energy Community, Eurostat and NREAP

Cost-competitive renewable energy potential

Montenegro has significant additional cost-competitive hydro potential (1.3 GW), the deployment of which may be limited, however, due to environmental protection requirements. Solar PV and wind can also be considered interesting investment options for the country. In the low cost of capital scenario, they can provide additional cost-competitive capacity of up to 300 MW of solar and 1.7 GW of wind (Figure 4.16 and Figure 4.17). This is significantly higher than the deployment levels by 2020 foreseen in the NREAP. Regarding wind energy, the most interesting locations with relatively high wind speeds are the coastal areas and the hills around Nikšić.

Figure 4.16: Cost-competitive solar PV potential in Montenegro in 2016

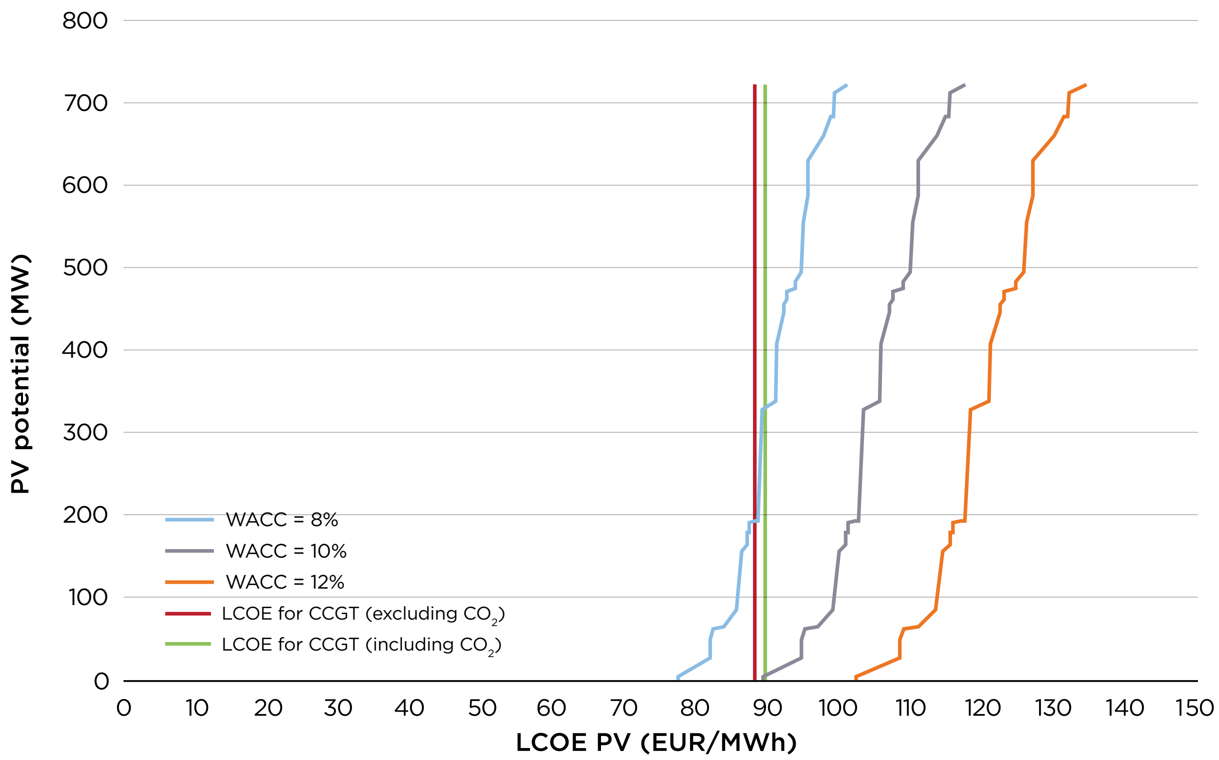


Figure 4.17: Cost-competitive wind potential in Montenegro in 2016

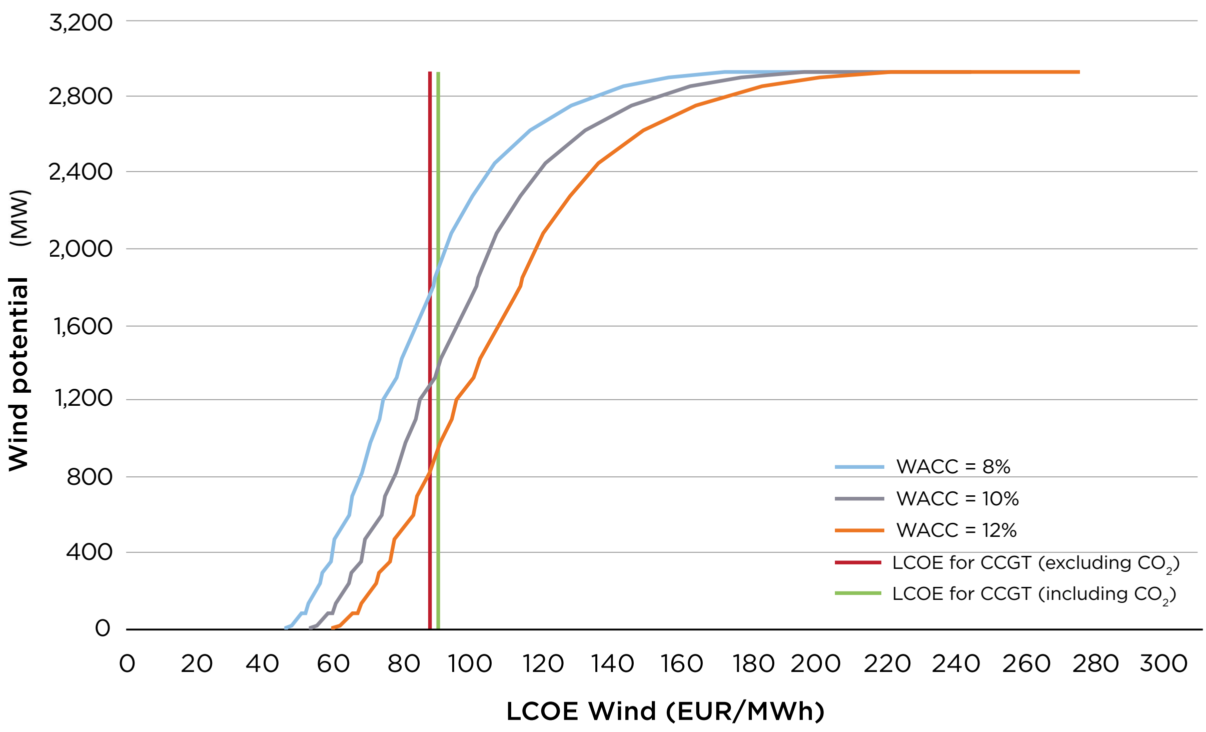


Figure 4.9: LCOE ranges and weighted averages of renewable energy technologies in Montenegro (medium cost of capital)

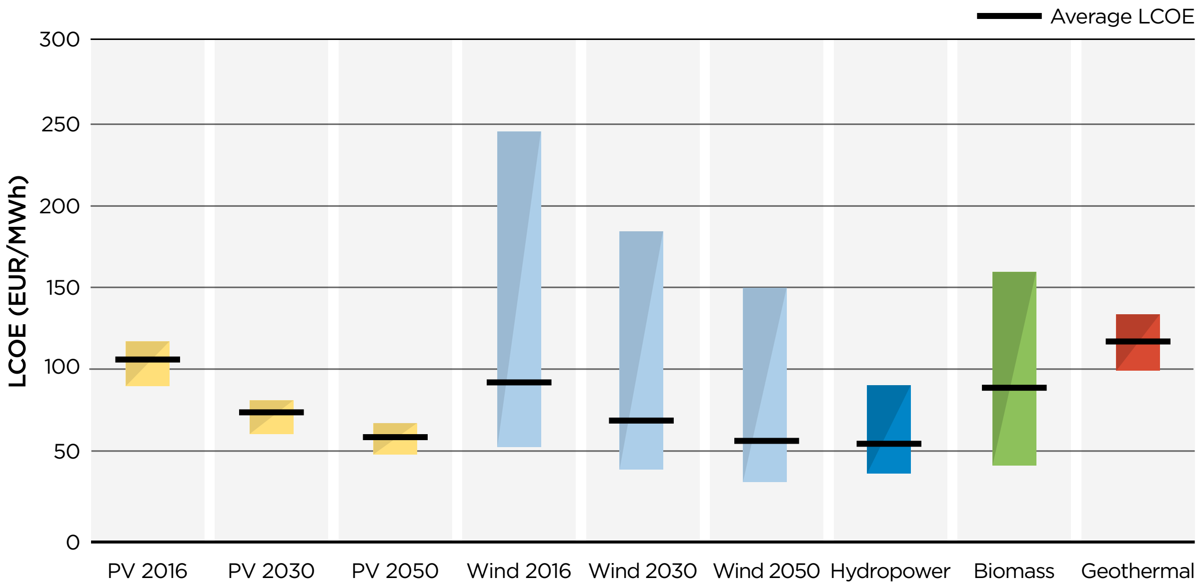


Table 4.12: Potential for renewable-based electricity in Montenegro

Technologies	2009	2015		2020 (NREAP)	Additional cost-competitive potential			Technical potential	
	MW	MW	GWh	MW	MW		GWh	MW	GWh
Solar PV	0.0	0.0	0.0	10.0	**2016**	**0.0 – 330.1**	0 – 491.1	722.5	1,075.8
					2030	**722.5**	1,075.8		
					2050	**722.5**	1,075.8		
Wind	0.0	0.0	0.0	151.2	**2016**	**941.9 - 1,725.0**	2,720.7 – 4.477,4	2,936.0	6,480.9
					2030	**2,456.4 – 2,804.9**	5,826.7 – 6,336.3		
					2050	**2,904.9 -2,929.1**	6,452.1 – 6,475.4		
Hydro	635.7	668.0	1,782.7	826.0		**1,296.0**	2,857.9	2,040.0	5,022.0
≤ 10 MW	8.7	18.8	50.2	97.5		**87.2**	269.6	140.0	400.0
> 10 MW	627	649.0	1,732.0	728.5		**1,209.0**	2,579.1	1,900.0	4,622.0
Pumping	0.0	0.0	0.0	n.a		**n.a**	n.a	n.a	n.a
Biomass	0.0	0.0	0.0	29.3		**17.4 - 123.1**	50.0 - 425.0	198.0	686.0
Biogas	0.0	0.0	0.0	6.9		**17.4 - 26.1**	50.0 - 75.0	87.0	250.0
Solid Biomass	0.0	0.0	0.0	22.4		**0.0 – 97.0**	0.0 – 350.0	97.0	350.0
Biowaste	0.0	0.0	0.0	0.0		**0.0**	0.0	14.0	86.0
Geothermal el.	0.0	0.0	0.0	0.0		**0.0 – 1.4**	0.0 - 10.0	1.4	10.0
Total (2016)	635.7	668.0	1,782.7	1,016.5	**2016**	**2,255.3 – 3,475.6**	5,628.6 – 8,256.4	5,897.9	13,274.7

Note: The lower values of the ranges of the additional cost-competitive potential represent the high cost of capital scenario, while the upper values represent the low cost of capital scenario.

Based on Energy Community and NREAP

Investment framework for renewable energy

A FIT system is currently in place in Montenegro. This applies to all RETs and foresees support for 12 years. In addition, a net metering scheme for plants with a capacity of up to 50 kW was introduced at the beginning of 2016. For solar PV, however, the overall quota is only 10 MW, although net metering for solar PV is likely to be exempted from the quota limitations.

In the net metering scheme, an energy supplier is obliged to off-take all of the excess electricity on a monthly basis. A prosumer pays only for the net amount of energy taken from the grid and corresponding net non-energy costs (grid costs and other fees). Because Montenegro has many hours of sunshine per year, this scheme makes small PV systems very interesting for investors, especially in the tourism sector.

The main obstacles to developing large wind power projects in the country are the land-lease and expropriation procedures. Privately owned plots are very difficult to acquire because the owners are not always known. Along with this, the land registry office lacks documentation on individual plots and no cadastral maps exist (Todorović, 2016). In addition, models of financing renewable energy projects should be taken into consideration as another important hurdle for future renewables expansion, along with the need for better investor awareness of national environmental requirements (Dakovic, 2016).

Yet, according to foreign investors, the PPA in Montenegro offers a stable framework for investment in renewables. Although every producer is a part of the separate balancing group, there is no charge for any deviations in planned production. If there is any kind of delay in payment, the off-taker is obliged to pay default interest for the delay period. Moreover, renewable energy producers can easily switch between participation in the support scheme and presence in the market. They are entitled to sell electricity on the electricity market for a minimum of 12 months, but this period is deducted from the total duration time of their privileged producer status (COTEE, 2016).

4.7 Republic of Moldova

Current status

In the Republic of Moldova, the role of renewable energy in electricity is very limited because power is mainly generated from gas (380 MW). The country is highly dependent on energy imports, with these covering 87% of its energy consumption (AITT, 2014). As the NREAP indicates, the government does not intend to further expand hydropower; instead, wind power plants are expected to provide additional renewable energy capacity. Only a fraction of the wind capacity planned for 2020 had been installed by 2015, however (1.1 MW vs. 149 MW).

Electricity consumption increased by more than 20% from 2009 to 2014 and is expected to rise further. The country is currently implementing a new support scheme for renewables that is based on auctioning.

Table 4.13: Renewable energy deployment in the Republic of Moldova

Renewable energy shares [%] in	2009	2014	2020 (NREAP)
Gross final energy consumption (GFEC)	11.9	14.9	17
Electricity consumption	1.75	1.8	10

Based on Energy Community, Eurostat and NREAP

Cost-competitive renewable energy potential

The Republic of Moldova's renewable energy potential is one of the region's largest. This is particularly true for wind, which could provide up to 20 GW of cost-competitive capacity in the low cost of capital scenario. In addition, over 20% of the country's technical solar PV potential (1 GW) can already be considered an interesting investment option (Figure 4.19 and Figure 4.20). Moreover, the Republic of Moldova has moderate potential for hydro generation, but there are only two major hydropower plants in place. Although there is no intention to significantly expand hydropower in the country, construction of SHHPs (on the Dniester or Prut rivers, for example) could be further investigated. Because there is a lack of planned hydropower projects in the Republic of Moldova, cost estimations for this technology are not available (Figure 4.21).

Figure 4.19: Cost-competitive solar PV potential in the Republic of Moldova in 2016

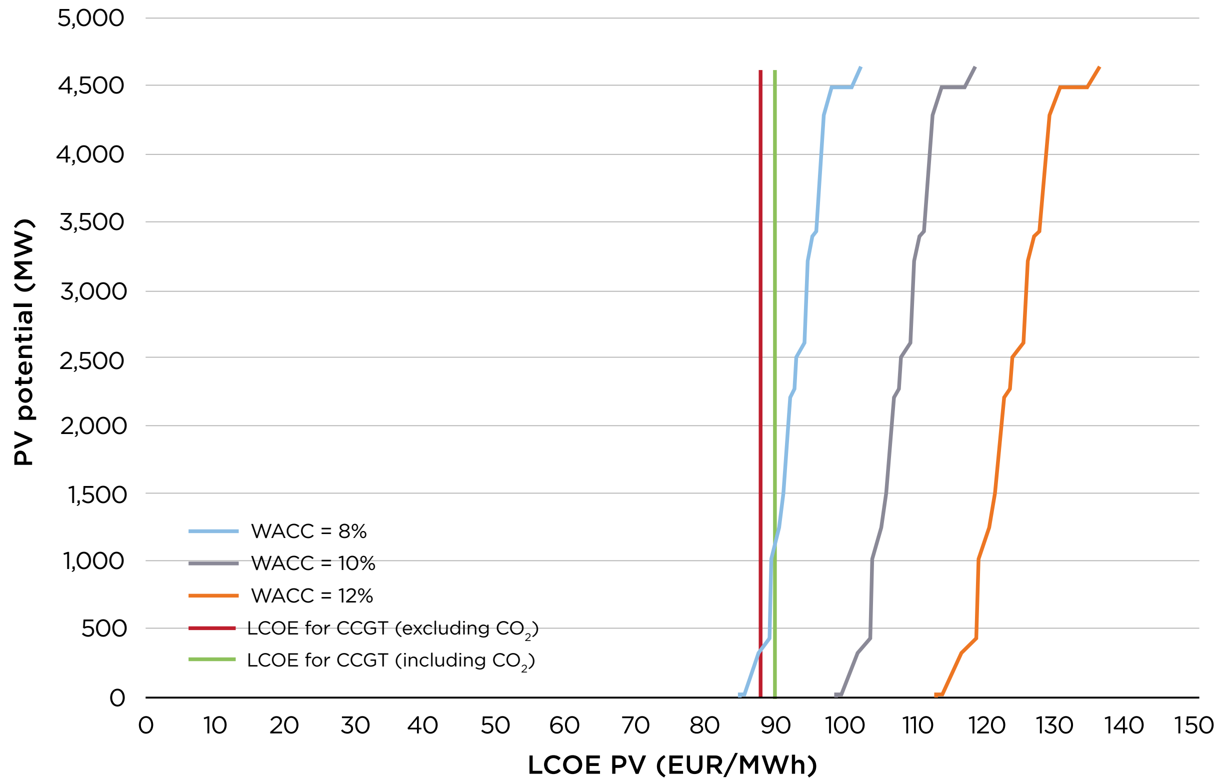


Figure 4.20: Cost-competitive wind potential in the Republic of Moldova in 2016

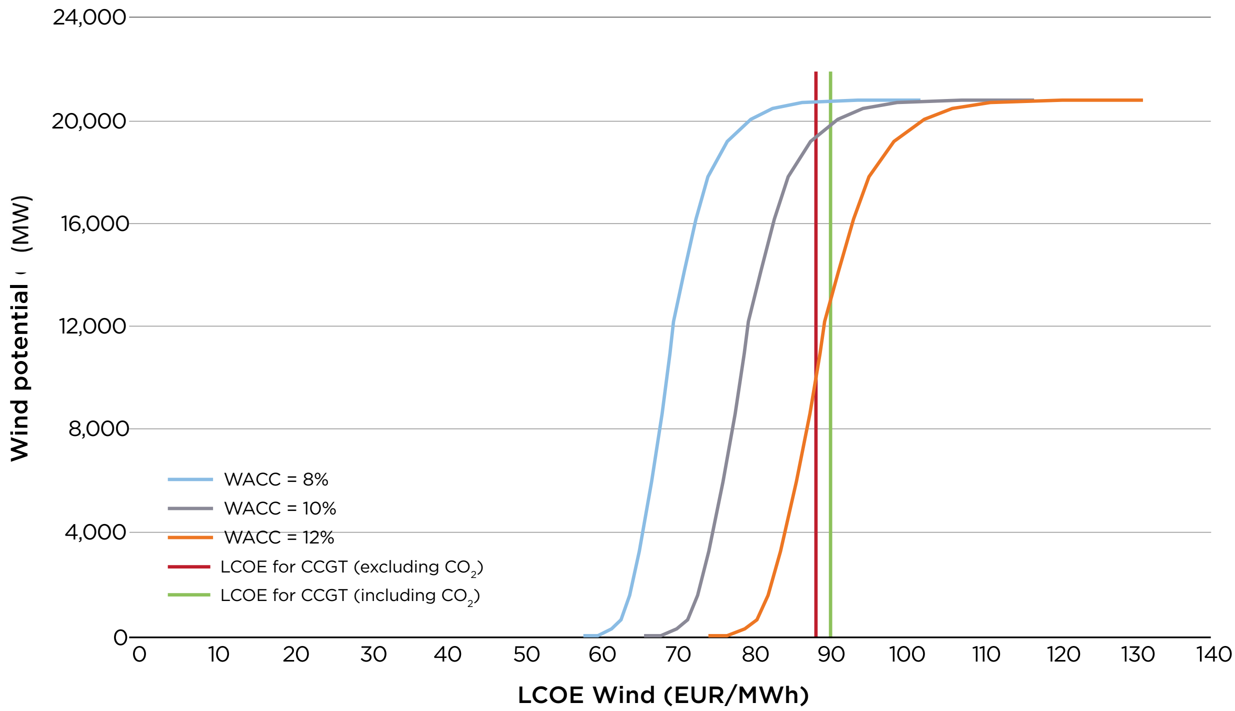


Figure 4.21: LCOE ranges and weighted averages of renewable energy technologies in the Republic of Moldova (medium cost of capital)

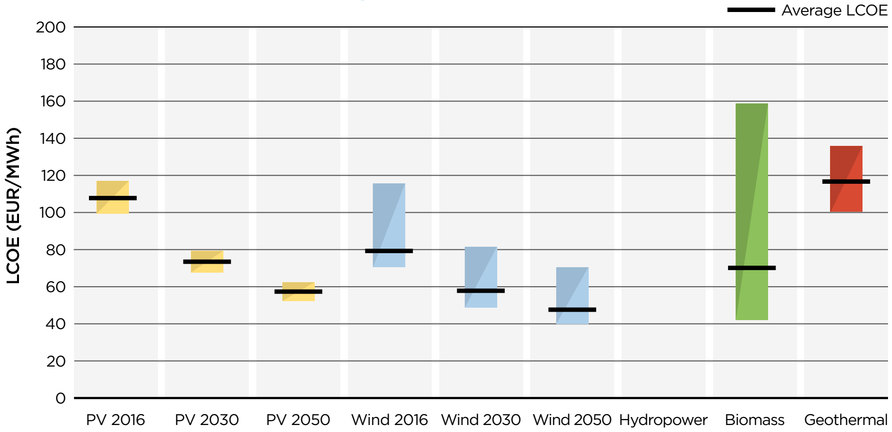


Table 4.14 shows that the Republic of Moldova plans a moderate expansion of wind at a level that is only a fraction of the identified cost-competitive potential in the country. In the low cost of capital scenario, there is an LCOE as low as EUR 60/MWh in the most suitable locations (Figure 4.20).

In addition, there is significant cost-competitive solar PV potential, with an LCOE starting from EUR 85/MWh in the low cost of capital scenario, which is not reflected in government strategies up to 2020.

Table 4.12: Potential for renewable-based electricity in the Republic of Moldova

Technologies	2009	2015		2020 (NREAP)	Additional cost-competitive potential			Technical potential	
	MW	MW	GWh	MW		MW	GWh	MW	GWh
Solar PV	0.0	1.3	0.3	0.0	**2016**	**0 – 1,030.0**	0 – 1,370.2	4,648.0	6,044.0
					2030	**4,646.5**	6,043.6		
					2050	**4,646.5**	6,043.6		
Wind	0.0	1.1	1.5	149.0	**2016**	**11,894.5 – 20,799.0**	29,939.6 – 50,110.5	20,869.1	50,235.7
					2030	**20,868.0**	50,234.2		
					2050	**20,868.0**	50,234.2		
Hydro	11.0	16.0	58.3	16.0		**n.a**	n.a	840.0	3,361.0
≤ 10 MW	0.0	0.0	0.0	0.0		**n.a**	n.a	275.0	1,100.0
> 10 MW	11.0	16.0	58.3	16.0		**n.a**	n.a	565.0	2,261.0
Pumping	n.a	n.a	n.a	n.a		**n.a**	n.a	n.a	n.a
Biomass	0.0	2.8	13.9	10.0		**24.0 - 753.4**	147.2 - 4,810.6	850.0	5,388.0
Biogas	0.0	2.8	13.9	10.0		**24.0 - 34.4**	147.2 - 227.6	134.0	805.0
Solid Biomass	0.0	0.0	0.0	0.0		**0.0 – 716.0**	0.0 – 4,583.0	716.0	4,583.0
Biowaste	0.0	0.0	0.0	0.0		**0.0**	0.0	n.a	n.a
Geothermal el.	0.0	0.0	0.0	0.0		**0.0**	0.0	n.a	n.a
Total (2016)	11.0	21.2	74.0	175.0	**2016**	**11,918.5 – 22,579.4**	30,086.8 – 56,291.3	27,207.1	65,028.7

Note: The lower values of the ranges of the additional cost-competitive potential represent the high cost of capital scenario, while the upper values represent the low cost of capital scenario.

Based on: Energy Community and NREAP.

Investment framework for renewable energy

The current renewable energy legal framework is not considered a favourable instrument for attracting investments. It is based on a methodology of generally applicable tariff calculation, in which producers calculate their own tariffs annually and submit them for approval to the National Agency for Energy Regulation (ANRE). A new law on the promotion of the use of electric energy from renewables, which will introduce a new remuneration system based on tendering, was adopted in 2016 and will enter into force in March 2017.

Pursuant to the new law, two support options for renewables will be in place (Schönherr, 2016). Installations up to 10 kW (subject to confirmation by the ANRE) will be eligible to receive a fixed tariff, the level of which is still to be determined. Larger installations – a concept still to be defined by the government – will have to participate in tenders to receive support.

Furthermore, the new law specifies administrative procedures to remove regulatory and non-regulatory barriers to the development of renewable energy, in line with the Renewable Energy Source Directive. In addition, the ANRE is obliged to develop mandatory clauses for the PPAs. On the basis of these, the central electricity supplier designated by the government will purchase electricity from renewables producers. Several elements of the system, including eligible producers, require further regulation. Whether the new law will be an effective tool to encourage the deployment of renewables remains to be seen (Schönherr, 2016).

4.8 Romania

Current status

The power sector in Romania is almost equally divided between renewable and non-renewable energy producers. The most significant contributor on the one hand is hydro, while fossil fuel power plants (coal, gas and oil) are the largest contributors on the other. The installed capacity of coal power plants is 6.4 GW and gas power plants is 5.6 GW, together amounting to almost 50% of all installed capacity in the country. In addition, there is a nuclear power plant at Cernavodă, with an installed capacity exceeding 1 GW.

Romania achieved its overall 2020 renewable energy source target in 2014. An investment boom in wind and solar energy that lasted until 2013 led to major expansion of renewables capacity. This included the installation of Europe's largest 600 MW onshore wind park. New large hydro plants including pump storage – such as the 1 000 MW Tarnita-Lăpuștești plant – are planned to be built on the Danube.

As a consequence of an unexpected investment boom in the solar PV and wind sectors, several reforms have significantly decreased the economic viability of renewable energy projects and led investors to leave the market. Developments in Romania were also perceived as negative signals for the investment climate in the entire Western Balkan region.

Table 4.15: Renewable energy source deployment in Romania

Renewable energy shares [%] in	2009	2014	2020 (NREAP)
Gross final energy consumption (GFEC)	17.8	24.9	24
Electricity consumption	30.1	41.7	42,6

Based on: Energy Community, Eurostat and NREAP.

Cost-competitive renewable energy potential

Romania has the largest additional cost-competitive solar PV potential in SEE (up to 16.9 GW). The country also possesses enormous technical wind potential (84 GW), out of which up to 50 GW could constitute an interesting investment option in the low cost of capital scenario. Additional developments in biomass and hydropower should also be considered. The total additional cost-competitive renewable energy potential (up to 71 GW) is approximately six times higher than the deployment level today or the level envisaged in the NREAP by 2020 (Table 4.16).

Figure 4.22: Cost-competitive solar PV potential in Romania in 2016

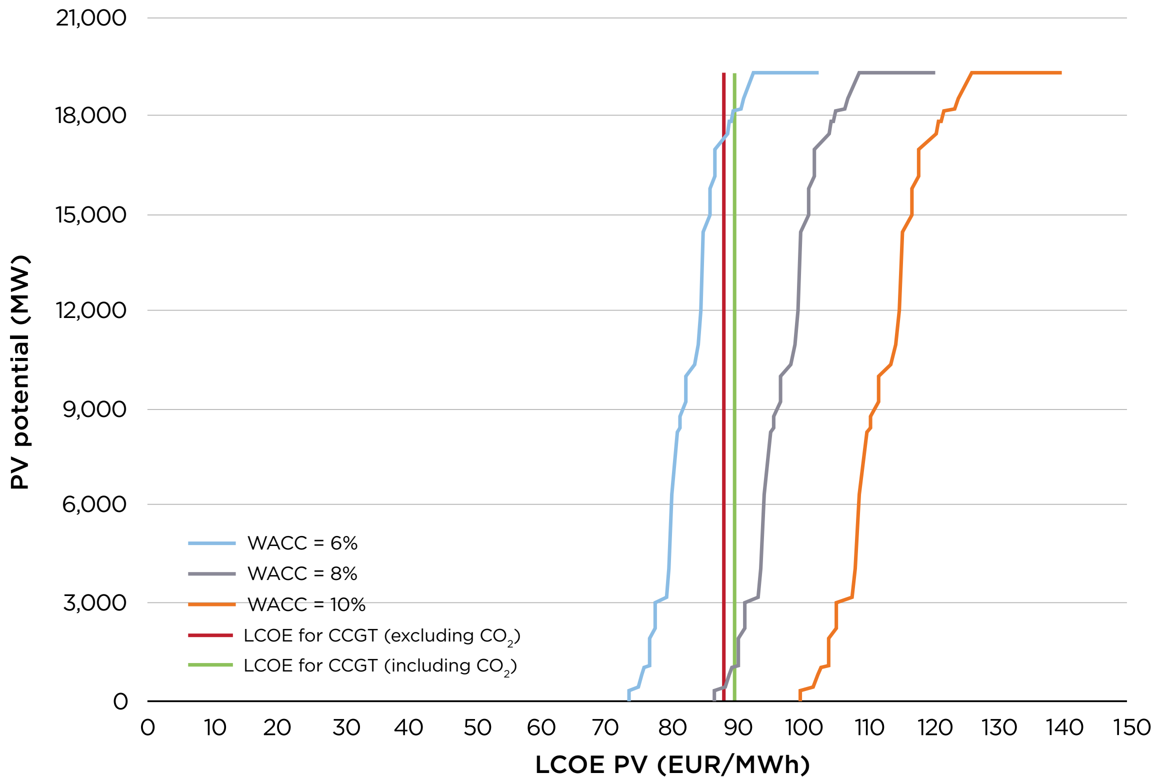


Figure 4.23: Cost-competitive wind potential in Romania in 2016

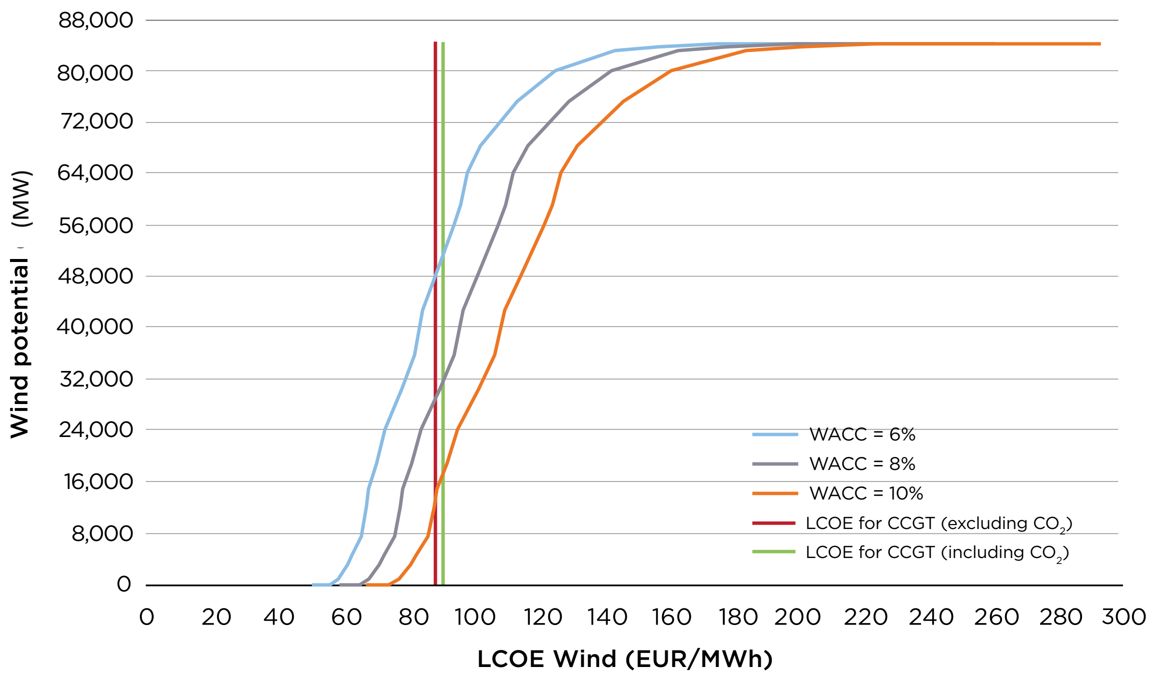


Figure 4.24: LCOE ranges and weighted averages of renewable energy technologies in Romania (medium cost of capital)

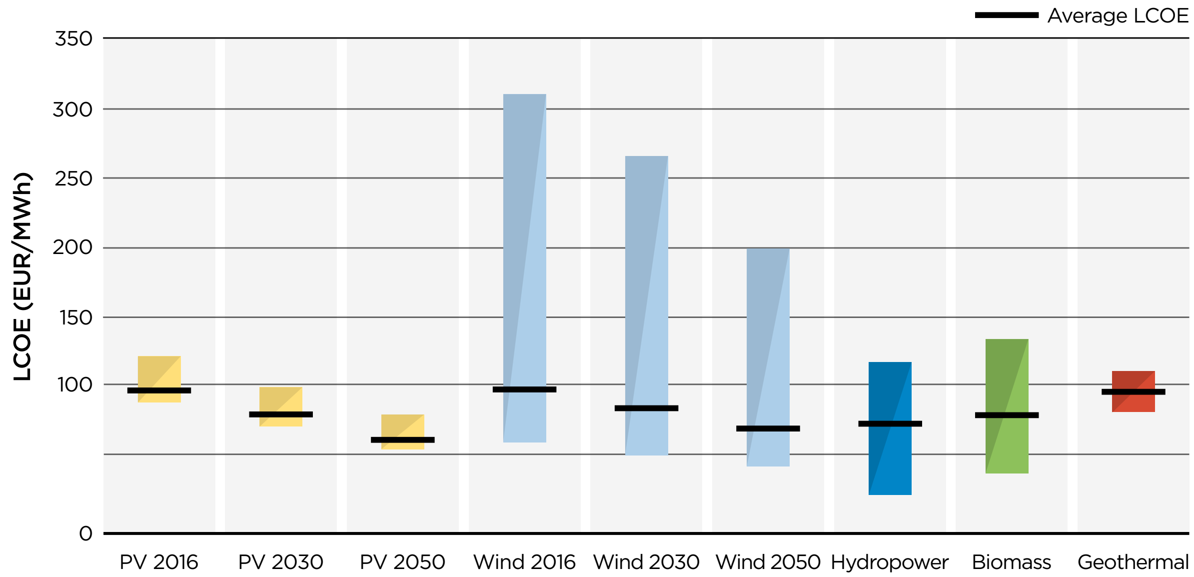


Table 4.16: Potential for renewable-based electricity in Romania

Technologies	2009	2015		2020 (NREAP)	Additional cost-competitive potential			Technical potential	
	MW	MW	GWh	MW		MW	GWh	MW	GWh
Solar PV	0.0	1,301.0	1,626.0	260.0	**2016**	**0.0 – 16,906.6**	0.0 – 22,700.7	19,346.3	25,805.8
					2030	**18,044.1 - 18,045.3**	24,178.3 - 24,179.8		
					2050	**18,045.3**	24,179.8		
Wind	1.3	3,244.0	5,958.0	4,000.0	**2016**	**12,181.0 – 45,974.0**	31,322.0 – 97,266.7	84,193.8	154,033.9
					2030	**53,470.6 – 74,781.2**	109,782.9 – 141,173.6		
					2050	**78,728.0 – 80,801.5**	145,861.4 – 147,962.4		
Hydro	6,289.0	6,613.0	16,127.0	7,729.0		**1,534.0**	3,292.0	15,385.0	38,000.0
≤ 10 MW	325.0	509.0	844.0	729.0		**302.0**	1,040.0	3,218.0	6,000.0
> 10 MW	5,964.0	5,747.0	13,172.0	7,000.0		**1,232.0**	2,252.0	12,167.0	32,000.0
Pumping	0.0	357.0	n.a	0.0		**n.a**	n.a	n.a	n.a
Biomass	0.0	119.3	639.7	600.0		**289.0 – 2,444.7**	1,469.0 – 11,978.6	2,979.0	14,629.0
Biogas	0.0	15.0	51.0	195.0		**289.0 – 1,505.0**	1,469.0 – 7,549.0	1,520.0	7,600.0
Solid Biomass	0.0	104.3	599.4	405.0		**0.0 – 939.7**	0.0 – 4,429.6	1,044.0	5,029.0
Biowaste	n.a	n.a	n.a	n.a		**0.0**	0.0	415.0	2,000.0
Geothermal el.	0.0	0.1	n.a	0.0		**0.0 - 357.0**	0.0 – 2,500.0	357.0	2,500.0
Total (2016)	6,290.3	11,277.4	24,350.7	12,589.0	**2016**	**14,004.0 – 71,216.0**	36,083.0 – 137,873.7	122,261.1	234,968.7

Note: The lower values of the ranges of the additional cost-competitive potential represent the high cost of capital scenario, while the upper values represent the low cost of capital scenario.

Based on: Energy Community and NREAP

Investment framework for renewable energy

A support scheme, namely a quota system and trading of Green Certificates, was introduced in 2004 and became operational in 2010. The mandatory share of annual electricity from renewables was planned to increase from 8.3% to 20% by 2020 (Government of Romania, 2010). Due to a good support system, important investments occurred early on, when the Fântânele-Cogealac Wind Farm, Europe's largest onshore wind farm (600 MW), was developed. Guaranteed access to the grid was originally given for all renewables that qualified for the Green Certificates scheme (Regulatory Authority for Energy, 2011), but this was later subjected to annual caps.

In 2013, as a consequence of the unexpected investment boom in the solar PV and wind sector, renewable energy quotas were reduced from those set in the original plans. This led to a significantly lower demand for Green Certificates and consequently less income for investors. In addition, a series of measures decreased the attractiveness of the market. Amongst others, these included a reduction in the issuance of Green Certificates, the postponement of their allocation and trade limitations (Schönherr, 2014). As a result, several project developers pulled out of the country.

Another important framework condition is that a PPA may be concluded between the renewable power producer and any eligible consumer only after commissioning, provided that they obtain an energy supply license from the Regulatory Authority for Energy, ANRE. The banks usually require the duration of a PPA to be at least five years, but there is no consistent approach in this regard (Bpv Braun Partners, 2012).

Because Romania has no precise regulations regarding smart metering, only a few pilot projects have evolved (Balkan Green Energy News, 2016). According to the NREAP, however, small-scale and decentralised installations up to 1 MW do not require set-up authorisation. If these installations are not integrated into a consumer's electricity system, they are considered to be independent electricity production sites, and a production licence for their owner is necessary.

4.9 Serbia

Current status

The Serbian power sector is dominated by coal-based generation, which has an installed capacity of 3.9 GW. This is complemented by a significant contribution from hydropower plants (2.9 GW) and, to some extent, by 353 MW from gas power plants (Energy Community, 2016). Most of the existing HPPs were developed during Yugoslav times.

Even though Serbia has committed to giving renewables a 27% share in final energy consumption by 2020, only 10.8 MW of solar PV and 5 MW of biomass had been installed by the end of 2015. A significant development is foreseen in the wind sector, as the NREAP assumes its expansion to 500 MW by 2020. Despite the country's plans, however, only 10.4 MW of wind energy had been developed by early 2016, including a 9.9 MW wind farm that was commissioned in November 2015. Lack of a bankable PPA is perceived as the main cause behind slow progress in renewables.

In June 2016, a new PPA model was published, aimed at addressing investor risk perceptions. In addition, a one-stop-shop for construction permits aims to improve administrative procedures, especially in terms of obtaining construction permits. Smaller projects still face problems on the local level, however, in particular concerning land rights. Despite the most recent improvements in the permit procedures and the adopted amendments of the PPA, Serbia might not achieve its 2020 NREAP target, especially for large and small hydro energy (Kalmar, 2016; Opačić, 2016; Jovic, 2016; Djurisic, 2016).

Table 4.17: Renewable energy deployment in Serbia

Renewable energy shares [%] in	2009	2014	2020 (NREAP)
Gross final energy consumption (GFEC)	21.2	23.1	27
Electricity consumption	28.7	32.3	36.6

Based on Energy Community, Eurostat and NREAP

Cost-competitive renewable energy potential

Serbia has significant additional cost-competitive potential for wind (up to 5.6 GW), but this can be realised only if a lower cost of capital is ensured (Figure 4.26). There is also potential for large hydropower plants, mainly located on the Ibar River, the Morava River, the Danube and the Drina River. New pump storage plants could also provide over 3 000 MW, but they are not considered cost-effective in this study. Furthermore, Serbia possesses large solar PV potential (6.9 GW). The deployment of this today could be expensive, but it will become a competitive supply option in forthcoming years (Figure 4.25 and Table 4.18).

Hydropower remains the most cost-competitive RET in Serbia. The LCOEs of solar PV and wind are expected to decrease in the forthcoming years (Figure 4.27), but they currently could be as low as EUR 84/MWh and EUR 60/MWh, respectively, in the most suitable locations (Figure 4.25 and Figure 4.26).

Figure 4.25: Cost-competitive solar PV potential in Serbia in 2016

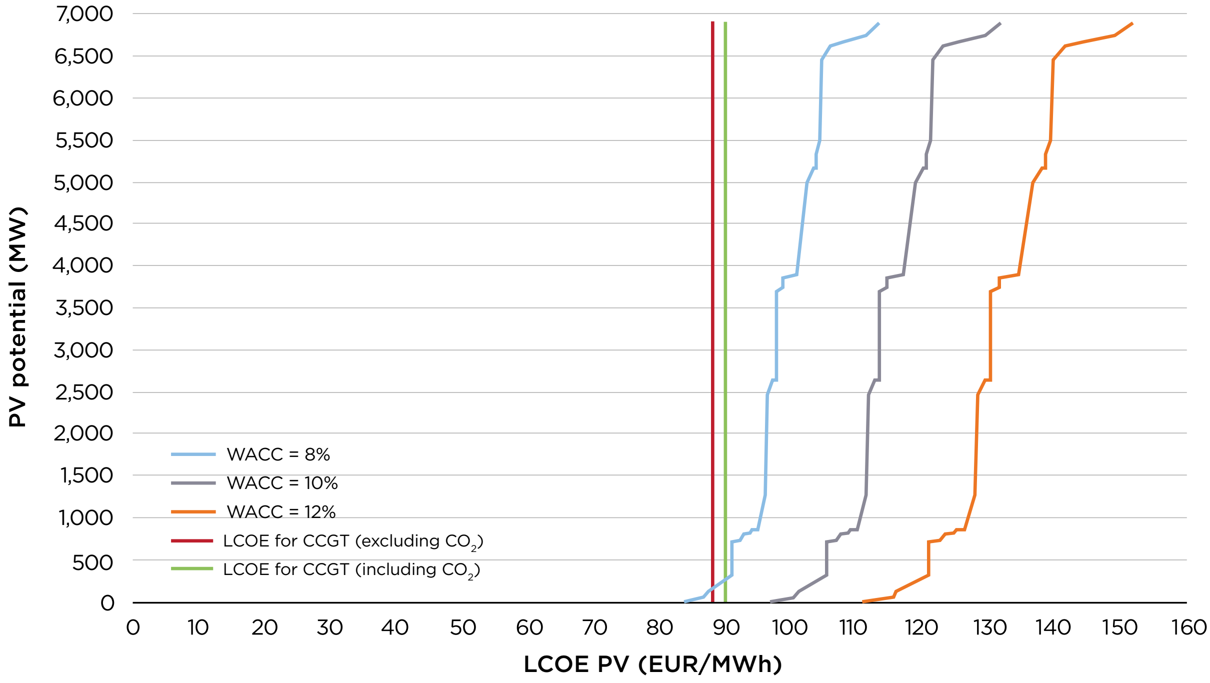


Figure 4.26: Cost-competitive wind potential in Serbia in 2016

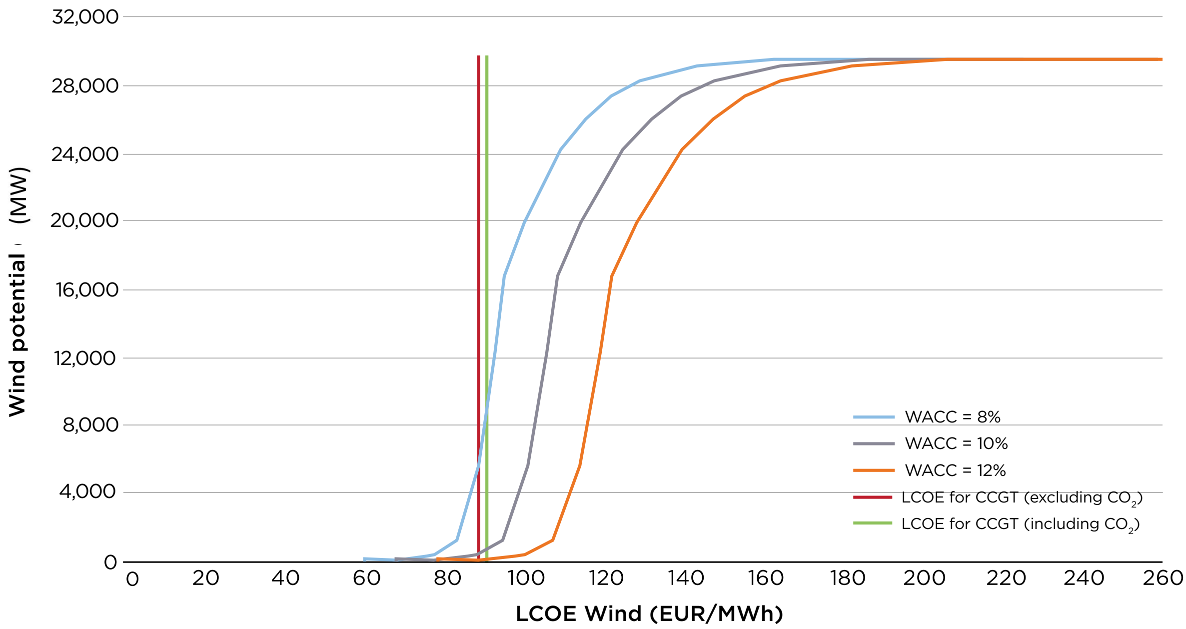


Figure 4.27: LCOE ranges and weighted averages of renewable energy technologies in Serbia (medium cost of capital)

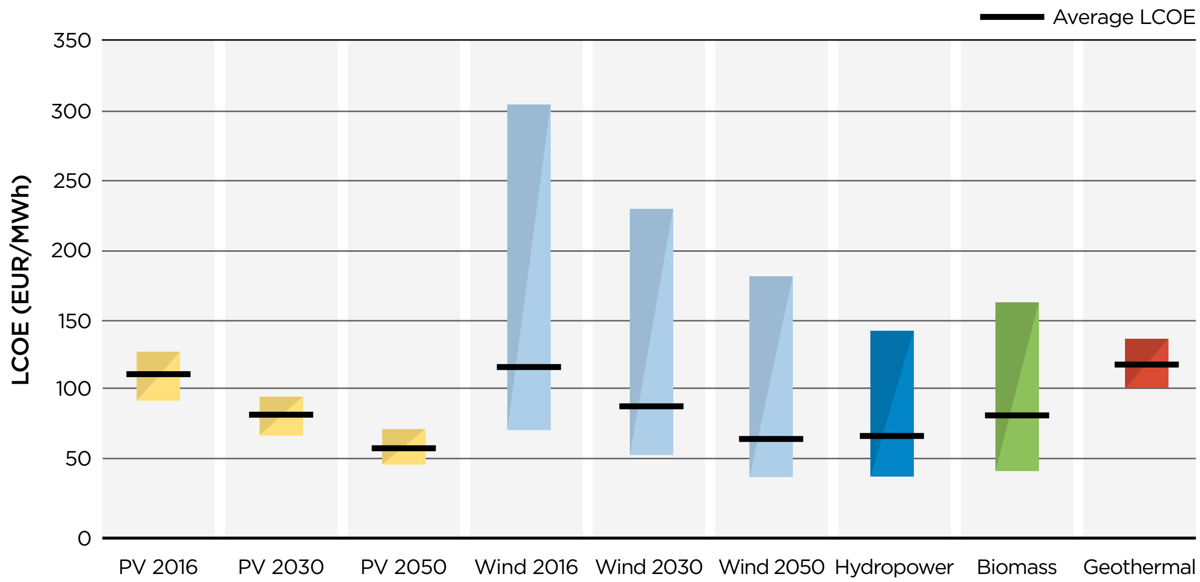


Table 4.18: Potential for renewable-based electricity in Serbia

Technologies	2009	2015		2020 (NREAP)	Additional cost-competitive potential			Technical potential	
	MW	MW	GWh	MW		MW	GWh	MW	GWh
Solar PV	0.0	10.8	9.2	10.0	**2016**	**0 – 165.5**	0.0 – 243.0	6,901.7	9,307.5
					2030	**6,742.3 – 6,890.9**	9,093.3 – 9,298.2		
					2050	**6,890.9**	9,298.2		
Wind	0.0	0.5	0.7	500.0	**2016**	**116.8 – 5,598.9**	305.7 – 11,473.9	29,670.0	52,386.4
					2030	**24,387.6 – 28,748.4**	45,093.7 – 51,362.5		
					2050	**29,455.6 – 29,635.0**	52,187.1 – 52,359.4		
Hydro	2,838.0	2,898.0	11,005.8	3,276.0		**1,152.0**	4,456.1	4,736.0	18,000.0
≤ 10 MW	16.0	63.2	240.0	204.0		**98.0**	401.2	500.0	1,900.0
> 10 MW	2,208.0	2,220.8	20,765.8	2,458.0		**1,054.0**	4,054.9	4,236.0	16,100.0
Pumping	614.0	614.0	0.0	614.0		**n.a**	n.a	n.a	n.a
Biomass	0.0	4.9	21.9	143.0		**129.9-1,194.3**	820.5 - 7,475.7	1,671.0	10,446.0
Biogas	0.0	4.9	21.9	43.0		**129.9-197.3**	820.5 – 1,241.7	674.0	4,212.0
Solid Biomass	0.0	0.0	0.0	100.0		**0.0 - 997.0**	0.0 – 6,234.0	997.0	6,234.0
Biowaste	n.a	n.a	0.0	0.0		**0.0**	0.0	109.0	651.0
Geothermal el.	0.0	0.0	0.0	1.0		**0.0 - 10.0**	0.0 – 70.0	10.0	70.0
Total (2016)	2,224.0	2,914.2	11,037.6	3,316.0	**2016**	**1,398.7 – 8,120.7**	5,582.3 – 23,718.7	42,988.7	90,209.9

Note: The lower values of the ranges of the additional cost-competitive potential represent the high cost of capital scenario, while the upper values represent the low cost of capital scenario.

Based on Energy Community and NREAP

Investment framework for renewable energy

The slow expansion of wind has occurred despite the introduction in November 2009 of a FIT of EUR 92/MWh for a period of 12 years, which investors consider to be sufficient. The other renewable technologies are also entitled to benefit from the support scheme (with technology-specific caps), but the quota for solar PV is capped at the low level of only 10 MW. The main cause behind the slow progress in renewables has been the lack of a bankable PPA. In addition, complex procedures to obtain permits have been noted as a significant obstacle, despite substantial improvements during recent years (Continental Wind Serbia, 2016).

The previous PPA (a new model was adopted in 2016) did not provide enough investor security because it was concluded only after project construction. Moreover, it lacked adequate provisions such as an option for international arbitration and immunity from any retroactive legal changes (Lakovic et al., 2016). Consequently, due to the associated risks, it hampered development of large projects and made financing difficult to secure. Smaller projects are, however, less exposed to these risks. For instance, a recently commissioned wind park, Vetropark Kula d.o.o., received a EUR 10 million loan, despite operating under the previous PPA. This loan was provided with a 6-7% interest rate with a two-year grace period and 10-12-year repayment period (Continental Wind Serbia, 2016).

Larger projects, such as the Continental Wind 158 MW wind park, required greater investor security, so the government designed a new PPA model, which was published in June 2016. This is expected to address the issues of consequences of changes in law, grid failure, arbitration and bankruptcy of an off-taker.

Stakeholder expectations are that the 2020 wind energy target will be reached once a bankable PPA is implemented. In addition, investors have already locked in substantial investments in the preliminary PPA (P-PPA). Obtaining this P-PPA requires an upfront deposit amounting to 2% of the value of the overall investment, which is not returned if the project is terminated. Since 2013, around 800 MW of wind projects have obtained the P-PPA, which indicates that the Serbian wind energy target of 500 MW will most likely be reached. On the other hand, hydro projects are still at the developmental phase, which makes reaching the expected hydro expansion levels for 2020 (small and large) unlikely, according to stakeholders (Continental Wind Serbia, 2016; Kalmar Kranjski Jovic, 2016).

The development of solar PV has not been significantly supported in Serbia. The quota for PV of 10 MW has already been exhausted, mainly by larger investors. A small quota was set due to fears that large amounts of solar PV would push up the electricity price (Continental Wind Serbia, 2016). Furthermore, there is a lack of funds for promoting small-scale private investments, such as solar PV on family houses. Net metering schemes have apparently not been discussed yet because the low, regulated electricity price makes net metering or net billing unviable. In addition, SHHP developers face difficulties at the local level, where assistance from local authorities is lacking.

Complex administrative procedures for obtaining permits have been outlined as an additional significant obstacle, despite substantial improvements during recent years (Continental Wind Serbia, 2016). The 2014 Law on Planning and Construction regulated the creation of a one-stop-shop at the local and national levels. The ministry responsible for construction and local authorities were required to designate a separate organisational unit within their jurisdiction to conduct a unified procedure for issuing the construction permit and other associated permits. The law also established an electronic permit procedure.

These changes came into effect in early 2016 and are supposed to streamline and accelerate the process. Under the previous framework, an investor was responsible for obtaining up to 40 documents from various institutions, and developing a wind project could take as long as four or five years (Opačić, 2016). Moreover, before the law came into effect, an investor was obliged to acquire property at the very beginning of the construction permit process. Because land ownership rights are very complex in Serbia, this had been slowing down project development. Currently, the permit process can be conducted in parallel with property acquisition (Continental Wind Serbia, 2016). There are still doubts, however, over how much the new one-stop-shop will actually improve the situation and whether the e-permit process will work in practice (Opačić, 2016).

4.10 Slovenia

Current status

Slovenia has an electricity production mix consisting of 1.3 GW of large hydro, 0.9 GW of thermal (lignite) and 0.7 GW of nuclear. The production from other sources, such as SHPP and solar PV, is gradually increasing, however, and the country is on track to meet its 2020 target. While the electricity generation mix allows a high degree of self-sufficiency, in recent years, Slovenia has also suffered from a high energy import dependency, in particular of petroleum products and natural gas. Electricity demand rose slightly from 2005 to 2014, but a stronger increase is expected by 2020.

Table 4.19: Renewable energy deployment in Slovenia

Renewable energy shares [%] in	2009	2014	2020 (NREAP)
Gross final energy consumption (GFEC)	16.2	21.9	25
Electricity consumption	28.5	33.9	39.3

Based on Energy Community, Eurostat and NREAP

Cost-competitive renewable energy potential

The largest additional cost-competitive renewable energy potential in Slovenia is constituted by large hydro on several as-yet-unexploited or partially exploited rivers. These include the Sava, the Drava and the Soča rivers. Due to the varied geography, there is limited potential for large-scale solar PV: up to 57 MW could be additionally deployed at present, if low-cost capital were available (Table 4.20). There is also significant technical wind potential, but currently only 434 MW can be harvested in a cost-effective manner (Figure 4.29). Moreover, difficult terrain poses barriers to wood biomass extraction, limiting the country's biomass potential.

In Slovenia, the LCOEs of planned hydropower plants are often rather high, as many rivers are already exploited (Figure 4.30). Both wind and solar PV could be deployed today with LCOEs as low as EUR 75/MWh in the most suitable locations.

Figure 4.28: Cost-competitive solar PV potential in Slovenia in 2016

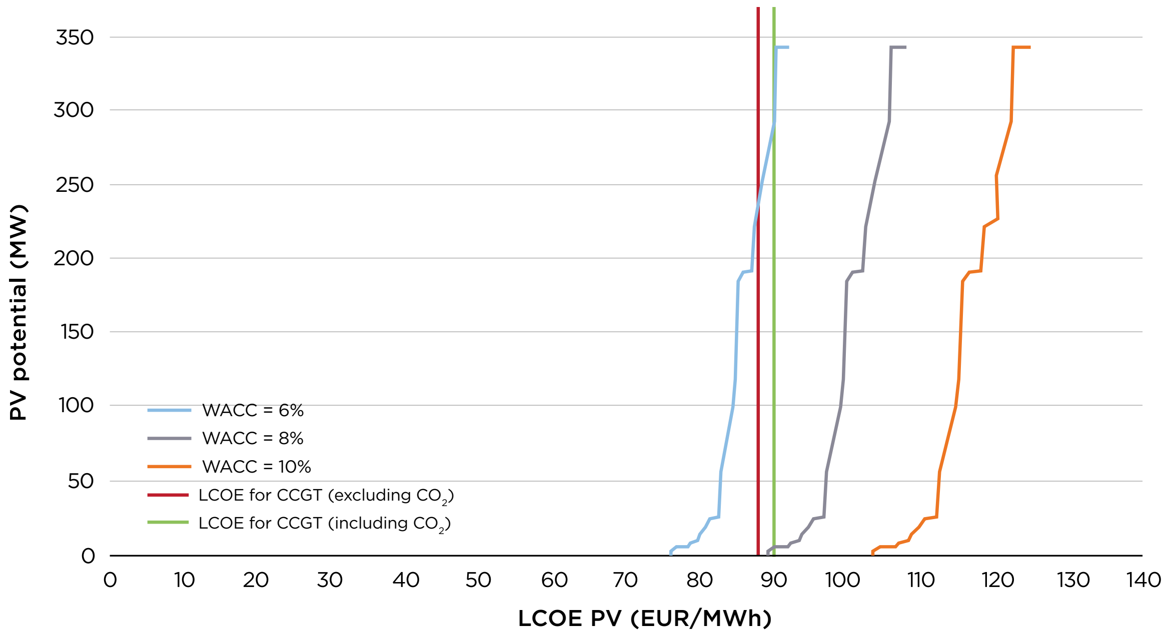


Figure 4.29: Cost-competitive wind potential in Slovenia in 2016

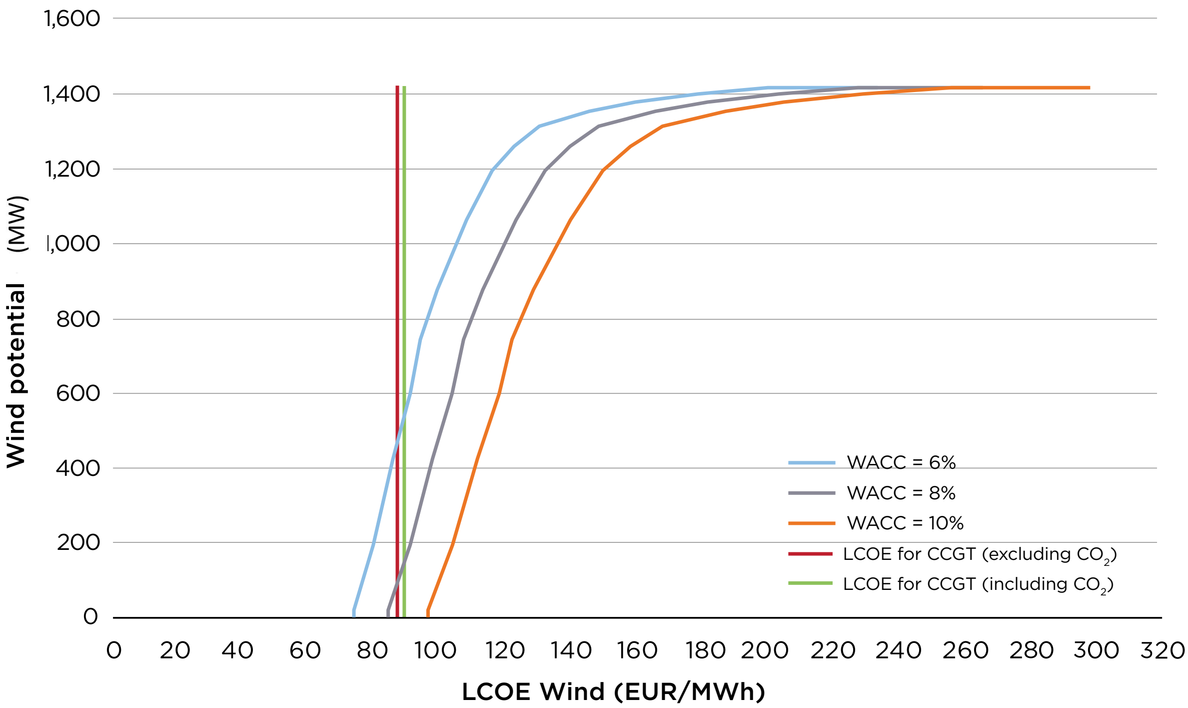


Figure 4.30: LCOE ranges and weighted averages of renewable energy technologies in Slovenia (medium cost of capital)

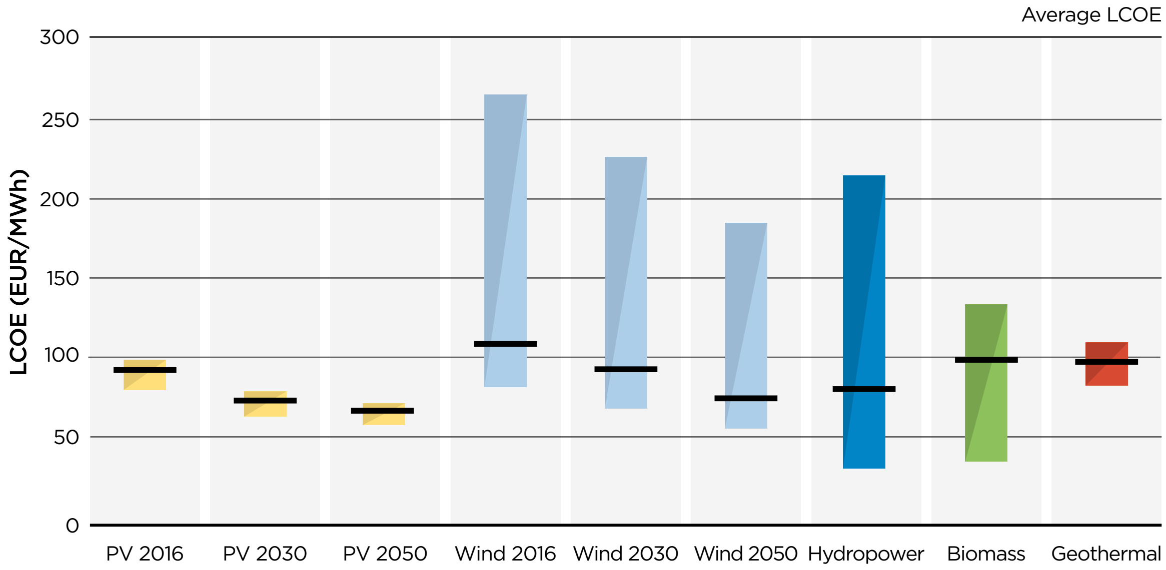


Table 4.20: Potential for renewable-based electricity in Slovenia

Technologies	2009	2015		2020 (NREAP)	Additional cost-competitive potential			Technical potential	
	MW	MW	GWh	MW		MW	GWh	MW	GWh
Solar PV	0.0	240.0	276.6	139.0	**2016**	**0.0 – 57.1**	0.0 – 110.1	344.1	477.8
					2030	**104.1**	171.2		
					2050	**104.1**	171.2		
Wind	0.0	4.0	5.0	106.0	**2016**	**0.0 – 434.2**	0.0 – 844.0	1,421.4	2,296.0
					2030	**744.7 – 1,255.3**	1,373.8 – 2,117.9		
					2050	**1,334.6 – 1,389.8**	2,212.4 – 2,268.3		
Hydro	981.0	1,296.0	4,378.0	1,354.0		**453.0**	1,340.0	3,804.0	16,261.0
≤ 10 MW	145.0	157.0	389.0	177.0		**180.0**	720.0	804.0	4,261.0
> 10 MW	836.0	959.0	4,001.0	1,176.0		**273.0**	620.0	3,000.0	12,000.0
Pumping	0.0	180.0	n.a	0.0		**n.a**	n.a	n.a	n.a
Biomass	18.0	63.0	263.4	96.0		**0.0 – 263.0**	0.0 – 1,057.0	343.0	1,420.0
Biogas	3.0	32.0	134.2	61.0		**0.0 – 50.0**	0.0 - 286.0	82.0	420.0
Solid Biomass	15.0	31.0	129.2	34.0		**0.0 – 213.0**	0.0 – 771.0	244.0	900.0
Biowaste	n.a	n.a	n.a	n.a		**0.0**	0.0	17.0	100.0
Geothermal el.	0.0	0.0	0.0	0.0		**0.0 – 70.0**	0.0 – 540.0	70.0	540.0
Total (2016)	999.0	1,603.0	4,923.0	1,695.0	**2016**	**453.0 – 1,277.3**	1,340.0 – 3,891.1	5,982.5	20,994.8

Note: The lower values of the ranges of the additional cost-competitive potential represent the high cost of capital scenario, while the upper values represent the low cost of capital scenario.

Based on Energy Community and NREAP

Investment framework for renewable energy

The FIT support scheme for renewables was adopted in 2009. Despite the on-going recession, the high FIT level prompted a construction boom of new solar PV plants. Due to this rapid expansion, the support scheme fund was nearly drained by 2012. As a result, the FITs for solar PV were drastically lowered, from around EUR 400/MWh in 2009 to below EUR 150/MWh in 2013. In addition, a capacity cap on each technology was introduced. These measures led to the suspension of almost all planned investments in solar PV plants. Meanwhile, the FIT for other RETs was maintained at the same level or slightly increased to promote diversification of generation capacity.

In Slovenia, new hydropower plants face the most significant problems in acquiring environmental permits and water use concessions because the country has very strict environmental provisions. In addition, many water bodies are included in Natura 2000 areas, where even more rigorous rules are applied. Indeed, since the establishment of Natura 2000, no new hydropower plants have been built in the protected areas.

PPAs are signed for a period of 15 years for all renewable energy units and for ten years for renewable energy installations with Combined Heat and Power (CHP). Producers with power plants under 1 MW of installed capacity are entitled to obtain a guaranteed purchase price (FIT) or operational subsidy (premium) in addition to the market price. They can chose one or the other once a year. Renewable energy power plants between 1 MW and 125 MW (200 MW for CHP) are only entitled to benefit from the operational subsidy model.

As the Slovenian solar PV market is at a complete standstill, a big push is currently taking place in the field of net metering as an alternative to FIT. In December 2015, the Slovenian government issued a regulation on self-supply of electricity from renewable energy sources and provided rules for the operation of net metering, making the system operational as of May 2016. Only installations up to 11 kW are eligible, but the total number of approved installations is subject to state control. For households, a total of 7 MW can be installed per annum, and for business owners, a total of 3 MW per annum. If consumption exceeds the production level, a prosumer pays only for the excess energy and related additional charges. Any surplus of production is, however, transferred to the energy supplier without compensation.

4.11 The former Yugoslav Republic of Macedonia

Current status

The structure of the electricity generation system of the former Yugoslav Republic of Macedonia comprises hydropower plants (699 MW) and fossil fuel-based power plants (1 297 MW), amongst which the most significant contribution is made by lignite (Energy Community, 2016). Electricity demand is expected to rise by 2020, according to the NREAP.

The renewable energy target agreed with the EnC for 2020 is 28%, yet the country's NREAP, published in 2016, gives a 21% target for that year, while aiming to meet the 28% target only by 2030. The Ministry of Environment is in the process of recalculating the target, with this including new data from the household survey recently conducted by the State Statistical Office (Dedinec, 2016).

SHPPs are the fastest developing renewable energy source in the country. By 2015, more than 95 MW of these (58 MW with a FIT) had been installed (Dedinec, 2016). The current expected wind deployment level up to 2020 defined by the NREAP is only 50 MW, which has been fully reached by one wind farm developed by the state-owned utility Elektrane na Makedonija (ELEM). Currently, the Bogdanci wind power plant has commissioned 36.8 MW, while 13.8 MW are being developed in the second phase (Energy Agency of the Republic of Macedonia, 2016). Going beyond the level specified in the NREAP, however, current government policy allows a FIT for 65 MW of wind power plants up to the end of 2016, 100 MW by the end of 2020 and 150 MW up to the end of 2025 (Dedinec, 2016). The quota for solar PV (18 MW) has been largely exhausted, with close to 17 MW already built.

Table 4.21: Renewable energy deployment in the former Yugoslav Republic of Macedonia

Renewable energy shares [%] in	2009	2014	2020 (NREAP)
Gross final energy consumption (GFEC)	17.4	16.9	21
Electricity consumption	16.7	16.1	25.6

Based on Energy Community, Eurostat and NREAP

Cost-competitive renewable energy potential

The largest additional cost-competitive potential comes from utility-scale solar PV (up to 1.2 GW) and hydro (680 MW). The large-scale hydro potential is mainly located on the Vardar River and to a lesser extent on the Black Drin River. The country also has significant wind potential, which, however, could only be deployed in a relatively expensive way due to low wind speeds of less than 6 m/s (Figure 4.32). Use of the former Yugoslav Republic of Macedonia's geothermal potential for electricity is limited due to the relatively low temperatures of the reservoirs (the highest temperature recorded is 78ºC, in the Kocani region).

Figure 4.31: Cost-competitive solar PV potential in the former Yugoslav Republic of Macedonia

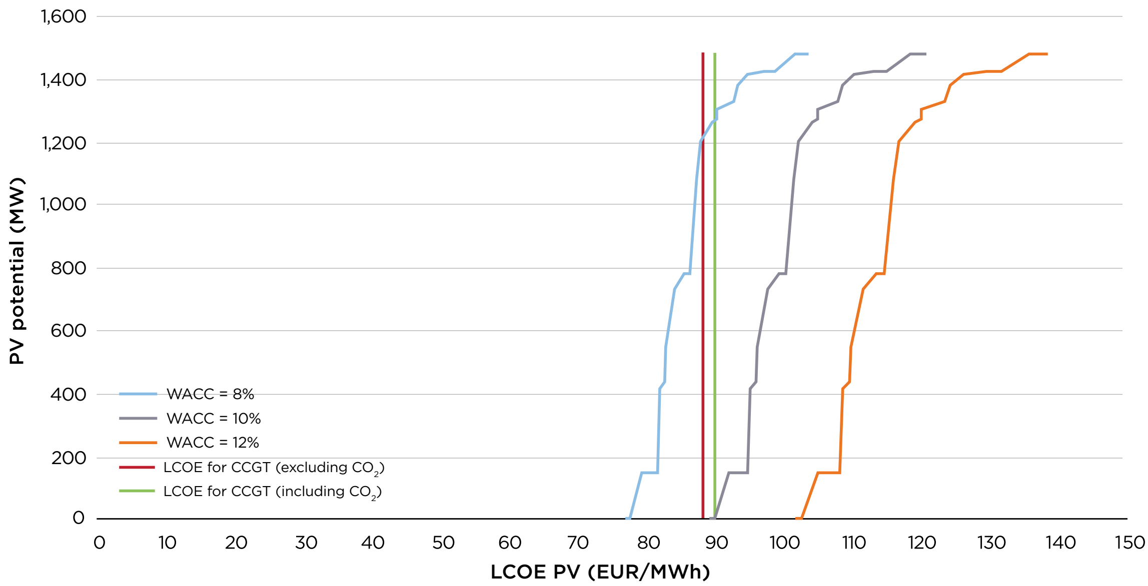


Figure 4.32: Cost-competitive wind potential in the former Yugoslav Republic of Macedonia in 2016

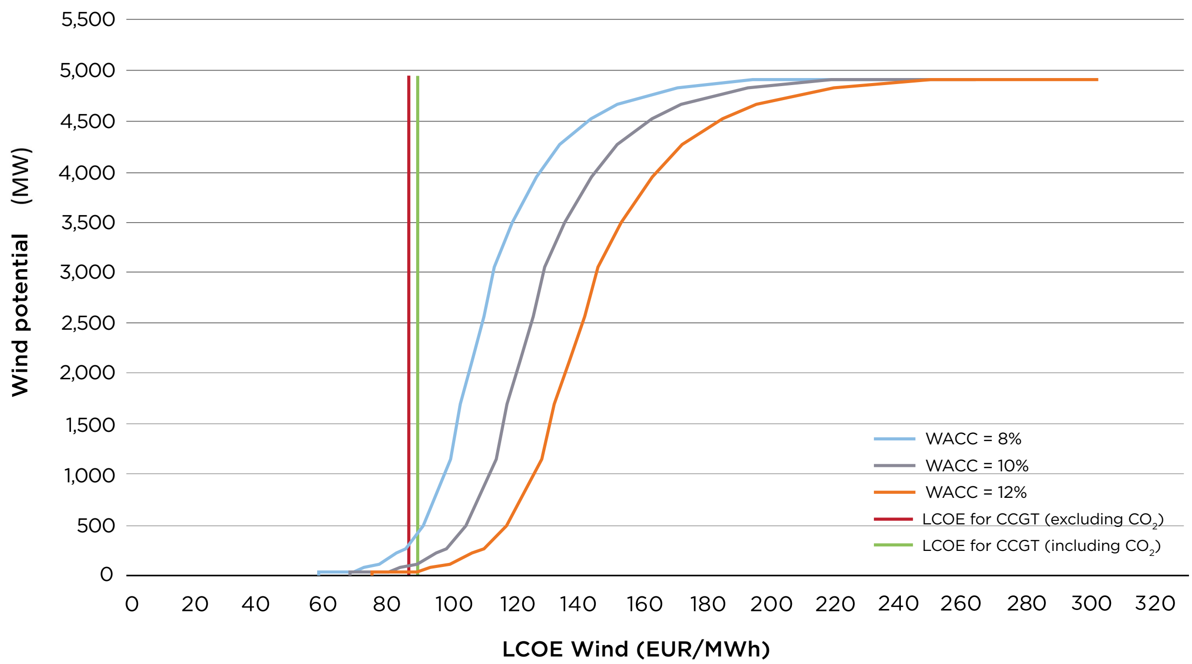
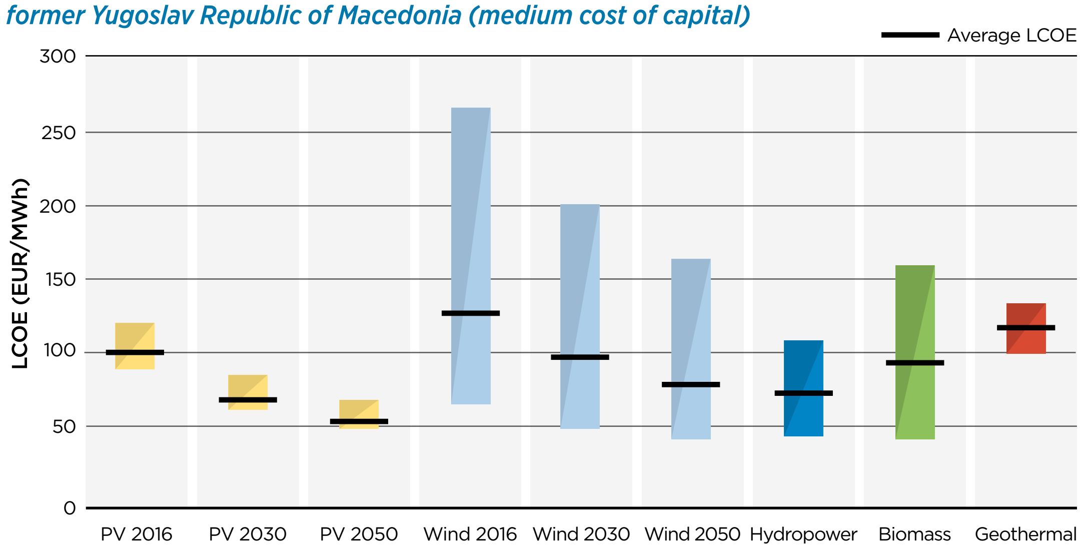


Figure 4.33: LCOE ranges and weighted averages of renewable energy technologies in the former Yugoslav Republic of Macedonia (medium cost of capital)



Cost-competitive hydro and solar PV potential significantly exceeds the deployment level envisaged in the NREAP by 2020, while only limited wind potential can be harvested in a cost-effective manner, given the methodology and assumptions of this study (Table 4.22). Notably, however, the former Yugoslav Republic of Macedonia receives preferential loans with lower interest rates than the ones assumed by the authors, strongly reducing the LCOE and making the first wind park in the country bankable.

Table 4.22: Potential for renewable-based electricity in the former Yugoslav Republic of Macedonia

Technologies	2009	2015		2020 (NREAP)	Additional cost-competitive potential			Technical potential	
	MW	MW	GWh	MW		MW	GWh	MW	GWh
Solar PV	0.0	16.7	11.4	25.4	**2016**	**0.0 – 1,247.6**	0.0 – 1,897.8	1,479.6	2,225.6
					2030	**1,462.9**	2,214.2		
					2050	**1,462.9**	2,214.2		
Wind	0.0	36.8	69.8	50.0	**2016**	**8.1 – 318.6**	51.8 – 707.5	4,940.4	7,655.4
					2030	**2,354.1 – 4,230.9**	4,158.9 – 6,842.9		
					2050	**4,627.6 – 4,882.9**	7,313.2 – 7,569.4		
Hydro	553.3	699.0	1,275.7	709.0		**645.0**	2,445.5	1,636.0	4,006.0
≤ 10 MW	38.6	95.6	174.5	141.0		**74.9**	226.7	255.0	670.0
> 10 MW	514.7	603.4	1,101.2	569.0		**570.1**	2,246.4	1,381.0	3,336.0
Pumping	n.a	0.0	0.0	n.a		**n.a**	n.a	n.a	n.a
Biomass	0.0	4.0	n.a	14.0		**0.0 - 22.0**	n.a	50.0	310.0
Biogas	0.0	4.0	n.a	6.0		**0.0 - 2.0**	n.a	20.0	120.0
Solid Biomass	0.0	0.0	0.0	8.0		**0.0 - 20.0**	n.a	20.0	130.0
Biowaste	0.0	n.a	n.a	0.0		**0.0**	0.0	10.0	60.0
Geothermal el.	0.0	0.0	0.0	0.0		**0.0 - 10.0**	0.0 - 70.0	10.0	70.0
Total (2016)	553.3	726.5	1,356.9	798.4	**2016**	**653.1– 2,243.2**	2,497.3 – 5,120.8	8,116.0	14,267.0

Note: The lower values of the ranges of the additional cost-competitive potential represent the high cost of capital scenario, while the upper values represent the low cost of capital scenario.

Based on Energy Community and NREAP

Investment framework for renewable energy

The current FIT framework includes a 15-year support for solar PV, biomass and biogas, and a 20-year support for SHPP and wind power plants. In addition, new support frameworks are being considered for introduction that will spur additional renewable energy development, since there is high investor interest (Dukovski, 2016). The authorities are, however, concerned about increasing electricity prices for households, so there is limited political will to expand the quotas for solar PV, according to stakeholders (Lazarevski, 2016; Ivanovski, 2016).

Administrative procedures are considered by some investors to be ineffective and unclear, especially for non-energy-related permits (construction, land usage and environmental permits). In addition, frequent legal and policy changes affect the development of large-scale projects and significantly reduce the pace of investments (Lazarevski, 2016).

From a technical point of view, the lack of indemnity for damages to investors caused by a reduction or interruption in energy delivery from the system, or reduced electricity uptake (as defined by the grid codes), is also considered an important barrier. Litigation is the only legally protective measure envisaged in the grid code (Ivanovski, 2016). Moreover, slow and complex permitting procedures, insufficient transparency in public tenders, and grid connection issues are perceived as the main obstacles for small-scale installations, including SHPPs (Lazarevski, 2016). Clear rules regarding connection expenses have not been established yet and insufficient grid capacity hinders prospective investments (Lazarevski, 2016; Ivanovski, 2016). An update of the list of potential SHPP sites, including their legal status, is also reported as necessary (Ivanovski, 2016).

There are, however, continuing efforts to improve investment frameworks for renewables. Simplification of the building permit procedure and the introduction of a one-stop-shop for renewables are being considered (Dukovski, 2016). Moreover, guidelines for investors on the required procedures were published in 2016, and the Ministry of Economy plans to publish these in Macedonian, Albanian and English on its website (Ministry of Economy, Energy Department, 2016).

Although the current PPA model is considered adequate for larger projects, the only large project with a PPA is the state-owned Bogdanci wind park. In addition, smaller hydro and solar PV projects have been developed to a great extent – there are, for example, more than 95 MW of small hydro in place. This indicates that this model is also suitable for smaller investments.

The Electricity Transmission System Operator of Macedonia (MEPSO) is required to sign the PPA with any investor requesting to be admitted to the support system. Furthermore, renewably sourced electricity has priority status on the electricity market. There is, however, no additional protection for producers if there are payment defaults by the off-taker. Up to now, there have been no disputes with investors concerning the PPA (Dukovski, 2016) and no problems or delays in payment have been reported. Some international financial institutions, however, advocate stronger protection for renewable energy producers (Ivanovski, 2016).

Currently, PPAs are only awarded to projects that are in the framework of the support scheme, but a more open approach is being considered, according to the Energy Agency. This might provide opportunities for new business models, such as net metering. Due to relatively low electricity prices, however, further legislation and additional incentives may be needed to spur the development of such projects.

4.12 Ukraine

Current status

Ukraine's power sector is the largest among the SEE countries being investigated in this study. Coal-based power plants account for almost 50% of the country's installed capacity, with the remainder accounted for by nuclear, gas and renewable energy-based power plants. Among the latter, capacity for hydro amounts to 5.8 GW, while in recent years there have also been projects amounting to 1.3 GW in solar PV and wind. These are not sufficient, however, to ensure achievement of the country's 2020 renewable energy target.

After a major economic recession, Ukraine's economy achieved only modest growth during 2015. This recession was also followed by soaring inflation, which reached 44% in 2015. It was also accompanied by high bank interest rates, which reached 20-30% (Mills and Albanese, 2015). The overall economic climate in Ukraine is therefore still considered unfavourable (Volkov, 2016).

Table 4.23: Renewable energy deployment in Ukraine

Renewable energy shares [%] in	2009	2014	2020 (NREAP)
Gross final energy consumption (GFEC)	5.5	3.8	11
Electricity consumption	7.1	6.4	11

Based on Energy Community, Eurostat and NREAP.

Cost-competitive renewable energy potential

Ukraine possesses the largest additional cost-competitive wind potential of any country in this study (up to 119.2 GW). This is despite the high cost of capital assumed (Figure 4.35). A further potential for wind (up to 200 GW) and solar PV (up to 70 GW) can be unlocked by 2030 if more stable frameworks are provided. In addition, opportunities for further investment in SHPPs, particularly in western regions, may be investigated. Ukraine also has sufficient high-temperature geothermal deposits (120-180°C) to enable production of geothermal electricity.

Figure 4.34: Cost-competitive solar PV potential in Ukraine in 2016

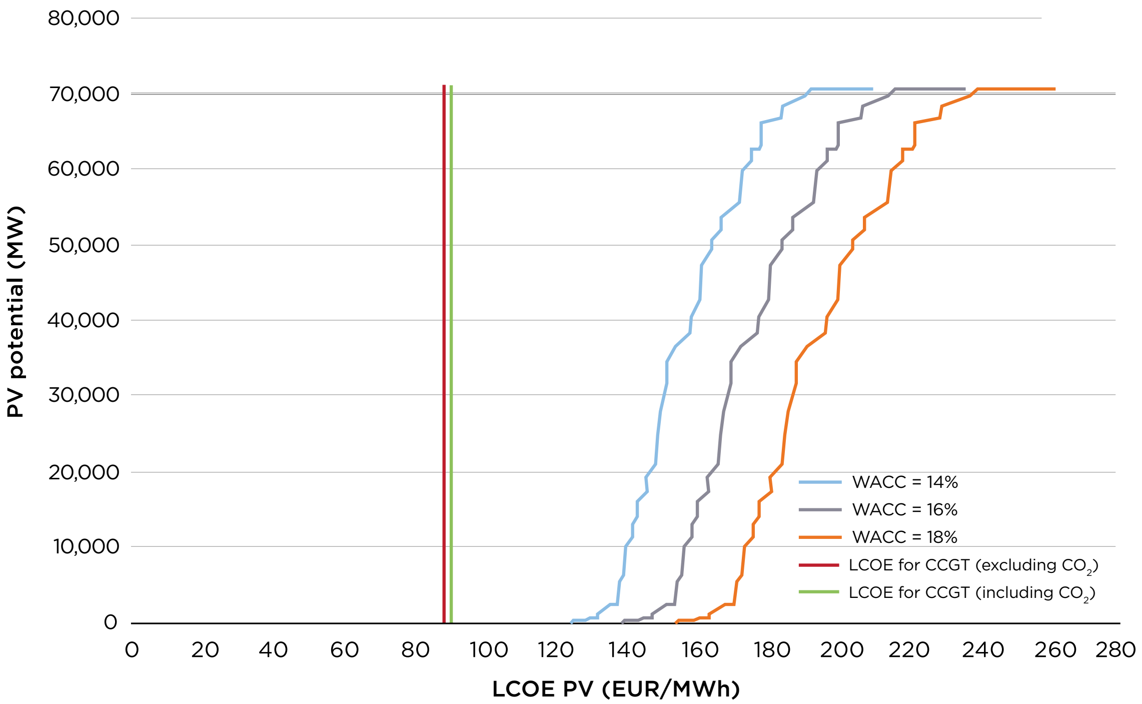


Figure 4.35: Cost-competitive wind potential in Ukraine in 2016

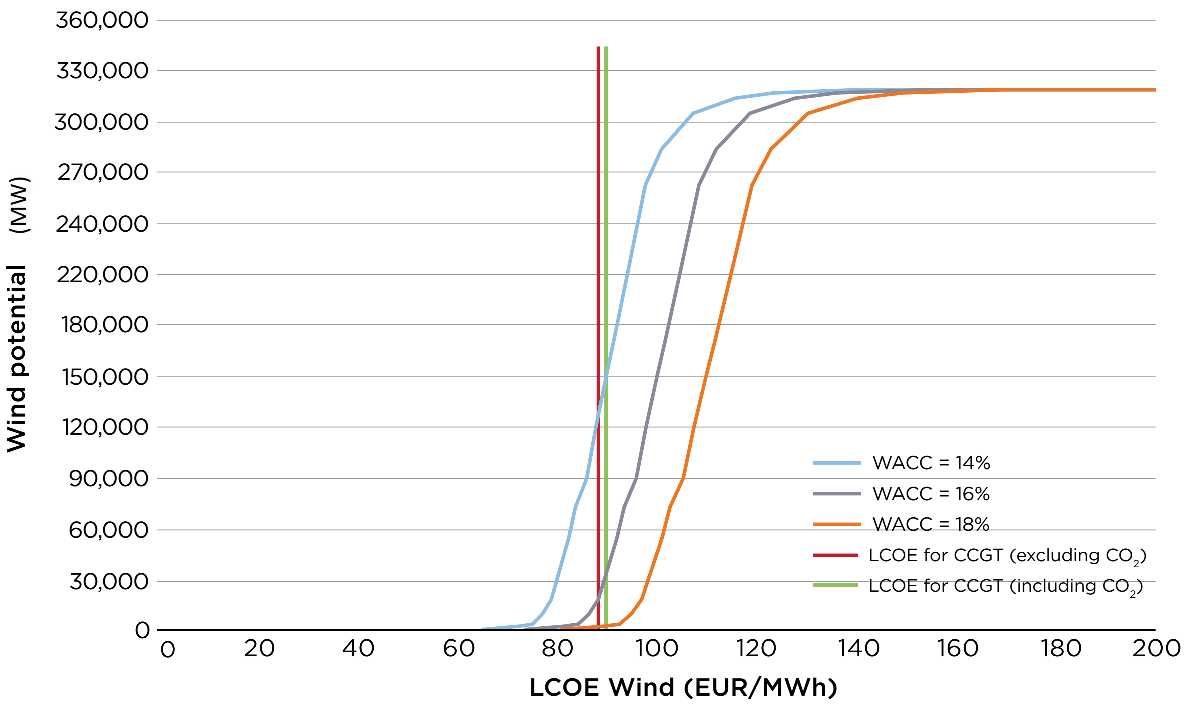


Figure 4.36: LCOE ranges and weighted averages of renewable energy technologies in Ukraine (medium cost of capital)

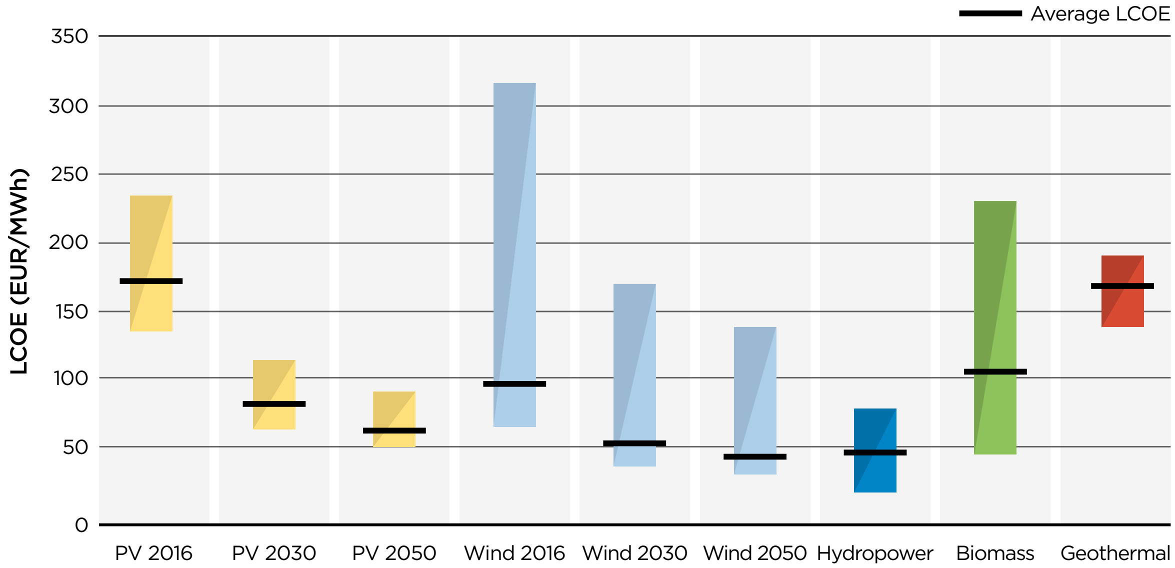


Table 4.24: Potential for renewable-based electricity in Ukraine

Technologies	2009	2015		2020 (NREAP)	Additional cost-competitive potential			Technical potential	
	MW	MW	GWh	MW		MW	GWh	MW	GWh
					2016	0.0	0.0		
Solar PV	0.0	825.0	859.0	2,300.0	2030	53,264.7 – 69,785.8	67,655.6 – 87,451.0	70,611.6	88,370.6
					2050	69,785.8	87,451.0		
					2016	231.3 – 119,083.8	1,197.6 – 350,875.2		
Wind	76.0	513.9	1,363.2	2,280.0	2030	318,583.5 – 319,891.1	855,048.0 – 856,898.9	320,580.9	858,452.3
					2050	320,022.2 – 320,067.0	857,045.8 – 857,089.2		
Hydro	4,549.0	5,703.5	8,487.0	5,350.0		5,578.5	13,733.0	8,950.0	21,500.0
≤ 10 MW	49.0	88.0	274.5	150.0		n.a	n.a	3,750.0	8,500.0
> 10 MW	4,500.0	4,581.0	8,213.0	5,200.0		n.a	n.a	5,200.0	13,000.0
Pumping	n.a	1,034.5	n.a	n.a		n.a	n.a	n.a	n.a
Biomass	0.0	51.4	136.4	950.0		1,696.8	10,278.0	14,643.0	78,389.0
Biogas	0.0	16.2	46.1	290.0		1,696.8	10,278.0	8,565.0	51,389.0
Solid Biomass	0.0	35.2	90.7	660.0		0.0	0.0	6,078.0	27,000.0
Biowaste	n.a	n.a	n.a	n.a		0.0	0.0	n.a	n.a
Geothermal el.	0.0	0.0	0.0	20.0		0.0	0.0	n.a	n.a
Total (2016)	4,625.0	7,093.8	10,845.6	10,900.0	2016	7,506.6 – 126,359.1	25,441.8 – 375,119.4	414,785.5	1,046,711.9

Note: The lower values of the ranges of the additional cost-competitive potential represent the high cost of capital scenario, while the upper values represent the low cost of capital scenario.

Based on Energy Community and NREAP.

Investment framework for renewable energy

The Ukrainian support system includes a FIT (Green Tariff), available until 1 January 2030, for wind, solar PV, SHPPs, biomass (including biogas) and geothermal energy. The Green Tariff is bound to the EUR/UAH exchange rate and is adjusted on a quarterly basis, but it is not indexed to inflation. Moreover, a premium is paid on the tariff depending on the extent of local content. If there is more than 30% local content, there is a 5% increase in the provided tariff, while more than 50% content gives a 10% increase.

Given the significant potential for wind and solar PV, the State Agency on Energy Efficiency and Energy Savings of Ukraine has recognised renewable energy development as an opportunity to increase energy security and help revive the economy. Provided equipment is produced in Ukraine, the authorities see the industry as a potential engine of job creation (State Agency on Energy Efficiency and Energy Savings of Ukraine, 2015a). These developments, however, largely depend on decreasing investors' fear of default, creating reliable policy environments, making modifications to the FIT and improving overall financing conditions (State Agency on Energy Efficiency and Energy Savings of Ukraine, 2015b).

In June 2015, amendments to the Electricity Law reduced the tariff levels, a move mostly affecting solar energy. The tariff for ground-mounted solar PV decreased from the previous EUR 339/MWh to EUR 160/MWh in 2016 (Skhlapak, 2016). In addition, the 50% local content requirement was abolished and the above premium system introduced, whereby the Green Tariff is increased progressively with the amount of local content. For solar energy, the FIT reduction is considered reasonable, as the previous level led to over-support (Borgo, 2016).

A PPA is currently awarded after the project is constructed, commissioned and connected to the grid, which creates problems in securing financing. Consequently, many projects that were announced have not been completed. In addition, during the crisis the government introduced a state of emergency in the electricity sector. This led to delays in PPA payments. Following lawsuits by investors, however, shortfalls in profits have been compensated and the situation has been stabilised. Uncertainty about the security of future payments still remains among investors, though. The need for an earlier entry into the support system has been voiced, possibly with a preliminary PPA, which would take effect once the project is in operation. Meanwhile, the current system is prohibitive for project financing, as there is no legal document that can be used by an investor in order to guarantee payments from the Green Tariff (Skhlapak, 2016).

Net billing is legally defined in Ukraine and has the biggest potential in the residential sector. Households can install both solar PV and wind power plants up to 30 kW capacity and sell electricity to the grid on a net metering basis. For any surpluses, the Green Tariff is provided. The main obstacle to a wider adoption of net billing is the access to finance, since current bank interest rates are very high and prohibitive. Nevertheless, there are more than 400 small-scale installations, with a cumulative capacity of about 5 MW, or less than 1% of total renewable capacity (Skhlapak, 2016).

5 ADDRESSING REGION-WIDE BARRIERS FOR AN ACCELERATED UPTAKE OF RENEWABLES*

5.1 Administrative barriers and market access

In most of the SEE region, complex administrative procedures and regulations, perceived by investors as somewhat opaque, hamper investment. Barriers include, amongst others, the involvement of a large number of institutions in the permit procedure and insufficient availability of information. Administrative barriers for wind energy in particular lead to a long project development period (e.g., Bosnia and Herzegovina, Kosovo and Serbia) and a higher risk perception by investors. In early 2016, Serbia introduced a one-stop-shop solution to facilitate the permit process, but whether this will actually lead to any game-changing benefits for project developers remains to be seen. Most countries in the region are still expected to follow this path. In addition, access to the market is partly reported to work for international investors only with the help of local partners who are aware of the context and have better access to local institutions and procedures.

5.2 Design of support schemes

The design of support schemes has provided limited help in the uptake of renewables in the region. Retroactive cuts in Romania and Bulgaria have also led to market uncertainties. In addition, there are several cases of over- or under-support of renewable technologies due to insufficient expertise in setting appropriate support levels, or in adjusting these levels to changing technology costs.

In Bosnia and Herzegovina, for example, the FIT for solar PV was too high, given technology prices, yet only the Republika Srpska (BiH/RS) started to reduce the support level, in 2016. Another example is Albania, where the support scheme was established without sufficient expert studies to thoroughly examine the potential effects of the measure. This led to an increase in the electricity price and the setting of a new formula to calculate FIT for electricity generated by SHPPs.[22] On the other hand, in Kosovo, support for wind generation was considered insufficient. Support schemes across the region are now expected to be revised to comply with the new EU state aid guidelines, which provide for the gradual introduction of competitive bidding processes for allocating public support.[23]

22 See Section 4.1 for more details.
23 See Section 1.3 for more details.

5.3 Design and approval of PPAs

The design of PPAs and the approval of PPAs after the construction of a power plant are still problems in some countries (e.g., Bosnia and Herzegovina and Ukraine). Large wind energy investments suffer most from poor PPA design, while for hydro the risks, as perceived by international investors, are considered to be lower.

In Serbia, a new PPA was adopted in June 2016 and is expected to address the bankability issues that have characterised the old PPA and disabled project financing and development. Kosovo has recently introduced a measure to grant the final PPA along with the preliminary project authorisation, rather than after the completion of construction. This reduces the investment risk, because developers are guaranteed stable future revenues earlier in the development process.

**A more comprehensive list of barriers has been presented in IRENA (2016c).*

5.4 Grid integration problems limiting renewable energy expansion

Grid connection issues, including access to the grid (e.g., Bosnia and Herzegovina and Kosovo), are common in the region. The overall ability of the grid to integrate large renewable energy projects, such as large-scale solar PV and wind energy, can also be an issue (e.g., Kosovo). In some countries, limitations to renewable energy expansion exist due to the technical inability to integrate renewables into the grid. In Croatia, for example, the energy development strategy from 2009 had a target of 1 200 MW of renewable energy capacity by 2020, but later, a cap of 400 MW was set. Similar problems exist in the rest of SEE. Transmission system operators (TSOs) tend to be restrictive regarding the amount of renewable energy that may be integrated into the grid, as there is insufficient experience with non-hydro technologies. In Bulgaria, for example, renewable energy producers are exposed to rules limiting generation to specific times of the day and that set an upper ceiling on the amount of electricity eligible for feed-in support.

5.5 Access to finance

The instability of governments and of legislation is an important factor leading to a lack of trust in renewables by the banks in most of SEE. This includes unpredictable and partly retroactive changes in the support systems. In combination with the other barriers presented, these create high-risk perceptions, in particular in the non-EU part of the region, resulting in difficult and expensive access to capital. Consequently, capital costs are markedly higher in the non-EU compared to the EU countries. An extreme example is Ukraine, where bank interest rates are currently as high as 30%. Many countries, however, are starting to stabilise the investment context and address major hurdles to renewable energy expansion.

The SEE region is also seeing a growing interest in **citizen financing participation** schemes. These can play a supplementary role to traditional financial models based on state-level support and bank loans.

These schemes offer private investors the opportunity to jointly invest in renewable energy projects, spreading the risk and providing a sense of community ownership, while also increasing the social acceptability of such projects. Thus, these new financial business models are often perceived as a possible solution to ensure the continued expansion of new renewable energy power plants. These models may have application to small, simple, low-maintenance and modular systems, and solar PV in particular (Yildiz, 2014).

With the increasing popularity of crowd-based online technology for raising funds in the energy sector, private investors can choose among various citizen financing possibilities with different business models. A closed fund, for instance, does not envisage any influence by citizen investors on business decisions, while in an energy cooperative, each investor has one vote, irrespective of the equity invested.

In citizen financing schemes, a project funding structure is often divided into three tiers: a bank loan, representing the largest share; individual private investors; and citizen investors participating through crowdfunding (CF) platforms (Enercoop, 2016b). With a discussion on introducing CF to the SEE region now begun, the first experiences with energy cooperatives have already occurred in Croatia.

Crowdfunding

CF can be divided into four different categories, each describing the motivation of potential investors: lending-based, equity-based, donations, and reward-based CF. Each category is affected differently by various institutions and related legitimacy issues (REScoop, 2016).

Figure 5.1 CF categories

Source: REScoop (2016).

Globally, the most commercially popular concepts are equity- and reward-based CF, while the most money is collected for energy sector projects through lending-based CF. Indeed, with an increasing number of projects receiving funding through lending-based CF, a significant amount of money has been invested in recent years. Around the world, for example, renewable energy CF has raised over EUR 165 million and funded more than 300 projects. This number is expected to increase considerably in the coming years (Citizenenergy, 2016).

Different CF platforms are available to support different project sizes. On the one hand, the Trillion Fund, based in the United Kingdom, raised a GBP 15 million investment in the energy company Good Energy Bond. In this instance, a 7.25% return on investment was offered and a minimum investment of GBP 500 was required (Trillion Fund, 2016). On the other hand, the French project, Lumière Nouvelle d'Esnandes, had a total value of just EUR 5 000 and a local use, solar PV panel scheme. This project did not assume a minimum contribution level (LUMO, 2016).

Energy cooperatives

Among the different citizen financing schemes, **energy cooperatives** hold a vital place in the SEE region. Cooperatives are autonomous associations owned, controlled and operated by a group of users for their mutual social, economic and cultural benefit, primarily gathering residents from the local community, municipality, regional or national administrative units (Yildiz, 2014). Energy cooperatives seem to be a growing actor in the transition to renewables, enabling the involvement of citizens in the political, social and financial aspects of renewable energy deployment. Through their activity, they also help democratisation of the energy sector, which still largely operates within traditional centralised structures and concepts (Yildiz, 2014). In 2014, about 2 400 renewable energy source cooperatives were identified across Europe. These are being supported and developed by the European Federation for Renewable Energy Cooperatives (RESCoops), connecting groups and cooperatives of citizens for renewable energy and energy efficiency (REScoop, 2016). RESCoops are ruled by International Cooperation Alliance principles (Enercoop, 2016a).

Despite some positive developments in Croatia (see Box 5.1), citizen financing schemes in SEE are, however, still only the subject of limited public discussion. The scientific community's knowledge is also insufficient, according to stakeholders. A coordinated support action including access to information, education, training and the design or adaptation of appropriate country-specific business models would be required to further popularise citizen financing schemes. Activities could include the demonstration of good renewable energy investment examples across the region, the establishment of local CF platforms dedicated to renewable energy investments in SEE and the establishment of more REScoops across the region. These actions could be arranged in cooperation with the existing REScoops in neighbouring countries and could be of particular interest to members of national diaspora who have decided to invest in their home countries (Green Energy Cooperative ZEZ, 2016).

Because REScoops are inherently grass-root movements, governments have limited potential as promoters of these cooperatives. They can, however, support them through a number of measures. These could include the introduction of a minimum share of local community ownership in renewables projects on public land (as, for example, in Denmark), the allocation of a renewable energy project quota for local communities and REScoops (as in Scotland) and the establishment of dedicated agencies to assist in the setting up process and to provide co-financing of project documentation (Scottish Government, 2015). In addition, local authorities could provide support by encouraging local citizens to invest in REScoops (Green Energy Cooperative ZEZ, 2016).

Box 5.1. Energy co-operatives in SEE: The Croatian experience

The SEE region has a long history of cooperatives, a legacy providing modern energy cooperatives with both benefits and challenges. During the period of the early second half of the 20th century, when the SEE region was under communist rule, cooperatives were a common way of organising social life and business in rural areas. These organisations were mostly dismantled after the fall of communism, however, and the notion of a cooperative is still perceived by many as a relic of those previous regimes. The term "cooperative" therefore carries a negative connotation, associated with the historical legacy of forced collectivisation. It is also widely assumed to be relevant only to the agricultural sector. Educational activities and appropriate communication are therefore necessary to improve the image of cooperatives and develop an understanding of the related benefits (Enercoop, 2016b).

The most successful developments in this regard may be observed in Croatia, which could serve as an example for the entire region. Joining the EU on 1 July 2013 is seen as the key enabler of this advancement, as all stakeholders were exposed to EU energy frameworks, including rules on the common energy market and the deployment of renewables. The new approach enabled discussions and actions leading to changes in the electricity generation structure.

A dialogue on Renewable Energy Cooperatives was started in 2013 by the United Nations Development Programme (UNDP) Croatia and ten other organisations (nongovernmental organisations [NGOs], local municipalities and cooperatives). By organising seminars across the country, as well as providing information on websites and in manuals, increasing support for the concept of renewable energy cooperatives has been gained. As a result, ten cooperatives were set up in 2013 with various energy focuses, including biomass, solar PV, electro mobility, biogas, wind and energy efficiency in buildings. Furthermore, the relevant international experience has been transferred to Croatia through the EU-funded project Citizenergy, which was launched in March 2014 (Citizenenergy, 2016). Citizenergy is a platform that brings together energy cooperatives and CF platforms offering renewable energy projects seeking investors. Currently, it comprises 19 CF platforms and renewable energy source cooperatives.

Initiatives aimed at raising awareness and providing support in setting up the REScoops are carried out, amongst others, by the Zelena Energetska Zadruga (ZEZ), which has been established as a spin-off from the above-mentioned project led by UNDP. These activities serve as a catalyst for starting partnerships between REScoops and renewable power producers and thus play an important role in the success of the energy cooperatives in Croatia (Ezok, 2016). One of the first ZEZ projects is Sustaincamp, which aims to implement renewables, energy efficiency and environmental protection measures in camp sites (ZEZcoop, 2016).

Another REScoop in Croatia is the Energetska Zadruga OTOK KRK, located on Krk, Croatia's biggest island. Membership includes Krk Town and all the island's seven municipalities, as well as NGOs and local companies. Its goal is to achieve the island's energy independence, with zero CO_2 emissions by the year 2030. To this end, several projects are already in progress, including biomass and biogas power plants (180-340 kW); PV-net-metering on 200 residential roofs, plus several megawatts of PV installed on the ground; light-emitting diode (LED) street lights; electric vehicles, with nine charging stations built in 2016; wind energy, with 36 MW potential; and a pumped-storage hydropower plant. Three hundred people have shown interest in joining the Krk REScoop, and the first projects are already funded (ZEZcoop, 2016; Ezok, 2016).

5.6 Capacity-building needs for further solar PV development

Increased skills in the region are also necessary to allow the accelerated uptake of renewables. In particular, variable RETs require specific attention due to the inherently higher risks faced by investors, in solar PV and wind, for example. To tap the vast cost-competitive potential of solar PV as a typical variable RET, adequate capacities are required to implement the necessary infrastructure.

To determine the capacity-building needs of the SEE region, an important insight is the baseline from which each EU member or CP is starting. Two categories can be distinguished: large solar PV expansion that has already occurred (Bulgaria, Romania and Slovenia) and limited deployment of solar PV.

In the SEE countries where **significant solar PV expansion has already occurred**, relatively high levels of technical capacity for plant installation have already been achieved, even if installation growth has since stalled due to cuts in financial support for PV. Much of the acquired capacity remains even if skilled installers have left the country or moved into different fields (ZEZcoop, 2016). While such events can result in the loss of skills (e.g., Croatia or Bulgaria), the capacity to install PV plants can be very quickly ramped up and regained. There are still many engineers and technicians skilled in PV technology in the region who can relatively quickly re-enter the PV installation business should the need for their skills arise.

In those areas of SEE with **limited deployment of solar PV**, the low levels of financial support for PV installations have not stimulated the demand for skilled technicians and engineers. Therefore, while ramping up the capacity of PV installers may be relatively quick, educating a new generation of technically proficient engineers to join the workforce would take a longer time. It may take up to five years to build up skill levels to equal those of the post-PV boom countries.

There are also several types of skills needed for the successful uptake and implementation of solar PV projects in these countries. They include academic, technical, planning and operational, entrepreneurial, and policy design skills.

Academic skills

As part of the legacy of previous, socialist regimes, SEE's education systems are traditionally technically oriented. Teachers and university professors grew up with a conventional energy paradigm, however, where electricity is generated in large power plants, and solar PV is viewed as expensive, complicated and of low efficiency. Educators may lack sufficient knowledge of smart grid technology and advanced methods of forecasting and dealing with the variability and volatility of renewable energy production. A new approach is necessary to convey adequate information to students and enable them to face a new paradigm in which small-scale and distributed renewable energy generation is expected to slowly replace large-scale conventional power plants. Academic systems typically take a long time to adapt, since this involves accreditation, and the universities lack knowledgeable experts and sufficient experience of international collaboration to achieve knowledge transfer.

Technical skills

Most of the countries in the SEE region have sufficient technical skills in place to install solar PV systems, or they could be quickly ramped up should the opportunity present itself. Adequate technical skills can lead to a competitive advantage for SEE countries – for example, in establishing a home market for solar PV equipment and exporting knowledge. Such activities are regarded as highly important in order to compensate for job losses in fossil generation.

Planning and operational skills

In the part of SEE with limited deployment of solar PV, there is a lack of renewable energy integration planning skills. Both Distribution System Operators (DSOs) and TSOs have limited expertise on how to manage and integrate electricity from volatile sources. Coordination between the TSOs and DSOs also needs to be improved. The countries with significant installed solar PV base (e.g., Bulgaria and Slovenia) do not suffer from such drawbacks.

Entrepreneurial skills

In SEE, entrepreneurial experience with investments in renewable energy generation lags behind, in solar PV in particular. In the part of the region with limited deployment of solar PV, there are only a few private solar PV investors. This is mainly due to non-existent or insufficiently attractive support measures for private investors, coupled with a lack of understanding of the risk mitigation measures. There is also a limited awareness of alternative financing mechanisms. The Croatian REScoop stakeholder workshop series on REScoop establishment may be a good model for raising awareness with private and small business investors, as well as with policy and other decision makers.

Policy skills

In SEE, especially where deployment of solar PV has been limited so far, significant improvement of skills and knowledge in the renewable energy support policy design field may be required. Following recent developments in the solar PV technology market and the influence of policy developments in the EU (e.g., the introduction of smart grids, the European energy market, self-consumption initiatives and renewable energy targets for 2020 and beyond), SEE governments need to be able to design appropriate renewable energy support policies, as well as well-founded and realistic action plans, to achieve internationally agreed policy targets.

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7 APPENDICES

7.1 Appendix 1: Details of the PV potential calculation methodology

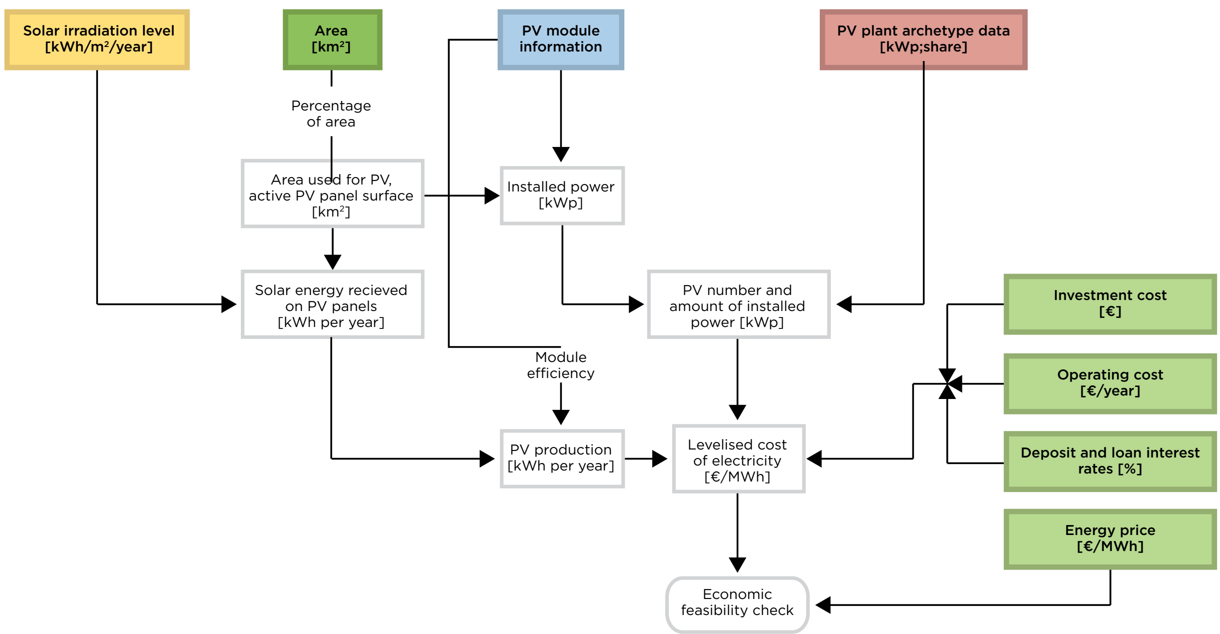
Investors decide the size of their PV installation based on various parameters (e.g., available space, grid proximity, financing options, etc.). The size of the plant also determines the construction costs, playing a prominent role in the economic feasibility of PV installation.

To take the PV plant size into account, PV plant archetypes were introduced to classify the PV plants based on their installed power, as proposed in the ISE Fraunhofer study (Wirth, 2015). Since our focus was on grid-connected, ground-mounted, large-scale PV plants, only the two largest archetypes were used (Table 7.1). The share of the archetypes in the PV plant mix influences the overall costs of the mix.

Table 7.1: PV plant archetypes

PV archetype group	PV plant size (kWp)	Average [kWp]	Share (%)
1	10-500	250	50
2	>500	1000	50

Figure 7.1: Economic evaluation algorithm for PV



7.1.1 Technical potential analysis

Irradiation data

To calculate the technical PV potential, information about solar irradiation and the associated area was provided through a suitability analysis performed by IRENA. Each country was covered with a mesh of squares, or Area Unit (AUs), tailored to best cover the shape of its territory. The AU width, length and associated land cover for each country are shown in Table 7.2.

Table 7.2: Area unit sizes

	Width (m)	Length (m)	Land cover (m^2)
Albania	927.670	926.040	859,059.5
Bosnia and Herzegovina	817.392	817.529	668,241.7
Bulgaria	802.046	801.919	643,175.9
Croatia	816.430	816.773	666,838.0
Kosovo	851.757	853.551	727,018.0
Montenegro	863.533	861.674	744,083.9
Republic of Moldova	866.128	864.990	749,192.1
Romania	786.835	786.684	618,990.5
Serbia	864.950	863.872	747,206.1
Slovenia	750.276	750.483	563,069.4
The former Yugoslav Republic of Macedonia	820.699	821.549	674,244.4
Ukraine	777.976	778.305	605,502.6

The amount of irradiation (kWh/m2/year) for the land area where the solar PV resources are scored with a suitability level score of 60% and above, and the associated average distance to the grid, were provided by IRENA.

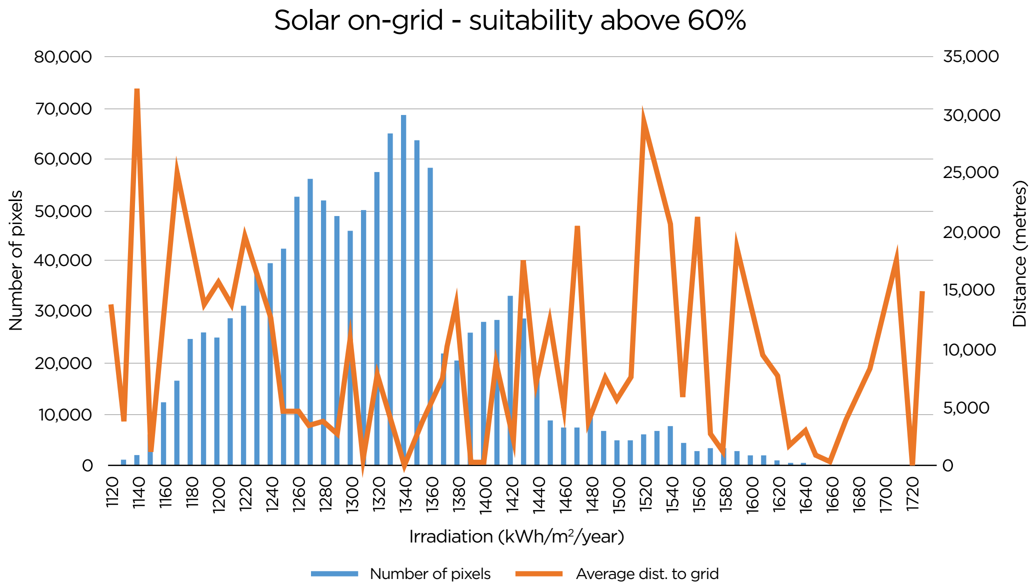
An example of data for the SEE region is shown in Table 7.3 and Figure 7.2. In the table, the total area (expressed in number of AUs) within the 60% suitability range is shown per the irradiation level. For all the area in the region for one irradiation level bin, an average distance to the grid has been calculated (e.g., the average distance to the grid of the area with irradiation between 1 200 and 1 300 kWh/m2/year is 15.6 km).

Table 7.3: Example of technical potential information for 60% suitability level in SEE

	>60% suitability level	
Irradiation [kWh/m^2/year]	Area size [AU]	Average distance to grid [m]
1200	113641	15598
1300	433269	9201
1400	458016	4289
1500	150322	9150
1600	45284	14829
1700	5720	5267
1800	33	10859

For the same set of data, Figure 7.2 shows detailed histogram information on the number of AUs per irradiation bin and the associated average distance to the grid for every histogram bin.

Figure 7.2: Example of irradiation information for 60% and above suitability level in SEE



Solar PV production calculation

The amount of PV energy produced was calculated for each PV plant archetype within every irradiation-based area (the area). Since the entire area cannot be fully used only for installation of PV plants, a uniform share, α_{PV} = 1% of the surface within the area to be used to build PV plants, was assumed. The surface available for PV installation – S_{PVarea} – is calculated using (1):

$$S_{PVArea} = S_{Area} \cdot \alpha_{PV} \quad (1)$$

Parameter	Description
S_{PVArea}	Surface available for PV plants within particular irradiation level area [km²]
S_{Area}	Surface of particular irradiation level area [km²]
α_{PV}	PV area of availability [%]

We have assumed that each PV plant is constructed by combining a number of standard 250 Wp panels (the Standard Panel). This way, the area covered by each PV plant S_{PV} could be estimated (2).

$$S_{PV} = h_{pv} \cdot l_{PV} \quad (2)$$

Parameter	Description
S_{Panel}	Surface of a Standard Panel [m²]
h_{PV}	Height of a Standard Panel [m]
l_{pv}	Length of a Standard Panel [m]

The number of Standard Panels within the Area N_{PVarea} can be calculated (3):

$$S_{PV\ panel\ Area} = S_{PVArea} \cdot \phi_{Panel} \qquad N_{PVArea} = \frac{S_{PV\ panel\ Area}}{\frac{S_{Panel}}{10^6}} \quad (3)$$

Parameter	Description
N_{PVArea}	Number of Standard Panels in the Area
S_{PVArea}	Surface available for PV plants within the Area [km²]
S_{PV}	Surface of a Standard Panel [m²]
$S_{PV\ panel\ Area}$	Active surface of the PV panels in the area
ϕ_{Panel}	Ratio of PV panel surface to PV plant area

The production parameters of the Standard Panel were used to determine the production of all PV plant archetypes. Based on the share ßi of each PV plant archetype in the Area, the average number of Standard Panels constituting each PV plant archetype can be determined (4).

$$N_{PVsize,i} = \frac{N_{PVArea} \cdot \beta_i}{100} \quad (4)$$

Parameter	Description
$N_{PVsize,i}$	Average number of Standard Panels in the Area for the PV archetype i
N_{PVArea}	Number of Standard Panels in the Area
β_i	Share of the PV archetype i [%] in the Area

To calculate the average installed capacity of each PV archetype $P_{inst,i}$ the Standard Panel capacity P_{Pinst} is multiplied by their average number in the archetype (5).

$$P_{inst,i} = N_{PVsize,i} \cdot P_{Pinst} \quad (5)$$

Parameter	Description
$P_{inst,i}$	Installed power in the Area for the PV archetype i [MW]
$N_{PVsize,i}$	Number of PV panels in the Area for a PV archetype i
P_{Pinst}	Standard Panel capacity [MW]

The efficiency of the PV panels determines the amount of energy the panel can gain from the irradiation. The energy produced W_{area} is obtained by multiplying irradiation w_{Irr} in the Area with the PV module surface and the efficiency of PV panel η, (6).

$$W_{Area} = \frac{w_{Irr} \cdot \eta \cdot S_{PVArea}}{100 \cdot 10^6} \quad (6)$$

Parameter	Description
W_{Area}	Energy produced in the Area [MWh]
w_{Irr}	Irradiation in the Area [MWh/m^2/year]
η	Efficiency factor of the Standard Panel [%]
S_{PVArea}	Surface available for PV plants within the Area [km^2]

Energy production $W_{PV,i}$ for the PV archetype is needed to calculate LCOE for each PV archetype, using (7).

$$W_{PV,i} = \frac{W_{Area} \cdot \beta_i}{100} \quad (7)$$

Parameter	Description
$W_{PV,i}$	Energy produced in the Area for a PV archetype [MWh]
W_{Area}	Energy produced in the Area [MWh]
β_i	Share of PV archetype i [%]

7.1.2 Economic analysis

In the economic analysis, the technical potential is converted to the LCOE. The following assumptions are used in the process:

- The AU size covering the land area is defined in Table 7.2.
- There are two PV plant archetypes, differing in the size of PV installation.
- The available area of a country (region) is covered by the shares among the archetypes, shown in Table 7.1.
- Only 1% of the Unit Area can be used as an Active Area where PV plants can be installed. Of the Active Area, 10.7% is assumed as fully covered with PV panels, while other area is used for accompanying facilities (Trinasolar, 2014; Nellis, 2012; Larach, 2015).
- A single PV panel covers an area of 1.63 m2 and has an installed capacity of 250 W (Table 7.4).
- The LCOE of PV plants will be calculated and compared to the LCOE of traditional fossil fuel generating units (CCGTs).

Based on the above information, the PV plant generation per active area can be calculated as shown in Table 7.4.

Table 7.4: Area calculation parameters

Active area	PV panel surface	Number of panels	Installed power
1 km^2	107,000 m^2	65,644	16,411 kW

Parameters used for the economic analysis of the PV plant cost are shown in Table 7.5.

The parameter values in the economic calculations can be divided into two groups. The cost of the equipment, which is influenced by international trends and is bought from the major suppliers, is presumed to be the same for all countries and is treated as a regional parameter. Some of the services, on the other hand, are influenced by the economic situation in each country and are therefore country-specific:

- Regional parameters: these have the same value for the entire SEE region (e.g., equipment cost).
- Country-specific parameters: these are either gathered from national studies or appropriately scaled according to the national GDP information (e.g., installation work cost, maintenance and grid access expenses).

Table 7.5: Economic calculation parameters

Region-wide parameters*	Country-specific parameters
Panel rated power [Wp]	Distance to grid [km]
Panel price [EUR]	Yearly maintenance [EUR/m^{2}]
Inverter price (15 kW) [EUR]	Medium voltage (MV) grid access connection fee [EUR]
Hardware cost [EUR/panel]	WACC [%]
Mounting construction [EUR/panel]	Electrical and mechanical installation work [EUR/panel]
Yearly operating cost [% of the main investment]	
Equipment technical lifetime [years]	
MV power cable [EUR/km]	
Documentation cost [% of the main investment]	
Yearly insurance cost [% of the main investment]	
Connection cable [EUR/km]	

*The assumed values are included in Table 7.8.

All the PV plants are assumed to be constructed from typical PV panels (Table 7.6) and equipped with suitable inverters. The dimensions of the Standard Panel used were 1.65 m x 0.991 m. The inverter used for PV panels is 15 kW and the number of inverters used was determined based on the number and the size of the PV plants installed.

Table 7.6: Typical PV module information

Module peak power [Wp]	Height [m]	Length [m]	Area [m^2]	Efficiency factor [%]
250	1.65	0.99	1.63	16

7.1.3 Investment cost comparison

A comparison of the investment costs and O&M costs for large-scale utility PV plants, normalised to the installed power of a 1 kW plant, were calculated for all the countries and territories analysed. Results for 2016 can be seen in Table 7.7. Investment costs for 2030 and 2050 were calculated using a 3% yearly technology cost reduction factor. While the cost of individual building elements for both archetypes is the same, their total costs differ in the 6% discount applied to the cost of modules, inverter hardware and the mounting costs of the larger PV plant archetype.

Table 7.7: Large utility-scale PV plant investment cost [EUR/MW] comparison

2016	Investment cost [EUR/kW]	O&M [EUR/kW/year]
SEE	1,356.1	14.0
Albania	1,402.7	14.1
Bosnia and Herzegovina	1,354.4	13.7
Bulgaria	1,299.3	13.9
Croatia	1,327.9	14.3
Kosovo	1,303.6	13.3
Montenegro	1,477.5	14.8
Republic of Moldova	1,231.2	12.5
Romania	1,339.5	14.4
Serbia	1,450.7	14.5
Slovenia	1,347.8	15.1
The former Yugoslav Republic of Macedonia	1,348.2	13.9
Ukraine	1,390.3	13.7

7.1.4 Comparison of the costs of PV generation with fossil fuel generation costs

To determine whether a PV plant project at the chosen location is economically viable, its LCOE is compared to the LCOE of a fossil fuel generation plant; more specifically, to coal, lignite and natural gas-fired power plants. The LCOE has been calculated based on the following formula:

$$LCOE = \frac{I_0 + \sum_{t=1}^{n} \frac{A_t}{(1+i)^t}}{\sum_{t=1}^{n} \frac{M_{t,el}}{(1+i)^t}} \qquad (8)$$

Where:

I_0	Investment expenditure
A_t	Annual total costs in year t
$M_{t,el}$	Produced quantity of electricity in the respective year in kWh
i	WACC in %
n	Economic operational lifetime
t	Time

The technical PV potential of a country (obtained in Section 7.1.1) is exploitable under ideal conditions, but to determine practical economic feasibility, economic factors need to be taken into account. **The economic PV potential** is determined as the cumulative technical PV potential for all PV plants for which the $LCOE_{PV}$ is equal or lower than the $LCOE_{FF}$ of the fossil fuel generation plants. The economic PV potential expresses the amount of solar PV potential that is economically viable, compared to the cost of fossil fuel-based production of electricity.

The $LCOE_{PV}$ of a region or a country is calculated in the following way. It is calculated separately for each area within the same irradiation histogram bin, $LCOE_{PV,Irrad}$ and then summed together. PV plant varies among the two PV plant archetypes, applied to the chosen irradiation level areas. It can be calculated as $LCOE_{PV,Irrad}$ using (9).

$$LCOE_{PV} \leq LCOE_{FF} \qquad (9)$$

W_{PV} is the annual PV generated energy, expressed as a product of the average annual electricity yield per kilowatt of installed power at the selected area W_{pot} (in kWh/kWp) and the installed PV plants capacity PPV in the area, (10).

$$LCOE_{PV,\,\mathrm{Irrad}} = \frac{C_{sum}}{W_{PV}} (annual) \qquad (10)$$

Cost calculation is performed at PV plant level and is then accumulated for each PV plant archetype. C_{sum} represents the sum of the annual cost for all the PV plants of particular group size installed in specific irradiation area group, (11).

$$W_{PV} = W_{pot} \cdot P_{PV} \qquad (11)$$

The cost of capital C_{cap} represents an annuity tied to the investment cost, defined as a product of annuity factor a and investment cost $C_{Inv.}$ The operational cost of PV plant $C_{o\&m}$ comprise insurance $C_{ins,}$ yearly maintenance cost C_m and operating cost C_o, (12).

$$W_{PV} = W_{pot} \cdot P_{PV} \tag{11}$$

The cost of capital C_{cap} represents an annuity tied to the investment cost, defined as a product of annuity factor a and investment cost C_{Inv}. The operational cost of PV plant $C_{o\&m}$ comprise insurance C_{ins}, yearly maintenance cost C_m and operating cost C_o, (12).

$$C_{sum} = \sum_{i=1}^{N} (C_{cap} + C_{o\&m})_i = \sum_{i=1}^{N} (a \cdot C_{inv} + C_{o\&m})_i \tag{12}$$

The investment cost C_{Inv} sums up the equipment cost C_{eq} (e.g., modules, inverters, transformers) and the associated installation cost, (13).

$$C_{o\&m} = C_{ins} + C_m + C_o \tag{13}$$

$$\begin{gathered} C_{Inv} = C_{Inst} + C_{eq} \\ C_{eq} = C_{Modules} + C_{Inverters} + C_{Hardware} + C_{Mounting} + C_{Installation} + C_{documentation} \end{gathered} \tag{14}$$

The cost of installation C_{Inst} depends on the size of the PV archetype and the type of equipment associated with it, while the equipment cost C_{eq} is composed of the following cost parameters:

- PV module cost: the PV module market price for Europe is used [24]
- inverter cost: market price for Europe [25]
- hardware equipment cost
- mounting construction costs
- mechanical and electrical installation cost
- planning and documentation costs

Cost information regarding the last four categories was harvested from the IRENA Renewable Cost Database. The mechanical and electrical installation costs were scaled appropriately for other countries using the Gross Domestic Product per capita (GDP_{PC}) that was chosen as an indicator representing the economic conditions in each country. When determining the costs for a specific country, one-third of the cost is scaled using the GDP_{PC} of the country. Two-thirds of the costs are the same for every country, as they are assumed to represent the market value of particular costs.

24 IRENA REsource, http://resourceirena.irena.org/gateway/dashboard/?topic=3&subTopic=32.

25 Assumed based on PVinsights (2016).

Table 7.8: Parameters for economic calculation of solar PV installations

SEE Region

Module price [EUR]	Module size Wp	Inverter price [EUR]	Hardware cost [EUR/panel]	Racking and mounting construction [EUR/panel]	Inverter [kWp]	Technical life time	Cable cost MV [EUR/km]	Operating cost [% of investment/year]	Documentation and planning cost [% of investment]	Insurance cost [% of investment/year]
142.5	250	1,800	31	31	15	25	10,000	0.3	11.5	0.4

	Electrical and mechanical installation work per module [EUR]	Maintenance [EUR/m²/year]	Connecting to grid MV [EUR/plant]	GDPpc [USD] – based on World Bank (2015)
Albania	39.39	0.80	283.6	11,305.4
Bosnia and Herzegovina	38.96	0.79	280.5	10,509.7
Bulgaria	42.71	0.87	307.5	17,511.8
Croatia	45.05	0.92	324.4	21,880.5
Kosovo	38.53	0.79	277.4	9,712.0
Montenegro	41.63	0.85	299.7	15,485.8
Republic of Moldova	36.03	0.74	259.4	5,038.5
Romania	44.80	0.91	322.5	21,403.1
Serbia	40.55	0.83	292.0	13,481.9
Slovenia	50.00	1.02	360.0	31,122.4
The former Yugoslav Republic of Macedonia	40.78	0.83	293.6	13,907.9
Ukraine	37.57	0.77	270.5	7,915.9
SEE Region	41.33	0.84	297.6	14,939.6

The annuity factor *a* is expressed as in (15). The project investor's required interest rate, *r*, is associated with the WACC by (15). WACC is calculated as the average of the after-tax cost of a company's various capital sources, showing the value of each euro to the company. WACC also includes the country risk. The WACC value is used as the interest rate *r* in various financial calculations, such as for Net Present Value (NPV) and the Internal Rate of Return (IRR).

$$a = \frac{(1+r)^N \cdot r}{(1+r)^N - 1} \quad (15)$$

7.2 Appendix 2: Details of the wind potential calculation methodology

An example of data for wind power plants can be seen in Table 7.9.

Since the entire area cannot be fully used only for the installation of wind power plants, a uniform share of the surface within the Area to be used to build wind power plants was assumed, a_{PV} = 1% (IRENA, 2016b).

Table 7.9: Example of wind technical potential information for the 60% suitability level

	>60 % suitability level	
Wind [m/s]	Area size [AU]	Average distance to grid [m]
2	1	2,003
3	1,203	6,819
4	104,325	6,751
5	376,518	2,467
6	703,080	3,530
7	78,251	7,191
8	750	18,674
9	67	10,532
10	1	785

The surface available for wind installation, S_{PVarea}, is calculated using:

$$S_{WindArea} = S_{Area} \cdot \alpha_{Wind} \quad (16)$$

Parameter	Description
$S_{WindArea}$	Surface available for wind plants within a particular wind speed level area [km²]
S_{Area}	Surface of particular wind speed level area [km²]
α_{Wind}	Wind turbine area of availability [%]

In wind turbine available area, on average, 20[26] wind turbines per km² are built (Nelja, 2015; Power Technology, 2012).

$$N_{wind} = 20 \cdot S_{WindArea} \quad (17)$$

Parameter	Description
$S_{WindArea}$	Surface available for wind plants within particular area [km²]
20	Number of wind turbines per km²
N_{wind}	Number of wind turbines in a particular area

26 The Fântânele-Cogealac Wind Farm in Romania covers an area of 11 km² and includes 240 wind turbines, each with an installed power of 2.5 MW. The installed capacity of the wind park is 600 MW, with 21.8 wind turbines per km².

$$P_{ParkInstal} = N_{wind} \cdot P_{instal}$$

(18)

Parameter	Description
$P_{ParkInstal}$	Installed power of all wind turbines in a park [W]
P_{instal}	Installed power of one wind turbine [W]; in our case, 3,450 kW
N_{wind}	Number of wind turbines in a particular area/park

The installed power of all the wind plants in a particular wind park is calculated by multiplying the number of wind power turbines by their installed power, which in our case is 3 450 kW.

The following method was applied to calculate the wind energy from the wind resource potential:

- Determine the possible number of wind turbines for each wind speed histogram bin using IRENA data on number of pixels and concentration of wind turbines per km²;
- The number of wind turbines for each bin is multiplied by the capacity (in MW) to obtain the installed power (MW);
- Produced energy in MWh (WWT) is calculated using the online calculator provided by the Swiss Wind Power Data website.[27] The calculator approximates distribution of wind speed based on the average wind speed that was provided from IRENA and uses the wind distribution to calculate energy production of the wind turbines.

27 *www.wind-data.ch.*

Calibration of the model

The full load hours – and thus the amount of electricity generated – are very sensitive to certain technical assumptions. The authors investigated the technology currently planned or implemented in the region and adjusted our assumptions accordingly. In particular, the plant and rotor size is in the middle range of concrete plants that are being implemented or planned.

The LCOE has been calculated based on the following formula:

$$LCOE = \frac{I_0 + \sum_{t=1}^{n} \frac{A_t}{(1+i)^t}}{\sum_{t=1}^{n} \frac{M_{t,el}}{(1+i)^t}}$$

(19)

Where:

I_0	Investment expenditure
A_t	Annual total costs in year *t*
$M_{t,el}$	Produced quantity of electricity in the respective year in kWh
i	WACC in %
n	Economic operational lifetime
t	Time

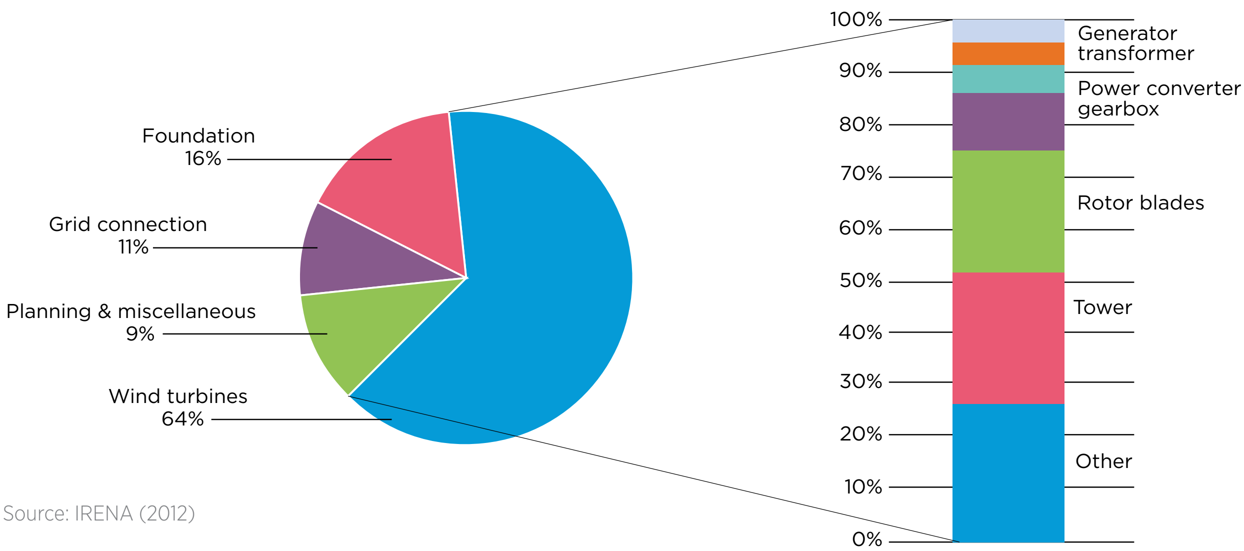
Wind costs

For calculation of investment costs for wind power plants, a breakdown of costs from the literature (IRENA, 2016b) was used, where shares for each major sector were defined. Breakdown of the cost allocation can be seen in Figure 7.3. As a basis for the investment cost, a value of EUR 1600/kW has been used, taking a conservative approach.[28] From the assumed basis value, all the shares of the components were calculated. The initial, 11%, literature-based investment cost of grid connection was subtracted from overall investment costs. Data on average distance of each wind power group to the grid were provided by IRENA, with country-specific grid connection costs calculated and included in the investment costs. The country-specific data then ranges between EUR 1 451/kW and EUR 1 836/kW for 2016. Investment costs for 2030 and 2050 were calculated using a 1.5% yearly technology cost reduction factor.

Differences among the countries also exist in the O&M costs. One-third of the cost is scaled with the specific GDP_{PC} of the country, while the other two-thirds of the costs are the same for every country and are based on market data. The value was set to EUR 50/kW for global data and then scaled for SEE countries (IRENA, 2016b). Values can be found in Table 7.10.

The price of turbines, which also includes all the costs for transformers and other turbine-related costs, was calculated as a share of the base value. The same was done with planning and miscellaneous and with costs for foundation (Table 7.10).

Figure 7.3: Capital cost breakdown for a typical onshore wind power system and turbine



Source: IRENA (2012)

28 Investment cost of operational or planned wind power plant varies significantly in the region. It could range from about EUR 1100 to about EUR 1800/kW (Vukasovic M., 2015).

Table 7.10: Investment costs for wind energy in 2016

SEE Region

Wind turbines [EUR/kW]	Planning & Miscellaneous [EUR/kW]	Foundation [EUR/kW]
1,024	144	256

2016	Total investment cost [EUR/kW]	Grid connection [EUR/kW]	O&M [EUR/kW/year]
Albania	1,522.4	98.4	38.3
Bosnia and Herzegovina	1,625.7	201.7	38.0
Bulgaria	1,567.5	143.5	41.1
Croatia	1,525.3	101.3	43.0
Kosovo	1,569.0	145.0	37.6
Montenegro	1,835.9	411.9	40.2
Republic of Moldova	1,450.8	26.8	35.6
Romania	1,550.8	126.8	42.8
Serbia	1,610.7	186.7	39.3
Slovenia	1,469.6	45.6	47.1
The former Yugoslav Republic of Macedonia	1,633.1	209.1	39.5
Ukraine	1,584.3	160.3	36.8
SEE Region	1,578.8	154.8	39.9

7.3 Appendix 3: Cost calculations for biomass, hydro and geothermal electricity

7.3.1 Hydropower

Data on planned hydropower plants and their costs were collected by Joanneum Research (JR) over the period 2015-16. These data were also complemented during preparation of this study via additional surveys (NREAPs, nation energy plans, feasibility studies, etc.), as well as via interactions with stakeholders and national energy experts (see chapter 7.4).

Possible large-scale plants are well known in the region, while in some of the CPs, only some small-scale plants are already planned and known, despite the present technical potential. In these cases, the cost-potential structure could be estimated based on technical potential and cost data from the known and planned plants, as well as from other relevant sources. In Ukraine, for example, there is insufficient information on planned plants, but a cost distribution for small-scale plants based on feasibility studies has been used. For Romania and Bulgaria, LCOE ranges have been gathered based on literature. For the Republic of Moldova, there is no available information on hydropower costs, as there are no intentions to significantly expand hydropower in the country.

Table 7.11: Hydropower cost assumptions

2016		Investment costs [EUR/kW]	Average O&M costs [EUR/kW year]	Operational lifetime (years)	Capacity factor
Albania	Small	1,150 – 3,000	40	50	0.36
	Large	2,500 – 3,800			0.53
Bosnia and Herzegovina	Small	1,400 – 4,080	40	50	0.56
	Large	1,058 – 3,700			0.38
Bulgaria	Small	1,140 – 4,510	40	50	0.47
	Large	1,700 – 2,800			0.32
Croatia	Small	1,400 – 8,000	40	50	0.35
	Large	580 – 6,916			0.31
Kosovo	Small	1,017 – 2,182	40	50	0.55
	Large	941 (Zhur)			0.16
Montenegro	Small	1,000 – 2,778	40	50	0.32
	Large	482 – 1,900			0.26
Republic of Moldova	Small	n.a	40	50	n.a
	Large				
Romania	Small	1,880 – 4,550	40	50	0.41
	Large	568 – 3,760			0.30
Serbia	Small	2,200 – 2,795	40	50	0.38
	Large	667 – 2,761			0.47
Slovenia	Small	1,300 – 3,000	40	50	0.32
	Large	847 – 7,733			0.43
The former Yugoslav Republic of Macedonia	Small	1,200 – 2,580	40	50	0.34
	Large	1,000 – 4,154			0.26
Ukraine	Small	n.a	40	50	n.a
	Large				
SEE Region	Small	1,000 – 8,000	40	50	0.32-0.55
	Large	482 – 7,733			0.16-0.47

7.3.2 Biomass power

Information on biomass potential was based on existing data of JR and Vienna University of Technology (TU Wien) and validated with the help of country experts, NREAPs or other studies (see chapter 7.4). For the calculations of the biomass LCOEs, we used average investment and O&M costs as well as average electricity generation for the different technologies provided by Held et al. (2014) that relate to biogas, solid biomass and biowaste. These types of plants are agricultural biogas plants; landfill gas plants; sewage gas plants; solid biomass co-firing; and solid biomass and biowaste incineration plants, with all of them as CHP systems. Non-CHP options have not been considered, as these are unlikely to be implemented. The costs are shown in Table 7.12. For electricity generation, an average for biomass of 5 500 full load hours was used.

Table 7.12: Costs for biomass plants

Type of power plant (CHP)	Average investment costs [EUR/kW]	Average O&M costs [EUR/kW year]	Typical plant size [MW]
Agricultural biogas plant	4,102.5	162.5	0.1 - 0.5
Landfill gas plant	1,935.0	71.5	0.75 – 8
Sewage gas plant	3,410.0	153.0	0.1 - 0.6
Solid biomass co-firing	485.0	178.5	-
Solid biomass incineration plant	3,487.5	131.0	1 – 25
Biowaste incineration plant	6,732.5	163.0	2 - 50

As shown in the corresponding graphs in the country chapters, a weighted average LCOE was calculated for biogas, solid biomass and biowaste. Co-firing was not included, as its potential is assumed to be limited. Co-firing is highly context-specific in terms of existing or future fossil fuel power plant capacities and their abilities to (additionally) co-fire biomass. For the economic potential of biogas, however, a differentiation between agricultural, landfill and sewage gas plants was undertaken, as the underlying costs differ substantially. The used data for biogas potentials are not always broken down to these biogas types. Therefore, an attribution of the potential was done that corresponds to the shares of the biogas types of existing biogas installations in the whole EU and the region using Eurostat data. [29]

This led to a distribution of the technical biogas potential of 70% for "Other biogases from anaerobic fermentation", which primarily consists of agricultural biomass, 20% for landfill gas and 10% for sewage sludge gas.

29 Because Eurostat consumption data do not include a differentiation within the biogas category, the indicator 109a for primary production was used.

7.3.3 Geothermal power

Data for geothermal potential were collected via a literature survey. This was updated with, as well as complemented by, information on the temperatures of the geothermal reservoirs in the region that provided a basis for the assumed technology choice (see chapter 7.4).

For geothermal power, the three major technologies are flash steam plants, dry steam plants and binary plants. While the cheaper flash and dry steam plants can use steam directly harvested from the geothermal source, binary plants require a more complicated and thus more expensive technology, but allow the use of lower temperature resources (below about 150°C). The latter plant type was chosen for the analysis because SEE is primarily characterised by relatively low temperatures in its geothermal resources.

For the LCOE of geothermal power, cost ranges as provided by the Joint Research Centre (Sigfússon and Uihlein, 2015) for 2010 for a so-called organic rankine cycle binary power plant from a hydrothermal system were used. These gave investment costs of EUR 6 470-7 470/kWe and average O&M costs of EUR 145/kW/year. For generation, a range in the capacity factor of between 80% and 95% was used. The lower end of this range takes into account halts in operations for, amongst other reasons, maintenance and repair, or regulation of electricity fed to the grid.

7.4 Appendix 4: Sources of information on biomass, geothermal and hydropower potential

Albania

Large hydro: Zavalani O., P. Marango and J. Kaçani (2010), Renewable Energy Potentials of Albania, Polytechnic University of Tirana, Tirana, Albania.

Small hydro: The value from the NREAP that represents the total capacity of small hydro concessions. This is slightly higher than previous estimates of small hydro potential – e.g., USAID (2009): Stocktaking report for regional assessment of renewable energy regional finding and country summaries.

Biomass: The technical potential for biomass is based on Albania's NREAP.

Geothermal electricity: The geothermal electricity potential in Albania is close to zero. Some national studies conclude that there is no potential at all (e.g., Islami, 2011: Geothermal energy potential Albania), while others (e.g., Ortner, Tuerk and Resch (2014): Indigenous energy resources of South East Europe - Feasibility of enhanced RES-E deployment, Policy brief, European Climate Foundation) indicated a possible minor potential.

Bosnia and Herzegovina

Hydro: Based on values given in:

- ADEG Project (EU/FP6/INCO/ADEG), Advanced Decentralized Energy Generation System for Western Balkan Countries.
- Kenezvic, T. (2007), Energetska efikasnost i obnovljivi izvorienergije, Prioriteti energetske strategije u BIH, Fonacija Heinrich Boll, pp. 91-93.
- Karakosta et al. (2012), Analysis of Renewable Energy Progress in Western Balkan Countries, Elsevier, Vol. 16, Issue 7, September 2012, pp. 5 166-5 175.

Solid biomass: Ministry of Foreign Affairs, Hungary, and EU Strategy for Danube Region COM (2010) 715 Danube Region Action Plan, 2014. The value is higher than in previous studies, e.g., Petar Gvero, Semin Petrovic, Sasa Papuga and Milovan Kotur (2013), "Biomass as Potential Sustainable Development Driver – Case of Bosnia and Herzegovina, Biomass Now - Sustainable Growth and Use", Dr. Miodrag Darko Matovic (Ed.), InTech, DOI: 10.5772/51551.

Biogas and Geothermal: Based on Ortner, Tuerk and Resch (2014): Indigenous energy resources of South East Europe - Feasibility of enhanced RES-E deployment, Policy brief, European Climate Foundation.

Bulgaria

Hydro: The total hydro potential assumed is in between the results of studies giving a higher potential, e.g., KPMG (2010), Central and Eastern European Hydro outlook, and other studies indicating a lower potential, e.g., Ortner, Tuerk and Resch (2014), Indigenous energy resources of South East Europe – Feasibility of enhanced RES-E deployment, Policy brief, European Climate Foundation. Notably, due to environmental concerns, Bulgaria's economical potential for large-scale hydropower is now almost fully exploited (Bulgarian Alternative Energy Company, http://baec.bg/sector_info.html, accessed June 2016).

Biomass: Based on Ortner, Tuerk and Resch (2014): Indigenous energy resources of South East Europe - Feasibility of enhanced RES-E deployment, Policy brief, European Climate Foundation.

Geothermal: Geo SEE (2014), EU South East Europe Programme Bulgaria - State of the art of country and local situation.

Croatia

Hydro: Based on several studies, such as Low Emissions Development Strategy 2050 and KPMG (2010), Central and Eastern European Hydro outlook. The authors took a conservative view and proposed lower figures than some previous studies, such as Matijasevic (2015), Potential of Small Hydropower Plants in Croatia, München, 24 February 2015.

Biomass and biogas: Based on the 2008 Energy Strategy and the Framework for Low-Emission Development Strategy (2013).

Geothermal electricity: Average of different sources. The Croatian energy strategy has slightly lower values. Kolbah et al. (2015), Croatia Country Update, 2015 and on suggest far higher values.

Kosovo

Hydro: The entire large hydro potential is the possible HPP Zhur (see e.g., World Bank (2011), Development and Evaluation of Power Supply Options for Kosovo). Small hydro potential was assumed based on Ministry of Energy and Mining, MEM 2010, Study for New Hydropower plant, Prishtina.

Biogas: Avdiu, N., A. Hamiti (2011), Renewable Energy Policy and Market Developments in Kosovo, EA4EPQ, 2011.

Solid biomass: Average of three sources:

- Avdiu, N., A. Hamiti (2011), Renewable Energy Policy and Market Developments in Kosovo.
- EA4EPQ, 2011; Kosovo forecast document.
- Mercados Energy Markets International (2009), Kosovo - Regulatory Framework for RES – Procedures and Methodology for RES Electricity Pricing Task 1 Report, May 2009.

Montenegro

Hydro potential: Energy development strategy of Montenegro by 2030, update 2012.

Biowaste: Values from the NREAP.

Biomass and Biogas: Based on the NREAP, complemented by SYNENERGY (2011) and C. Panoutsou et al. (2010), Study on Economic biomass potential for heat & electricity/ CHP in the Western Balkans, Moldova & Ukraine, Hellenic Aid/USAID.

Geothermal: Based on Ortner, Tuerk and Resch (2014), Indigenous energy resources of South East Europe - Feasibility of enhanced RES-E deployment, Policy brief, European Climate Foundation.

Republic of Moldova

Hydro: Technical potential: Security of Supply Statements of the Republic of Moldova, 2013.

Biomass: Zaharia (n.d.): Bioenergy in Moldova: Current status, potential and opportunities for development, UNDP presentation.

Romania

Hydro: Based on EU RETS project (2012), *An overview of the renewable energies sector in Romania*.

Solid biomass: Based on the EU Access project (2008), Maps and databases on the biomass potential. Only part of this is assumed to be used in CHP plants, with the rest used for heating in the residential sector.

Biogas: Based on Cheriyska et al. (2009), "Biogas Potential in Bulgaria," Biogas for Eastern Europe, Summary Report.

Geothermal: Based on Ortner, Tuerk and Resch (2014): Indigenous energy resources of South East Europe – Feasibility of enhanced RES-E deployment, Policy brief, European Climate Foundation.

Serbia

Hydro total:

- Energy Sector Development Strategy of Republic of Serbia up to 2025, with projections to 2030.
- NREAP.
- Panić et al. (2013), Small hydropower plants in Serbia: Hydropower potential, current state and perspectives.

Biomass and biogas: The NREAP indicates 39.5 TWh as technical biomass potential, while biogas is not explicitly mentioned. The authors have based the division of biomass and biogas on SYNENERGY (2011) and C. Panoutsou et al. 2010, Study on economic biomass potential for heat & electricity/ CHP in the Western Balkans, Moldova & Ukraine, Hellenic Aid/ USAID. For solid biomass, the authors assumed that only 50% would be used in CHP plants, with the rest for heating in the residential sector.

Biowaste: NREAP.

Geothermal: There is only one area in Serbia with high temperatures – Vranjska Banja. The investor Reservoir Capital plans to implement 10-20 MW. The authors assumed the lower value in this range.

Slovenia

Hydro, biomass, geothermal: Technical potentials are based on Gubina et al. (2007), Priprava strokovnih podlag za določitev nacionalnih potencialov za pogajanja z evropsko komisijo o določitvi nacionalnih ciljev. For geothermal electricity, the authors took the upper limit of the technical potential that assumes that new generation technologies will be deployed. Higher capacity factors for hydro and thus higher production values than in other studies, e.g., KPMG (2010), Central and Eastern European Hydro outlook, were assumed.

The former Yugoslav Republic of Macedonia

Hydro: Government of Macedonia (2010), *Strategy for utilizing RES by 2020*.

Biomass and geothermal: Draft strategy for energy development up to 2035.

Ukraine

Hydro: Total hydro potential: REMAP 2030 (2015), Background paper on renewable energy prospects for Ukraine, April 2015. Small hydropower potential based on Ukraine Sustainable Energy Lending Facility (USELF) (2011), Renewable Energy in Ukraine Technical Report: Small Hydro.

Biomass: Based on REMAP 2030 (2015), Background paper on renewable energy prospects for Ukraine, April 2015.

7.5 Cost-competitive renewable energy potential: Region-wide tables

Table 7.13: Cost-competitive solar PV potential in 2016

2016	Low cost of capital scenario				Medium cost of capital scenario				High cost of capital scenario				Full technical potential	
Technology price EUR/ MWh	No CO_2		With CO_2		No CO_2		With CO_2		No CO_2		With CO_2			
	88		90		88		90		88		90			
	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh
Albania	1,705	2,676	1,918	3,001	71	115	226	356	0	0	0	0	2,378	3,706
Bosnia and Herzegovina	932	1,385	1,002	1,486	0	0	0	0	0	0	0	0	2,964	4,135
Bulgaria	7,129	10,130	7,129	10,130	2,130	3,048	4,862	6,931	0	0	0	0	7,129	10,130
Croatia	3,218	4,356	3,218	4,356	419	619	614	904	0	0	0	0	3,218	4,356
Kosovo	281	404	436	628	0	0	0	0	0	0	0	0	581	835
Montenegro	189	279	330	491	0	0	3	4	0	0	0	0	723	1,076
Republic of Moldova	310	416	1,031	1,371	0	0	0	0	0	0	0	0	4,648	6,044
Romania	16,963	22,707	18,208	24,327	448	632	1,905	2,636	0	0	0	0	19,346	25,806
Serbia	124	176	176	252	0	0	0	0	0	0	0	0	6,902	9,308
Slovenia	221	288	297	387	0	0	4	5	0	0	0	0	344	448
The former Yugoslav Republic of Macedonia	1,198	1,810	1,264	1,909	0	0	2	3	0	0	0	0	1,480	2,226
Ukraine	0	0	0	0	0	0	0	0	0	0	0	0	70,611	88,340
SEE Region	**32,270**	**44,629**	**35,009**	**48,337**	**3,068**	**4,414**	**7,615**	**10,840**	**0**	**0**	**0**	**0**	**120,323**	**156,408**

Table 7.14: Cost-competitive wind potential in 2016

2016	Low cost of capital scenario				Medium cost of capital scenario				High cost of capital scenario				Full technical potential	
Technology price EUR/ MWh	No CO_2		With CO_2		No CO_2		With CO_2		No CO_2		With CO_2			
	88		90		88		90		88		90			
	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh
Albania	2,153	5,397	2,153	5,397	1,339	3,715	1,473	4,012	876	2,609	987	2,886	7,483	13,654
Bosnia and Herzegovina	5,230	13,406	5,862	14,655	3,671	10,093	4,147	11,143	2,256	6,725	2,557	7,476	13,141	26,336
Bulgaria	18,685	36,622	18,685	36,622	5,468	12,246	7,549	16,360	1,829	4,428	2,519	6,003	29,804	52,851
Croatia	10,881	22,822	12,092	24,937	5,689	12,290	5,689	12,960	2,236	5,624	2,236	5,624	14,807	29,153
Kosovo	135	287	135	287	31	77	38	92	10	28	14	37	2,329	3,850
Montenegro	1,725	4,477	1,725	4,477	1,197	3,331	1,339	3,654	825	2,427	942	2,721	2,936	6,481
Republic of Moldova	20,710	49,942	20,800	50,112	19,344	47,092	19,344	47,092	7,818	20,026	11,896	29,941	20,869	50,236
Romania	42,866	92,131	49,218	103,225	27,876	63,935	30,884	69,885	15,425	37,280	15,425	37,280	84,194	154,034
Serbia	2,298	4,945	5,599	11,475	276	685	397	960	73	194	117	306	29,670	52,386
Slovenia	438	849	438	849	21	44	104	214	0	0	0	0	1,421	2,296
The former Yugoslav Republic of Macedonia	252	573	355	777	104	259	104	259	35	96	45	122	4,940	7,655
Ukraine	119,598	352,238	119,598	352,238	18,427	58,497	32,006	100,057	404	1,408	745	2,561	320,581	858,452
SEE Region	**224,971**	**583,689**	**236,660**	**605,052**	**83,422**	**212,933**	**103,072**	**266,689**	**31,785**	**80,845**	**37,481**	**94,956**	**532,176**	**1,257,384**

Table 7.15: Additional cost-competitive hydropower potential in 2016

2016	Medium cost of capital scenario				Full technical potential	
LCOE EUR/MWh	No CO_2		With CO_2			
	88		90			
	MW	GWh	MW	GWh	MW	GWh
Albania	2,141	7,034	2,169	7,034	4,813	15,572
Bosnia and Herzegovina	2,510	9,400	2,510	9,400	6,110	24,498
Bulgaria	1,642	4,668	1,661	4,751	9.022	13,353
Croatia	987	2,528	987	2,528	3,035	8,500
Kosovo	137	641	137	641	495	1,348
Montenegro	1,296	2,858	1,296	2,858	2,040	5,022
Republic of Moldova	n.a	n.a	n.a	n.a	840	3,361
Romania	1,434	2,949	1,534	3,292	15,385	38,000
Serbia	1,152	4,456	1,152	4,456	4,736	18,000
Slovenia	424	1,250	453	1,340	3,804	16,261
The former Yugoslav Republic of Macedonia	645	2,446	645	2,446	1,636	4,006
Ukraine	5,579	14,114	5,579	14,114	8,950	21,500
SEE Region	**17,947**	**52,344**	**18,125**	**52,860**	**60,866**	**169,421**

Table 7.16 Cost-competitive biomass potential in 2016

2016	Low cost of capital scenario				Medium cost of capital scenario				High cost of capital scenario				Full technical potential	
LCOE EUR/MWh	No CO_2		With CO_2		No CO_2		With CO_2		No CO_2		With CO_2			
	88		90		88		90		88		90			
	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh
Albania	788	4,989	788	4,989	83	504	83	504	83	504	83	504	1,832	11,195
Bosnia and Herzegovina	858	5,470	858	5,470	30	180	30	180	30	180	30	180	938	6,220
Bulgaria	1,096	6,000	1,096	6,000	837	4,600	837	4,600	74	400	74	400	1,193	6,290
Croatia	593	3,721	593	3,721	410	2,531	410	2,531	52	340	52	340	930	5,743
Kosovo	36	240	36	240	14	84	14	84	14	84	14	84	115	715
Montenegro	123	425	123	425	17	50	17	50	17	50	17	50	198	686
Republic of Moldova	756	4,824	756	4,825	27	161	27	161	27	161	27	161	850	5,388
Romania	2,564	12,629	2,564	12,629	1,500	7,309	1,500	7,309	304	1,520	304	1,520	2.979	14,629
Serbia	1,199	7,497	1,199	7,498	135	842	135	842	135	842	135	842	1,671	10,446
Slovenia	326	1,320	326	1,320	269	1,026	269	1,026	16	84	16	84	343	1,420
The former Yugoslav Republic of Macedonia	26	166	26	166	4	24	4	24	4	24	4	24	50	310
Ukraine	1,713	10,277	1,713	10,278	1,713	10,278	1,713	10,278	1,713	10,278	1,713	10,278	14,643	78,389
SEE Region	**10,078**	**57,560**	**10,078**	**57,560**	**5,039**	**27,589**	**5,039**	**27,589**	**2,470**	**14,467**	**2,470**	**14,467**	**25,287**	**138,231**

Table 7.17: Cost-competitive geothermal potential in 2016

2016	Low cost of capital scenario				Medium cost of capital scenario				High cost of capital scenario				Full technical potential	
LCOE EUR/MWh	No CO_2		With CO_2		No CO_2		With CO_2		No CO_2		With CO_2			
	88		90		88		90		88		90			
	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh
Albania	1	10	1	10	0	0	0	0	0	0	0	0	1	10
Bosnia and Herzegovina	7	50	7	50	0	0	0	0	0	0	0	0	7	50
Bulgaria	200	1,400	200	1,400	200	1,400	200	1,400	0	0	0	0	200	1,400
Croatia	64	450	64	450	64	450	64	450	0	0	0	0	64	450
Kosovo	n.a	n.a	n.a	n.a	0	0	0	0	0	0	0	0	n.a	n.a
Montenegro	1	10	1	10	0	0	0	0	0	0	0	0	1	10
Republic of Moldova	n.a	n.a	n.a	n.a	0	0	0	0	0	0	0	0	n.a	n.a
Romania	357	2,500	357	2,500	357	2,500	357	2,500	0	0	0	0	400	2,800
Serbia	10	70	10	70	0	0	0	0	0	0	0	0	10	70
Slovenia	70	540	70	540	70	540	70	540	0	0	0	0	70	540
The former Yugoslav Republic of Macedonia	10	70	10	70	0	0	0	0	0	0	0	0	10	70
Ukraine	0	0	0	0	0	0	0	0	0	0	0	0	n.a	n.a
SEE Region	**721**	**5,100**	**721**	**5,100**	**692**	**4,890**	**692**	**4,890**	**0**	**0**	**0**	**0**	**763**	**5,400**

Table 7.18: Cost-competitive solar PV potential in 2030

2030	Low cost of capital scenario				Medium cost of capital scenario				High cost of capital scenario				Full technical potential	
Technology price EUR/MWh	No CO_2		With CO_2		No CO_2		With CO_2		No CO_2		With CO_2			
	100		107		100		107		100		107			
	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh
Albania	2,378	3,706	2,378	3,706	2,378	3,706	2,378	3,706	2,371	3,696	2,378	3,706	2,378	3,706
Bosnia and Herzegovina	2,964	4,135	2,964	4,135	2,964	4,135	2,964	4,135	2,964	4,135	2,964	4,135	2,964	4,135
Bulgaria	7,129	10,130	7,129	10,130	7,129	10,130	7,129	10,130	7,129	10,130	7,129	10,130	7,129	10,130
Croatia	3,218	4,356	3,218	4,356	3,218	4,356	3,218	4,355	3,218	4,356	3,218	4,356	3,218	4,356
Kosovo	581	835	581	835	581	835	581	835	581	835	581	835	581	835
Montenegro	723	1,076	723	1,076	723	1,076	723	1,076	723	1,076	723	1,076	723	1,076
Republic of Moldova	4,648	6,044	4,648	6,044	4,648	6,044	4,648	6,044	4,648	6,044	4,648	6,044	4,648	6,044
Romania	19,346	25,806	19,346	25,806	19,346	25,806	19,346	25,806	18,541	24,743	19,345	25,804	19,346	25,806
Serbia	6,902	9,308	6,902	9,308	6,902	9,308	6,902	9,308	6,342	8,536	6,753	9,103	6,902	9,308
Slovenia	344	448	344	448	344	448	344	448	343	447	344	448	344	448
The former Yugoslav Republic of Macedonia	1,480	2,226	1,480	2,226	1,480	2,226	1,480	2,226	1,480	2,226	1,480	2,226	1,480	2,226
Ukraine	70,611	88,340	70,611	88,340	68,245	85,608	70,508	88,225	42,964	54,948	54,090	68,515	70,611	88,340
SEE Region	**120,323**	**156,408**	**120,323**	**156,408**	**117,957**	**153,676**	**120,220**	**156,293**	**91,303**	**121,169**	**103,652**	**136,376**	**120,323**	**156,408**

Table 7.19: Cost-competitive solar PV potential in 2050

2050	Low cost of capital scenario				Medium cost of capital scenario				High cost of capital scenario				Full technical potential	
Technology price EUR/ MWh	No CO_2		With CO_2		No CO_2		With CO_2		No CO_2		With CO_2			
	107		127		107		127		107		127			
	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh
Albania	2,378	3,706	2,378	3,706	2,378	3,706	2,378	3,706	2,378	3,706	2,378	3,706	2,378	3,706
Bosnia and Herzegovina	2,964	4,135	2,964	4,135	2,964	4,135	2,964	4,135	2,964	4,135	2,964	4,135	2,964	4,135
Bulgaria	7,129	10,130	7,129	10,130	7,129	10,130	7,129	10,130	7,129	10,130	7,129	10,130	7,129	10,130
Croatia	3,218	4,356	3,218	4,356	3,218	4,356	3,218	4,356	3,218	4,356	3,218	4,356	3,218	4,356
Kosovo	581	835	581	835	581	835	581	835	581	835	581	835	581	835
Montenegro	723	1,076	723	1,076	723	1,076	723	1,076	723	1,076	723	1,076	723	1,076
Republic of Moldova	4,648	6,044	4,648	6,044	4,648	6,044	4,648	6,044	4,648	6,044	4,648	6,044	4,648	6,044
Romania	19,346	25,806	19,346	25,806	19,346	25,806	19,346	25,806	19,346	25,806	19,346	25,806	19,346	25,806
Serbia	6,902	9,308	6,902	9,308	6,902	9,308	6,902	9,308	6,902	9,308	6,902	9,308	6,902	9,308
Slovenia	344	448	344	448	344	448	344	448	344	448	344	448	344	448
The former Yugoslav Republic of Macedonia	1,480	2,226	1,480	2,226	1,480	2,226	1,480	2,226	1,480	2,226	1,480	2,226	1,480	2,226
Ukraine	70,611	88,340	70,611	88,340	70,611	88,340	70,611	88,340	70,611	88,340	70,611	88,340	70,611	88,340
SEE Region	**120,323**	**156,409**	**120,323**	**156,409**	**120,323**	**156,409**	**120,323**	**156,409**	**120,323**	**156,409**	**120,323**	**156,409**	**120,323**	**156,409**

Table 7.20: Cost-competitive wind potential in 2030

2030	Low cost of capital scenario				Medium cost of capital scenario				High cost of capital scenario				Full technical potential	
Technology price EUR/ MWh	No CO_2		With CO_2		No CO_2		With CO_2		No CO_2		With CO_2			
	100		107		100		107		100		107			
	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh
Albania	6,496	12,540	6,990	13,160	5,734	11,468	6,148	12,064	4,516	9,569	5,210	10,673	7,483	13,654
Bosnia and Herzegovina	12,372	25,447	12,810	26,000	11,420	24,106	11,961	24,886	8,466	19,374	10,619	22,892	13,141	26,336
Bulgaria	27,172	49,849	27,928	50,824	25,030	46,831	26,265	48,610	18,685	36,622	23,529	44,556	29,805	52,851
Croatia	14,649	28,962	14,721	29,055	14,224	28,362	14,497	28,755	12,092	24,937	12,972	26,406	14,807	29,153
Kosovo	2,236	3,733	2,315	3,834	1 ,956	3,339	2,129	3,587	1,273	2,273	1,673	2,910	2,329	3,850
Montenegro	2,753	6,270	2,805	6,336	2,550	5,975	2,698	6,194	2,350	5,648	2,456	5,827	2,936	6,481
Republic of Moldova	20,869	50,236	20,869	50,236	20,869	50,236	20,869	50,236	20,869	50,236	20,869	50,236	20,869	50,236
Romania	75,065	143,312	78,025	147,132	68,144	133,597	71,708	138,730	49,218	103,225	56,715	115,741	84,194	154,034
Serbia	28,228	50,691	28,749	51,363	26,103	47,694	27,379	49,533	19,848	37,674	24,388	45,094	29,670	52,386
Slovenia	1,094	1,902	1,259	2,123	869	1,571	970	1,723	438	849	749	1,379	1,421	2,296
The former Yugoslav Republic of Macedonia	3,988	6,552	4,268	6,913	3,088	5,285	3,588	6,006	1,145	2,201	2,391	4,229	4,940	7,655
Ukraine	320,277	858,107	320,405	858,262	319,587	857,154	320,135	857,924	318,290	855,125	319,097	856,411	320,581	858,452
SEE Region	**515,199**	**1,237,560**	**521,143**	**1,245,238**	**499,574**	**1,215,619**	**508,347**	**1,228,249**	**457,191**	**1,147,732**	**480,668**	**1,186,353**	**532,176**	**1,257,384**

Table 7.21: Cost-competitive wind potential in 2050

2050	Low cost of capital scenario				Medium cost of capital scenario				High cost of capital scenario				Full technical potential	
Technology price EUR/ MWh	No CO_2 107		With CO_2 127		No CO_2 107		With CO_2 127		No CO_2 107		With CO_2 127			
	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh
Albania	7,314	13,514	7,414	13,605	7,135	13,326	7,314	13,514	6,772	12,896	7,238	13,437	7,483	13,654
Bosnia and Herzegovina	13,041	26,252	13,103	26,308	12,917	26,122	13,079	26,287	12,644	25,799	12,982	26,193	13,141	26,336
Bulgaria	29,208	52.309	29,677	52,757	28,911	51,991	29,435	52,538	27,928	50,824	28,911	51,991	29,805	52,851
Croatia	14,790	29,136	14,807	29,153	14,752	29,093	14,801	29,146	14,721	29,055	14,780	29,125	14,807	29,152
Kosovo	2,329	3,850	2,329	3,850	2,325	3,845	2,329	3,850	2,291	3,805	2,329	3,850	2,329	3,850
Montenegro	2,905	6,452	2,929	6,475	2,881	6,426	2,919	6,466	2,753	6,270	2,904	6,452	2,936	6,481
Republic of Moldova	20,869	50,236	20,869	50,236	20,869	50,236	20,869	50,236	20,869	50,236	20,869	50,236	20,869	50,236
Romania	82,942	152,860	84,046	153,920	80,389	150,007	83,525	153,445	78,025	147,132	81,972	151,819	84,194	154,034
Serbia	29,553	52,285	29,636	52,360	29,094	51,783	29,553	52,285	28,749	51,363	29,456	52,188	29,670	52,386
Slovenia	1,359	2,240	1,394	2,273	1,311	2,185	1,380	2,260	1,194	2,038	1,339	2,217	1,421	2,296
The former Yugoslav Republic of Macedonia	4,775	7,501	4,920	7,639	4,664	7,383	4,837	7,564	4,268	6,931	4,664	7,383	4,940	7,655
Ukraine	320,560	858.433	320,581	858,452	320,491	858,361	320,578	858,449	320,277	858,107	320,536	858,409	320,581	858,452
SEE Region	**529,644**	**1,255,066**	**531,704**	**1,257,028**	**525,739**	**1,250,760**	**530,617**	**1,256,039**	**520,491**	**1,244,436**	**527,981**	**1,253,299**	**532,176**	**1,257,384**

7.6 Power systems of South East Europe in 2015

Table 7.22: Power systems of SEE in 2015

(MW)	Non-hydro renewables	Hydro	Coal (including lignite)	Natural gas	Oil	Nuclear	Total
Albania	0.0	1,797.0	0.0	0.0	98.0	0.0	**1,895.0**
Bosnia and Herzegovina	9.5	2,150.0	1,865.0	0.0	0.0	0.0	**4,024.5**
Bulgaria	1,772.0	3,221.6	4,885.0	888.7	275.0	1,926.0	**12,968.3**
Croatia	517.7	2,195.0	328.0	589.0	920.0	0.0	**4,549.7**
Kosovo	1.5	49.4	1,171.0	0.0	0.0	0.0	**1,221.9**
Montenegro	0,0	668.0	218.5	0.0	0.0	0.0	**886.5**
Republic of Moldova	5.2	16.0	0.0	380.0	0.0	0.0	**401.2**
Romania	4,664.4	6,613.0	5,914.5	4,322.2	1,024.3	1,300.0	**23,838.4**
Serbia	16.2	2,898.0	3,905.0	353.0	0.0	0.0	**7,172.2**
Slovenia	57.5	699.0	800.0	287.0	210.0	0.0	**2,053.5**
The former Yugoslav Republic of Macedonia	307.0	1,296.0	825.0	378.0	2.0	688.0	**3,496.0**
Ukraine	1,390.3	5,703.5	24,824.8	10,775.1	0.0	13,107.0	**55,800.7**
SEE Region	8,741.3	27,307.0	44,736.8	17,973.0	2,529.3	17,021.0	**118,307.9**

Based on Energy Community, GlobalData and IRENA data

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