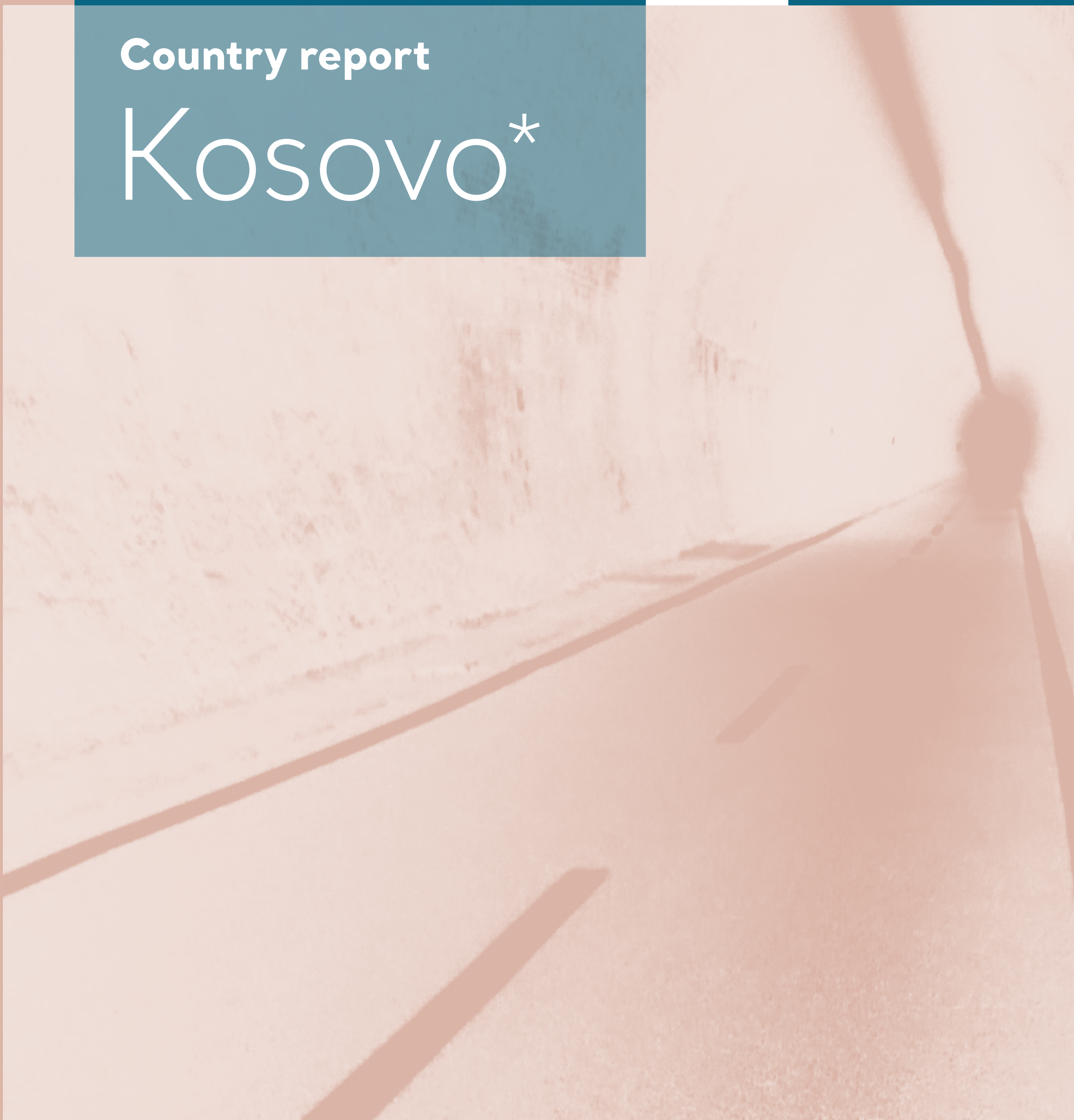
SEERMAP

South East Europe Electricity Roadmap

SOUTH EAST EUROPE ELECTRICITY ROADMAP

Country report

Kosovo*



SEERMAP: South East Europe Electricity Roadmap
Country report: Kosovo* 2017

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The South East Europe Electricity Roadmap (SEERMAP) project develops electricity sector scenarios until 2050. The project focuses on 9 countries in South East Europe: Albania, Bosnia and Herzegovina, Bulgaria, Greece, Kosovo*, former Yugoslav Republic of Macedonia, Montenegro, Romania and Serbia. The implications of different investment strategies in the electricity sector are assessed for affordability, energy security, sustainability and security of supply. In addition to analytical work, the project focuses on trainings, capacity building and enhancing dialogue and cooperation within the SEE region.

** This designation is without prejudice to positions on status, and it is in line with UNSCR 1244 and the ICJ Opinion on the Kosovo declaration of independence.*

Further information about the project is available at: **www.seermap.rekk.hu**

Funding for the project was provided by the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management and the European Climate Foundation.

The project was carried out by a consortium of 5 partners, and involved 9 local partners as subcontractors. The consortium was led by the Regional Centre for Energy Policy Research (REKK).

The **Regional Centre for Energy Policy Research (REKK)** is a Budapest based think tank, and consortium leader of the SEERMAP project. The aim of REKK is to provide professional analysis and advice on networked energy markets that are both commercially and environmentally sustainable. REKK has performed comprehensive research, consulting and teaching activities in the fields of electricity, gas and carbon-dioxide markets since 2004, with analyses ranging from the impact assessments of regulatory measures to the preparation of individual companies' investment decisions.

The **Energy Economics Group (EEG),** part of the Institute of Energy Systems and Electrical Drives at the Technische Universität Wien (TU Wien), conducts research in the core areas of renewable energy, energy modelling, sustainable energy systems, and energy markets. EEG has managed and carried out many international as well as national research projects funded by the European Commission, national governments, public and private clients in several fields of research, especially focusing on renewable and new energy systems. EEG is based in Vienna and was originally founded as research institute at TU Wien.

The **Electricity Coordination Centre (EKC)** provides a full range of strategic business and technical consultancy and engineering leading models and methodologies in the area of electric power systems, transmission and distribution systems, power generation and electricity markets. EKC was founded in 1993 and provides consultant services from 1997 in the region of South-East Europe, Europe as well as in the regions of Middle East, Eastern Africa and Central Asia. EKC also organises educational and professional trainings.

The work of **OG Research** focuses on macroeconomic research and state of the art macroeconomic modelling, identification of key risks and prediction of macroeconomic variables in emerging and frontier markets, assessment of economic developments, and advice on modern macroeconomic modelling and monetary policy. The company was founded in 2006 and is based in Prague and Budapest.

The **Energy Regulators Regional Association (ERRA)** is a voluntary organisation comprised of independent energy regulatory bodies primarily from Europe, Asia, Africa, the Middle East and the United States of America. There are now 30 full and 6 associate members working together in ERRA. The Association's main objective is to increase exchange of information and experience among its members and to expand access to energy regulatory experience around the world.

Local partners in SEERMAP target countries

Institute for Development Policy (INDEP, Kosovo*) is a Prishtina based think tank established in 2011 with the mission of strengthening democratic governance and playing the role of public policy watchdog. INDEP is focused on researching about and providing policy recommendations on sustainable energy options, climate change and environment protection.

POLIS University (U_Polis, Albania) is young, yet ambitious institution, quality research-led university, supporting a focused range of core disciplines in the field of architecture, engineering, urban planning, design, environmental management and VET in Energy Efficiency.

ENOVA (Bosnia and Herzegovina) is a multi-disciplinary consultancy with more than 15 years of experience in energy, environment and economic development sectors. The organization develops and implements projects and solutions of national and regional importance applying sound knowledge, stakeholder engagement and policy dialogue with the mission to contributing to sustainable development in South East Europe.

The **Center for the Study of Democracy (CSD, Bulgaria)** is a European-based interdisciplinary non-partisan public policy research institute. CSD provides independent research and policy advocacy expertise in analysing regional and European energy policies, energy sector governance and the social and economic implications of major national and international energy projects.

FACETS (Greece) specialises in issues of energy, environment and climate, and their complex interdependence and interaction. Founded in 2006, it has carried out a wide range of projects including: environmental impact assessment, emissions trading, sustainability planning at regional/municipal level, assessment of weather and climate-change induced impacts and associated risks, forecasting energy production and demand, and RES and energy conservation development.

MACEF (Macedonia) is a multi-disciplinary NGO consultancy, providing intellectual, technical and project management support services in the energy and environmental fields nationally and worldwide. MACEF holds stake in the design of the energy policy and energy sector and energy resources development planning process, in the promotion of scientific achievements on efficient use of resources and develops strategies and implements action plans for EE in the local self-government unit and wider.

Institute for Entrepreneurship and Economic Development (IPER, Montenegro) is an economic thing tank with the mission to promote and implement the ideas of free market, entrepreneurship, private property in an open, responsible and democratic society in accordance with the rule of law in Montenegro. Core policy areas of IPER's research work include: Regional Policy and Regional Development, Social Policy, Economic Reforms, Business Environment and Job Creation and Energy Sector.

The **Energy Policy Group (EPG, Romania)** is a Bucharest-based independent, non-profit think-tank grounded in 2014, specializing in energy policy, markets, and strategy. EPG seeks to facilitate an informed dialogue between decision-makers, energy companies, and the broader public on the economic, social, and environmental impact of energy policies and regulations, as well as energy significant projects. To this purpose, EPG partners with reputed think-tanks, academic institutions, energy companies, and media platforms.

RES Foundation (Serbia) engages, facilitates and empowers efficient networks of relationships among key stakeholders in order to provide public goods and services for resilience. RES stands for public goods, sustainability and participatory policy making with focus on climate change and energy.

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1 | Executive summary

South East Europe is a diverse region with respect to energy policy and legislation, with a mix of EU member states, candidate and potential candidate countries. Despite this diversity, shared challenges and opportunities exist among the countries of the region. The electricity network of the South East Europe region is highly interconnected, energy policies are increasingly harmonised and the electricity market is increasingly integrated as a result of the EU accession process, the Energy Community Treaty and more recently the Energy Union initiative warranting a regional perspective on policy development.

A model-based assessment of different long term electricity investment strategies was carried out for the region within the scope of the SEERMAP project. The project builds on previous work in the region, in particular IRENA (2017), the DiaCore and BETTER EU research projects and the SLED project, as well as on EU level analysis, in particular the EU Reference Scenario 2013 and 2016. The current assessment shows that alternative solutions exist to replace current generation capacity by 2050, with different implications for affordability, sustainability and security of supply.

According to national plans and terms of the Energy Community acquis, more than half of the current fossil generation capacity in Kosovo* will be phased out before 2025 and all of it by 2050. The scenario analysis provides two options for replacing this capacity: either it will be substituted by a capacity mix that enables Kosovo* to rely almost exclusively on RES generation (wind, hydro and solar) and imports, or by a mixture of RES and new fossil capacities. In the latter case this includes the planned CCS equipped 600 MW lignite plant planned for 2041, as well as another 500MW of lignite capacity with some gas capacity not equipped with CCS. This report compares the advantages and disadvantages of each scenario. Only the first pathway enables Kosovo* to reduce its emissions in line with EU targets for 2050.

A set of five models covering the electricity and gas markets, the transmission network and macro-economic system were used to assess the impact of 3 core scenarios:

- The 'no target' scenario reflects the implementation of current energy policy (including implementation of renewable energy targets for 2020 and completion of all power plants listed in official planning documents) combined with a CO_2 price (applied from 2030 onwards for non-EU states), but no 2050 CO_2 target in the EU or Western Balkans;
- The 'decarbonisation' scenario reflects a long-term strategy to significantly reduce CO_2 emissions according to indicative EU emission reduction goals for the electricity sector as a whole by 2050, driven by the CO_2 price and strong, continuous RES support;
- The 'delayed' scenario envisages an initial implementation of current national investment plans followed by a change in policy from 2035 onwards that leads to the same emission reduction target by 2050 as the 'decarbonisation' scenario. The attainment of the target is driven by the CO_2 price and increased RES support from 2035 onwards.

The modelling work carried out under the SEERMAP project identifies the following key findings with respect to the different electricity strategy approaches that Kosovo* can take:

- In all scenarios, the existing, almost exclusively lignite based generation capacity will be phased out completely by 2040. In the 'decarbonisation' scenario, Kosovo's* is set to embark on an electricity sector development path leading to an energy mix based almost exclusively on RES capacities by 2050. In the other two scenarios a significant reduction in emissions is achieved through a mix of renewables (wind, hydro and solar) and carbon capture technology (CCS) that is installed at the new 600 MW lignite fuelled power unit planned for 2041. In the 'no target' and 'delayed' scenarios Kosovo* gets a late start in RES deployment, without major growth until 2040.
- Kosovo* is expected to meet the overall decarbonisation target for the EU28+Western Balkans region only in the 'decarbonisation' scenario, the other two scenarios fall short of the EU emission reduction target for 2050. The 'no target' and 'delayed' scenarios include the construction of fossil fuel plants (Kosova e Re and a 300 MW gas fired plant) that are not equipped with CCS and responsible for additional carbon emissions in 2050. By 2050 approximately 90% of lignite based generation comes from the CCS-equipped power plant, as the Kosova e Re plant is priced out of the market due to the high carbon price.
- The role of gas is and remains minor in the generation mix of Kosovo*. Gas is most significant in the 'no target' scenario, where a total of 300 MW of gas capacity is installed, but even in this scenario at its peak gas contributes less than 15% to the total generation mix.
- Kosovo* is making a distinct policy choice by incorporating CCS, a new technology that has not reached commercial maturity. The analysis suggests that investing in renewables is a feasible alternative. More than 60 % in the 'delayed' and above 95% in the 'decarbonisation' scenario of generated electricity comes from renewables source.
- If a renewables based strategy is chosen, long term planned action offers clear advantages over delayed action:
  - Stranded cost is a magnitude higher in the 'delayed' scenario compared to the 'decarbonisation,' 8.1 EUR/MWh versus 0.1 EUR/MWh;
  - The renewables support needed to incentivise investment is considerable in the 'delayed' scenario, estimated at 15.4 EUR/MWh support level (16% of total electricity cost) over the last ten years, because towards the end of the modelled period rapid deployment of additional capacities is required.
  - The price of electricity follows a similar trajectory under all scenarios and only diverges after 2045, when prices with more RES in the electricity mix are lower as a result of the low marginal cost of RES electricity production.
- Kosovo* is likely to become a net electricity importer in the 'decarbonisation' scenario. Its generation adequacy margin is negative in this scenario from 2025 onwards, implying that there are some hours of the year when domestic capacity is insufficient to satisfy domestic demand. This underlines the importance of the physical and commercial integration of national electricity markets. If Kosovo* were to build sufficient domestic generation capacity to satisfy domestic demand in all hours of the year this would imply an average reserve capacity cost of 40mEUR/year from 2025 onwards.
- Under all scenarios there is a significant increase in the wholesale electricity price compared with current (albeit historically low) price levels. This is true across the entire SEE region – and in fact the EU as a whole – in all scenarios for the modelled time period, driven by the increasing price of carbon and natural gas. Despite higher absolute wholesale prices, household expenditure on electricity as a share of disposable income increases only slightly in all scenarios according to the macroeconomic analysis.

Furthermore, the positive implication of higher wholesale prices is that investment in electricity generation becomes more attractive to investors, addressing the current underinvestment in the sector.

- Transmission network investment adds close to 70mEUR in addition to investments included in ENTSO-E TYNDP (2016), but this is negligible in comparison to investment needed for generation capacity.

A number of robust no regret policy recommendations can be provided based on results across all scenarios:

- The high growth of RES from a low baseline in all scenarios suggests a policy focus on enabling RES integration; investing in transmission and distribution networks, enabling demand side management and RES production through a combination of technical solutions and appropriate regulatory practices, and promoting investment in storage solutions including hydro and small scale storage.
- RES potential can be exploited with the help of policies eliminating barriers to RES investment. De-risking policies that reduce high financing and high capital costs are especially relevant in the region including Kosovo*, as it would allow for cost-efficient renewable energy investments.
- Co-benefits of investing in renewable electricity generation can strengthen the case for increased RES investment. Co-benefits include health and environmental benefits from reduced emissions to air, however, these benefits are not addressed in this report.
- Policy makers need to address the trade-offs with fossil fuel investments. Lignite based capacities are expected to result in considerable stranded costs which need to be weighed against short term benefits that these power plants can provide.
- Policymakers need to consider the limited role of natural gas in the electricity mix of Kosovo*. The benefits of a (limited) role for gas in the electricity system should be weighed against the related gas network and generation costs.
- Regional level planning improves system adequacy compared with national plans emphasizing reliance on domestic production capacities.

2 | Introduction

2.1 Policy context

Over the past decades EU energy policy has focused on a number of shifting priorities. Beginning in the 1990s, the EU started a process of market liberalisation in order to ensure that the energy market is competitive, providing cleaner and cheaper energy to consumers. Three so-called energy packages were adopted between 1996 and 2009 addressing market access, transparency, regulation, consumer protection, interconnection, and adequate levels of supply. The integration of the EU electricity market was linked to the goal of increasing competitiveness by opening up national electricity markets to competition from other EU countries. Market integration also contributes to energy security, which had always been a priority but gained renewed importance again during the first decade of the 2000s due to gas supply interruptions from the dominant supplier, Russia. Energy security policy addresses short and long term security of supply challenges and promotes the strengthening of solidarity between member states, completing the internal market, diversification of energy sources, and energy efficiency.

The Energy Community Treaty and related legal framework translates EU commitments on internal energy market rules and principles into commitments for the candidate and potential candidate countries. Other regional processes and initiatives, such as CESEC and the Western Balkan 6 initiative, also known as the Berlin Process, also have implications for regional energy policy and legislation, infrastructure and markets.

Climate mitigation policy is inextricably linked to EU energy policy. Climate and energy were first addressed jointly via the so-called '2020 Climate and energy package' initially proposed by the European Commission in 2008. This was followed by the '2030 Climate and energy framework', and more recently by the new package of proposed rules for a consumer centred clean energy transition, referred to as the 'winter package' or 'Clean energy for all Europeans'. The EU has repeatedly stated that it is in line with the EU objective, in the context of necessary reductions according to the IPCC by developed countries as a group, to reduce its emissions by 80-95% by 2050 compared to 1990, in order to contribute to keeping global average temperature rise below 2°C compared with pre-industrial levels. The EU formally committed to this target in the 'INDC of the European Union and its 28 Member States'. The 2050 Low Carbon and Energy Roadmaps reflect this economy-wide target. The impact assessment of the Low Carbon Roadmap shows that the cost-effective sectoral distribution of the economy-wide emission reduction target translates into a 93-99% emission reduction target for the electricity sector (EC 2011a). The European Commission is in the process of updating the 2050 roadmap to match the objectives of the Paris Agreement, possibly reflecting a higher level of ambition than the roadmap published in 2011.

2.2 The SEERMAP project at a glance

The South East Europe Electricity Roadmap (SEERMAP) project develops electricity sector scenarios until 2050 for the South East Europe region. Geographically the SEERMAP project focuses on 9 countries in South East Europe: Albania, Bosnia and Herzegovina, Kosovo* (in line with UNSCR 1244 and the ICJ Opinion on the Kosovo* declaration of independence), former Yugoslav Republic of Macedonia (Macedonia), Montenegro and Serbia (WB6) and Bulgaria, Greece and Romania (EU3). The SEERMAP region consists of EU member states, as well as candidate and potential candidate countries. For non-member states some elements of EU energy policy are translated into obligations via the Energy Community Treaty, while member states must transpose and implement the full spectrum of commitments under the EU climate and energy acquis.

Despite the different legislative contexts, the countries in the region have a number of shared challenges. These include an aged electricity generation fleet in need of investment to ensure replacement capacity, consumers sensitive to high end user prices, and challenging fiscal conditions. At the same time, the region shares opportunity in the form of large potential for renewables, large potential of hydro generation which can be a valuable asset for system balancing, a high level of interconnectivity, and high fossil fuel reserves, in particular lignite, which is an important asset in securing electricity supply.

Taking into account the above policy and socio-economic context, and assuming that the candidate and potential candidate countries will eventually become member states, the SEERMAP project provides an assessment of what the joint processes of market liberalisation, market integration and decarbonisation mean for the electricity sector of the South East Europe region. The project looks at the implications of different investment strategies in the electricity sector for affordability, sustainability and security of supply.

The aim of the analysis is to show the challenges and opportunities ahead and the trade-offs between different policy goals. The project can also contribute to a better understanding of the benefits that regional cooperation can provide for all involved countries. Although ultimately energy policy decisions will need to be taken by national policy makers, these decisions must recognise the interdependence of investment and regulatory decisions of neighbouring countries. Rather than outline specific policy advise in such a complex and important topic, our aim is to support an informed dialogue at the national and regional level so that policymakers can work together to find optimal solutions.

2.3 Scope of this report

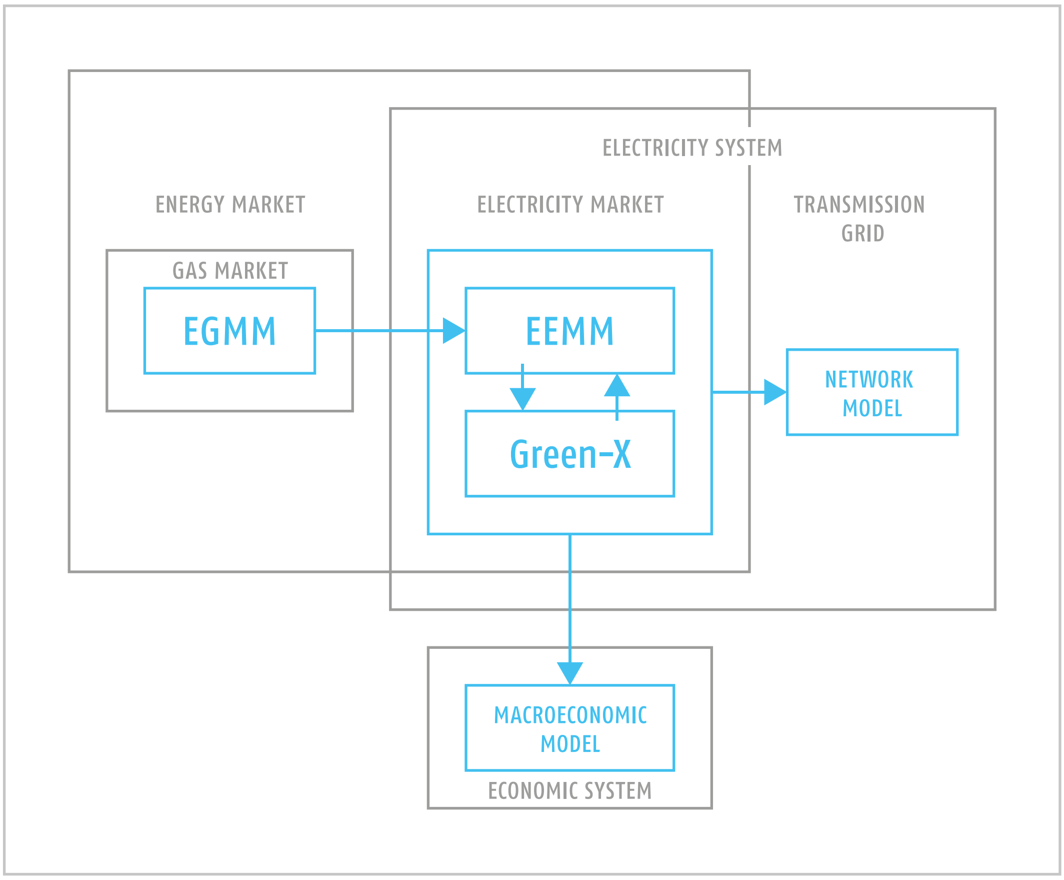
This report summarises the contribution of the SEERMAP project to the ongoing policy debate on how to enhance the decarbonisation of the electricity sector in Kosovo*. We inform on the work undertaken, present key results gained and offer a summary of key findings and recommendations on the way forward. Please note that further information on the analysis conducted on other SEERMAP countries can be found in the individual SEERMAP country reports, and a Regional Report is also produced.

The present modelling work incorporates available policy documents of the future energy strategy of Kosovo*, but the results do not reflect government position of the country.

3 | Methodology

Electricity sector futures are explored using a set of five high resolution models incorporating the crucial factors which influence electricity policy and investment decisions. The European Electricity Market Model (EEMM) and the Green-X model together assess the impact of different scenario assumptions on power generation investment and dispatch decisions. The EEMM is a partial equilibrium microeconomic model. It assumes that the electricity market is fully liberalised and perfectly competitive. In the model, electricity generation as well as cross border capacities are allocated on a market basis without gaming or withholding capacity: the cheapest available generation will be used, and if imports are cheaper than producing electricity domestically demand will be satisfied with imports. Both production and trade are constrained by the available installed capacity and net transfer capacity (NTC) of cross border transmission networks respectively. Due to these capacity constraints, prices across borders are not always equalised. Investment in new generation capacity is either exogenous in the model (based on official policy documents), or endogenous. Endogenous investment is market-driven; power plant operators anticipate costs over the upcoming 10 years and make investment decisions based exclusively on profitability. If framework conditions (e.g. fuel prices, carbon price, available generation capacities) change beyond this timeframe then the utilisation of these capacities may change and profitability is not guaranteed.

FIGURE 1
THE FIVE MODELS USED FOR THE ANALYSIS
A detailed description of the models is provided in a separate document ("Models used in SEERMAP")



The EEMM models 3400 power plant units in a total of 40 countries, including the EU, Western Balkans, and countries bordering the EU. Power flow is ensured by 104 interconnectors between the countries, where each country is treated as a single node. The fact that the model includes countries beyond the SEERMAP region incorporates the impact of EU market developments on the SEERMAP region.

The EEMM model has an hourly time step, modelling 90 representative hours with respect to load, covering all four seasons and all daily variations in electricity demand. The selection of these hours ensures that both peak and base load hours are represented, and that the impact of volatility in the generation of intermittent RES technologies on wholesale price levels is captured by the model. The model is conservative with respect to technological developments and thus no significant technological breakthrough is assumed (e.g. battery storage, fusion, etc.).

The Green-X model complements the EEMM with a more detailed view of renewable electricity potential, policies and capacities. The model includes a detailed and harmonised methodology for calculating long-term renewable energy potential for each technology using GIS-based information, technology characteristics, as well as land use and power grid constraints. It considers the limits to scaling up renewables through a technology diffusion curve which accounts for non-market barriers to renewables but also assumes that the cost of these technologies decrease over time, in line with global deployment (learning curves). The model also considers the different cost of capital in each country and for each technology by using country and technology specific weighted average cost of capital (WACC) values.

An iteration of EEMM and Green-X model results ensures that wholesale electricity prices, profile based RES market values and capacities converge between the two models.

In addition to the two market models, three other models are used:

- the European Gas Market Model (EGMM) to provide gas prices for each country up to 2050 used as inputs for EEMM;
- the network model is used to assess whether and how the transmission grid needs to be developed due to generation capacity investments, including higher RES penetration;
- macroeconomic models for each country are used to assess the impact of the different scenarios on macroeconomic indicators such as GDP, employment, and the fiscal and external balances.

4 | Scenario descriptions and main assumptions

4.1 Scenarios

From a policy perspective, the main challenge in the SEE region in the coming years is to ensure sufficient replacement of aging power plants within increasingly liberalised markets, while at the same time ensuring affordability, security of supply and a significant reduction of greenhouse gas emissions. There are several potential long-term capacity development strategies which can ensure a functioning electricity system. The roadmap assesses 3 core scenarios:

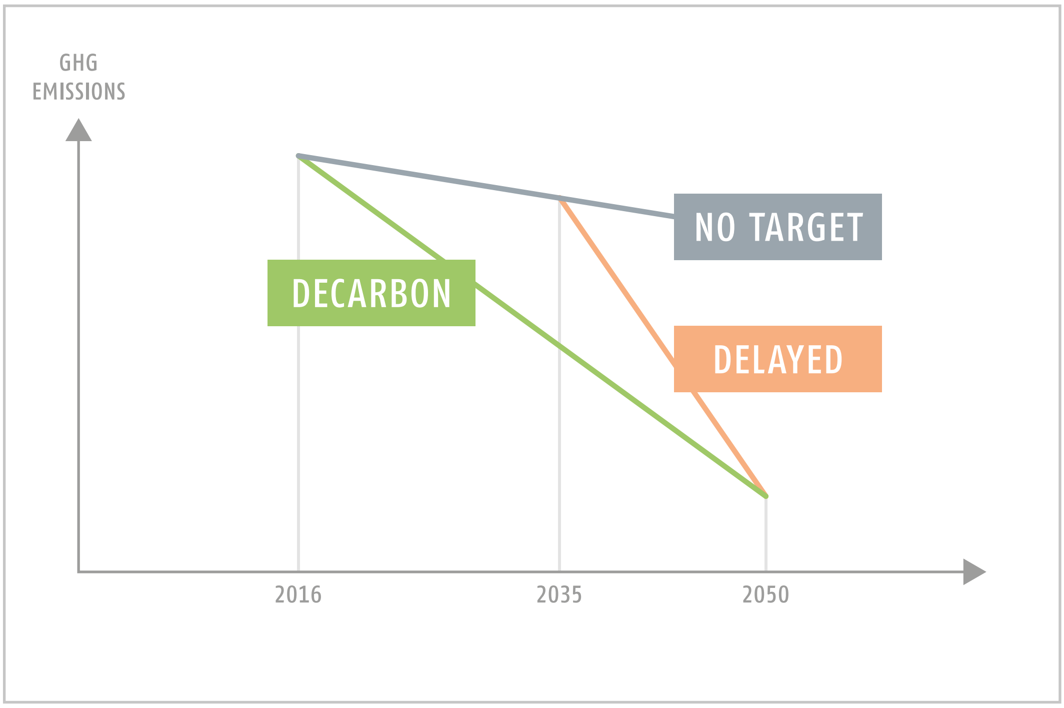
- The 'no target' scenario reflects the implementation of current energy policy and no CO_2 target in the EU and Western Balkans for 2050;
- The 'decarbonisation' scenario reflects a continuous effort to reach significant reductions of CO_2 emissions, in line with long term indicative EU emission reduction goal of 93-99% emission reduction for the electricity sector as a whole by 2050;
- The 'delayed' scenario involves an initial implementation of current investment plans followed by a change in policy direction from 2035 onwards, resulting in the realisation of the same emission reduction target in 2050 as the 'decarbonisation' scenario.

The modelling work does not take into account the impacts of the new Large Combustion Plant BREF (Commission Implementing Decision of 2017/1442), as it entered into force in July 2017.

The same emission reduction target of 94% was set for the EU28+WB6 region in the 'delayed' and 'decarbonisation' scenarios. This implies that the emission reductions will be higher in some countries and lower in others, depending on where emissions can be reduced most cost-efficiently.

The scenarios differ with respect to the mix of new technologies, included in the model in one of two ways: (i) the new power plants entered exogenously into the model based on policy documents, and (ii) the different levels and timing of RES support

FIGURE 2
THE CORE SCENARIOS



resulting in different endogenous RES investment decisions. The assumptions of the three core scenarios are the following:

- In the 'no target' scenario all currently planned fossil fuel power plants are entered into the model exogenously. Information on planned power plants is taken from official national strategies/plans and information received from the local partners involved in the project. We have assumed the continuation of current renewable support policies up to 2020 and the gradual phasing out of support between 2021 and 2025. The scenario assumes countries meet their 2020 renewable target but do not set a CO_2 emission reduction target for 2050. Although a CO_2 target is not imposed, producers face CO_2 prices in this scenario, as well as in the others.
- In the 'decarbonisation' scenario, only those planned investments which had a final investment decision in 2016 were considered, resulting in lower exogenous fossil fuel capacity. With a 94% CO_2 reduction target, RES support in the model was calculated endogenously to enable countries to reach their decarbonisation target by 2050 with the necessary renewable investment. RES targets are not fulfilled nationally in the model, but are set at a regional level, with separate targets for the SEERMAP region and for the rest of the EU.
- The 'delayed' scenario considers that currently planned power plants are built according to national plans, similarly to the 'no target' scenario. It assumes the continuation of current RES support policies up to 2020 with a slight increase until 2035. This RES support is higher than in the 'no target' scenario, but lower than the 'decarbonisation' scenario. Support is increased from 2035 to reach the same CO_2 emission reduction target as the 'decarbonisation' scenario by 2050.

Due to the divergent generation capacities, the scenarios result in different generation mixes and corresponding levels of CO_2 emissions, but also in different investment needs, wholesale price levels, patterns of trade, and macroeconomic impacts.

4.2 Main assumptions

All scenarios share common framework assumptions to ensure the comparability of scenarios with respect to the impact of the different investment strategies over the next few decades. The common assumptions across all scenarios are described below.

Demand:

- Projected electricity demand is based – to the extent possible – on data from official national strategies. Where official projections do not exist for the entire period until 2050, electricity demand growth rates were extrapolated based on the EU Reference scenario for 2013 or 2016 (for non-MS and MS respectively). The PRIMES EU Reference scenarios assume low levels of energy efficiency and low levels of electrification of transport and space heating compared with a decarbonisation scenario. The average annual electricity growth rate for the SEERMAP region as a whole is 0.74% over the period 2015 and 2050. The annual demand growth rate for countries within the region is varies significantly, with the value for Greece as low as 0.2%, and for Bosnia and Herzegovina as high as 1.7%. Whereas the growth rate in all EU3 countries is below 0.7%, Macedonia is the only country in the WB6 where the growth rate is below 1% a year. For Kosovo*, demand figures for 2015 and 2016 were provided by our local partner, and PRIMES projections were used up to 2050. These figures indicate an average annual growth rate in electricity demand of 1.3% between 2015 and 2050.
- Demand side management (DSM) measures were assumed to shift 3.5% of total daily demand from peak load to base load hours by 2050. The 3.5% assumption is a conservative estimate compared to other projections from McKinsey (2010) or TECHNOFI (2013). No demand side measures were assumed to be implemented before 2035.

Factors affecting the cost of investment and generation:

- Fossil fuel prices: Gas prices are derived from the EGMM model. The price of oil and coal were taken from IEA (2016) and EIA (2017) respectively. The price of coal is expected to increase by approximately 15% by 2050 compared with 2016. In the same period gas prices increase by around 76% and oil prices by around 250%, because of historically low prices in 2016. Compared to 2012-2013 levels, only a 15-20% increase in oil prices is assumed by 2050.
- Cost of different technologies: Information on the investment cost of new generation technologies is taken from EIA (2017).
- Weighted average cost of capital (WACC): The WACC has a significant impact on the cost of investment, with a higher WACC implying a lower net present value and therefore a more limited scope for profitable investment. The WACCs used in the modelling are country-specific, these values are modified by technology-specific and policy instrument-specific risk factors. The country-specific WACC values in the region are assumed to be between 10 and 15% in 2016, decreasing to between 9.6 and 11.2% by 2050. The value is highest for Greece in 2016, and remains one of the highest by 2050. In contrast, the WACC values for the other two EU member states, Romania and Bulgaria, are on the lower end of the spectrum, as are the values for Kosovo* and Macedonia. The country-specific WACC for Kosovo* was assumed to be 10.5% in 2015, decreasing to 9.6% by 2050. Other studies also estimated WACC values for the region and confirm that values are high.
- Carbon price: a price for carbon is applied for the entire modelling period for EU member states and from 2030 onwards in non-member states, under the assumption that all candidate and

potential candidate countries will implement the EU Emissions Trading Scheme or a corresponding scheme by 2030. The carbon price is assumed to increase from 33.5 EUR/tCO_2 in 2030 to 88 EUR/tCO_2 by 2050, in line with the EU Reference Scenario 2016. This Reference Scenario reflects the impacts of the full implementation of existing legally binding 2020 targets and EU legislation, but does not result in the ambitious emission reduction targeted by the EU as a whole by 2050. The corresponding carbon price, although significantly higher than the current price, is therefore a medium level estimate compared with other estimates of EU ETS carbon prices by 2050. For example, the Impact Assessment of the Energy Roadmap 2050 projected carbon prices as high as 310 EUR under various scenarios by 2050 (EC 2011b). The EU ETS carbon price is determined by the marginal abatement cost of the most expensive abatement option, which means that the last reduction units required by the EU climate targets will be costly, resulting in steeply increasing carbon price in the post 2030 period.

Infrastructure:

- Cross-border capacities: Data for 2015 was available from ENTSO-E with future NTC values based on the ENTSO-E TYNDP 2016 (ENTSO-E 2016) and the 100% RES scenario of the E-Highway projection (ENTSO-E 2015b).
- New gas infrastructure: In accordance with the ENTSO-G TYNDP 2017 both the Transadriatic (TAP) and Transanatolian (TANAP) gas pipelines (see Annex 2) are built between 2016 and 2021, and the expansion of the Revithoussa and the establishment of the Krk LNG terminals are taken into account. No further gas transmission infrastructure development was assumed in the period to 2050.

Renewable energy sources and technologies:

- Long-term technical RES potential is estimated based on several factors including the efficiency of conversion technologies and GIS-based data on wind speed and solar irradiation, and is reduced by land use and power system constraints. It is also assumed that the long term potential can only be achieved gradually, with renewable capacity increase restricted over the short term. A sensitivity analysis measured the reduced potential of the most contentious RES capacities, wind and hydro. The results of the sensitivity analysis are discussed in section 5.5.
- Capacity factors of RES technologies were based on historical data over the last 5 to 8 years depending on the technology.

Annex 2 contains detailed information on the assumptions.

5 | Results

5.1 Main electricity system trends

The current, almost exclusively lignite based generation capacity mix will be phased out completely by 2040, with more than half of the capacity decommissioned before 2025 according to national plans. In the 'decarbonisation' scenario Kosovo* is set to embark on an electricity

FIGURE 3
INSTALLED CAPACITY IN THE 3 CORE SCENARIOS UNTIL 2050 (GW) IN KOSOVO*, 2020-2050

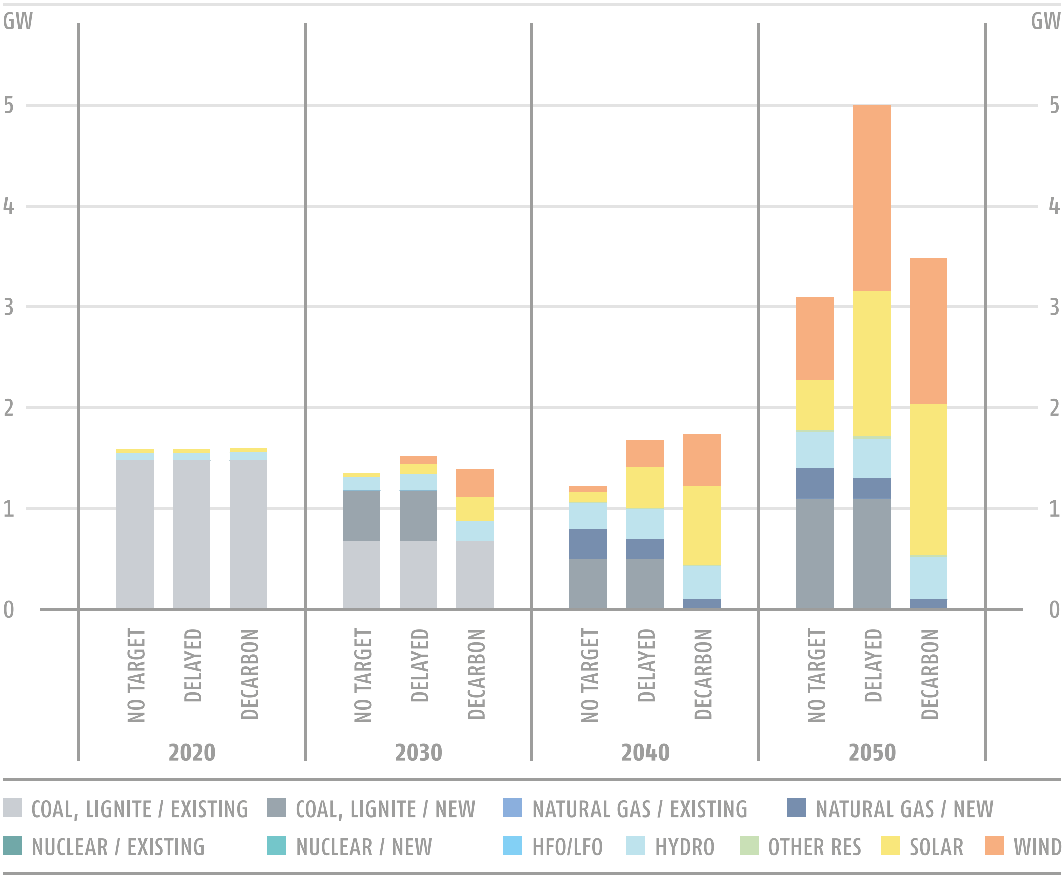


FIGURE 4
ELECTRICITY GENERATION AND DEMAND (TWh) AND RES SHARE (% OF DEMAND) IN KOSOVO*, 2020-2050

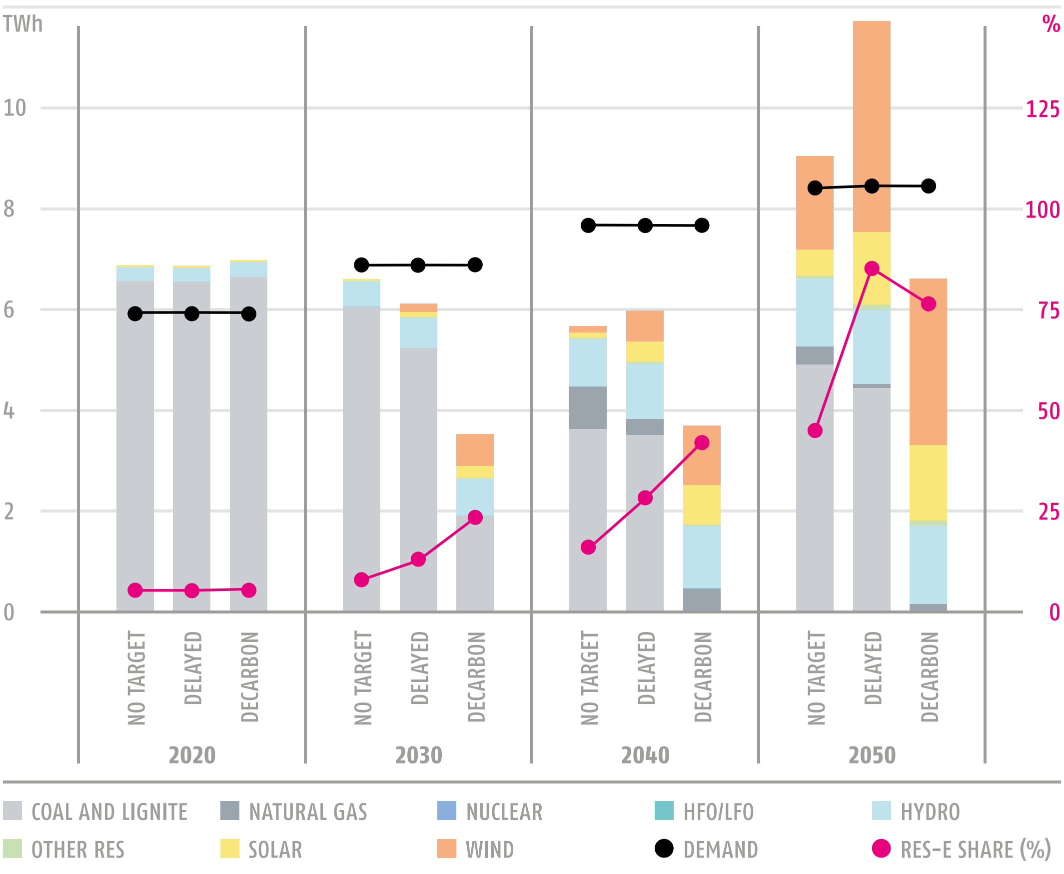
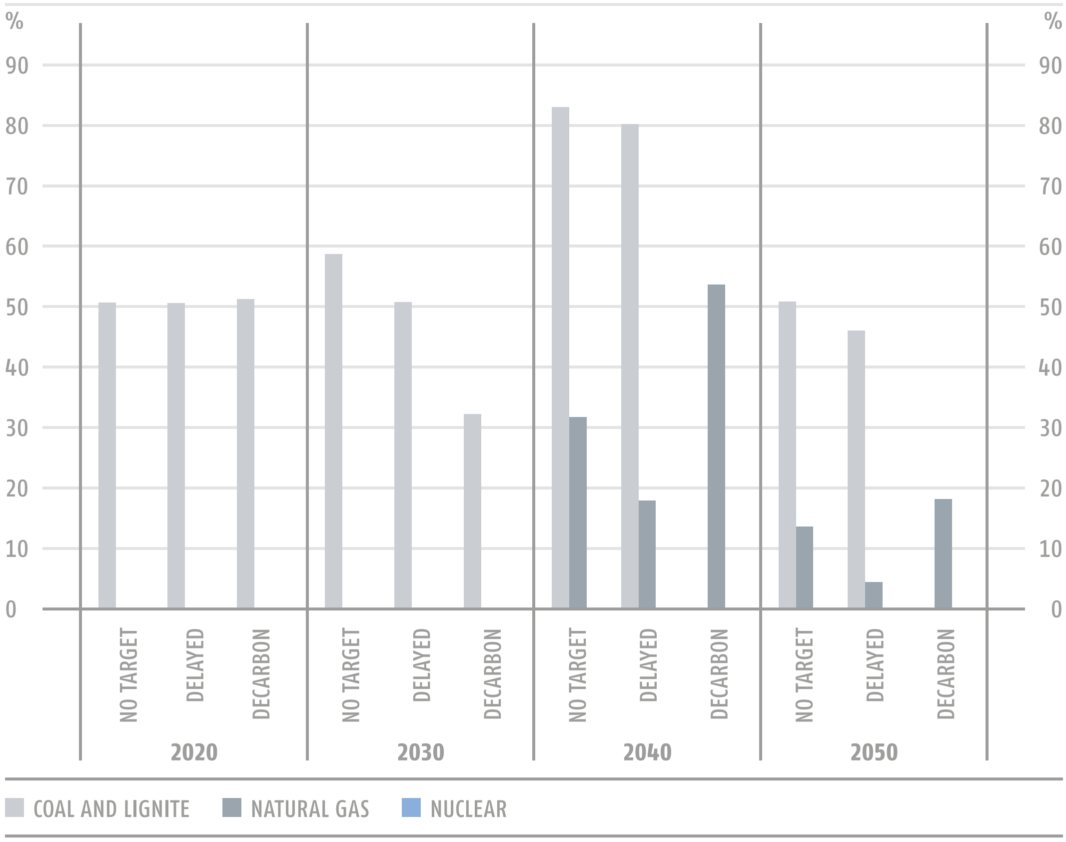


FIGURE 5
UTILISATION RATES OF CONVENTIONAL GENERATION IN KOSOVO*, 2020-2050 (%)



sector development path that will lead to an energy mix almost entirely comprised of RES capacities by 2050. In the other two scenarios significant emission reduction is achieved with a mix of renewables (wind, hydro and solar) and fossil fuels; approximately half of this capacity is equipped with carbon capture and storage technology (CCS). However, these two scenarios do not ensure achievement of the EU emission reduction targets and are characterised by a relatively late start in RES deployment demonstrating growth from 2040.

The development of capacities is mirrored in the electricity generation mix. Lignite based generation remains substantial (approximately half of total generation in 2050) in the 'no target' and the 'delayed' scenarios where outgoing capacities are replaced with a total of 1100 MW of new lignite capacity. In the 'decarbonisation' scenario, new lignite powered units are not added and lignite production ceases from 2040. By 2050 approximately 90% of lignite based generation comes from the CCS-equipped power plant, as the other plant is priced out of the market due to the high carbon price.

Currently natural gas plays no role in Kosovo's* electricity generation and will only play a minor role in future scenarios after 2020. There are no gas power plants in 2020 and the new capacities built later do not exceed 300 MW (the exact volume is scenario dependent, with 300 MW in the 'no target', 200 MW in the 'delayed' and 100 MW 'decarbonisation' scenarios). Gas-based generation peaks in 2040 at less than 15% of electricity production in the 'no target' scenario, and is even lower in the other two scenarios. By the end of the modelled time horizon gas is not competitive due to the combination of high gas and carbon prices and declines in all scenarios. Renewable generation, meanwhile, increases from a very low 2016 baseline, when hydro generation is the only RES source and plays a negligible role alongside lignite based generation. The increase in wind and solar is especially large in the 'delayed' and 'decarbonisation' scenarios, but the uptake of these technologies (both in terms of capacities and generation) depends on the scenario: in the 'decarbonisation' scenario it starts earlier, from 2030 while in the 'delayed' scenario there is only a significant increase in capacity in the last modelled decade when both the wholesale price and RES support increase.

With expanding RES production capacities and the new CCS unit in both the 'no target' and 'delayed' scenarios, Kosovo* is projected to become a net electricity exporter by 2040. In the 'delayed' scenario when both RES and fossil fuel based generation are relatively high, Kosovo* is expected to export more than 3.2 GWh electricity compared to 8.4 GWh of consumption. The 'decarbonisation' scenario implies continued net imports from 2025 onwards.

The policy choice favouring new gas-fired capacities is not supported by projected utilisation rates. The development of gas infrastructure in the region from the point of view of the electricity sector in Kosovo* has little added value, considering the minor role played by gas in electricity generation in all three scenarios. Utilisation rates are below 30% for new gas capacities with the exception of the 'decarbonisation' scenario in 2040 where only 100 MW is assumed and when gas is still competitive. But by 2050 this is no longer the case because of rising natural gas and carbon allowance prices. Lignite plant utilisation is mostly low as well at close to 50% on average for most of the modelled time horizon. Similarly to gas, in 2040 utilisation rates spike, reaching 83% in the 'no target' scenario and 80% in the 'delayed' scenario when total lignite capacity is low as old units are phased out (only new PPs operate) and RES deployment has not ramped up. By 2050 the lignite power plant not equipped with CCS, Kosova e Re, is not commercially viable. Generally low utilisation prospects raise the risk of new gas and lignite investments being stranded. This issue is discussed further in section 5.4.

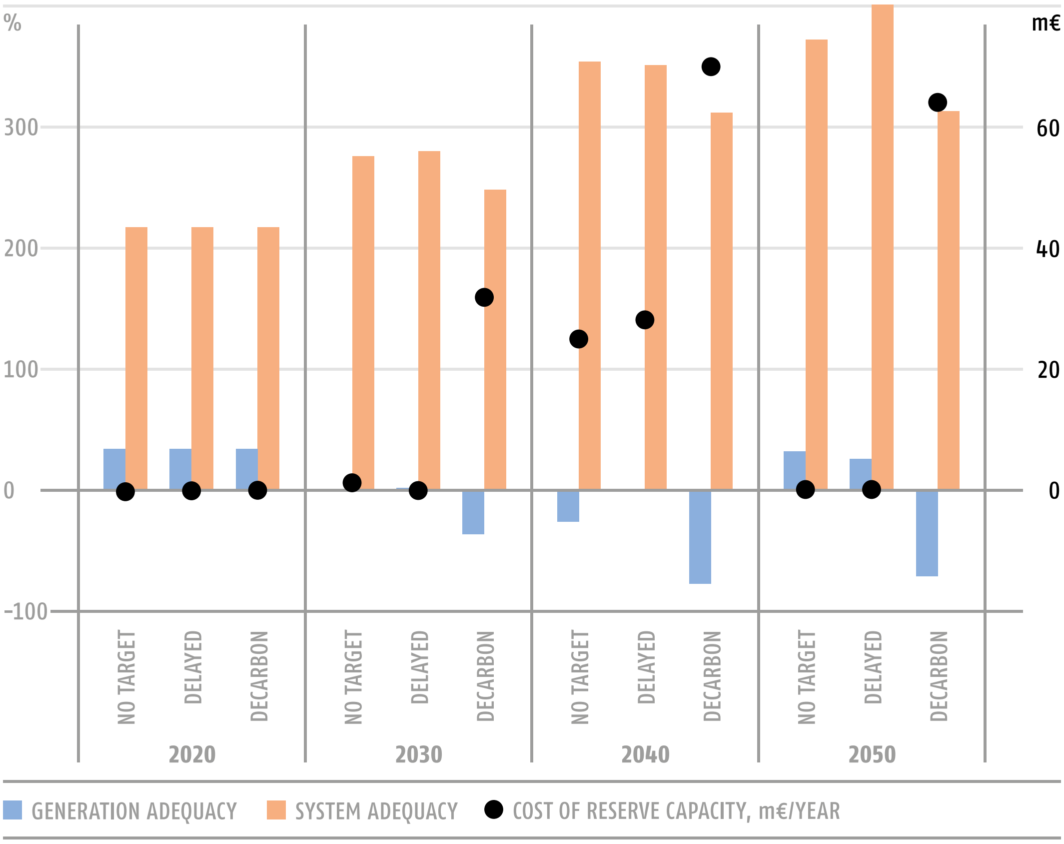
5.2 Security of supply

Even though the physical and commercial integration of national electricity markets improves security of supply, concerns of decision makers often remain regarding the extent and robustness of this improvement, particularly in the context of a high share of renewables. In order to assess the validity of such concerns three security of supply indices were calculated for all countries and scenarios: the generation capacity margin, the system adequacy margin, and the cost of increasing the generation adequacy margin to zero.

The generation adequacy margin is defined as the difference between available capacity and hourly load as a percentage of hourly load. If the resulting value is negative then the load cannot be satisfied with domestic generation capacities alone in a given hour, and imports are needed. The value of the generation adequacy margin was calculated for all of the modelled 90 representative hours, and of the 90 calculated values, the lowest generation adequacy margin value was taken into account in the generation adequacy margin indicator. For this calculation, assumptions were made with respect to the maximum availability of different technologies: fossil fuel based power plants are assumed to be available 95% of the time, hydro storage 100% and for other RES technologies historical availability data was used. System adequacy was defined in a similar way, but net transfer capacity available for imports was considered in addition to available domestic capacity. This is a simplified version of the methodology formerly used by ENTSO-E. (See e.g. ENTSO-E, 2015, and previous SOAF reports)

For Kosovo*, the generation adequacy margin turns negative in 2025 and remains so throughout the modelled period in the 'decarbonisation' scenario. In the other two scenarios the generation adequacy margin turns positive at the end of the period. A negative value means that domestic generation capacity is not sufficient to satisfy

FIGURE 6
GENERATION AND SYSTEM ADEQUACY MARGIN FOR KOSOVO*, 2020-2050 (% OF LOAD)



domestic demand in all modelled hours of the year. The system adequacy margin, however, is positive for all hours of all years.

In addition to the adequacy margin indicators, the cost of increasing the generation adequacy margin to zero was calculated for countries with initially negative values. The cost of the required capacity was defined as the yearly fixed cost of an open cycle gas turbine (OCGT) which has the capacity to ensure that the generation adequacy margin reaches zero. In the 'decarbonisation' scenario this cost is 22 mEUR in 2025, but rises by 2040 and 2050 to 60-70mEUR/year. This underlines the importance of physical and commercial integration of national electricity markets.

5.3 Sustainability

The CO_2 emissions of the three core scenarios were calculated based on representative emission factors for the region. Due to data limitations this calculation did not account for greenhouse gases other than CO_2 and does not include emissions related to heat production from cogeneration.

The 94% overall decarbonisation target for the EU28+Western Balkans region translates into a higher than average level of decarbonisation in the Kosovo* electricity sector in the 'decarbonisation' scenario, where a 99% emission reduction is achieved. However, delayed action jeopardises this achievement, as the decarbonisation target of the EU is not reached in this scenario; with new fossil capacities deployed in both the 'no target' and 'delayed' scenarios. In both scenarios, 2050 CO_2 emissions in the electricity sector compared with 1990 are reduced by 84%. The high (although insufficient) level of emission reduction, despite the significant share of

FIGURE 7
CO_2 EMISSIONS UNDER THE 3 CORE SCENARIOS IN KOSOVO*, 2020-2050 (mt)

lignite in the electricity mix, is made possible by the deployment of CCS technology in the new 600MW lignite plant, commissioned in 2041.

The share of renewable generation as a percentage of gross domestic consumption in the 'no target' scenario increases significantly compared with low initial levels, but still only reaches 44.8% in 2050. In both the 'delayed' and 'decarbonisation' scenarios the share of renewable generation reaches around 80% in 2050. The utilisation of RES technical potential is highest in the 'delayed' scenario in 2050, over 80% for hydro, 91% for wind and 71% for solar. In the 'decarbonisation' scenario, utilisation of wind potential is significantly lower at 72%.

5.4 Affordability and competitiveness

In the market model (EEMM) the wholesale electricity price is determined by the highest marginal cost of the power plants needed to satisfy demand. The price trajectories are independent of the level of decarbonisation and similar in all scenarios, only diverging after 2045 when the two scenarios with decarbonisation targets result in lower wholesale prices. This is due to the fact that towards 2050 the share of renewables is high enough to satisfy demand in most hours at a low cost, driving the average annual price down.

The price development has several implications for policy makers. Retail prices depend on the wholesale price as well as taxes, fees and network costs. It is therefore difficult to project retail price evolution based on wholesale price information alone, but it is an important determinant of end user prices and could affect affordability for consumers. The average annual price increase in Kosovo* over the entire period is 2.9% in the 'no target', 2.2% in the 'delayed' and 2.3% in the 'decarbonisation' scenarios, with a fall in wholesale prices over the last five years of the modelled time period leading to lower growth in the latter two scenarios. Although the price increase is high, prices in Europe were at historical lows in 2016 for the starting point of the analysis and will rise to approximately 60 EUR/MWh

FIGURE 8
WHOLESALE ELECTRICITY PRICE IN KOSOVO*, 2020-2050 (€/MWh)

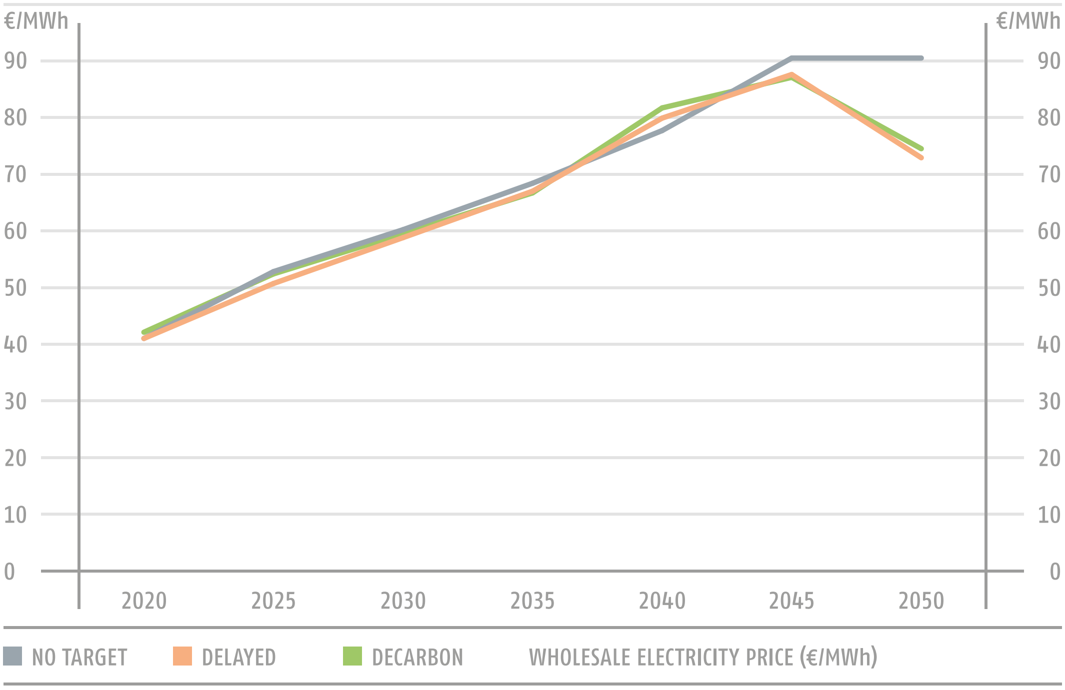


FIGURE 9
CUMULATIVE INVESTMENT COST FOR 4 AND 10 YEAR PERIODS, 2016-2050 (bn€)

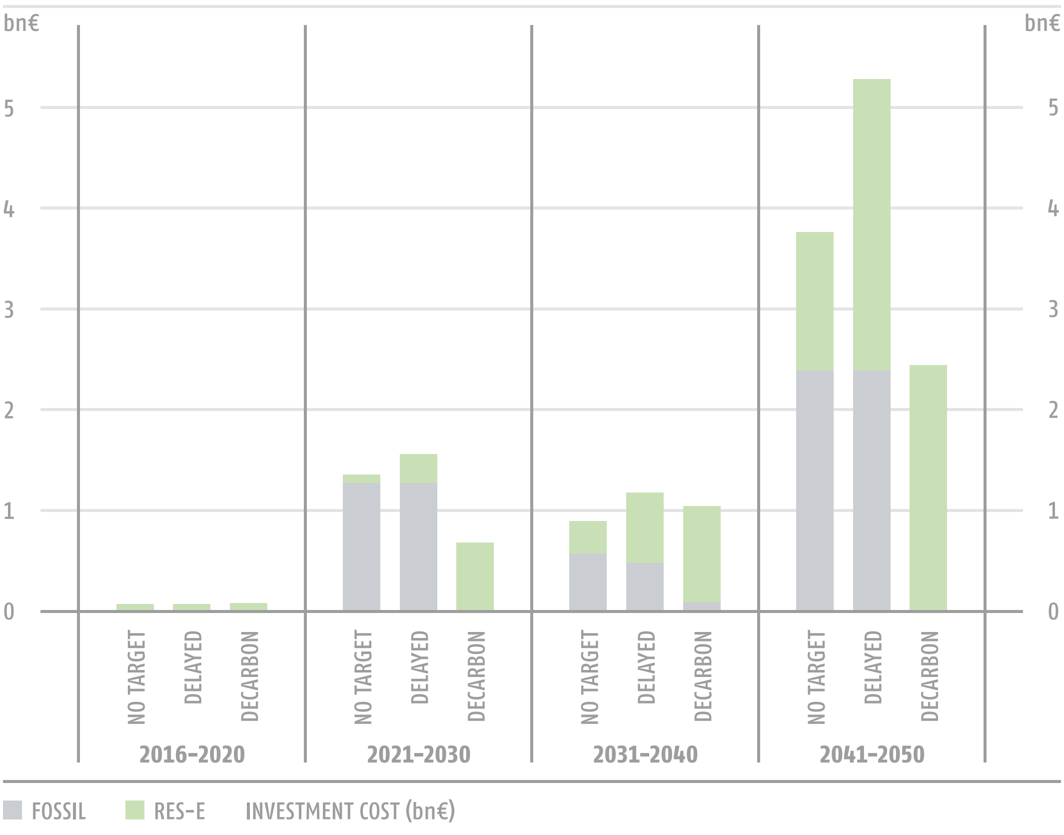
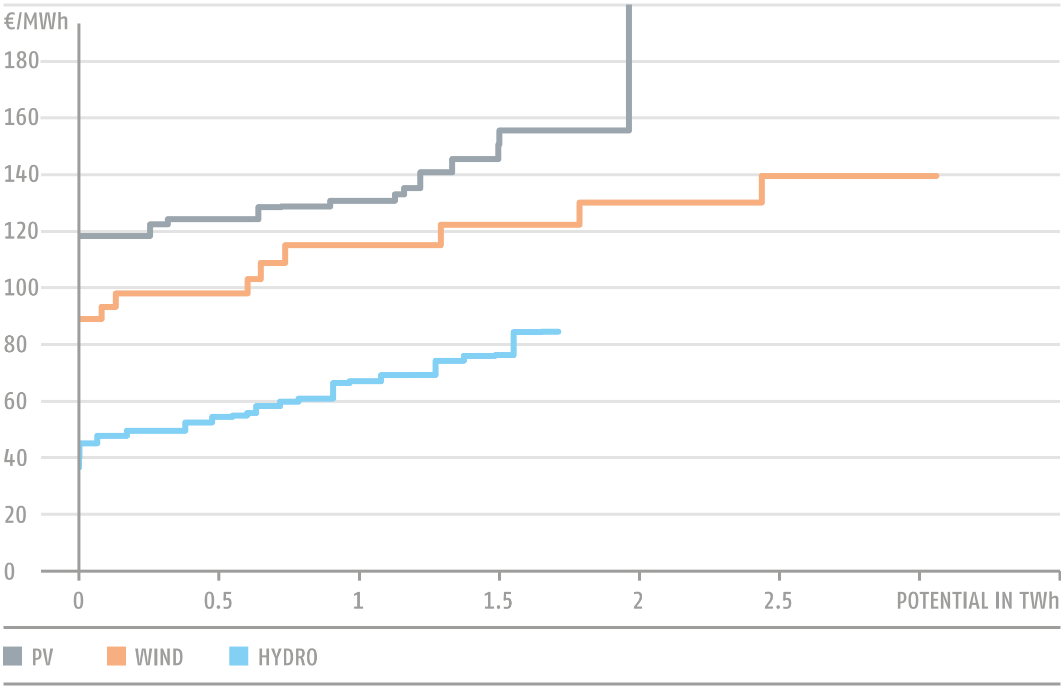


FIGURE 10
LONG TERM COST OF RENEWABLE TECHNOLOGIES IN KOSOVO* (€/MWh)



by 2030, similar to price levels 10 years ago. Still, the macroeconomic analysis in Section 5.7 shows that if affordability is measured as the share of household electricity expenditure in disposable income, electricity expenditure remains relatively stable even with the significant increase in wholesale electricity prices. The price increase also has three positive implications, incentivising investment for new capacities, incentivising energy efficiency and reducing the need for RES support.

The overall investment requirement until 2050 is lowest in the 'decarbonisation' scenario since no fossil power units are built. The investment required for new capacities increases significantly in the last decade in the 'no target' and the 'delayed' scenarios, when more than half of the investment is needed to fund the lignite power plant with CCS technology deployed in 2041, in accordance with national plans.

Investments are assumed to be financed by private actors based on a profitability requirement (apart from the capacities planned in the national strategies), factoring in the different cost structure of renewables, i.e. higher capital expenditure and low operating expenditure in their investment decisions. From a social point of view, the consequences of the overall investment level are limited to the impact on GDP and external balance and debt. These impacts are discussed in more detail in section 5.7.

Although RES technologies are already at grid parity in some locations with costs falling further, some support will still be needed in 2050 to incentivise new investment. This is partly due to the locational impact: as the best locations with highest potential are used first, therefore, the levelised cost of new RES capacities might increase over time. The relationship between the cost of RES technologies and installed capacity is shown in Figure 10; the figure does not account for the learning curve impacts which were also considered in the Green-X model.

The renewables support needed to incentivise RES investments in the 'decarbonisation' scenario remains negligible (under 2 EUR/MWh) throughout the entire period. In the 'delayed' scenario rapid deployment of additional capacities towards the end of the modelled period are needed to achieve 2050 decarbonisation targets, raising required

FIGURE 11
AVERAGE RES SUPPORT PER MWh OF TOTAL ELECTRICITY CONSUMPTION AND AVERAGE WHOLESALE PRICE, 2016-2050 (€/MWh)

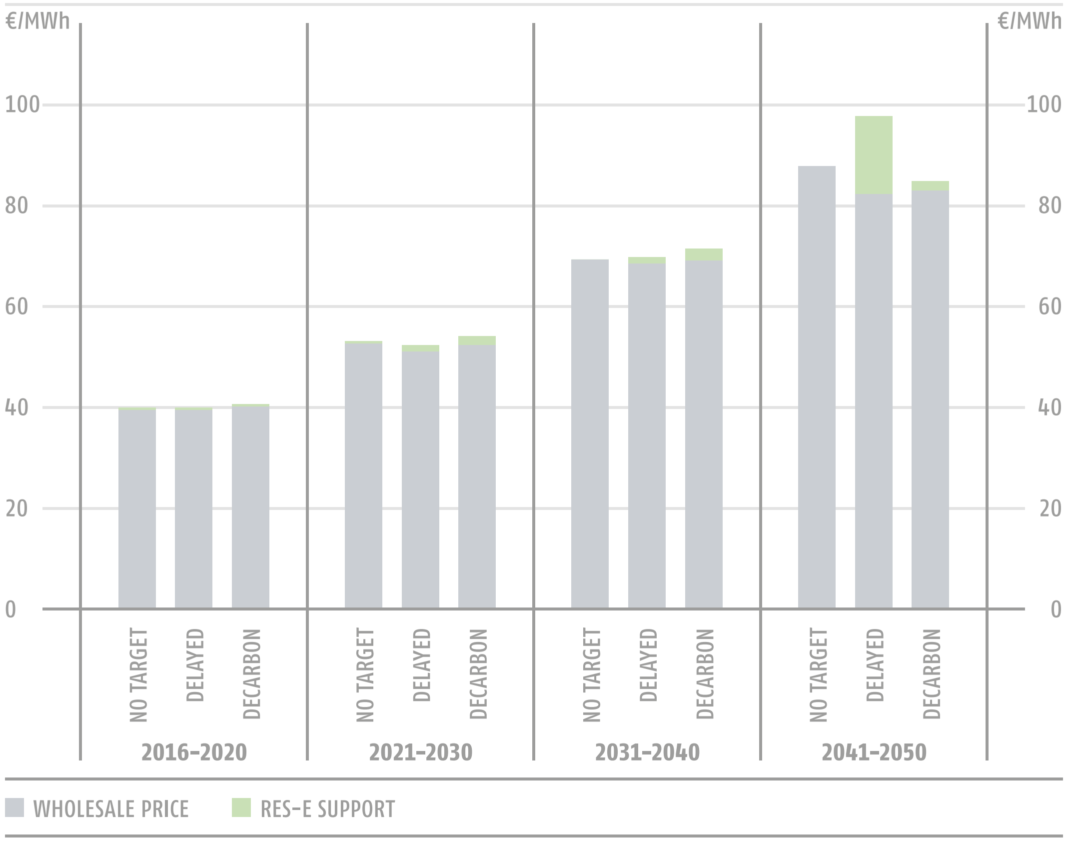
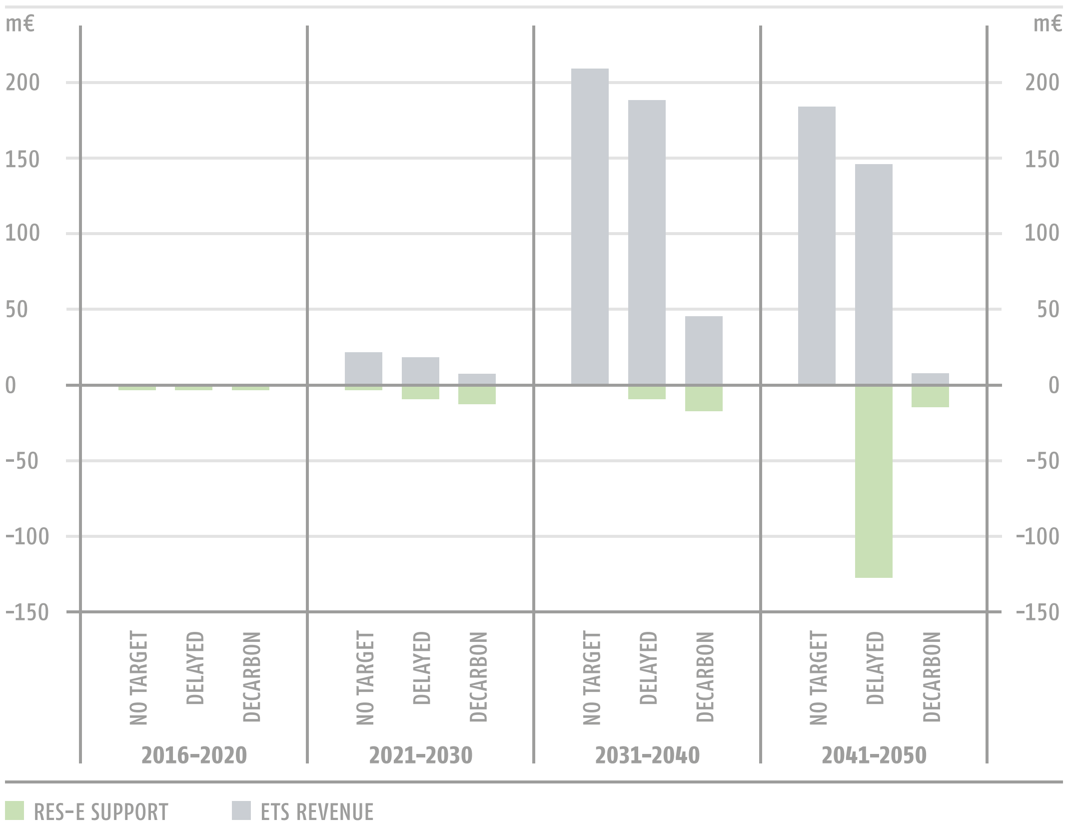


FIGURE 12
CUMULATIVE RES SUPPORT AND AUCTION REVENUES FOR 4 AND 10 YEAR PERIODS, 2016-2050 (m€)



support to an estimated 15.4 EUR/MWh on average over the last decade, equivalent to 16% of total electricity cost.

Renewable energy investments may be incentivised with a number of support schemes using funding from different sources; in the model sliding feed-in premium equivalent values are calculated. Revenue from the auction of carbon allowances under the EU ETS is a potential source of financing for renewable investment. Figure 12 contrasts cumulative RES support needs with ETS auction revenues, assuming 100% auctioning, and taking into account only allowances to be allocated to the electricity sector.

With a significant share of fossil power plants, auction revenues are expected to be higher in Kosovo* in the 'no target' and the 'delayed' scenarios than in the 'decarbonisation' scenario when lignite based generation is phased out by 2040. RES support required during the modelled time horizon is modest in all scenarios with the exception of the last decade in the 'delayed' scenario. RES support is lower than revenues from carbon allowances in all scenarios over the entire period with the exception of the last five years in the 'decarbonisation' scenario. Hence RES support can be almost fully financed from ETS revenues in Kosovo* and there is no need to add a RES support surcharge in the bill of final consumers.

A financial calculation was carried out on the stranded costs of fossil based generation plants that are expected to be built in the period 2017-2050. New fossil generation capacities included in the scenarios are defined either by national energy strategy documents and entered into the model exogenously, or are built by the investment algorithm of the EEMM. The model's investment module assumes 10 year foresight, meaning that investors have limited knowledge of the policies applied in the distant future. The utilisation rate of fossil fuel generation assets drops below 15% in most SEERMAP countries after 2040; this means that capacities which generally need to have a 30-55 year lifetime (30 for CCGT, 40 for OCGT and 55 for coal and lignite plants) with a sufficiently high utilisation rate in order to ensure a positive return on investment will face stranded costs.

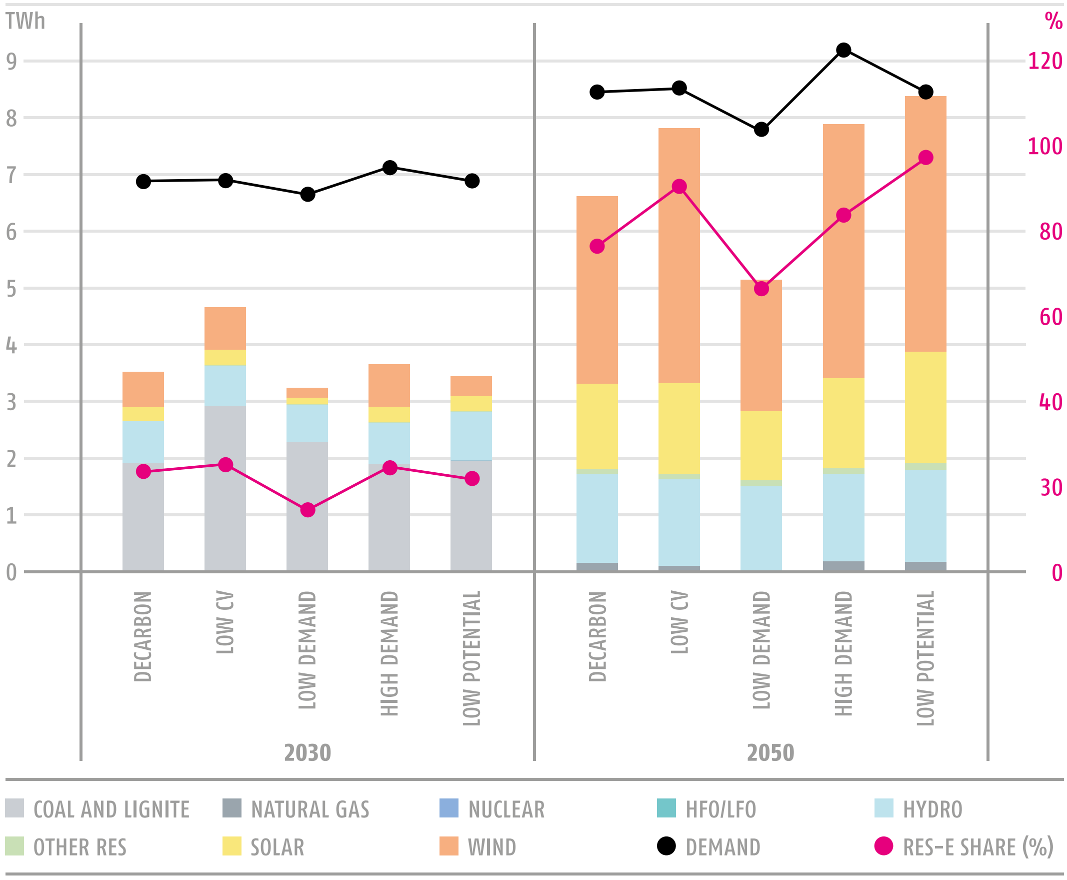
Large stranded capacities might call for public intervention with all the associated cost borne by society/electricity consumers. For this reason we have estimated the stranded costs of fossil based generation assets that were built in the period 2017-2050. The calculation is based on the assumption that stranded costs will be collected as a surcharge on the consumed electricity (as is the case for RES surcharges) for over a period of 10 years after the these lignite based capacities become unprofitable.

Based on this calculation, unprofitable fossil plants would receive 7.8 EUR/MWh in the 'no target' scenario and 8.1 EUR/MWh in the 'delayed' scenario, financed by a surcharge on consumption. This is the highest figure (together with Bosnia and Herzegovina) in the SEERMAP region, and is significantly higher than the renewable support needed to enable Kosovo* to meet EU emission reduction targets in the 'decarbonisation' scenario. The start-up of the two lignite plants planned under the current national energy strategy is a key risk factor in this respect. By contrast, the stranded asset surcharge is only 0.1 EUR/MWh in the 'decarbonisation' scenario. These costs are not included in the wholesale price values shown in this report. Expressed as absolute values, stranded costs are expected to be above 600 mEUR in the 'no target' and 'delayed' scenarios, but only 9 mEUR in the 'decarbonisation' scenario.

5.5 Sensitivity analysis

In order to assess the robustness of the results, a sensitivity analysis was carried out with respect to assumptions that were deemed most controversial by stakeholders during consultations and tested for the following assumptions:

FIGURE 13
GENERATION MIX (TWh) AND RES SHARE (% OF DEMAND) IN THE SENSITIVITY RUNS IN 2030 AND 2050



- Carbon price: to test the impact of a lower CO_2 price, a scenario was run which assumed that CO_2 prices would be half of the value used for the three core scenarios for the entire period until 2050;
- Demand: the impact of higher and lower demand growth was tested, with a +/-0.25% change in the growth rate for each year in all the modelled countries (EU28+WB6), resulting in a 8-9% deviation from the core trajectory by 2050;
- RES potential: the potential for large-scale hydropower and onshore wind power were assumed to be 25% lower than in the core scenarios; this is where the NIMBY effect is strongest and where capacity increase is least socially acceptable.

The changes in assumptions were only applied to the 'decarbonisation' scenario since it represents a significant departure from the current policy for many countries, and it was important to test the robustness of results in order to convincingly demonstrate that the scenario could realistically be implemented under different framework conditions.

The most important conclusions of the sensitivity analysis are the following:

- The CO_2 price is a key determinant of wholesale price, with a 50% reduction resulting in close to a 33% decline in the wholesale price in the long term. However, to ensure that the same decarbonisation target is met more RES support is required in this scenario. As a result the sum of the wholesale price and RES support is higher in this scenario than in the 'decarbonisation' scenario.

- A lower carbon price allows for more lignite production in 2030, but does not make a difference over the long term, as lignite is phased out by 2040 even with a low carbon price. A low carbon price also leads to a higher uptake of wind production in 2050 compared to the 'decarbonisation' scenario.
- In the low-demand scenario in 2030, RES technologies have a significantly lower share in production than in the 'decarbonisation' scenario, while lignite can actually increase its production level. Gas has no role in a low demand scenario.
- Low hydro and wind potential result in significantly higher RES support than in the 'decarbonisation' scenario, and by 2050 RES support is higher than the wholesale electricity price in this sensitivity run.

5.6 Network

Kosovo's* transmission system is already well-connected with the neighbouring countries but additional network investments in internal high voltage transmission lines and at the distribution level will be needed. The network will have to cope with higher RES integration and cross-border electricity trade and peak load that is expected to increase significantly from 1182 MW in 2016 (ENTSO-E DataBase) to 1630 MW in 2030 (SECI DataBase) and 2310 MW in 2050.

For the comparative assessment, a 'base case' network scenario was constructed with development according to the SECI baseline topology and trade flow assumptions. The network effect of the future higher RES deployment in 'delayed' and 'decarbonisation' scenarios was compared to this 'base case' scenario.

The network analysis covered the following ENTSO-E impact categories:

- **Contingency analysis:** Analysis of the network constraints anticipates contingencies that could be solved by investments of 72.5 mEUR by 2050.

TABLE 1 | OVERLOADINGS IN THE SYSTEM OF KOSOVO*, 2030 AND 2050

	Overloading	Solution	Units (km or pcs)	Cost m€
2030	WPP Bela Anta – WPP Košava, or OHLs 110 kV WPP Bela Anta – WPP Alibunar	Reconstruction of the OHL from 150 mm^2 to 240/40 mm^2	65	6.5
2050	n.a.	SS Skakavica (AL) + 400 kV OHLs (to Tirana (AL) and Prizren (KS)	130 + SS 400 kV	65

- **TTC and NTC assessment:** Total and Net Transfer Capacity (TTC/NTC) changes were evaluated between Kosovo* and all of its neighbours for all scenarios relative to the 'base case'. The production pattern (including the production level and its geographic distribution), and load pattern (load level and its geographical distribution, the latter of which is not known) have a significant influence on NTC values between Kosovo* and the neighbouring electricity systems. Figure 14 presents the changes in NTC values for 2030 and 2050 where two opposing outcomes on the NTC values resulting from higher RES

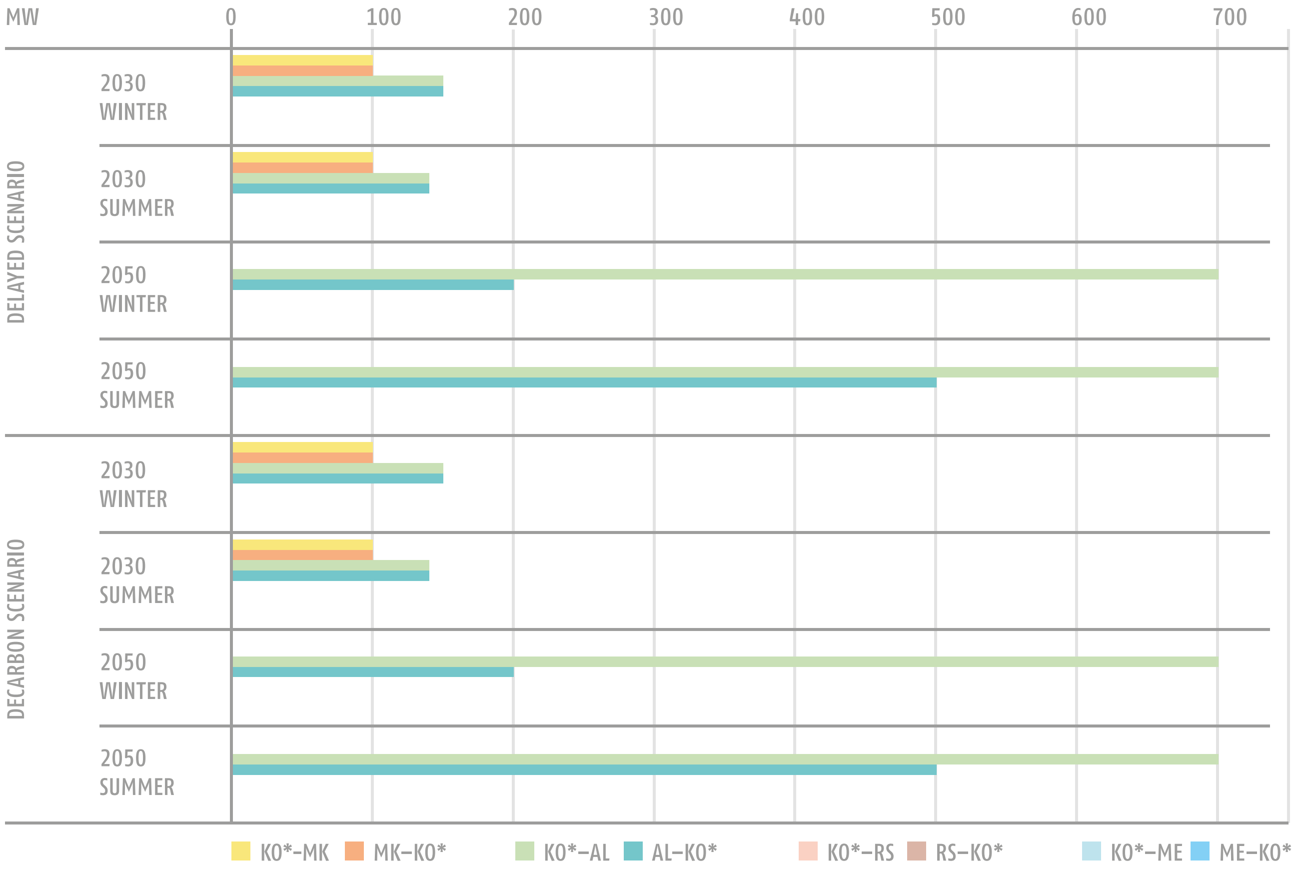


FIGURE 14
NTC VALUE CHANGES IN 2030 AND 2050 IN THE 'DELAYED' AND 'DECARBONISATION' SCENARIOS COMPARED TO THE 'BASE CASE' SCENARIO

deployments. First, high concentration of RES in a geographic area may cause congestion in the transmission network, reducing NTCs and requiring further investment. Second, if RES generation replaces imported electricity, it may increase NTC for a given direction.

The results depict NTC values increasing in both directions with Albania and Macedonia in the RES intensive 'decarbonisation' and 'delayed' scenarios, especially in 2050 with Albania.

- **Network losses:** Transmission network losses are affected in different ways. On the one hand losses are reduced as renewables, especially PV, are connected mostly to the distribution network and as a result the distance between production and consumption decreases. On the other hand, high levels of electricity trade in 2050 (summer), will increase transmission network losses (Figure 15).

As the figure illustrates, the higher RES deployment in the two scenarios reduces transmission losses to around 5 MW in 2030 and increases or decreases by 10-15 MW in 2050 depending on the period (winter or summer) across the modelled hours. This represents a 14 GWh yearly loss variation in the 'decarbonisation' scenario and 34 GWh in the 'delayed' scenario in 2030. In 2050, loss changes are more significant in the 'decarbonisation' scenario compared to the 'delayed' one. If monetised with the base-load price, the concurrent benefit for TSOs of avoiding a loss of 21 GWh is around 1.5 mEUR per year.

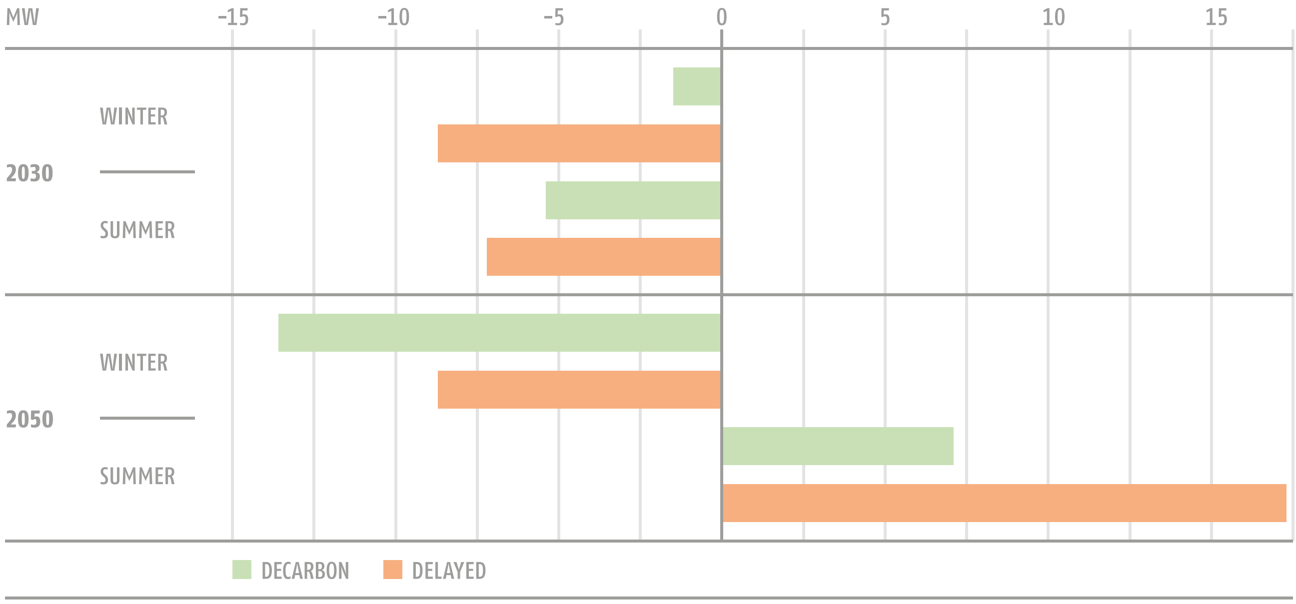


FIGURE 15
LOSS VARIATION COMPARED TO THE BASE CASE IN THE 'DELAYED' AND 'DECARBONISATION' SCENARIOS (MW, NEGATIVE VALUES INDICATE LOSS REDUCTION)

Overall, some investment in the transmission network is necessary to accommodate new RES capacities in Kosovo's* electricity system, but the estimated cost of network investments remain below 173 mEUR for the period, above the investments contained in ENTSO-E TYNDP (2016). This figure includes not only the transmission network costs, but those necessary for connecting facilities, as well as reinforcement of the national grid to facilitate the expected increase in RES generation. It does not include, however, investment needs related to the development of the distribution network, which may be significant due to the increase in solar generation capacity in particular.

5.7 Macroeconomic impacts

A 'baseline' scenario differing from the three core scenarios was constructed for the macroeconomic analysis to serve as a basis for comparison whereby only power plants with a final investment decision by 2016 are built, investment rates in the sector remain unchanged for the remaining period, no 'decarbonisation' targets are set and no additional renewable support is included beyond existing policies. The 'baseline' scenario assumes lower levels of investment than the three core scenarios.

Kosovo* will experience the highest economic growth in the SEERMAP region at 3.5% per annum on average for the whole modelled period on account of large infrastructural investments and strong remittance inflows. This rate ensures solid convergence toward the EU and a better position in the region by 2050. Given the lack of reliable employment statistics, we assume no employment growth in the baseline scenario. Both fiscal and external debt levels will stabilize at current levels close to 25%, below the regional average. This does not pose a significant risk to economic development.

Household electricity expenditure is estimated at 2.4% of disposable income, which is slightly lower than the average value in the SEE region. In the baseline scenario this ratio is projected to remain roughly constant throughout the modelled period.

The three core scenarios exhibit a notable investment effect compared to the baseline. Additional investment is highest in the 'no target' and 'delayed' scenarios. In

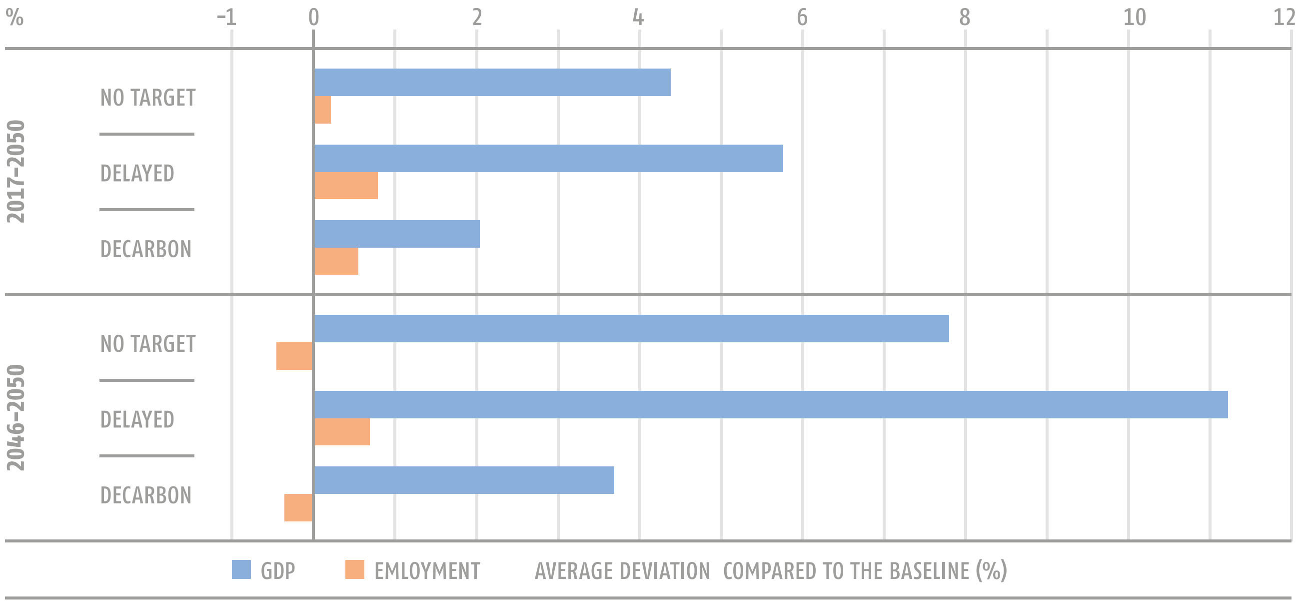


FIGURE 16
GDP AND EMPLOYMENT IMPACTS COMPARED WITH THE 'BASELINE' SCENARIO

both cases, there are two investment peaks in the 2021-2025 and 2041-2045 periods with an additional investment of 3.5% and 4.0% of GDP respectively. In the 'decarbonisation' scenario, the additional investment is lower and spread out, hovering around 0.4-0.6% of GDP.

The macroeconomic results were evaluated along three dimensions: macroeconomic gain, macroeconomic vulnerability and affordability. Macroeconomic gain explains the extent to which the scenarios contribute to greater overall economic activity, measured by GDP and employment across two time dimensions. First, the average difference over the whole time horizon (2016-2050) is compared with the baseline. Then the long term effect is determined by the deviation from the baseline in the period 2046-2050. It is important to note that because the population remains the same across scenarios GDP gains also reflect GDP per capita effects.

According to the results, each core scenario leads to significant macroeconomic gains. In the 'no target' and 'delayed' scenarios GDP rises by around 4% and 6%, respectively compared to the baseline, while in the 'decarbonisation' scenario gains are a more moderate 2%. Long term GDP effects are even higher, reaching 11% in the 'delayed', 8% in the 'no target' and 4% in the 'decarbonisation' scenario. This is reflective of different investment levels in each scenario. Employment effects are very moderate in all three cases.

Long term GDP gains in the 'decarbonisation' and 'delayed' scenarios emerge from two sources. The additional investment raises the level of productive capital in the economy and the newly installed, mostly foreign technologies increase overall productivity. The lower employment gains compared to the GDP effect are explained by two factors: (i) the energy investments are relatively capital intensive and (ii) the initial employment gains are translated into higher wages in the longer term, as labour supply remains the same across scenarios.

The macroeconomic vulnerability calculation captures how the additional investments contribute to the sustainability of the fiscal and external positions of the country measured by the fiscal and external balances and the public and external debt indicators. While the fiscal and external balances are compared to the 'baseline' scenario over

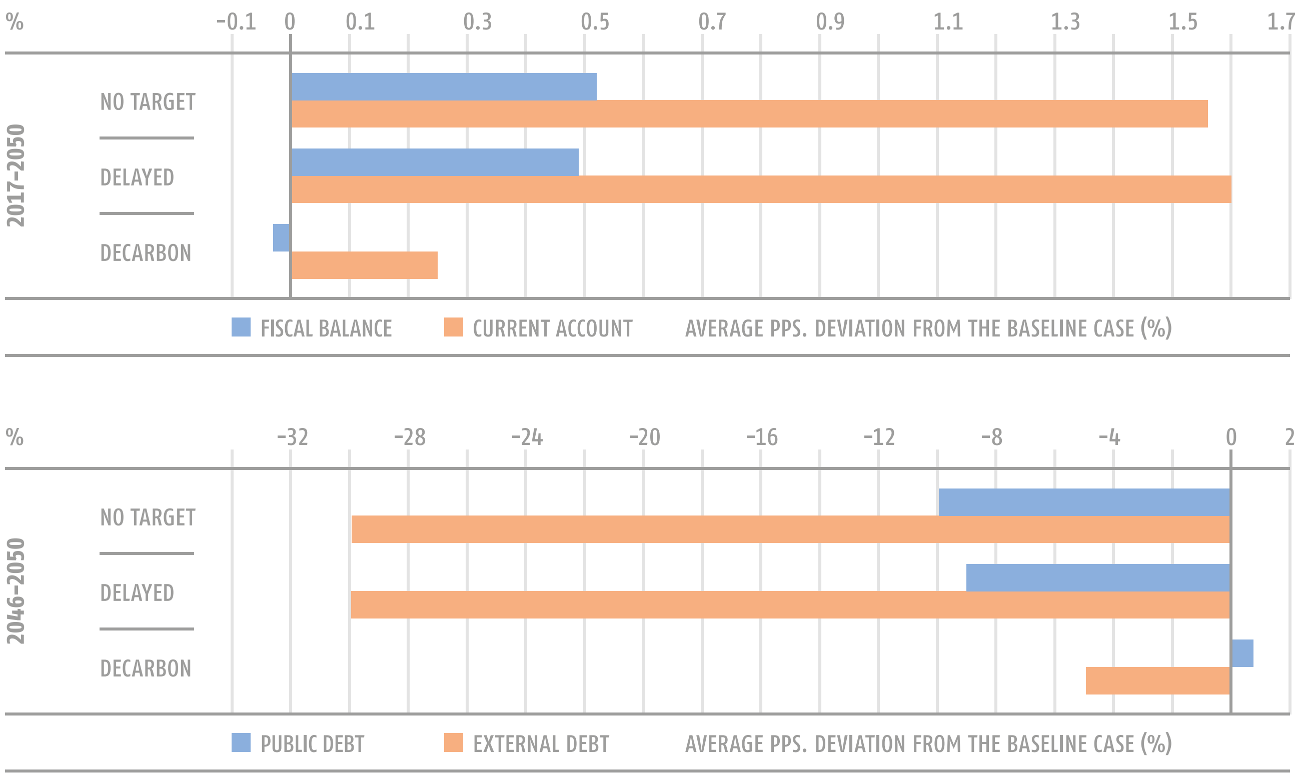


FIGURE 17
PUBLIC AND EXTERNAL BALANCES AND DEBT IMPACTS COMPARED WITH THE 'BASELINE' SCENARIO

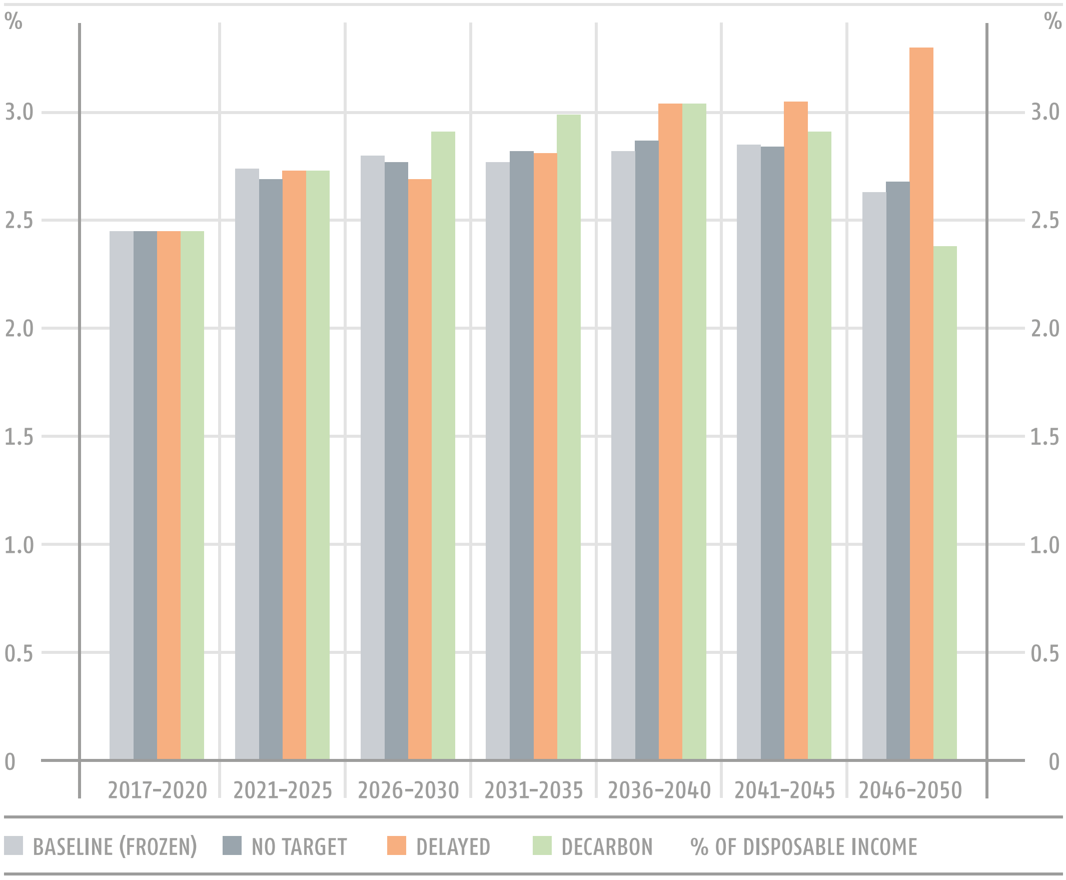
the whole projection horizon (2017-2050), the debt indicators focus on the long term effects, with the difference from the baseline only calculated at the end of the modelled period. This approach is consistent with the fact that debt is accumulated from past imbalances.

Each core scenario improves the macroeconomic vulnerability indicators of Kosovo*. In the 'no target' and 'delayed' scenarios, external debt levels fall by almost 30% of GDP and public debt by 10% by 2050. Differences in the external debt profiles are primarily explained by the change in net energy trade relative to the 'baseline' scenario. The fiscal balance also improves significantly, by close to 0.5% of GDP, in the 'delayed' and 'no target' scenarios due to higher CO_2 revenues from significant fossil investments. However, the fiscal and external balance remains practically unchanged in the 'decarbonisation' scenario since the changes in the current account and fiscal deficit are small compared to the baseline.

Affordability measures the burden of the electricity bill for households as the ratio of household electricity expenditure to household disposable income. The indicator is tracked closely throughout the whole period in order to identify notable increases.

In the core scenarios, household electricity affordability improves slightly over time, but follows a largely similar path as the 'baseline' scenario. The smallest difference compared to the 'baseline' scenario is in the 'no target' scenario, where increasing real wholesale prices push up costs very slightly. While in most periods household electricity expenditure is somewhat higher than in the baseline, similar to other countries in the region, a substantial decline in expenditure in the 'decarbonisation' scenario is observable in the 2046-2050 period, primarily due to the large fall in real wholesale electricity prices at the end of the simulation period. The effect of lower wholesale electricity prices is more than offset by higher renewable support in the 'delayed' scenario, leading to a more than 20% increase in electricity expenditure.

FIGURE 18
HOUSEHOLD ELECTRICITY EXPENDITURE 2017-2050



6 | Policy conclusions

The modelling work carried out under the SEERMAP project identifies some key findings with respect to the different electricity strategy approaches that Kosovo* can pursue. These results, **robust and relevant across all scenarios, can lead to a set of the following no regret policy options.**

MAIN POLICY CONCLUSIONS

Regardless of whether or not Kosovo* pursues an active policy to decarbonise its electricity sector, RES-based capacities will expand significantly from current low levels:

- Kosovo* is set to achieve a 44% of RES-share in electricity consumption by 2050 even if no emission reduction target is set; the share of RES even reaches 85% in the 'delayed' scenario;
- The high penetration of RES found in all scenarios suggests that energy policy of Kosovo* should focus on enabling RES integration.
- Compared with other countries in the region, the share of lignite in the generation mix remains significant even in 2050 in both the 'no target' and 'delayed' scenarios due to

reliance on CCS technology. However, the plant not equipped with CCS is priced out of the market due to the high carbon price;

If a strategy based largely on renewables is chosen, planned long term action is more advantageous than delayed action:

- Stranded cost is a magnitude higher in the 'delayed' scenario compared to the 'decarbonisation' scenario: 8.1 EUR/MWh versus 0.1 EUR/MWh. This cost in the 'delayed' scenario is significantly higher than the required RES support in the 'decarbonisation' scenario.
- The renewables support needed to incentivise these investments is considerable in the 'delayed' scenario towards the end of the modelled period when rapid deployment of capacities is needed. This is estimated to be 15.4 EUR/MWh (16% of total electricity cost).
- The wholesale electricity price is identical in the 'delayed' and 'decarbonisation' scenarios, meaning the lack of new fossil capacities in the 'decarbonisation' scenario does not drive up prices. The price of electricity follows a similar trajectory under all scenarios and only diverges after 2045, when prices with more RES in the electricity mix are lower as a result of the low marginal cost of RES electricity production.
- Kosovo* is likely to become a net electricity importer in the 'decarbonisation' scenario, with a negative generation adequacy by 2020, underlining the importance of the physical and commercial integration of national electricity markets in scenarios with a high RES share. Alternatively, relying on national capacity alone would imply a reserve capacity cost of 40mEUR/year on average between 2025-2050, reaching 60-70mEUR/year from 2040.

Questions regarding the role of natural gas:

- Gas-fired production remains insignificant by 2050 in all scenarios. At its peak in the 'no target' scenario gas contributes less than 15% to total electricity generation, raising questions over the need for new gas infrastructure investments.

6.1 Main electricity system trends

In all scenarios, the current almost exclusively lignite based generation capacity mix will be phased out completely by 2040. In the 'decarbonisation' scenario Kosovo* follows an electricity sector development path that leads to an energy mix based almost exclusively on RES capacities by 2050. In the other two scenarios, a significant reduction in emissions is achieved through a mix of renewables (mostly wind, hydro and solar) and carbon capture technology (CCS) installed with a new 600 MW lignite fuelled power unit planned to be put into operation in 2041. The current lignite based generation capacity will be phased out completely by 2030, substituted by new lignite and gas based units in the 'no target' and 'delayed' scenarios. In these scenarios RES capacity increase is significant only after 2040. **The country faces a policy choice regarding the role of natural gas.** Gas based generation remains negligible in all scenarios, raising the question of how Kosovo* should position itself towards gas infrastructure developments in the SEE region.

The high penetration of RES in all scenarios suggests that a robust no-regret action for Kosovo* energy policy is to focus on enabling RES integration. This involves:

- investing in transmission and distribution networks,
- enabling demand side management and RES production through a combination of technical solutions and appropriate regulatory practices, and
- promoting investment in storage solutions including hydro and small scale storage.

A long term planned effort for renewable energy appears more advantageous than delayed action. Delayed action only results in an 84% emission reduction, falling short of the EU decarbonisation target for 2050. In addition, the stranded cost of fossil generation assets is significantly lower in the 'decarbonisation' scenario, at around 9 mEUR compared with 664 mEUR in the 'delayed' scenario. Finally, if action is delayed, **a disproportionate effort towards the end of the modelled period is required to meet the CO_2 emissions target.**

6.2 Security of supply

Kosovo* is expected to become a net electricity importer in the 'decarbonisation' scenario. Due to the high level of connectivity with its neighbours, **the system adequacy margin remains positive throughout the entire period,** even though installed generation capacity within the country does not enable Kosovo* to satisfy domestic demand using domestic generation in all hours of the year for all years.

In order to prepare for a significant share of intermittent generation, Kosovo* should work on the no regret measures discussed above to enable a high share of RES penetration without compromising security of supply, with demand side measures, increased network connections and storage solutions.

The network modelling results suggest that Kosovo* would need to invest an estimated 72.5 mEUR in transmission in addition to investments included in ENTSO-E TYNDP 2016.

6.3 Sustainability

Kosovo* will begin non-hydro RES deployment from zero and as such the integration of renewables is a novel challenge to the country. Renewable potential can be gained through policies eliminating barriers to RES investment. **A no-regret step involves de-risking policies addressing high cost of capital** to allow for cost-efficient renewable energy investment.

In Kosovo* CO_2 emissions in the electricity sector are reduced by 99% in the 'decarbonisation' scenario. Without a decarbonisation target, emission reduction is projected to reach 84% with some new fossil capacities not equipped with CCS technology leading to carbon emissions. This is below the EU decarbonisation target for 2050.

6.4 Affordability and competitiveness

Electricity sector decarbonisation does not drive up wholesale electricity prices compared to a scenario in which no emission reduction target is set. The wholesale price of electricity is not driven by the level of decarbonisation but by the CO_2 price, applied across all scenarios, and the price of natural gas, because natural gas based production is the marginal production unit needed to meet demand in a significant number of hours of the year in the region.

The wholesale price of electricity follows a similar trajectory under all scenarios and only diverges after 2045, when the wholesale electricity price is lower in scenarios with higher levels of RES in the electricity mix due to the low marginal cost of RES electricity production.

Under all scenarios wholesale electricity prices increase compared with current (albeit historically low) price levels. This is driven by the price of carbon and the price of natural gas, both of which increase significantly by 2050. This has implications for affordability since the wholesale price will transmit to end user prices. However, the price increase also has a positive impact by attracting needed investment to replace outgoing capacity. In addition, **the macroeconomic analysis shows that despite the high absolute growth in wholesale prices, the core scenarios do not affect household electricity expenditure significantly due rising household disposable income.**

Although not included in the model, **electricity wholesale price volatility is also expected to increase,** ceteris paribus, in a world with a high share of intermittent renewables. **Demand and supply side measures such as increased storage capacity can mitigate this volatility.** Over the long-term, policy decisions will need to address the acceptable level of price volatility considering the costs of supply and demand side measures.

The high initial investment into RES technologies imply that the profitability of the investment is very sensitive to the cost of capital, which is significantly higher in the SEERMAP region, also in Kosovo*, than in Western European member states. Although much of the value of the cost of capital depends on country risk linked to the overall macroeconomic performance, **the cost of capital can be reduced to some extent through interventions by policymakers by ensuring a stable policy framework and putting in place de-risking measures. As outlined above, such measures are a no-regret step, yielding minimal system cost and consumer expenditures.**

The significant difference between support requirements in the 'delayed' and 'decarbonisation' scenarios at the end of the modelled period provides a strong argument favouring long-term planning. Stranded costs are also significantly higher if action is delayed. Long-term planning would also provide investors with the necessary stability to ensure that higher level of renewable investments will take place.

7 | References

EC (2011) Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A Roadmap for moving to a competitive low carbon economy in 2050. COM(2011) 112 final

EC (2013) EU Energy, Transport and GHG Emissions Trends to 2050. Reference Scenario 2013. *(https://ec.europa.eu/transport/sites/transport/files/media/publications/doc/trends-to-2050-update-2013.pdf)*

EC (2016) EU Reference Scenario 2016. Energy, transport and GHG emissions Trends to 2050. *(https://ec.europa.eu/energy/sites/ener/files/documents/ref2016_report_final-web.pdf)*

Ecofys & Eclareon (2017): Mapping the cost of capital for wind and solar energy in South Eastern European Member States. *(http://www.ecofys.com/files/files/ecofys-eclareon-2016-wacc-wind-pv-south-east-europe.pdf)*

EIA (2017) Annual Energy Outlook 2017 with Projections to 2050. US energy Information Administration, January 2017. *(https://www.eia.gov/outlooks/aeo/pdf/0383(2017).pdf)*

ENTSO-E (2015) Scenario Outlook and Adequacy Forecast 2015. Brussels, 2015. *(https://www.entsoe.eu/Documents/SDC%20documents/SOAF/150630_SOAF_2015_publication_wcover.pdf)*

ENTSO-E (2016) Ten-Year Network Development Plan 2016. *(http://tyndp.entsoe.eu/)*

ENTSO-G (2017) Ten-Year Network Development Plan 2017. *(https://www.entsog.eu/public/uploads/files/publications/TYNDP/2017/entsog_tyndp_2017_main_170428_web_xs.pdf)*

Fraunhofer ISI (2016) Policy Dialogue on the Assessment and Convergence of RES Policy in EU Member States. Final Report of the DiaCore project. *(http://www.diacore.eu/images/files2/DIACORE_Final_Report.pdf)*

IEA (2017) World Energy Outlook. Paris, France. IEA/OECD.

IRENA, Joanneum Research and University of Ljubljana (2017), Cost-Competitive Renewable Power Generation: Potential across South East Europe, International Renewable Energy Agency (IRENA), Abu Dhabi.

Ministry of Economic Development: Energy Strategy of the Republic of Kosovo* 2017-2026. (Draft version) March 2017.

Ministry of Environment and Spatial Planning: Climate Change Framework Strategy (CCFS) for Kosovo*

McKinsey (2010) Transformation of Europe's power system until 2050. Summary of findings. September 2010. Düsseldorf. *(http://www.mckinsey.com/~/media/mckinsey/dotcom/client_service/epng/pdfs/transformation_of_europes_power_system.ashx)*

TECHNOFI (2013) E-Highway 2050. Selection and characterization of the most impacting demand-side technologies. Paris, 2013, *(http://www.e-highway2050.eu/fileadmin/documents/Results/D3/report_demand_technologies_selection_a.pdf and http://www.e-highway2050.eu/fileadmin/documents/Results/D3/report_demand_technologies_selection_b.pdf)*

CIEMAT (2015) Bringing Europe and Third countries closer together through renewable energies. BETTER project Summary Report *(http://better-project.net/sites/default/files/BETTER_Summary%20Report_0.pdf)*

Regional Centre for Energy Policy Research (2015) Decarbonisation modelling in the electricity sector. Regional report. Support for Low Emission Development in South East Europe (SLED) project. *(http://sled.rec.org/documents/SLED_Regional_ELEC_ENG.pdf)*

Annexes

Annex 1 | Model output tables

TABLE A1 | 'NO TARGET' SCENARIO

			2016	2020	2025	2030	2035	2040	2045	2050
Installed capacity, MW	Coal, lignite	Existing	1 478	1 478	678	678	678	0	0	0
		New	0	0	500	500	500	500	1 100	1 100
	Natural gas	Existing	0	0	0	0	0	0	0	0
		New	0	0	0	0	200	300	300	300
	Nuclear	Existing	0	0	0	0	0	0	0	0
		New	0	0	0	0	0	0	0	0
	HFO/LFO		0	0	0	0	0	0	0	0
	Hydro		49	75	87	136	191	254	311	359
	Wind		1	1	1	1	0	60	240	814
	Solar		0	38	38	38	56	104	238	504
	Other RES		0	0	0	1	3	5	10	17
Gross consumption, GWh			5 647	5 944	6 297	6 883	7 437	7 680	8 056	8 413
Net electricity generation, GWh	Total		6 843	6 886	7 090	6 604	5 842	5 679	10 854	9 042
	Coal and lignite		6 642	6 565	6 724	6 054	4 962	3 635	7 823	4 908
	Natural gas		0	0	0	0	98	836	1 044	361
	Nuclear		0	0	0	0	0	0	0	0
	HFO/LFO		0	0	0	0	0	0	0	0
	Hydro		199	281	325	507	715	948	1 162	1 342
	Wind		2	2	2	1	0	136	546	1 855
	Solar		0	38	38	38	56	104	240	507
	Other RES		0	0	2	5	11	19	39	68
Net import, GWh	Total		-1 197	-941	-793	279	1 596	2 001	-2 798	-629
	ME		69	-319	-805	-225	-144	-92	-985	-207
	RS		182	-205	-1 596	1 122	465	2 660	-777	-1 388
	MK		-750	-120	1 320	-762	354	-638	-558	-940
	AL		-697	-296	287	144	921	70	-479	1 907
Net import ratio, %			-21.2%	-15.8%	-12.6%	4.0%	21.5%	26.1%	-34.7%	-7.5%
RES-E share (RES-E production/gross consumption, %)			3.6%	5.4%	5.8%	8.0%	10.5%	15.7%	24.7%	44.8%
Utilisation rates of RES-E technical potential, %	Hydro		na	na	na	na	na	na	na	73%
	Wind		na	na	na	na	na	na	na	40%
	Solar		na	na	na	na	na	na	na	25%
Utilisation rates of conventional power production, %	Coal and lignite		51.3%	50.7%	65.2%	58.7%	48.1%	83.0%	81.2%	50.9%
	Natural gas		na	na	na	na	5.6%	31.8%	39.7%	13.7%
	Nuclear		na	na	na	na	na	na	na	na
Natural gas consumption of power generation, TWh			–	–	–	–	0.20	1.48	1.87	0.62
Security of supply	Generation adequacy margin		38%	34%	3%	-1%	11%	-26%	24%	32%
	System adequacy margin		228%	217%	178%	276%	389%	354%	396%	372%
CO_2 emission	Emission, Mt CO_2		8.2	8.0	7.2	6.4	5.2	3.9	4.0	0.9
	CO_2 emission reduction compared to 1990, %		-41.7%	-39.9%	-25.9%	-12.0%	9.8%	32.7%	29.9%	84.2%
Spreads	Clean dark spread, €(2015)/MWh		25.4	30.8	42.8	14.7	13.5	13.9	6.5	-13.6
	Clean spark spread, €(2015)/MWh		-2.9	-0.5	5.3	-5.2	-4.6	-5.7	-2.7	-10.9
Price impacts	Electricity wholesale price, €(2015)/MWh		34.7	41.0	52.8	60.2	68.4	77.7	90.5	90.5
	Total RES-E support/gross consumption, €(2015)/MWh, five year average		na	0.5	0.6	0.4	0	0	0	0
	Revenue from CO_2 auction/gross consumption, €(2015)/MWh		0	0	0	31.4	29.3	25.2	34.5	9.5
Investment cost, m€/5 year period	Coal and lignite		na	0	1 274	0	480	0	2 390	0
	Natural gas		na	0	0	0	0	91	0	0
	Total Fossil		na	0	1 274	0	480	91	2 390	0
	Total RES-E		na	74	16	68	109	216	437	936
	Total		na	74	1 290	68	588	308	2 828	936
Main assumptions	Coal price, €(2015)/GJ		1.78	1.95	1.93	1.89	1.98	2.04	2.04	2.04
	Lignite price, €(2015)/GJ		0.98	1.07	1.06	1.04	1.09	1.12	1.12	1.12
	Natural gas price, €(2015)/MWh		18.79	20.74	23.78	25.98	28.07	31.64	32.72	33.00
	CO_2 price, €(2015)/t		8.60	15.00	22.50	33.50	42.00	50.00	69.00	88.00

TABLE A2 | 'DELAYED' SCENARIO

			2016	2020	2025	2030	2035	2040	2045	2050
Installed capacity, MW	Coal, lignite	Existing	1 478	1 478	678	678	678	0	0	0
		New	0	0	500	500	500	500	1 100	1 100
	Natural gas	Existing	0	0	0	0	0	0	0	0
		New	0	0	0	0	200	200	200	200
	Nuclear	Existing	0	0	0	0	0	0	0	0
		New	0	0	0	0	0	0	0	0
	HFO/LFO		0	0	0	0	0	0	0	0
	Hydro		49	75	119	162	231	296	354	395
	Wind		1	1	71	71	70	269	1 024	1 841
	Solar		0	38	93	104	167	403	877	1 438
	Other RES		0	0	1	2	4	8	15	26
Gross consumption, GWh			5 647	5 945	6 301	6 886	7 441	7 675	8 063	8 457
Net electricity generation, GWh	Total		6 844	6 875	7 428	6 119	5 935	5 982	11 407	11 730
	Coal and lignite		6 643	6 555	6 724	5 240	4 630	3 514	6 519	4 441
	Natural gas		0	0	0	0	99	315	291	80
	Nuclear		0	0	0	0	0	0	0	0
	HFO/LFO		0	0	0	0	0	0	0	0
	Hydro		199	281	444	605	861	1 105	1 322	1 473
	Wind		2	2	163	162	161	613	2 335	4 195
	Solar		0	38	94	105	168	406	883	1 441
	Other RES		0	0	3	7	15	29	57	101
Net import, GWh	Total		-1 197	-931	-1 127	767	1 506	1 693	-3 344	-3 274
	ME		-119	-635	-872	-45	578	-132	-316	-297
	RS		363	113	-1 619	2 552	1 038	-973	-6 999	-10 089
	MK		-742	-65	887	-1 778	-879	-263	96	763
	AL		-699	-344	477	39	770	3 061	3 874	6 349
Net import ratio, %			-21.2%	-15.7%	-17.9%	11.1%	20.2%	22.1%	-41.5%	-38.7%
RES-E share (RES-E production/gross consumption, %)			3.6%	5.4%	11.2%	12.8%	16.2%	28.1%	57.0%	85.3%
Utilisation rates of RES-E technical potential, %	Hydro		na	na	na	na	na	na	na	80%
	Wind		na	na	na	na	na	na	na	91%
	Solar		na	na	na	na	na	na	na	71%
Utilisation rates of conventional power production, %	Coal and lignite		51.3%	50.6%	65.2%	50.8%	44.9%	80.2%	67.7%	46.1%
	Natural gas		na	na	na	na	5.7%	18.0%	16.6%	4.5%
	Nuclear		na	na	na	na	na	na	na	na
Natural gas consumption of power generation, TWh			–	–	–	–	0.20	0.64	0.59	0.16
Security of supply	Generation adequacy margin		38%	34%	7%	2%	15%	-30%	21%	26%
	System adequacy margin		228%	217%	182%	280%	393%	351%	397%	401%
CO_2 emission	Emission, Mt CO_2		8.2	8.0	7.2	5.5	4.8	3.6	2.6	0.9
	CO_2 emission reduction compared to 1990, %		-41.7%	-39.6%	-25.9%	4.7%	16.6%	37.7%	54.9%	84.3%
Spreads	Clean dark spread, €(2015)/MWh		25.4	30.8	40.6	13.4	12.0	16.2	3.7	-31.2
	Clean spark spread, €(2015)/MWh		-2.9	-0.5	3.1	-6.6	-6.1	-3.4	-5.6	-28.4
Price impacts	Electricity wholesale price, €(2015)/MWh		34.7	41.0	50.7	58.8	67.0	79.9	87.6	72.9
	Total RES-E support/gross consumption, €(2015)/MWh, five year average		na	0.5	1.9	0.6	0.6	1.8	3.5	27.2
	Revenue from CO_2 auction/gross consumption, €(2015)/MWh		0	0	0	26.7	27.1	23.4	22.2	9.4
Investment cost, m€/5 year period	Coal and lignite		na	0	1 274	0	480	0	2 390	0
	Natural gas		na	0	0	0	0	0	0	0
	Total Fossil		na	0	1 274	0	480	0	2 390	0
	Total RES-E		na	74	207	78	164	537	1 439	1 450
	Total		na	74	1 481	78	644	537	3 830	1 450
Main assumptions	Coal price, €(2015)/GJ		1.78	1.95	1.93	1.89	1.98	2.04	2.04	2.04
	Lignite price, €(2015)/GJ		0.98	1.07	1.06	1.04	1.09	1.12	1.12	1.12
	Natural gas price, €(2015)/MWh		18.79	20.74	23.78	25.98	28.07	31.64	32.72	33.00
	CO_2 price, €(2015)/t		8.60	15.00	22.50	33.50	42.00	50.00	69.00	88.00

TABLE A3 | 'DECARBONISATION' SCENARIO

			2016	2020	2025	2030	2035	2040	2045	2050
Installed capacity, MW	Coal, lignite	Existing	1 478	1 478	678	678	678	0	0	0
		New	0	0	0	0	0	0	0	0
	Natural gas	Existing	0	0	0	0	0	0	0	0
		New	0	0	0	0	100	100	100	100
	Nuclear	Existing	0	0	0	0	0	0	0	0
		New	0	0	0	0	0	0	0	0
	HFO/LFO		0	0	0	0	0	0	0	0
	Hydro		49	80	135	196	265	330	375	417
	Wind		1	1	74	277	368	517	962	1 448
	Solar		0	38	98	238	409	783	1 341	1 494
	Other RES		0	0	1	2	4	8	15	25
Gross consumption, GWh			5 647	5 942	6 298	6 884	7 441	7 670	8 064	8 453
Net electricity generation, GWh	Total		6 844	6 984	3 862	3 529	3 704	3 699	5 451	6 618
	Coal and lignite		6 643	6 644	3 088	1 917	891	0	0	0
	Natural gas		0	0	0	0	555	471	449	160
	Nuclear		0	0	0	0	0	0	0	0
	HFO/LFO		0	0	0	0	0	0	0	0
	Hydro		199	300	503	734	992	1 232	1 401	1 557
	Wind		2	2	169	631	839	1 179	2 194	3 302
	Solar		0	38	99	240	412	788	1 349	1 501
	Other RES		0	0	3	7	15	30	57	98
Net import, GWh	Total		-1 197	-1 042	2 435	3 355	3 737	3 971	2 613	1 834
	ME		-119	-486	-53	397	271	292	194	510
	RS		363	216	1 076	3 985	1 473	784	-3 950	-6 964
	MK		-742	84	1 278	-1 274	-369	-1 066	504	257
	AL		-699	-856	134	247	2 361	3 962	5 865	8 031
Net import ratio, %			-21.2%	-17.5%	38.7%	48.7%	50.2%	51.8%	32.4%	21.7%
RES-E share (RES-E production/gross consumption, %)			3.6%	5.7%	12.3%	23.4%	30.3%	42.1%	62.0%	76.4%
Utilisation rates of RES-E technical potential, %	Hydro		na	na	na	na	na	na	na	85%
	Wind		na	na	na	na	na	na	na	72%
	Solar		na	na	na	na	na	na	na	74%
Utilisation rates of conventional power production, %	Coal and lignite		51.3%	51.3%	52.0%	32.3%	15.0%	na	na	na
	Natural gas		na	na	na	na	63.3%	53.7%	51.3%	18.2%
	Nuclear		na	na	na	na	na	na	na	na
Natural gas consumption of power generation, TWh			–	–	–	–	0.96	0.81	0.77	0.28
Security of supply	Generation adequacy margin		38%	34%	-34%	-36%	-28%	-77%	-74%	-71%
	System adequacy margin		228%	217%	141%	248%	358%	312%	313%	313%
CO_2 emission	Emission, Mt CO_2		8.2	8.2	3.7	2.3	1.2	0.2	0.2	0.1
	CO_2 emission reduction compared to 1990, %		-41.7%	-41.7%	36.3%	60.5%	78.3%	97.2%	97.3%	99.0%
Spreads	Clean dark spread, €(2015)/MWh		25.4	31.9	42.4	14.1	11.7	17.9	3.2	-29.6
	Clean spark spread, €(2015)/MWh		-2.9	0.6	4.9	-5.9	-6.3	-1.7	-6.1	-26.8
Price impacts	Electricity wholesale price, €(2015)/MWh		34.7	42.1	52.4	59.5	66.7	81.7	87.1	74.5
	Total RES-E support/gross consumption, €(2015)/MWh, five year average		na	0.5	1.3	2.3	2.6	2.0	0.9	2.7
	Revenue from CO_2 auction/gross consumption, €(2015)/MWh		0	0	0	11.1	7.1	1.1	1.3	0.6
Investment cost, m€/5 year period	Coal and lignite		na	0	0	0	0	0	0	0
	Natural gas		na	0	0	0	91.6	0	0	0
	Total Fossil		na	0	0	0	91.6	0	0	0
	Total RES-E		na	81	243	439	396	559	1 310	1 135
	Total		na	81	243	439	487	559	1 310	1 135
Main assumptions	Coal price, €(2015)/GJ		1.8	2.0	1.9	1.9	2.0	2.0	2.0	2.0
	Lignite price, €(2015)/GJ		0.98	1.07	1.06	1.04	1.09	1.12	1.12	1.12
	Natural gas price, €(2015)/MWh		18.79	20.74	23.78	25.98	28.07	31.64	32.72	33.00
	CO_2 price, €(2015)/t		8.60	15.00	22.50	33.50	42.00	50.00	69.00	88.00

TABLE A4 | SENSITIVITY ANALYSIS – LOW CARBON PRICE

			2016	2020	2025	2030	2035	2040	2045	2050
Installed capacity, MW	Coal, lignite	Existing	1 478	1 478	678	678	678	0	0	0
		New	0	0	0	0	0	0	0	0
	Natural gas	Existing	0	0	0	0	0	0	0	0
		New	0	0	0	0	100	100	100	100
	Nuclear	Existing	0	0	0	0	0	0	0	0
		New	0	0	0	0	0	0	0	0
	HFO/LFO		0	0	0	0	0	0	0	0
	Hydro		49	75	129	189	259	324	370	412
	Wind		1	1	97	329	643	977	1 682	1 983
	Solar		0	38	112	267	553	1 008	1 313	1 630
	Other RES		0	0	2	3	5	8	15	25
Gross consumption, GWh			5 651	5 948	6 309	6 905	7 469	7 691	8 107	8 513
Net electricity generation, GWh	Total		6 922	7 052	3 913	4 664	5 820	4 717	6 801	7 816
	Coal and lignite		6 721	6 731	3 087	2 924	2 580	0	0	0
	Natural gas		0	0	0	0	228	232	216	102
	Nuclear		0	0	0	0	0	0	0	0
	HFO/LFO		0	0	0	0	0	0	0	0
	Hydro		199	281	483	708	969	1 209	1 382	1 527
	Wind		2	2	222	751	1 467	2 228	3 830	4 490
	Solar		0	38	113	268	557	1 014	1 314	1 596
	Other RES		0	0	9	13	20	33	60	100
Net import, GWh	Total		-1 271	-1 104	2 396	2 241	1 648	2 974	1 305	697
	ME		68	-725	96	-25	422	59	-15	-582
	RS		-109	1 154	1 626	3 358	752	-972	-5 568	-6 282
	MK		-570	-539	775	-1 272	-1 314	70	1 252	766
	AL		-661	-994	-100	179	1 788	3 817	5 636	6 794
Net import ratio, %			-22.5%	-18.6%	38.0%	32.5%	22.1%	38.7%	16.1%	8.2%
RES-E share (RES-E production/gross consumption, %)			3.6%	5.4%	13.1%	25.2%	40.3%	58.3%	81.2%	90.6%
Utilisation rates of RES-E technical potential, %	Hydro		na	na	na	na	na	na	na	83.5%
	Wind		na	na	na	na	na	na	na	98.0%
	Solar		na	na	na	na	na	na	na	80.8%
Utilisation rates of conventional power production, %	Coal and lignite		51.9%	52.0%	52.0%	49.2%	43.4%	na	na	na
	Natural gas		na	na	na	na	26.0%	26.5%	24.6%	11.6%
	Nuclear		na	na	na	na	na	na	na	na
Natural gas consumption of power generation, TWh			0	0	0	0	0.4	0.4	0.4	0.2
Security of supply	Generation adequacy margin		38%	34%	-34%	-36%	-28%	-77%	-74%	-71%
	System adequacy margin		228%	217%	142%	250%	362%	321%	326%	323%
CO_2 emission	Emission, Mt CO_2		8.3	8.3	3.7	3.5	3.1	0.1	0.1	0
	CO_2 emission reduction compared to 1990, %		-43.5%	-43.7%	36.3%	39.7%	45.4%	98.6%	98.7%	99.4%
Spreads	Clean dark spread, €(2015)/MWh		22.5	28.4	36.4	3.3	-1.4	7.8	-15.3	-54.2
	Clean spark spread, €(2015)/MWh		-5.8	-3.0	-1.1	-16.7	-19.5	-11.8	-24.5	-51.5
Price impacts	Electricity wholesale price, €(2015)/MWh		31.8	38.5	46.5	48.7	53.5	71.6	68.6	49.9
	Total RES-E support/gross consumption, €(2015)/MWh, five year average		na	0.5	4.6	7.9	11.9	14.8	18.6	37.7
	Revenue from CO_2 auction/gross consumption, €(2015)/MWh		0	0	0	16.8	17.7	0.5	0.6	0.4
Investment cost, m€/5 year period	Coal and lignite		na	0	0	0	0	0	0	0
	Natural gas		na	0	0	0	92	0	0	0
	Total Fossil		na	0	0	0	92	0	0	0
	Total RES-E		na	74	277	537	738	858	1 297	938
	Total		na	74	277	537	829	858	1 297	938
Main assumptions	Coal price, €(2015)/GJ		1.78	1.95	1.93	1.89	1.98	2.04	2.04	2.04
	Lignite price, €(2015)/GJ		0.98	1.07	1.06	1.04	1.09	1.12	1.12	1.12
	Natural gas price, €(2015)/MWh		18.79	20.74	23.78	25.98	28.07	31.64	32.72	33.00
	CO_2 price, €(2015)/t		4.30	7.50	11.25	16.75	21.00	25.00	34.50	44.00

TABLE A5 | SENSITIVITY ANALYSIS – LOW DEMAND

			2016	2020	2025	2030	2035	2040	2045	2050
Installed capacity, MW	Coal, lignite	Existing	1 478	1 478	678	678	678	0	0	0
		New	0	0	0	0	0	0	0	0
	Natural gas	Existing	0	0	0	0	0	0	0	0
		New	0	0	0	0	0	0	0	0
	Nuclear	Existing	0	0	0	0	0	0	0	0
		New	0	0	0	0	0	0	0	0
	HFO/LFO		0	0	0	0	0	0	0	0
	Hydro		49	78	124	176	246	310	363	404
	Wind		1	1	71	75	82	217	822	1 020
	Solar		0	38	93	120	208	424	855	1 213
	Other RES		0	0	1	2	4	8	15	25
Gross consumption, GWh			5 647	5 884	6 158	6 647	7 088	7 207	7 505	7 761
Net electricity generation, GWh	Total		6 844	6 948	3 811	3 244	2 804	2 110	4 149	5 154
	Coal and lignite		6 643	6 616	3 088	2 287	1 474	0	0	0
	Natural gas		0	0	0	0	0	0	0	0
	Nuclear		0	0	0	0	0	0	0	0
	HFO/LFO		0	0	0	0	0	0	0	0
	Hydro		199	292	462	657	917	1 160	1 358	1 510
	Wind		2	2	163	171	187	494	1 874	2 326
	Solar		0	38	94	121	210	427	860	1 220
	Other RES		0	0	3	7	15	29	57	97
Net import, GWh	Total		-1 197	-1 064	2 347	3 403	4 284	5 097	3 357	2 607
	ME		164	-545	-106	19	408	600	403	827
	RS		180	373	893	4 310	3 395	2 789	-1 876	-5 565
	MK		-639	-23	1 212	-1 392	-1 190	-983	-347	362
	AL		-902	-870	349	466	1 671	2 691	5 177	6 982
Net import ratio, %			-21.2%	-18.1%	38.1%	51.2%	60.4%	70.7%	44.7%	33.6%
RES-E share (RES-E production/gross consumption, %)			3.6%	5.6%	11.7%	14.4%	18.8%	29.3%	55.3%	66.4%
Utilisation rates of RES-E technical potential, %	Hydro		na	na	na	na	na	na	na	82.0%
	Wind		na	na	na	na	na	na	na	50.4%
	Solar		na	na	na	na	na	na	na	60.1%
Utilisation rates of conventional power production, %	Coal and lignite		51.3%	51.1%	52.0%	38.5%	24.8%	na	na	na
	Natural gas		na	na	na	na	na	na	na	na
	Nuclear		na	na	na	na	na	na	na	na
Natural gas consumption of power generation, TWh			0	0	0	0	0	0	0	0
Security of supply	Generation adequacy margin		38%	35%	-34%	-35%	-35%	-85%	-82%	-79%
	System adequacy margin		228%	219%	144%	250%	357%	317%	325%	322%
CO_2 emission	Emission, Mt CO_2		8.2	8.1	3.7	2.7	1.7	0	0	0
	CO_2 emission reduction compared to 1990, %		-41.7%	-41.0%	36.3%	52.8%	69.6%	100.0%	100.0%	100.0%
Spreads	Clean dark spread, €(2015)/MWh		25.4	31.6	42.3	14.6	15.3	25.2	0.2	-28.8
	Clean spark spread, €(2015)/MWh		-2.9	0.3	4.8	-5.4	-2.8	5.6	-9.1	-26.0
Price impacts	Electricity wholesale price, €(2015)/MWh		34.7	41.8	52.4	60.0	70.2	89.0	84.1	75.3
	Total RES-E support/gross consumption, €(2015)/MWh, five year average		na	0.5	2.5	1.4	1.2	0.2	0	0
	Revenue from CO_2 auction/gross consumption, €(2015)/MWh		0	0	0	13.7	10.4	0	0	0
Investment cost, m€/5 year period	Coal and lignite		na	0	0	0	0	0	0	0
	Natural gas		na	0	0	0	0	0	0	0
	Total Fossil		na	0	0	0	0	0	0	0
	Total RES-E		na	78	211	111	197	450	1 235	599
	Total		na	78	211	111	197	450	1 235	599
Main assumptions	Coal price, €(2015)/GJ		1.8	2.0	1.9	1.9	2.0	2.0	2.0	2.0
	Lignite price, €(2015)/GJ		0.98	1.07	1.06	1.04	1.09	1.12	1.12	1.12
	Natural gas price, €(2015)/MWh		18.79	20.74	23.78	25.98	28.07	31.64	32.72	33.00
	CO_2 price, €(2015)/t		8.60	15.00	22.50	33.50	42.00	50.00	69.00	88.00

TABLE A6 | SENSITIVITY ANALYSIS – HIGH DEMAND

			2016	2020	2025	2030	2035	2040	2045	2050
Installed capacity, MW	Coal, lignite	Existing	1 478	1 478	678	678	678	0	0	0
		New	0	0	0	0	0	0	0	0
	Natural gas	Existing	0	0	0	0	0	0	0	0
		New	0	0	0	0	100	100	100	100
	Nuclear	Existing	0	0	0	0	0	0	0	0
		New	0	0	0	0	0	0	0	0
	HFO/LFO		0	0	0	0	0	0	0	0
	Hydro		49	78	132	193	263	327	373	415
	Wind		1	1	97	329	629	975	1 586	1 972
	Solar		0	38	112	267	553	1 029	1 356	1 589
	Other RES		0	0	2	3	5	9	16	27
Gross consumption, GWh			5 647	6 001	6 440	7 130	7 803	8 149	8 682	9 209
Net electricity generation, GWh	Total		6 844	6 994	3 926	3 660	4 345	4 945	6 827	7 893
	Coal and lignite		6 643	6 662	3 088	1 904	842	0	0	0
	Natural gas		0	0	0	0	509	428	391	182
	Nuclear		0	0	0	0	0	0	0	0
	HFO/LFO		0	0	0	0	0	0	0	0
	Hydro		199	292	494	723	982	1 222	1 393	1 544
	Wind		2	2	222	751	1 434	2 224	3 615	4 482
	Solar		0	38	113	268	557	1 035	1 362	1 578
	Other RES		0	0	9	13	21	36	65	106
Net import, GWh	Total		-1 197	-993	2 514	3 470	3 459	3 203	1 855	1 316
	ME		20	-598	264	256	382	120	17	-235
	RS		206	129	768	3 249	1 542	-1 121	-4 487	-6 853
	MK		-840	142	1 106	-247	-1 333	-63	516	978
	AL		-584	-667	376	213	2 868	4 267	5 809	7 426
Net import ratio, %			-21.2%	-16.5%	39.0%	48.7%	44.3%	39.3%	21.4%	14.3%
RES-E share (RES-E production/gross consumption, %)			3.6%	5.5%	13.0%	24.6%	38.4%	55.4%	74.1%	83.7%
Utilisation rates of RES-E technical potential, %	Hydro		na	na	na	na	na	na	na	84.1%
	Wind		na	na	na	na	na	na	na	97.5%
	Solar		na	na	na	na	na	na	na	78.7%
Utilisation rates of conventional power production, %	Coal and lignite		51.3%	51.5%	52.0%	32.1%	14.2%	na	na	na
	Natural gas		na	na	na	na	58.1%	48.8%	44.7%	20.8%
	Nuclear		na	na	na	na	na	na	na	na
Natural gas consumption of power generation, TWh			0	0	0	0	0.9	0.7	0.7	0.3
Security of supply	Generation adequacy margin		38%	33%	-35%	-37%	-30%	-78%	-75%	-73%
	System adequacy margin		228%	215%	138%	241%	345%	302%	301%	295%
CO_2 emission	Emission, Mt CO_2		8.2	8.2	3.7	2.3	1.2	0.1	0.1	0.1
	CO_2 emission reduction compared to 1990, %		-41.7%	-42.1%	36.3%	60.7%	79.6%	97.4%	97.6%	98.9%
Spreads	Clean dark spread, €(2015)/MWh		25.4	32.3	42.6	49.6	56.2	69.3	71.6	61.5
	Clean spark spread, €(2015)/MWh		-2.9	1.0	5.1	7.5	10.4	16.7	16.9	6.2
Price impacts	Electricity wholesale price, €(2015)/MWh		34.7	42.4	52.7	59.5	66.5	80.0	82.3	72.2
	Total RES-E support/gross consumption, €(2015)/MWh, five year average		na	0.5	4.4	6.1	8.2	8.6	8.8	21.6
	Revenue from CO_2 auction/gross consumption, €(2015)/MWh		0	0	0	10.6	6.3	0.9	1.1	0.6
Investment cost, m€/5 year period	Coal and lignite		na	0	0	0	91.6	0	0	0
	Natural gas		na	0	0	0	0	0	0	0
	Total Fossil		na	0	0	0	92	0	0	0
	Total RES-E		na	78	279	537	721	889	1 199	993
	Total		na	78	279	537	812	889	1 199	993
Main assumptions	Coal price, €(2015)/GJ		1.8	2.0	1.9	1.9	2.0	2.0	2.0	2.0
	Lignite price, €(2015)/GJ		0.98	1.07	1.06	1.04	1.09	1.12	1.12	1.12
	Natural gas price, €(2015)/MWh		18.79	20.74	23.78	25.98	28.07	31.64	32.72	33.00
	CO_2 price, €(2015)/t		8.60	15.00	22.50	33.50	42.00	50.00	69.00	88.00

TABLE A7 | SENSITIVITY ANALYSIS – LOW RENEWABLE POTENTIAL

			2016	2020	2025	2030	2035	2040	2045	2050
Installed capacity, MW	Coal, lignite	Existing	1 478	1 478	678	678	678	0	0	0
		New	0	0	0	0	0	0	0	0
	Natural gas	Existing	0	0	0	0	0	0	0	0
		New	0	0	0	0	100	100	100	100
	Nuclear	Existing	0	0	0	0	0	0	0	0
		New	0	0	0	0	0	0	0	0
	HFO/LFO		0	0	0	0	0	0	0	0
	Hydro		49	80	149	229	315	376	420	437
	Wind		1	1	56	157	439	971	1 710	1 981
	Solar		0	38	107	260	649	1 275	1 698	1 963
	Other RES		0	0	2	3	5	9	17	30
Gross consumption, GWh			5 647	5 942	6 298	6 884	7 441	7 670	8 068	8 453
Net electricity generation, GWh	Total		6 844	6 990	3 887	3 451	4 338	5 421	7 696	8 384
	Coal and lignite		6 643	6 650	3 088	1 960	918	0	0	0
	Natural gas		0	0	0	0	568	483	452	174
	Nuclear		0	0	0	0	0	0	0	0
	HFO/LFO		0	0	0	0	0	0	0	0
	Hydro		199	300	555	857	1 178	1 405	1 568	1 629
	Wind		2	2	127	359	1 001	2 215	3 899	4 507
	Solar		0	38	108	262	653	1 283	1 709	1 958
	Other RES		0	0	9	13	21	36	67	116
Net import, GWh	Total		-1 197	-1 048	2 411	3 434	3 103	2 249	372	69
	ME		225	-990	-334	294	388	223	453	495
	RS		157	751	1 505	3 428	1 357	-675	-3 806	-6 300
	MK		-625	7	1 101	-863	-1 071	-1 057	-281	307
	AL		-954	-816	139	575	2 430	3 758	4 006	5 567
Net import ratio, %			-21.2%	-17.6%	38.3%	49.9%	41.7%	29.3%	4.6%	0.8%
RES-E share (RES-E production/gross consumption, %)			3.6%	5.7%	12.7%	21.7%	38.3%	64.4%	89.8%	97.1%
Utilisation rates of RES-E technical potential, %	Hydro		na	na	na	na	na	na	na	88.6%
	Wind		na	na	na	na	na	na	na	97.9%
	Solar		na	na	na	na	na	na	na	97.3%
Utilisation rates of conventional power production, %	Coal and lignite		51.3%	51.4%	52.0%	33.0%	15.5%	na	na	na
	Natural gas		na	na	na	na	64.8%	55.1%	51.6%	19.9%
	Nuclear		na	na	na	na	na	na	na	na
Natural gas consumption of power generation, TWh			0	0	0	0	1.0	0.8	0.8	0.3
Security of supply	Generation adequacy margin		38%	34%	-34%	-34%	-25%	-74%	-72%	-70%
	System adequacy margin		228%	217%	141%	246%	362%	323%	329%	325%
CO_2 emission	Emission, Mt CO_2		8.2	8.2	3.7	2.3	1.3	0.2	0.2	0.1
	CO_2 emission reduction compared to 1990, %		-41.7%	-41.8%	36.3%	59.6%	77.6%	97.1%	97.3%	99.0%
Spreads	Clean dark spread, €(2015)/MWh		25.4	32.0	42.4	49.8	56.4	71.1	74.9	63.8
	Clean spark spread, €(2015)/MWh		-2.9	0.7	4.9	7.6	10.6	18.4	20.1	8.4
Price impacts	Electricity wholesale price, €(2015)/MWh		34.7	42.2	52.5	59.6	66.8	81.7	85.6	74.4
	Total RES-E support/gross consumption, €(2015)/MWh, five year average		na	0.5	4.2	4.2	6.8	9.3	13.8	104.8
	Revenue from CO_2 auction/gross consumption, €(2015)/MWh		0	0	0	11.3	7.3	1.1	1.3	0.6
Investment cost, m€/5 year period	Coal and lignite		na	0	0	0	0	0	0	0
	Natural gas		na	0	0	0	0	0	0	0
	Total Fossil		na	0	0	0	0	0	0	0
	Total RES-E		na	81	241	398	824	1 246	1 358	698
	Total		na	81	241	398	824	1 246	1 358	698
Main assumptions	Coal price, €(2015)/GJ		1.8	2.0	1.9	1.9	2.0	2.0	2.0	2.0
	Lignite price, €(2015)/GJ		0.98	1.07	1.06	1.04	1.09	1.12	1.12	1.12
	Natural gas price, €(2015)/MWh		18.79	20.74	23.78	25.98	28.07	31.64	32.72	33.00
	CO_2 price, €(2015)/t		8.60	15.00	22.50	33.50	42.00	50.00	69.00	88.00

TABLE A8 | BREAK DOWN OF CUMULATIVE CAPITAL EXPENDITURE BY RES TECHNOLOGY (m€)

Capital expenditures	No target 2016-2050	Delayed 2016-2050	Decarbon 2016-2050
Biogas	22	33	68
Solid biomass	15	20	220
Biowaste	0	0	0
Geothermal ele.	0	1	4
Hydro large-scale	150	180	193
Hydro small-scale	358	404	437
Central PV	144	426	579
Decentralised PV	208	608	683
CSP	0	0	0
Wind onshore	959	2 278	1 979
Wind offshore	0	0	0
RES-E total	1 856	3 949	4 162

TABLE A9 | DEVELOPMENT OF SUPPORT EXPENDITURES (FOR RES TOTAL) OVER TIME (5-YEAR TIME PERIODS)

Support expenditures in M€	2016-2020	2021-2025	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050	Total
No target	**16**	**21**	**12**	**1**	**–**	**–**	**–**	**50**
Central PV	6	13	10	1	–	–	–	30
Decentralised PV	1	3	2	0	–	–	–	6
Wind onshore	–	–	–	–	–	–	–	–
Delayed	**16**	**71**	**21**	**24**	**68**	**142**	**1 132**	**1 474**
Central PV	6	20	11	2	5	14	128	187
Decentralised PV	1	5	2	2	10	22	169	212
Wind onshore	–	21	2	5	17	62	600	707
Decarbon	**16**	**49**	**77**	**94**	**78**	**35**	**111**	**461**
Central PV	6	21	25	20	24	11	66	173
Decentralised PV	1	4	4	1	0	0	4	15
Wind onshore	–	19	43	62	32	0	34	189

Annex 2 | Assumptions

Assumed technology investment cost trajectories: RES and fossil

TABLE A10 | ASSUMED SPECIFIC COST TRAJECTORIES FOR RES TECHNOLOGIES (2016 €/kW)

Technology	2015	2020	2025	2030	2035	2040	2045	2050
Biogas (low cost options: landfill and sewage gas)	1 663	1 608	1 555	1 504	1 454	1 406	1 360	1 315
Biogas (high cost options: agricultural digestion in small-scale CHP plants)	5 602	5 378	5 163	4 956	4 758	4 568	4 385	4 210
Solid biomass (low cost options: cofiring)	619	597	574	553	533	513	494	476
Solid biomass (medium cost options: large-scale CHP)	2 505	2 410	2 318	2 230	2 145	2 064	1 985	1 910
Solid biomass (high cost options: small/medium-scale CHP)	4 067	3 912	3 764	3 621	3 483	3 351	3 223	3 101
Biowaste	6 840	6 573	6 317	6 070	5 833	5 606	5 387	5 177
Geothermal electricity (average cost trend for SEERMAP region – i.e. mix of high-temperature (default technology concepts) and medium-temperature resources (novel enhanced systems))	2 570	3 273	2 410	2 963	3 482	3 269	3 038	3 167
Hydro large-scale*	1 304	1 333	1 464	1 396	1 618	1 667	1 608	1 765
Hydro small-scale*	1 321	1 338	1 402	1 763	1 919	1 956	1 944	1 994
Photovoltaics*	1 309	1 015	908	824	764	693	640	596
Wind onshore*	1 491	1 395	1 311	1 271	1 246	1 199	1 150	1 125
Wind offshore*	3 797	2 693	2 636	2 521	2 407	2 293	2 416	2 346

Source: Green-X database

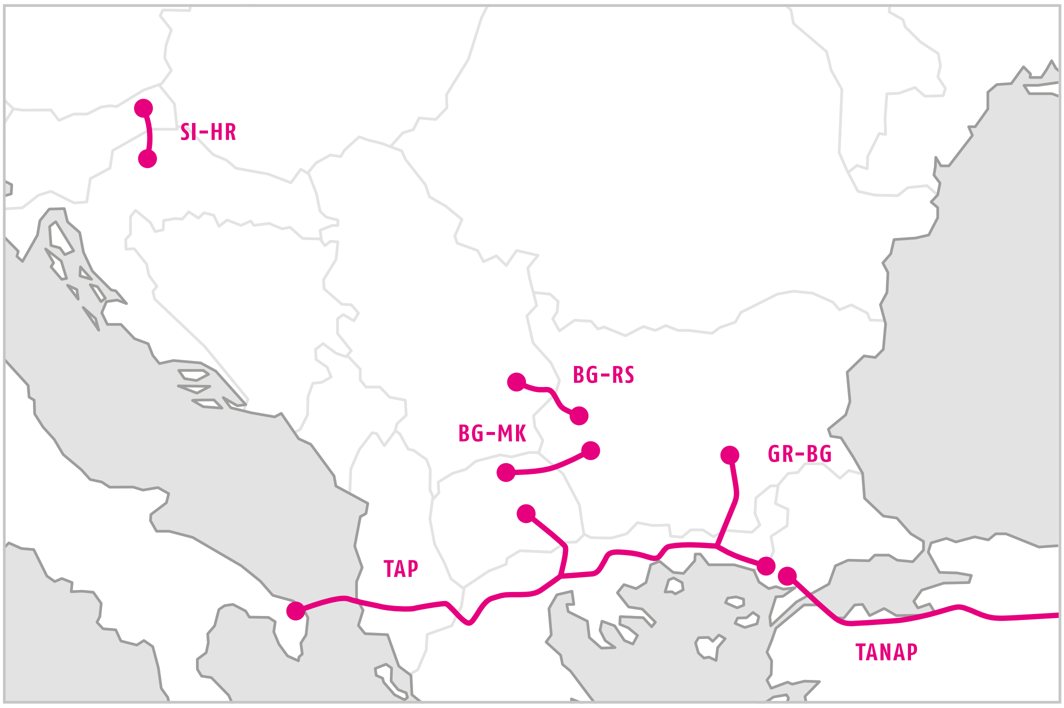
Infrastructure (table for the whole region)

TABLE A11 | NEW GAS INFRASTRUCTURE IN THE REGION

Pipeline	From	To	Capacity, GWh/day	Date of commissioning
BG-RS	BG	RS	51	2018
RS-BG	RS	BG	51	2018
TR-GR2_TAP	TR	GR	350	2019
GR-MK_TAP	GR	MK	25	2019
AZ-TR_TANAP	AZ	TR	490	2018
GR-BG	GR	BG	90	2018
GR-BG	GR	BG	151	2021
GR-IT_TAP	GR	IT	334	2019
SI-HR2	SI	HR	162	2019
HR-SI	HR	SI	162	2019
GR-AL	GR	AL	40	2019
BG-MK	BG	MK	27	2020
HR-LNG		HR	108	2020
BG-RO	BG	RO	14	2016
RO-BG	RO	BG	14	2016
GR-LNG expansion		GR	81	2017
RO-HU (BRUA)	RO	HU	126	2020
HU-RO (BRUA)	HU	RO	77	2020

Source: ENTSO-G TYNDP

FIGURE A1
NEW GAS INFRASTRUCTURE INVESTMENT ASSUMED TO TAKE PLACE IN ALL SCENARIOS



Source: ENTSO-G TYNDP 2017

TABLE A12 | CROSS BORDER TRANSMISSION NETWORK CAPACITIES

From	To	Year of commissioning	Capacity, MW O → D	Capacity, MW D → O
ME	IT	2019	500	500
ME	IT	2023	700	700
BA_FED	HR	2022	650	950
BG	RO	2020	1 000	1 200
GR	BG	2021	0	650
RS	RO	2023	500	950
ME	RS	2025	400	600
AL	RS	2016	700	700
AL	MK	2020	250	250
RS	ME	2025	500	500
RS	BA_SRP	2025	600	500
BA_SRP	HR	2030	350	250
HR	RS	2030	750	300
HU	RO	2035	200	800
RS	RO	2035	500	550
RS	BG	2034	50	200
RS	RO	2035	0	100
RS	BG	2034	400	1 500
GR	BG	2030	250	450
KO*	MK	2030	1 100	1 200
KO*	AL	2035	1 400	1 300
MD	RO	2030	500	500
BG	GR	2045	1 000	1 000
HU	RO	2043	1 000	1 000
HU	RO	2047	1 000	1 000
IT	ME	2045	2 000	2 000
IT	GR	2037	2 000	2 000
IT	GR	2045	3 000	3 000

Source: ENTSO-E TYNDP 2017

Generation units and their inclusion in the core scenarios

TABLE A13 | LIST OF GENERATION UNITS INCLUDED EXOGENOUSLY IN THE MODEL IN THE CORE SCENARIOS

Unit name	Installed capacity [MW]	Expected year of commissioning	Expected year of decommissioning	Fuel type	Type	CCS	No target	Delay	De-carbon
Kosovo A1	65	1962	2023	lignite	thermal	no	yes	yes	yes
Kosovo A2	125	1965	2023	lignite	thermal	no	yes	yes	yes
Kosovo A3	200	1970	2023	lignite	thermal	no	yes	yes	yes
Kosovo A4	200	1971	2023	lignite	thermal	no	yes	yes	yes
Kosovo A5	210	1975	2023	lignite	thermal	no	yes	yes	yes
Kosovo B1	339	1983	2040	lignite	thermal	no	yes	yes	yes
Kosovo B2	339	1984	2040	lignite	thermal	no	yes	yes	yes
Kosova e Re Power	500	2023	2063	lignite	thermal	no	yes	yes	no
Kosovo GAS TPP	200	2035	2065	natural gas	thermal	no	yes	yes	no
NEW TPP	600	2041	2081	lignite	thermal	yes	yes	yes	no

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