



Republic of Bulgaria

**Advisory Services on a National Climate Change
Adaptation Strategy and Action Plan**

***Appendix 3:
Assessment of the
Energy Sector***

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DISCLAIMERS

This report was produced by the World Bank team to provide advisory support to the Ministry of Environment and Water (MoEW) in Bulgaria. The findings, interpretations, and conclusions expressed in this report do not necessarily reflect the views of the Executive Directors of the World Bank or of the Government of Bulgaria or its MoEW.

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Abbreviations and Acronyms

ACER	Agency for the Cooperation of Energy Regulators
ACR	Adaptive Capacity Report
AR5	Assessment Report 5
ARCC	Adaptation and Resilience in the Context of Change Network
BAS	Bulgarian Academy of Sciences
BCCI	Bulgarian Chamber of Commerce and Industry
BEERCLE	Bulgarian Energy Efficiency and Renewable Energy Credit Line
BEH	Bulgarian Energy Holding EAD
BFSA	Bulgarian Food Safety Agency
CAMS	Copernicus Climate Change Service and Atmosphere Monitoring Service
CBA	Cost-Benefit Analysis
CC	Climate Change
CCA	Climate Change Adaptation
CCRA	Climate Change Risk Assessment
CDD	Cold Degree Day
CEF	Connecting Europe Facility
CEIB	Confederation of Employers and Industrialists in Bulgaria
CHP	Combined Heat and Power
CoM	Council of Ministers
DFRMP	Danube Flood Risk Management Plan
DG CAA	Directorate General “Civil Aviation Administration”
DHPP	District Heating Power Plant
DPSIR	Driving-Pressure-State-Impact-Respond
DRR	Disaster Risk Reduction
DSM	Demand-side management
EBRD	European Bank for Reconstruction and Development
EC	European Commission
ECMWF	European Centre for Medium Range Weather Forecasts
ECR	Economics of Climate Resilience
EDF	Électricité de France
EE	Energy Efficiency
EEA	European Environment Agency
EES	Electricity Energy System
EIB	European Investment Bank

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EMEPA	Enterprise for Management of Environment Protection Activities
ENTSO-E	European Network of Transmission System Operators
EO Earth	Observations
EPC	Energy Performance Contracting
EPSRC	Engineering and Physical Sciences Research Council
ERSA	Energy from Renewable Sources Act
ESCO	Energy Service Company
EU ETS	European Union Emissions Trading System
EU	European Union
EWRC	Energy and Water Regulatory Commission
ExAAA	Executive Agency Automobile Administration
ExAEMDR	Executive Agency for Exploration and Maintenance of the Danube River
ExAMA	Executive Agency Maritime Administration
ExARA	Executive Agency Railway Administration
ExEA	Executive Environment Agency
ExFA	Executive Forest Agency
FRMP	Flood Risk Management Plan
GDP	Gross Domestic Product
GFCS	Global Framework for Climate Services
GHG	Greenhouse Gas
GVPP	Gas-Vapor Power Plant
HDD	Heating Degree Day
HPP	Hydroelectric Power Plant
HPSP	Heat Production and Supply Power Plant
IBEX	Independent Bulgarian Energy Exchange EAD
IBSGas	Interconnection Bulgaria — Serbia
ICPDR	International Commission for the Protection of the Danube River
IEA	International Energy Agency
IGB	Interconnection Greece — Bulgaria
IOAF	Infrastructure Operators Adaptation Forum
IPCC	Intergovernmental Panel on Climate Change
ITB	Interconnector between Turkey and Bulgaria
JI	Joint Implementation
KIDSF	Kozloduy International Decommissioning Support Fund
MAFF	Ministry of Agriculture, Food and Forestry

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MC	Ministry of Culture
MDB	Multilateral Development Bank
MEc	Ministry of Economy
ME _n	Ministry of Energy
ME _x	Ministry of Exterior
MF	Ministry of Finance
MH	Ministry of Health
MI	Ministry of Interior
MMI	Mini Maritsa Iztok EAD
MoEW	Ministry of Environment and Water
MRDPW	Ministry of Regional Development and Public Works
MTITC	Ministry of Transport, Information Technology and Communications
NAP	National Adaptation Programme
NAPCC	National Action Plan on Climate Change
NAS	National Adaptation Strategy
NCA	Multi-Criteria Analysis
NECCC	National Expert Council on Climate Change
NEEAP	National Energy Efficiency Action Plan
NEK	Natsionalna Elektrieska Kompania (National Electricity Company)
NGO	Non-Governmental Organization
NIMH	National Institute for Meteorology and Hydrology
NIP	National Investment Plan
NPP	Nuclear Power Plant
NPV	Net Present Value
NRA	Nuclear Regulatory Agency
NREAP	National Renewable Energy Action Plan
NSI	National Statistical Institute
NTEF	National Trust EcoFund
OP	Operational Programme
PCI	Project of Common Interest
PSHPP	Pumped-Storage Hydroelectric Power Plant
PV	Photovoltaic
PVPP	Photovoltaic Power Plant
R&D	Research and Development
RCP	Representative Concentration Pathway

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REECL	Residential Energy Efficiency Credit Line
RTE	Réseau de Transport d'Électricité (Electricity Transmission Network, France)
SE4ALL	Sustainable Energy for All
SEDA	Sustainable Energy Development Agency
SEFF	Sustainable Energy Financing Facility
SRP	Sector Resilience Plan
T&D	Transmission and Distribution
TEN-E	Trans-European Networks for Energy
TENs	Trans-European Networks
TPP	Thermal Power Plant
TSO	Transmission System Operator
UGS	Underground Gas Storage
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WFD	Water Framework Directive
WGII	Working Group II
WPP	Wind Power Plant
ZLED	Zero Liquid Effluent Discharge

Glossary¹

Climate change refers to a change in climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to the natural climate variability observed over comparable time periods.

Global warming refers to the gradual increase, observed or projected, in the global surface temperature, as one of the consequences of radiative forcing caused by anthropogenic emissions.

Adaptation is the process of adjustment to actual or expected adverse effects of climate change and taking appropriate action to prevent or minimize the damage they can cause. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects.

Mitigation (of climate change) is a human intervention to reduce the sources or enhance the sinks of greenhouse gases (GHGs).

Vulnerability to climate change is the degree to which any system is susceptible to, and unable to cope with, the negative impacts that climate change imposes upon it. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.

Resilience is the opposite of vulnerability and is defined as the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change.

Risk is the potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as the probability or likelihood of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur.

¹ Definitions are based on WGII AR5 (IPCC 2014).

Executive Summary

1. Climate change is affecting all regions in Europe, but the impacts are not uniform. Southeastern and southern Europe, where Bulgaria is situated, are projected to be hotspot regions, having the highest numbers of severely affected sectors and domains. The European Environment Agency (EEA) report (EEA 2016) states that extreme weather events will become more frequent and intensive in the future.

2. Climate change is a substantial energy security concern not only because direct flooding and natural disasters can damage power plants and transmission lines, disrupt the delivery of fuels to power generation facilities, and destroy renewable energy infrastructure but also because it has severe impacts on food security and health. Energy plays a fundamental role in supporting all aspects of modern life. It is essential to the smooth running of social and political systems as well as to economic growth and sustainable development. Ensuring a reliable energy supply, which will also be able to satisfy the demand in a changing climate, will become a growing challenge in the future.

3. The energy sector faces multiple threats from climate change, in particular from extreme weather events and increasing stress on water resources. Greater resilience to climate change impacts will therefore be essential to the technical viability of the energy sector and its ability to cost-effectively meet the energy demand. Energy sector stakeholders, including governments, regulators, energy companies, and financial institutions will need to define climate change resilience and adaptation challenges and identify actions needed to address these challenges.

4. There is a two-way relationship between the energy sector and climate change. Energy production is a highly polluting industry and significantly affects the level of generated harmful emissions, which in turn cause climate change. However, the cycle turns, and climate change in itself affects the energy sector. Both internationally and in Bulgaria, emphasis has typically been placed on the role of the energy sector in mitigating human-induced climate change, but comparatively little attention has been paid to the impacts of climate change on the energy sector. This has begun to change in recent years with increased recognition that mitigation and adaptation must be undertaken in tandem. Climate change mitigation and adaptation are key partners in any strategy to combat climate change.

5. Changes in climate and weather extremes will affect the energy sector both positively and negatively, though negative impacts prevail. Energy infrastructure is vulnerable to a range of climate stressors, including temperature, precipitation, sea level rise, and extreme events. Specifically, climate change is expected to change the intensity, frequency, and distribution of extreme heat, precipitation, and storms, exacerbating the vulnerability of energy infrastructure.

6. Generally, all areas of energy infrastructure need to respond to climate impacts on their performance. According to all climate change scenarios, projections for Bulgaria show increasing temperatures and decreasing summer precipitation by the end of the current century, therefore an associated increase in the number of dry spells and droughts. Power plants will experience some reduction in output as higher air and water temperatures affect the efficiency of their cooling systems. In the medium term, thermal power (thermal power plant [TPP] and

nuclear power plant [NPP]) is expected to be the main contributor to electricity generation in Bulgaria (80 percent of electricity generation in 2024), hence the importance of addressing climate change risks to generation assets. Warming temperatures due to climate change may create favorable conditions for some invasive species that can damage energy infrastructure. Transmission lines already face damage and disruption from extreme precipitation, floods, and winter storms. Climate change will likely lead to higher numbers of disruptions: exposed cables/trunk routes due to erosion or damage of transportation infrastructure, increased transmission line losses, increased damage to aboveground infrastructure from extreme storms and wind. Hydropower generation is likely to suffer from reduced precipitation, particularly in the summer season due to changing climate patterns.

7. Climate change has the potential to affect energy demand through changes in demand for heating and cooling. Projected increases in summer temperatures will result in increased use of air conditioning. Since the beginning of the 1980s, Europe has started experiencing a markedly declining overall trend in heating degree days (HDDs) and a markedly increasing trend in cold degree days (CDDs), pointing to a general increase in cooling needs and a general decrease in heating needs.

8. It is crucial that energy sector stakeholders in Bulgaria understand that the sector faces multiple threats from climate change, particularly from extreme weather events and increasing stress on water resources. Greater resilience to climate change impacts will be essential to the technical viability of the energy sector and its ability to cost-effectively meet the rising energy demands driven by global economic and population growth.

9. Climate change impacts can be costly, but a wide range of adaptation options exist that can be implemented at different stages of project implementation. In a number of circumstances, the costs of inaction could be far higher than well-planned and implemented efforts to improve energy sector resilience to climate change. Inadequate attention to these impacts can increase the long-term costs of energy sector investments, the likelihood that they will not deliver intended benefits, and the probability of eventual failure under climate stress. It may be appropriate to promote no-risk or low-risk adaptation measures that deliver development benefits at low cost regardless of the nature and extent of changes in climate (for example where uncertainty regarding climate change is high, and where large climate-proofing capital investments cannot be easily justified).

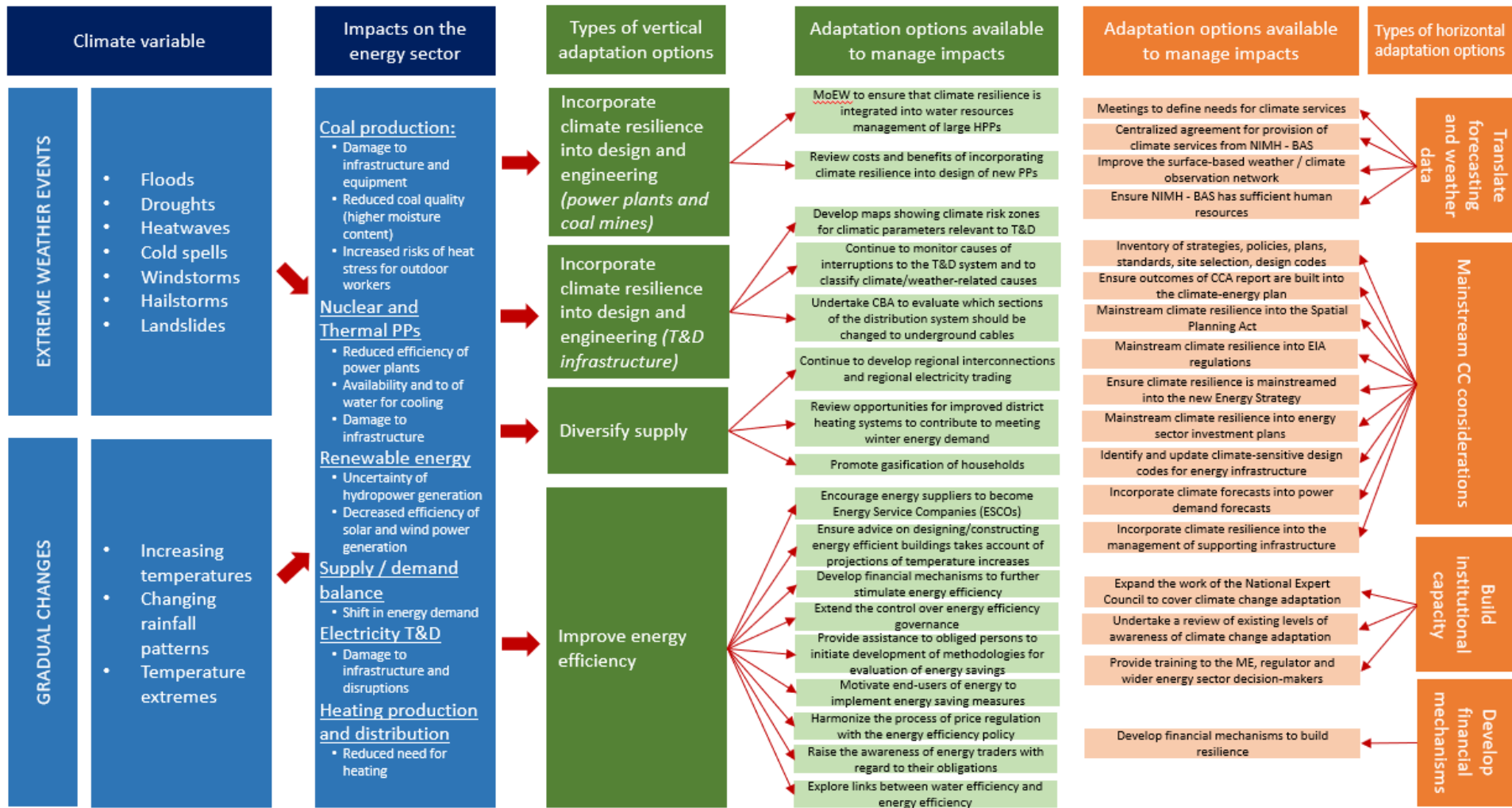
10. Given that the energy sector in Bulgaria is facing climate-related challenges already, and as there are uncertainties over future climate change, there is a suite of adaptation measures that can help increase the climate resilience of Bulgaria's energy sector today, as well as in the future: (a) translate monitoring, forecasting, and weather data for the energy sector; (b) mainstream climate change considerations within energy sector policies and plans to ensure that energy infrastructure is located, planned, designed, and maintained to be resilient to climate change, including increasingly extreme weather events; (c) incorporate climate resilience into design and engineering of new power plants and into operations and contingency planning for existing power plants and coal mines; (d) incorporate climate resilience into design and engineering of new transmission and distribution (T&D) infrastructure and into operations and contingency planning for existing T&D infrastructure; (e) diversify supply, including regional

energy trade, district heating/cooling, gasification of households and small-scale renewables to increase overall energy system resilience; (f) improve energy efficiency in public and private sector buildings to ensure that the existing supply and demand balance is maintained; (g) build institutional capacity and knowledge networks at all operational levels; and (h) develop financial mechanisms to build resilience.

11. Adaptation is a long-term process – some adaptation options identified will need to be fast-tracked over the coming decade and others can wait until later. Even in areas of high vulnerability, not all adaptation has to start at once; some measures can be implemented at short notice, whereas others require long-term planning and preparation. Some measures, such as physical actions (Capital Expenditure - CAPEX) leading to the intended adaptation outcome (for example changes in design and engineering) will require more time and full implementation and will only be realized over the longer term. Operational actions (for example changes to operating procedure at power plants) are generally more flexible or reversible than physical ones, so should be started earlier. However, measures such as those associated with improving the enabling environment and governance framework (for example mainstreaming climate change within sector policies and plans and building institutional capacity and knowledge networks) should be started immediately.

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Figure 1. Simplified illustration of impacts of climate change and identified adaptation options



Source: World Bank design.

Introduction – Climate Change in Bulgaria

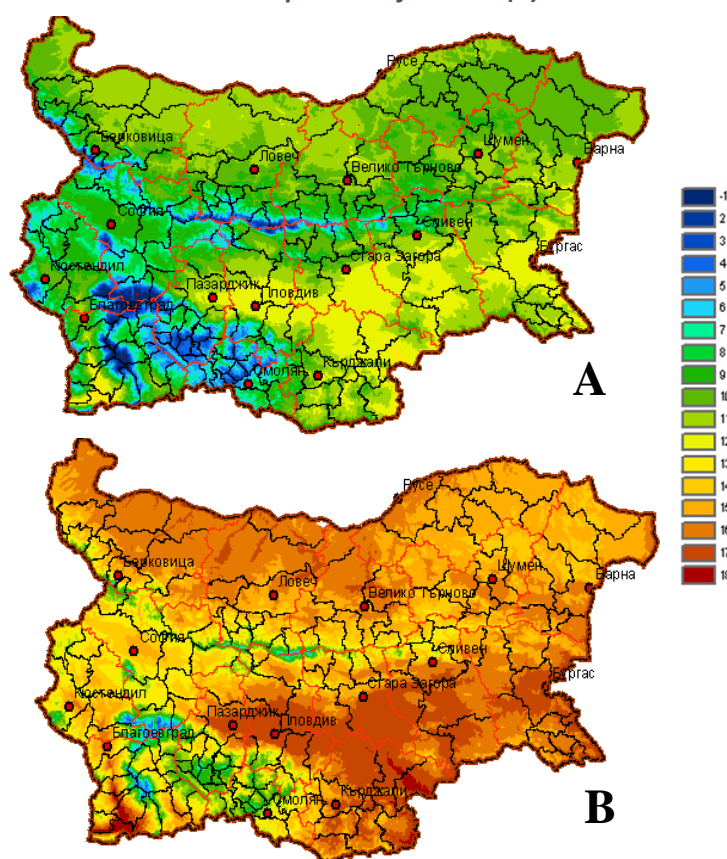
12. Bulgaria is situated in one of the regions that is particularly vulnerable to climate change (mainly through temperature increase and extreme precipitation) and to the increased frequency of climate change-related extreme events, such as droughts and floods. The risks inflicted by climate change-related events may lead to loss of human life or cause considerable damage, affecting economic growth and prosperity, both nationally and trans-boundary.

13. Consensus exists in the scientific community that climate change is likely to increase the frequency and magnitude of extreme weather events. Over the past decades, in Bulgaria this frequency has increased significantly. The most common hydrometeorological and natural hazards are extreme precipitation and temperatures, storms, floods, wildfires, landslides, and droughts. The number of deaths and victims due to natural hazards is considerable, indicating weather and climate vulnerability. The vulnerability of Bulgaria's population and businesses to the impacts of climate change is accelerated by a relatively high degree of poverty in the most affected areas, the continuing concentration of the country's population in several industrial and urban regions, and various consequences of the transition from a state-controlled economy to a free-market economy. A growing body of evidence suggests that economic losses from climate- and weather-related disasters have also been rising.

14. Scientific projections indicate that global temperature will rise between 1.8°C and 4°C by 2100, with the temperature increase in Europe expected to be even higher than the estimated global average.

15. Research conducted by the Department of Meteorology, National Institute of Meteorology and Hydrology at the Bulgarian Academy of Sciences (NIMH-BAS) projects an increase in annual air temperature in Bulgaria of between 0.7°C and 1.8°C by 2020. Even warmer temperatures are expected by 2050 and 2080, with projected increases of between 1.6°C and 3.1°C and between 2.9°C and 4.1°C, respectively. Generally, the temperature increase is expected to be more significant during the summer season (from July to September).

Figure 2. Average year temperature for 1961–1990 (A); Pessimistic climate scenario for average year temperature for 2080 (B)



Source: NIMH-BAS.

16. In terms of the expected changes in rainfall patterns, a reduction in precipitation is likely, leading to a significant reduction of the total water reserves in the country. In this regard, projections suggest a decrease in precipitation by approximately 10 percent by 2020, 15 percent by 2050, and up to 30–40 percent by 2080. In most climate change scenarios, rainfall during the winter months is likely to increase by the end of the century, but significant decrease in rainfall during the summer months is expected to offset this increase.

17. According to the available climate change scenarios for Bulgaria, there is a trend toward increased frequency of extreme events and disasters, as demonstrated by frequent occurrences of heavy rainfalls, heat and cold waves, floods and droughts, hurricane winds, forest fires, and landslides.

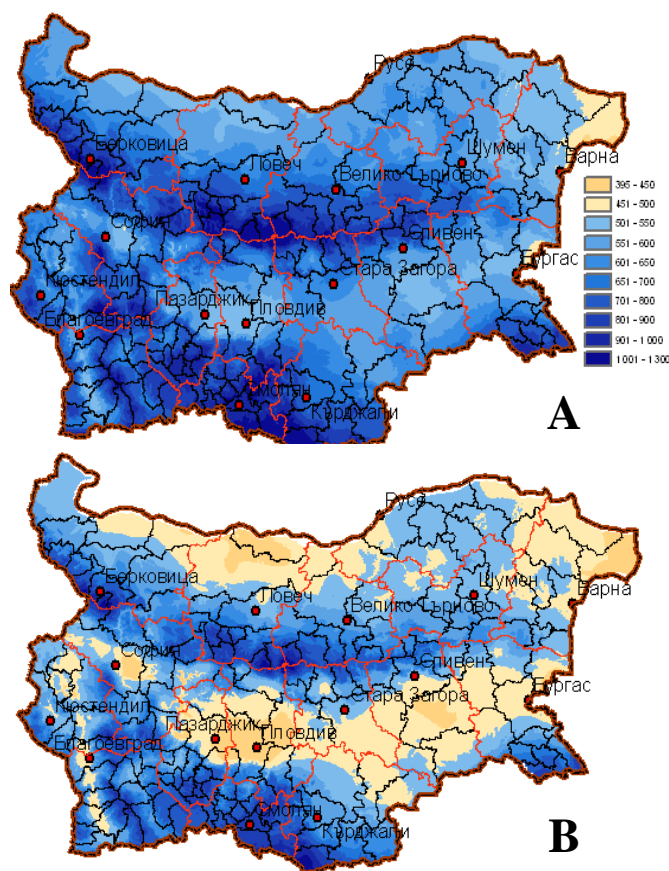
18. Biodiversity, land and aquatic ecosystems, as well as water resources, agriculture, and forestry sectors are expected to be affected by the anticipated changes. These changes would further affect society and its citizens as well as the economy as a whole.

19. Climate change impacts do not affect all people and territories equally due to different levels of exposure, existing vulnerabilities, and adaptive capacities to cope. The risk is greater for the segments of the society and businesses that are less prepared and more vulnerable.

20. This report aims to provide insight into climate change-related risks and vulnerabilities of the energy sector in Bulgaria. It describes the sector’s legal and policy context in relation to climate change and provides options on adapting to the changing climate circumstances.

21. **This report aims to inform on vulnerabilities to the Bulgarian energy sector and identification of adequate climate change adaptation options.** The report is part of a set of nine sectoral assessment reports considered under the climate adaptation support program for Bulgaria, which will form the baseline for the National Climate Change Adaptation Strategy and Action Plan (NCCAS). The report follows the general logic and structure as proposed for all sectors and is divided into three parts: (a) part one of the report (Chapter 1) focuses on the climate change risks and vulnerabilities’ assessment; (b) part two comprises a gap analysis of the policy, legal and institutional context (Chapter 2); and (c) part three focuses on the identification and prioritization of adaptation options (Chapter 3). This sector assessment was

Figure 3. Precipitation per Year for 1961–1990 (A); Precipitation per Year for 2080, According to the Pessimistic Scenario (B)

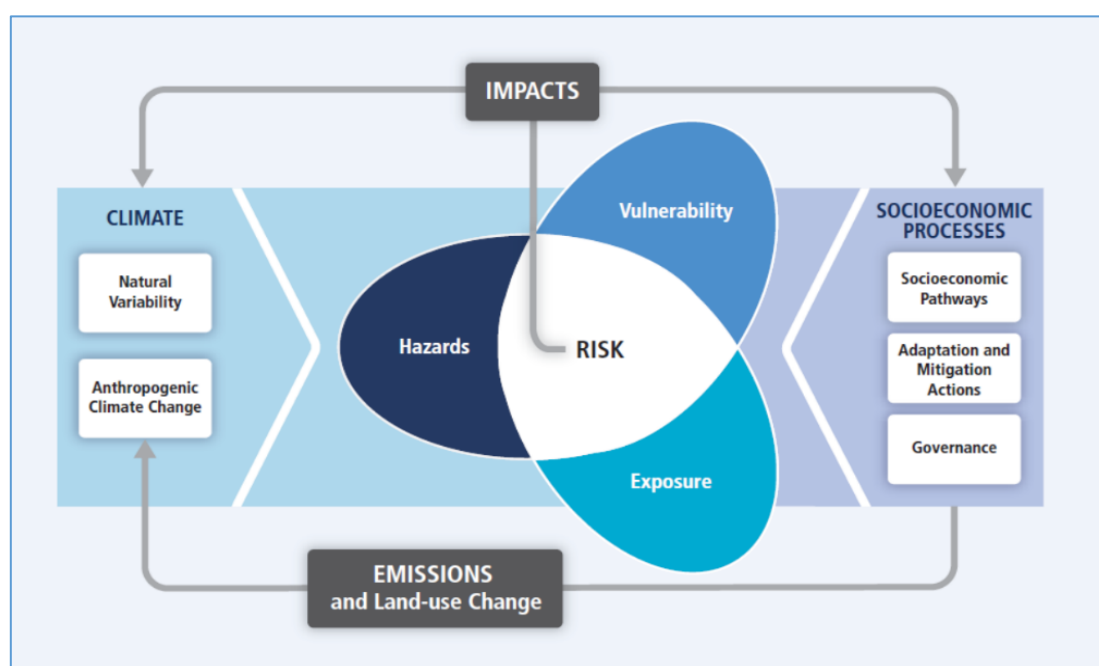


Source: NIMH-BAS.

carried out during March – November 2017, as a combination of quantitative and above all, qualitative analysis. Several workshops have been organized as part of an ongoing consultation process, bringing in the wealth of expertise of various stakeholders.

22. **The report uses the terms and definitions of risk, vulnerability and adaptation options as introduced by Working Group II (WGII), Assessment Report 5 (AR5) (IPCC 2014).** Risk of climate-related impacts results from the interaction of climate-related hazards with vulnerability and exposure. Changes in both the climate system (left side in *Figure 4*) and socio-economic processes, including adaptation and mitigation (right side in *Figure 4*) are drivers of hazards, exposure, and vulnerability. This understanding reveals the importance of the adaptation options. When they are properly identified and implemented on time, vulnerability, hazards and/or exposures will be reduced, thus mitigating risk.

Figure 4. General concept of WGII AR5



Source: IPCC 2014.

Chapter 1. Risk and Vulnerability Assessment and Analysis

1.1. Sector Characteristics and Trends

23. **The energy sector in Bulgaria is highly important in terms of its contribution to gross domestic product (GDP).** The industry and energy sectors account for around 20 percent of GDP. The forecast is for stabilization of the GDP growth around 2.5% per year in mid-term perspective². The major limits to the growth perspective are related to the inefficient state-owned enterprises, weak finances of the local authorities and issues related with the sustainability of the second pillar of the pension system. In the longer term, limitation results from the aging and decreasing population, delay of the structural reforms, weak investments due to deficiencies in the business environment. Growth is supported by contracting of the EU funds in 2014-2021 programming period and restoration of the private investments in closer outlook.

24. **Bulgaria is one of most energy-intensive countries in Europe and is highly dependent on imported energy resources.** Energy intensity³ in Bulgaria is 448.5 kgoe per €1,000, compared to the average energy intensity of 120.4 kgoe per €1,000 (2015 data, Eurostat, see *Annex 5*) in the European Union (EU) (28 countries). Geographical differences between countries on the continent are obvious - the economies in Eastern Europe use much more energy per unit of GDP than those in the west, with the most energy-intensive countries clustered in the Balkans - Bulgaria, Serbia, Macedonia and Kosovo. The reason for this is, on the one hand, the more service-oriented structure of Western European economies and, on the other hand, more energy-efficient technologies used in manufacturing. All European countries (except Iceland) have reduced the energy intensity of their economies over the last 20 years, and Bulgaria is among the countries with the largest decline. These countries can be divided into two groups:

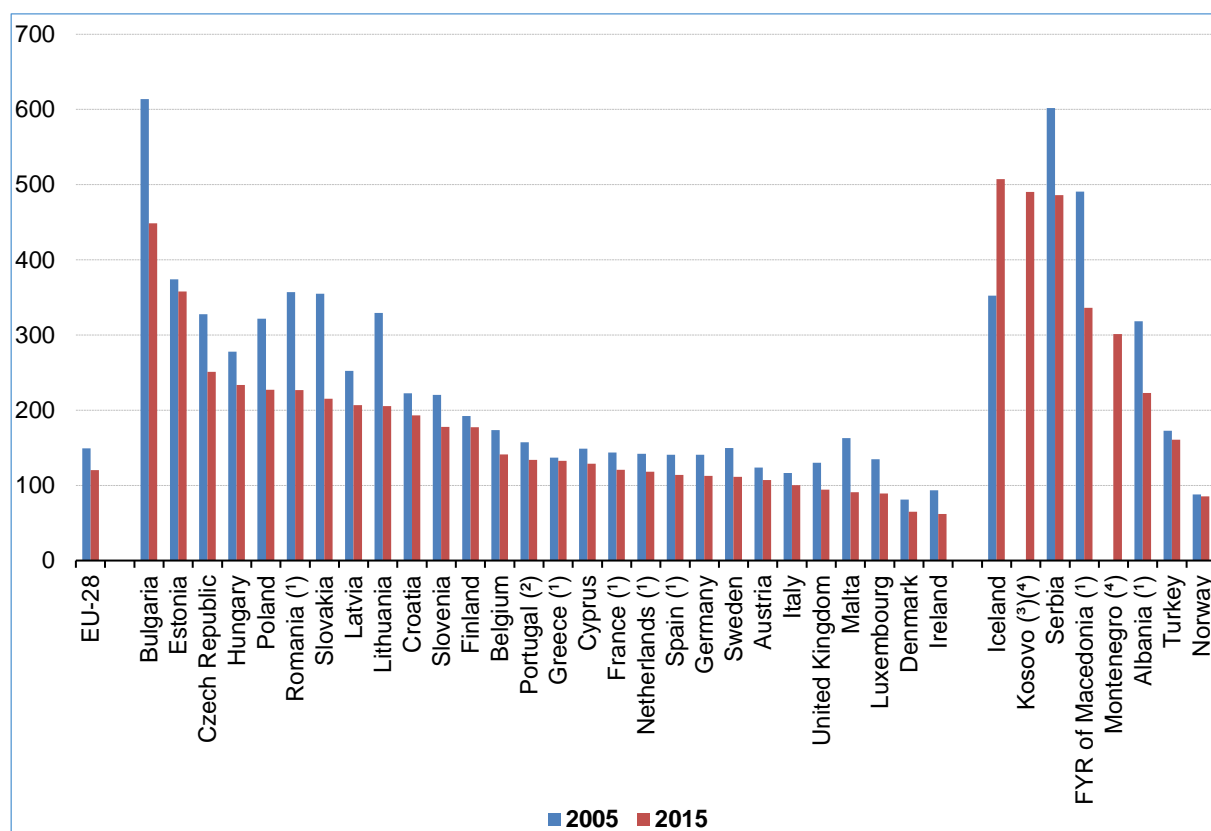
- Countries from Eastern Europe, including Bulgaria, that have undergone fundamental transformation and modernization of the economy.
- Countries with restrictive and aggressive policies in the field of ecology and energy efficiency, such as Denmark and Sweden.

25. Although Bulgaria has significantly improved its performance, it remains the most energy-intensive country in the EU (see *Figure 5*). The high energy intensity of the Bulgarian industry provides potential for introducing energy efficiency measures.

² EU Reference Scenario 2016

³ Energy intensity of the economy is the ratio between the gross inland consumption of energy and the GDP for a given calendar year. It measures the energy consumption of an economy and its overall energy efficiency (kg of oil equivalent per €1,000).

Figure 5. Energy intensity of the economy, 2005 and 2015
(kg of oil equivalent per 1 000 EUR of GDP)



Source: Eurostat.

26. The energy dependence⁴ of Bulgaria in 2014 was 34.5 percent (see Annex 4). However, this low value somewhat hides the true picture due to the Eurostat methodology for calculating energy dependence, which recognizes nuclear energy as a local resource. Aside from energy import dependence, it is also important to consider the sources of imports and the diversity of suppliers in order to gauge a country's exposure to energy supply shocks: the less the sources are diversified, the larger is the risk of supply interruption. In fact, natural gas, crude oil, and nuclear fuel in Bulgaria are almost entirely imported and their import is traditionally satisfied only by the Russian Federation.⁵ Although there are on-going oil and gas exploration efforts in the Black Sea, carried out by a consortium consisting of Total, OMV, and Repsol, domestic extraction of natural gas is declining and there are small proven reserves. One of the fields with the highest potential appears to be Han Asparuch. It is in deep Black Sea waters, close to the Romanian offshore fields and controlled by Total, OMV and Repsol. In 2016, the main users of the natural gas transmission and distribution networks in the country were the public provider Bulgargaz EAD, extraction companies, and traders. Natural gas supply to consumers is carried out mainly via the national gas transmission network, a complex facility consisting of 1,835 kilometers of gas pipelines and high-pressure gas branches, three compressor stations with a total installed capacity of 58 MW, gas regulation stations, metering stations, electrochemical protection systems, communication system, an information system,

⁴ Energy dependence shows the extent to which an economy relies upon imports to meet its energy needs.

⁵ National Development Program: Bulgaria 2020, 2012.

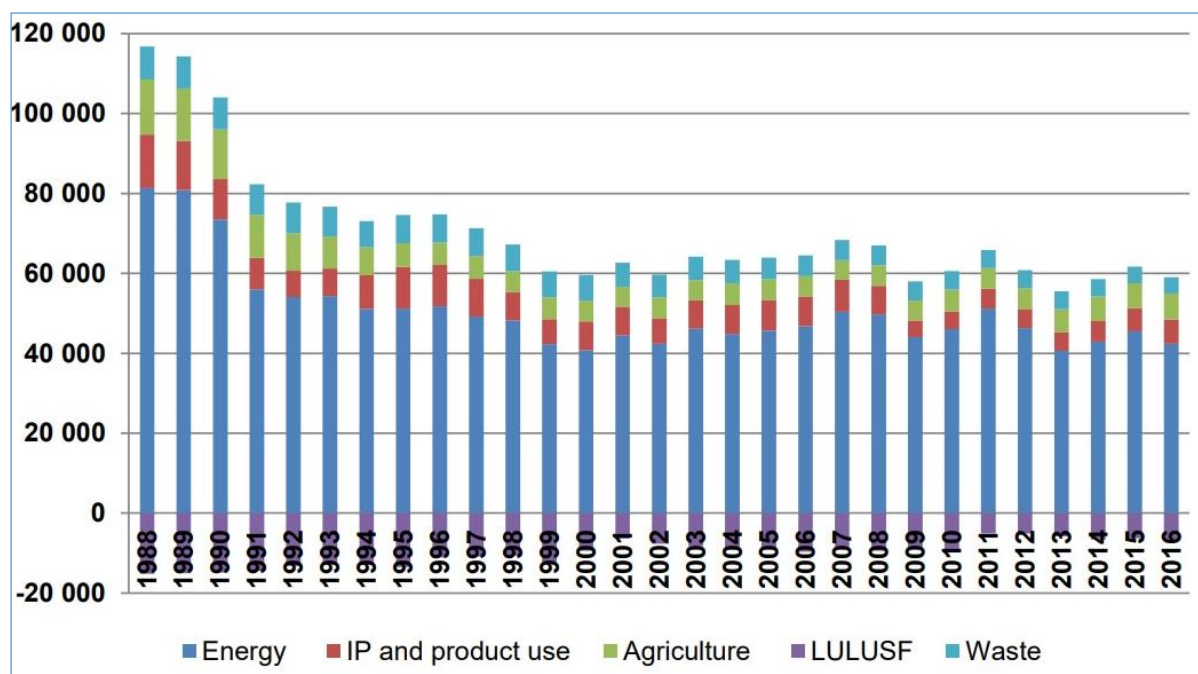
and other auxiliary facilities. The natural gas transmission network has sufficient capacity to meet the current natural gas demand and by 2016 about 40 percent of the system’s maximum technical capacity was used. Natural gas transported through the national transmission network comes from imports from Russia (approximately 97.4 percent) and local production (approximately 2.6 percent).⁶

27. Unlike most European countries, in Bulgaria natural gas is almost not used directly as a resource for heating and household needs. This reduces the risks to end users when the supply is interrupted. The predominant amount of heat is produced with natural gas. When using natural gas to produce heat, the risks to end-users are much lower. Heating production and distribution companies are required to maintain 90-day reserves of alternative fuels that create a buffer between natural gas supply and heat supply to consumers.

28. Import dependence on electricity production is significantly lower which is due to the traditionally intensive use of indigenous lignite and hydropower. Moreover, the prices of the national electricity mix are stable and almost independent of the unmanageable changes in the prices of liquid fuels and natural gas.

29. The energy sector is directly or indirectly responsible for the majority of anthropogenic greenhouse gas (GHG) emissions. *Figure 6* below shows the GHG aggregated emission trends by IPCC sectors. The Energy sector, where GHG emissions come from fuel combustion, headed the list in 2016 with the biggest share – 71.8 percent. Sector Agriculture ranked the second place with 11.0 percent, followed by sectors Industrial processes (IP) with 10.3 percent and Waste with 6.9 percent.

Figure 6. Total greenhouse gas emissions in Bulgaria in CO₂-eq. per IPCC sector 1988–2016



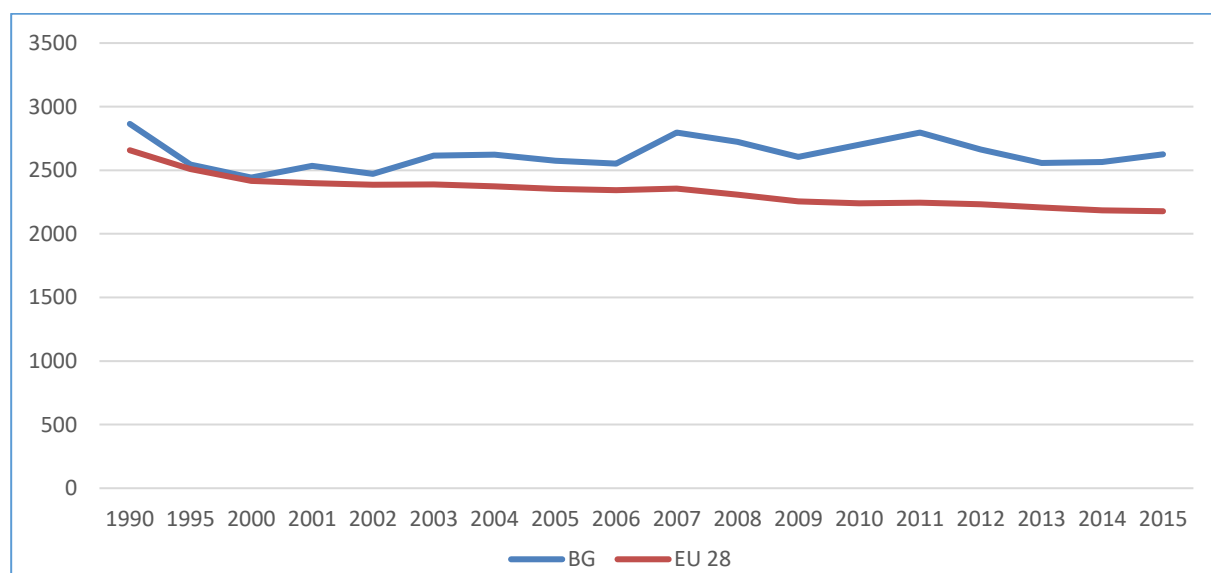
Source: National Inventory Report 2018.

⁶ EWRC Bulgaria, Annual Report to the European Commission

30. **Emissions from the energy sector⁷ in 2016 decreased by 47.9% compared to the base year (42,386 Gg CO₂e in 2016 compared to 81,320 Gg CO₂e in 1988).** Compared to previous year, the emissions in 2016 decreased with 6.9 percent mostly due to the decrease in electricity production from fossil fuels in the energy industries sector. Main source of emissions in the energy sector is fuel combustion of solid fuels, which is responsible for 57.8 percent of the emissions from fuel combustion in 2016, followed by liquid fuels with 29.0 percent and gaseous fuels with 12.2 percent. The main reasons for the decrease of the GHG emission trend in energy sector are the transition from a centrally-planned economy to a market-based economy, reconstructing of the economy and subsequent economic slowdown. This led to a sharp drop in demand for electricity production from thermal power production.

31. Although the total amount of CO₂ emissions per tonne oil equivalent slightly decreased in 2015 compared to 1990 (from 2,864.5 to 2,625.4 kg CO₂/toe), **Figure 7** shows that unlike values of this indicator in the EU 28, in Bulgaria there is no clearly expressed trend for decrease. Moreover, the difference between the values of the indicator in Bulgaria and EU 28 is constantly increasing.

Figure 7. Carbon Intensity of the energy mix - kg CO₂/toe



Source: Data from EU Commission, DG ENER, Unit A4, Energy Statistics.

32. **All sectors will have to contribute to the transition to a low-carbon economy, but according to the Roadmap 2050⁸ electricity will play a central role in the low carbon economy.** The analysis shows that it can almost entirely eliminate CO₂ emissions by 2050 and offers the prospect of partially replacing fossil fuels in transport and heating. The share of low carbon technologies in the electricity mix in the EU is estimated to increase from around 45 percent today to around 60 percent in 2020, including through meeting the renewable energy target, to 75 to 80 percent in 2030, and nearly 100 percent in 2050. As a result, and without prejudging Member States' preferences for an energy mix which reflects their specific national

⁷ According to the IPCC guidelines, the Energy sector consists of the following categories: • 1.A.1. Energy Industries • 1.A.2. Manufacturing Industries and Construction • 1.A.3. Transport • 1.A.4. Other Sectors • 1.A.5. Other • 1.B. Fugitive Emissions from Fuels

⁸ COM(2011) 112 final

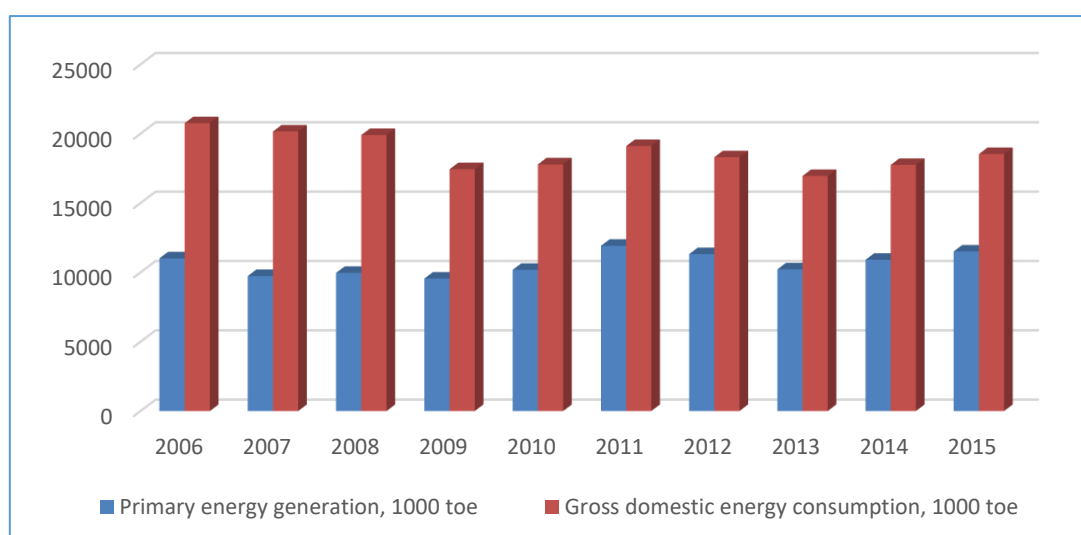
circumstances, the EU electricity system could become more diverse and secure. A wide range of existing technologies will need to be widely deployed, including more advanced technologies, such as photovoltaics, that will continue to become cheaper and thus more competitive over time.

33. Given that the central role of electricity in the low carbon economy requires significant use of renewables, many of which have variable output, considerable investments in networks are required to ensure continuity of supply at all times. Investment in smart grids is a key enabler for a low carbon electricity system, notably facilitating demand-side efficiency, larger shares of renewables. In this context, future work should consider how the policy framework can foster these investments at EU, national and local level and incentivize demand-side management.

1.1.1. Primary energy supply

34. Primary energy generation meets about 62 percent of gross domestic energy consumption. This has remained relatively unchanged over the past few years (*Figure 8*) and any fluctuations result from changes in consumption (MEn 2016).

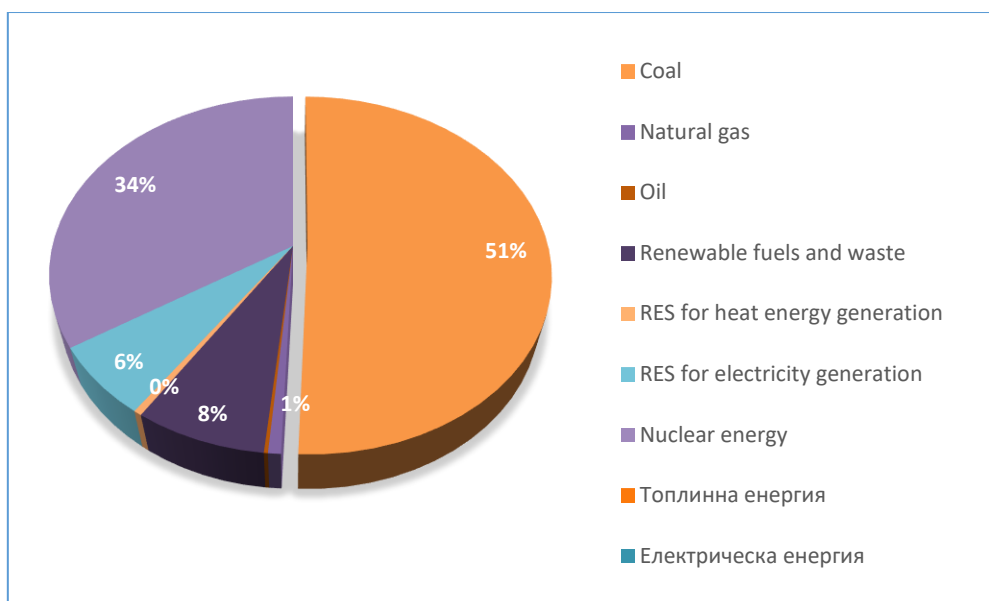
Figure 8. Primary energy generation and consumption



Sources: National Statistical Institute (NSI), Energy statistics.

35. Energy generation is heavily dependent on coal. As shown in *Figure 9*, coal contributes over half of the primary energy supply, followed by nuclear energy at 34 percent. Coal production, especially lignite coal, plays an important role in ensuring national energy security and guaranteeing Bulgaria’s energy independence. The importance of local coal production for the energy sector is determined by changes in the contribution from nuclear power, the growing prices of liquid fuels, and the need to ensure the energy security of the country. As highlighted by the National Development Program: Bulgaria 2020, the shutdown of units 1–4 of nuclear power plant (NPP) Kozloduy resulted in a need to increase coal production, which in 2015 amounted to 35.9 million tons.

Figure 9. Structure of primary energy generation (percent), 2015



Sources: NSI, Energy statistics.

36. **Lignite coal is practically the only local conventional source of energy, providing 94.3 percent of the extracted coal.** Mini Maritsa Iztok EAD (MMI) accounted for 90 percent of the country’s total lignite coal extraction in 2015. Its mines cover an area of some 240 km², being the largest mining site in southeast Europe. The company supplies four power plants with lignite: Maritsa East 2 thermal power plant (TPP) (1,620 MW) Maritsa Iztok East 3 TPP (908 MW), AES Galabovo TPP (670 MW) and Brikell TPP (200 MW). MMI also supplies lignite to the 120 MW Maritsa 3 TPP in Dimitrovgrad. More than 40 percent of the country’s electricity is generated from lignite supplied by MMI (European Association for Coal and Lignite 2017). Lignite coal is characterized by a low calorific value and high content of ash sulfur, and nitrogen. The combustion process is characterized by high emissions of sulfur dioxide, nitrogen oxides, dust, and GHGs, and therefore requires substantial investments to comply with EU environmental requirements. The vast majority of coal consumption (97.2 percent) is for the production of electricity and heat.

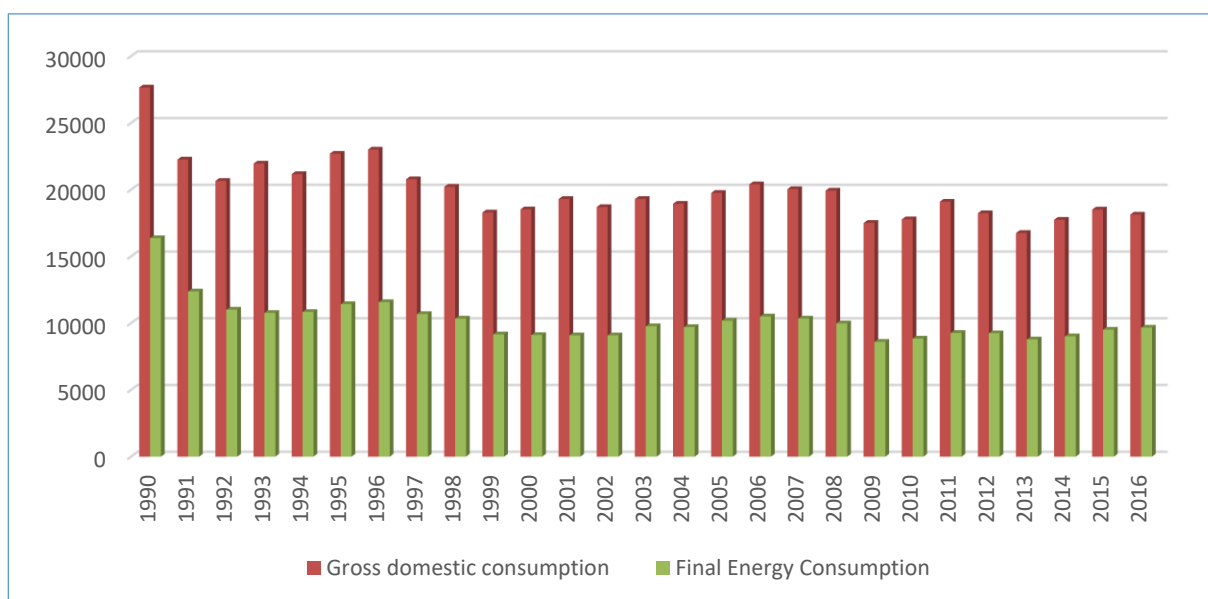
37. In general, the primary energy balance of the country is well structured in terms of variation and location of used energy resources. Proven reserves of lignite coal are sufficient to secure power generation for 50–55 years. Renewable energy sources are estimated at some 6 million toe per year, which at current energy consumption equals to about 15 percent. Natural gas deposits are modest but are interesting as a local resource. Such factors significantly contribute toward security of supplies and relative stability of prices, and therefore to the economy’s competitiveness.

38. **Natural gas is produced in modest amounts, and oil in insignificant amounts.** In 2015, extraction of natural gas in the country amounted to 84.7 million m³ and oil was negligible. Imports of natural gas in Bulgaria for 2015 are estimated at 3,008.5 million m³ and imports of oil and oil products amounted to 2,743 thousand tons. There is one gas storage facility (‘Chiren’) in the country with a capacity of active gas of about 450 million m³ per year. In 2015, 294.9 million m³ of natural gas were pressurized at the storage. Consumption of natural gas in

the country for 2015 is estimated at 2,916 million m³. Demand for natural gas and oil in Bulgaria is secured primarily by imports from Russia.

39. The trends in total energy consumption in Bulgaria are similar to those of the EU-28 for the period 1990–2016, given the cycles of economic development. Gross energy consumption and final energy consumption follow the same trend with a decline in energy consumption in the late 1990s when a transition to a market economy followed by the typical restructuring of the sectors and a significant drop in industrial consumption. In the first years after 2000 there has been a rise and a further decline since 2007 due to the economic crisis. Over the last 3 years, energy consumption has started to increase.

Figure 10. Gross Domestic consumption and final energy consumption, ktoe (1990–2016)



Source: Data from EU Commission, DG ENER, Unit A4, Energy Statistics.

40. Nearly half of the energy (48 percent as an average for the period 2000–2016) available for gross domestic consumption is lost in the transformation, transmission and distribution process, while for the EU28 this share is less than 30 percent. Since 2010 there is an upward trend in the amount of available energy for final consumption, reaching 55 percent from gross domestic consumption in 2016. However, Bulgaria remains in the penultimate place in the EU just before Estonia and far behind the EU28 average of 73 percent (see *Figure 10*). 36 percent of the energy for gross domestic consumption is lost in transformation, 3 percent in distribution and 6 percent is consumed by the energy sector for the realization and maintenance of the main activity of the enterprises, extracting and producing energy resources (see *Figure 11*).

Figure 11. Energy losses (percentage of gross domestic consumption, 2016)



Source: Data from EU Commission, DG ENER, Unit A4, Energy Statistics.

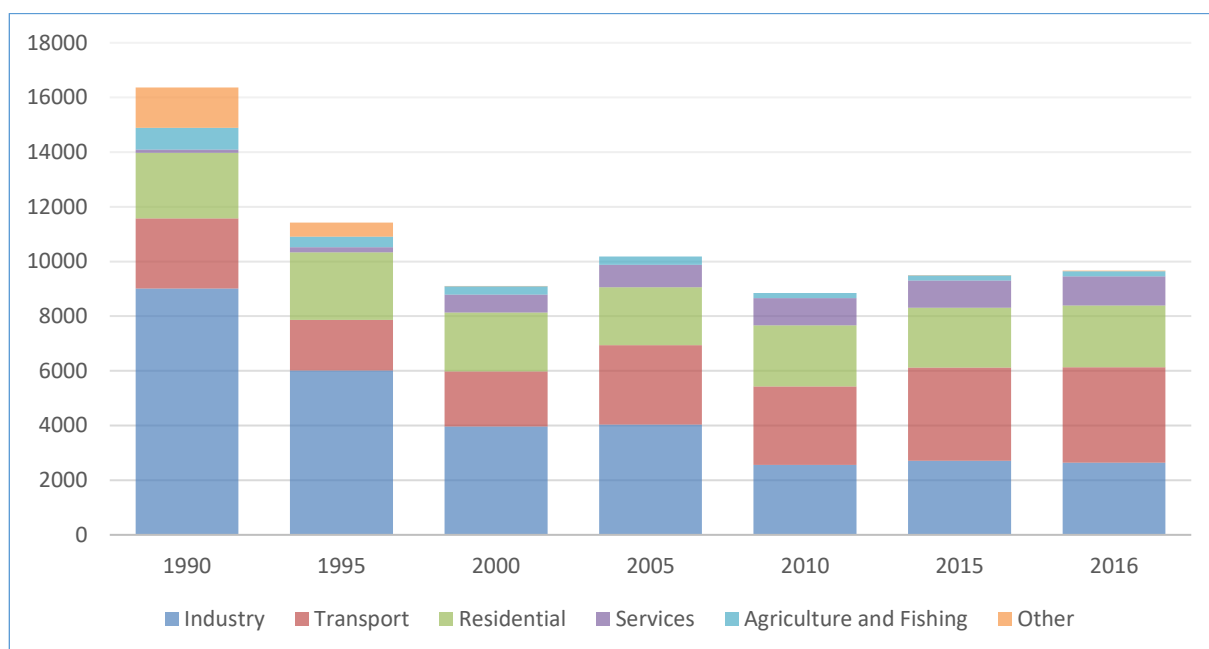
41. The main reasons are the outdated infrastructure, the technological base and the power transmission network in the energy sector as well as the lack of investment due to low electricity prices for end users.

42. **Between 1990 and 2016, energy consumption in Bulgaria has been affected by a number of unfavorable factors such as economic shocks, significant population decline by about 1.5 million, restructuring of the economy, rising energy prices - all factors limiting consumption of energy for household and non-household needs.**⁹ There is a general decline in the final energy consumption in Bulgaria with over 40 percent during the period under review, due mostly to a decrease in the consumption of the industry sector from 9 017 thousand

⁹ BAS, Preparation of a National Strategy in the field of energy (with a focus on electricity), Interim Report 1, 2017.

toe in 1990 to 2 641 thousand toe in 2016. Consumption in the agriculture, forestry and fishery sector is minimal and continues to decline over the same period, while in the services sector there is an increase of more than 8 times - a direct consequence of the changed economic structure not only nationally, but also globally, demonstrating the strong interrelation between energy consumption and economic development. At the same time, consumption of the residential sector remained relatively stable in terms of volume. In percentage terms, there is a significant drop in the share of industry in final energy consumption and an increase in the share of transport and services, which justifies the expectation of continuing this trend in the future. The share of households also increased, remaining relatively stable after 2008. These trends are similar to those in the EU 28, which shows how strong the convergence process is in this direction. By 1990, in Bulgaria, the final energy consumption was concentrated in the industry sector, which consumed over 2/3 of the total consumption for the country. Since the early 1990s, because of the restructuring of the economy, the share of final energy consumption in industry has declined steadily, dropping to 27 percent in 2016.

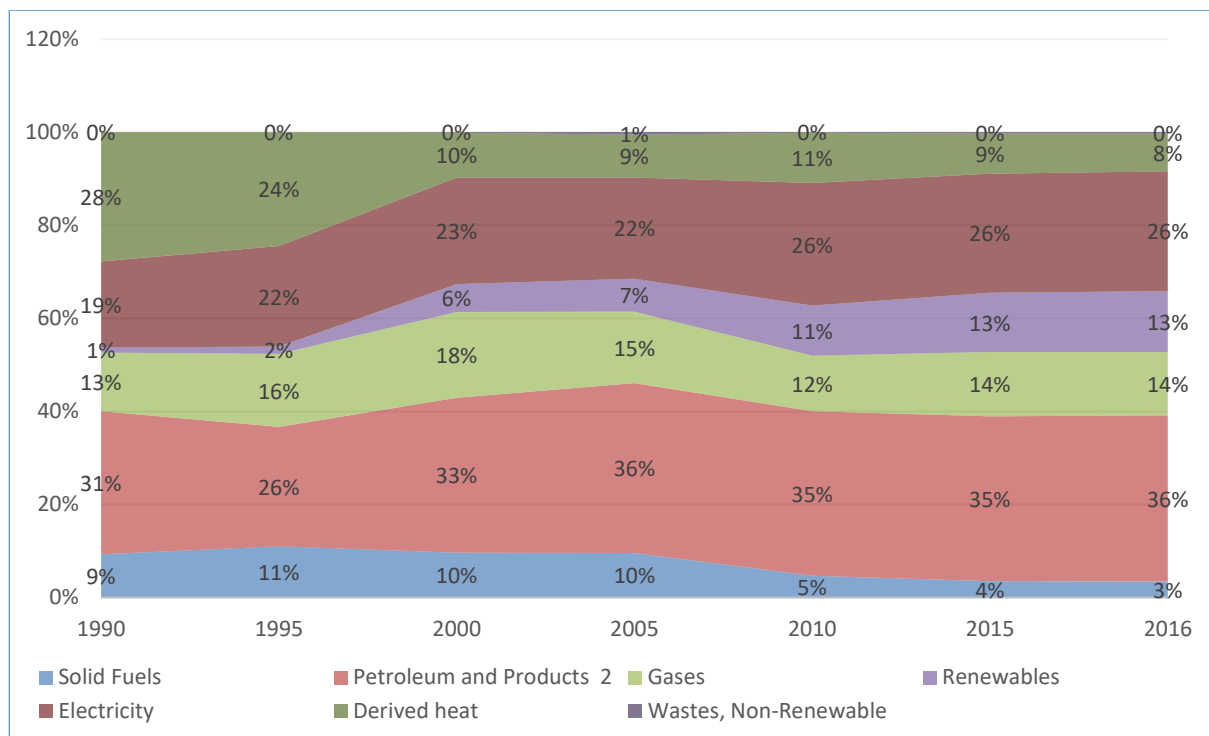
Figure 12. Structure of final energy consumption by sector, ktoe (1990–2016)



Source: Data from EU Commission, DG ENER, Unit A4, Energy Statistics

43. The structure of final energy consumption by type of fuel indicates that there is a process of decreasing the share of heat while maintaining the position of electricity.

Figure 13. Structure of final energy consumption by type of fuel, percentage (1990–2016)

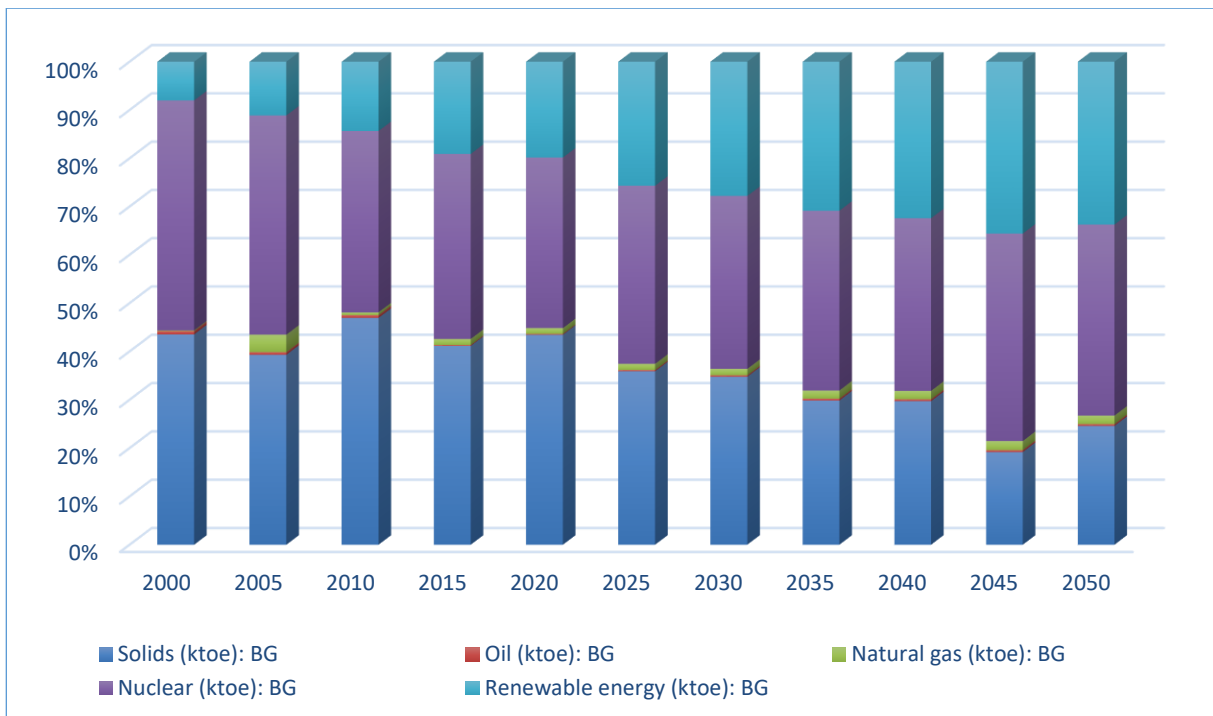


Source: Data from EU Commission, DG ENER, Unit A4, Energy Statistics.

44. In the energy mix structure, the share of petroleum and products steadily increases and reaches 36 percent in 2016. By 1996, heat represents a significant share taking over the share of electricity but after 1996 electricity gradually increases its share, reaching 26 percent in 2016. At the same time there is a gradual increase in the share of natural gas and the share of solid fuels as an energy product shows a clear reduction trend and accounts for only 3 percent of final energy consumption in 2016.

45. **Figures from the EU Reference scenario 2016 show that the total energy production is not expected to increase significantly over the studied period (until 2050) – 7 percent increase by 2030 and 11 percent by 2050 compared to 2000.** However, the generation mix will change considerably in favor of renewables while solids will decrease. The shares of oil and natural gas remain insignificant.

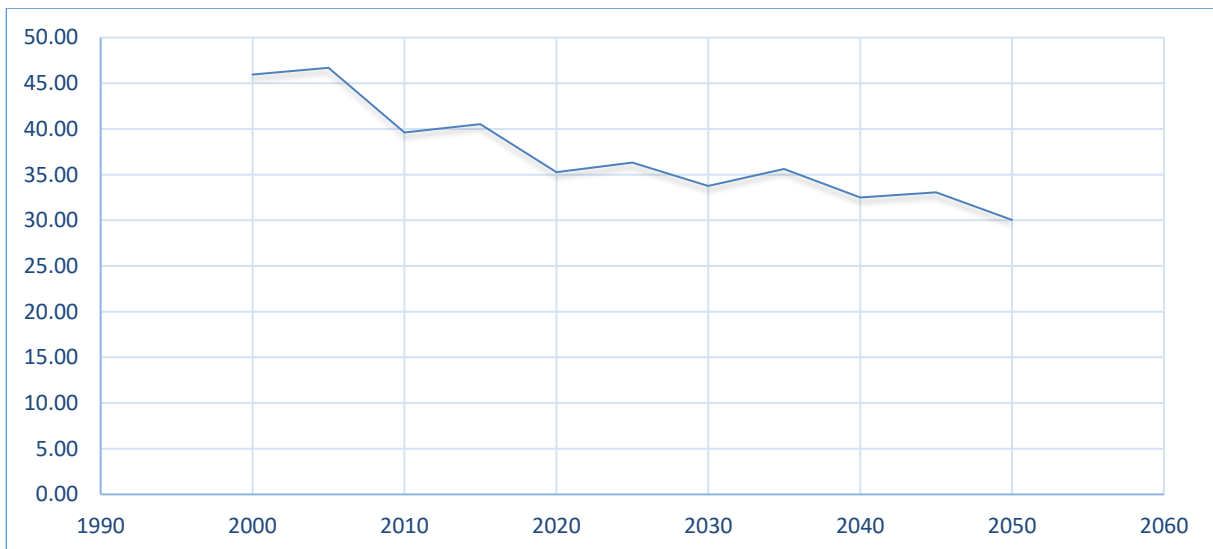
Figure 14. Energy Production by type (incl. recovery of products) (ktoe): BG



Source: EU Reference scenario 2016.

46. If current policies are implemented and targets are met, the import dependency will continue to follow its downward trend. This is mostly due to decrease in gross domestic consumption and increase in energy production (see *Figure 15*).

Figure 15. Import dependency (percentage)



Source: EU Reference scenario 2016.

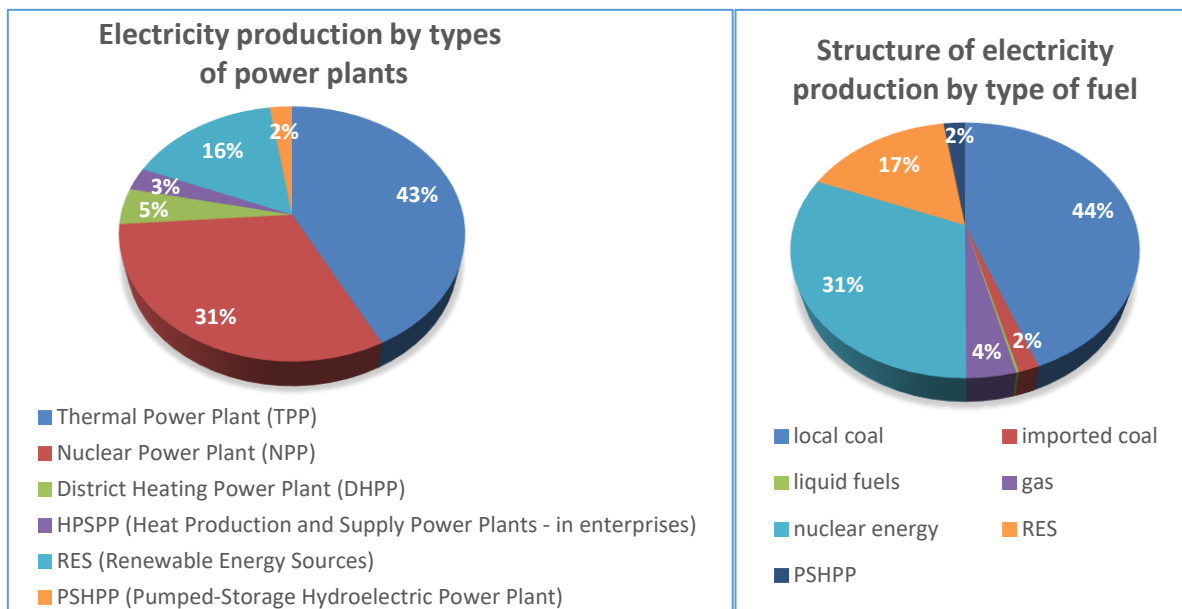
1.1.2. Electricity generation

47. Bulgaria has a diverse electricity generation mix, including thermal, nuclear and plants using renewable energy sources (hydro, wind, solar, and biomass) (MEN 2016).

48. Electricity production is dominated by TTPs using coal, followed by the NPP

Kozloduy. Local coal and nuclear fuel hold the main share in the structure of electricity production by type of fuel, as shown in *Figure 16*. The share of local energy sources for electricity production in 2015 is estimated at 95.6 percent, with imports only constituting 4.4 percent (nuclear power is considered as a local energy source).

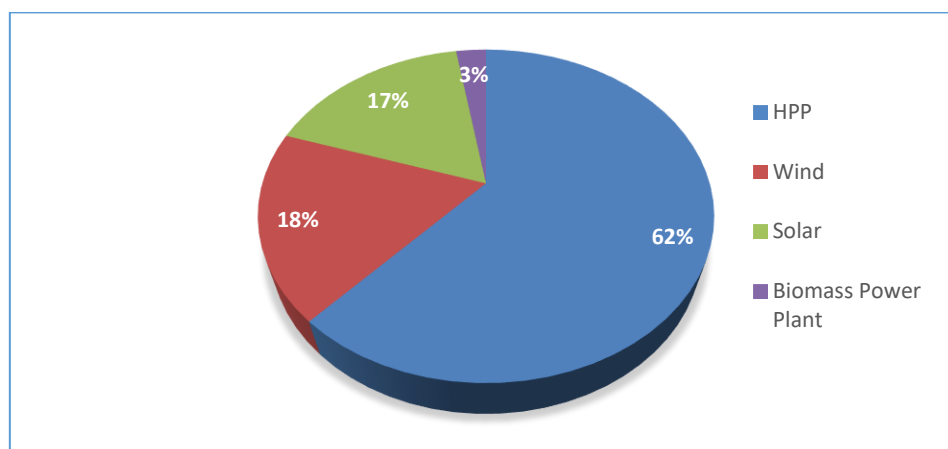
Figure 16. Structure of gross electricity production by type of power plant and type of fuel



Sources: NSI, *Energy Statistics, Bulletin for the condition and development of the energy sector in the Republic of Bulgaria 2016*.

49. Renewable energy sources currently contribute one-fifth of the energy needs for domestic electricity. In 2015, electricity generated from renewable sources covered 19.1 percent of gross domestic electricity consumption in the country: as shown in *Figure 17*, hydropower provides over half of the energy generated from renewable sources, followed by wind and solar energy, with respectively 18 percent and 17 percent of the gross electricity production from renewable sources.

Figure 17. Gross domestic production of energy from renewable energy sources 2015 (percentage)

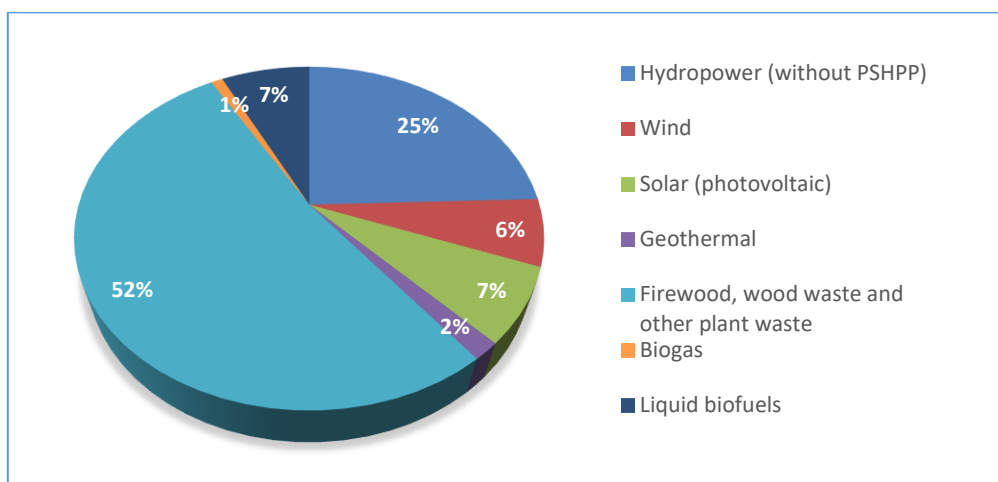


Source: Ministry of Energy (MEEn).

Climate Change Adaptation – Assessment of the Energy Sector

50. Gross domestic consumption of energy from renewable sources is presented in **Figure 18**. As the figure shows, firewood, wood waste, and other plant waste have the largest share in the structure of consumption (52 percent), followed by hydropower (25 percent). In the longer term it will be necessary to reduce the use of firewood and in this way to: (1) reduce pollution, (2) increase effectiveness in heating, (3) increase carbon-sequestration of wood, and (4) use wood resources for other highly valued purposes.

Figure 18. Gross domestic consumption of energy from renewable energy sources 2015 (percentage)



Source: NSI, Energy Statistics.

51. **Nearly all hydropower systems in the country have been designed, built, and operated as multipurpose hydro engineering systems.** This ensures they meet the demands of all water users and water consumers beyond the energy sector (irrigation, drinking and industrial water supply, recreation, and fish farming) depending on the capacity of each system. Total capacity of cascades and large hydroelectric power plants (HPPs) is 2,844.81 MW, with 2,583.50 MW for the Iztochnobelomorski (East Aegean) region only as presented in **Table 1**. As of 2010, the number of small HPPs in operation in the country is about 110.

Table 1. Total capacity of cascades and big HPPs in Bulgaria

Cascade/HPP name	Capacity (MW)
Dunavski region	124.81
Iztochnobelomorski region, incl.:	2,583.50
- Dospat-Vucha	481
- Batak hydropower cascade	232.8
- Belmeken-Sestrimo-Chaira	1535
- Arda	274.4
- Tundzha	44.2
- Individual HPPs	16.1
Chernomorski region	-
Zapadnobelomorski region	136.5
Total	2,844.81

Source: National Climate Change Risk and Vulnerability Assessment for the Sectors of the Bulgarian Economy (2014).

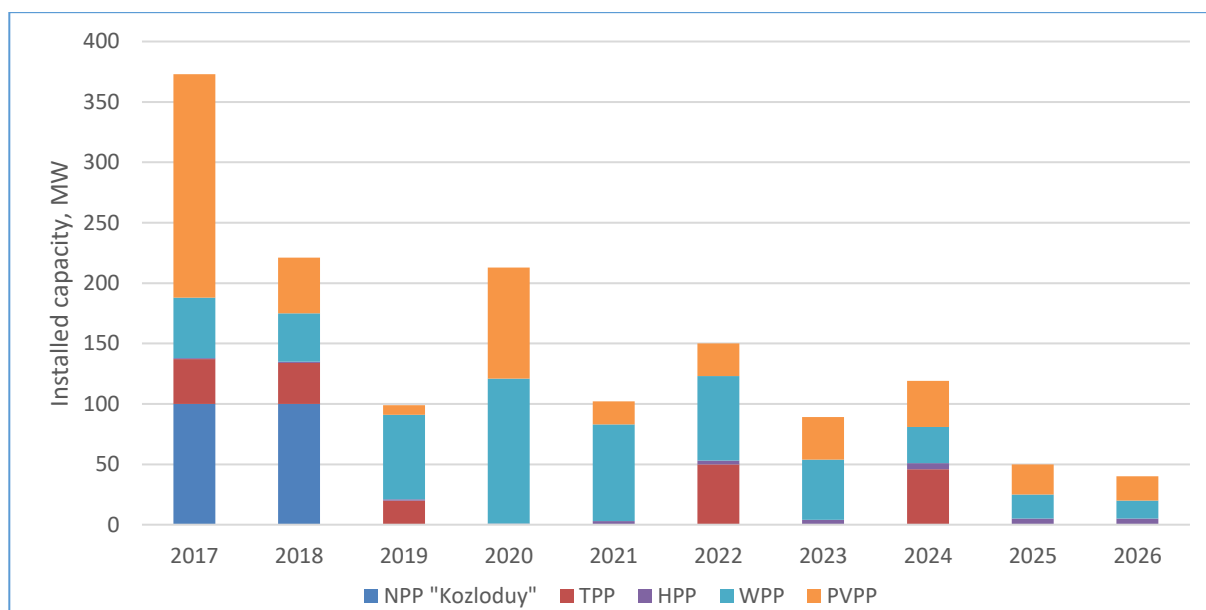
52. **Currently, the energy sector cannot rely on large HPPs to cover base consumption load.** Power generation by HPPs varies depending on the annual water amounts, with the highest peak reached in 2005, at 4,336 GWh. In 2017, the estimated electricity generation from HPP and PSHPP by the 10-year development plan of the Transmission System Operators (TSOs) is 4,142 GWh covering 10.6 percent of the gross electricity consumption.

53. **The capacity of the electricity system to integrate wind and solar power plants is limited.** The operating power of wind power plants (WPPs) and photovoltaic power plants (PVPPs) is directly dependent on the intensity of wind and solar radiation. Changes in operating power of WPP and PVPP is compensated by conventional power plants. From the point of view of the requirements for regulating the exchange capacity of the electricity energy system (EES) of Bulgaria within the European Network of Transmission System Operators (ENTSO-E)¹⁰ network, the capacity of the system to integrate new WPPs and PVPPs is limited and is determined by the available regulatory capacities and the available regulatory range. The increased amount of renewable energy will cause large and sudden changes in the production-consumption balance of the EES. Insufficient regulatory capacity also hinders the implementation schedules for the exchange of electricity with neighboring EES. Currently, installed power plants from renewable energy sources cannot provide additional services to the system operator (primary frequency regulation and secondary frequency and power regulation) and cannot participate in EES emergency management and EES restoration after severe accidents. PVPPs cannot participate in covering the maximum winter load, which is around 7:00–9:00 p.m. and WPPs produce the most electricity from 2:00–6:00 a.m., when the consumption is the lowest and there is a surplus of electricity in the system.

54. **Electricity generation capacity of Bulgaria is planned to increase over 2017–2026.** As *Figure 19* shows, this increase will affect all types of power plants. New 1,506 MW power capacity is envisaged for commissioning until 2026, 1,119 MW of which is renewable energy sources power capacity. A detailed breakdown by type of renewable energy sources and power capacities to be commissioned for 2017–2026, as well as the existing power capacity is provided in *Annex 6* and *Annex 7*.

¹⁰ ENTSO-E represents 43 electricity TSOs from 36 countries across Europe. ENTSO-E was established and given legal mandates by the EU's Third Legislative Package for the Internal Energy Market in 2009, which aims at further liberalizing the gas and electricity markets in the EU (<https://www.entsoe.eu/>).

Figure 19. New power capacity by type of power plants, 2017–2026



Source: TSO, 10-year Plan.

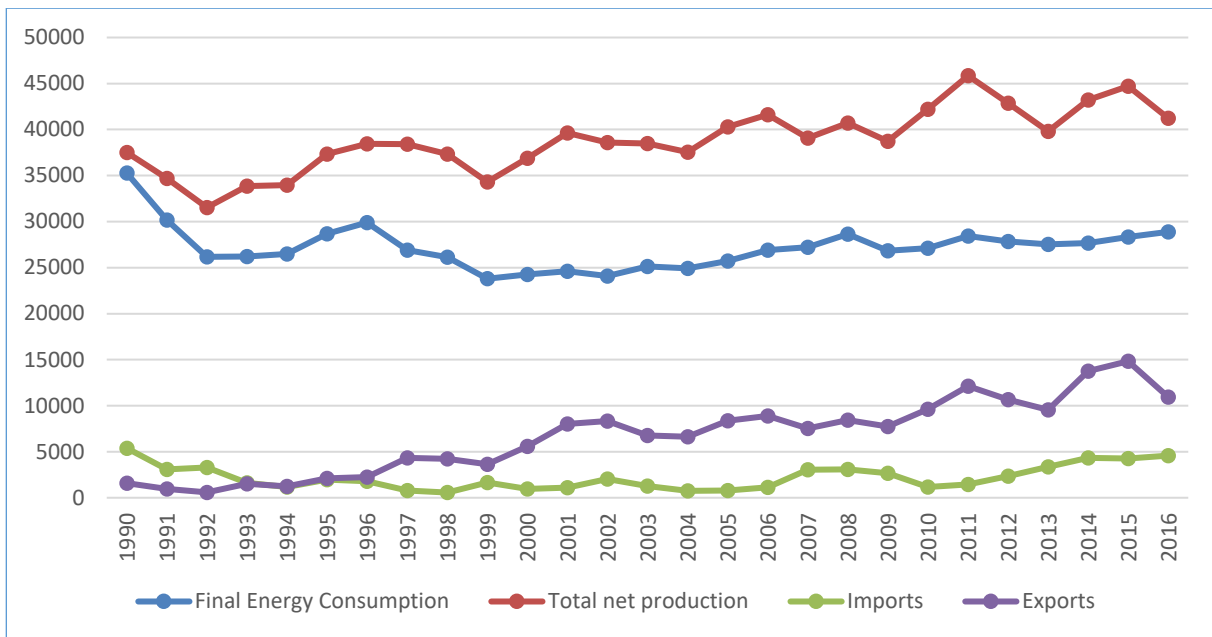
1.1.3. Supply/demand balance

55. For the period 1990–2016 the final electricity consumption in Bulgaria decreased by 18 percent. At the beginning of the period there was a significant decline, and after the restructuring of the economy after 2000, a gradual increase started. The financial and economic crisis has an impact on electricity consumption, falling by 6.3 percent in 2009. The post-crisis recovery is volatile, but by 2016 it rises by 7.6 percent. In 2013 and 2014, electricity consumption has been decreasing, driven not only by the economic crisis and its secondary effects on the economy and income, but also by energy efficiency measures, which makes them important factors in the dynamics of electricity consumption. The change in domestic electricity consumption is directly related to the change in economic growth – the acceleration of economic growth in the country leads to gradual increase in electricity consumption. This interrelation is most obvious in the manufacturing sectors of the economy, whereas the electricity consumption of households, is characterized by relative stability, regardless of the phase of the business cycle.

56. **Currently, electricity production in the country fully meets local needs, which guarantees the independence of the country in terms of electricity supply.** In the last 10 years, energy consumption in Bulgaria has remained relatively constant and close to 35,000 GWh, while the electricity export and net production show variability and a slight tendency toward an increase, as shown in *Figure 20*. Bulgaria is a leading exporter of electricity in southeast Europe. Data from the NSI shows that in 2015, the gross electricity production was estimated at 48,416 GWh and the export of electricity was 14,697 GWh, which accounts for 30 percent of the gross production.

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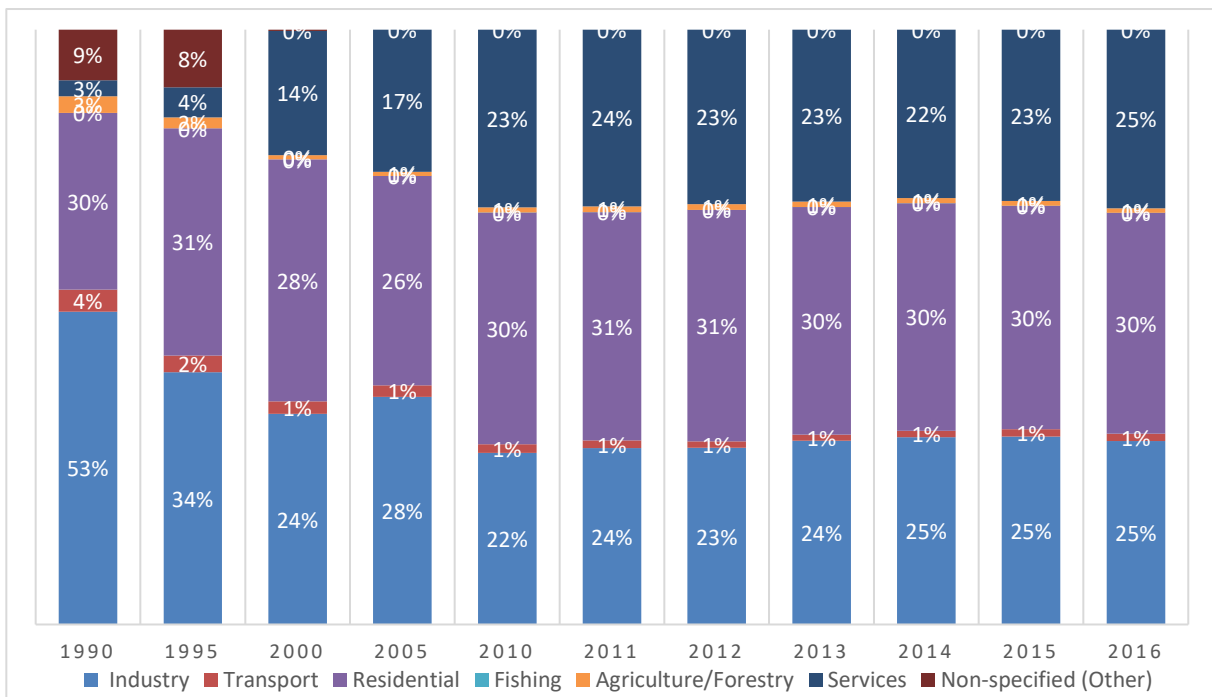
Figure 20. Electricity supply and consumption, 1990–2016 (GWh)



Source: Eurostat.

57. The structure of electricity consumption by consumer groups (*Figure 21*) shows that the decrease of final electricity consumption in the period 1990–2016 is mostly due to the decrease of electricity consumption in the industry, transport and agriculture sectors, while electricity consumption by households remains stable and consumption in the Services sector increases. The high growth of electricity use in the services sector is linked to the high growth of the sector's gross added value and shows the direct dependence between the levels of economic activity in the country and the consumption of electricity.

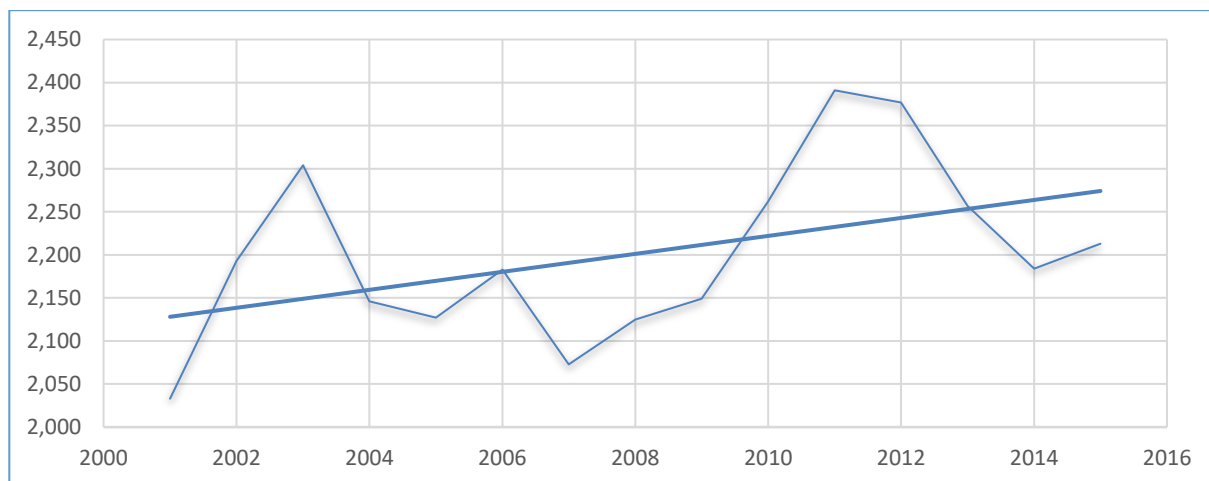
Figure 21. Structure of electricity consumption by sector, percentage



Source: Eurostat.

58. **Between 2000 and 2015, there has been a trend toward an increase in the energy consumption of households in Bulgaria, with sharp peaks during some years.** One of the factors identified as contributing to this trend, as shown in *Figure 22*, is the influence of the climate variability on energy demand.

Figure 22. End energy consumption of households (thousands of tons of oil equivalent)



Source: NSI.

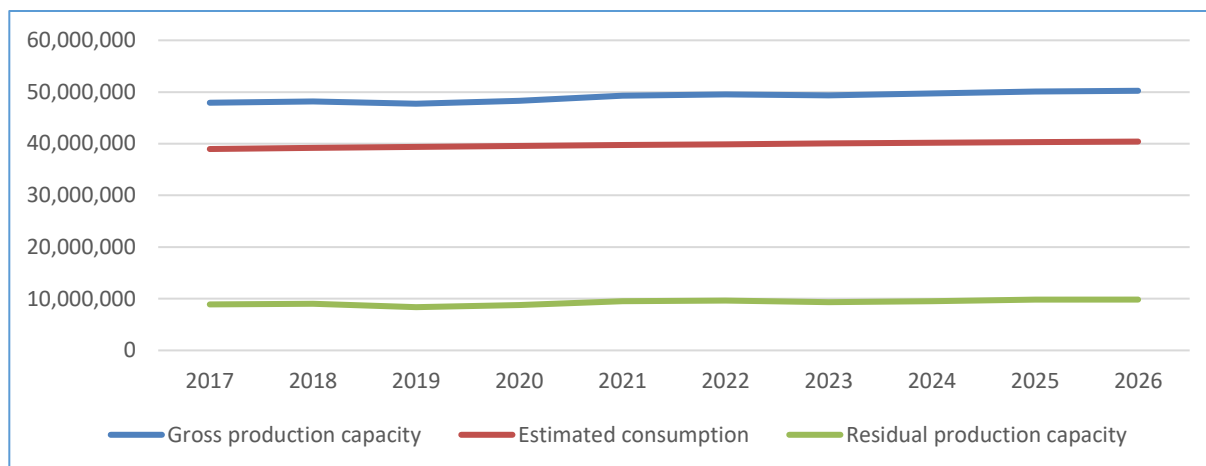
59. **Forecasts for future electricity consumption suggest an increase towards the 2020s, although the rate of change is dependent on the adoption of energy efficiency measures.** The 10-year plan of the TSO (2017) considers two main scenarios for the development of electricity consumption in the future: maximum and minimum scenarios (as shown in *Annex 8*). **The maximum electricity consumption scenario coincides with the reference trend of the European Commission (EC) for end electricity consumption for the period 2015–2025.** The maximum scenario envisages an upward trend where gross electricity consumption is expected to reach 40,410 GWh in 2026 due to delays in the implementation of energy efficiency measures. The minimum scenario also forecasts an increase in electricity consumption but at a lower rate (38,130 GWh in 2026) compared to the maximum scenario due to the timely implementation of energy efficiency measures.

60. **No power supply deficits are expected in the country by the 2020s under normal weather and emergency conditions, due to the availability of sufficient production capacity.** This is a major conclusion identified in the 10-year plan of the TSO. The energy balance forecast was made based on the maximum electricity consumption scenario. The country will have a residual production capacity of 8 to 10 TWh per year or more than 20 percent of all available capacity, as shown in *Figure 23*. It should be noted that this is mainly due to the increase in renewable energy sources.

61. **To fully capitalize on the future size of the electricity export potential, a number of changes are needed in the renewable energy sources market.** This includes good forecasts for hourly electricity generation from renewable energy sources and implementing expert economic strategies involving local producers in the regional electricity markets. In the presence of more competitive foreign market participants, imports may be needed, which would complicate the management of the production-consumption balance within the country. Apart

from technical difficulties, this would also create financial problems for local condensing power plants due to unused spare capacity. In this respect, it is necessary to integrate national electricity markets in the region, including a regional balancing market and a regional market for reserved capacity.

Figure 23. Forecast gross electricity energy balance with maximum consumption scenario, 2017–2026 (MWh)

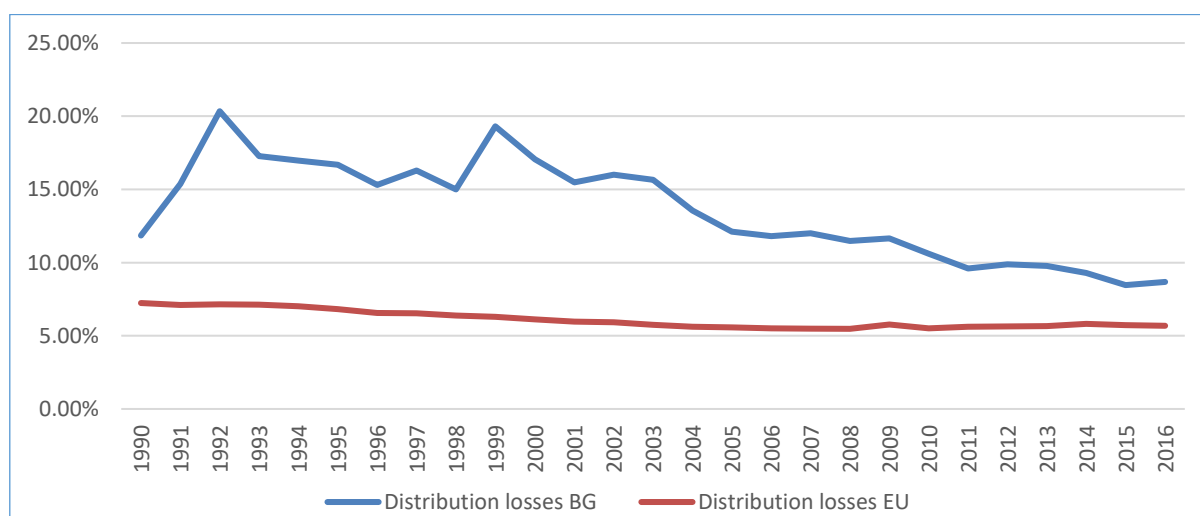


Source: Data from the Plan for Development of the Transmission Electricity Network of Bulgaria for the Period 2017–2026.

1.1.4. Electricity transmission and distribution

62. The national transmission and transborder electricity grid is well developed; however, significant investment in the grid is needed to reduce transmission and distribution losses. Since 1990, there has been a clear downward trend in the percentage of losses from transmission and distribution of electricity (see **Figure 24**). During the observed period in Bulgaria, the share of losses in 1992 was the largest - 20.3 percent of net electricity production and in 2015 – the lowest (8.5 percent). In 2016, it slightly increased to 8.7 percent. In the EU, the decrease is from 7.2 percent in 1990 to 5.7 percent in 2016. These figures show that in terms of this indicator our country is getting closer to the EU average.

Figure 24. Electricity distribution losses, percentage of net electricity production



Source: Eurostat.

63. **The necessary investments for the development of the electricity grid for the period 2017–2026 are estimated at BGN 1.27 billion, BGN 148.1 million of which European grant financing.** These is an estimate of all costs for construction, extension, reconstruction and modernization of the network as well as for system protection and management for the period of the 10-year plan of the TSO. The electric transmission grid of Bulgaria has a good geographical structure and can reliably service the transmission of energy from power plants to consumers. Distribution grids on the territory of Bulgaria are under serious development and have changed in configuration in recent years. 100 percent of the population in Bulgaria has access to electricity.¹¹ **The electricity grid is owned by the TSO, which holds the license for the transmission of electricity.** All electricity production companies and their clients use the TSO transmission network. The distribution of electricity is provided by regional companies. The electricity grid includes the following assets:

- High-voltage transmission lines with a total length of 15,235 km, including: 400 kV – 2,571 km, 220 kV – 2,704 km, and 110 kV – 9,960 km; and
- A total of 297 electrical substations, including 8 substations 400/220/110 kV, 7 substations 400/110 kV, 1 key substation 400 kV, 16 substations 220/110 kV, 4 key substations 110 kV, and 261 110/MV substations.

A map with the main transmission lines is provided in *Annex 9*.

64. **In general, under a normal operating scheme the technical capacity of Bulgaria's electricity transmission network transmits the planned quantities of electricity, both to satisfy the needs of local consumers and to export to neighboring countries.** However, there are features, repair schemes and regimes for each region of the country, which require a significant development of the power grid to meet the security criteria, adjust the stresses within the allowable limits, and reduce the losses.

65. **To improve the security of electricity transmission and distribution (T&D), the TSO periodically prepares an investment program determining the development of the transmission grid (400 kV, 220 kV, and 110 kV).** The current 10-year plan (until 2026) does not envisage further development of the 220-kV transmission network except for the construction of a second power supply in the Rousse area. The development of the 110-kV grid will improve the security of the transmission of the electricity produced from renewable energy sources, provide connection of conventional power plants, secure the supply of individual areas in case of emergency repairs. The 10-year plan of the TSO includes a detailed assessment of the necessary investments for the construction and reconstruction of the network, including the development of optical network and automated dispatch management system. The investments amount to roughly BGN 120 million on average per year for 2017–2026.

1.1.5. Heating production and distribution

66. **Centralized heat supply is provided by district heating companies and is the main form of heating and hot water supply in densely populated urban areas.** Households, together with the public and private sector, in the largest settlements (Sofia, Plovdiv, Varna,

¹¹ World Bank, Sustainable Energy for All (SE4ALL) database from the SE4ALL Global Tracking Framework led jointly by the World Bank, International Energy Agency (IEA), and the Energy Sector Management Assistance Program. <http://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=BG&page=1>

Burgas and Pleven) use their services. According to NSI data for 2016, 26.5 percent of households in the cities have central heating.

67. Centralized heat supply can be considered an alternative to domestic heating with natural gas or electricity. District heating in major cities of the country is carried out by cogeneration plants. The largest share of input fuels used to produce heat are natural gas, followed by imported coal and domestic coal. The total generated heat in 2016 was 7.5 TWh with final consumption of heat – 5.59 TWh most of which consumed by household customers.¹²

68. District heating is a well-developed environmental and economic type of heating in major cities in the country.¹³ Combined generation of heat and power boosts efficiency and reduces costs for production of two types of output. Licenses for carrying out heat supply activities have been issued by Energy and Water Regulatory Commission (EWRC) to over 20 regional heat supply companies. Licenses have also been granted to TPPs, which are part of the assets of industrial enterprises. Most of these companies possess installations for cogeneration of electricity and heat and possess a license for selling electricity obtained by cogeneration applying the preferential prices approved by EWRC. Except for Toplofikatsia Sofia AD, which provides heating services to over 70 percent of all consumers in the country and is 100 percent municipality-owned, all other heat supplying companies are privately owned. They provide district heating in 12 large towns across the country.

69. A major problem of heat supply is the outdated production capacity. Almost 90 percent of the installed combined generation capacities are between 20 and 36 years. The outdated transmission infrastructure is another cause of significant losses along the route to the end clients. The investments in building distribution networks with low pressure and the maintenance costs increase the price per unit of heat considerably above the costs of the existing district heating networks, if they are upgraded.

1.1.6. Assessment of strengths and weaknesses of the sector

70. A number of strengths and weaknesses have been identified in the energy sector,¹⁴ as outlined below. These include a number of non-climate factors which will serve to reduce or amplify the vulnerability of the sector to future climate change and are explored in more detail in *sub-chapter 1.3*.

Strengths

- Coal is the only local conventional energy resource for electricity production in Bulgaria, source of energy independence, and long-term employment.
- Nuclear energy is a source of reliable and emission-free electricity production and is a critical input for meeting demands for electricity of the economy and households in the country.
- The national power production mix is risk-free and practically independent from fluctuations and unpredictable price changes of liquid fuels and natural gas. Power production in the country fully meets and exceeds internal demand due to which Bulgaria is a leading

¹² Newsletter MEn

¹³ National Climate Change Risk and Vulnerability Assessment for the Sectors of the Bulgarian Economy, 2014 Section 6: Vulnerability and risk analysis and assessment of the energy sector.

¹⁴ Ibidem.

exporter of electricity in southeast Europe.

- The increasing share of renewable energy can satisfy peak consumption in the summer, especially considering the expected growing needs of energy for cooling in the warmer summers to come. Renewable energy is the only available environment-friendly and free primary resource that provides diversification and energy independence.

- National transmission and transborder electricity grid is well developed, with a good geographical structure and can reliably service the transmission of energy from power plants to consumers. Distribution grids on the territory of Bulgaria are under development and have changed in configuration in recent years.

- District heating is a well-developed environmental and economic type of heating in big towns in the country. Combined generation of heat and power boosts efficiency and reduces costs for production of two types of output.

- Well-developed basic gas-transmission infrastructure with significant free capacity is available in the country. Regional and municipal gas-distribution licenses covering the greater part of the country have been issued for construction of a gas-distribution network. A gas storage – Chiren – serves to compensate seasonal fluctuations in consumption and secure the emergency, operational, and strategic reserve.

- Bulgaria has a strategic geographic position providing significant options for diversification of sources and routes for oil and gas supplies to the country. National intentions and efforts are focused on future passage of gas pipeline routes from Russia, the Caspian region, the Middle East and North Africa – to the north-west and to the west, through Bulgaria.

Weaknesses

- Local coal has low calorific value, high content of sulfur, ash, and nitrogen, and power generated from it is a major emitter of GHGs. Environmental restrictions will impose limitations on operations and/or shutdown of coal plants.

- Power generation facilities in Bulgaria in general are old with major facilities being modernized. Yet, these plants (even the new AES one) must continue to make large investments to comply with stricter environmental (Industrial Emissions Directive – Large Combustion Plants Best Available Techniques Reference Document, 2017) and safety requirements (particularly being applicable to NPPs) that impose high costs on society. After shutting down blocks 1–4 at NPP Kozloduy, export capacity is reduced creating potential for higher share of imported energy carriers in the power production mix and increased emission intensity.

- Significant investment in the power grid is needed to reduce transmission losses. Maintenance and development of the power grid is hampered because of insufficient and untimely investments and lack of mandatory development plans.

- Worsening financial results of district heating companies and critically low collection rate of receivables create problems for security of heat energy supplies and for their development.

- Natural gas is supplied to Bulgaria along one route whose capacity is full and from one supplier – the Russian Federation. Intersystem connections between Bulgaria and neighboring countries are not available. Still no mechanisms are functioning at the EU level for solidarity

actions in case of restricted or cancelled gas supplies to Member States and no coordinated EU foreign energy policy to third countries has been put in place.

- Low energy efficiency has a negative impact on the country's competitiveness. This is due to the outdated energy infrastructure leading to significant losses in energy transmission, outdated machines that enterprises use, relatively low energy prices that do not encourage the introduction of energy-saving technologies, and relatively difficult access to financial resources for their purchase. Sustainable economic growth in recent years has been accompanied by a trend toward reduction of energy intensity.

71. In conclusion, currently the national power production mix is well diversified and practically independent from fluctuations and unpredictable price changes of liquid fuels and natural gas. Relying on nuclear, lignite and renewables, power production in the country fully meets and exceeds internal demand providing for historical role of Bulgaria as leading exporter of electricity in Southeast Europe.

72. Local lignite is the only one available significant local energy source, perceived as source of security of supplies. However, recent changes in regulatory environment and tightened environmental requirements under LCP BREF challenge the mid- and long-term perspective of operation especially of the lignite fired coal power plants (some 33 percent of the installed power generation capacities). The Bulgarian Government clearly outlined its support to continued operation of the plants and achievement of derogation option, however the process is ongoing and there is no clear final decision yet.

73. Renewable energy being available “for free” environment-friendly primary resource that provides diversification and energy independence has been in strategic focus as clear path for development of the sector. Bulgaria has been among the first EU Member States to achieve its 2020 renewable energy target (16 percent share of renewables from final energy consumption) but this progress has been based on substantial support mechanisms (such as feed-in tariffs, priority and obligatory buy-out of RES electricity, and so on). The support mechanisms combined with certain regulatory practices led to accumulation in significant financial deficit in the sector and at present, the stakeholders are in process of finding out market-based mechanism for integration of RES capacities and condition future RES development on competitive basis.

74. From the other point of view, electricity demand forecasts vary and are derived from the overall economic and social development. Depending on the electricity demand growth expectations (from modest to some very optimistic levels) and operation of the existing generation capacities (determined by tighter environmental requirements, strategic priorities/decarbonization commitments and market situation in terms of competitiveness) there will be need for commissioning of new flexible and competitive capacities.

75. Clear choice would be renewables – wind and solar in particular, considering the overall technological development and competitive LCOE achieved. However, vulnerability and intermittency of RES generation coupled with the mismatching at times demand and generation profiles (mismatching peaks of demand and generation for example) challenge the system flexibility and require additional investments and efforts. Existing storage facilities (such as PSHPP Chaira) provide for some system flexibility but would require additional investments

(expansion) and market-based infrastructures (incl. IT) for integration of growing RES capacities at optimized system cost.

76. District heating sector is another clear sustainable development option based on co-generation, subject to modernization and additional investments for compliance with the environmental requirements. Heat transmission losses are an issue as well. Financial stabilization of the sector and social issues (as affordability and collection of payments) have been majors concern for the future of this sub-sector.

77. New flexible gas-fired power generation plants could be also an option, but subject to the overall development of the gas market, allowing truly competitive offerings and reliable supplies.

78. At present the gas supplies to the country are from one source and via one route and the Ukranian gas crisis from 2009 proved Bulgaria is 100 percent dependent on Russian gas supplies states. Real efforts in infrastructure development have been done since 2009 to interconnect the Bulgarian gas transmission system with neighboring countries targeting commercial operation of interconnectors in 2020. If completed, backed with the well-developed national transmission system and market reforms implemented in compliance with the EU-acquis, interconnectors could provide for market opening and increased competition (based on diversified sources and routes of supplies) that could be expected to result in increased role of gas in primary energy mix, incl. increased level of households gasification, more sustainable participation of the natural gas in electricity generation and stabilized district heating sector. Yet, while Bulgaria has among highest border price of natural gas and among the lowest electricity prices for final consumers, stimuli for shift from electricity to natural gas at household level are difficult to offer.

79. Last but not least, both electricity and gas markets at present are characterized with high level of concentration and limited competition. This would require significant targeted efforts towards market liberalization and allowing market forces to bring benefits to consumers in terms of secure and affordable sustainable supplies. Regional and EU processes of market integration should be considered as another driver for competitiveness and sustainability of the sector providing for wider options for RES integration.

1.2. Past and Present Weather Events and their Consequences and Response Actions in the Sector in Bulgaria

80. Countries in southeast Europe, including Bulgaria, are currently exposed to a variety of natural hazards, including floods, droughts, forest fires, earthquakes, and landslides. Increased temperatures, reduced precipitation, changes in river flows and ecosystems, and extreme events, including droughts and floods, are affecting certain regions in Bulgaria, particularly the lowest parts of the Arda, Tundzha, Maritsa, and Byala river basins.

81. In recent years, extreme weather events have caused some damage and disruption to the energy sector, which has knock-on consequences for other sectors. The most notable events are summarized in *Table 2*. Fortunately, extreme weather events have not significantly affected energy infrastructure to date and have mostly led to damages in the electricity grid and temporary power cuts. However, given the importance of energy infrastructure and supply to

other sectors, through their use of energy, even minor outages can have cascading consequences and amplify the initial impact. An increase in the frequency and intensity of such weather events is likely to pose challenges to the sector in the future.

Table 2. Historical weather events and their consequences for the energy sector

Type of extreme weather event	Description of historical event
Heavy rainfall and flooding	2007: Heavy rainfalls in the Stara Zagora region caused floods and suspension of coal production at Maritsa Iztok Mines.
	2014: Heavy flooding in eastern Bulgaria in June resulted in loss of life (at least a dozen people) and significant impacts for the energy, agriculture and the tourism sector. One transformer station was washed away in floodwater and another was buried in the mud and debris, rendering it completely inaccessible. The storm also caused extensive damage to the electricity distribution network in Varna, Dobrich, and Veliko Tarnovo. A large number of transformer substations were flooded, and medium and low voltage pylons were damaged. During the storm, the electricity distribution company implemented emergency procedures, including the shutdown of separate power lines and facilities to avoid accidents and life-threatening situations.
Winter storms and heavy snowfall or hailstorms	2014: Severe hailstorm on July 8 caused widespread damage in the Bulgarian capital, Sofia.
	2014: Winter storms in northwest Bulgaria caused icing of 70 electricity pylons, cutting off 70 km conductors and damage to the power transmission network. Fallen trees were also a problem. A total of 25,000 people was left without electricity. The Sazalia River overflowed and flooded electricity substations and the municipalities of Lovech and Galabovo in central and southeast Bulgaria.
	2015: Windstorms and snowstorms in Smolyan and Montana regions and in south Bulgaria caused damage to the power transmission network and electricity disruption.
	2016: Heavy snowfall cut off the power supply of 450,000 people.
Windstorms	2017: A long period of extremely low temperatures in January led to extreme loads not only in Bulgaria but also in the Balkan region. January 10, 2017 saw the highest load for the past 20 years, with electricity consumption reaching 7,690 MW. Between January 7 and 12, consumption was over 7,100 MW for 42 hours.
	2013: Windstorms in the regions of Shumen, Sliven, Veliko Tarnovo and Gabrovo broke down electricity pylons, cut off conductors and caused electricity disruption.

82. Local response actions are largely the responsibility of the regional electricity transmission companies. They have 24/7 emergency teams available so that they can deal with accidents on time. In the event of more serious disasters, a National Crisis Headquarters is formed, headed by the Minister of Interior, to assess the situation and plan further actions.

83. In response to the extreme event in January 2017, when sustained cold temperatures

resulted in extreme loads on the energy system, the TSO implemented emergency measures. These included restrictions on electricity exports from Bulgaria and redirecting part of the electricity from the exchange to household consumers to ensure the security of the Bulgarian electricity system and the provision of electricity to consumers. To bear the sustained increase in electricity consumption, the production capacity of the ‘cold reserve’¹⁵ had to be used. The activation of the reserve capacity was delayed as the coal reserve of two of the companies with reserve maintenance contracts (TPP ‘Rousse’ and TPP ‘Bobov Dol’) was frozen due to the extremely low temperatures.

84. Typically, power lines in mountainous regions suffer the largest damages as storms are more severe. They are also most difficult to repair due to the terrain. Due to frequent winter storms and heavy snowfall in the Rhodopi Mountain, the regional electricity transmission company (EVN) started to replace some of the overhead lines with underground cables. Another measure to reduce the damages of such weather events was initiated by the Ministry of Energy – the amendment of the Regulation on the servitude of energy infrastructure.¹⁶

1.3. Sector-Related Climate Change Risks and Vulnerabilities

85. There is a two-way relationship between the energy sector and climate change. Energy production is a highly polluting industry and seriously affects the level of generated harmful emissions, which in turn cause climate change. However, the cycle does not end here. The cycle turns and climate change in itself affects the energy sector.¹⁷

86. In many cases, construction projects fail to take into account the expected environmental impacts (Pascal 2009). When specialists discuss execution of ‘environmental impact assessments’, almost always the subject of assessment is how the facility will affect the environment and not how the environment may affect the facility. Though engineers and specialists check the site before preparing the drawings for the relevant facility, they usually assume the parameters of the site to be constant and not variable values. The general assumption is that river levels will remain the same, soil will not sink, and precipitation will be within predictable scales. Most specialists are not accustomed and often are not prepared to include issues related to changes in the relief caused by environmental processes in their plans. It is not sufficient to assess the impact of a given energy site on the environment assessment shall also be made of the impact of the changing environment on the energy facility. Then, to the extent possible, the impact of these changes shall be reflected in the planning and their consequences estimated in the price.

87. Energy infrastructure is vulnerable to a range of climate stressors, including temperature, precipitation, sea level rise, and extreme events. Specifically, climate change is expected to change the intensity, frequency, and distribution of extreme heat, precipitation, and storms, exacerbating the vulnerability of energy infrastructure. Climate change risks and vulnerabilities for each of the elements of the energy system introduced in sub-chapter 1.1 are discussed below, with a summary provided in *Table 3* and *Table 4*.

¹⁵ The ‘cold reserve’ is reserved power capacity purchased by the TSO that is not intended to operate for a certain period of time and is activated in case of a deficit (Energy Act, Additional provisions, § 1, 61)

¹⁶ Adopted on 8.10.2004, last amendment 29.09.2015

¹⁷ National Climate Change Risk and Vulnerability Assessment for the Sectors of the Bulgarian Economy, 2014

1.3.1. Primary energy supply

88. **Water is critical for mining operations and any climate-related impacts on the quality and availability of water resources will have implications for efficiency and cost** (ICMM 2013). The results of the analysis of water resources in Bulgaria, based on the current trends in air temperature and precipitation, as well as the use of simulation models and climate scenarios, show that annual river runoff is likely to be reduced in the 21st century. The main reasons for this, the observed trends of warming and the precipitation deficit, are expected to continue in the coming decades.¹⁸

89. **Heavy precipitation, on the other hand, may present risks to operations and damage infrastructure and equipment that result in interruption to production.** Lignite coal from the Maritsa Iztok Coal Basin is extracted in opencast mines and coal is transported to TPPs by rail lines. In 2015, heavy rainfall halted coal production at Mine 1, as overflow of dam ‘Kovachevo’ flooded the mine and its rail line. Mine site conditions can be affected as precipitation patterns change, through increased risk of flooding, subsidence, landslides, soil erosion, and changing groundwater levels. Analysis shows that risk of floods is increasing, with climate change being one of the main reasons.¹⁹

90. **Precipitation increases, and flooding may also lead to reduced coal quality through higher moisture content of opencast mining.** Lignite from the Maritsa Iztok Coal Basin have high ash (16–45 percent) and moisture (50–60 percent) content.

91. **With predicted increasing frequency and intensity of heat waves, weather-related heat exposure is presenting a growing challenge to occupational health and safety.** Higher temperatures directly increase the risks of heat stress for outdoor workers. Heat exposure can also exacerbate chronic diseases. Outdoor workers, in particular those undertaking highly intensive and physical activity under the sun, are susceptible to heat stress during heat waves when preventive measures are not adequately adopted (Xiang et al. 2014).

1.3.2. Electricity generation

Nuclear and thermal power plants

92. **Generally, all areas of energy infrastructure need to respond to climate impacts on their performance.** TPPs can be designed to operate under diverse climatic conditions, from the cold Arctic to the hot tropical regions and are normally well adapted to the prevailing conditions. However, they might face new challenges and will need to respond by hard (design or structural methods) or soft (operating procedures) measures as a result of climate change (Xiang et al. 2014).

93. **In the medium term, thermal power (TPP and NPP) is expected to be the main contributor to electricity generation in Bulgaria, hence the importance of addressing climate change risks to generation assets.** Despite rapid growth rates of renewable energy, thermal electricity generation (NPP and TPP) is expected to account for around 80 percent of electricity generation in Bulgaria in 2024 (TSO, 10-year plan). Electricity production facilities are exposed to a range of climate risks, including accelerated weathering, increased likelihood

¹⁸ Bulgarian Academy of Sciences, National Institute of Meteorology and Hydrology 2010, Climate Changes

¹⁹ Council of Ministers, Protocol No 15/16.04.2014 ‘Strategy for reducing the risk of disasters 2014–2020’.

of damage or destruction, operational changes in fuel extraction processes, and reduced generation efficiency.

94. Climate change can affect the output, efficiency, and financial viability of thermal electricity generation. According to all climate change scenarios, projections for Bulgaria show increasing temperatures and decreasing summer precipitation by the end of the current century, therefore an associated increase in the number of dry spells and droughts. Power plants will experience some reduction in output as higher air and water temperatures affect the efficiency of their cooling systems. An increase in ambient temperature results in a decrease in the difference between ambient and combustion temperature, reducing the efficiency of gensets, boilers, and turbines (Contreras-Lisperguer 2008).

95. Another issue is likely to be the access to sufficient water for cooling and returning it to the source at a temperature low enough to prevent damage to aquatic ecosystems (ADB 2012). The volume of water required for fuel processing, cooling, and power production can be considerable. NSI data shows that 78 percent of water consumption in the economy in 2015 was used for cooling in the energy sector. The three largest TPPs in the ‘Maritsa East’ Complex are situated in one of the regions most affected by heat waves (Gocheva et al. 2006). Due to increased drought risk in the future and greater competition for water resources, some power plants may also face reduced ability to abstract and discharge cooling water. There is a direct correlation between rising air temperature and rising water temperature. This may result in significant changes in water ecosystems and impairment of fresh water quality. Currently, the trend for the energy sector to be one of the highest water users in the country is likely to continue in future; however, appropriate temperature characteristics is equally important to securing adequate water quantity.

96. Warming temperatures due to climate change may create favorable conditions for some invasive species that can damage energy infrastructure. In recent years, invasive zebra mussel populated Ovcharitsa Lake (the cooling lake of Maritsa East 2 TPP). The mussel briefly clogged the pipes of the cooling system and increased the risk of equipment failure. The River Basin Management Plan of the East Aegean Region provided measures to address the problem. An EU-funded initiative²⁰ investigated the link between climate change and the spread of aquatic species outside their traditional geographic range. The report concludes that rising temperatures will help warm water species that have been introduced into temperate regions to become better established. Increases in the magnitude and frequency of floods will also aid the dispersal of alien aquatic species, such as zebra mussels (*Dreissena polymorpha*).

97. Rozov Kladenets and Ovcharitsa lakes (the cooling lakes of the three largest TPPs in Bulgaria) offer highly suitable conditions for eutrophication and development of invasive species, as they are generally warmer due to their technogenic origin. Climate change may aggravate these problems and hamper normal power generation. Moreover, reduced water inflow due to climate change could impede the operation of TPPs as they may not have enough water to operate. Water supply infrastructure is likely to require enhanced maintenance to be able to service the power plants effectively.

²⁰ CHAOS Result in Brief, Project ID: 251801, Funded under: FP7-PEOPLE, Country: Italy.

Renewable energy

98. **Hydropower generation is likely to suffer from reduced precipitation, particularly in the summer season due to changing climate patterns.** Increased temperatures, reduced precipitation, changes in river flows and ecosystems, and dry spell on the one hand and sudden flooding events on the other hand are a fact in certain regions in Bulgaria, namely the lowest parts of the Arda, Tundzha, Maritsa, and Byala river basins. River flow will change because of changes in precipitation patterns and the reduced snow and ice cover in mountainous regions.²¹

99. **HPPs with annual (multi-annual) volume regulation will be faced with increased requirements for management of multipurpose dams.** Successful management of a given hydropower installation depends on the capacity to forecast the water volume entering the system (Pascal 2009). Before its construction, river level, hydrological cycles and precipitation characteristics are evaluated. Until recently, these data were considered to be constant values. For example, flow may fluctuate on decade cycles, which were largely deemed to be predictable, and based on that dam walls, turbines, and reservoirs were constructed. With the advancement of climate change, these fixed values turn into variables. Mountainous regions in Europe are exposed to more flooding in wintertime and spring, while summer tends to be dry. These fluctuations may disrupt the regime of hydroelectric generators, erode infrastructure, and damage important regional industries.

100. **Run-of-river HPPs are more sensitive to climate change impacts than HPPs on dams.** Run-of-river dams utilize some or all of a river's flow to produce electricity without impounding any significant amount of water upstream (Blackshear et al. 2011). As a result, run-of-river facilities have no storage capacity to buffer fluctuations in water flow. These facilities provide only base power generation, lacking the ability to store water for periods of peak demand. Climate change will lead to altering timing and magnitude of precipitation for traditional rainy and dry seasons and peak snowmelt. By delivering water supply at varied and unpredictable times, temporal variability has a negative impact on hydroelectric production. Run-of-river facilities are more vulnerable than HPPs on reservoir dams, which have the capacity to store water, thereby accounting for these variations in reservoir volume.

101. **Solar power generation can also be vulnerable to a number of climate change impacts.** Generation of electricity and heat from solar sources is vulnerable to increased cloud cover associated with increased rainfall. During cloud cover, solar photovoltaic panel output can decrease by 40 to 80 percent within a few seconds, increasing just as dramatically when the sky clears (ADB 2012). If cloudiness increases under climate change, the intensity of solar radiation and hence the output of electricity would be reduced. Higher wind speeds can also increase dust particle deposits, which decrease solar photovoltaic cell output, but higher winds can also cool the modules, increasing efficiency and output (ADB 2012).

102. **For wind power systems, turbine performance and ultimately energy output is sensitive to frequency distribution, average speed, and timing of winds.** Changes in wind patterns and intensity due to climate change could affect the productivity of existing wind farms thus challenging the balance and management of the energy system. These changes could also influence the decisions for the development of future sites. Even if average annual wind speeds

²¹ National Climate Change Risk and Vulnerability Assessment for the Sectors of the Bulgarian Economy, 2014.

remain unaltered, a change in the diurnal wind pattern can affect daily wind power production, significantly improving—or reducing—the match between wind energy input to the grid and daily load demands (ADB 2012). Abnormally weak seasonal winds can also significantly reduce annual energy production (ADB 2012). In extreme, stormy, conditions, wind turbines can be damaged (for example, undermining the foundations and causing subsidence) and potentially shut down under very high winds. Climate modelling results show uncertainty of climate change's effect on wind resources; this uncertainty alone could hinder the development of infrastructure for wind-based generating capacity.

Supply/demand balance

103. **The T&D grids are increasingly challenged by new seasonal and regional demand patterns.** At the same time, they are also subject to new balancing requirements arising from the integration of significant volumes of electricity produced from renewable sources (typically sparsely distributed). Despite this dual challenge, a high degree of reliability needs to be ensured. Due to their comparatively lower physical robustness, older regional distribution networks are particularly vulnerable to extreme weather events (for example flashovers in rural areas).

104. **Climate change has the potential to affect energy demand through changes in demand for heating and cooling.** Projected increases in summer temperatures will result in increased use of air conditioning (USAID 2012). Climate change may also add stress to energy infrastructure, including changes in energy requirements for residential and industrial cooling and heating, the timing and magnitude of peak demand, and adjustments in energy consumption for transportation, construction, and agricultural activities.

105. **Increased temperatures due to climate change may lead to a shift in energy demand.** Since the beginning of the 1980s, Europe has started experiencing a markedly declining overall trend in heating degree days (HDDs) and a markedly increasing trend in cold degree days (CDDs), pointing to a general increase in cooling needs and a general decrease in heating needs. The decrease in HDDs has been particularly strong in the Alpine areas and the Baltic and Scandinavian countries, whereas the increase in CDDs is particularly strong in southern Europe, around the Mediterranean and in the Balkan countries. Bulgaria is among the countries with noticeable overlapping of medium to strong HDD and CDD effects (EEA 2017).

1.3.3. Electricity transmission and distribution

106. **Transmission lines face damage and disruption from extreme precipitation, floods and winter storms.** Climate change will likely lead to higher numbers of disruptions: exposed cables/trunk routes due to erosion or damage of transportation infrastructure, increased transmission line losses, increased damage to above-ground infrastructure from extreme storms and wind, direct mechanical damage to power distribution infrastructure caused by short circuit of power lines, indirect mechanical damage and short circuit by trees blown over or debris blown against overhead lines, physical damage (including collapse) of overhead lines and towers caused by ice build-up.

107. **The functioning of infrastructure in mountainous areas can be increasingly threatened by an increased frequency and intensity of natural hazards (such as landslides,**

rock falls or floods). Most phenomena are linked to the increasing ambient temperature that leads to a loss of glacier mass and consequent morphological transformations, reduced snow cover, thawing of permafrost, and changing precipitation patterns. Climate change is projected to result in later seasonal snow, less snow coverage, earlier wet snow avalanches, and generally shorter snow seasons. Furthermore, transmission losses will increase due to increased temperatures, resulting in higher effective demand.

108. **Increased frequency of heat waves associated with climate change could affect the efficiency of electricity transmission.** Higher air temperatures may make it necessary to reduce the amount of electrical current passing through overhead power lines in particular. Known as ‘de-rating’, this ensures that the equipment does not overheat. Although helping prevent power outages, de-rating decreases transmission capacity, which with rising demand may become significant.

109. **Power lines sag as they heat up due to two main factors: warmer temperatures and increased amounts of energy transmitted through the lines.** As temperatures rise due to climate change, some lines would likely hang below the minimum distance from the ground required by law which may cause disruptions and revenue loss (Ouranos 2016). Power lines may exceed established maximum design temperatures and breach minimum ground clearance because of thermal expansion. Where little network redundancy exists to transfer the loads of overloaded circuits, power interruptions could be experienced, along with increased risk of cascading network failures. The risk of overloads can increase when temperatures rise, and more people use air conditioners and fans.

1.3.4. Heating production and distribution

110. **Climate change is not expected to change total energy demand substantially, but there may be significant seasonal effects.** Increasing temperatures due to climate change may gradually reduce the need for heating. As explained in the section ‘Supply/demand balance’ the European Environment Agency (EEA) report identifies Bulgaria as one of the EU countries with medium to strong HDD effects. The decrease of population-weighted HDDs across Europe during the period 1981–2014 was on average 9.9 HDDs per year.

1.3.5. Assessment of climate change risks and vulnerabilities for the energy sector

111. **Changes in climate and weather extremes will affect the energy sector both positively and negatively, though negative impacts prevail.** A summarized list of potential direct risks and opportunities for the energy sector in Bulgaria organized by climate variable is presented in *Table 3*.

Table 3. Climate change adaptation – potential direct risks and opportunities for the energy sector

Energy	Risks	Opportunities
Higher temperature (including heat spells and heat waves)	• Reduced efficiency of TPP and NPP	• Reduced demand for winter heating
	• Lowers solar power cell efficiency and energy output	
	• Damaged infrastructure due to eutrophication and invasive species	
	• Transmission losses and de-rating	

Climate Change Adaptation – Assessment of the Energy Sector

Energy	Risks	Opportunities
	<ul style="list-style-type: none"> • Lowers capacity of underground conductors if high ambient temperature increases soil temperature • Increased demand for energy for space cooling • Health and safety issues for outdoor workers (for example heat stress) 	
Lower temperatures (including cold spells and cold waves)	<ul style="list-style-type: none"> • Damage to T&D infrastructure due to ice build-up • Wind turbine blade icing affecting output • Freezing coal in storages • Disrupted coal imports due to suspended transport along the Danube 	
More precipitation and humidity	<ul style="list-style-type: none"> • Flooding of mine sites and infrastructure, with impacts for supply of coal to TPP and potential environmental pollution (for example tailing dams, waste storage sites) 	<ul style="list-style-type: none"> • Increase in river flow affecting the performance of hydropower (small and large)
	<ul style="list-style-type: none"> • Flooding of power generation assets (for example TPP and NPP) causing power disruption and/or increased CAPEX to repair assets 	
	<ul style="list-style-type: none"> • Flooding of hydropower assets, increased siltation of reservoirs, dam overtopping, and energy wastage 	
	<ul style="list-style-type: none"> • Flooding of T&D infrastructure (for example substations) causing power disruption and/or increased CAPEX to repair assets 	
	<ul style="list-style-type: none"> • Reduced performance of solar sources due to increased cloud cover associated with increased precipitation 	
Droughts	<ul style="list-style-type: none"> • Restricted availability of cooling water for TPP and NPP due to water scarcity and elevated water temperatures 	
	<ul style="list-style-type: none"> • Reduction in river flow affecting the performance of hydropower (small and large) 	
	<ul style="list-style-type: none"> • Soil shrinkage damaging oil and gas pipelines and T&D infrastructure underground 	
Increase of winds and storms	<ul style="list-style-type: none"> • Damage to T&D infrastructure (for example from falling trees) causing power disruption and/or increased CAPEX to repair assets 	
	<ul style="list-style-type: none"> • Damage or disruption to renewable energy sources infrastructure (for example wind and solar) causing downtime and/or increased CAPEX to repair assets 	<ul style="list-style-type: none"> • Increased efficiency and output from solar with cooling effect of wind
Sea level rise	<ul style="list-style-type: none"> • Flooding of oil refineries causing increased CAPEX to repair assets 	
Landslides	<ul style="list-style-type: none"> • Damage to T&D infrastructure causing power disruption and/or CAPEX to repair assets 	
	<ul style="list-style-type: none"> • Land instability at mine sites with impacts for supply of coal to TPP and potential environmental pollution (for example tailing dams, waste storage sites) 	

112. A more detailed list of climate change risks identified for each infrastructure element of the energy sector in Bulgaria is presented in *Table 4*.

Table 4. Climate change risk register for the energy sector in Bulgaria

Infrastructure Element	Climate change risks
Coal mining	<ul style="list-style-type: none"> • Extreme weather events increase physical risk to business operations, for example due to flooding. • Precipitation increase, and flooding may lead to reduced coal quality (higher moisture content of opencast mining) • Cold spells may lead to freezing coal in storages
Nuclear and Thermal Power Plants	<ul style="list-style-type: none"> • Destroyed infrastructure due to flooding and landslides; expenses for protection facilities • Increased water demand for cooling in dry spells; droughts could threaten the supply of cooling water to the power station. • Reduced efficiency due to higher air and water temperatures • Discharge water can cause ecological problems (thermal pollution) and lead to power station being shut down. • Warming temperatures may create favorable conditions for some invasive species and eutrophication which can damage energy infrastructure • Cold spells may lead to disruption of energy production in TPPs due to freezing coal in storages or suspended transport along the Danube River
Hydro	<ul style="list-style-type: none"> • Intense rainfall could lead to increased overflow and risk of flooding of the surrounding environment. • Changes in rainfall intensity have the potential to affect hydropower generation particularly where decreased summer rain affects levels in watercourses, as these plants require constant water flows. • Loss of efficiency and physical damage to renewable energy sources due to increased storminess • Changes in precipitation patterns or variability could create greater uncertainty when investing in hydropower facilities and could alter output but could also result in local benefits from increased hydropower output in some regions. • Hydropower production could also be affected by increased silting of sediment into reservoirs caused by increased erosion and sediment displacement as a consequence of climate change.
Wind	<ul style="list-style-type: none"> • Increased storminess will lead to loss of efficiency and damage to infrastructure. • If climate change affects wind speeds and wind patterns (this is uncertain), this would affect power output from wind turbines.
Solar	<ul style="list-style-type: none"> • Increased cloudiness will lead to reduced electricity generation • Extreme weather events (windstorms and hailstorms) may lead to physical damage to infrastructure
Electricity Grid	<ul style="list-style-type: none"> • Increased frequency of extreme weather events will lead to physical damage to T&D infrastructure • Increased ambient temperatures could affect the efficiency of electricity transmission. • Power lines may exceed established maximum design temperatures and breach minimum ground clearance because of thermal expansion which may cause power interruptions.

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Infrastructure Element	Climate change risks
	<ul style="list-style-type: none"> Warming temperatures will increase demand for electricity in the summer season (as more people use air conditioners and fans), thus posing a risk of overloads.
Gas Transmission	<ul style="list-style-type: none"> Soil shrinkage due to drought could affect oil and gas pipelines. The deformation of the ground has the potential to damage the foundations of buildings and other infrastructure. One of the most widespread forms of subsidence is the shrinking and swelling of clay soils due to excessive rainfall, drought, or land use changes. Susceptibility to shrinkage of soil is influenced by the rainfall of the preceding two-year period. Increased temperatures also lead to more evaporation and evapotranspiration which, in turn, leads to further drying and shrinking soils.
Human/ Workforce	<ul style="list-style-type: none"> Increased heat-related health and safety risks for maintenance workers Increased air-conditioning requirements and costs Decreased heating requirements and costs

113. Climate change vulnerability and risk analysis and evaluation of the energy sector in Bulgaria shows that agriculture and forestry, energy, water supply and crucial infrastructure will be among the most affected sectors. *Table 5* was drafted on the basis of the climate scenario prepared for Bulgaria (general part of ‘National climate change risk and vulnerability assessment for the sectors of the Bulgarian economy’) and application of the Risk and Vulnerability Evaluation Methodology DPSIR (Driving-Pressure-State-Impact-Respond).

Table 5. Energy system sensitivity to climate change

1	Climate scenario IPCC AR5	Likely outcome in the time range 2016-2035			Expected impact (positive (+) insignificant or none (0) and negative (-))			Sensitivity level 1 – Low, 2 – Moderate, 3 – High		
		3	4	5	7	8	9	10	11	12
Power production	Scenario	ΔT°C	ΔP%	Ex↓,↑	ΔT°C	ΔP%	ΔEx	ΔT°C	ΔP%	ΔEx
Nuclear Power Plant (NPP)	RCP2.6	1.5-2.0	0-10							
	RCP4.5	1.5-2.0	0-10							
	RCP6	1.0-2.0	0-10	↓↑	-	+	+/-	1	1	1
	RCP8.5	1.5-2.0	0-10							
Hydro power plants (HPP)	RCP2.6	1.5-2.0	0-10							
	RCP4.5	1.5-2.0	0-10							
	RCP6	1.0-2.0	0-10	↑	-	+	+/-	3	3	3
	RCP8.5	1.5-2.0	0-10							
Wind power plants (WPPs) Photovoltaic power plants (PVPs)	RCP2.6	1.5-2.0	0-10							
	RCP4.5	1.5-2.0	0-10							
	RCP6	1.0-2.0	0-10	↓↑	0	-	-	1	2	3
	RCP8.5	1.5-2.0	0-10							
Substations, overhead power lines (systemic and distribution)	RCP2.6	1.5-2.0	0-10							
	RCP4.5	1.5-2.0	0-10	↑↓	-	-	-	1	3	3
		1.0-2.0	0-10							

Note: T – temperature, P – precipitation, Ex – extreme events

Source: National Climate Change Risk and Vulnerability Assessment for the Sectors of the Bulgarian Economy 2014.

114. Based on **Table 5**, sensitivity is ranked at 1.9 according to the ‘National Climate Change Risk and Vulnerability Assessment for the Sectors of the Bulgarian Economy - Special Section’. Adaptation capacity is assessed as insufficient (index of 3), that is, no conditions have been created for handling the problem. In this specific analysis, the most simplistic approach to assessing the systems’ adaptation capacity was chosen. It is expressed as follows:

- 1) High adaptation capacity. Adaptation directives, strategies, and programs are implemented as well as for minimization of the risk of climate change in the sector;
- 2) Sufficient adaptation capacity. Adaptation directives, strategies, and programs are partially implemented as well as for minimization of the risk of climate change in the sector;
- 3) Insufficient adaptation capacity. No measures are taken to address the risk of climate change in the sector.

A detailed analysis of the legal framework in the sector is presented in Chapter 2.

115. **The conclusion of the Climate Change Vulnerability and Risk Analysis and Assessment of Bulgaria’s Economic Sectors (2014) is that the energy sector is ‘extremely resilient’ to expected impacts in the period until 2035.** In this assessment, energy sector vulnerability (V) was calculated using the formula $V = \text{sensitivity}/\text{adaptation capacity} = 1.9/3 = 0.63$. The received index 0.63 corresponds to the category ‘extremely resilient’ to expected impacts until 2035 according to the climate change vulnerability evaluation scale. The specific indexes are as follows: temperatures 1.0 – extremely resilient; precipitation 0.78 – extremely resilient; extremes 0.47 – moderately resilient; total 0.63 – very resilient.

116. **The high resilience of the energy infrastructure to climate change is because it is relatively well planned and maintained.** Being part of the critical infrastructure, the energy infrastructure is built, maintained, and operated following well-proven construction codes, regulations, and good practices. It takes due account of siting characteristics, among which are weather extremes (for example temperature, rainfall, water supply, or wind) and other inputs (geology, earthquake, land use, and so on) based on historical records plus an engineering ‘safety’ margin. Of course, as the intensity of climate change impacts is increasing, there is a need to incorporate climate issues (based not only on historical records but also including projections on future climatic conditions) into design, planning, and maintenance procedures to ensure timely adaptation of installations and to avoid future negative externalities. New energy infrastructure projects should integrate those factors in their feasibility analysis, both from an economic and a safety point of view.²²

A summary of potential impacts for the energy sector is provided in **Annex 1**.

1.4. Conclusions

117. The vulnerability and risk analysis shows that the energy sector will be among the sectors in Bulgaria that will be affected by climate change. Bulgaria is already exposed to a variety of natural hazards, including floods, droughts, forest fires, earthquakes, and landslides. Increased temperatures, reduced precipitation, changes in river flows and ecosystems, and

²² EC, SWD (2013) 137.

extreme events have caused some damage and disruption to the energy sector. Fortunately, extreme weather events have not significantly affected the energy infrastructure to-date and have mostly led to damages in the electricity grid and temporary power cuts. However, given the importance of energy infrastructure and supply to other sectors, through their use of energy, even minor outages can have cascading consequences and amplify the initial impact. An increase in the frequency and intensity of such weather events is likely to pose challenges to the sector in the future.

118. Therefore, the challenges that Bulgaria must meet are immense and colored with uncertainty. To reduce the vulnerability of the sector, there is a need to direct efforts to reducing energy intensity and energy dependence of the country while at the same time improving its energy security.

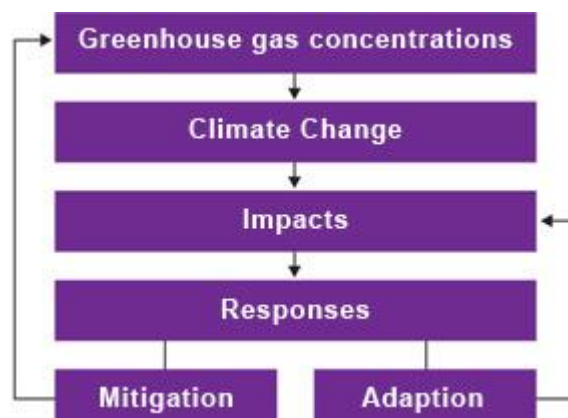
119. As an EU Member State, Bulgaria falls under the ‘Intended Nationally Determined Contribution of the EU and its Member States’ to reduce emissions of GHGs at least by 40 percent by 2030, compared to 1990. This goal will have to be achieved in the period 2021–2030 (UNFCCC 2015). All sectors of the economy will need to consider opportunities to reduce energy use and increase energy efficiency. These mitigation efforts represent additional costs that should be considered in planning for a low-carbon future.

Chapter 2. Baseline – Policy Context

2.1. State of Awareness, Understanding of Future Consequences of Climate Change, Knowledge Gaps in the Sector

120. Both internationally and in Bulgaria, emphasis has typically been placed on the role of the energy sector in mitigating human-induced climate change, but comparatively little attention has been paid to the impacts of climate change on the energy sector (IEA 2014). This has begun to change in recent years with increased recognition that mitigation and adaptation must be undertaken in tandem. Climate change mitigation and adaptation are key partners in any strategy to combat climate change (ACT 2015) (see *Figure 25*). As effective mitigation can restrict climate change and its impacts, it can also reduce the level of adaptation required by communities and nations.

Figure 25. Relationship between mitigation and adaptation



Source: ACT 2015.

121. In Bulgaria, there is increasing awareness on climate change issues. However, policy making is almost exclusively focused on identification and implementation of climate change mitigation measures and not on CCA. The 2011 National Energy Strategy till 2020 (discussed in sub-chapter 2.4).

122. Bulgaria's CCA legal framework and policies in the sector and the Third National Action Plan on Climate Change (NAPCC 2012) did not explicitly stipulate policies and actions on adapting to climate change. The main strategic objective of the national policy on the subject is to outline the framework for action in combating climate change and to direct the country's efforts toward actions that reduce the negative impacts of climate change and meet the commitments under the Europe 2020 Strategy.²³ The energy sector, as the largest emitter of GHGs in the country, is of prime importance for the implementation of the national reduction targets.

123. It is crucial that energy sector stakeholders in Bulgaria understand that the sector faces multiple threats from climate change, particularly from extreme weather events and increasing stress on water resources. Greater resilience to climate change impacts will be essential to the technical viability of the energy sector and its ability to cost-effectively meet

²³ National Trust EcoFund, The Climate and Me

the rising energy demands driven by global economic and population growth. Energy sector stakeholders, including governments, regulators, utilities/energy companies and financial institutions (banks, insurers, and investors), will need to

- Define climate change resilience and adaptation challenges
- Identify actions needed to address these challenges (IEA 2015)

2.2. Experience with CCA in the Energy Sector in Other (EU) Countries

124. **Bulgaria can learn from other countries' approaches to managing climate risks facing their energy sector.** The information provided in the current sub-chapter presents a brief overview of the experience of the EU countries with the elaboration of CCA policies (National Adaptation Strategy [NAS]) in the energy sector. Examples of good practice serve an important function: such examples illustrate the range of possible response options and the numerous approaches to cope with various challenges. This enables actors to learn from each other and, to some extent, mutually address the challenges of adaptation.

2.2.1. Austria

125. **The development process of the Austrian adaptation strategy began in September 2007.**²⁴ The initiative arose from the Kyoto Forum. The starting point for the development of recommendations for actions on adaptation was the outcome of the 'Survey of the Current State of Adaptation to Climate Change in Austria', in which the development of an Austrian adaptation strategy was recommended.

126. **Austria's adaptation priorities are underpinned by scientific data and an extensive consultation process.** Between June 2008 and November 2011 recommendations for adaptation in 14 areas were developed, commissioned by the Lebensministerium and the Austrian Climate and Energy Fund. Conclusions regarding sectoral and regional climate impacts as well as a first qualitative evaluation of vulnerabilities supported the development of draft adaptation measures. Workshops hosted by the

Lebensministerium accompanied the development process of the NAS. At these workshops, the current state of work was presented and discussed with a wide audience.

Austria – recommendations for action

1. **Optimization** of network infrastructure
2. Promotion of **decentralized energy generation** and grid feed-in
3. Increased research on potential methods of **energy storage**
4. Stabilization of the transport and distribution network through appropriate climate-adapted **system planning**
5. **Optimization of the interaction between generation** (from various sources) **and consumption** in the power supply system under varying supply and demand
6. Consideration of the effects of climate change in energy sector decision-making and research activities, for example, in view of a further **diversification** of the energy supply
7. **Reduction of demand** by means of increasing end energy efficiency and reducing internal loads
8. Development of an **energy supply strategy** on the basis of a comprehensive forecast of power and heating demand that takes 'adaptation scenarios' into account

²⁴ The Austrian Strategy for Adaptation to Climate Change, Vienna 2012

127. **The Austrian adaptation strategy is accompanied by an action plan, which provides recommendations in each area for action, including energy.** The key actions for the energy sector are provided in the text box ‘Austria – recommendations for action’. The action plan describes the recommendations in detail, providing a list of options as well as their objectives and key actors.

2.2.2. France

128. **France recognizes that energy generation, transport and consumption are influenced by the climate and will therefore have to adapt to climate change.** Some energy infrastructures have long life-spans and will thus eventually be exposed to a climate that differs from the current climate. The consultations that paved the way for the French ‘National Climate Change Impact Adaptation Plan’ produced a series of recommendations to respond to the issues identified for the energy sector, as presented in the text box ‘France – energy action sheet’. Recommendations relating to

France – energy action sheet

1. **Manage the emergence of peaks** in summer energy consumption through an electrical capacity obligation mechanism.
2. Promote the use of more **efficient cooling equipment** (air conditioning) or equipment using renewable or recoverable energy.
3. Make all **hydrogeological and climate data** available.
4. Integrate climate change into the **monitoring indicators of the Framework Water Directive** so that the effects of thermal discharge can be isolated from those associated with global warming.
5. **Identify French Industrial sectors** that are **vulnerable to climate change** and potential opportunities (2030–2050).

mainstreaming climate change in regulations for comfort and energy consumption in the home, as well as research programs, have been incorporated in the plan. Raising public awareness of best practice was also seen as a key priority and has been included in the communications component of this plan.

129. **The issue of cooling energy plants in hot weather has been addressed by mainstreaming climate change in the water quality monitoring data of the European Water Framework Directive²⁵ (WFD).** The heat wave of 2003, which caused significant problems for energy generation in France, highlighted vulnerability in the system and led to action in a number of areas. For instance, cooling systems for power plants have received significant additional funding to improve efficiency, notably in hot weather. Research into the effects of thermal discharge on biodiversity has also been launched through a partnership between industry and research organizations. Moreover, a mixed government/industry group dealing specifically with heat discharge is already operational.

130. **Actions proposed for the energy sector in France’s adaptation plan focus on managing the issue of peaks of electricity consumption in hot weather.** Priority is also given to methods to promote more energy-efficient cooling methods.

²⁵ Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for Community action in the field of water policy

131. **Climate change impacts on industrial sectors have been recognized; however, further studies on the macro level changes are expected.** Climate change could potentially affect some industries at a production level (manufacturing processes, supplies of raw materials, and so on) and at a marketing level (changes in markets, and so on) The importance of this theme, which has not been the focus of in-depth study in France, was highlighted during the preliminary consultation. A research-related action is therefore proposed at the end of the action sheet.

2.2.3. Albania

132. **Albania’s First National Communication to the UNFCCC (2002) highlighted some key vulnerabilities of the energy sector, including effects on energy demand for space heating, space cooling, water heating, and refrigeration.** It estimated that rising temperatures could lead to a 12 to 16 percent reduction in energy demand for space heating in the residential sector by 2025, compared to the 1990 baseline.

133. **In contrast, demand for cooling is projected to increase in hotter summers.** However, energy

demand drivers are not limited to temperature, with precipitation, wind speed, and cloud cover also being important factors. Because over 90 percent of Albania’s domestic electricity is generated by hydropower facilities, it is particularly vulnerable to projected decreases in precipitation.

134. **To build greater understanding of potential risks and management options, workshops with energy stakeholders were undertaken in 2009.** These were organized by the Government of Albania and the World Bank and focused on climate risks and vulnerabilities in the country’s energy sector as well as opportunities presented by climate change. Participants included a cross section of stakeholders from the government, key agencies and institutions, academia, private sector, and civil society. They concluded that there are several critical actions that Albania could take to support optimal use of energy, water resources, and operation of hydropower plants, as presented in the text box ‘Albania – critical actions’.

Albania – critical actions

1. **Improve the way that institutions monitor, forecast, and disseminate information** on meteorological and hydrometeorological conditions.
2. **Improve energy efficiency** by encouraging and helping end users to manage their demand for power.
3. **Diversify energy supply**, domestically and through trade.
4. Ensure that **the management and development of water resources** integrates all sectors.
5. Build **climate resilience** into all new investments.

2.3. EU CCA Legal Framework and Policies in the Sector

135. During the last two decades, the EU has taken a leading role in negotiating commitments to reduce GHG emissions and promoting international solidarity for supporting adaptation to climate change on a global scale. This is also reflected in the priority given to climate change – both mitigation and adaptation – on the EU strategic policy agenda.

136. **The EC published its *White Paper on Adapting to Climate Change: Towards a European Framework for Action*²⁶ in April 2009, with the aim of increasing the climate resilience of a number of sectors, including production systems and physical infrastructure.** While it emphasizes that protecting existing and future infrastructure from the impact of climate change is predominantly a Member State responsibility, it nevertheless recognizes that the EU has an important role in promoting best practice, through support for infrastructure development. Improving the resilience of existing energy networks requires a common and coordinated approach for assessing the vulnerability of critical infrastructure to extreme weather events.

137. **The White Paper identified that the following actions should be taken in the sector of production systems and physical infrastructure:**

- Take account of climate change impacts in the Strategic Energy Review process
- Develop methodologies for climate-proofing infrastructure projects and consider how these could be incorporated into the Trans-European Networks for Energy (TEN-E) guidelines and guidance on investments under the Cohesion Policy in the current period
- Explore the possibility of making climate impact assessment a condition for public and private investment

138. **In April 2013, the EC adopted an EU strategy on adaptation to climate change,²⁷ which sets out a framework and mechanisms for further improving the EU's preparedness for current and future climate impacts.** The strategy aims to make Europe more climate-resilient. By taking a coherent approach and providing for improved coordination, it will enhance the preparedness and capacity of all governance levels to respond to the impacts of climate change. Two of its key objectives include provision of funding to help Member States build up their adaptation capacities and addressing gaps in knowledge about adaptation and further developing the European climate adaptation platform (Climate-ADAPT²⁸), as the one-stop shop for adaptation information in Europe. The third key objective is to mainstream adaptation measures into EU policies and programs, as the way to 'climate-proof' EU action. The concrete action regarding energy identified by the strategy is Action 7: Ensuring more resilient infrastructure.

139. **The EC aims to increase the climate resilience of infrastructure, including energy, by providing strategic frameworks.** These include the staff working document on 'Adapting Infrastructure to Climate Change'²⁹ (2013) and 'Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy'³⁰ (2015). These documents guide the assessment of new and existing technical infrastructure, including energy infrastructure, in view of their resilience to current and future climate risks and the respective adaptation measures.

²⁶ White Paper on Adapting to Climate Change: Towards a European Framework for Action, EC, COM (2009) 147/4

²⁷ 'An EU Strategy on adaptation to climate change', COM (2013) 216 final

²⁸ <http://climate-adapt.eea.europa.eu/> focuses on EU-level information, with links to national action. Several Member States have developed national information platforms

²⁹ 'Adapting Infrastructure to Climate Change', EC, SWD (2013) 137 final

³⁰ 'A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy', EC, COM (2015) 80 final, 25 February 2015

140. **Infrastructure projects that receive EU funding should take climate-proofing into account, based on methodologies to be developed and incorporated into the TEN-E³¹ guidelines and EU Cohesion Policy.** The Connecting Europe Facility³² (CEF) objectives are clearly aligned with climate change mitigation goals, but the critical issue of infrastructure resilience to climate change impacts is mentioned only briefly in the recital to the Regulation (Milieu Ltd 2015). Building resilience to climate change into infrastructure, or ‘climate proofing’ is a key challenge for the EU, and one of the three key objectives of the EU Adaptation Strategy (discussed earlier). Climate change resilience is mentioned in the CEF, and TEN-E regulations³³ and is referenced as well in the cost-benefit assessment for TEN-E projects of common interest³⁴ (PCIs).

2.4. Bulgarian CCA Legal Framework and Policies in the Sector

141. The main piece of legislation related to climate change is the Climate Change Mitigation Act. It outlines the institutional responsibilities and stakeholder involvement mechanisms, as presented in *Figure 26*. Due to a traditionally better understanding of mitigation issues and the relative ease of emissions monitoring as compared to climate change effects monitoring, in many projects and the resulting documents there is a confusion between climate change mitigation and adaptation, although the two areas may involve completely different sets of measures. The primary focus of climate change adaptation in Bulgaria tends to be on social adaptation to extreme events, whereas environmental adaptation is less well-defined and regulated.

142. **No specific legal acts are in place in Bulgaria that deal solely with CCA in the energy sector.** Adaptation is in all cases one of the aspects that is included in a number of laws, either directly or indirectly. The principal objectives of climate-related policy in Bulgaria are the development of a highly efficient and green energy sector and establishment of a single internal energy market, while overcoming high energy and carbon intensity of the economy and dependency on energy imports.³⁵ The key climate change mitigation legislation is represented by the Climate Change Mitigation Act³⁶ and the NAPCC.

143. **The energy sector has the largest share of total emissions of GHGs in the country and that defines its paramount importance for the implementation of the national targets for reducing GHG emissions.** The production of electricity and thermal energy from coal contributes for over 90 percent of the GHG emitted in the sector where the major potential for reduction of emissions is concentrated³⁷. The policies and measures in the energy sector provided in the NAPCC are based on those set out in the Energy Strategy of Bulgaria till 2020

³¹ TEN-E. See Green Paper ‘Towards a secure, sustainable and competitive European energy network’, COM (2008)782 final.

³² The CEF is a key EU funding instrument to promote growth, jobs, and competitiveness through targeted infrastructure investment at the European level.

³³ CEF Regulation, recital 8; TEN-E Regulation recital 9 plus various references to climate resilience for specific infrastructure categories.

³⁴ A list of 195 key energy infrastructure projects known as PCIs. See <https://ec.europa.eu/energy/en/topics/infrastructure/projects-common-interest>

³⁵ ‘Climate Change Legislation in Bulgaria’. An excerpt from the 2015 Global Climate Legislation Study A Review of Climate Change Legislation in 99 Countries.

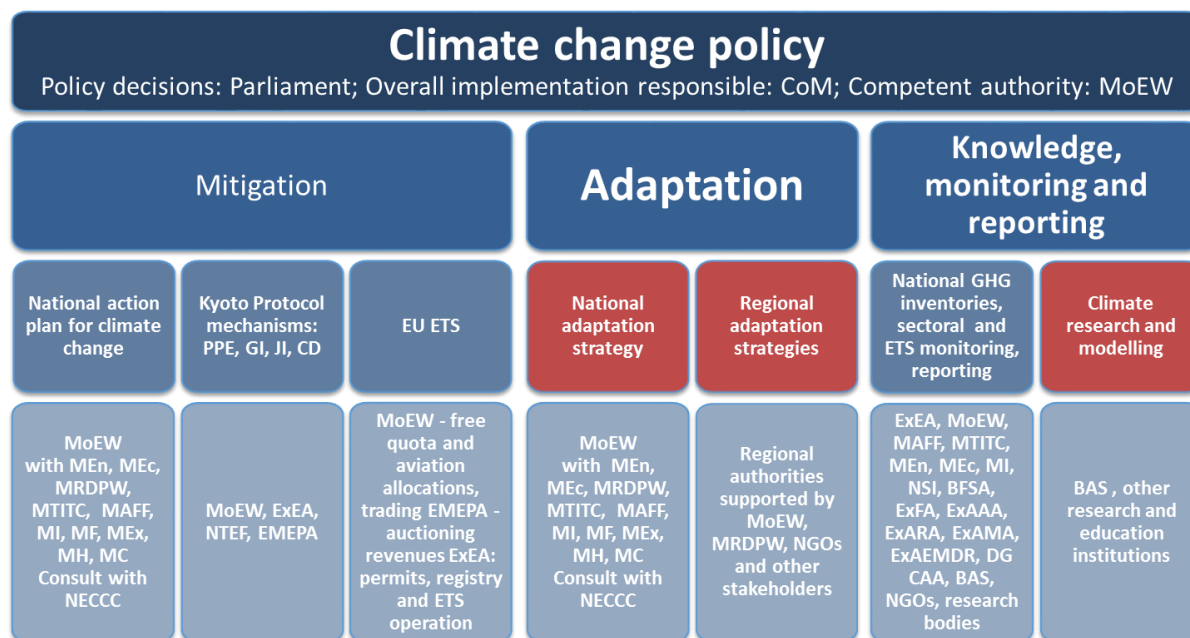
³⁶ Adopted in 2014, last amended SG85 of October 24, 2017.

³⁷ Republic of Bulgaria: Sixth National Communication on Climate Change, United Nations Framework Convention on Climate Change, 2013.

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and the National Action Plan for Renewable Energy. It targets at achieving a GHG emissions reduction of more than 8.5 percent by 2020 compared to 2005 levels and furthermore aims at a 20 percent share by 2020 of renewables in energy production. The policies and measures planned to achieve the objectives of the country with regard to climate change are presented by sectors and represent the most significant and voluminous part of the action plan.

Figure 26. Structure and main actors in implementing the Bulgarian climate change policy



Note: All abbreviations used in this figure could be found within the Abbreviations and Acronyms section.

Source: World Bank design.

2.4.1. Energy Act and the National Energy Strategy till 2020

144. **One of the aims of the Energy Act³⁸ is to create conditions for the promotion of the combined generation of electricity and heat, introducing the requirements of the related EU directives.** It regulates the generation; import and export; transmission; transit transmission; distribution of electricity, heat, and natural gas; oil and oil product transmission; trade in electricity, heat, and natural gas. It furthermore controls the use of instruments such as Green Certificates, regulations for licensing activities in the power generation sector, and the regular development of the National Energy Strategy.

145. **The National Energy Strategy till 2020 reflects the up-to-date European energy policy framework and the global trends in the development of energy technologies.** It provides, among others, for overcoming the negative changes of climate. It lays down the main national targets for the energy sector: 16 percent share of energy from renewables in gross final energy consumption by 2020, 10 percent share of energy from renewables in the gross final energy consumption in transport by 2020, and energy efficiency increase by 25 percent by 2020. The main priorities in the energy strategy are to guarantee the security of energy supply, attain the targets for renewable energy, increase the energy efficiency, develop a competitive energy market and policy for the purpose of meeting the energy needs, and protect consumer interests.

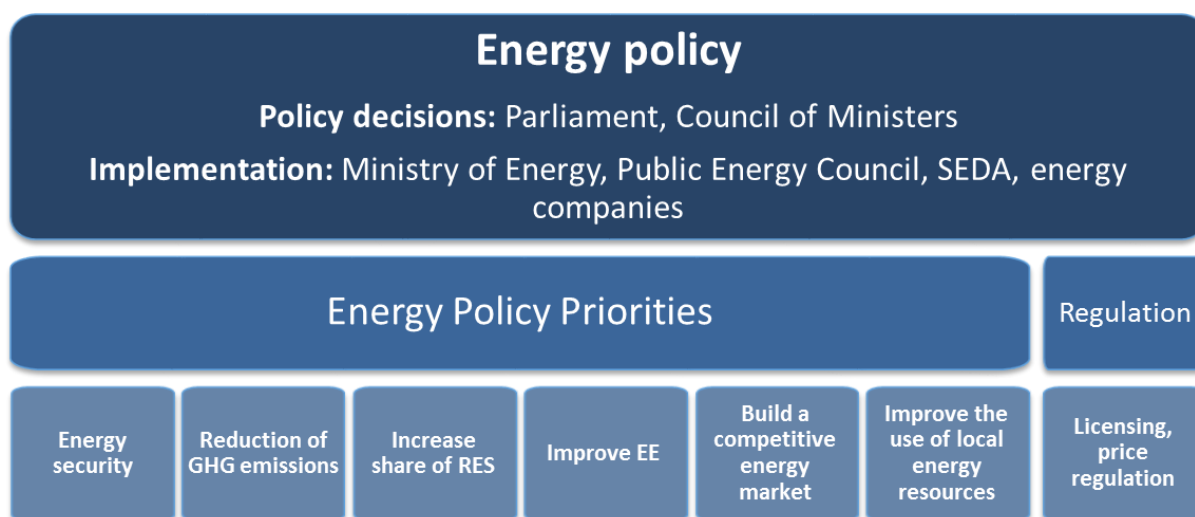
³⁸ Adopted in 2003, last amended SG 58 of July 18, 2017.

146. These priorities also determine the Government’s vision for development of the energy sector, namely:

- (a) Maintaining a safe, stable and reliable energy system
- (b) Keeping the energy sector as a leading branch of the economy with definite orientation to foreign trade
- (c) Focusing on clean and low-emission energy from nuclear and renewable sources
- (d) Balancing between quantity, quality, and prices of the electric power produced from renewable sources, nuclear energy, coal, and natural gas
- (e) Transparent, efficient, and highly professional management of the energy companies

147. **Although the National Energy Strategy has no provisions for CCA, it is compliant with EU policy.** This includes the EU Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy.³⁹ The overall concept of Bulgaria’s energy strategy also corresponds to the EU policy on CCA, which aims to achieve a more climate-resilient energy infrastructure. The main priorities of the Bulgarian energy policy are presented in *Figure 27*.

Figure 27. Structure and main actors in implementing the Bulgarian energy policy



Source: World Bank design.

2.4.2. Energy from Renewable Sources Act⁴⁰ and National Action Plan on Energy from Renewable Sources

148. **The Energy from Renewable Sources Act (ERSA) replaces the Renewable and Alternative Energy Sources and Biofuels Act (2008), which was the first national legislation entirely dedicated to the renewable energy sources, mainly introducing the requirements of the related EU directives.** The 2008 Act established support mechanisms providing for equal preferential treatment for producers of electricity (referring to so-called Green Certificates), as well as for inclusion of utilities that generate electricity from renewable energy sources and biofuels. The act resulted in a rapid development of renewable energy

³⁹ COM/2015/080 final

⁴⁰ Adopted in 2011, last amended SG 58 of July 18, 2017

sources, namely wind and photovoltaic (PV), which put upward pressure on electricity prices. As a result, in June 2011 the Parliament adopted the ERSA. The new legislation kept renewable energy sources preferential treatment options but introduced a preference for energy from biomass and shifted the balance of power from renewable energy sources producers to grid operators and allowed for a substantial reduction of the prices of energy from PV. The act regulates the public relations associated with production and consumption of: (a) electricity, heating and cooling from renewable sources; (b) gas from renewable sources; and (c) biofuels and energy from renewable sources in transport. The 2015 amendment of the act repealed the preferential tariffs for solar power plants with the exception of small roof plants up to 30 kW.

149. **The ERSA also regulates the adoption of the National Renewable Energy Action Plan (NREAP) and national schemes to support the use of energy from renewable sources.** The main focus is the joint projects and schemes for the production of energy from renewable sources with other EU Member States.

150. **The promotion of renewable energy sources is often seen as a climate change mitigation measure, but it also has adaptation co-benefits.** Energy sector diversification is frequently seen as an important adaptation measure that can reduce the vulnerability and improve the adaptive capacity of the energy system to environmental change,⁴¹ although currently the Bulgarian legislative framework does not explicitly recognize this aspect. As existing infrastructure ages there may be a new window of opportunity to build a more decentralized energy structure, based on locally available renewable energy sources situated in secure locations. This would reduce the probability of suffering large-scale outages when centralized power systems are compromised. This sort of regional, network-based system might also prove more flexible and adaptive and therefore more able to cope with the increasing variability and unpredictability caused by climate-driven environmental change.

2.4.3. Energy Efficiency Act and National Energy Efficiency Action Plan 2014–2020

151. **This act,⁴² implementing EU energy efficiency directives, lays down the foundations of Bulgaria’s energy efficiency policy.** It aims to promote energy efficiency through a system of measures for enhancing security of energy supply, competition in the energy sector and environment protection. It also mandates the Council of Ministers to submit the *National Energy Efficiency Strategy* to the National Assembly for adoption and elaborates regularly *National Action Plans for Energy Efficiency*. It creates the **Energy Efficiency and Renewable Sources Fund**, with the income mainly raised from grants from international financial institutions, international funds, Bulgarian and foreign natural or legal persons, with a mandate to support a broad range of investments, with priority funding for (a) implementation of measures to increase energy efficiency in end use, and (b) use of renewable energy in final energy consumption.

152. **Energy efficiency is another climate change related policy that is traditionally seen as a mitigation measure; however, energy-saving, and demand-side management (DSM) measures provide a cost-effective, win-win solution for mitigation and adaptation**

⁴¹ World Bank, Energy Sector Management Assistance Programme, “Climate Impacts on Energy Systems, Key issues for energy sector adaptation”.

⁴² Adopted in 2015, last amended SG 105 of December 30, 2016.

concerns in a context of rising demand and supply constraints. Adapting to variations in building energy demand involve reducing energy demand (especially) for cooling and for the specific case of electricity, compensating for impacts that coincide with peak demand (DSM).⁴³

2.4.4. Program for accelerated gasification of Republic of Bulgaria till 2020

153. **This program aims to improve the energy efficiency in the household heating sector.** The government aims to increase the percentage of households connected to the natural gas grid to 30 percent in 2020 and replace the electricity used for heating by highly efficient natural gas appliances. The program sets the target of 1 million households connected to the improved gas infrastructure, for an estimated investment of about BGN 400 million (US\$257 million). The estimated benefits are reducing the energy intensity of primary energy consumption by around 6 percent in 2020 compared to 2009, that is, about one-third of the overall energy intensity target for Bulgaria. Currently, the country is behind on the 30 percent target, due to a variety of issues, including regulatory and high investment needs by gas distribution companies. The needed natural gas distribution infrastructure is still in process of construction and household consumers connected to the natural gas distribution network are few. Household consumption is very low – 2.28 percent of the total consumption in the country.⁴⁴ In 2016, the number of household customers increased by around 7 percent. It can be concluded that, although with much potential, the household gasification development is slow and rapid increase in the potential fulfilment of the network cannot be expected.

154. **As highlighted earlier, the improvement of energy efficiency, the diversification of energy sources and the reduction of energy intensity are important measures for the energy sector in Bulgaria that will contribute to increasing the system’s adaptive capacity.**

2.4.5. Disaster risk management-related legislation

155. **As identified in Chapter 1, increased frequency of extreme events may pose serious risks for energy infrastructure. Some of these risks are addressed in the legislation.** The resilience of the energy infrastructure is a question of paramount importance as high impact disasters at certain critical facilities might threaten the health and life of the population.

156. **A detailed analysis of the legislation in this field is provided in the Disaster Risk Management Sector Report within the current National CCA Strategy.** This section only provides a short list of the most important acts/plans that deal with ensuring the safety of energy infrastructure.

157. **The National Disaster Protection Program sets the objectives, priorities, and tasks for disaster protection in the country for five years. It is a key policy document on prevention, containment and overcoming of the consequences of disasters and accidents and outlines the guidelines for establishing an efficient, financially and technologically secured national disaster prevention and response system.** The program provides an analysis of critical infrastructure, recognizing that the protection of critical infrastructure⁴⁵ is an essential

⁴³ World Bank, Energy Sector Management Assistance Program, “Climate Impacts on Energy Systems, Key issues for energy sector adaptation”.

⁴⁴ EWRC Bulgaria, Annual Report to the European Commission

⁴⁵ As of 2013 critical infrastructures are the strategic sites and activities identified in the annex to Decree of the Council of Ministers 181/2009, which identifies 19 groups of activities/sites in the energy sector. Additional critical infrastructures will

element of the security policy of the Republic of Bulgaria and the EU. Critical infrastructure is the infrastructure that provides services that are vital to the functioning of our society. Loss of service due to disturbing or destroying a critical infrastructure can have a serious impact on population health, the environment, the economy, public confidence, and security. The complex interdependence between the various infrastructures means that an event may also result in the domino effect on infrastructures that are not directly and clearly related to the affected one. This requires the protection of critical infrastructures covering all hazards, natural disasters, human activities, and terrorist threats. The risk assessment of identified critical infrastructures and their sites and the introduction of measures to reduce their vulnerability are carried out by the owners/operators of critical infrastructures.

158. **The Flood Risk Management Plans⁴⁶ (FRMPs) were developed in accordance with the European Floods Directive⁴⁷ and focus on prevention, protection, and preparedness, including prediction and early warning system.** They include maps of areas at risk of flooding, which show the adverse effects of flooding on the sites and areas of economic activity in the region under threat, based on available country information. These maps provide valuable information on the exposure of critical infrastructure to flooding. Furthermore, the FRMPs define five priorities including, among others, Priority 2: A higher level of protection of critical infrastructure and businesses, along with a summary of the measures and their prioritization.

159. **The Safe Use of Nuclear Energy Act⁴⁸** regulates the safe use of nuclear energy and ionizing radiation and the safe management of radioactive waste and spent fuel as well as the rights and obligations of the persons carrying out these activities to ensure nuclear safety and radiation protection. In accordance with the provisions of the law,⁴⁹ the NPPs (NPP Kozloduy is the only one in Bulgaria to date) are subject to periodical safety review. **The Regulation on the Safety of NPPs** defines the main requirements for the scope and the process of the review. This is a detailed procedure covering all aspects of the operation of the NPP, including an analysis of external events and hazards.⁵⁰ For each hazard, the review shall verify that the occurrence and consequences of the hazard are sufficiently low and whether specific protective or mitigating measures are necessary. It should also check that the used analytical methods and tools, safety standards and hazard analysis data are up-to-date and valid. The review uses the knowledge gained from actual events at the NPP, the experience of managing such events (for example external floods, seismic events, and tornadoes) to improve existing procedures.

160. **The Ordinance on the Safety of NPPs⁵¹ covers the design phase determining the basic criteria and rules for nuclear safety and radiation protection of the NPPs.** It also includes the organizational measures and the technical requirements for ensuring the safety of

be established in accordance with the Ordinance on the Procedure, Means and Competent Bodies for Establishing Critical Infrastructures and Their Sites and Risk Assessment for them, adopted with Decree of the Council of Ministers No. 256 of 17.10.2012, last amended SG 27 of April 5, 2016.

⁴⁶ See http://www5.moew.government.bg/?page_id=24259.

⁴⁷ EU Directive 2007/60/EC on the assessment and management of flood risks.

⁴⁸ Adopted in 2002, last amended SG 58 of July 18, 2017.

⁴⁹ Art. 16, p. 3 and Art. 20 of the Safe Use of Nuclear Energy Act bind the continuation of licenses for the operation of nuclear facilities with conducting an assessment of the nuclear safety and radiation protection and an assessment of the actual condition of the nuclear facility by limiting this period to 10 years.

⁵⁰ Bulgarian Nuclear Regulatory Agency, 'Guide for carrying out periodic safety review of nuclear power plants', Safety Factor 8, p. 23-25.

⁵¹ Adopted in 2016, last amended SG 76 of September 30, 2016.

site selection, design, construction, commissioning and operation. The design of the NPP should take into account the following external events and hazards: extreme climatic conditions, earthquakes, floods, electromagnetic fields, and so on (Article 13). During the design and operation of the NPP and in the implementation of all related activities, measures shall be taken to (a) control the radiation exposure of humans and the discharge of radioactive substances into the environment, (b) limiting the occurrence of events that may lead to loss of control of the core and nuclear fission chain reaction, and (c) reducing the consequences of such events if they occur. The main weakness in this direction indicated by stakeholders is that the legal framework does not include requirements with criteria for existing plants, which gives rise to problems in the definition of corrective and compensatory CCA measures.

2.5. Institutional Framework and Stakeholder Community in Bulgaria

2.5.1. Institutional framework

Ministry of Energy

161. **The energy policy in Bulgaria is governed by the MEn.** Its main responsibility is to define the strategic objectives and priorities in the sector and carry out the energy policy of the country, including the effective use of resources, security of supply, energy efficiency, and energy dependence. The main role of the MEn, in cooperation with the Ministry of Environment and Water (MoEW) and other related institutions, organizations and entities in the area of CCA, lies with the Strategies and Policies for Sustainable Energy Development Directorate; the Energy Security and Crises Management Directorate; Natural Resources, Concessions, and Control Directorate; as well as the Energy Projects and International Cooperation Directorate. Though the ministry does not have a specific unit responsible for CCA, its activities in this area are governed by existing legislation.

162. **Experts of the ministry participate in the Inter-Ministerial Committee on Climate Change and the Inter-Ministerial Working Group for Development of the National Allocation Plan.** The remit of groups, which were established in 2000 and 2005 respectively, is to coordinate climate measures in key sectoral policies.

Sustainable Energy Development Agency

163. **The Sustainable Energy Development Agency (SEDA) to the Minister is responsible for the implementation of national policies in the area of energy efficiency and of renewable sources and biofuels utilization.** As such, the agency contributes to carry out the national policy in climate change mitigation and adaptation.

Energy and Water Regulatory Commission

164. **The Energy and Water Regulatory Commission (EWRC) is an independent specialized state body, which is responsible for the regulation of the activities in the energy sector and water supply and sewerage.**⁵² The regulatory activities of the EWRC in the energy sector⁵³ include the following:

- Issues of **licenses** for electric/heat power generation, electric/heat power or natural gas transmission, electricity or natural gas distribution, natural gas storage in natural gas

⁵² Energy Act, Article 10.

⁵³ Energy Act, Article 21.

storage and/or liquefaction facilities or import, unloading and regasification of liquefied natural gas in a liquefied natural gas facility, electricity trade, the organized power exchange, electricity or natural gas public provision, electricity or natural gas public supply, electricity or natural gas supply from end suppliers, traction electricity distribution through rail transport distribution networks, and electricity supply from a supplier of last resort;

- Monitors the fulfilment of the public service obligations, including user and environmental protection;
- Decides on the affiliation of electricity lines, heat and gas pipelines and their ancillary facilities to the transmission or distribution networks and give binding instructions to repurchase and/or provide access to them, at the proposal of the TSO, or the distribution network operator;
- Cooperates with the regulatory authorities of other Member States of the EU and with the Agency for the Cooperation of Energy Regulators⁵⁴ (ACER) on cross-border issues and concludes cooperation agreements with national regulatory authorities;
- Monitors the level and effectiveness of market liberalization and competition at wholesale and retail markets and monitors the connection with the energy markets of other countries, members of the EU; and
- Supervises the development of the electricity and gas networks.

Nuclear Regulatory Agency

165. **The Nuclear Regulatory Agency (NRA) performs its functions in accordance with the Safe Use of Nuclear Energy Act. Its main responsibility is to guarantee the nuclear safety and radiation protection in the country.** The Chairman of the agency is an independent specialized authority of the executive power who is responsible for regulating the safe use of nuclear energy and ionizing radiation, the safe management of radioactive waste and spent fuel. The NRA conducts inspections to assess the nuclear safety of the NPP, carries out stress tests, and participates in emergency planning and response activities in case of nuclear or radiation accidents.

166. **Due to the nature of its functions, the agency has certain responsibilities and obligations, which overlap with the subject of CCA, although not specifically defined as related to it.** Following the Fukushima disaster in 2011, the NRA asked the operator of NPP Kozloduy to review the readiness for response action to extreme events. No significant deficiencies requiring urgent measures to increase safety or limit the operation of the units were identified. Nevertheless, several actions were proposed for improving the protection of the power plant,⁵⁵ including measures to improve **preparedness** (for example, availability, sufficiency, and stockpiles of fuels and reagents, review of the emergency plan and identification of measures to improve the awareness and preparedness of the population in Kozloduy and surrounding municipalities to act in case of an accident at NPP Kozloduy), **protection** (for example, reassessment of the maximum level of flooding at the site, assessment

⁵⁴ The ACER is a European Union Agency, created by the Third Energy Package to further progress the completion of the internal energy market both for electricity and natural gas.

⁵⁵ NRA, Stress test reports, Initial safety review of Kozloduy NPP in the light of events in Fukushima.

of the evacuation routes, number of submersible pumps for drainage, emergency measures for cleaning and restoring the operational suitability of the Danube dyke and drainage channels in Kozloduyski valley) and **monitoring** (for example, improvement of the coordination during the activation of the NPP Kozloduy Emergency Plans).

Municipalities

167. **At the local level, municipalities are responsible for efficient production, supply and use of energy** (for example, energy savings through buildings renovation, energy-efficient street lighting). They are mandated by the Energy Efficiency Act to prepare municipal energy efficiency plans. Municipalities can also develop their own CCA strategy and action plan. A total of 25 Bulgarian cities are currently signatories to the Covenant of Mayors Initiative, three (Burgas, Dimitrograd, and Smolyan) of them with adaptation commitments.⁵⁶ In 2016, Sofia municipality adopted their adaptation strategy to climate change, containing adaptation measures in the energy sector.

2.5.2. Stakeholder community

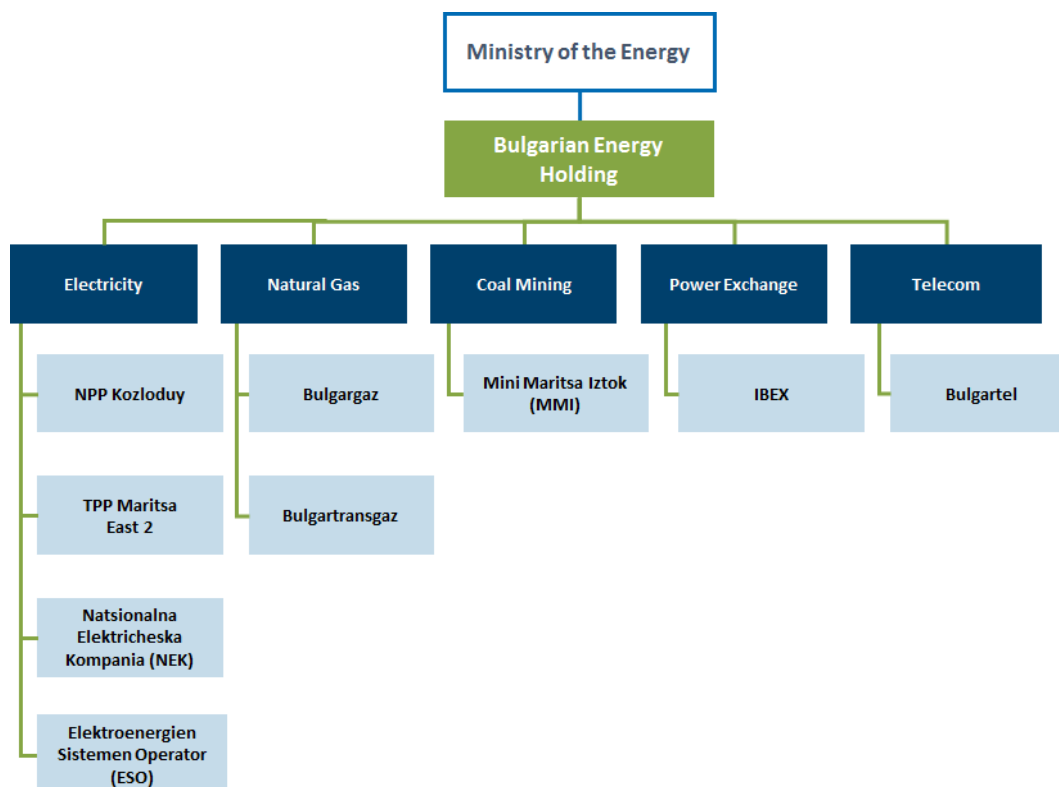
Energy companies

168. **The Bulgarian Energy Holding EAD (BEH EAD) was established in 2008 by decision of the Minister of Economy and Energy.** BEH is the holding company for a group of companies that are principally engaged in electricity generation, supply and transmission, natural gas transmission, supply and storage and coal mining. BEH Group holds a leading position in the electricity and gas market in Bulgaria and, through electricity exports, in the Balkans. BEH is wholly owned by the Bulgarian state and is the largest state-owned company in terms of total assets in the country. The rights of ownership of the state are exercised by the Minister of Energy.

In 2015, the market share of BEH in national electricity generation was 59 percent, when it had an installed electricity generation capacity of 6.3 GW and generated 29.24 TWh of electricity. The structure of BEH is shown in *Figure 28*. BEH owns 100 percent of the share capital of: Maritsa Iztok Mines EAD, TPP Maritsa Iztok 2 EAD, NPP Kozloduy EAD, *Natsionalna Elektricheska Kompania* (National Electricity Company, NEK) EAD, TSO EAD, Independent Bulgarian Energy Exchange EAD (IBEX), Bulgargaz EAD, Bulgartransgaz EAD, and Bulgartel EAD.

⁵⁶http://www.covenantofmayors.eu/about/about/signatories_en.html?q=Search+for+a+Signatory...&country_search=bg&population=&date_of_adhesion=&status=&commitments1=1&commitments2=1

Figure 28. Structure of BEH



Source: BEH Website, <http://www.bgenh.com/index.php/en/about-beh/profile>

➤ Coal mining

169. **Maritsa Iztok Mines EAD is a subsidiary of BEH EAD, which is at the beginning of the technological process for electric power generation in TPPs in the Maritsa Iztok complex.** The mines operate the largest lignite field in Bulgaria, which supplies coal to four TPPs for electricity generation and a factory for the production of briquettes. In 2014, the total coal output at the Maritsa Iztok Mines was 32.3 million tons (ME n 2016), which represents 90 percent of the total output of coal used for the generation of electricity and heat in Bulgaria.

170. The priority share in the brown coal production belongs to the coal mines in the Pernik and Bobovdol basins. Black coal production is realized in ‘Balkan 2000 Mines EAD’.

➤ Natural gas

171. **The companies engaged in domestic production of natural gas are ‘Petroceltic’ and ‘Oil and Gas Exploration and Production Plc.’**

172. **Bulgargaz EAD is the public provider of natural gas whose functions are related to the purchase and sale of natural gas.** Bulgartransgaz EAD is a combined operator whose functions are related to the transmission, transiting, and storage of natural gas. Both companies were established as a result of legal and organizational restructuring of the National Gas Company, and at present are subsidiaries of BEH EAD.

173. **Gas distribution is organized by private regional and local companies.** In 2014 the major market share of 59.4 percent was held by the subsidiaries of Overgas AD, Citigas Bulgaria – with market share of 16.2 percent, Black Sea Technology with 10.7 percent and other gas distribution companies with total market share of 13.7 percent.

➤ Oil and oil products

174. **The oil and oil products market in the country is completely liberalized.** The largest oil refinery on the Balkan Peninsula operates in Bulgaria, with Lukoil as majority shareholder. Among the major players in the trade in oil and oil products are Lukoil, Petrol, OMV, Shell, Eko, Rompetrol, Naftex, Pristaoil, Opet, and Hellenic Petroleum (MEn 2016).

➤ Electric Power

175. **The National Electric Company EAD (NEC) is a subsidiary of BEH EAD and involved in generation of electricity.** The company carries out licensed activities in electricity generation from hydropower plants and pumped-storage hydroelectric power plants (PSHPP) and acts as a single buyer of electricity under long-term bilateral power purchase agreements and PPAs with feed-in tariffs (RES and co-generation).

176. **The Electricity System Operator EAD is the owner of the power transmission grid.** It is responsible for the control of the electrical power system of the Republic of Bulgaria, synchronization of the operation of the national electrical power system with the electrical power systems of the European countries, operation and maintenance of the transmission network, and organization of balancing the energy market.

177. **IBEX holds a license to operate the electricity exchange in Bulgaria for 10 years.** IBEX EAD was established in January 2014.

178. **The distribution of electricity in the regulated market is performed by regional companies, operators of the electricity distribution network.** These include ENERGO-PRO Grid AD (southeast Bulgaria) and CEZ Distribution Bulgaria AD (west Bulgaria), and EVN Bulgaria Distribution AD (southwest Bulgaria).

Bulgarian Academy of Sciences

179. **The BAS carries out research and development (R&D) activities on climate change, examining fluctuations, adaptation of the individual sectors, and so on.** Climate change is monitored by the NIMH at BAS with the former being the chief executive of research and operational activities in meteorology, agrometeorology and hydrology in Bulgaria. The institute cooperates with other relevant organizations on regional, EU, and international level to develop climate change mitigation and adaptation measures. The activities of BAS are supported by government budget, donors, and other sources.

Private sector

180. **At the national level, the most notable organizations are the Confederation of Employers and Industrialists in Bulgaria (CEIB), represented by its Environmental Protection Directorate, and the Bulgarian Chamber of Commerce and Industry (BCCI).** Many of the energy producers' associations and other industries are members of the CEIB, BCCI, or both. The activities of all private sector organizations must comply with the existing regulatory framework concerning climate change and other environmental protection acts. These organizations' activities are self-financed and/or under different operational programmes (OPs) for the period 2014–2020.

Non-Governmental Organizations

181. **The Bulgaria Climate Coalition spans over 100 organizations and is represented by 19 members.** The Coalition comprises nongovernmental organizations (NGOs), companies, individual members and people working or active in the area of mitigating or preventing anthropogenic climate change around the world. These include WWF, Greenpeace Bulgaria, Borrowed Nature Association, Green Policy Institute, Regional Ecologic Centre-Sofia, EU for the Earth, and others. The Bulgaria Climate Coalition is a platform for combining the efforts of its members in advocacy, education, scientific, business, and public awareness activities in various areas for the purposes of mitigating anthropogenic climate change. Currently, their remit does not focus extensively on CCA.

International organizations

182. **Bulgaria is not a member country of the IEA.** The IEA is an autonomous intergovernmental organization that works to ensure reliable, affordable and clean energy for its 29 member countries and beyond. With respect to climate change, the IEA works to help member countries develop their energy policy, so they can effectively address climate change. This includes finding and sharing examples of best practice, for which the IEA maintains databases of member countries' climate, efficiency, and renewable energy policies. The threat that climate change poses to energy systems is a new area of interest for the IEA but one that goes to the IEA's core mission of enhancing energy security. To help address this new challenge, the IEA launched the Nexus Forum in 2012 as a platform to enhance awareness of the impacts of a changing climate on the energy sector and share emerging experience on building energy sector resilience.⁵⁷

2.6. Financial and Human Resources in Bulgaria

183. **The financing of CCA measures requires considerable mobilization of funds.** In preparing the EU Strategy on Adaptation to Climate Change, the EC made certain cost estimates. According to these estimates, the cost of not adapting to climate change could reach at least EUR 100 billion a year by 2020, rising to EUR 250 billion a year by 2050 (EC 2015). Improved access to funding will be a key factor in strengthening resilience to climate change. It will be necessary to mobilize funds at all levels, including private investments. With regard to public finance resources, the main sources available are the funds from the EU budget and the national budget.

184. **The Cohesion Policy financially supports the development of climate-resilient infrastructure under the current programming period of the regional funds (2014–2020) under Thematic Objective 5.**⁵⁸ The EU Cohesion Policy provides funding for EU Member States and regions to help them achieve the EU's strategic goals, and in particular to support the development of regions that lag behind in economic terms. The EC stressed the potential for regions to use the funds to support the sustainable growth priority of the Europe 2020 Strategy, in particular to contribute to a resource-efficient, low-carbon, climate-resilient economy. The proposed regulations for the EU Cohesion Policy for 2014–2020 place greater emphasis on the challenge of climate change than in the past, in recognition of the importance

⁵⁷ <https://www.iea.org/topics/climatechange/climatechangesubtopics/resilience/>.

⁵⁸ Priorities for 2014-2020 http://ec.europa.eu/regional_policy/en/policy/how/priorities.

of this issue for wider EU strategic development objectives. Member States and regions are able to target funds specifically for the transition to a low-carbon economy (Thematic Objective 4) and for adaptation to climate change (Thematic Objective 5). The proposed regulations recognize sustainable development as a horizontal principle and state that funding programs must promote CCA, disaster resilience, and risk prevention and management in the programs.

185. **The total amount of available funds for Bulgaria under Thematic Objective 5 exceeds €66.7 million.**⁵⁹ Priority Axis 4 ‘Flood and Landslides Risk Prevention and Management’ of OP ‘Environment’, is aimed at the implementation of thematic objective 5 of the General Regulation: ‘Promoting climate change adaptation, risk prevention and management.’ Priority Axis 4 is co-financed by the Cohesion Fund with a budget of €78.5 million. The measures provided under Priority Axis 4 aim to provide resistance to disasters, prevent risks to human health and the environment, and mitigate the consequences of floods. The implementation of certain measures of Priority Axis 3 ‘Natura 2000 and biodiversity’ will also contribute to CCA.

186. **The role of the national budget and the budgets of local communities is to co-finance the aforementioned European and international sources and to independently finance measures. Because CCA** measures often overlap with climate change mitigation measures, sustainable energy and transport policy measures, and policy measures aimed at improving the quality of the environment, it is necessary to identify areas of commonality, which may facilitate the mobilization of funds. Currently, climate change mitigation measures are mainly financed from the state budget, the Enterprise for Managing Activities on Environmental Protection, the National Trust Eco Fund and the National Science Fund. Other contributions come from EU Environmental Funds, Kyoto Protocol Joint Implementation Mechanism and Green Investment Scheme, and other international and bilateral agreements.

187. **Despite the fact that Bulgaria is an Annex I Party of the United Nations Framework Convention on Climate Change (UNFCCC), as a country with economy in transition, it has no commitments to provide financial resources and technology transfer to developing countries.**⁶⁰ The country rather accepts financial and technological help, mainly within the framework of the Joint Implementation (JI) mechanism. The JI mechanism is a convenient way for Bulgaria to receive economic, technical, and expert help with GHG mitigation efforts. In terms of technologies transfer, Bulgaria has no obligations to support technology transfer, under Article 11 of the Kyoto Protocol, for countries out of Annex I of the Convention.

188. **The CEF finances the development, construction, and improvement of infrastructure projects in the transport, energy and digital sectors as a part of the EU’s Trans-European Networks (TENs) policy.**⁶¹ CEF Energy supports the development and construction of infrastructure necessary to complete the priority energy corridors, which are

⁵⁹ Breakdown of the Available Funds By Thematic Objective by MS for 2014–2020 <https://cohesiondata.ec.europa.eu/dataset/Thematic-Objective-5-Climate-change-and-risk-preve/rzpg-9kf2/data>.

⁶⁰ Republic of Bulgaria: Sixth National Communication on Climate Change, United Nations Framework Convention on Climate Change, Sofia, 2013.

⁶¹ Study on climate mainstreaming in the programming of centrally managed EU funds CLIMA.A.2/ETU/2014/0020r, Final report, September 10, 2015.

considered integral to meeting EU energy objectives and complete the internal market. To be eligible for CEF funding, projects must first be selected as PCIs by groups comprising of EC, Member State, and national and European regulatory authorities. The PCIs identified in Bulgaria are in the sectors of electricity and natural gas and are visualized on the interactive map of PCI.⁶²

189. **Climate change objectives and targets are effectively mainstreamed into the CEF instrument.** However, this does not guarantee that the potential for the outputs of CEF to deliver climate change benefits will be maximized or even realized. CEF grants only support PCIs, which under the TEN-E regulation go through rigorous assessment and selection procedures that include assessment of GHG emissions and vulnerability to climate change impacts, although there are no specific requirements or criteria determining how the climate change vulnerability assessment should be carried out. As a result, contribution to climate change goals within the CEF grants is often assumed to take place due to the very nature of the projects. Nevertheless, there are real opportunities to use the CEF funding for further climate mainstreaming goals in such a way that it would also improve the robust delivery of the infrastructure projects.

190. **In the current financial perspective, the EU budget, in addition to providing funds for adaptation from structural funds, provides support for adaptation programs and projects within the programs Horizon 2020 and LIFE.** As of 2017, 252 projects have been awarded funding under the Horizon 2020 Programme.⁶³ The largest share of the funding was spent on ‘Secure, Clean and Efficient Energy - €6,731,124, where 34 Bulgarian organizations are involved in the implementation of 42 projects. An example is the municipality of Burgas, which together with the cities of Bordeaux, Warsaw, Lisbon, London, and Milan, is implementing the Sharing Cities project for the deployment of intelligent systems in areas such as electric mobility, intelligent energy management systems, intelligent street lighting and energy efficiency of buildings.

191. **Adaptation measures are also supported by several other EU funds and international financial institutions.** These include the European Investment Bank (EIB), the European Bank for Reconstruction and Development (EBRD), and the World Bank. To date, these have largely focused on the implementation of energy efficiency measures and renewable energy in Bulgaria, for instance:

➤ [Energy Efficiency and Renewable Sources Fund](#)⁶⁴

192. It was established pursuant to the Energy Efficiency Act, with intergovernmental agreements between the Global Environment Facility (through the World Bank), the Government of Austria and the Government of Bulgaria. The fund operates according to the provisions of the Energy Efficiency Act, the ERSA and the agreements with the donors. The Energy Efficiency and Renewable Sources Fund offers the following financial products in the field of energy efficiency to Bulgarian companies, municipalities, and private individuals:

- Credits below market interest rates

⁶² Interactive map of PCI: http://ec.europa.eu/energy/infrastructure/transparency_platform/map-viewer/main.html.

⁶³ <http://horizon2020.mon.bg/en>.

⁶⁴ <http://www.bgeef.com/display.aspx>.

- Partial credit guarantees
- Portfolio guarantees

➤ [Kozloduy International Decommissioning Support Fund](#)

193. In November 1999, the Bulgarian Government and the EC signed a Memorandum of Understanding in which the Bulgarian Government undertook a firm commitment to close and decommission Units 1–4 of the NPP Kozloduy. The Kozloduy International Decommissioning Support Fund (KIDSF), administered by the EBRD, was established to support the decommissioning activities and mitigate the negative consequences of the units' early closure. The main priorities of the KIDSF in the non-nuclear sector are: security of energy supply; rehabilitation and modernization of energy generation, T&D sectors; energy efficiency; and environment.

194. The projects funded by the KIDSF are related to energy efficiency in public buildings and street lighting, rehabilitation of heat transmission systems, rehabilitation and extension of the national electricity grid, rehabilitation of networks for electricity distribution and heat supply, gas supply and transmission of natural gas, measures relating to the implementation of environmental requirements, utilization of renewable energy sources, and so on.

➤ [European Economic Area \(EEA\) Financial Mechanism 2009–2014, Programme BG04 'Energy Efficiency and Renewable Energy'](#)

195. The MEn is the program operator of the BG04 program 'Energy Efficiency and Renewable Energy Sources', financed by the European Economic Area Financial Mechanism 2007–2014. With a budget of €15 million, energy efficiency and renewable energy sources measures are funded in 32 municipalities across the country focusing on socially oriented buildings – kindergartens, schools, hospitals, and elderly homes. Part of the funds are also provided to businesses - biomass and NGO projects - training projects. All projects were completed on time, many of them have been successfully completed.

196. In the new programming period 2014–2021, the MEn was again designated as the program operator, with funds raised more than twice – €33 million. The programming stage is currently under way and the first calls for applications will be opened in 2018.

- [Other sources](#) – OPs; credit lines: Residential Energy Efficiency Credit Line (REECL)⁶⁵ and Bulgarian Energy Efficiency and Renewable Energy Credit Line (BEERCL)⁶⁶, both offered by the EBRD.

197. **Existing energy companies' budgets, private investment, and loans are other potential sources of funding for CCA measures.** It will be necessary to mobilize funds at all levels, including private investments – corporate financing from energy private and state energy companies and loans from international financial institutions and commercial banks. With regard to public finance resources, the main sources available are the national budget and the funds from the EU budget.

198. **With respect to human resources, Bulgaria is identified as not having enough**

⁶⁵ See: <http://www.reecl.org>

⁶⁶ See: <http://beerecl.com>

capacity to deal with natural and manmade disaster risks, such as floods, droughts, forest fires, landslides, coastal erosion, earthquakes, and the effects on the biodiversity (EC 2013). This lack of capacity is likely to be equally applicable to the energy sector. In their recent report (MEn 2017) the MEn noted the insufficient number of experts in the implementation of the daily duties and tasks in the MEn. Each directorate has prepared a report on its activities and has presented the lack of administrative capacity as a major problem. The report also highlights that one of the main priorities should be to increase the administrative capacity in the specialized administration.

2.7. Sector Participation in CC(A) Specific International Cooperation or Information Exchange

199. **As discussed in sub-chapter 2.5, Bulgaria is not a member country of the IEA.** The IEA is increasingly expanding their focus to include consideration of CCA, and although a number of their resources are freely available, member countries will have enhanced access to information sharing forums and platforms. The IEA also launched the Climate-Energy Security Nexus Forum in 2012 as a platform to enhance awareness of the impacts of a changing climate on the energy sector and to share emerging experiences and expertise in building resilience.

200. **In 2009, the World Meteorological Organization established a Global Framework for Climate Services (GFCS)⁶⁷ to guide the development and application of science-based climate information and services in support of decision making in climate-sensitive sectors.** The GFCS provides a worldwide mechanism for coordinated actions to enhance the quality, quantity and application of climate services. In 2015, energy became a new priority area of the GFCS in addition to health, water, disaster risk reduction (DRR), and food security and agriculture. The strategy for the energy sector is to improve climate services and provide decision makers with enhanced tools and systems to analyze and manage risks, under current hydrometeorological conditions as well as in the face of climatic variability and change.

201. **‘Towards an Energy Union with forward-looking climate policy’ is one of six key strategic priorities of the Trio Presidency (Estonia, Bulgaria and Austria) which will preside over the Council of the EU successively between July 2017 and December 2018.** The priority area includes the following.⁶⁸

- A sustainable, resilient, and effective Energy Union achieving energy security through regional cooperation as well as diversification of sources, suppliers, and routes and while keeping administrative burden as low as possible, delivering on the legislative proposals of the ‘Clean Energy for all Europeans’ package, accomplishing market integration, in particular of renewables and contributing to investments, better interconnection and cooperation within the Energy Community framework.
- Climate policy delivering on the commitments of the Paris Agreement and the EU's 2030 targets focusing on reducing the GHG emissions in the EU Emissions Trading System (ETS), non-ETS sectors, and ETS aviation; reflecting the principles of fairness, solidarity, and cost-effectiveness as outlined by the EC Conclusions of October 2014.

⁶⁷ <http://www.wmo.int/gfcs/>.

⁶⁸ Note from the General Secretariat of the Council of the European Union 9934/17 from 2 June 2017, ‘18-month Programme of the Council (1 July 2017 – 31 December 2018)’.

The three Presidencies will promote a decarbonized, environment-friendly, and healthy mobility and transport system.

202. **Bulgaria’s Presidency of the Council of the EU provides the country with the opportunity to put forward its strategic priorities into the center of the political agenda of the Union.** Following the ‘Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy’,⁶⁹ the EC on November 30, 2016 presented an energy package with legislative and non-legislative proposals ‘Clean Energy for All Europeans’. The Bulgarian MEn prepared draft framework positions on the eight legislative proposals; negotiations on the majority of these dossiers are expected to continue during the Bulgarian Presidency. Other initiatives include legislative proposals for amendment of regulations and directives in the energy sector (MEn 2017). It is not clear at present how strongly climate resilience features within Bulgaria’s proposals and whether there will be an opportunity to include explicit reference to adaptation actions.

2.8. Ongoing and Foreseen CCA Related Actions

203. As outlined earlier, Bulgaria currently does not implement any measures/actions explicitly targeted at CCA. However, a number of activities and initiatives in the sector mainly dealing with mitigation efforts provide synergies with adaptation.

National Plan ‘Climate – Energy’ 2030 and National Energy Strategy 2050

204. **Bulgaria abides by its commitments to the EU 2030 Climate-Energy Package.** This framework, adopted in October 2014, brings together different climate and energy policy objectives, including security of energy supply, competitiveness of the economies through a high-tech approach and effectiveness of costs and resources, reduction of GHG emissions and others.

205. **For realization of these basic objectives, the Bulgarian Government is developing a national plan ‘Climate – Energy’ and a new Energy Strategy.** A working group was set up at the MEn to prepare the strategy, which is expected to be completed next year. The document will be subject to wide public discussion with all stakeholders to achieve maximum public consensus on the policies and measures envisaged in the new Energy Strategy.

206. **Bulgaria faces a serious challenge related to the new levels of sulfur dioxide, nitrogen oxides and mercury discussed in the framework of the regulation to the EC Large Combustion Plants (MEn 2017).** It puts at risk the generation of electricity from the available local lignite resources. Between 3,000 and 5,000 MW installed power capacity is threatened by closure as over 45 percent of the electricity in the country is generated by TPPs. These power plants provide power supply continuity and are an important source of cold reserve and balancing power. The EC has confirmed that an individual derogation from the new values is possible, but this will only postpone the problem over time. The burden of carbon dioxide costs and investment in environmental projects in the cost of energy production will continue to increase.

⁶⁹ COM(2015) 80 final ‘Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy’

National Investment Plan 2020

207. **The main objective of the implementation of the National Investment Plan (NIP) is to ensure a sustainable transition to a low-carbon economy based on the modernization of generating capacity, clean technologies, reconstruction and modernization of the infrastructure, diversification of the energy mix and diversification of energy supply sources.** The NIP 2013–2020 was adopted within 2011 pursuant to the requirements of Article 10c (1) and (4) of the Directive 2003/87/EC of the European Parliament and of the Council for the allocation of free GHG emission allowances (CO₂) for 2013–2020. The NIP includes all operators eligible for the derogation under Article 10c of Directive 2003/87/EC.

208. The total number of operators included in the NIP is 27: 11 DHPPs; 7 TPPs; 4 factory TPPs; 3 operators of electricity and electricity distribution networks, Bulgartransgaz EAD - operator of the national gas transmission network, and NEC EAD - supplier of electricity from last resort.

Diversification of energy sources

209. **Bulgaria is implementing a number of PCIs for construction and development of the gas network, aiming to improve the security and diversification of natural gas supplies in Europe:**⁷⁰ gas interconnection Bulgaria - Serbia (IBS); interconnector between Turkey and Bulgaria (ITB); interconnection Greece - Bulgaria (IGB); Chiren underground gas storage (UGS) expansion; necessary rehabilitation, modernization, and expansion of the Bulgarian transmission system; infrastructure to allow the development of the Bulgarian gas hub Balkan; pipeline system from Bulgaria to Slovakia (Project 'Eastring'); gas pipeline aiming at expanding the capacity on the interconnection of the Northern ring of the Bulgarian and Romanian gas transmission networks (transmission corridor Bulgaria–Romania–Hungary–Austria).

Energy efficiency

210. **Bulgaria has significant potential for implementing energy efficiency measures.** The need to improve energy efficiency in Bulgaria is one of the main priorities of the Bulgarian Government. Increasing energy efficiency will contribute to curbing carbon dioxide and other GHG emissions and will therefore help prevent climate change. For the implementation of energy efficiency, the Council of Ministers adopts the following plans and programs:

- National Energy Efficiency Action Plans (NEEAPs)
- A national plan for buildings with near-zero energy consumption
- A national plan for improving the energy performance of heated and/or cooled buildings owned by the state administration
- A national long-term program to encourage investment to implement measures for improved energy performance of public and private national housing and commercial buildings

211. Bulgaria has already set its national energy efficiency targets by December 31, 2020 in the NEEAP 2014–2020, which has been approved by the EC. The national indicative target for

⁷⁰ Commission Delegated Regulation (EU) 2016/89 of 18 November 2015 amending Regulation (EU) No 347/2013 of the European Parliament and of the Council as regards the Union list of projects of common interest.

energy savings by 2020 is 716 ktoe (8,325.65 GWh) energy savings on final energy consumption and 1590 ktoe (18,488.52 GWh) for primary energy consumption, of which 169 ktoe (1,965.13 GWh – 11 percent) in the transformation, T&D processes in the energy sector.

2.9. Gaps and Barriers

Awareness and communication

212. **Companies in the energy sector in Bulgaria are generally aware of the risks, but they are not yet taking sufficient forward-looking action.** While companies have emergency plans, they have not incorporated the increased risks associated with more frequent or intense extreme weather events associated with climate change. A major barrier preventing them from taking action in this direction is the uncertainty and lack of tools to incorporate climate change risks into their corporate decision making.

213. **Communication with the public about the impacts of climate change, levels of vulnerability, and the need to start adapting is largely absent in Bulgaria.** With respect to the energy, a key area for public awareness raising and education is around DSM as discussed further in Section 3.1.7).

Institutional capacity and human resources

214. **The government has an active role to play in building climate resilience, however, this is currently constrained by limited institutional capacity and human resources.** One of the main conclusions from the ‘National Climate Change Risk and Vulnerability Assessment for the Sectors of the Bulgarian Economy - Special Section’ was that adaptation capacity within the energy sector is insufficient (index of 3), that is, no conditions have been created for handling the problem. The government’s role includes creating an enabling environment that facilitates resilience-building actions, developing stimulating and supportive policies and setting an example by integrating future climate concerns into current planning for publicly controlled assets and enterprises (IEA 2015). Enabling frameworks imply favorable and facilitative conditions for businesses to act. Government and business activities that enhance resilience to climate change can be facilitated through access to information (for example climate data, research results and climate services), stakeholder engagement and collaboration, clear institutional links and coordination among different levels and domains of governments, and public-private partnerships.

Policy, planning and legislation

215. **Integrating CCA considerations is an important first step toward adaptation action.** For CCA to be sustainable and applicable on a wide scale, it must be incorporated into the sector and cross-sector policy and legislation. In Bulgaria, most CCA measures relate closely to, or directly overlap with, existing strategies, policies, and programs (for example Energy Strategy, National Energy Efficiency Strategy, National Security Strategy, DRR Strategy). This commonality should be exploited and expanded to include specific reference to CCA.

Access to sector-specific information

216. **Climate information includes the collection and tracking of statistical data on weather and climate, the development of scenarios of future regional and local weather**

patterns, and the communication of data and information to all stakeholders (IEA 2015). Governments should support the development and dissemination of climate information.

217. **Currently, climate data are not widely used by energy companies in Bulgaria in their operational planning and risk management.** Companies find it difficult to locate climate change information and apply it to operations (for example, how warming temperatures will affect production capacity; to what extent heat waves might affect energy supply and costs).

218. **There is a lack of easily accessible, scientifically credible, and sector specific information on climate change** (Center for Climate and Energy solutions 2013). Not enough detailed data are yet available for companies to adequately understand climate change impacts at the facility or operational level, where decisions to fortify systems or add redundancies are often made. Although many climate-simulation data are available in the public domain, they are enormous in volume, complex in nature, and easy for a non-expert in the field to misinterpret. Climate service providers can help facilitate data access, processing, and interpretation and provide customized data, training, or software. Companies need a way to connect the information available from climate models to the companies' specific issues of concern. They need tools that refine climate change information to address specific variables (for example, duration of extreme heat, runoff from higher-than-average rainfall) at specific locations and that can cover shorter time frames of concern to companies. Provision of such information will affect how companies perceive and prioritize risks.

219. **For many companies in the energy sector in Bulgaria, it is also too costly to pay for sector-specific climate data.** This, coupled with the inherently uncertain nature of such data, drives their efforts to actions regarding management of more urgent short- and long-term risks to the company, reduction of costs, and provision of greater value to customers.

Uncertainty of climate data

220. **Decision makers around the world are faced with the challenge of dealing with uncertainty in projections of global and regional climate change.**⁷¹ Even though the vast majority of climate scientists predict significant global changes across the coming decades – higher temperatures, more frequent/intense storms, more frequent droughts, sea level rise – uncertainties associated with the magnitude, timing, and location of such impacts remain. Where information about impacts is available, the uncertainty ranges of the occurrence of a given event are often too broad for energy sector stakeholders to use for concrete planning processes. Furthermore, the nature and magnitude of risks change at each region/site, making it difficult for companies to develop a long-term picture of a wider range of possible risks and response actions.

Financial resources

221. **Lack of sufficient financial resources is a significant barrier for CCA.** Currently, Bulgaria is dependent on EU funding, especially for large investment projects.

222. **Improving infrastructure brings significant costs.** Even where adaptation measures can be implemented alongside routine maintenance, more exacting standards are likely to

⁷¹ Working Group, I Contribution to The IPCC Fifth Assessment Report Climate Change 2013: The Physical Science Basis., TS.6.4 Key Uncertainties in Projections of Global and Regional Climate Change, p.115

require more expensive materials and subject to more stringent testing.⁷² It may be difficult to match the costs to investors with the benefits of a more resilient infrastructure, which will be felt by the country as a whole.

223. **Companies' investment in building resilience competes with other objectives and resources, many of which are more immediate and tangible.** Short-term costs and cash flows are often considered more important than benefits that may not be realized until much later. Capital, especially for smaller companies, is limited and investments in long-lived assets such as facilities or equipment involves high upfront costs and financial hurdles.

224. **Climate change impacts can be costly, but a wide range of adaptation options exist that can be implemented at different stages of project implementation** (ADB 2013). These measures can generally be divided into engineering and non-engineering options:

- Engineering measures include more robust designs in general; decentralized generation systems to spread risks; components certified as humidity, salt, and/or temperature resilient; air or low-water cooling systems; redundancy in control systems; improved supply-side and end use efficiency; and a range of technology-specific adaptations.
- Non-engineering measures include more robust operation and maintenance procedures, land rezoning to restrict future investments to less vulnerable locations, decentralized local planning, integration of adaptation and mitigation planning, integration of climate change and disaster management planning, improving forecasting of supply and demand with climate change, integrating power sector planning with that of water supply and other sectors, and improving local models used to predict storms and flood hazards.

225. **In a number of circumstances, the costs of inaction could be far higher than well-planned and implemented efforts to improve energy sector resilience to climate change.** Inadequate attention to these impacts can increase the long-term costs of energy sector investments, the likelihood that they will not deliver intended benefits, and the probability of eventual failure under climate stress. It may be appropriate to promote no-risk or low-risk adaptation measures that deliver development benefits at low cost regardless of the nature and extent of changes in climate (for example, where uncertainty regarding climate change is high, and where large climate-proofing capital investments cannot be easily justified).

2.10. Conclusions

226. Climate change adaptation represents an entirely new activity for institutions in the energy sector in Bulgaria. The decisions and actions that need to be taken in the future will require effective cooperation between stakeholders at all levels.

227. **Without a well-integrated and coordinated national effort, the energy sector is currently not sufficiently prepared to deal effectively with climate challenges. An uncoordinated approach to adaptation would result in a set of isolated activities that may lead to unintended consequences,** conflicting decisions and potential maladaptation. For this reason, appropriate institutional structures and legislative framework are identified as critical components of the enabling environment for climate change adaptation in the energy sector.

⁷² The Royal Academy of Engineering, Infrastructure, Engineering and Climate Change Adaptation – ensuring services in an uncertain future, 2011

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These include:

- Establish leadership on climate change adaptation at the highest level of government (within the MEn) and establish a durable vision for the future energy policy with regard to CCA.
- Aim to develop a coordination mechanism with different stakeholders in the energy sector: energy operators, NGOs, and so on.
- Identify and reduce barriers to adaptation that currently exist in legislation.
- Learn from international best practice and establish a database of adaptation actions in the energy sector.
- Encourage private-sector investments and the development of technologies for adaptation solutions.

Chapter 3. Adaptation Options

3.1. Identified Adaptation Options

228. **There is a suite of adaptation measures that can help increase the climate resilience of Bulgaria’s energy sector.** The measures that are the main focus for this sub-chapter of the report are those specifically addressing near- and long-term climate risks of high magnitude, as presented in Chapter 1. Given that the energy sector in Bulgaria is facing climate-related challenges, and as there are uncertainties over future climate change, these measures have been selected because they will help improve the resilience of the sector today, as well as in the future. The identified adaptation measures for the energy sector are as follows:

- (a) Translate monitoring, forecasting and weather data for the energy sector
- (b) Mainstream climate change considerations within energy sector policies and plans
- (c) Incorporate climate resilience into design and engineering of new power plants and into operations and contingency planning for existing power plants and coal mines
- (d) Incorporate climate resilience into design and engineering of new T&D infrastructure and into operations and contingency planning for existing T&D infrastructure
- (e) Diversify supply, including regional energy trade, district heating/cooling, gasification of households, and small-scale renewables to increase overall energy system resilience
- (f) Improve energy efficiency in public and private sector buildings to ensure that the existing supply and demand balance is maintained
- (g) Build institutional capacity and knowledge networks
- (h) Develop financial mechanisms to build resilience

Each of these measures is explored in more detail below.

3.1.1. Translate monitoring, forecasting, and weather data for the energy sector

229. **Monitoring, forecasting and weather data can increase preparedness for weather-related hazards and improve the operation of infrastructure now and under climate change.** These types of data allow to better understand the particular vulnerabilities facing local infrastructure from extreme weather and long-term climate change, including changes in HDDs and CDDs. Accurate hazard, exposure, and vulnerability mapping in particular offers a powerful tool for managing climate risks to energy generation and T&D infrastructure. There are several European data portals relevant for the energy sector, as detailed in *Box 1*.

230. **Energy sector operators do have access to weather- and climate-related data; however, there is a need for more business focused/sector-specific information.** Historical data are being used by the sector, but stakeholders felt this will almost certainly be out-of-date. Future climate change projections are rarely used in the sector for practical/operational decisions, although this does depend on the circumstance. For instance, use of future climate data is better for planning energy efficiency measures and investments with longer life-spans (for example renewable energy projects and new NPP Bellene). Stakeholders commented that there is appetite and interest in using future climate data more widely and systematically. There is also a benefit from building up a stronger database of how extreme climate events have affected the energy sector, covering multiple elements of the system (for example from coal to

power generation to transmission). Some weather- and climate-related data have a fee associated and this may be a constraint for smaller operators.

231. The individual adaptation actions that have been identified to help deliver this measure are presented in **Table 6**. Underlying all these actions is the need for more robust financing of NIMH-BAS.

Table 6. Individual actions that help deliver against Measure 1: ‘Translate monitoring, forecasting and weather data for the energy sector’

CLIMATE CHANGE ADAPTATION OPTIONS	
I. Translate monitoring, forecasting, and weather data for the energy sector	
1.	Meetings between energy sector decision makers/operators (MEn, NEC, ESO, power plant operators/engineers, distribution companies, district heating companies), MoEW, and NIMH to define needs of energy sector decision makers/operators for climate services to build climate resilience in the sector. These climate services may include the following: <ul style="list-style-type: none">• Very short-term forecasting for an extreme event (for example flood – expected flow to HPPs; landslide – damage to T&D infrastructure; heavy rainfall – pre-emptive checks of drainage systems at NPPs; high temperatures – sagging of T&D lines and overheating of substations; icing – T&D infrastructure)• Operational forecasting tools, typically one year ahead and revised every month (for example inflows into HPPs to include data on snow water equivalent)• Longer-term projections of climatic conditions aligned with life of assets (for example 30 years for T&D infrastructure; 100–150 years for dams)• Where possible, consider the use of Earth Observations (EO) data (for example, satellite data for landslides)
2.	The MEn to put in place a centralized agreement for provision of climate services from the NIMH for energy sector climate resilient decision making. (An existing agreement with the MoEW may provide a template for this.
3.	Improve the surface-based weather/climate observation network.
4.	Ensure the NIMH-BAS has sufficient human resources, including appropriate expertise and ongoing staff professional development, to provide a sustainable service that meets the needs for weather/climate information from users.

Box 1. Learning from international best practice: EC climate services tailored to the energy sector

The Copernicus Climate Change Service (C3S) and Atmosphere Monitoring Service (CAMS) have a critical role to play in making climate data accessible for the energy industry. Both these services are delivered by the European Centre for Medium Range Weather Forecasts (ECMWF) in Reading (U.K.), on behalf of the EC.

Copernicus is a global network of thousands of land, air and marine-based sensors, as well as a constellation of more than 100 satellites. They make millions of observations a day to build the most detailed picture available of the Earth’s climate and help the energy sector manage existing assets and plan for the future.

Copernicus is set to make that unprecedented volume of data – including on temperature, wind speed, UV and air quality – accessible to the energy sector in three ways:

- (a) Providing it free of charge for unrestricted use by policy makers, public authorities, businesses and scientists alike
- (b) Providing forecasts for key atmospheric variables – for example forecasts of aerosol depth to help assess solar yield
- (c) Developing dedicated climate indicators for the sector – for example national supply and demand profiles

Sources: <https://climate.copernicus.eu/clim4energy-service-providing-climate-change-indicators-tailored-energy-sector>, <http://www.energy-uk.org.uk/press-releases/energy-uk-blogs/5926-making-climate-data-accessible-for-the-energy-industry.html>.

3.1.2. Mainstream climate change considerations within energy sector policies and plans

232. **Bulgaria has made good progress in mainstreaming CCA within national plans; however greater focus should now be placed on developing sector-specific policies and plans.** The current energy policy, strategies, and action plans underway and planned will benefit Bulgaria’s economy and help address the future energy needs of the population. In line with European energy policy, the ‘Energy Strategy of the Republic of Bulgaria till 2020’ recognizes the importance of overcoming the negative impacts of climate change. However, details of how this will be achieved are currently lacking. Energy sector stakeholders consulted noted that specific measures identified through the development of this sectoral assessment could be included in the future Climate-Energy Action Plan [currently in preparation]. Although the exact contents of the new Energy Strategy are unknown, assuming that some of the key features of the existing strategy (as presented in **Figure 27** – namely energy security, increased share of RES, building a competitive market, with appropriate price regulation) remain national priorities, there are clear opportunities for climate resilience to be incorporated. For instance, ensuring energy security requires an understanding on how climate change may affect the overall supply-demand balance. Furthermore, new generation facilities (including RES) will need to be designed to ensure their climate resilience over the lifetime of the asset, which will ensure the market is competitive and prices are fair for the consumer.

233. **For CCA to be sustainable and applicable on a wide scale, it must be incorporated into the sector and cross-sector policy and legislation.** Most CCA measures relate closely to, or directly overlap with, existing strategies, policies, and programs (for example Energy Strategy, National Energy Efficiency Strategy, National Security Strategy, DRR Strategy). It is recommended that adaptation is more closely integrated with mitigation, disaster management, and other sector planning (including water supply).

234. **Sectoral policies and plans should focus on ensuring that energy infrastructure is located, planned, designed and maintained to be resilient to climate change, including increasingly extreme weather events.** The decisions energy owners and operators, regulators, and the government make over the next few years must be informed by an understanding of climate risks. If they are not, the country may be locked into infrastructure development pathways that do not provide adequate protection against future climate impacts and may be detrimental to the economy. There are economic benefits to be gained by adapting infrastructure to a changing climate, as long as decisions are taken at the right time. Current decisions and investment plans being considered for Bulgaria’s energy sector include commissioning

additional conventional generation capacity by 2024, including at NPP Kozloduy, ‘Haskovo’ Gas-Vapour Power Plant (GVPP), and hydropower facilities on the Gorna Arda cascade, together additional capacity from new renewable energy systems and upgrades to the T&D network (as detailed in Chapter 1). To ensure these assets perform effectively over their planned life-spans, it will be crucial that climate change considerations are integrated into their design and operation. An international example of strong sector-based plans, including investments to increase the climate resilience of critical infrastructure, is provided in **Box 2**, which focuses on U.K. ‘Sector Security and Resilience Plans’.

235. **The IEA has identified many examples of emerging and recommended policies that should be considered** (ADB 2013); a number of these have relevance for the new Energy Strategy currently being developed:

- *Design and safety standards.* New/updated design and safety standards are needed for equipment and infrastructure to withstand the extreme weather events of the future.
- *Permissions and zoning.* The location of energy sector assets may determine the scale of their vulnerability to current and future climate change impacts. Governments could use zoning with assigned vulnerability criteria based on climate forecasts when developing infrastructure plans and delivering construction permits. Governments could also use individual permitting processes for new energy infrastructure projects to request an assessment of climate vulnerabilities and require necessary adjustments to make planned infrastructure resilient to the anticipated climate change impacts.
- *Efficiency standards.* Enhanced water and energy efficiency standards would reduce exposure to climate change impacts, including disruptions in water and energy availability as well as changes in water temperature. DSM measures such as technology performance standards, smart meters, and information campaigns can be applied to energy and water users.
- *Innovation/R&D.* Government support is necessary for accelerated innovation in resilient energy systems. Technological innovation in the deployment of energy efficiency, smart grids and renewables can help achieve both mitigation and adaptation objectives.

236. **For mainstreaming to be effective, decision making should take place on the basis of the best available knowledge.** This will include climate data, information on the impacts for different regions and components of the energy systems, including supply and demand, as well as potential adaptation actions. A key area where knowledge needs to be improved is around the future energy balance, particularly power demand, in light of future climate scenarios. Energy planners and policy makers are likely to be mapping to a certain model of the future, but that future is changing. For instance, extra demand for air conditioning in the face of rising temperatures will significantly affect power demand. The energy sector has experience of handling significant changes in the base loads, for instance the cold winter in 2016–2017 caused a number of challenges for the electricity company. To prevent reactive responses, it will be important to take a more considered and proactive approach to assess the impacts of climate variability and change on power demand. Stakeholders stated that to analyze how the sector will operate in the future, 10 years of historic data is needed. It is not clear at present

whether such data are readily available.

237. **Traditional planning approaches that use historic data may need to be revisited and adjusted to reflect anticipated climate trends.** Changing climate conditions that deviate from historical climate ranges may adversely affect the integrity of the design, operation, and management of engineered systems.⁷³ It is important to take all reasonable measures to ensure that those systems appropriately anticipate the impact of changing climate conditions. In some cases, changing climate conditions result in impacts that pose unaccounted for risks. There is a need to review and implement changes in the use of historic data as a basis for future energy investments (for example, introduce weighting that reflects recent climate trends and adjust the life of investments where energy resources are affected by climate change). Experts should review design standards used within their professional practice to ensure that these standards reasonably represent the current and anticipated climate that the engineered system will experience over its useful operating life.

238. **A broad range of stakeholders need to be involved in mainstreaming adaptation efforts.** This will include national government ministries, sector authorities, and subnational governments. Stakeholder involvement helps ensure that policies are informed by practical knowledge and experience ‘from the ground’. The MoEW is responsible for strategic planning on climate resilience at the national level and is starting to consider the issue. However, at the operational level, energy sector stakeholders commented that little attention and action has been given to the topic. There are isolated examples of action, such as the structuring of generation plans by the District Heating Association to factor in the decrease in HDDs in the winter season and the activity of replacing some of the overhead T&D lines with underground cables by the regional electricity transmission company (EVN). Nevertheless, the consensus among stakeholders is that each organization is generally following their own priorities, with limited cross-sector thinking and collaboration.

239. The individual adaptation actions that have been identified to help deliver this measure are presented in *Table 7*.

Table 7. Individual actions that help deliver against Measure 2: ‘Mainstream climate change considerations within energy sector policies and plans’

CLIMATE CHANGE ADAPTATION OPTIONS	
II. Mainstream climate change considerations within energy sector policies and plans	
5.	Undertake an inventory of strategies, policies, plans, standards, energy infrastructure design norms and so on to identify those where climate resilience should be incorporated
6.	Ensure outcomes of Climate Change Adaptation report (Sector Assessment for Energy) are built into the climate-energy plan
7.	Mainstream climate resilience into the Spatial Planning Act
8.	Mainstream climate resilience into EIA regulations, following EC requirements
9.	When the new Energy Strategy is developed, ensure climate resilience is mainstreamed into it
10.	Mainstream climate resilience into energy sector investment plans, by defining climate risks in terms of probability and consequence

⁷³ Canadian Engineering Qualifications Board, Principles of Climate Change Adaptation for Engineers.

11. Identify climate-sensitive design norms for energy infrastructure; evaluate costs and benefits of updating design norms vs. doing nothing, and make decisions about which design norms to update
12. Incorporate seasonal climate forecasts and long-term climate change projections into seasonal and long-term power demand forecasts (ESO and MEn)
13. Incorporate climate resilience and improved contingency planning into the management of infrastructure that supports the energy sector (for example dykes and access roads for NPPs)

Box 2. Learning from international best practice: U.K. Sector Security and Resilience Plans

‘Sector Security and Resilience Plans’ set out the resilience of the United Kingdom’s important infrastructure to the relevant risks identified in the National Risk Assessment. Produced annually, they include a program of measures to improve resilience where needed, including reducing vulnerability to weather and climate-related factors. Individual plans are classified, but the Cabinet Office produces a summary Sector Resilience Plan (SRP) for Critical Infrastructure. The 2010 SRPs focused on the resilience of the U.K.’s Critical National Infrastructure to flooding. The 2011 SRPs extended the scope to allow assessment of other natural hazards and/or less critical assets. The 2012 SRPs extended the scope to allow assessment of the resilience of the sectors’ most important infrastructure to all risks (threats and hazards). In 2016, one of the key priorities is the continuing assessment of flood risks to energy assets and flood protection enhancement programs.

Source: <https://www.gov.uk/government/publications/sector-security-resilience-plan-2016>.

3.1.3. Incorporate climate resilience into design and engineering of new power plants, and into operations and contingency planning for existing power plants and coal mines

Thermal, nuclear, solar, and wind power plants

240. **In the medium term, thermal electricity generation is expected to be the main contributor and as such, ensuring optimal performance is crucial to maintain the existing supply and demand balance.** Despite rapid growth rates of renewable energy, thermal electricity generation (both TPP and NPP) is expected to account for around 80 percent of electricity generation in Bulgaria in 2024 (TSO 2015). This highlights the importance of TPP and NPP to the overall functioning of the energy system. Climate-related fluctuations in the base load have affected the supply and demand balance (for example cold winter of 2016–2017). In addition to more proactive planning and modelling of the future energy balance considering future climate scenarios (as discussed in Section 3.1.1), a review of contingency plans to deal with sharp demand peaks induced by climate variability (for example cold periods when extra heating is required or warm periods when space cooling demand increase) should take place.

241. **Given the potential for power plants to be shut-down when the temperature of intake water is elevated, or reservoir/river levels fall below certain thresholds, contingency planning should be reviewed, and monitoring efforts be enhanced.** The categorization of TPPs and NPPs as ‘national critical infrastructure’, in terms of energy security, has meant that funds are allocated for ongoing monitoring and control of operational parameters. Contingency plans for restricted water abstraction are likely to be in place at each power generation facility; however, details are not currently available and therefore, it has not been possible to assess their

robustness in the face of future climate change. Stakeholders did highlight the case of the potential new NPP (Bellene), where increased water temperatures in the Danube were raised as a potential issue. In the end, this was categorized as a negative issue for the new NPP. In terms of data collection, the NEK is responsible for monitoring reservoir levels, water temperatures and condition of ecosystems, particularly invasive species and vegetation. In recent years, higher water temperatures have led to significant eutrophication and algal growth in the cooling lakes used by the three largest TPPs in Bulgaria (Rozov Kladenets and Ovtcharitsa). This has created a number of operational challenges for the TPPs, as discussed in Chapter 1. Developing a longer-term dataset of environmental changes over time will help understand the nature of the problem and justify any intervention needed (for example remedial measures to remove algae and other invasive species).

242. **Physical changes to TPPs and NPPs may be needed to reduce water consumption in the face of increasingly scarce water resources.** It is likely that the existing water abstraction systems were designed using historical climate conditions and that baseline is no longer appropriate, creating a need to improve TPP and NPP performance in terms of water withdrawal and consumption. This can be achieved by recycling and reusing process water, changing production processes, using low water technologies, and reducing leakage. Globally, the energy sector is adopting increasingly sophisticated and costly on-site treatment processes, such as dry (air) cooling, desalination, and reverse osmosis, as exemplified in **Box 3** and **Box 4**. Energy consumption and the generation of brine are major environmental drawbacks of desalination, but the practice may be preferable to further depletion of freshwater resources (EEA 2009). There is also potential for a greater use of alternative water sources, particularly as cooling (and boiler feed) water does not typically need to be of high quality.⁷⁴ Such alternative sources can be less affected by drought than higher quality freshwater sources.

Box 3. Learning from international best practice: Adapting EDF's NPPs to withstand hotter temperatures and heat waves (France)

In response to the 2011–2015 national climate change adaptation plan in France, where most of the Group's nuclear fleet and distribution networks are concentrated, the *Électricité de France* (EDF) Group drew up a CCA strategy, which was adopted in June 2010. The strategy covers current and future industrial facilities, customer offers, generation/consumption optimization, and R&D.

In France, EDF is coordinating Action 3.3 of the National CCA Plan: “In the energy sector, improve performance in terms of water withdrawal and consumption by existing and future power plants.”

The strategy for adapting to climate change relies on four main plans of action:

- Assess the impacts of climate change on installations and activities
- Adapt the installations concerned to make them less sensitive to extreme weather
- Take into account future climate conditions in the design of new installations
- Improve the resilience to changes and extreme situations that are more difficult to predict

EDF's NPPs were designed to withstand external weather-related stress. To improve their efficiency in hot weather, major renovation works of nearly €400 million to 2019 are planned in air-cooled (dry) power plants, including:

- Systems to monitor thermal performance in all power plants

⁷⁴ Canadian Engineering Qualifications Board, Principles of Climate Change Adaptation for Engineers

- Refurbishment of 15 natural-draught cooling towers to enable them to withstand higher temperatures
- Ongoing renovation of environmental monitoring stations to ensure uninterrupted measurement of the physical and chemical properties of water

Source: <http://rapport-dd-2013.edf.com/en/preparing-to-adapt-to-climate-change>

Box 4. Learning from international best practice: Water-saving measures at ESKOM's coal-fired power plants (South Africa)

Eskom has introduced a number of innovative technologies and approaches over the last two decades to save water. These include dry (air) cooling, desalination of polluted mine water for use at the power stations, and technical improvements on treatment regimes to maximize the beneficial use of water. In doing so, Eskom has saved more than 200 million liters of water per day.

Dry cooling technology

Eskom has implemented dry cooling technology on its power stations wherever feasible. Because it does not rely on evaporative cooling for the functioning of the main systems overall power station, water use is approximately 15 times lower than a conventional wet-cooled power station. However, this is offset by the fact that dry-cooled stations are comparatively less efficient than wet-cooled stations and there is higher capital and operating costs associated with the technology.

Matimba power station in the Limpopo Province is the largest direct-dry-cooled station in the world, with an installed capacity greater than 4,000 MW. It makes use of closed-circuit cooling technology reducing water consumption to around 0.1 liters per kWh of electricity distributed, compared with about 1.9 liters on average for the wet-cooled stations. The choice of dry-cooled technology for Matimba was largely influenced by the scarcity of water in the area.

Kendal power station near Witbank in the Mpumalanga Province is the largest indirect dry-cooled power station in the world with an installed capacity of greater than 4,100 MW. Indirect dry-cooling entails the cooling of the water through indirect contact with air in a cooling tower, a process during which virtually no water is lost in the transfer of the waste heat. Water consumption at the plant is around 0.08 liters per kWh of electricity distributed. The move to dry-cooled technology has resulted in estimated combined savings in excess of 70 million m³ per year.

Desalination

Where power station design permits, Eskom has endorsed a policy of zero liquid effluent discharge (ZLED) at its wet-cooled stations in which water is cascaded from good to poor quality uses until all pollutants are finally captured in the ash dams. The effective use of this practice has seen the company introduce the use of desalination plants at Lethabo and Tutuka. These treatment processes allow the company to introduce polluted mine water from the tied collieries for reuse at the power stations. This assists with the prevention of negative environmental impacts on both the surface and groundwater.

Sources: webarchive.nationalarchives.gov.uk/20130123162956/http://www.defra.gov.uk/abstraction-reform/files/Eskom-case-study.pdf,

www.eskom.co.za/OurCompany/SustainableDevelopment/ClimateChangeCOP17/Documents/WaterManagement.pdf

243. **With respect to the construction of a new unit at Kozloduy nuclear plant, building resilience to climate change at the design stage will be more economically efficient than retrofitting the asset later.** The greatest opportunity to manage climate risks presents itself at the very beginning of a project lifecycle when important concept and design decisions have not yet been made (such as site and technology selection). Early stages of the planning process could be used to screen the project for climate change risks and opportunities and decide

whether further consideration and analysis is justified. Later stages could be used to undertake more detailed climate change-related analyses and refine how climate change considerations can be integrated within site selection and project design.

244. **Following the Fukushima Daiichi nuclear accident, flooding of power stations has become a key area of concern for the power sector.** Flood and storm surge events give rise to the potential for possible partial or complete equipment shutdown, water damage, staffing issues and commodity supply disruption. It will be important for the site of any new infrastructure to be assessed for flood risk and if potential areas of concern are identified, changes to plant layout and the provision of particular protection against flooding may be required. Stakeholders consulted highlighted that after Fukushima there were numerous meetings and many international requirements. In particular, the international nuclear regulator developed a methodology on the basis of which each country had to conduct stress tests for their NPPs. Therefore, there is a national action plan, covering seismicity, accidents and others. Kozloduy NPP takes management of natural hazards seriously and has two documents with measures. These are monitored by the NRA and reported to the International Nuclear Energy Agency. The program includes 10 implementation measures that require more considerable investment.

245. **For new solar power generation facilities, sites should be selected where expected changes in cloud cover, airborne grit, snowfall, and turbidity are relatively low.** For solar photovoltaic systems, where temperature increase or significant heat waves are expected, it will be useful to consider solar modules with a higher temperature coefficient (ADB 2013). String or micro inverters should be included in the design, since they are easy to cool down (ADB 2013).

246. **For new wind power, sites should be chosen taking into account expected changes in wind speeds, storm surges, sea level rise, and river flooding during the lifetime of the turbines.** Where wind speeds are likely to increase, it may be possible to capture greater wind energy with taller towers, or to design new systems better able to capture the energy of increased wind speeds (ADB 2013).

Coal mining infrastructure

247. **Mining practices at Bulgaria's coal mines should be reviewed to reduce exposure to flood-related damage, including environmental pollution, and potential supply chain disruption for TPPs.** If mining infrastructure cannot limit mine spillage to the environment during heavy rainfall and flood events, mine operators will face potential litigation, in addition to potential harm to people and the environment. Facilities must be designed or modified to comply with the new parameters that climate change brings, as exemplified in **Box 5**. Although the exact characteristics of this case study from South Africa may be different from the Maritsa East mining basin, the general point of reviewing design standards for their robustness to future changes is applicable across multiple contexts in the energy sector (for example, storm water drainage at generation facilities, construction of wind turbines to withstand stronger winds, and so on). Contingency plans for the supply chain, particularly for TPPs reliant on the supply of local coal, should also be developed to ensure power generation capacity is uninterrupted. At present, it has not been possible to assess whether mining practices and contingency plans

consider potential weather and climate-related impacts.

Box 5. Learning from international best practice: Anglo American Platinum's response to flood risk at Amandelbult mine (South Africa)

The Amandelbult mine has implemented storm water controls to minimize the mixing of clean and dirty water so that even under significantly higher flows, the risk of flooding will be minimized. With a nominal increase in height of the containment wall/bund (500mm), a doubling of future flood flows will be contained within the existing canal.

Source: <http://www.srk.co.uk/en/newsletter/mine-water-management/changing-climate-affects-mine-planning-south-africa>

Hydropower plants

248. **The operation and performance of HPP should be assessed considering potential future river flow conditions.** Drawing upon hydrological and meteorological data, existing hydropower infrastructure could be operated differently to improve its climate resilience and safety, as exemplified in the Tajikistan and Australian case studies below (**Boxes 6** and **7**). For instance, one option explored at the HPP Qairokkum in Tajikistan was to make changes to the operating rule curve to maximize head and minimize spill by extending the duration of full storage level from June to October. Although the exact characteristics of these case studies may be different from HPPs in Bulgaria, the general point about reviewing operating procedures is important to highlight due to the low cost to benefit ratio of such actions.

249. **A range of technical measures could be implemented to reduce climate risks.** This could include investments in improved/efficient turbines, turbine runners, and generators designed to cope with projected future water flows, control and shut off valves to reduce water losses, spillways designed to cope with higher extreme flows, and landslide early warning systems. These measures are applicable to existing assets, together with planned assets, particularly considering the current trend to increase the installed capacity of small-scale hydropower⁷⁵ and the government's continued focus on the optimal utilization of the hydropower potential of the country.⁷⁶ Modifications to designs to build in 'headroom' for climate change are generally much cheaper than retrofit later. At present, it is not understood whether climate change has been factored into the design and operation of existing HPPs and planned infrastructure investments, including the Gorna Arda cascade (with planned installed capacity of 166 MW [TSO 2015]).

Box 6. Learning from international best practice: Updating operating and safety procedures at HPP Qairokkum (Tajikistan)

Integrating climate resilience into Qairokkum's operations has meant revisiting the plant's dam operating rules and safety procedures in light of the newly available hydrological and meteorological data. Operating rules and dam safety procedures were adopted during the Soviet era and were based on hydrological and meteorological observations from the early 1980s. Models of extreme flood events and corresponding emergency response measures

⁷⁵ Between 2013 and 2016, installed capacity from small-scale hydropower has increased by approximately 10.5 percent while estimated potential has increased by approximately 53 percent (Source: The World Small Hydropower Development Report (2016). UNIDO, and International Center on Small Hydro Power. <http://www.smallhydroworld.org/menu-pages/reports/2016/>)

⁷⁶ Energy Strategy 2020 of the Republic of Bulgaria

have been updated. This has meant considering the new hydrological and meteorological data as well as the projected climate change impact.

Source: <http://2014.sr-ebrd.com/case-studies/rehabilitating-a-hydropower-plant-in-tajikistan>

Box 7. Learning from international best practice: Hydro Tasmania’s upgrade and retrofit program to increase climate resilience (Australia)

Hydro Tasmania concentrates on continuous plant upgrades and refurbishments to ensure efficient and economic resource use within a changing climate. The company has established partnerships with leading climate research institutions to better understand how water inflows into its reservoirs are likely to evolve in the future. This informs its hydrological modelling and helps it manage water inflow volatility into reservoirs, balancing the risk of shortfall against the risk of spill. By integrating climate data and hydrological modelling into its business processes and planning, Hydro Tasmania has mainstreamed climate change into its operations, minimizing its business vulnerability to climate change. To raise awareness, Hydro Tasmania regularly engages with its staff on issues related to climate. Climate change projects are promoted within the company and project outcomes and impacts are shared among staff. This ensures that employees understand climate change risks, options, solutions and actions.

Source: <https://www.hydro.com.au/environment/climate-change-and-climate-resilience/climate-change-adaptation-and-building-climate-res>

250. The individual adaptation actions that have been identified to help deliver this measure are presented in *Table 8*.

Table 8. Individual actions that help to deliver against Measure 3: ‘Incorporate climate resilience into design and engineering of new power plants, and into operations and contingency planning for existing power plants and coal mines’

CLIMATE CHANGE ADAPTATION OPTIONS	
III. Incorporate climate resilience into design and engineering of new power plants and into operations and contingency planning for existing power plants and coal mines	
14.	MoEW to ensure that climate resilience is integrated into water resources management and associated decisions affecting the operation of large HPPs
15.	Review costs and benefits of incorporating climate resilience into design of new power plants

3.1.4. Incorporate climate resilience into design and engineering of new T&D infrastructure and into operations and contingency planning for existing T&D infrastructure

251. **Physical climate resilience measures should be integrated into the upgrade of the national T&D network.** Some parts of Bulgaria’s T&D network are now reaching the end of their useable life. As outlined in the Electric System Operator’s current 10-year plan (until 2024) (TSO 2015), there are plans for construction of a second power supply in the Rousse area and the development of the 110-kV grid, with the objectives of improving the security of the transmission of the electricity produced from renewable energy sources, providing connection of conventional power plants and securing the supply of individual areas in case of emergency repairs. Plans for new assets should be revamped to withstand ongoing or expected climate impacts, including considering asset location and transmission line routes (to avoid landslide-

prone areas or flood zones for example), temperature extremes, weight loads of towers, peak expected wind speeds, insulation of transmission lines, depth of pilings, effects of freeze-thaw cycles, choice of building materials, and other essential choices given local climate conditions (Ebinger and Vergara 2011). For example, higher peak temperatures and increased number of consecutive hot days can lead to sagging of the power lines and greater transmission losses. This reduced efficiency and financial loss can be addressed by upgrading the thermal capacity of transmission lines and substations to withstand higher temperature thresholds and other weather extremes; an approach being taken by BC Hydro in Canada (Toth and Gurney 2008) (discussed further in **Box 8**). Energy sector stakeholders did highlight that ordinance #3 covers the expansion and sagging of power lines under higher temperatures and updated data on temperatures in a given region will always be used. However, at present, it is unclear when this ordinance was last updated and whether design standards are solely based on historical data.

252. **Retrofitting of isolated T&D assets that are exposed to climate conditions outside their design parameters may also be appropriate to increase their lifespan and operating efficiency.** Efforts can include identifying and increasing the resilience of weak points in T&D assets to withstand extreme weather events, higher temperatures, and other expected climate hazards. An example of retrofitting includes increasing the height and strength of flood protection measures around assets exposed to riverine or flash flooding. Other measures can include fortification of vulnerable assets and increasing thermal rating of existing lines (Toth and Gurney 2008). In France, one of the transmission companies has installed anti-cascade towers to prevent the ‘domino effect’ of collapsing towers, which can result during storm events (as discussed further in **Box 9**). There is evidence that the T&D companies are taking action to reduce exposure to climate-related disruption and damage, for instance, frequent winter storms and heavy snowfall in the Rhodopi Mountain has led to the regional electricity transmission company (EVN) replacing some of the overhead lines with underground cables.

253. **One large advantage of the Bulgarian energy system is that interconnections with neighboring TSOs provide a backup during disruption, with electricity imported or exported depending on where a shortage arises.** Regulations require operators to have 10-year plans and connectivity to neighboring countries is a focus of the activity. Nevertheless, stakeholders did comment that contingency plans for outages (of up to 10 days) should be reviewed.

254. The individual adaptation actions that have been identified to help deliver this measure are presented in **Table 9**.

Table 9. Individual actions that help deliver against Measure 4 ‘Incorporate climate resilience into design and engineering of new T&D infrastructure and into operations and contingency planning for existing T&D infrastructure’

CLIMATE CHANGE ADAPTATION OPTIONS
IV. Incorporate climate resilience into design and engineering of new T&D infrastructure and into operations and contingency planning for existing T&D infrastructure
16. Develop maps showing climate risk zones for climatic parameters relevant to T&D infrastructure, to inform decisions about parts of the T&D networks that require climate resilience actions

17. Continue to monitor causes of interruptions to the T&D system and to classify climate/weather-related causes, to understand weather hazards that lead to most outages and to identify any trends in their frequency
18. Undertake cost-benefit analysis (CBA) to evaluate whether additional sections of the distribution system should be changed to underground cables, considering changes in the frequency and severity of extreme events and consequent damages to the network

Box 8. Learning from international best practice: BC Hydro adaptation measures to protect transmission lines

In 2009, BC Hydro developed a comprehensive climate change strategy. While the first part of the strategy mainly relates to the reduction of GHG emissions from sources of electricity generation and corporate operations, the last part focuses on consideration of adaptation in corporate and project risk management processes. The strategy includes adaptation actions ranging from collaborative research on impacts and corporate climate risk assessments to practical changes that help manage climate risks operationally. With respect to their transmission infrastructure, BC Hydro has undertaken the following actions:

- Conducted climate risk assessments to identify climate change impacts on assets and infrastructure. During the assessment phase, the company identified all likely climate change impacts on its T&D grid and estimated the potential increase in outages and financial consequences if no actions were taken.
- Used research carried out by the University of Alberta and the University of British Columbia to gather data on potential changes in future wind speed and direction, icing loads, and precipitation to assess impacts on transmission lines.
- Modified maintenance regimes and line design standards to increase their resilience to wind and ice loads, exceeding the current Canadian standard requirement.
- Explored the potential for new corrosion-resistant materials, by BC Hydro's R&D department that would extend the lifetime of new transmission lines in a future climate. BC Hydro is testing and deploying the use of 'high performance corrosion resistant materials' in new assets to increase the capacity of T&D infrastructure to withstand extreme weather.

Source: <http://nrt-trn.ca/bc-hydro-case-study>



Box 9. Learning from international best practice: RTE (France) retrofitting infrastructure to cope with wind storms

To reduce the risk of increasing maintenance and operating cost due to weather extreme, *Réseau de Transport d'Electricité* (RTE) instigated a series of risk management measures to ensure that any disruption to the T&D network is rectified within five days. A series of preventive measures have also been made, including physical changes to infrastructure. Anti-cascade towers have been installed every 5–10 kilometers to prevent the 'domino effect' of

collapsing towers, which can result during storm events. High wind hazard maps have also been developed for new investment.

Source: http://www.iea.org/media/workshops/2013/nexus/Session2_3Henry_20131023RTEResiliencyofpowergrids.pdf

3.1.5. Diversify supply, including regional energy trade, district heating/cooling, gasification of households, and small-scale renewables to increase overall energy system resilience

255. **Diversification and decentralization of generation technologies is useful to increase the climate resilience of Bulgaria’s energy sector.** Bulgaria has a diverse mix of generation sources,⁷⁷ which can help in emergency/force majeure conditions when one source is disrupted. However, as existing infrastructure ages there may be a new window of opportunity to build a more decentralized energy structure, based on locally available renewable energy sources situated in secure locations or existing district heating systems. Provided these assets are designed to cope with the climate conditions,⁷⁸ they will experience over their lifetimes that diversification and decentralization is a useful strategy in the face of climate change uncertainties. As highlighted by a stakeholder, district heating has the potential to alleviate energy demand and help during peak demand periods through cogeneration. In Bulgaria, there is a ‘cold reserve’ to cope with extreme peaks in demand, which is a TPP generation capacity. If this reserve could be shifted to consumers, as exemplified in **Box 10**, the system would be more resilient to deal with peak demands for electricity, independent of a reserve.

256. **A more regional, network-based system will be more flexible and adaptive and reduces the potential for large-scale outages when centralized power systems are compromised.** Although such events are typically rare, they have the potential to cause significant disruption in Bulgaria because of the level of interconnectivities. Energy systems are so interconnected with other systems – such as transport, water, communication, healthcare and the private sector – that the loss of power for any length of time would cause widespread damage.

257. **Bulgaria has a variety of renewable energy sources and micro-grid systems are a viable option to build climate resilience, particularly in more remote rural locations.** These options include small HPP, solar, wind, and biomass. Typically, construction times for small-scale renewable technology are short and they could be operational within a few years, thus addressing exposure to current climate variability. Micro-grids powered by distributed generation have the ability to disconnect from the central grid during a major climate event to maintain electricity supply to critical loads (Stout and Hotchkiss 2017). With micro-grids serving critical loads during a blackout, utilities have more flexibility in restoring generation stations, responding to critical outages, and shutting down systems before a major event to prevent damage (Stout and Hotchkiss 2017).

258. **The implementation of micro-grid systems is essential, especially with a view to the recast of Directive 2009/28/EC, which introduces a new, binding target for the EU for 2030 of at least 32% of energy produced from renewable energy sources in gross final**

⁷⁷ Although by far the largest contributor to electricity generation is from TPP and NPP (>70 percent - see Chapter 1)

⁷⁸ For example, small HPPs should be designed with water storage to buffer the effects of variability in hydrological conditions.

energy consumption, including a review clause by 2023 for an upward revision of the EU level target⁷⁹. The objectives and targets stem from the Union policy on energy and from the need to preserve, protect and improve the quality of the environment and to promote the prudent and rational utilization of natural resources, as provided for under the EU Treaties. Therefore, the integrated national energy and climate plan covering the first period from 2021 to 2030 should pay particular attention to this action.

259. **Diversification of supply will have beneficial effects for the Forestry sector.** On the one hand, forests are one of the providers of renewable energy source (that is, wood). However, carbon sequestration functions of forests are important and therefore long-term use of wood has to be promoted, which contradicts high usage of wood as energy source, especially for household heating facilities. This is extremely important for Bulgaria because currently more than half of the annual harvest is used as firewood primarily in small cities and villages, which contributes to pollution and decreases the opportunities for carbon sequestration. Transition to modern heating systems can be expected to decrease pollution, decrease the use of firewood and increase the potential for carbon sequestration.

260. The individual adaptation actions that have been identified to help deliver this measure are presented in *Table 10*.

Table 10. Individual actions that help deliver against Measure 5 ‘Diversify supply, including regional energy trade, district heating/cooling, gasification of households and small-scale renewables, to increase overall energy system resilience’

CLIMATE CHANGE ADAPTATION OPTIONS
V. Diversify supply, including regional energy trade, district heating/cooling, gasification of households, and small-scale renewables to increase overall energy system resilience
<p>19. Continue to develop regional interconnections and regional electricity trading</p> <p>20. Review opportunities for improved district heating systems to contribute to meeting winter and summer energy demand</p> <p>21. Promote gasification of households to contribute to meeting winter energy demand</p>

Box 10. Learning from international best practice: Moving from fossil fuel to renewable sources for Sweden’s district heating system

District heating has been available in Sweden since the 1950s. In 2013, district heating was responsible for 58 percent of the total energy use in dwelling and non-residential premises. Half of the district heating was used in multi-dwelling buildings, while the non-residential premises accounted for 38 percent and one- and two-dwelling accounted for 12 percent.

Several different fuels can be used for district heating production and when originally established heat was mainly produced in TPPs. However, since the 1970s there has been a major transition toward renewable fuels and a steady increase in cogeneration, which currently represents around 40 percent, compared with 30 percent in 2003.

⁷⁹ Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the Governance of the Energy Union, amending Directive 94/22/EC, Directive 98/70/EC, Directive 2009/31/EC, Regulation (EC) No 663/2009, Regulation (EC) No 715/2009, Directive 2009/73/EC, Council Directive 2009/119/EC, Directive 2010/31/EU, Directive 2012/27/EU, Directive 2013/30/EU and Council Directive (EU) 2015/652 and repealing Regulation (EU) No 525/2013

In 2013, biomass accounted for 60 percent and waste heat for 8 percent of the input energy in district heating production. The use of heat pumps has decreased in the district heating system in recent years and the use of electric boilers has almost completely disappeared since the early 2000s. The use of waste has increased in the past decade.

Source: <http://www.business-sweden.se/globalassets/invest-new/data-center/energy-in-sweden-till-webben.pdf>

3.1.6. Improve energy efficiency in public and private sector buildings (residential, commercial, and industrial)

261. **Increased risk of overheating will drive the need for additional cooling of buildings and improving energy efficiency will help address any future demand-side challenges facing the energy sector.** Investments in energy efficiency should be targeted at public and private sector buildings that use significant amounts of energy for summertime cooling. Detailed information on energy used for space cooling in commercial buildings is unavailable for Bulgaria; however, studies in the United States show that cooling energy use is highest for office buildings, warehouse and storage buildings, hotels, schools and universities, hospitals, and the retail sector (EIA 2003). Higher temperatures have the potential to lead to increased energy use and GHG emissions, unless low-energy cooling designs and technologies are used, which are capable of coping with the increased temperatures that buildings will experience over their lifetimes. Stakeholders referred to Ordinance No. 15⁸⁰ which covers the integration of climate factors in the design of district heating systems, highlighting the fact that the underlying data have not been updated since the 1980s. As such, this is an important action, to ensure that thermal comfort of buildings is maintained in a changing climate.

262. **Improved energy efficiency is already a priority for the national government of Bulgaria and is being implemented through the Energy Efficiency Act and NEEAP 2014–2020.** EU legislation for energy efficiency is fully transposed into Bulgaria law, through the Energy Efficiency Act and secondary legislation is transposed into Energy Efficiency Directives 2012/27 and 2001/31, with the latter specifically focused on energy efficiency of buildings. In alignment with the requirements of the 2012 Directive, the National Efficiency Action Plan stipulates various measures for the promotion of energy efficiency, covering generation right through end user demand. One of these measures is the National Energy Efficiency Scheme within the framework of which fuel and energy suppliers to end clients meet their individual annual energy savings targets through the provision of energy-efficient services and the implementation of measures for improving the end-consumption energy efficiency in all sectors (industry, transport, households, and services). Reports on the implementation of these measures are drawn up on an annual basis. In compliance with the European requirements regarding the national building stock, the national legislation regulates the preparation of a national long-term program for mobilizing investments for the implementation of measures to improve the energy performance of buildings from the public and private national housing and commercial building stock and a national plan for improvement of the energy performance for heating and/or cooling of state-owned buildings, used by the state administration. Stakeholders commented that these integrated energy-climate plans are a ‘work in progress’, covering the time horizon to 2030. Given that the lifespan of most buildings will extend beyond 2030, there

⁸⁰ Ordinance No 15 of 28 July 2005 laying down technical rules and standards for the design, construction and operation of sites and facilities for heat production, transmission and distribution

is a need to review these plans in the light of climate projections beyond 2030.

263. **Sources of funding for energy efficiency are numerous and could be expanded if energy efficiency is also recognized as a measure to improve climate resilience.** Through the highly successful Energy Efficiency and Renewable Sources Fund, investments are being made to increase energy efficiency for end users. There are also various OPs for energy efficiency in households and public buildings. International finance institutions are also supporting a number of energy efficiency programs in Bulgaria. For instance, the EBRD, through one of its Sustainable Energy Financing Facilities (SEFFs), is providing funding for implementation of energy efficiency measures in the residential sector (as discussed in **Box 11**). Stakeholders also highlighted that there is a Norwegian-funded program on energy efficiency and renewable energy, with dual objectives of energy savings and emissions reductions. Across Europe, an increasing number of energy efficiency funds and programs are developing (as exemplified in **Box 12 and 13**) and this trend is only likely to continue in the future, due to the combined adaptation and mitigation benefits.

264. The individual adaptation actions that have been identified to help deliver this measure are presented in **Table 11**.

Table 11. Individual actions that help deliver against Measure 6 ‘Improve energy efficiency in public and private sector buildings, to ensure that the existing supply and demand balance is maintained’

CLIMATE CHANGE ADAPTATION OPTIONS
VI. Improve energy efficiency in public and private sector buildings to ensure that the existing supply and demand balance is maintained
<p>22. Encourage energy suppliers to become Energy Service Companies (ESCOs)</p> <p>23. Ensure advice on designing/constructing energy-efficient buildings takes account of projections of temperature increases to ensure building performance will not be compromised under higher temperature conditions</p> <p>24. Develop financial mechanisms to further stimulate energy efficiency in the industry sector*</p> <p>25. Extend the control over energy efficiency governance, especially in industrial systems*</p> <p>26. Provide assistance to obliged persons to initiate the development of methodologies for evaluation of energy savings that demonstrate the fulfilment of individual energy saving targets, especially in the case of energy savings used in the industry sectors*</p> <p>27. Advance efforts to motivate end users of energy to implement energy saving measures, especially households*</p> <p>28. Harmonize the process of regulating the prices of electricity, heat and natural gas with the policy of improving the energy efficiency in the country*</p> <p>29. Raise the awareness of energy traders with regard to their obligations under the Energy Efficiency Act and the possibilities for their implementation*</p> <p>30. Work with stakeholders in the water sector to explore links between water efficiency (that is, losses from the system) and energy efficiency</p> <p><i>* Actions identified in the SEDA Annual Report (2017), Annex 1: Annual Report on the implementation of the National Energy Efficiency Action Plan 2014–2020. All the other actions presented in this table were identified through a series of stakeholder consultation meetings held in September 12–14, 2017.</i></p>

Box 11. Learning from international best practice: EBRD, SEFFs in Bulgaria

Through SEFFs, the EBRD extends credit lines to local financial institutions that seek to develop sustainable energy financing as a permanent area of business. Finance for sustainable energy projects is provided for two key areas: energy efficiency and small-scale renewable energy. Local financial institutions on-lend the funds which they have received from the EBRD to their clients, which include small and medium sized businesses, corporate and residential borrowers, and renewable energy project developers. The SEFF model was originally developed in Bulgaria in 2004 and has now been rolled out across 20 of the countries where the EBRD invests.

One of the SEFFs in Bulgaria is the REECL. This aims to give Individuals, Association of Apartment Owners or Service Providers (Housing Management Companies, ESCO, developers and construction companies) across the country an opportunity to realize the benefits of energy efficiency home improvements by providing them with loans and investment incentives through local participating banks. Specific energy efficiency measures include double-glazing; wall, floor, and roof insulation; efficient biomass stoves and boilers; solar water heaters; efficient gas boilers and gasification installations; heat pump systems; building-integrated photovoltaic systems; heat-exchanger stations and building installations; balanced mechanical ventilation systems with heat recovery; and energy efficient lifts.

As of 2012, €50 million of EBRD funding had been provided for residential energy efficiency. The REECL is supported by grant funding and technical assistance from the KIDSF.

Sources: <http://www.ebrd.com/downloads/sector/eecc/seff-bulgaria.pdf>, <http://reecl.org/en/>,
<http://www.ebrd.com/downloads/research/factsheets/seff.pdf>

Box 12. Learning from international best practice: Slovakia's Energy Efficiency Fund

The Slovak Republic's Energy Efficiency Action Plans aim to achieve energy savings in individual sectors of consumption, amounting to 9 percent of the average annual national consumption from 2001 to 2005. The action plan has sought to form the necessary legislative environment, establish an effective monitoring and information system, define and implement low-cost organizational and technical measures, and provide financial support mechanisms. The latter includes the planned establishment of an Energy Efficiency Fund to provide grants supporting specific energy efficiency-related activities.

The action plan categorizes energy-saving measures according to various sectors, including:

- Updating building regulations for new and existing (non-industrial) buildings
- Establishing building documentation package, with transparent information on audits and energy certification
- Improving energy efficiency and thermal properties of public sector buildings
- Improving monitoring and verification of building energy performance
- Introducing voluntary energy certificates/audits
- Investment support for refurbishment of prefabricated buildings
- Implementation of the eco-design directive
- Providing information campaigns and consultancy services on energy-efficient appliances

Source: <http://www.iea.org/policiesandmeasures/pams/slovakia/name-24214-en.php>

Box 13. Learning from international best practice: Renovation of social housing using EPC in Italy

The FRESH project ('Financing Energy Refurbishment for Social Housing' – an IEE supported project between 2009–2012) aimed at demonstrating that emergency performance contracting (EPC) can work for residential buildings, particularly for the refurbishment of social housing. Social housing is typically provided by local authorities for a subsidized rent whereas the utility costs are paid for by the tenants. Rent may be increased as a result of refurbishment, however the interventions need 100 percent agreement from tenants. The possible rent

increase is insignificant due to social reasons; therefore, EPC seems to be an alternative to finance investments. The pilot project in Italy was a 13-apartment building. The selected technologies were heating and hot water systems. The envisaged energy savings are 35 percent of baseline energy consumption.

Source: Milin et al. 2011, at <https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/european-esco-market-report-2013>

3.1.7. Build institutional capacity and knowledge networks

265. **Adaptation is about taking systematic and strategic action, and this requires skilled and experienced experts and appropriate institutional structures and processes** (GIZ 2011). There is a need for capacity building at all operational levels. Adaptation to climate change requires new or adapted information, interpretation, and decision-making skills, as well as management structures and processes, that is, institutional capacity. Training emergency response teams is imperative for a fast and proper response in the case of a disaster and also for quick repair and restoration actions. Training for data management, modelling, and forecasting is necessary to start integrating climate forecasts into energy system planning. These activities can be organized in cooperation with government-led capacity-building programs.

266. **It is crucial that energy sector stakeholders can identify climate change risks and understand how to deal with them.** Integrating this knowledge into day-to-day operations and longer-term planning processes will enable the sector to optimize electricity generation, T&D, and ensure existing safety standards continue to be met. It is important that supporting governance and review structures allow for periodic site inspections, reviews of underpinning scientific evidence, and updates to design standards/manuals used by engineers. Stakeholders recognized that human resources, both quantity and quality, are a key barrier to Bulgaria's adaptive capacity.

267. **Within the energy sector, information on asset and network resilience should be shared between different owners and operators.** Systemwide modelling and assessment should be encouraged, to explore different climate risks and adaptation scenarios. Stakeholders commented that currently there is insufficient collaboration and interaction between different owners and operators.

268. **Emphasis should also be placed on establishing cross-sectoral working groups to manage interconnected services and minimize the risks of cascade failures that could be exacerbated by climate change.** Cascade failure impacts occur when failure in one area of infrastructure leads to failures in a number of other areas. There is a need to develop understanding of the interplay of impacts between different sectors and the development of skills in systems thinking is likely to be crucial. To ensure that vulnerabilities in one sector do not threaten the resilience of others, it is important for organizations to share data and collaborate across networks. New institutional and informational links should be incorporated into established processes of decision making and management. For example, Canada launched an adaptation platform in 2012 to promote collaboration and produce information and tools that could be used by all sectors and regions to understand and adapt to the effects of a changing climate. The platform includes an energy sector working group. A priority area for Bulgaria is the interdependency between the energy and water sectors. A further example of an effective

cross-sectoral working group is the ‘Infrastructure Operators Adaptation Forum’ (IOAF) in the United Kingdom (see **Box 14**). Stakeholders highlighted that the National Climate Change Expert Council, at the MoEW, brings together experts from all sectors. However, the remit, responsibilities and arrangements of this cross-sectoral group are unclear at present; for instance, the emphasis placed on climate resilience compared to climate change mitigation, frequency of meetings, sectoral representation.

269. The individual adaptation actions that have been identified to help deliver this measure are presented in **Table 12**.

Table 12. Individual actions that help deliver against Measure 7 ‘Build institutional capacity and knowledge networks’

CLIMATE CHANGE ADAPTATION OPTIONS	
VII. Build institutional capacity and knowledge networks	
31.	Expand the work of the National Expert Council (led by MoEW) to cover climate change adaptation (in addition to mitigation)
32.	Undertake a review of existing levels of awareness of climate change adaptation within the MEn, regulator and wider energy sector decision makers/operators
33.	Provide training to the MEn, regulator, and wider energy sector decision makers/operators on climate change adaptation, including information on best practice for energy sector climate resilience from other countries

Box 14. Learning from international best practice: The U.K.’s ‘Adaptation and Resilience in the Context of Change Network’ (ARCC) and ‘Infrastructure Operators Adaptation Forum’ (IOAF)

The ARCC brings together researchers and stakeholders involved in adaptation to technological, social and environmental change in the infrastructure and built environment sectors. Funded by the Engineering and Physical Sciences Research Council (EPSRC), the ARCC focuses on three core objectives:

- 1) Building community cohesion to develop in-depth understanding and synergies across the network
- 2) Provision and integration of knowledge to help ensure policy and practice have the best available evidence
- 3) Enhanced accessibility and uptake of research outputs to meet the needs of a diverse stakeholder community on time

One of the projects funded is the IOAF. It is coordinated by the Environment Agency and enables forum members to learn from each other and work together to reduce vulnerability and realize opportunities presented by points of dependency between infrastructure systems. Members are drawn from infrastructure operators, regulators, government, trade associations, professional bodies, and academia.

The IOAF’s vision is for “Our assets and services to be resilient to today’s natural hazards and prepared for the future climate.”

Work continues through ARCC network leadership of the IOAF Working Group 5 on ‘Interdependencies and cascade failure risks’. This builds on previous dialogues, ongoing links with the Infrastructure and Projects Authority, the U.K. Regulators Network, and three major research infrastructure research projects (ICIF, ITRC, and iBuild).

Sources: <http://www.arcc-network.org.uk/>, <http://www.arcc-network.org.uk/infrastructure/ioaf/>

270. **It is equally important to link climate knowledge with action and persuade businesses, communities, and individuals to adjust their behavior in ways that promote adaptation and limit emissions (UNEP 2006).** Successful adaptation involves collaboration across a multitude of interested partners and decision makers: international, national, and local governments, private sector, NGOs and community groups, and others that have important roles to play. For example, it is critical to facilitate dialogue between weather-water-climate scientists and energy decision makers to address cross-cutting issues for energy production and efficiency.

271. **Communication is important to increase public consciousness about the impacts of climate change, the levels of vulnerability, and the need to start adapting.** Without communication, the public remains uninformed about its role and the governmental efforts on adaptation. Active campaigns of engagement and dissemination should be encouraged, and further influence should be placed on the importance of participatory processes. Improved communication between science, policy, and society will result in higher level of awareness and understanding of the need to adapt to climate change.

272. **In terms of action the general public can take, DSM is an adaptation action that all energy companies should consider promoting.** Engaging the public in managing electricity demand is a way to increase climate resilience. A highly effective international example is provided by the ÉcoWatt Initiative in France (Ouranos 2016) (see **Box 15**⁸¹).

Box 15. Learning from international best practice: The ÉcoWatt Initiative – Engaging the public in climate resilience

The French Transmission Operator, RTE, had originally planned a new transmission line for the Provence-Alpes-Côte d'Azur (PACA) region to ensure a consistent supply of electricity, even during periods of extreme cold. However, the initial plan failed due to environmental concerns. So, they decided to collaborate with local communities and the Government of France by creating the initiative that later became ÉcoWatt to make the population aware that the risk of major power outages still exists and help them take action to prevent outages.

ÉcoWatt aims to control electricity consumption by educating consumers and by alerting them to potentially major power outages. At the core of ÉcoWatt is a website that uses color codes to indicate the current state of the electricity system: green indicates no risk of outage, orange shows moderate risk, and red indicates high risk. When an orange or red situation arises, all

ÉcoW'acteurs—people and organizations who have subscribed to ÉcoWatt—receive alerts by email, SMS, Facebook, or Twitter. In addition, the company suggests Éco'Gestes—actions to reduce consumption—based on the type of alert.

The impact on peak demand was significant during orange and red alerts: a decline of approximately 2–3 percent.



Snapshot of the ÉcoWatt system webpage

⁸¹ See <https://www.ouranos.ca/en/programs/energy-adaptation-case-studies/>

3.1.8. Develop financial mechanisms to build resilience

273. **The financial sector is increasingly involved in energy sector resilience, providing large amounts of finance and varied ways to reduce the financial impacts of major disruptive weather events affecting the energy sector** (Wang et al. 2016). Using financial protection strategies can increase the financial resilience of governments, utilities, private sector, and households. Financial protection focuses mainly on providing ex ante mechanisms so that appropriate levels of finance are available to maintain power and quickly recover from power supply disruptions during and following natural disasters (Wang et al. 2016). Financial protection options also assist in mitigating the contingent liability for economic participants of the power sector, caused by expenses from managing the direct impacts of a disaster, as well as the indirect impacts to consumers due to electricity price fluctuations (Wang et al. 2016). Based on experience in other countries, a number of financial protection mechanisms are available for the energy sector (as detailed in **Boxes 16 and 17**). With the case of the Uruguay ‘Energy Stabilization Fund’ (**Box 17**), it is recommended that the Ministry of Energy evaluates how a similar fund could operate in Bulgaria under EU state-aid legislation and identifies potential synergies with the Bulgarian ‘Security of the Power System Fund’.

Box 16. Learning from international best practice: Typical financial protection mechanisms in the energy sector

Based on experience in other country contexts, the following mechanisms have been used to protect the energy sector from weather-related risks:

- Insurance of equipment items and structures against meteorological or geological damage (for example transformers, generators, and power stations and substations, including buildings and civil structures)
- Annual contingency budgets generally noted in annual financial returns against their associated business areas
- Accumulated reserves with varying levels of liquidity sometimes allocated to specific contingencies or across various risks based on probability analysis
- Overdraft facilities of up to 15 percent of an organization’s value to provide for rapid preapproved liquidity
- Contingent credit facilities (pre- or post-event), which are typically more expensive than overdraft facilities
- Budget reallocations from normal operational or investment spending when a major event occurs
- National government backing, sometimes with a pre-agreed contingent limit
- Electricity market hedging, using numerous types of risk products (for example, future energy maximum price contracts)
- Bilateral future energy contracts (with unders, overs, and caps)

Source: <http://documents.worldbank.org/curated/en/469681490855955624/pdf/113894-ESMAP-PUBLIC-FINALEnhancingPowerSectorResilienceMar.pdf>

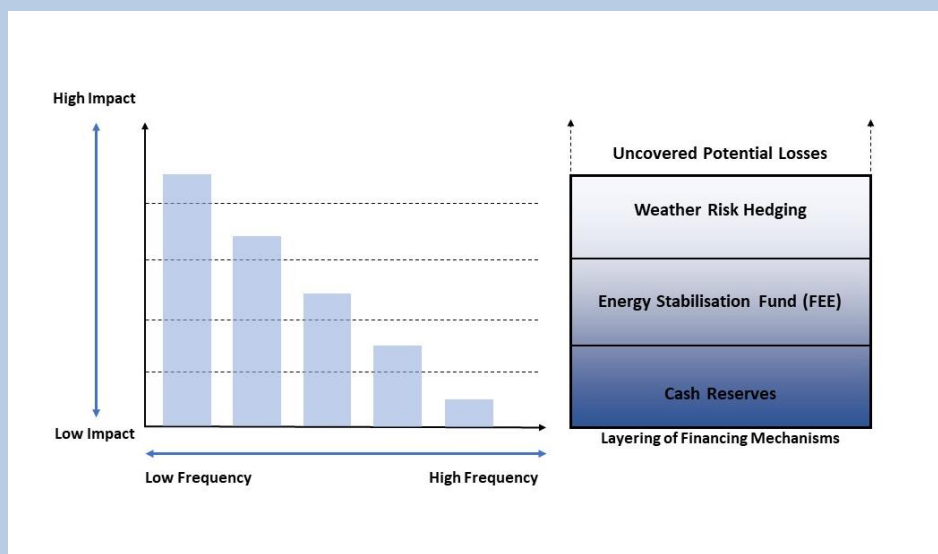
Box 17. Learning from international best practice: Typical financial protection mechanisms in the energy sector

Government-administered, contingent event funds have been operating in some countries for many decades (for example, for seismic risk protection in Japan and New Zealand). However, trust funds held specifically for contingent events affecting the electricity sector are quite rare,

thus this mechanism is viewed as an emerging practice. Uruguay provides one example of how this financial mechanism can work.

In response to high energy price risks faced by its state-owned public electric company (UTE) due to hydropower variability, Uruguay has implemented the Energy Stabilization Fund. This government-administered trust fund retains reserves up to a ceiling level and UTE contributes an annual fee when the fund falls below the ceiling level. Based on well-defined rules, funds are disbursed to UTE during severe drought events that exhaust the company's cash reserves. If the fund has insufficient reserves to meet the defined rules, the government obtains contingent financing up to the ceiling amount. Above this level of risk financing, a further layer of weather-risk hedging is provided, after which risks are not covered.

Figure 29. UTE's Financial Protection Layering against High Energy Cost



Source: <http://documents.worldbank.org/curated/en/469681490855955624/pdf/113894-ESMAP-PUBLIC-FINALEnhancingPowerSectorResilienceMar.pdf>

274. **The use of financial risk management systems as a potential measure to adapt the energy sector was raised by one of the Bulgarian stakeholders consulted.** The stakeholders highlighted that weather-risk hedging through appropriate financial instruments (derivatives) originates in the energy sector as a result of the strong correlation between the climate and the consumption of energy resources. In their opinion, most of the risks associated with unusually high or low temperatures, insufficient wind speed, rainfall, and so on, could be successfully managed with option contracts and transferred to large international hedge funds. According to the stakeholders, in view of the Bulgarian context of limited financial, technological, and time resources, the use of weather-risk derivatives could be a suitable medium-term solution for the energy sector.

275. **While all licensed energy companies in Bulgaria are obliged to provide insurances⁸² for the term of their license, the contribution of insurance companies to climate change mitigation and adaptation in Bulgaria and the insurance mechanisms used by the state are still unsatisfactory** (World Bank Group 2014). Despite the increasing awareness of the need for protection against disasters, further action and consistent steps will need to be taken by the government to establish Financial Disaster Risk Management to address

⁸² Ordinance № 3 of 21 March 2013 for Licensing of the Activities in the Energy Sector, Article 59

the growing challenges of climate change. The combination of insurance products, early warning systems, information campaigns, infrastructure adaptation measures, and strict regulations can significantly contribute to overcoming the negative impacts of climate change.

276. Weather-risk hedging through appropriate financial instruments (derivatives) is a potential measure to adapt the energy sector to future unfavorable climatic conditions.

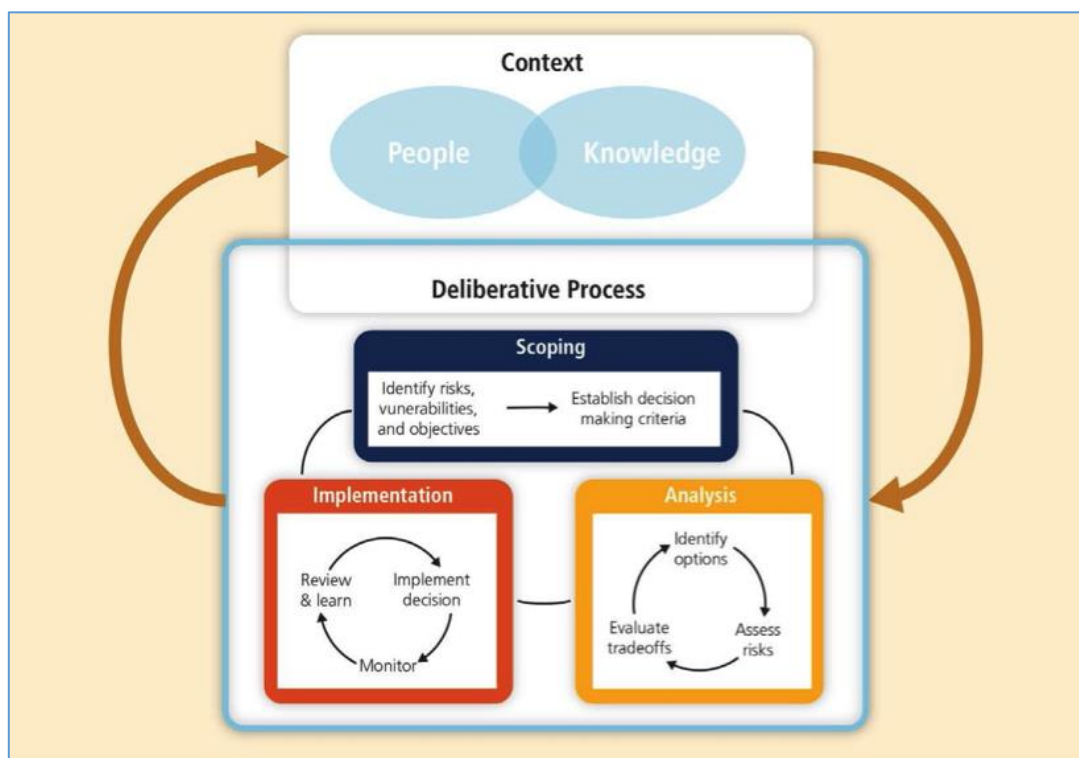
3.2. Experience with Selecting Adaptation Options in the Sector in Other EU Countries

277. **Based on national adaptation planning and private sector activities in other country contexts, a number of common features emerge with respect to the selection of adaptation options.** These include the following:

1) **The importance of a robust risk assessment as a starting point.** In line with international best practice (for example the IPCC 2014; *Figure 30*), an important first step for adaptation planning is to gain an understanding of the nature and possible future severity of climate change risks and opportunities. For instance, in the United Kingdom, one of the major pieces of research underpinning the *National Adaptation Programme* (NAP) (2013) was the U.K. *Climate Change Risk Assessment* (CCRA). The sequence of research and publications that culminated in the UK NAP is outlined in *Box 18*. Similarly, private sector energy owners and operators in the United Kingdom were requested as part of the UK Climate Change Act (2008) *Adaptation Reporting Powers*⁸³ to assess climate risks and opportunities, and then provide details of their responses and proposals. The framework below depicts the assessment process and indicates multiple feedbacks within the system and extending to the overall context.

Figure 30. Framework promoted by the IPCC, showing the iterative nature of risk management

⁸³ The Secretary of State has the power to direct reporting authorities to produce reports on what they are doing to adapt to climate change. The power is referred to as the Adaptation Reporting Power⁸³. Reports were submitted between December 2010 and December 2011 by 91 key infrastructure providers across a number of sectors, including water, energy, transport and public administration. The reports are available for download at <https://www.gov.uk/government/publications/adaptation-reporting-power-received-reports>



Sources: IPCC 2014, Willows and Connell 2003.

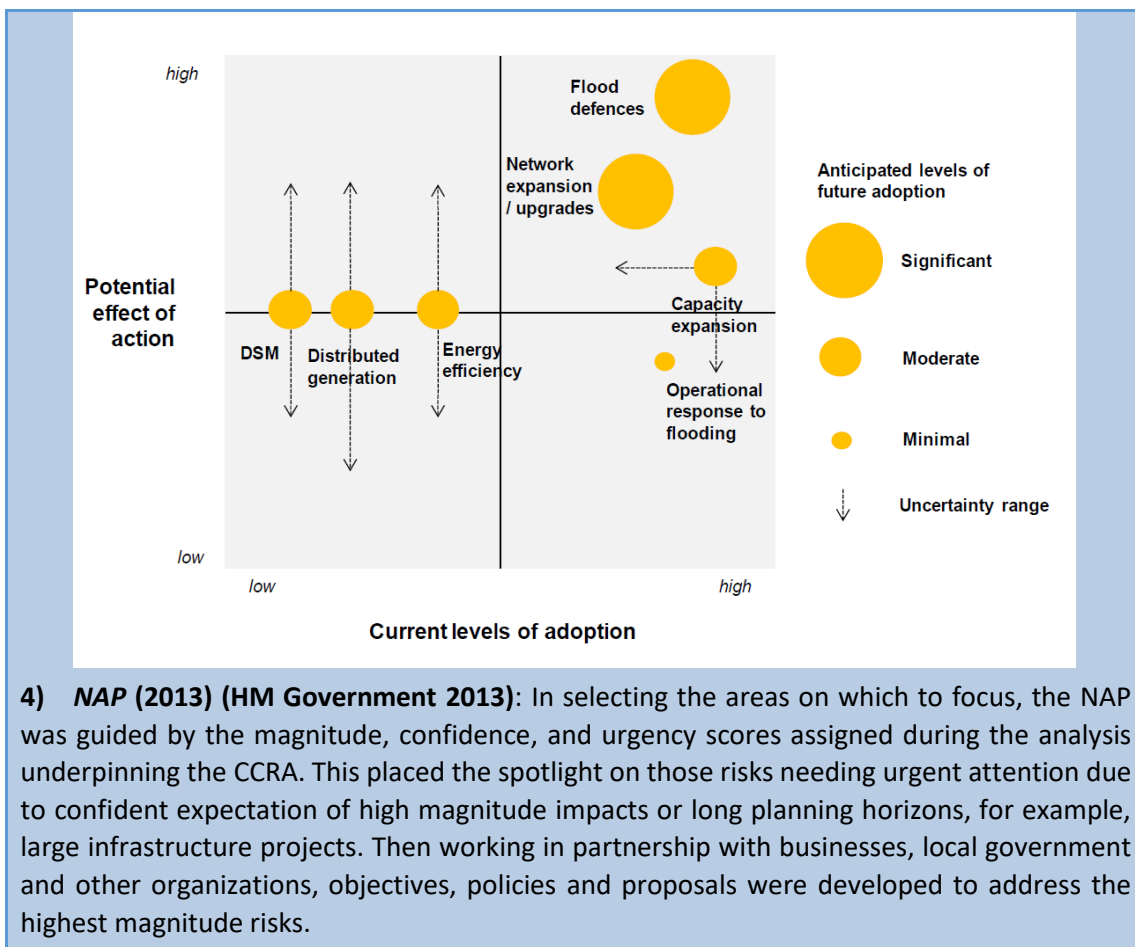
Box 18. Learning from international best practice: Sequence of research and publications in the United Kingdom leading to the NAP, highlighting the importance of a robust risk assessment as a starting point

1) U.K. CCRA (2012) (Defra 2012): The first U.K. CCRA, published in 2012, provides a detailed inventory and analysis of the climate risks and opportunities facing 11 key sectors, including energy, with an indication of their potential magnitude and significance. Where possible, an attempt was made to express the size of individual risks in monetary terms (cost per year); however, due to a lack of available data it was sometimes necessary to use alternative costs (repair or adaption) to provide an estimate. This allowed for an initial comparison of the relative importance of different risks within and between sectors.

2) Adaptive Capacity Report (ACR) (2012) (Ballard, Black, and Lonsdale 2012): The ACR takes impacts and consequent risks derived from the CCRA and assessed whether the capacity to adapt is in place or is being developed on time for it to be realistic for policymakers to plan on the basis the risks are likely to be managed. The ACR distinguishes between two aspects of adaptive capacity, ‘structural adaptive capacity’ and ‘organizational adaptive capacity’.

3) Economics of Climate Resilience (ECR) (2013) (Defra 2013): The ECR explored the drivers of behavior that hinder or promote the adoption of adaptation actions by identifying and assessing market failures and other barriers to effective adaptation action. For each group of actions identified, the ECR provides a summary figure with details of the current and anticipated uptake of adaptation actions and associated effectiveness (an example is shown in **Figure 31**).

Figure 31. Summary of current and anticipated uptake of adaptation and associated effectiveness for the energy sector in the United Kingdom



2) **Priority is given to actions that address existing vulnerabilities.** It is widely proposed that the immediate imperative is to address climate variability (that is, extreme weather events) in its present form as part of the continuum of change. As such, emphasis is frequently placed on impacts to which individual sectors are susceptible, while also considering how these impacts may change over time, by incorporating future climate projections. Developing resilience to climate variability is a step toward adapting to climate change. The process of understanding and developing resilience in the face of extreme weather events can help stakeholders develop a clearer understanding of adaptation needs and ways to implement adaptation responses. This is exemplified by actions being taken by U.K. energy asset owners and operators to manage existing flood risks and in France to address current risks to cooling water abstraction (see earlier EDF case study).

3) **Focus should be placed on actions with long lead times.** It is important to take timely action for long lead time measures, which is frequently common in the energy sector because they often involve changes in infrastructure. Addressing the risks may take considerable time (years to decades) between decision and implementation, and the long-lived nature of the assets means it is important to ‘climate-proof’ the design from the outset.

4) **Awareness actions feature throughout adaptation best practice.** Raising awareness about climate risks, adaptation options, and also about how good climate risk management can save money, is a crucial first step in adaptation planning. Greater levels of awareness will help advance the capacity and skills in delivery teams and facilitate improved coordination, which

is particularly important when dealing with complex, cross-sectoral, and national-scale impacts and trade-offs.

5) **Knowledge gaps still exist and addressing these is an important adaptation priority.** It is impractical to assume that all uncertainties associated with current and future climate risks, and the management options available, can be removed. Nevertheless, targeted research can help reduce the uncertainties. However, it is also important to also recognize that evidence gaps should not prevent action on adaptation. Understanding where the evidence gaps and deficiencies in assessment methods lie will help identify appropriate robust strategies that take full account of the uncertainties in risk.

6) **Adaptation planning needs to be a cyclical and iterative process.** In line with international best practice, (for example IPCC 2014; *Figure 30*) adaptation is a continuous process, involving review, revision and redefinition. This cyclical approach promotes robust decision-making in the face of uncertainty by enabling decisions to be revisited in the light of new information, for instance, the level of potential climate change impacts and associated risks. This is reflected in the cyclical publishing of the U.K. CCRA ever five years. The U.K. NAP also recognizes that the program will inevitably evolve as knowledge grows, allowing re-evaluation of policy based on the underlying evidence.

3.3. Adaptation Options Assessed

3.3.1. Time

278. **Adaptation is a long-term process and priority actions for Bulgaria’s energy sector need to be identified.** Some adaptation measures and associated actions will need to be fast-tracked over the coming decade and others can wait until later. Even in areas of high vulnerability, not all adaptation has to start at once; some measures/actions can be implemented at short notice, whereas others require long-term planning and preparation (Fankhauser et al. 2013).

279. **The adaptation measures proposed for the energy sector will require planning and implementation across a range of time horizons.** Some measures such as those associated with improving the enabling environment and governance framework (for example mainstreaming climate change within sector policies and plans and building institutional capacity and knowledge networks) should be started immediately whereas, physical actions (CAPEX) leading to the intended adaptation outcome (for example changes in design and engineering) will require more planned implementation., Full implementation will only be realized over the longer term. Finally, operational actions (for example changes to operating procedure at power plants) are generally more flexible or reversible than physical one, so should be started earlier.

280. **Major energy infrastructure schemes typically have long lead times and the assets involved have long lives.** Furthermore, many schemes are part of long-term programs to improve the performance of critical public infrastructure systems. All these factors indicate the urgency in responding to risks associated with climate change and the importance of initiating early information gathering (for example monitoring, forecasting, and weather data), scoping (for example review of operations and contingency planning) and awareness raising (for example building institutional capacity). This highlights the interconnected nature of the adaptation options proposed for the energy sector; individual actions are unlikely to be implemented in isolation.

Table 13. Timing of adaptation options proposed for the energy sector

Adaptation category	Time		
	Now	1 – 10 years	10 – 50 years
1. Translate monitoring, forecasting, and weather data for the energy sector	Review existing use of weather/climate data by energy sector stakeholders	Improve access and accessibility to weather/climate data for energy sector stakeholders	
2. Mainstream climate change considerations within energy sector policies and plans	Undertake review of current policies and plans to identify areas where climate change can be integrated	Develop new sector policies and plans with explicit reference to CCA	
3. Incorporate climate resilience into design and	Undertake review of operations and contingency planning to	Review and amend requirements for existing power plants to ensure	Regular review and monitoring of the performance

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Adaptation category	Time		
	Now	1 – 10 years	10 – 50 years
engineering of new power plants and into operations and contingency planning for existing power plants and coal mines	identify areas of current and future vulnerability; review the robustness of Kozloduy ESIA to ensure full and accurate consideration of potential future climate impacts	they withstand ongoing or expected climate impacts; amend plans for new assets to ensure they withstand ongoing or expected climate impacts; implement practical measures (for example change production processes, redesign or modify existing facilities, amend operating practices)	of risk mitigation measures, making amendments where necessary
4. Incorporate climate resilience into design and engineering of new T&D infrastructure and into operations and contingency planning for existing T&D infrastructure	Undertake an assessment of areas of the T&D network particularly exposed to climate impacts; review design standards for new assets;	Amend plans for new assets to ensure they withstand ongoing or expected climate impacts	Regular review and monitoring of the performance of risk mitigation measures, making amendments where necessary
5. Diversify supply, including regional energy trade, district heating/cooling, gasification of households, and small-scale renewables to increase overall energy system resilience	Stress test current and future energy supply and demand to understand areas of vulnerability and required capacity	Develop renewable energy sources (small HPP, solar, wind, and biomass) and micro-grid systems	
6. Improve energy efficiency in public and private sector buildings	Undertake energy efficiency audits to identify the most energy-inefficient public and private sector buildings	Implement practical measures to improve energy efficiency	
7. Build institutional capacity and knowledge networks	Review current levels of awareness and knowledge of climate change within key institutions; implement initial capacity-building program	Continued dissemination and knowledge sharing on climate change impacts and responses by the energy sector (in Bulgaria and internationally)	
8. Develop financial mechanisms to build resilience			

3.3.2. Budget

281. **The costs associated with the adaptation measures and associated actions proposed for the energy sector range from No cost or low cost to high cost.** No- and low-cost measures are classified as those that can be absorbed within existing national/ministerial budgets, or those requiring minimal external support (for example from Multilateral Development Banks [MDBs]). These include the measures associated with improving the enabling environment and governance framework (for example mainstreaming climate change within sector policies and plans, reviewing of operations and contingency planning for power generation, improving weather/climate data, and building institutional capacity and knowledge networks). Medium-cost measures and actions are likely to require dedicated funding, either through identified line-items in national/ministerial budgets or external funding (for example, from MDBs or private finance). Actions falling into this category include improving the energy efficiency of buildings (for example EBRD's current SEFF support, as described in Section 3.1.5) and minor amendments to existing or planned assets to ensure climate resilience (for example T&D infrastructure). High-cost measures and actions are likely to require external financial and technical support and actions falling into this category include major retrofit of existing assets (for example power generation facilities) and significant modifications to plans for new assets (for example NPP Kozloduy). Nevertheless, improving the climate resilience of assets at the design phase typically involves lower costs compared to retrofit at a later date.

282. The adaptation options have been assessed in view of their costs and benefits, based on the experience in other countries/studies. The results are provided in *Annex 10*.

3.3.3. Cost-benefit analysis

283. **Benefits of adaptation measures and associated action in the energy sector can be viewed temporally, as either offering short-term or long-term benefits.** Measures and actions that offer short-term benefits are those which improve resilience to extreme events or those that improve the enabling environment and governance framework to facilitate more effective adaptation in the future (for example mainstreaming climate change within sector policies and plans and building institutional capacity and knowledge networks). Actions offering longer-term benefits are linked to energy assets, which frequently have long lifespans, and include amendments to existing or planned assets to ensure climate resilience (for example T&D infrastructure). In a broad sense, improved energy sector resilience is a potentially significant short- to long-term benefits, and this indicates an existing need to respond to risks associated with climate change.

284. **Benefits can also be viewed in terms of the wider socioeconomic or environmental benefits they offer.** For instance, the identified measure to improve energy efficiency in buildings has the potential to offer multiple co-benefits, namely climate change mitigation objectives, improved comfort for residents and workers, which if targeted at vulnerable groups (for example rural and urban poor) could address social inequality. In addition, the action to review the use of water for cooling processes by TPPs and NPPs has the potential to offer environmental co-benefits through reduced abstraction of freshwater.

285. The CBA for the sector (explained in more detail in *Annex 3*) focuses on the assessment of soft adaptation measures. The benefits gained as a result of their implementation are best

exemplified through the quantification of saved costs in main performance indicators (energy consumption in households, thermal energy consumption in households). Considering the complex impact of the adaptation options on the energy sector, these were not separately quantified in the current CBA. The net present value (NPV) in **Table 14** illustrates the monetary value of avoided losses as a result of implemented adaptation measures, while the cost effectiveness quantifies the benefits achieved in relation to the required investments/costs.⁸⁴

Table 14. Benefits of adaptation measures in the Energy sector under different climate scenarios until 2050 (in €, million)

Climate scenarios	NPV (€ million)	Cost-effectiveness (Benefit/Cost ratio)
Realistic scenario +2°C	67.01	1.05
Optimistic scenario +2°C	114.83	1.08
Pessimistic scenario +2°C	19.18	1.01
Realistic scenario +4°C	475.68	1.34
Optimistic scenario +4°C	548.20	1.39
Pessimistic scenario +4°C	403.16	1.29

286. The projection shows that on average, under the +2°C temperature rise realistic scenario, the total cash flow in NPV is projected at €67.0 million and at €475.7 million under the +4°C realistic scenario. The cash flow in NPV under the optimistic scenario is projected at €114.8 million at +2°C average and at €548.2 million at +4°C average. In the pessimistic scenario the future cash flow is €19.2 million at +2°C and €403.2 million at +4°C.

287. Within the current analysis, the cost-effectiveness of the adaptation measures is used to quantify the effect of investments under each scenario.⁸⁵ Under the +2°C realistic scenario the benefit/cost ratio is €1.05 (that is, the benefits achieved per Euro spent), and €1.34 under the +4°C realistic scenario. The benefit is higher at +4°C temperature rise. In that case, the benefit is €1.39 per one Euro of investment under the optimistic scenario and €1.29 per one Euro of investment under the pessimistic scenario.

288. Benefits of the adaptation measures for the energy sector exceed their costs making them a sound investment for society and their application will contribute to the reduction of energy consumption costs. The return on investments regarding restructuring energy power production is positive. The CBA analysis shows that investment in adaptation measures is economically efficient.

⁸⁴ The NPV of an adaptation option is given by the present value of the estimated benefits and costs. If NPV is more than zero, this indicates that the investment is efficient and incremental benefits of adaptation exceed the incremental resource costs. If NPV is <0 or B/C is <1, then the adaptation measures add no net benefit to the Energy sector. If NPV is >0 or B/C is >1, then it adds positive benefits. The positive value of NPV confirms that investments for adaptation are efficient.

The benefit-cost ratio (B/C) is the ratio of the present value of benefits to the present value of costs. When the B/C ratio is more than one, the present value of the option's benefits is larger than the present value of its costs.

⁸⁵ The cost-effectiveness refers to all measures.

3.3.4. Efforts

289. **In Bulgaria, energy infrastructure is viewed by some stakeholders as being resilient to climate change, due to the fact that it is relatively well planned and maintained.** Being part of the critical infrastructure, energy infrastructure is built, maintained, and operated following well proven construction codes, regulations, and good practices. It takes due account of siting characteristics, among which are weather extremes (for example temperature, rainfall, water supply, or wind) and other inputs (geology, earthquake, land use, and so on) based on historical records plus an engineering ‘safety’ margin. This technical-based view of the energy sector means that making the case for integrating climate resilience within best practice may be relatively easy.

290. **Whether the energy sector is aware of it or not, activity is likely to be underway to address current and future climate risks; scaling up, replicating, and expanding this activity provides an efficient way to improve resilience.** Identification of areas, where current levels of adoption are high, provides one way of increasing resilience with minimal effort. For example, actions to improve energy efficiency (for mitigation purposes) also offer climate-resilience benefits. There may be other examples of action that energy sector stakeholders are taking; however, at present these are not apparent.

291. **In contrast, physical measures are likely to involve significant more effort and may ultimately be constrained by external factors.** Such barriers to adaptation can be technological, institutional, financial, policy, and regulatory. For instance, the ability to develop flood defenses may be constrained by potential impacts on downstream communities and businesses and limited physical space at the site. There may therefore be a need to set up specific contingencies, on a case-by-case basis, to deal with any barriers to adaptation.

3.3.5. Indicators for measurement

292. **To evaluate the progress being made in each area identified as a priority for adaptation, regular review of the following three questions is proposed:⁸⁶**

- 1) **Is there a plan?** Assess whether policies and plans in each area address the relevant climate risks. For example, does the national energy sector strategy explicitly consider climate change and provide a basis for planning decisions that account for current and future flood risks?
- 2) **Are actions taking place?** Assess whether the actions by a range of stakeholders are being delivered and are helping reduce the impacts of climate change.
- 3) **Is progress being made in managing vulnerability?** Considering available data, assess whether vulnerabilities to climate change risks are increasing or decreasing.

293. Responses to each question are classified as either:

- **Red:** Plans and policies, delivery of actions, or progress in addressing vulnerabilities, are lacking;

⁸⁶ This is based on a methodology used by the U.K. Adaptation Sub-Committee to evaluate progress to improve climate resilience across a number of key sectors, including infrastructure. https://www.theccc.org.uk/wp-content/uploads/2015/06/6.736_CCC_ASC_Adaptation-Progress-Report_2015_FINAL_WEB_070715_RFS.pdf

- **Amber:** Adaptation priority has been partially addressed, some evidence of progress in some areas; or
- **Green:** Plans are in place, actions are being delivered, progress is being made.

3.3.6. Institutional arrangements

294. A range of energy sector stakeholders will need to be involved in both identifying and delivering specific adaptation actions, including government, regulators, energy companies and financial institutions (banks, insurers, and investors). Depending on the adaptation measure and associated actions in question, different stakeholders will take on a ‘leading’ or ‘supporting’ role, as depicted in *Table 15*. At present, it has not been possible to define the different roles as stakeholders will have to make commitments for the implementation of measures assigned to them. It is recommended that a multi-stakeholder consultation takes place to define individual roles for each of the adaptation measures.

Table 15. Institutional arrangements for each of the eight adaptation measures identified for the energy sector

Adaptation measure	‘Leading’ institution (and role)	‘Supporting’ institution(s) (and roles)
1. Translate monitoring, forecasting, and weather data for the energy sector		
2. Mainstream climate change considerations within energy sector policies and plans		
3. Incorporate climate resilience into design and engineering of new power plants and into operations and contingency planning for existing power plants and coal mines		
4. Incorporate climate resilience into design and engineering of new T&D infrastructure and into operations and contingency planning for existing T&D infrastructure		
5. Diversify supply, including regional energy trade, district heating/cooling, gasification of households, and small-scale renewables to increase overall energy system resilience		
6. Improve energy efficiency in public and private sector buildings		
7. Build institutional capacity and knowledge networks		
8. Develop financial mechanisms to build resilience		

3.3.7. Consequence no action/maladaptation

295. **Bulgaria’s energy infrastructure, composed of the facilities and systems integral to the functioning of the country, is a priority for adaptation.** Infrastructure systems are long-lived, often sensitive to severe weather, and their failure can have knock-on impacts on other networks and assets. Resilient energy networks and services are also a key attribute of economic competitiveness. Acting now to improve resilience makes economic sense, especially in the context of climate change.

296. **Most infrastructure assets are long-lived and costly to retrofit once they are built.** Energy infrastructure planning and design should therefore account for the projected changes and uncertainties in the future climate over the rest of the century and beyond for the longest-lived assets. Infrastructure can be built from the outset in light of these projections or designed in a way to allow it to be upgraded cost-effectively as the climate changes (termed as ‘managed adaptive’ approach).

3.4. Cross-cutting Issues, Trade-offs, and Synergies of Adaptation Options

297. **Management of water resources is a major cross-cutting issue, affecting the energy sector, together with the water sector, agriculture, biodiversity and ecosystems, urban environment, and tourism.** Adaptation measures and associated actions within the energy sector could have positive and negative consequences for stakeholders in other water-dependent sectors and regions, emphasizing the importance of cross-sectoral and regionally coordinated economic development and environmental management. For instance, the energy sector’s use of water for cooling processes will need to be made considering other users. Within the context of the Danube River Basin, the International Commission for the Protection of the Danube River (ICPDR) provides a key forum for coordinated action and the Danube River Basin Management Plan (2015) provides a framework for collaboration. Flooding is another cross-cutting issue, which requires a coordinated response. Again, with respect to the Danube River Basin, the Danube Flood Risk Management Plan (DFRMP) provides a useful framework for collaboration.

298. **DSM, through energy efficiency measures, intersects with the built environment.** An increase in energy efficiency of dwellings and public spaces can be achieved through construction of new buildings and refurbishment of existing stock. However, caution needs to be exercised to prevent highly energy-efficient, ‘air-tight’ buildings becoming a potential overheating risk, particularly considering the trend toward higher temperatures. Appropriate technology and design should be chosen considering these two objectives.

299. A number of climate change impacts in other sectors can also affect the energy sector. A summary of how climate change effects in other sectors affect the energy sector positively or negatively is presented in *Table 16*.

Table 16. Matrix of interdependencies

Affecting →	WATER SECTOR	
	Positively	Negatively
CC effect in ... (see below) ↑		
Agriculture		<ul style="list-style-type: none"> Increased demand for pumped irrigation due to more frequent/severe drought conditions and prolonged growing season will lead to increased demand for energy Increased demand for irrigation due to more frequent droughts would might lead to competition for water resources between the two sectors
Biodiversity and Ecosystems	<ul style="list-style-type: none"> Increased biomass production due to climate change may contribute to increased production of renewable fuels Regulating services may support increased water supply, including for energy production 	<ul style="list-style-type: none"> Increased restrictions/legislation to protect the natural environment may affect the location of energy assets Increased air and water temperature combined with changes in precipitation may lead to increase in invasive species causing damage to the cooling system of TPP and NPP
Forestry	<ul style="list-style-type: none"> Increased use of wood in construction will result in improved energy efficiency of housing stock 	<ul style="list-style-type: none"> Increased restrictions/legislation to protect the natural environment may affect the location of energy assets
Human Health		<ul style="list-style-type: none"> Increased heat-related health and safety risks for maintenance workers
Tourism		<ul style="list-style-type: none"> Prolonged summer season and higher summer temperatures will lead to increase in the number of tourists at the seaside, therefore increasing the need for cooling systems in summer (higher energy demand)
Transport		<ul style="list-style-type: none"> Lower levels of the Danube River due to more frequent/severe drought conditions will lead to suspended transport along the river, disrupting deliveries of imported coal. Cold spells in winter will freeze the Danube River and suspend transportation along the river, disrupting deliveries of imported coal.
Urban Environment	<ul style="list-style-type: none"> Reduced demand for heating due to warmer winter temperatures will lead to reduced demand for energy 	<ul style="list-style-type: none"> Increased demand for space cooling due to higher temperatures will lead to increased demand for energy
Water	<ul style="list-style-type: none"> Increase in river flow affecting the performance of hydropower (small and large) 	<ul style="list-style-type: none"> Increasing water scarcity will create tensions between different users (for example agriculture, public supply, and ecosystems) and will affect the availability of water for power generation (that is, cooling water and hydropower)

Note: The above matrix of sectoral interdependencies reflects how climate change effects in one sector affect the energy sector positively or negatively

3.5. Priority Setting Approach

300. Identification of CCA options is an important step in the process of establishing resilience to climate change. However, it is not realistic to expect that all identified adaptation options can be implemented simultaneously. Therefore, adaptation options are normally scored to establish a priority order for their implementation. In the framework of this report we have, following EU guidance,⁸⁷ prioritized the adaptation options specifically identified for the energy sector.

301. In support of the priority setting a prioritization meeting was organized in Sofia in November 2017, inviting a variety of stakeholders from the sector. The meeting used a basic version of the multi-criteria analysis (MCA) approach. MCA is an approach as well as a set of techniques that aims at providing an overall ordering of options, ranging from the most preferred to the least preferred. It represents a way of looking at complex problems that are characterized by a mix of monetary and non-monetary objectives. MCA breaks down options into more manageable pieces by using a set of criteria. The two groups of criteria used for the analysis were those of ‘Net Benefits’, further broken down into economic, social, and environmental benefits, and ‘Implementation Risks’, further broken down into financial, social, institutional, technical, and technological risks. This approach allows data and judgements to focus on the separate pieces that are then reassembled to present a coherent overall picture.

302. In carrying out the MCA (that is ‘scoring the different adaptation options’), the meeting benefited from the presence of stakeholders with professional knowledge and experience in the sector. Nevertheless, this priority setting effort must be considered as indicative and tentative, for three main reasons. First, the effort was carried out at an early stage in the process of developing a strategic view and planning of sector-specific CCA options. Second, not all those who were invited to the prioritization meeting used this invitation to attend. And third, a broader understanding of underlying information and notions at the side of the stakeholders would be beneficial to allow them to make more founded scores. Therefore, the current priority list only serves as a ‘first feel’ about the main direction of the actions to be taken first.

303. At a later stage, further attention should be paid to the priority setting process, both for this sector and across all economic sectors that play a role in the planning of Bulgaria’s CCA actions.

304. The five main priority adaptation options that were tentatively and indicatively identified for the energy sector are as follows:

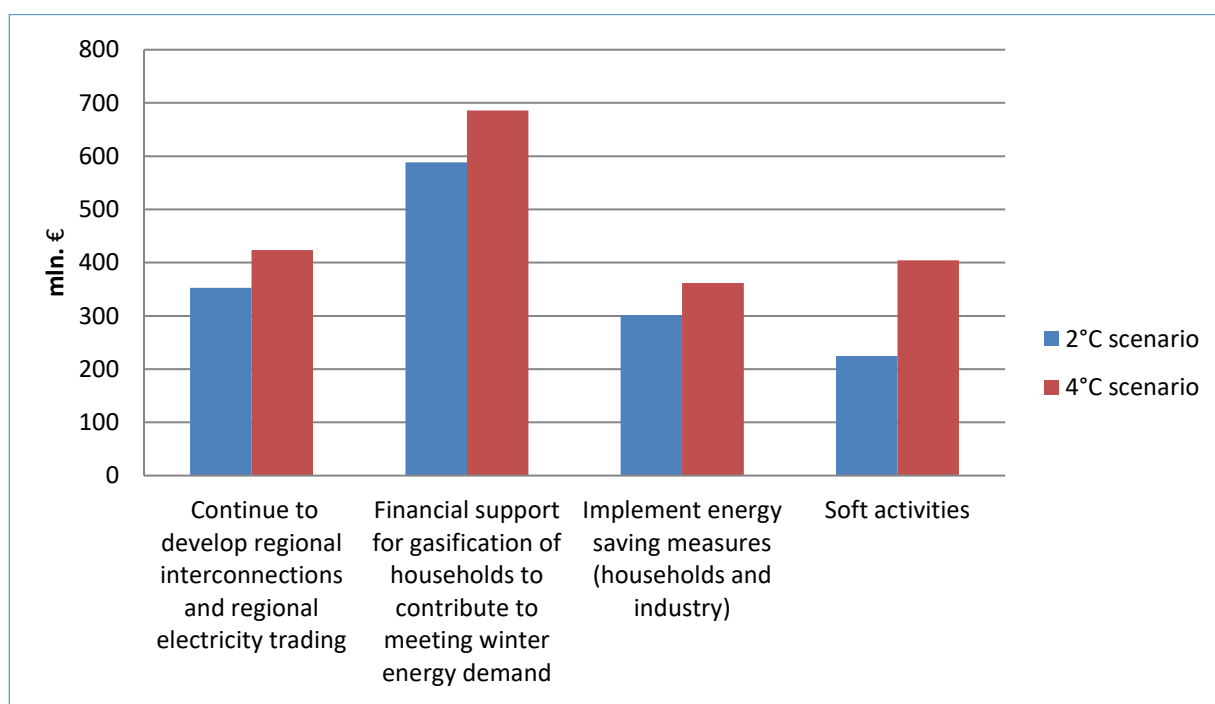
- 1) Advance efforts to motivate end users of energy to implement energy saving measures, especially households
- 2) Review costs and benefits of incorporating climate resilience into design of new power plants
- 3) MoEW to ensure that climate resilience is integrated into water resources management and associated decisions affecting the operation of large HPPs

⁸⁷ <http://climate-adapt.eea.europa.eu/knowledge/tools/adaptation-support-tool/step-4/prioritise-and-select>

- 4) Undertake an inventory of strategies, policies, plans, standards, energy infrastructure design norms and other, to identify those where climate resilience should be incorporated
- 5) When the new Energy Strategy is developed, ensure climate resilience is mainstreamed into it

305. The results of the CBA identify the most economically efficient adaptation actions and allow for their ranking. The adaptation measures for which the benefit exceeds the cost can be ranked as follows: Financial support for gasification; Continue to develop regional interconnections and regional electricity trading; Implement energy saving measures; soft activities; and others. The figure below shows the estimated contribution of selected adaptation measures in reaching the overall positive effects of climate change adaptation.

Figure 32. Prioritization of the adaptation measures (total NPV effects in € million)



3.6. Conclusions

306. The report highlights the importance of various measures to initiate a climate change adaptation process based on analysis of the risks and vulnerabilities of the energy sector in Bulgaria and examples of best international practice. As with any emerging policy, some measures may prove successful, others may not produce the expected results. The decision process about investments in adaptation will evolve and new decision needs will emerge in the future as information about climate change impacts improves and experience reveals the effectiveness of various early adaptation efforts.

307. This does not mean, however, that no actions should be taken now. In the short term, there are a number of critical actions that Bulgaria could take to help the energy sector better manage climate variability and lay the foundations of the sector resilience to climate change. There are many requirements for meeting the challenge of climate change. They include:

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- more sector-oriented and high-quality data;
- better monitoring and warning systems;
- greater interaction and growing interdisciplinarity between scientists and political and operational players in the field of adaptation to maximize technology transfer;
- increasing awareness and open-mindedness of all society to identify and prioritize the right problems.

308. Finally, the perceptions and behaviors, the processes and factors leading to decision-making, and the goals and convictions of individuals and communities appear fundamental to the adaptation of human systems because it is humans who will, in the end, make the right or wrong decisions influencing the future.

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Annex 1. Potential Climate Change Impacts on the Energy Sector in Bulgaria

Table 17. Potential climate change impacts on the energy sector in Bulgaria

Affected Energy Sector aspects	High temp		Low temp		Prolonged rainfall		Drought		Water table rise		Sea level rise		Specific effects of CC relevant for energy				Extreme Weather Events											
													River temp		River quality		Electric storms		Fog		Floods		Avalanches		Landslides		Storms	
	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D	P
ELECTRICITY																												
Coal power plants	M	H	L	L	L	M	M	H	L	L	-	-	M	H	M	M	U	U	L	U	M	H	L	L	L	L	L	U
Gas power plants	M	H	L	L	L	M	M	H	L	L	-	-	M	H	M	M	U	U	L	U	M	H	L	L	L	L	L	U
Nuclear power plants	M	H	L	L	L	M	M	H	L	L	-	-	M	H	M	M	U	U	L	U	M	H	L	L	L	L	L	U
Hydropower plants	L	H	L	L	M	M	H	H	L	L	-	-	L	L	L	M	U	U	L	U	H	H	L	L	M	L	L	U
Wind power plants	L	H	L	L	L	L	L	L	L	L	-	-	-	-	-	-	U	U	L	U	L	H	L	L	M	L	M	U
Solar photovoltaic power plants	-	-	L	L	M	M	L	L	L	L	-	-	-	-	-	-	U	U	M	U	L	H	-	-	L	L	M	U
Biomass power plants	L	H	L	L	L	M	L	L	L	L	-	-	-	-	-	-	U	U	L	U	M	H	L	L	L	L	L	U
Geothermal energy	L	H	L	L	L	M	L	L	L	L	-	-	-	-	-	-	U	U	L	U	M	H	L	L	L	L	L	U
PRIMARY ENERGY																												
Coal supply (international)	L	L	L	L	M	H	L	L	L	L	-	-	-	-	-	-	L	U	L	U	M	H	L	L	L	M	M	U
Coal supply (national)	M	M	L	L	H	H	M	L	M	L	-	-	-	-	-	-	L	U	L	U	H	H	L	L	M	M	M	U
Oil supply (international)	L	L	L	L	L	M	L	L	L	L	-	-	-	-	-	-	L	U	L	U	L	M	L	L	L	L	L	U
Gas supply (international)	L	L	L	L	L	M	L	L	L	L	-	-	-	-	-	-	L	U	L	U	L	M	L	L	L	L	L	U
Gas supply (national)	L	L	L	L	L	M	L	L	L	L	U	U	-	-	-	-	L	U	L	U	L	M	L	L	L	L	L	U
INFRASTRUCTURE																												
Transmission system	M	H	L	L	M	H	L	L	L	L	-	-	-	-	-	-	U	U	L	U	H	H	M	M	M	M	M	U
Distribution system	M	H	L	L	M	H	L	L	L	L	-	-	-	-	-	-	U	U	L	U	H	H	M	M	M	M	M	U
Sub stations	M	H	L	L	M	H	L	L	L	L	-	-	-	-	-	-	U	U	L	U	H	H	M	M	M	M	M	U
Communications/control systems	M	H	L	L	M	H	L	L	L	L	-	-	-	-	-	-	U	U	L	U	H	H	M	M	M	M	M	U
MARKET																												
Higher energy demand (summer cooling)	H	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lower energy demand (winter heating)	-	-	H ^a	H	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Legend: D = damage; P = probability of occurrence by 2050 at latest; U = unknown; H = high; M = medium; L = low
red = negative impact; green = positive impact; blank = neutral impact.

Note a: Reduction in the number and duration of cold spells/cold waves causes reduced demand for winter heating.

Annex 2. Climate Change Adaptation Options in Detail

Table 18. Adaptation options presented in detail

CLIMATE CHANGE ADAPTATION OPTIONS						
VIII. Translate monitoring, forecasting and weather data for the energy sector						
1. MEETINGS WITH NIMH-BAS TO DEFINE NEEDS FOR CLIMATE SERVICES						
Relevant to:	Primary Energy Supply	Electricity generation	Supply/Demand Balance	T&D	Heating production and distribution	
	X	X	X	X	X	
Description	<p>Organization of meetings between energy sector decision-makers/operators (MEn, NEC, ESO, power plant operators/engineers, distribution companies, district heating companies) MoEW and NIMH-BAS to define needs of energy sector decision makers/operators for climate services to build climate resilience in the sector. These climate services may include:</p> <ul style="list-style-type: none"> • Very short-term forecasting for an extreme event (for example flood – expected flow to HPPs; landslide – damage to T&D infrastructure; heavy rainfall – pre-emptive checks of drainage systems at NPPs; high temperatures – sagging of T&D lines and overheating of substations; icing – T&D infrastructure;) • Operational forecasting tools, typically one year ahead and revised every month (for example inflows into HPPs, to include data on snow water equivalent) • Longer-term projections of climatic conditions aligned with life of assets (for example 30 years for T&D infrastructure; 100–150 years for dams) • Where possible, consider the use of Earth Observations (EO) data (for example satellite data for landslides) 					
Option's relevance						
Economic	Ecologic	Social				
++	+	++				
Opportunities that arise	Investing in new equipment/technology has the potential to generate jobs in operation/maintenance. There is also the opportunity to explore with neighboring countries and other sectors how these climate services may offer wider benefits. This may allow Bulgaria to position itself as a leading innovator in the use and provision of climate services.					
Cross-cutting relevance	YES	Improving monitoring, forecasting, and weather data has the potential to offer benefits to multiple sectors. The use of such data extends beyond the energy sector, to cover for instance, transport, water, emergency planning and response.				
Risks addressed	All risks					
2. CENTRALIZED AGREEMENT FOR PROVISION OF CLIMATE SERVICES FROM NIMH-BAS						
Relevant to:	Primary Energy Supply	Electricity generation	Supply/Demand Balance	T&D	Heating production and distribution	
	X	X	X	X	X	
Description	MEn to put in place centralized agreement for provision of climate services from NIMH-BAS for energy sector climate resilient decision making. (An existing agreement with MoEW may provide a template for this)					
Option's relevance						
Economic	Ecologic	Social				
Opportunities that arise	Having a formalized agreement in place will facilitate the broader use of climate services within the energy sector.					
Cross-cutting relevance	YES	It is likely that other sectors using climate services may also require equivalent centralized agreements.				
Risks addressed	All risks					

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3. IMPROVE THE SURFACE-BASED WEATHER/CLIMATE OBSERVATION NETWORK						
Relevant to:	Primary Energy Supply	Electricity generation	Supply/Demand Balance	T&D	Heating production and distribution	
	X	X	X	X	X	
Description		NIMH-BAS have several automated stations, which need modernization. All other stations are non-automated. For these non-automated stations, there are not enough observers.				
Option's relevance						
Economic	Ecologic					
++	+	++				
Opportunities that arise		Investing in new equipment/technology has the potential to generate jobs in operation/maintenance. There is also the opportunity to explore with neighboring countries and other sectors how these climate services may offer wider benefits. This may allow Bulgaria to position itself as a leading innovator in the use and provision of climate services.				
Cross-cutting relevance		YES	Improving monitoring, forecasting, and weather data has the potential to offer benefits to multiple sectors. The use of such data extends beyond the energy sector, to cover for instance, transport, water, emergency planning and response.			
Risks addressed		All risks				
4. ENSURE NIMH - BAS HAS SUFFICIENT HUMAN RESOURCES						
Relevant to:	Primary Energy Supply	Electricity generation	Supply/Demand Balance	T&D	Heating production and distribution	
	X	X	X	X	X	
Description		Ensuring NIMH-BAS has sufficient human resources, including appropriate expertise and ongoing staff professional development, to provide a sustainable service that meets the needs for weather/climate information from users. Currently there is a lack of human resources/experts; the meteorology specialty has only one university graduate for 2017. There is an identified and urgent need for specialists with technical education.				
Option's relevance						
Economic	Ecologic					
++	+	++				
Opportunities that arise		Developing a highly qualified and skilled team of meteorologists/hydrologists/climate scientists has the potential to significantly strengthen the institutional capacity within hydrometeorological and climate services. There is the opportunity to explore with neighboring countries and other sectors how these climate services may offer wider benefits. This may allow Bulgaria to position itself as a leading innovator and educator in the use and provision of climate services.				
Cross-cutting relevance		YES	Improvement of NIMH-BAS human resources will have positive impact on the quality of climate services provided for all sectors. The use of such data extends beyond the energy sector, to cover for instance, transport, water, emergency planning and response.			
Risks addressed		All risks				

IX. Mainstream climate change considerations within energy sector policies and plans						
5. UNDERTAKE AN INVENTORY OF STRATEGIES, POLICIES, PLANS, STANDARDS, ENERGY INFRASTRUCTURE DESIGN NORMS AND SO ON, TO IDENTIFY THOSE WHERE CLIMATE RESILIENCE SHOULD BE INCORPORATED						
Relevant to:	Primary Energy Supply	Electricity generation	Supply/Demand Balance	T&D	Heating production and distribution	
	X	X	X	X	X	
Description	<p>The review of the legislative framework (chapter 2.4) shows that it needs revision to become instrumental for addressing climate change impact. Although at national level, some legislative and strategic documents as well as RBMPs and FRMPs consider climate change, other documents are not flexible enough in addressing climate change and its impact. Furthermore, roles and responsibilities for CCA have not yet been clarified. Subsector regulations do not have specific climate change related provisions as well.</p> <p>The IEA has identified many examples of emerging and recommended policies that should be considered:</p> <ul style="list-style-type: none"> • Design and safety standards • Permissions and zoning • Efficiency standards • Innovation/research and development (R&D) 					
Option's relevance						
Economic	Ecologic	Social				
++	+	+				
Opportunities that arise	When the legislation is oriented toward preventive climate change risk management, this saves financial resources for post-event recovery.					
Cross-cutting relevance	YES	Some legislative documents cut across multiple sectors (for example water, emergency planning and response).				
Risks addressed	All risks					
6. ENSURE OUTCOMES OF CLIMATE CHANGE ADAPTATION REPORT (SECTOR ASSESSMENT FOR ENERGY) ARE BUILT INTO THE CLIMATE-ENERGY PLAN						
Relevant to:	Primary Energy Supply	Electricity generation	Supply/Demand Balance	T&D	Heating production and distribution	
	X	X	X	X	X	
Description	<p>Bulgaria abides by its commitments to the EU 2030 Climate-Energy Package. This framework, adopted in October 2014, brings together different climate and energy policy objectives, including: security of energy supply, competitiveness of the economies through a high-tech approach and effectiveness of costs and resources, reduction of greenhouse gas emissions and others.</p> <p>For realization of these basic objectives, the Bulgarian government is developing a national plan 'Climate – Energy' and a new Energy strategy. The Climate-Energy Plan should consider and build on the outcomes of this CCA report. For climate resilience to be sustainable and applicable on a wide scale, it must be incorporated into this key national policy.</p>					
Option's relevance						
Economic	Ecologic	Social				
++	++	++				
Opportunities that arise	When the legislation is oriented toward preventive climate change risk management, this is likely to save financial resources for post-event recovery.					
Cross-cutting relevance	YES	National Energy policy affects all sectors of the economy.				
Risks addressed	All risks					

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7. MAINSTREAM CLIMATE RESILIENCE INTO THE SPATIAL PLANNING ACT						
Relevant to:	Primary Energy Supply	Electricity generation	Supply/Demand Balance	T&D	Heating production and distribution	
	X	X	X	X	X	
Description	Sectoral policies and plans should focus on ensuring energy infrastructure is located, planned, designed, and maintained to be resilient to climate change, including increasingly extreme weather events. The Spatial Planning Act is viewed as a key policy in ensuring that this objective is achieved.					
Option's relevance						
<table border="1"> <tr> <td>Economic</td> <td>Ecologic</td> <td>Social</td> </tr> <tr> <td>++</td> <td>++</td> <td>++</td> </tr> </table>						
Economic	Ecologic	Social				
++	++	++				
Opportunities that arise	When the legislation is oriented toward preventive climate change risk management, this is likely to save financial resources for post-event recovery.					
Cross-cutting relevance	YES	Spatial Planning Act cuts across multiple sectors (for example water, transport, housing, emergency planning and response).				
Risks addressed	All risks					
8. MAINSTREAM CLIMATE RESILIENCE INTO EIA REGULATIONS, FOLLOWING EC REQUIREMENTS						
Relevant to:	Primary Energy Supply	Electricity generation	Supply/Demand Balance	T&D	Heating production and distribution	
	X	X	X	X	X	
Description	The decisions energy owners and operators, regulators, and the government make over the next few years must be informed by an understanding of climate risks. If they are not, the country may be locked into infrastructure development pathways that do not provide adequate protection against future climate impacts and may be detrimental to the economy. There are economic benefits to be gained by adapting infrastructure to a changing climate, as long as decisions are taken at the right time. To ensure that assets planned for construction perform effectively over their planned lifespans, it will be crucial that climate change considerations are integrated into their design and operation.					
Option's relevance						
<table border="1"> <tr> <td>Economic</td> <td>Ecologic</td> <td>Social</td> </tr> <tr> <td>+</td> <td>+++</td> <td>++</td> </tr> </table>						
Economic	Ecologic	Social				
+	+++	++				
Opportunities that arise	When the legislation is oriented toward preventive climate change risk management, this is likely to save financial resources for post-event recovery.					
Cross-cutting relevance	YES	EIA regulations cut across multiple sectors (for example water, transport, housing, environment).				
Risks addressed	All risks					
9. WHEN THE NEW ENERGY STRATEGY IS DEVELOPED, ENSURE CLIMATE RESILIENCE IS MAINSTREAMED INTO IT						
Relevant to:	Primary Energy Supply	Electricity generation	Supply/Demand Balance	T&D	Heating production and distribution	
	X	X	X	X	X	
Description	The new 'Energy Strategy' is viewed as a highly important policy document, in terms of setting the national priorities and targets for the energy sector, both climate change mitigation and climate change adaptation. For climate resilience to be sustainable and applicable on a wide scale, it must be incorporated into this key national policy. A broad range of stakeholders needs to be involved in this process. This will include national government ministries, sector authorities, and sub-national governments. Stakeholder involvement helps to ensure that policies are informed by practical knowledge and experience 'from the ground'.					
Option's relevance						
<table border="1"> <tr> <td>Economic</td> <td>Ecologic</td> <td>Social</td> </tr> <tr> <td>++</td> <td>++</td> <td>++</td> </tr> </table>						
Economic	Ecologic	Social				
++	++	++				
Opportunities that arise	When the legislation is oriented toward preventive climate change risk management, this is likely to save financial resources for post-event recovery.					
Cross-cutting relevance	YES	National Energy policy affects all sectors of the economy.				
Risks addressed	All risks					

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10. MAINSTREAM CLIMATE RESILIENCE INTO ENERGY SECTOR INVESTMENT PLANS, BY DEFINING CLIMATE RISKS IN TERMS OF PROBABILITY AND CONSEQUENCE						
Relevant to:	Primary Energy Supply	Electricity generation	Supply/Demand Balance	T&D	Heating production and distribution	
	X	X	X	X	X	
Description	Sectoral policies and plans should focus on ensuring energy infrastructure is located, planned, designed, and maintained to be resilient to climate change, including increasingly extreme weather events. The decisions energy owners and operators, regulators, and the government make over the next few years must be informed by an understanding of climate risks. Energy operators utilize risk assessments to develop investment plans; for climate risks to be accurately incorporated into this business planning process, they need to be assigned a probability of occurrence and magnitude of consequence.					
Option's relevance						
Economic	Ecologic	Social				
++	+	+				
Opportunities that arise	When the legislation is oriented toward preventive climate change risk management, this is likely to save financial resources for post-event recovery.					
Cross-cutting relevance	YES	Some legislative documents cut across multiple sectors (for example water, emergency planning and response).				
Risks addressed	All risks					
11. IDENTIFY CLIMATE-SENSITIVE DESIGN NORMS FOR ENERGY INFRASTRUCTURE; EVALUATE COSTS AND BENEFITS OF UPDATING DESIGN NORMS VS. DOING NOTHING, AND MAKE DECISIONS ABOUT WHICH DESIGN NORMS TO UPDATE						
Relevant to:	Primary Energy Supply	Electricity generation	Supply/Demand Balance	T&D	Heating production and distribution	
	X	X	X	X	X	
Description	Sectoral policies and plans should focus on ensuring energy infrastructure is located, planned, designed and maintained to be resilient to climate change, including increasingly extreme weather events. The decisions energy owners and operators, regulators, and the government make over the next few years must be informed by an understanding of climate risks. Decision makers typically utilize a range of evaluation techniques (MCA, CBA, and other) to prioritize investment and it is critical such tools are also employed to consider climate-related risks.					
Option's relevance						
Economic	Ecologic	Social				
++	++	+				
Opportunities that arise	When the legislation is oriented toward preventive climate change risk management, this is likely to save financial resources for post-event recovery.					
Cross-cutting relevance	YES	Some legislative documents cut across multiple sectors (for example water, transport, housing, environment).				
Risks addressed	Climate-related risks to energy supply					
12. INCORPORATE SEASONAL CLIMATE FORECASTS AND LONG-TERM CLIMATE CHANGE PROJECTIONS INTO SEASONAL AND LONG-TERM POWER DEMAND FORECASTS (ESO AND MEN)						
Relevant to:	Primary Energy Supply	Electricity generation	Supply/Demand Balance	T&D	Heating production and distribution	
	X	X	X	X	X	
Description	A key area where knowledge needs to be improved is around the future energy balance, particularly power demand considering future climate scenarios. Energy planners and policymakers are likely to be mapping to a certain model of the future, but that future is changing. For instance, extra demand for air-conditioning in the face of rising temperatures will significantly affect power demand.					
Option's relevance						
Economic	Ecologic	Social				
++	-	++				
Opportunities that arise	There is the opportunity to reduce costs by taking a more considered and proactive approach (rather than reactive approach) to assess the impacts of					

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	climate variability and change on power demand.	
Cross-cutting relevance	YES	The approach taken to manage the nation's energy supply and demand balance affects all sectors of the economy, through the provision of energy, service reliability and costs.
Risks addressed	Climate-related risks to energy supply.	

13. INCORPORATE CLIMATE RESILIENCE AND IMPROVED CONTINGENCY PLANNING INTO THE MANAGEMENT OF INFRASTRUCTURE THAT SUPPORTS THE ENERGY SECTOR (FOR EXAMPLE DYKES AND ACCESS ROADS FOR NPPs)

Relevant to:	Primary Energy Supply	Electricity generation	Supply/Demand Balance	T&D	Heating production and distribution
	X	X	X	X	X
Description	The energy sector is reliant on a diverse suite of supporting infrastructure (for example water and transport networks). Cross-sectoral and sector-specific policies and plans should focus on ensuring that all supporting infrastructure is located, planned, designed, and maintained to be resilient to climate change, including increasingly extreme weather events. The decisions all infrastructure owners and operators, regulators, and the government make over the next few years must be informed by an understanding of climate risks and their interconnections between sectors.				
Option's relevance					
Economic	Ecologic	Social			
++	++	++			
Opportunities that arise	When the legislation is oriented toward preventive climate change risk management, this is likely to save financial resources for post-event recovery.				
Cross-cutting relevance	YES	Some legislative documents cut across multiple sectors (for example water, transport, emergency planning and response).			
Risks addressed	Risks to energy supply through damage to supporting infrastructure from extreme weather events				

X. Incorporate climate resilience into design and engineering of new power plants, and into operations and contingency planning for existing power plants and coal mines

14. MOEW TO ENSURE THAT CLIMATE RESILIENCE IS INTEGRATED INTO WATER RESOURCES MANAGEMENT AND ASSOCIATED DECISIONS AFFECTING THE OPERATION OF LARGE HPPs

Relevant to:	Primary Energy Supply	Electricity generation	Supply/Demand Balance	T&D	Heating production and distribution
		X	X		
Description	The operation and performance of HPP should be assessed considering potential future river flow conditions. Drawing upon hydrological and meteorological data, existing hydropower infrastructure could be operated differently to improve its climate resilience and safety.				
Option's relevance					
Economic	Ecologic	Social			
++	++	+			
Opportunities that arise	Operational changes are generally much cheaper than physical changes to infrastructure (that is, retrofit to existing or new capital expenditure).				
Cross-cutting relevance	YES	The approach taken to manage the nation's energy supply affects all sectors of the economy, through the provision of energy, service reliability and costs.			
Risks addressed	Climate-related risks to energy supply.				

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15. REVIEW COSTS AND BENEFITS OF INCORPORATING CLIMATE RESILIENCE INTO DESIGN OF NEW POWER PLANTS						
Relevant to:	Primary Energy Supply		Electricity generation	Supply/Demand Balance	T&D	Heating production and distribution
				X	X	
Description	Climate change should be factored into the design and operation of planned infrastructure investments. The greatest opportunity to manage climate risks presents itself at the very beginning of a project lifecycle when important concept and design decisions have not yet been made (such as site and technology selection). Early stages of the planning process could be used to screen the project for climate change risks and opportunities and decide whether further consideration and analysis is justified. Later stages could be used to undertake more detailed climate change-related analyses and refine how climate change considerations can be integrated within site selection and project design.					
Option's relevance						
Economic	Ecologic	Social				
++	+	+				
Opportunities that arise	Building resilience to climate change at the design stage will be more economically efficient than retrofitting the asset later.					
Cross-cutting relevance	YES	The approach taken to manage the nation's energy supply affects all sectors of the economy, through the provision of energy, service reliability and costs.				
Risks addressed	Climate-related risks to energy supply.					

XI. Incorporate climate resilience into design and engineering of new T&D infrastructure, and into operations and contingency planning for existing T&D infrastructure

16. DEVELOP MAPS SHOWING CLIMATE RISK ZONES						
Relevant to:	Primary Energy Supply		Electricity generation	Supply/Demand Balance	T&D	Heating production and distribution
					X	X
Description	Develop maps showing climate risk zones for climatic parameters relevant to T&D infrastructure, to inform decisions about which parts of the T&D networks require climate resilience actions. Wherever possible, asset location and transmission line routes should for example avoid landslide prone areas or flood zones. Choice of building materials, and other factors should be cognizant of local climate conditions, such as temperature extremes, weight loads of towers, peak expected wind speeds, effects of freeze-thaw cycles, and so on.					
Option's relevance						
Economic	Ecologic	Social				
++	+	+				
Opportunities that arise	Identifying and increasing the resilience of weak points in the T&D network and individual assets will improve service reliability in the long-term. Taking a more considered, holistic approach is likely to also reduce the need for reactive responses and repeated capital expenditure to fix reoccurring problems.					
Cross-cutting relevance	YES	The approach taken to manage the nation's energy supply affects all sectors of the economy, through the provision of energy, service reliability and costs.				
Risks addressed	Risks to energy supply through damage to T&D infrastructure from extreme weather events					

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17. CONTINUE TO MONITOR CAUSES OF INTERRUPTIONS							
Relevant to:		Primary Energy Supply	Electricity generation	Supply/Demand Balance	T&D	Heating production and distribution	
					X	X	
Description		Continue to monitor causes of interruptions to the T&D system and to classify climate/weather-related causes, to understand which weather hazards lead to most outages, and to identify any trends in their frequency.					
Option's relevance							
Economic	Ecologic						Social
++	+	+					
Opportunities that arise		Identifying and increasing the resilience of weak points in the T&D network and individual assets will improve service reliability in the long-term. Taking a more considered, holistic approach is likely to also reduce the need for reactive responses and repeated capital expenditure to fix reoccurring problems.					
Cross-cutting relevance		YES	The approach taken to manage the nation's energy supply affects all sectors of the economy, through the provision of energy, service reliability and costs.				
Risks addressed		Risks to energy supply through damage to T&D infrastructure from extreme weather events					

18. UNDERTAKE CBA TO EVALUATE WHETHER ADDITIONAL SECTIONS OF THE DISTRIBUTION SYSTEM SHOULD BE CHANGED TO UNDERGROUND CABLES, CONSIDERING CHANGES IN THE FREQUENCY AND SEVERITY OF EXTREME EVENTS, AND CONSEQUENT DAMAGES TO THE NETWORK							
Relevant to:		Primary Energy Supply	Electricity generation	Supply/Demand Balance	T&D	Heating production and distribution	
					X	X	
Description		Continue to monitor causes of interruptions to the T&D system and to classify climate/weather-related causes, to understand which weather hazards lead to most outages, and to identify any trends in their frequency. Individual investment decisions should be taken based on an understanding of the likelihood of occurrence and magnitude of consequence of individual climate risks and using robust decision-making tools (for example CBA).					
Option's relevance							
Economic	Ecologic						Social
+	+	-					
Opportunities that arise		Identifying and increasing the resilience of weak points in the T&D network and individual assets will improve service reliability in the long-term. Taking a more considered, holistic approach is likely to also reduce the need for reactive responses and repeated capital expenditure to fix reoccurring problems.					
Cross-cutting relevance		YES	The approach taken to manage the nation's energy supply affects all sectors of the economy, through the provision of energy, service reliability and costs.				
Risks addressed		Risks to energy supply through damage to T&D infrastructure from extreme weather events					

XII. Diversify supply, including regional energy trade, district heating/cooling, gasification of households and small-scale renewables, to increase overall energy system resilience

19. CONTINUE TO DEVELOP REGIONAL INTERCONNECTIONS AND REGIONAL ELECTRICITY TRADING

Relevant to:	Primary Energy Supply	Electricity generation	Supply/Demand Balance	T&D	Heating production and distribution
	X	X	X	X	X
Description	Diversification and decentralization is a useful strategy in the face of climate change uncertainties. A more regional, network-based system will be more flexible and adaptive and reduces the potential for large-scale outages when centralized power systems are compromised.				
Option's relevance					
Economic					
	++	++	+++		
Opportunities that arise	Renewable energy sources, and micro-grid systems are a viable option to build climate resilience, particularly in more remote rural locations, and they also offer climate change mitigation co-benefits. Renewable energy is also a market opportunity, to create jobs and growth.				
Cross-cutting relevance	YES	The approach taken to manage the nation's energy supply affects all sectors of the economy, through the provision of energy, particularly to vulnerable groups, service reliability, and costs.			
Risks addressed	Climate-related risks to energy supply				

20. REVIEW OPPORTUNITIES FOR IMPROVED DISTRICT HEATING SYSTEMS TO CONTRIBUTE TO MEETING WINTER AND SUMMER ENERGY DEMAND

Relevant to:	Primary Energy Supply	Electricity generation	Supply/Demand Balance	T&D	Heating production and distribution
	X	X	X	X	X
Description	District heating has the potential to alleviate energy demand and help cover heating and cooling demand during peak demand periods through cogeneration.				
Option's relevance					
Economic					
	+	-	+++		
Opportunities that arise	District heating systems are a viable option to build climate resilience, particularly in more remote rural locations.				
Cross-cutting relevance	YES	The approach taken to manage the nation's energy supply affects all sectors of the economy, through the provision of energy, particularly to vulnerable groups, service reliability, and costs.			
Risks addressed	Climate-related risks to energy supply				

21. PROMOTE GASIFICATION OF HOUSEHOLDS TO CONTRIBUTE TO MEETING WINTER ENERGY DEMAND

Relevant to:	Primary Energy Supply	Electricity generation	Supply/Demand Balance	T&D	Heating production and distribution
	X	X	X	X	X
Description	Promote gasification of households to contribute to meeting winter energy demand - gasification of households has the potential to help during peak demand periods, thus reducing the load on electricity transmission and distribution network.				
Option's relevance					
Economic					
	+	-	+		
Opportunities that arise	Eurostat data shows that in 2015 41.7 percent of the energy used in the Bulgarian households (including for heating and housekeeping) is electrical, while for Europe				

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	this percentage is 25. ⁸⁸ The use of electricity for heating by households leads to three times more primary energy costs than –the direct use of natural gas as outlined by the Energy Strategy of the Republic of Bulgaria till 2020. Replacing electricity with natural gas for heating and domestic household purposes will contribute to a threefold saving of primary energy. This would also create some mitigation co-benefits, as decreased electricity consumption will contribute to the reduction of GHG emissions. However, it should be acknowledged that natural gas is a fossil fuel and wherever possible, RES should be exploited.	
Cross-cutting relevance	YES	The approach taken to manage the nation’s energy supply affects all sectors of the economy, through the provision of energy, particularly to vulnerable groups, service reliability, and costs.
Risks addressed	Climate-related risks to energy supply	

XIII. Improve energy efficiency in public and private sector buildings (residential, commercial and industrial)

22. ENCOURAGE ENERGY SUPPLIERS TO BECOME ENERGY SERVICE COMPANIES (ESCOs)

Relevant to:	Primary Energy Supply	Electricity generation	Supply/Demand Balance	T&D	Heating production and distribution
	X	X	X	X	X
Description	Encourage energy suppliers to become energy service companies (ESCOs). An energy service company (ESCO) is a company that provides comprehensive energy solutions to its customers, including auditing, redesigning and implementing changes to the ways the customer consumes energy, the main goal being improved efficiency. ESCOs often use performance contracting, meaning that if the project does not provide returns on the investment, the ESCO is responsible to pay the difference, thus assuring their clients of the energy and cost savings.				
Option’s relevance					
Economic		Ecologic	Social		
+		++	++		
Opportunities that arise	Improving energy efficiency also offers climate change mitigation co-benefits.				
Cross-cutting relevance	YES	Climate change mitigation and levels of comfort in buildings.			
Risks addressed	Climate-related risks to energy supply and demand.				

23. ENSURE ADVICE ON DESIGNING/CONSTRUCTING ENERGY EFFICIENT BUILDINGS TAKES ACCOUNT OF PROJECTIONS OF TEMPERATURE INCREASES, TO ENSURE BUILDING PERFORMANCE WILL NOT BE COMPROMISED UNDER HIGHER TEMPERATURE CONDITIONS

Relevant to:	Primary Energy Supply	Electricity generation	Supply/Demand Balance	T&D	Heating production and distribution
	X	X	X	X	X
Description	Ensure advice on designing/constructing energy efficient buildings takes account of projections of temperature increases, to ensure building performance will not be compromised under higher temperature conditions.				
Option’s relevance					
Economic		Ecologic	Social		
+		++	++		
Opportunities that arise	Setting ambitious requirements and showing a clear direction of progressive tightening of energy performance develops markets for the building industry and investors, while stimulating technology development and innovation. Addressing EE in buildings can help to trigger many co-benefits such as tackling fuel poverty.				
Cross-cutting relevance	YES	Energy savings triggered by energy efficiency policies are just one of their many benefits. Other positive impacts include lower consumer bills, decreased public spending, CO ₂ reduction, and health benefits from improved thermal insulation of buildings.			
Risks addressed	Climate-related risks to energy supply and demand.				

⁸⁸ http://ec.europa.eu/eurostat/statistics-explained/index.php/Energy_consumption_in_households

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24. DEVELOP FINANCIAL MECHANISMS TO FURTHER STIMULATE ENERGY EFFICIENCY IN THE INDUSTRY SECTOR							
Relevant to:		Primary Energy Supply	Electricity generation	Supply/Demand Balance	T&D	Heating production and distribution	
		X	X	X	X	X	
Description		Sources of funding for energy efficiency are numerous and could be expanded if energy efficiency is also recognized as a measure to improve climate resilience.					
Option's relevance							
Economic	Ecologic						Social
++	++	-	Opportunities that arise				
Cross-cutting relevance		YES	Energy savings triggered by energy efficiency policies are just one of their many benefits. Other positive impacts include lower consumer bills, decreased public spending, CO ₂ reduction, and health benefits from improved thermal insulation of buildings.				
Risks addressed		Climate-related risks to energy supply and demand					
25. EXTEND THE CONTROL OVER ENERGY EFFICIENCY GOVERNANCE, ESPECIALLY IN INDUSTRIAL SYSTEMS							
Relevant to:		Primary Energy Supply	Electricity generation	Supply/Demand Balance	T&D	Heating production and distribution	
		X	X	X	X	X	
Description		Effective energy efficiency measures are implemented regionally and locally. This means that to work properly, an operational energy efficiency governance needs to be put in place to: coordinate energy efficiency efforts between the different layers of government, exchange good practices between regional and local entities, and provide feedback to policymakers when measures fall short of delivering energy savings.					
Option's relevance							
Economic	Ecologic						Social
++	++	-	Opportunities that arise				
Cross-cutting relevance		YES	Energy savings triggered by energy efficiency policies are just one of their many benefits. Other positive impacts include lower consumer bills, decreased public spending, CO ₂ reduction, and health benefits from improved thermal insulation of buildings.				
Risks addressed		Climate-related risks to energy supply and demand					
26. PROVIDE ASSISTANCE TO OBLIGED PERSONS TO INITIATE THE DEVELOPMENT OF METHODOLOGIES FOR EVALUATION OF ENERGY SAVINGS							
Relevant to:		Primary Energy Supply	Electricity generation	Supply/Demand Balance	T&D	Heating production and distribution	
		X	X	X	X	X	
Description		Provide assistance to obliged persons to initiate the development of methodologies for evaluation of energy savings which demonstrate the fulfilment of individual energy saving targets, especially in the case of savings energy used in the industry sectors.					
Option's relevance							
Economic	Ecologic						Social
++	+	++	Opportunities that arise				
Cross-cutting relevance		YES	Energy savings triggered by energy efficiency policies are just one of their many benefits. Other positive impacts include lower consumer bills, decreased public spending, CO ₂ reduction and health benefits from improved thermal insulation of buildings.				
Risks addressed		Climate-related risks to energy supply and demand.					

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27. ADVANCE EFFORTS TO MOTIVATE END-USERS OF ENERGY TO IMPLEMENT ENERGY SAVING MEASURES, ESPECIALLY HOUSEHOLDS							
Relevant to:		Primary Energy Supply	Electricity generation	Supply/Demand Balance	T&D	Heating production and distribution	
		X	X	X	X	X	
Description		<ul style="list-style-type: none"> Introduction of various incentives for behavioral change to motivate end users of energy to implement energy saving measures, especially households Smart metering and billing: making consumers more aware of their actual energy consumption so that they can change their behavior to save energy. 					
Option's relevance							
Economic	Ecologic						Social
++	+	++					
Opportunities that arise		Behavioral change is a powerful factor. Even the best regulations may fail, if behavior does not change. When people are motivated to change their behavior, with time it will become their normal behavior which will eventually contribute to climate change mitigation and adaptation.					
Cross-cutting relevance		YES	Energy efficiency policies are delivering in terms of reducing consumption, safeguarding security of supply, reducing CO ₂ emissions, creating jobs, and saving money for consumers. All this brings monetary and non-monetary benefits to industry and consumers, including those experiencing energy poverty. As discussed in a variety of literature on 'sustainable growth', energy efficiency can counter the adverse effects of economic downturn and lead to economic growth ⁸⁹ .				
Risks addressed		Climate-related risks to energy supply and demand.					

28. HARMONIZE PRICE REGULATION WITH THE POLICY OF IMPROVING THE ENERGY EFFICIENCY IN THE COUNTRY							
Relevant to:		Primary Energy Supply	Electricity generation	Supply/Demand Balance	T&D	Heating production and distribution	
		X	X	X	X	X	
Description		Harmonize the process of regulating the prices of electricity, heat and natural gas with the policy of improving the energy efficiency in the country.					
Option's relevance							
Economic	Ecologic						Social
++	+	-					
Opportunities that arise		Improving energy efficiency also offers climate change mitigation co-benefits and cost savings for the industrial sector.					
Cross-cutting relevance		YES	Energy savings triggered by energy efficiency policies are just one of their many benefits. Other positive impacts include lower consumer bills, decreased public spending, CO ₂ reduction and health benefits from improved thermal insulation of buildings.				
Risks addressed		Climate-related risks to energy supply and demand					

⁸⁹ European Commission, Good practice in energy efficiency

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29. RAISE THE AWARENESS OF ENERGY TRADERS WITH REGARD TO THEIR OBLIGATIONS UNDER THE ENERGY EFFICIENCY ACT AND THE POSSIBILITIES FOR THEIR IMPLEMENTATION

Relevant to:	Primary Energy Supply	Electricity generation	Supply/Demand Balance	T&D	Heating production and distribution
	X	X	X	X	X
Description					
Option's relevance			Raise the awareness of energy traders regarding their obligations under the Energy Efficiency Act and the possibilities for their implementation.		
Economic	Ecologic	Social			
+	+	-			
Opportunities that arise	Improving energy efficiency also offers climate change mitigation co-benefits and cost savings for the industrial sector.				
Cross-cutting relevance	YES	Energy savings triggered by energy efficiency policies are just one of their many benefits. Other positive impacts include lower consumer bills, decreased public spending, CO ₂ reduction, and health benefits from improved thermal insulation of buildings.			
Risks addressed	Climate-related risks to energy supply and demand.				

30. WORK WITH STAKEHOLDERS IN THE WATER SECTOR TO EXPLORE LINKS BETWEEN WATER EFFICIENCY (THAT IS LOSSES FROM THE SYSTEM) AND ENERGY EFFICIENCY

Relevant to:	Primary Energy Supply	Electricity generation	Supply/Demand Balance	T&D	Heating production and distribution
	X	X	X	X	X
Description					
Option's relevance			Establish cross-sectoral working groups to manage interconnected services, particularly between the water and energy sectors, to minimize the risks of cascade failures which could be exacerbated by climate change.		
Economic	Ecologic	Social			
+	+++	+			
Opportunities that arise	When the legislation is oriented toward preventive climate change risk management, this saves financial resources for post-event recovery.				
Cross-cutting relevance	YES	Water efficiency and energy efficiency are linked.			
Risks addressed	Climate-related risks to energy supply and demand.				

XIV. Build institutional capacity and knowledge networks

31. EXPAND THE WORK OF THE NATIONAL EXPERT COUNCIL (LED BY MOEW) TO COVER CLIMATE CHANGE ADAPTATION (IN ADDITION TO MITIGATION)

Relevant to:	Primary Energy Supply	Electricity generation	Supply/Demand Balance	T&D	Heating production and distribution
	X	X	X	X	X
Description					
Option's relevance			Expanding the remit of the National Expert Council, which is a cross-government group, will enable climate resilience to be fully embedded across all ministries and departments. Climate risks and actions are often interconnected between sectors, and cross-sectoral groups, such as the National Expert Council, provide the ideal forum for information sharing and collaboration.		
Economic	Ecologic	Social			
-	-	+			
Opportunities that arise	When the legislation is oriented toward preventive climate change risk management, this saves financial resources for post-event recovery.				
Cross-cutting relevance	YES	The approach taken to manage the nation's energy supply affects all sectors of the economy, through the provision of energy, service reliability and costs.			
Risks addressed	All risks				

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32. UNDERTAKE A REVIEW OF EXISTING LEVELS OF AWARENESS OF CLIMATE CHANGE ADAPTATION WITHIN THE MEN, REGULATOR AND WIDER ENERGY SECTOR DECISION-MAKERS/OPERATORS							
Relevant to:		Primary Energy Supply	Electricity generation	Supply/Demand Balance	T&D	Heating production and distribution	
		X	X	X	X	X	
Description		<p>There is a need for capacity building at all operational levels. Adaptation to climate change requires new or adapted information, interpretation and decision-making skills, as well as management structures and processes, that is institutional capacity. It is crucial that energy sector stakeholders can identify climate change risks and understand how to deal with them. Integrating this knowledge into day-to-day operations and longer-term planning processes will enable the sector to optimize electricity generation, and T&D, and ensure existing safety standards continue to be met.</p>					
Option's relevance							
Economic	Ecologic						Social
-	-	+					
Opportunities that arise		Developing a highly qualified and skilled team has the potential to significantly strengthen the institutional capacity.					
Cross-cutting relevance		YES	The approach taken to manage the nation's energy supply affects all sectors of the economy, through the provision of energy, service reliability and costs.				
Risks addressed		All risks					
33. PROVIDE TRAINING							
Relevant to:		Primary Energy Supply	Electricity generation	Supply/Demand Balance	T&D	Heating production and distribution	
		X	X	X	X	X	
Description		<p>Provide training to the MEn, regulator, and wider energy sector decision-makers/operators on climate change adaptation, including information on best practice for energy sector climate resilience from other countries</p>					
Option's relevance							
Economic	Ecologic						Social
-	-	+					
Opportunities that arise		Developing a highly qualified and skilled team has the potential to significantly strengthen the institutional capacity.					
Cross-cutting relevance		YES	The approach taken to manage the nation's energy supply affects all sectors of the economy, through the provision of energy, service reliability and costs.				
Risks addressed		All risks					

XV. Develop financial mechanisms to build resilience						
34. DEVELOP FINANCIAL MECHANISMS TO BUILD RESILIENCE						
Relevant to:	Primary Energy Supply	Electricity generation	Supply/Demand Balance	T&D	Heating production and distribution	
	X	X	X	X	X	
Description	Using financial protection strategies can increase the financial resilience of governments, utilities, the private sector, and households. Financial protection focuses mainly on providing ex ante mechanisms so that appropriate levels of finance are available to maintain power and quickly recover from power supply disruptions during and following natural disasters. Financial protection options also assist in mitigating the contingent liability for power sector economic participants caused by expenses from managing the direct impacts of a disaster, as well as the indirect impacts to consumers due to electricity price fluctuations.					
Option's relevance						
Economic	Ecologic	Social				
++	-	-				
Opportunities that arise	When financing is ensured, it creates opportunities for improvement of the infrastructure and new jobs as well. Financial protection options also assist in mitigating the contingent liability for power sector economic participants caused by expenses from managing the direct impacts of a disaster, as well as the indirect impacts to consumers due to electricity price fluctuations.					
Cross-cutting relevance	YES	The approach taken to manage the nation's energy supply affects all sectors of the economy, through the provision of energy, service reliability and costs.				
Risks addressed	All risks					

Annex 3. Cost-benefit Analysis

1. General Description

The energy sector is a sector with key importance for the economy and society. Climate change impacts can have large impacts on the performance of the energy sector, affecting citizens and the functioning of the public and private sectors. The conceptual framework of the cost-benefit-analysis (CBA) was developed based on climate change affecting the energy sector.

The purpose of this section is to:

- Estimate the parameters of a relationship between performance indicators and climate change indicators for the energy sector (temperature rise +2°C and +4°C, and precipitation changes). It is considered that climatic drivers associated with the impact assessment are average temperature and average precipitation.
- Develop a CBA model – appraising the costs and benefits of adaptation actions, thus measuring the efficiency of investments. It quantifies the anticipated costs and benefits of adaptation options with the aim of comparing them and determining whether the benefits outweigh the costs. Benefits are the advantages or positive effects of adaptation measures. Costs are the resources required to deliver adaptation measures. The effects are expressed as a decrease in costs because of measures taken.
- Evaluate and rank the adaptation options in terms of economic efficiency.

1.1. Description of the methodology

Climate effects were evaluated in an integrated assessment model, which combines a regression (or sensitivity) analysis with CBA, that is, assesses the value of the costs and benefits of each adaptation action - giving a net present value (NPV) - and compares the costs (investment expenditure) and benefits (costs avoided). Costs and benefits are expressed in monetary terms and a discount rate is used to determine the NPV of the adaptation measures.

The regression analysis - as a technique to assess adaptation measures under uncertainty - identifies those factors that have most influence on main sectoral indicators.⁹⁰ The effect can be positive or negative. Positive impact for example results in less heating degree days while an increase in cold degree days is a negative impact.

Regression analysis was used to determine the effect of climatic variables on the performance of the tourism indicators. This function is normally used when both the dependent and the explanatory variables are linear. The dependent variables are the main sectoral indicators where the independent variables are climatic (temperature and precipitation). Linear extrapolation of the key indicators was accounted aiming at identifying how the sector would develop under each scenario. Extrapolation quantified each individual indicator.

The estimation of the negative and positive effects of climatic change was developed according to distinct scenarios at +2°C and +4°C temperature rise by 2050. These main scenarios are divided into sub-scenarios: optimistic, realistic, and pessimistic. The sub-scenarios are

⁹⁰ The regression is linear; the dependent and the explanatory variables are linear.

considered in the context of efficient and effective implementation of the proposed climate change adaptation measures.

The projected effects of adaptation measures are expressed as a logarithmic function, which is a tool to measure the effects of investments that would be gradually made until 2050.

An assessment was carried out of the NPV and the benefits until 2050, holding all other aspects constant. The monetary value of the effects was discounted by 4.5 percent for public funding and by 8 percent for private funding.

The benefits are defined as the positive effect of the implementation of climate change adaptation measures in the energy sector.

1.2. Data collection procedures

The primary data used for the CBA was obtained from the Action Plan that is part of the draft proposal for a National Climate Change Adaptation Strategy and Action Plan for Bulgaria, and official statistical data.

The correlation determined whether there is a relationship between the performance indicators and climate factors. The relationship indicates which indicators are significantly dependent on climate change. Estimation of the correlation coefficient (dependence between each sectoral indicator and climate change factors [temperature and precipitation]) is used to stand out and select the critical variables (variables, which are highly sensitive to climate factors).

1.3. Model specifications - assumptions and limitations

A number of assumptions were made when preparing and carrying out the CBA.

- The projected trend value of each sector indicator is based on historical data (2005–2016).
- The main performance indicators are: end energy consumption and GHG emissions.
- Climate projection (temperature and precipitation) was applied to historical variances experienced in Bulgaria (1991–2015). The input data for climate factors consist of annual temperature (maximum, minimum, and average) and precipitation (maximum, minimum, and average).
- A baseline scenario is used to evaluate the development trend of the performance indicators under the +2°C and +4°C temperature rise scenarios. The baseline scenario reflects a continuation of current policies and plans, that is, a future in which no new measures are taken to address climate change.

2. Results of the Regression Analysis

The regression analysis comprises indicators, that show the present dynamics and development of the energy sector. The correlation indicates the relationships between climate change factors and performance indicators. A differential assessment was carried out by comparing the climate change effects on key performance indicators in all scenarios against the baseline scenario. The results display negative or positive effects on the indicators per scenario.

The statistical dependency between the performance indicators and climate change factors is not significant, which means that there is no explicit relationship. The reason is that a range of

factors (economic, social, human, management, and others) impacts on the performance indicators.

The correlation between higher temperatures and GHG emissions is negative; the relationship is not significant. The main reasons for a decline in GHG emissions in Bulgaria are a decrease of power production from thermal power plants, and the introduction of energy efficiency measures.⁹¹

The indicator ‘end consumption of energy’ is constant and it limits the calculation of a dependency with climate parameters. The seasonal effect of temperature and precipitation has not been quantified in the CBA.

The baseline scenario reflects a continuation of the current policies, that is, a future in which no new measures are taken to address climate change. According to the baseline scenario the expected total damage in monetary value will increase, due to a lack of adaptation measures.

The expected increasing price trend of GHG emissions has been incorporated in the calculations. Therefore, the growth of costs for GHG emissions has not just been defined by increased temperatures.

The indicative cumulative sector effects presented in the table below illustrate the difference between the baseline scenario (that is, without implementing selected adaptation options), and the +2°C and +4°C temperature rise scenarios until 2050.

Table 19. Expected cumulative sector effects from climate change in the Energy sector until 2050 without adaptation measures – baseline scenario (in € million)

Performance indicators	2°C scenario	4°C scenario
GHG Emissions (Gg CO₂e) (1 Gg = 1,000 tons)	180,267	360,535
GHG Emissions (million €)	10,593.31	37,969.65

The indicative cumulative costs until 2050 for covering the economic and social damage of GHG emissions are calculated at €10.5 billion at +2°C temperature rise and €37.9 billion at +4°C temperature rise.

All things being equal (without adaptation options), under the 2°C and 4°C scenarios, the GHG emissions are expected to increase. The sharp temperature variations impact the energy sector more than the average temperature increase.

3. Results of the Cost-benefit Analysis

The CBA for the sector focuses on the assessment of soft adaptation measures. The benefits gained as a result of their implementation are best exemplified through the quantification of saved costs in main performance indicators (energy consumption in households, thermal energy consumption in households). Considering the complex impact of the adaptation options on the energy sector, these were not separately quantified in the current CBA.

⁹¹ In 2016 Bulgaria's greenhouse gas emissions decreased by 49.41 percent compared with the base year. Emissions in 2016 were 4.4 percent decreased in comparison with the emissions of the previous year. Bulgaria's National Inventory Report 2018 – Submission under UNFCCC.

Increasing temperatures due to climate change may gradually change energy demand and energy used in the long run until 2050. Structural adaptation measures in the energy sector such as continuing development of regional interconnections and gasification of households can help households and businesses save on their energy consumption costs. The CBA has taken changes in energy consumption because of improved energy infrastructure and increased gas consumption into account.

The net present value (NPV) in **Table 20** illustrates the monetary value of avoided losses as a result of implemented adaptation measures, while the cost effectiveness quantifies the benefits achieved in relation to the required investments/costs.⁹²

Table 20. Benefits of adaptation measures in the Energy sector under different climate scenarios until 2050 (in €, million)

Climate scenarios	NPV (€ million)	Cost-effectiveness (Benefit/Cost ratio)
Realistic scenario +2°C	67.01	1.05
Optimistic scenario +2°C	114.83	1.08
Pessimistic scenario +2°C	19.18	1.01
Realistic scenario +4°C	475.68	1.34
Optimistic scenario +4°C	548.20	1.39
Pessimistic scenario +4°C	403.16	1.29

309. The projection shows that on average, under the +2°C temperature rise realistic scenario, the total cash flow in NPV is projected at €67.0 million and at €475.7 million under the +4°C realistic scenario. The cash flow in NPV under the optimistic scenario is projected at €114.8 million at +2°C average and at €548.2 million at +4°C average. In the pessimistic scenario the future cash flow is €19.2 million at +2°C and €403.2 million at +4°C.

310. Within the current analysis, the cost-effectiveness of the adaptation measures is used to quantify the effect of investments under each scenario.⁹³ Under the +2°C realistic scenario the benefit/cost ratio is €1.05 (that is, the benefits achieved per Euro spent), and €1.34 under the +4°C realistic scenario. The benefit is higher at +4°C temperature rise. In that case, the benefit is €1.39 per one Euro of investment under the optimistic scenario and €1.29 per one Euro of investment under the pessimistic scenario.

3.1. Prioritization of Adaptation Measures according to CBA

CBA can be used for decision making, as a tool to identify measures that efficiently use financial resources. CBA identifies the most economic adaptation actions and allows for their ranking based on economic efficiency.

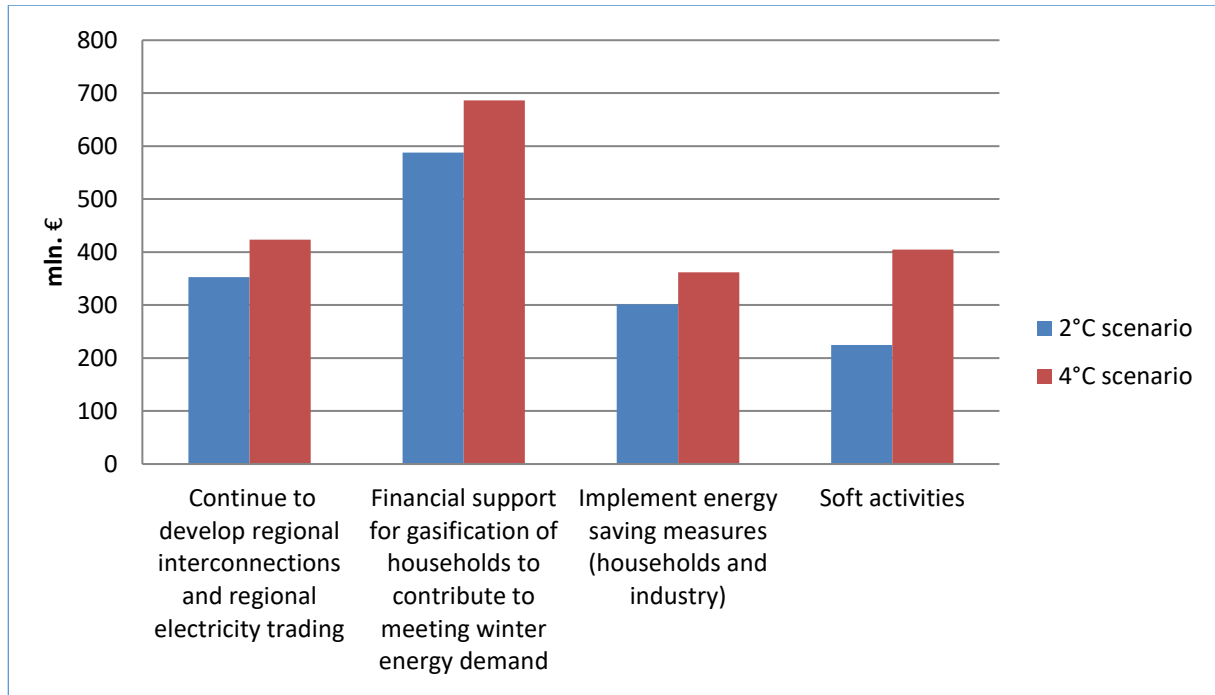
⁹² The NPV of an adaptation option is given by the present value of the estimated benefits and costs. If NPV is more than zero, this indicates that the investment is efficient and incremental benefits of adaptation exceed the incremental resource costs. If NPV is <0 or B/C is <1, then the adaptation measures add no net benefit to the Energy sector. If NPV is >0 or B/C is >1, then it adds positive benefits. The positive value of NPV confirms that investments for adaptation are efficient.

The benefit-cost ratio (B/C) is the ratio of the present value of benefits to the present value of costs. When the B/C ratio is more than one, the present value of the option's benefits is larger than the present value of its costs.

⁹³ The cost-effectiveness refers to all measures.

The prioritization is based on the total effect in NPV of all adaptation measures. The measures for which the benefit exceeds the cost can be ranked as follows: financial support for gasification of households, continued development of regional interconnections, soft adaptation measures, implementation of energy saving measures.

Figure 33. Prioritization of the adaptation measures (total NPV effect in € million)



4. Conclusion

Benefits of the above adaptation measures for the energy sector exceed their costs making them a sound investment for society. Application of these adaptation measures will contribute to the reduction of energy consumption costs. The return on investments regarding restructuring energy power production is positive. The NPV calculations show that investment in adaptation measures is economically efficient.

Annex 4. Energy Dependence (percentage)

geo/time	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
EU (28 countries)	46.7	47.4	47.5	48.8	50.2	52.2	53.6	52.8	54.5	53.5	52.6	54.0	53.4	53.1	53.5	54.1
Euro area (19 countries)	64.1	63.2	63.8	64.0	64.0	65.0	65.4	63.7	64.6	63.5	62.1	62.5	61.2	60.1	60.3	62.4
Belgium	78.1	80.6	77.6	79.6	79.9	80.1	79.6	76.9	81.1	75.6	78.2	75.4	76.1	77.4	80.0	84.3
Bulgaria	46.0	45.8	45.7	46.3	48.1	46.7	45.6	50.7	51.7	45.1	39.6	36.0	36.1	37.7	34.5	35.4
Czech Republic	22.8	25.0	26.2	24.9	25.3	27.8	27.6	25.0	27.8	26.9	25.5	28.8	25.4	27.7	30.3	31.9
Denmark	-35.0	-28.0	-41.8	-31.3	-47.0	-49.8	-35.5	-24.1	-20.5	-19.7	-15.7	-5.6	-2.6	12.2	12.2	13.1
Germany	59.4	60.9	60.1	60.5	61.0	60.5	60.9	58.4	60.9	61.2	60.3	61.9	61.5	62.7	61.7	61.9
Estonia	32.2	32.3	29.6	26.7	28.5	26.1	29.2	24.7	24.7	22.0	13.6	12.0	17.0	11.9	8.9	7.4
Ireland	84.8	89.5	88.9	89.4	90.4	89.6	90.9	87.5	90.7	88.9	86.6	90.0	85.1	89.3	85.3	88.7
Greece	69.5	68.9	71.5	67.5	72.7	68.6	71.9	71.2	73.3	67.6	69.1	65.1	66.4	62.2	66.2	71.9
Spain	76.6	74.7	78.5	76.7	77.6	81.4	81.2	79.6	81.3	79.1	76.7	76.3	73.1	70.4	72.9	73.3
France	51.5	50.8	51.1	50.5	50.7	51.6	51.5	50.4	50.8	51.0	49.0	48.8	48.3	48.1	46.1	46.0
Croatia	48.4	46.5	54.3	50.6	51.8	52.5	49.0	51.6	54.6	46.0	46.6	49.4	48.9	47.0	43.8	48.3
Italy	86.5	83.2	85.6	83.0	84.4	83.4	85.9	83.0	82.9	80.8	82.6	81.4	79.2	76.8	75.9	77.1
Cyprus	98.6	95.9	100.1	96.1	95.4	100.7	102.5	95.9	97.5	96.3	100.8	92.4	97.0	96.3	93.2	97.7
Latvia	61.0	59.3	58.7	63.2	69.4	63.9	66.7	62.5	58.8	60.4	45.5	59.9	56.4	55.9	40.6	51.1
Lithuania	59.4	46.2	41.6	43.8	46.6	56.8	62.0	61.2	57.8	49.9	81.8	81.7	80.3	78.3	78.0	78.4
Luxembourg	99.6	97.4	98.6	98.4	97.9	97.4	98.2	96.7	97.5	97.5	97.1	97.3	97.5	97.1	96.5	95.9
Hungary	55.2	53.5	56.8	62.0	60.9	63.1	62.7	61.2	63.2	58.6	58.2	51.9	52.3	52.4	61.8	55.6
Malta	100.3	99.8	99.8	99.8	99.8	100.0	100.0	100.0	100.0	99.9	99.0	101.3	101.0	104.1	97.7	97.3
Netherlands	38.1	34.2	34.7	39.1	32.1	38.0	38.3	37.8	34.3	36.4	30.3	30.1	30.6	26.1	33.8	51.9
Austria	65.4	64.9	67.9	70.8	71.0	71.8	72.7	69.2	69.2	65.5	62.9	70.3	64.5	61.6	66.1	60.8
Poland	9.9	9.9	10.6	13.2	14.5	17.2	19.6	25.5	30.2	31.6	31.3	33.4	30.6	25.6	28.6	29.3
Portugal	85.1	85.1	84.1	85.5	83.9	88.6	84.0	81.4	83.4	81.4	75.1	77.7	79.2	72.4	71.2	77.4
Romania	21.8	26.1	24.1	25.4	30.2	27.6	29.4	31.7	28.0	20.3	21.9	21.6	22.7	18.5	17.1	17.1
Slovenia	52.8	50.4	50.6	53.6	52.4	52.5	52.0	52.5	55.1	48.2	48.7	47.7	51.2	46.9	44.5	48.7
Slovakia	65.5	62.2	63.9	64.5	67.7	65.3	63.8	68.3	64.4	66.5	63.1	64.3	60.2	59.2	60.9	58.7
Finland	55.1	54.8	52.0	58.8	54.3	54.1	53.6	52.9	54.1	53.6	47.8	52.8	46.3	48.6	48.9	46.8
Sweden	40.7	37.7	37.2	42.8	36.3	36.8	36.8	35.4	37.1	36.7	36.6	36.3	28.7	31.6	32.0	30.1
United Kingdom	-16.9	-9.3	-11.9	-6.0	4.5	13.4	21.2	20.5	26.2	26.4	28.2	36.0	42.2	46.3	45.5	37.4

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geo/time	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Iceland	30.5	29.0	28.8	27.8	31.9	31.1	25.9	22.8	21.1	20.0	18.5	17.9	13.7	13.3	14.0	16.5
Norway	-733.1	-716.6	-803.1	-739.1	-740.1	-703.2	-667.4	-657.1	-570.5	-580.2	-499	-590.9	-566.9	-479.4	-592.5	-585.9
Switzerland	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Montenegro	:	:	:	:	:	42.1	44.8	54	45.9	42.9	26.3	36.2	34.2	23.4	29.9	29.8
Former Yugoslav Republic of Macedonia, the	39.9	38.2	45.7	38.1	41.2	41.8	43.3	46.4	44.8	43.9	43.0	44.5	47.9	46.7	51.8	52.6
Albania	46.6	53.3	54.6	51.1	48.3	50.5	41.8	50.9	52.0	47.7	30.5	37.4	22.0	28.1	34.2	14.0
Serbia	13.7	22.3	25.5	27.6	32.1	35.3	37.2	35.9	37.2	32.2	33.2	30.4	27.8	23.7	27.5	27.2
Turkey	66.3	65.1	67.8	71.1	70.4	71.6	72.6	74.3	72.2	70.4	69.3	70.7	75.3	73.9	74.8	77.5
Bosnia and Herzegovina	2.9	0.8	-0.4	-2.8	0.5	6.0	3.8	7.7	4.8	4.4	6.0	12.1	12.7	7.6	21.4	:
Kosovo (under United Nations Security Council Resolution 1244/99)	27.1	27.1	27.2	26.7	27.2	28.2	29.5	29.0	27.1	25.9	24.6	27.5	27.3	21.9	27.2	27.6
Source of Data:	Eurostat															
Last update:	12.04.2017															
Date of extraction:	25 Apr 2017 10:32:37 CEST															
Hyperlink to the table:	http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=tsdcc310															
General Disclaimer of the EC website:	http://ec.europa.eu/geninfo/legal_notices_en.htm															
Short Description:	Energy dependency shows the extent to which an economy relies upon imports in order to meet its energy needs. The indicator is calculated as net imports divided by the sum of gross inland energy consumption plus bunkers.															
Code:	tsdcc310															

Annex 5. Energy Intensity of the Economy (kg of oil equivalent per €1,000)

Gross inland consumption of energy divided by GDP (kg of oil equivalent per 1 000 EUR)																
geo\time	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
EU (28 countries)	154.9	154.9	152.8	153.9	151.6	149.2	145.1	138.5	137.5	135.5	137.6	130.3	129.9	128.2	121.6	120.4
Euro area (19 countries)	142.7	143.3	142.1	143.9	142.7	140.9	137.0	130.9	130.3	128.8	130.4	123.5	123.5	122.8	117.1	116.4
Belgium	190.4	186.8	176.9	183.2	178.0	173.3	166.2	157.8	162.8	159.3	166.8	153.3	146.8	152.1	141.6	141.3
Bulgaria	758.8	761.7	696.6	683.8	630.6	614.0	593.2	542.8	509.2	463.9	464.9	490.1	467.8	426.3	445.5	448.5
Czech Republic	361.6	359.5	358.1	361.0	352.5	327.6	314.4	297.3	283.9	280.6	290.5	274.5	274.9	276.4	261.2	251.0
Denmark	87.6	89.2	87.4	90.6	85.8	81.3	84.1	81.3	78.4	79.2	82.4	75.5	72.6	71.5	66.3	65.1
Germany	145.1	146.8	143.6	143.4	142.6	140.9	139.7	128.5	128.4	127.7	128.9	118.1	118.3	120.2	114.2	112.6
Estonia	466.4	457.6	416.0	427.8	412.3	373.9	331.1	344.4	352.2	372.0	417.9	390.4	370.3	400.2	387.7	358.0
Ireland	115.7	114.1	108.7	102.1	98.0	93.5	90.3	88.8	91.5	90.6	90.7	83.0	83.3	82.1	74.9	62.0
Greece	149.0	147.2	143.9	139.6	135.1	136.7	130.1	125.7	127.4	127.4	127.1	135.3	144.7	131.6	131.8	132.2
Spain	142.5	140.6	140.6	141.0	142.8	140.7	135.2	132.0	126.5	120.8	120.5	120.1	123.3	116.9	112.7	113.7
France	145.4	147.6	146.1	147.3	145.4	143.7	138.4	133.8	134.2	132.2	133.5	126.5	126.4	126.1	120.2	120.7
Croatia	238.7	239.6	233.7	237.4	228.0	222.5	210.9	209.2	199.4	208.1	209.5	207.3	201.9	197.7	189.6	194.1
Italy	112.0	110.5	111.2	116.7	115.3	116.6	113.2	111.5	111.6	110.1	110.9	106.9	105.7	103.5	97.9	100.4
Cyprus	168.5	164.4	160.8	169.8	152.4	148.9	148.0	147.4	149.4	147.9	142.0	138.9	134.2	124.1	128.4	128.7
Latvia	314.8	316.9	294.0	288.2	273.0	252.3	234.0	218.2	217.5	243.9	260.2	231.3	230.5	221.1	215.8	207.3
Lithuania	385.5	415.9	417.0	392.6	376.2	329.5	300.8	294.9	286.6	307.3	242.2	235.8	229.9	209.3	202.5	205.4
Luxembourg	118.7	122.1	122.7	127.2	136.4	134.8	126.1	114.1	115.6	113.9	115.5	110.8	108.7	101.6	93.6	89.1
Hungary	314.4	309.5	296.8	291.5	275.1	278.0	266.2	258.9	254.8	257.4	261.5	250.4	239.5	225.6	218.5	224.0
Malta	148.6	162.5	147.7	158.4	162.2	162.8	150.1	153.4	148.1	136.6	142.2	140.0	142.9	122.1	114.0	90.5
Netherlands	140.8	141.3	143.4	147.5	147.3	142.4	136.2	131.0	128.6	129.9	136.3	125.3	127.2	126.9	119.4	118.0
Austria	114.4	118.7	117.9	123.2	122.9	123.5	120.0	114.2	113.4	111.2	116.4	109.9	108.7	110.3	105.6	107.1
Poland	36.00	359.1	346.9	346.5	329.7	321.7	318.2	297.1	288.2	270.6	278.3	265.3	252.8	250.3	233.3	227.1
Portugal	151.3	149.6	154.7	152.2	154.6	157.4	147.8	144.1	139.6	142	135	133.8	131.2	133.5	130.6	133.9
Romania	441.7	422.4	417.1	412.3	375.1	357.2	342.1	318.8	293	278.3	282.5	285.4	274.4	243	233.8	226.7

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Gross inland consumption of energy divided by GDP (kg of oil equivalent per 1 000 EUR)																
geo/time	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Slovenia	231.3	235.9	230.4	226.6	223.8	220.2	208.4	195.1	199.7	199.7	202.4	201.0	198.3	195.5	183.7	177.6
Slovakia	436.9	434.2	416.9	393.7	368.6	355.1	324.7	277.3	269.0	260.7	264.2	250.3	236.3	237.1	220.1	215.1
Finland	205.0	204.5	212.1	219.8	213.3	192.1	200.6	189.7	181.7	186.7	198.3	186.6	183.3	181.9	186.4	177.2
Sweden	163.2	168.5	165.5	157.1	156.4	149.5	138.8	134.2	134.3	130.5	137.6	130.6	131.8	128.4	122.8	111.3
United Kingdom	147.2	144.0	139.0	137.1	133.1	130.1	125.0	117.6	116.6	114.9	116.2	106.7	108.2	104.7	95.8	94.3
Iceland	430.7	400.8	410.1	400.6	369.0	352.2	417.2	447.0	507.0	562.0	585.6	614.2	561.7	563.5	550.9	510.2
Norway	95.4	96.0	88.2	94.2	88.9	87.9	87.2	85.9	99.7	98.5	106.1	87.0	89.6	97.7	81.3	85.5
Switzerland	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Montenegro	:	:	:	:	:	:	:	:	:	:	:	351.6	341.1	306.2	294.7	301.1
Former Yugoslav Republic of Macedonia, the	501.3	500.8	484.6	517.4	486.1	490.8	471.3	461.7	429.4	401.3	397.4	425.1	411.5	373.4	350.5	336.3
Albania	346.9	325.9	343.9	324.4	335.6	318.5	288.7	258.1	249.7	247.7	238.1	241.6	224.6	250.1	243.7	225.7
Serbia	709.9	727.3	725.7	723.8	715.0	601.7	610.4	569.5	546.7	514.1	523.8	536.6	486.9	487.4	441.9	486.1
Turkey	195.5	192.3	192.2	190.9	180.0	172.7	177.7	181.9	178.3	186.8	183.9	176.4	177.0	160.2	160.7	161.1
Kosovo (under United Nations Security Council Resolution 1244/99)	:	:	:	:	:	:	:	:	539.6	577.0	571.7	553.2	504.7	473.5	448.3	490.4
Source of Data:	Eurostat															
Last update:	12.04.2017															
Date of extraction:	25 Apr 2017 10:28:05 CEST															
Hyperlink to the table:	http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=tsdec360															
General Disclaimer of the EC website:	http://ec.europa.eu/geninfo/legal_notices_en.htm															
Short Description:	This indicator is the ratio between the gross inland consumption of energy and the gross domestic product (GDP) for a given calendar year. It measures the energy consumption of an economy and its overall energy efficiency. The gross inland consumption of energy is calculated as the sum of the gross inland consumption of five energy types: coal, electricity, oil, natural gas and renewable energy sources. The GDP figures are taken at chain linked volumes with reference year 2010. The energy intensity ratio is determined by dividing the gross inland consumption by the GDP. Since gross inland consumption is measured in kgoe (kilogram of oil equivalent) and GDP in €1,000, this ratio is measured in kgoe per €1,000.															
Code:	tsdec360															

Annex 6. Renewable Electricity and Power Distribution Networks Estimated for Connection

Type of Renewable Energy Source	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	Total until 2026
Wind (MW)	50	40	70	120	80	70	50	30	20	15	545
Solar (MWp)	185	46	8	92	19	27	35	38	25	20	495
Hydro (MW)	1	1	1	1	3	3	4	5	5	5	29
Bio (MWe)	4	4	4	4	5	6	6	7	5	5	50
Total	240	91	83	217	107	106	95	80	55	45	1,119

Source: TSO 2017.

Annex 7. Existing Renewable Energy Sources, 2016 (MW)

Renewable Energy Source	2016
HPP (without pumps)	2,337
Wind farms	701
Photovoltaic	1,041
Biomass and biogas	66

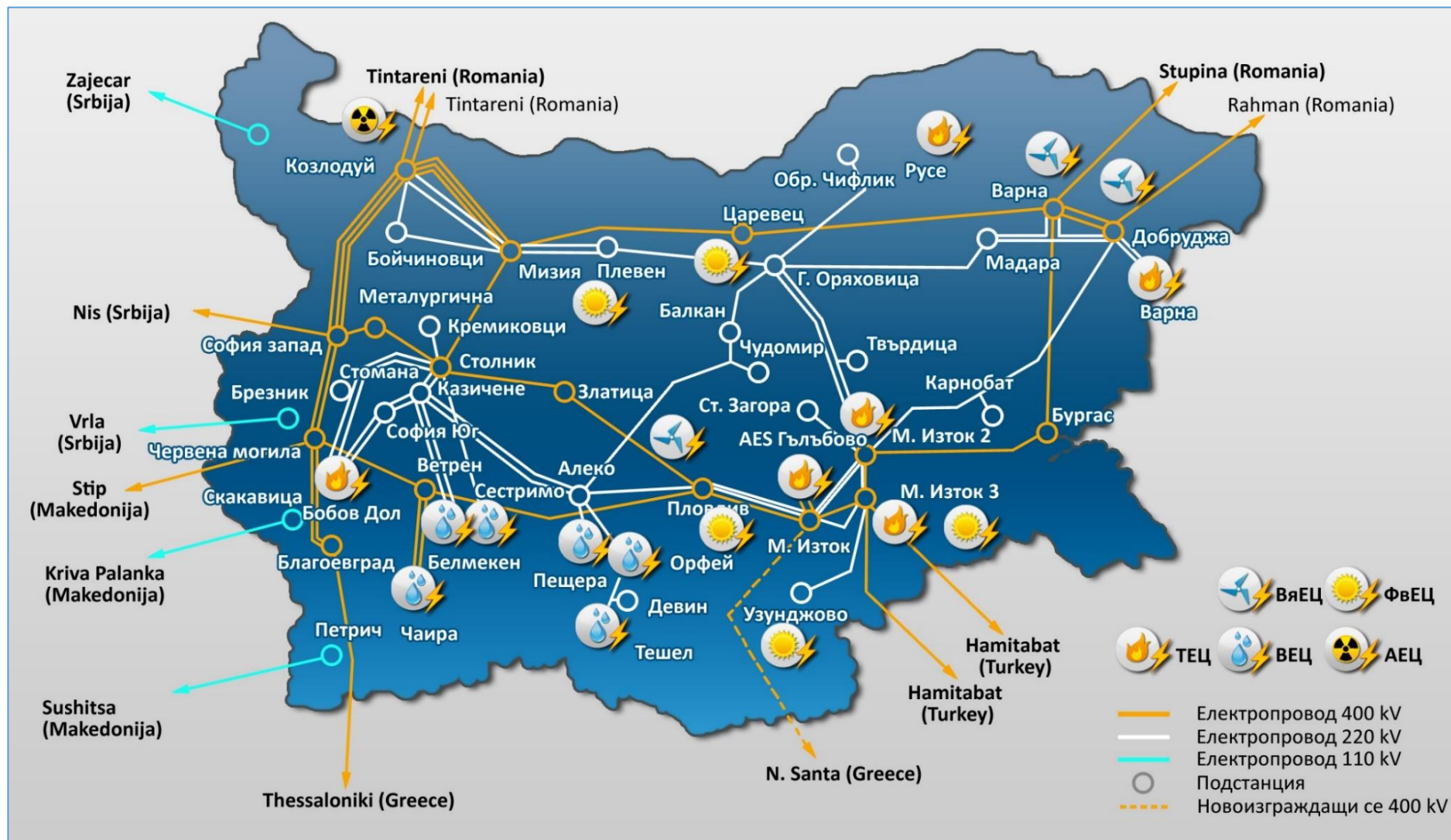
Source: TSO 2017.

Annex 8. Gross Electricity Consumption Forecast, 2015–2024 (GWh)

Year	2017	2018	2009	2020	2021	2022	2023	2024
Gross consumption, maximum scenario, GWh	40,130	40,810	41,400	41,920	42,340	42,680	42,890	43,040
Gross consumption, minimum scenario, GWh	39,420	39,810	40,110	40,310	40,480	40,620	40,740	40,860

Source: TSO 2015.

Annex 9. Transmission Lines



Annex 10. Bulgaria Energy Sector – Costs, Benefits, and Effectiveness of Climate Change Adaptation Options

Option type	Specific Option	Cost	Cost effectiveness/cost-benefit	Source
Overall improvements to energy sector		<ul style="list-style-type: none"> €897.1 million planned government investment for direct measures to improve energy sector in Bulgaria (1) average costs per ton of emission reductions for each sector including only measures with direct effect (2013-2020): €895.93 million (2) 	<ul style="list-style-type: none"> Expected savings of 18M tons of emissions at average cost of €50 per ton (1) €895.93 million investment from 2013–2020 expected to reduce emissions by 18 million tons CO₂ equivalent (Average price per reduced ton CO₂ eq. = €49.78) (2) 	<p>(1) Republic of Bulgaria. (2013). Sixth National Communication on Climate Change. United Nations Framework Convention on Climate Change. http://unfccc.int/files/national_reports/annex_i_natcom/submitted_natcom/application/pdf/vi_nc_bulgaria_2013_22102014_final_-_resubmission.pdf</p> <p>(2) Republic of Bulgaria, Ministry of Environment and Water. (2012). Third National Action Plan on Climate Change for the Period 2013–2020. Sofia. http://www4.unfccc.int/nap/Documents%20NAP/Third%20National%20Action%20Plan%20for%20the%20Period%202013-2020.pdf</p>
Mainstream climate change considerations within energy sector policies and plans	Undertake review of current policies and plans to identify areas where climate change can be integrated	<ul style="list-style-type: none"> Support the transition to a low-carbon economy by implementing EE projects in municipal buildings under Operational Programme 'Regions in Growth 2014–2020' (OPRG): €111.5 million (1) 	<ul style="list-style-type: none"> Expected savings from implementation of National Energy Efficiency Strategy: 1,238 ktoe by 2020 (2) Support the transition to a low-carbon economy by implementing EE projects in municipal buildings under Operational Programme 'Regions in Growth 2014–2020' (OPRG): 31.8 ktoe/y (1) 	<p>(1) Republic of Bulgaria, Ministry of Economy and Energy. (2014). National Energy Efficiency Action Plan 2014–2020. Sofia. https://ec.europa.eu/energy/sites/ener/files/documents/NEEAPBulgaria_en.pdf</p> <p>(2) Republic of Bulgaria. (2011). Second National Energy Efficiency Action Plan, 2011–2013. Sofia. http://www.seea.government.bg/documents/Second_Energy_Efficiency_Action_Plan_EN.pdf</p>
	Develop new sector policies and plans with explicit reference to climate change adaptation			

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Option type	Specific Option	Cost	Cost effectiveness/cost-benefit	Source
Review of operations and contingency planning for power generation (thermal and nuclear power plants, coal mining, hydropower)	Undertake review of operations and contingency planning to identify areas of current and future vulnerability	<ul style="list-style-type: none"> Average value of lost load (VOLL) in €/kWh: 3.96 (households), 27.96 (industry), 9.38 (agriculture), 22.5 (public/service) (1) Value of lost load of average undelivered GWh in industry sector: Romania - €1,920.9 (79.8 percent value loss in industry sector of total value loss); EU - €81,833 (60.8 percent value loss in industry sector of total value loss) (1) 	<ul style="list-style-type: none"> Benefit of adaptation options (EU 26): €133.5 million - 2,309.6 million (industry), €13.8 million - 260.9 million (households), €4.5 million - 14.1 million (agriculture), €106.5 million - 663.7 million (public/service) (1) €122.67 million investment expected to reduce emissions by 4.68 million tons CO₂ equivalent by 2020 (2) Construction of hydro cascade Gorna Arda and Sredna Vucha: 408 kt from substitution of electricity generated in power system after 2012 (3) Construction of small and micro HPP in different country regions: 0.2 Mton from substitution of electricity generated from fossil fuels in power system (annual reduction in 2010; +69 MW until 2010) (3) 	<p>(1) Susanne Altvater, Debora de Block, Irene Bouwma, Thomas Dworak, Ana Frelih-Larsen, Benjamin Görlach, Claudia Hermeling, Judith Klostermann, Martin König, Markus Leitner, Natasha Marinova, Sabine McCallum, Sandra Naumann, Daniel Osberghaus, Andrea Prutsch, Christiane Reif, Kaj van de Sandt, Rob Swart, Jenny Tröltzsch, (2012): Adaptation Measures in the EU: Policies, Costs, and Economic Assessment. https://www.ecologic.eu/sites/files/publication/2012/altvater_12_climate_proofing_report_2.pdf</p> <p>(2) Republic of Bulgaria, Ministry of Environment and Water. (2012). Third National Action Plan on Climate Change for the Period 2013–2020. Sofia. http://www4.unfccc.int/nap/Documents%20NAP/Third%20National%20Action%20Plan%20for%20the%20Period%202013-2020.pdf</p> <p>(3) Republic of Bulgaria. Second National Action Plan on Climate Change, 2005–2008.</p>
	Implement practical measures (for example change production processes, redesign or modify existing facilities, amend operating practices)	<ul style="list-style-type: none"> Total annual adaptation cost estimates for additional cooling of thermal power plants (Bulgaria): €58.9 million (9.2 percent of total EU27 costs) (1) Annual cost estimate of cooling nuclear power plants in Bulgaria: €58.6 million (1) Annual cost estimate for recirculation cooling in fossil power plants: €0.8M (Slovakia), €3.5 million (Slovenia), €10.7 million (Hungary) (1) Annual cost estimate for additional dry cooling systems in gas-fired power plants: €1.6 million (Romania), €1.9 million (Hungary) (1) Early warning system for extreme weather dangers to a power plant (for EU): €6,000 - 		<p>(1) Susanne Altvater, Debora de Block, Irene Bouwma, Thomas Dworak, Ana Frelih-Larsen, Benjamin Görlach, Claudia Hermeling, Judith Klostermann, Martin König, Markus Leitner, Natasha Marinova, Sabine McCallum, Sandra Naumann, Daniel Osberghaus, Andrea Prutsch, Christiane Reif, Kaj van de Sandt, Rob Swart, Jenny Tröltzsch, (2012): Adaptation Measures in the EU: Policies, Costs, and Economic Assessment. https://www.ecologic.eu/sites/files/publication/2012/altvater_12_climate_proofing_report_2.pdf</p> <p>(2) Republic of Bulgaria, Ministry of Environment and Water. (2012). Third National Action Plan on Climate Change for the Period 2013–2020. Sofia.</p>

Climate Change Adaptation – Assessment of the Energy Sector

Option type	Specific Option	Cost	Cost effectiveness/cost-benefit	Source
		216,000 up front cost and €22,810 - 45,420 total annual operating costs (1) <ul style="list-style-type: none"> Improvement of production efficiency in existing coal-fired power plants in Bulgaria from 2013–2020: €122.67 million (estimated, depending on technological solutions) (2) 		http://www4.unfccc.int/nap/Documents%20NAP/Third%20National%20Action%20Plan%20for%20the%20Period%202013-2020.pdf
Incorporate climate resilient design and engineering during the upgrade of transmission and distribution infrastructure	Undertake an assessment of areas of the T&D network particularly exposed to climate impacts; Review design standards for new assets	<ul style="list-style-type: none"> National Centre for Atmospheric Research climate scenario, 2010–2050 infrastructure costs for ECA (\$ billions at 2005 prices, no discounting): 108.8 (power and wires baseline), 0.6 (power and wires adaptation) (1) 	<ul style="list-style-type: none"> Decrease of losses in T&D networks expected to result in 1,100 kt from decreasing of electricity losses in power system (annual reduction in 2010) (2) Decreasing of losses in the heat transmission networks expected to result in 900 kt from decreasing of heat losses in distribution network and substations (annual reduction in 2010) (2) 	(1) World Bank (2010). The Cost to Developing Countries of Adapting to Climate Change: New Methods and Estimates. http://siteresources.worldbank.org/EXTCC/Resources/EACC-june2010.pdf (2) Republic of Bulgaria. Second National Action Plan on Climate Change, 2005–2008.
	Amend plans for new assets to ensure they withstand ongoing or expected climate impacts			
	Regular review and monitoring of the performance of risk mitigation measures, making amendments where necessary			
Incorporate climate resilient design and engineering during the construction of a new unit at Kozloduy nuclear plant	Review the robustness of the ESIA to ensure full and accurate consideration of potential future climate impacts			
	Amend plans (where necessary) to ensure they withstand ongoing or expected climate impacts		<ul style="list-style-type: none"> Improvement of the operation of Kozloduy nuclear plant: 946 kt from substitution of electricity generated in power system (annual reduction in 2010) 	Republic of Bulgaria. Second National Action Plan on Climate Change, 2005–2008.

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Option type	Specific Option	Cost	Cost effectiveness/cost-benefit	Source
	Regular review and monitoring of the performance of risk mitigation measures, making amendments where necessary			
Diversify supply, including small-scale renewables and district heating, to increase overall energy system resilience	Stress-test current and future energy supply and demand, to understand areas of vulnerability and required capacity			
	Develop renewable energy sources (small HPP, small HPP, solar, wind and biomass) and micro-grid systems	<ul style="list-style-type: none"> • “1000 sunny roofs” national program in Bulgaria, 2015–2020: €72 million estimate (1, 2) • Increase to 15 percent of share of electric energy from renewable energy sources (2013–2020): €2,138.4 million (1, 2) • Increase capacity for generation of pumped-storage hydroelectricity in Bulgaria (2013–2020): €125.7 million (2) • Use of biomass in the combustion units of installations by large companies to increase use of waste as alternative fuel: €40 million (2) • Construction of installations for mechanical and biological treatment and installations for treatment and recovery of compost and biogas in Bulgarian municipalities (2013–2020): €113 million (2) • Biogas development: €12.3 million (capture and flaring in new/existing landfills, 2013–2016), €18.4 million (capture and flaring in landfills to be closed, until 2016), €0.1 million (evaluation of biogas energy potential of from to-be-closed landfills, 2013–2014), €0.2 million (measure of biogas flow in combustion systems, 2013–2015) €88.9 million (anaerobic sludge stabilization, capture/burning of biogas in new/reconstructed urban plants, 2013–2015), 	<ul style="list-style-type: none"> • Increased share of energy for heating and cooling from renewable sources expected to reduce emissions by 488,000 tons by 2020 (1) • “1000 sunny roofs” expected to reduce emissions by 107,200 tons of CO₂ equivalent (cost per ton of saved emissions = €668) (1) • Biomass combustion by large companies expected to reduce emissions by 3.88 million CO₂ equivalent by 2020 (2) • Construction/installations for compost and biogas recovery expected to reduce emissions by 5.82 million CO₂ equivalent by 2020 (2) • Biogas development: 5.07 million CO₂ equivalent tons from capture/flaring of landfills, 1.02 million CO₂ equivalent tons from anaerobic sludge stabilization, capture/burning of biogas in new/reconstructed urban plants (2) • Biomass for electricity and heat production expected to result in annual 2010 reduction of 0.05 million tons from introduction of heating installations on wood-fired boilers, installation on biomass for production of electricity and thermal energy, combined production of electricity and heat with biogas from waste disposal sites (5) 	<p>(1) Republic of Bulgaria. (2013). Sixth National Communication on Climate Change. United Nations Framework Convention on Climate Change. http://unfccc.int/files/national_reports/annex_i_natcom/submitted_natcom/application/pdf/vi_nc_bulgaria_2013_22102014_final_-_resubmission.pdf</p> <p>(2) Republic of Bulgaria, Ministry of Environment and Water. (2012). Third National Action Plan on Climate Change for the Period 2013–2020. Sofia. http://www4.unfccc.int/nap/Documents%20NAP/Third%20National%20Action%20Plan%20for%20the%20Period%202013-2020.pdf</p> <p>(3) Republic of Bulgaria. National Development Programme: Bulgaria 2020. https://www.eufunds.bg/archive/documents/1357828564.pdf</p> <p>(4) Republic of Bulgaria, Ministry of Economy, Energy, and Tourism. (2011). National Renewable Energy Action Plan. http://pvtrin.eu/assets/media/PDF/EU_POLICI/ES/National%20Renewable%20Energy%20Action%20Plan/203.pdf</p>

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Option type	Specific Option	Cost	Cost effectiveness/cost-benefit	Source
		<p>€0.3 million (measurement of the biogas flow rate captured in combustion systems, 2014–2020) (2)</p> <ul style="list-style-type: none"> mechanical-biological waste treatment, part of the integrated project for management of municipal waste in Sofia: €184 million (3) Cost to consumers for technology shifts (not including integration to power grid) (4): <ul style="list-style-type: none"> water power plants up to 1 MW: €75.75 million for 1,321 GWh water power plants 1-10 MW: €141.94 million for 6,392 GWh Solar: €887.79 million for 2,916 GWh Wind: €1052.85 million for 21,564 GWh Solid biomass: €315.62 million for 3,611 GWh Biogas: €38.49 million for 2,360 GWh Total: €2042 million for 35,803 GWh 		(5) Republic of Bulgaria. Second National Action Plan on Climate Change, 2005–2008.
<p>Improve energy efficiency in public and private sector buildings, to ensure the existing supply and demand balance is maintained</p>	<p>Undertake energy efficiency audits to identify the most energy inefficient public and private sector buildings</p>	<ul style="list-style-type: none"> Sanitation of communal, public and state buildings at the percentage rate required by Bulgaria’s energy efficiency directive (for 2015–2020, energy audits of buildings and registry of state-owned and municipal buildings with total floor space over 250 m²): €17.5 million (1) Energy efficiency inspections for hot-water boilers and air-conditioning systems: €15.3 million (2) Energy audits of industrial systems consuming >3,000 MWh energy per annum: €441.9 million (2) Audit/certification/passportisation of buildings: €893.2 million (2) Kozloduy International Decommissioning Support Fund use for funding efficiency projects in non-nuclear sector municipal/public buildings: €55.2 million (2) 	<ul style="list-style-type: none"> Energy audits and registry expected to reduce emissions by 0.2 million tons CO₂ equivalent (1) Audits of industrial systems and implementation of recommended measures: 1,756 GWh per year impact on energy savings by 2020 (3) <ul style="list-style-type: none"> 208 industrial systems audits in 2016 show energy savings of 82.7 GWh per year, CO₂ emissions savings of 41 kt per year, and €12.3 million/year (4) Energy efficiency inspections for hot-water boilers and air-conditioning systems: 10 ktoe per year (2) Energy audits of industrial systems consuming >3,000 MWh energy per annum: 151 ktoe per year (2) 	<p>(1) Republic of Bulgaria, Ministry of Environment and Water. (2012). Third National Action Plan on Climate Change for the Period 2013-2020. Sofia. http://www4.unfccc.int/nap/Documents%20NAP/Third%20National%20Action%20Plan%20for%20the%20Period%202013-2020.pdf</p> <p>(2) Republic of Bulgaria, Ministry of Economy and Energy. (2014). National Energy Efficiency Action Plan 2014–2020. Sofia. https://ec.europa.eu/energy/sites/ener/files/documents/NEEAPBulgaria_en.pdf</p> <p>(3) Republic of Bulgaria. (2011). Second National Energy Efficiency Action Plan, 2011-2013. Sofia. http://www.seea.government.bg/documents/Second_Energy_Efficiency_Action_Plan_EN.pdf</p> <p>(4) Republic of Bulgaria, Ministry of Energy. (2017). National Energy Efficiency Action Plan</p>

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Option type	Specific Option	Cost	Cost effectiveness/cost-benefit	Source
		<ul style="list-style-type: none"> Funding of efficiency projects in under Operational Programme 'Regional Development' (OPRD): €36.3 million (municipal buildings), €16.9 million (multi-family residential buildings) (2) 	<ul style="list-style-type: none"> Audit/certification/passportisation of buildings: 214 ktoe per year (2) <ul style="list-style-type: none"> 2,130 buildings audited in 2016 show expected energy savings of 769.2 GWh/year, CO₂ emission savings of 266.6 kt/year, and €51.2 million per year from implementing prescribed measures (4) Kozloduy International Decommissioning Support Fund use for funding efficiency projects in non-nuclear sector municipal/public buildings: 65 ktoe per year (2) Funding of efficiency projects under Operational Programme 'Regional Development' (OPRD): 53 ktoe per year (municipal buildings), 16.9 ktoe per year (multi-family residential buildings) (2) 	2014-2020: Updated 2017. Sofia. https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive/national-energy-efficiency-action-plans
	Implement practical measures to improve energy efficiency	<ul style="list-style-type: none"> Total investment in energy efficiency for Bulgaria is expected to be approximately €485 million (1, 2) Investment of €122.8 million between 2013 and 2020 to reduce greenhouse gas emissions in Bulgaria, reduce resource use, and lower energy costs to increase efficiency of existing power plants (1) Investment of €368 million in Bulgaria to transition from coal to natural gas power in energy sector (1, 2) High efficiency cogeneration is expected to cost about €400 million (1, 2) Implementation of energy efficiency measures in Bulgarian urban municipal educational infrastructure (46 projects): €67.4 million (3) Financing of energy efficiency measures in multifamily buildings in 36 Bulgarian municipalities: budget of €48.6 million (3) 	<ul style="list-style-type: none"> Total investment in energy efficiency for Bulgaria (€485.5 million) expected to reduce emissions by 3.5 million tons (average cost of saved emissions = €138 per ton) (1) Greenhouse gas emissions investment expected to reduce emissions by 4.68 million CO₂ equivalent (average cost of saved emissions = €26 per ton) (1) Transition from coal to natural gas expected to reduce emissions by 11.7 million tons of CO₂ equivalent by 2020 (2) High efficiency cogeneration is expected to reduce emissions by 1.6 million tons of CO₂ equivalent (average cost of saved emissions = €253 per ton) (1, 2) <ul style="list-style-type: none"> Upgrading of cogeneration plants and district heating boilers by natural gas turbines was expected to result in 2010 annual reduction of 867.5 kt from substitution of electricity generated from coal and liquid fuels in power system (7) 	<p>(1) Republic of Bulgaria. (2013). Sixth National Communication on Climate Change. United Nations Framework Convention on Climate Change. http://unfccc.int/files/national_reports/annex_i_natcom/submitted_natcom/application/pdf/vi_nc_bulgaria_2013_22102014_final_-_resubmission.pdf</p> <p>(2) Republic of Bulgaria, Ministry of Environment and Water. (2012). Third National Action Plan on Climate Change for the Period 2013-2020. Sofia. http://www4.unfccc.int/nap/Documents%20NAP/Third%20National%20Action%20Plan%20for%20the%20Period%202013-2020.pdf</p> <p>(3) Ecologic Institute and eclareon. (2014). Country Report: Bulgaria. Assessment of climate change policies in the context of the European Semester. Berlin. https://ec.europa.eu/clima/sites/clima/files/st</p>

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Option type	Specific Option	Cost	Cost effectiveness/cost-benefit	Source
		<ul style="list-style-type: none"> • Housing Renovation Fund to provide low-interest loans/bank guarantees for home owners who cannot afford co-financing of energy efficiency measures: ~€6.9 million (3) • 30 percent gasification of households by 2020: €920 – 3,578 per household, depending on technological solutions (2) • Implementation of the measures in the Program for Accelerated Gasification of Bulgaria (household and services sectors): €204 million (4) – 396 million (minimum investment) (2) • National Renovation Programme for Residential Buildings in Bulgaria (NRPRBRB) 2006–2020: €2.1 billion (5) • Financing energy efficiency projects in municipal buildings under Operational Programme “Regional Development” (related to mandatory energy auditing measure): €62 million (5) • Development and implementation of standards for electricity consumption per employee in the public sector: no additional financing needed (5) • Develop a national plan to increase the number of nearly zero-energy buildings: €23 million (6) • Annual mandatory renovation of 3 percent of the TFA of central administration buildings (2014–2020): €6.93 million per year (6) • Achievement of individual energy-saving targets by building and industrial systems owners: €424.6 million (6) • Higher energy-efficiency requirements for public contracts: €104.9 million (6) 	<ul style="list-style-type: none"> • Gas supply to 30 percent of households by 2020 and substitution of electricity used for heating purposes expected to save over €500 million in energy costs (3) • Natural gas instead of electricity for heating and domestic purposes estimated to save at least 100kWh per year (up to 1,800 kWh/ per year per household) (3) • Implementation of Program for Accelerated Gasification of Bulgaria expected to reduce emissions by 2.45 million CO₂ equivalent (2), reduce energy intensity of primary energy consumption by ~6 percent in 2020 compared to 2009 (4) • National Renovation Programme for Residential Buildings in Bulgaria (NRPRBRB) 2006–2020 expected to have average energy savings of 25–35 kWh per m² per FA per year (energy savings of 35.5 percent compared to prior) and reduce CO₂ emissions by over 523,000 tons per year (5) • Development and implementation of standards for electricity consumption per employee in the public sector: 93 GWh per year impact on energy savings by 2020 (5) • Develop a national plan to increase the number of nearly zero-energy buildings: 5 ktoe (6) • Achievement of individual energy-saving targets by building and IS owners: 117 ktoe per year (6) • Higher energy-efficiency requirements for public contracts: 36 ktoe per year (6) 	<p>rategies/progress/reporting/docs/bg_2013_en.pdf</p> <p>(4) Nachmany, M. et al. (2015). “Climate Change Legislation in Bulgaria”. In <i>The 2015 Global Climate Legislation Study: A Review of Climate Change Legislation in 99 Countries</i>. http://bioresproject.eu/wp-content/uploads/2016/02/Climate-Change-Legislation-2015-BULGARIA.pdf</p> <p>(5) Republic of Bulgaria. (2011). Second National Energy Efficiency Action Plan, 2011–2013. Sofia. http://www.seea.government.bg/documents/Second_Energy_Efficiency_Action_Plan_EN.pdf</p> <p>(6) Republic of Bulgaria, Ministry of Economy and Energy. (2014). National Energy Efficiency Action Plan 2014–2020. Sofia. https://ec.europa.eu/energy/sites/ener/files/documents/NEEAPBulgaria_en.pdf</p> <p>(7) Republic of Bulgaria. Second National Action Plan on Climate Change, 2005–2008.</p>

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Option type	Specific Option	Cost	Cost effectiveness/cost-benefit	Source
Translate monitoring, forecasting and weather data for the energy sector	Review existing use of weather/climate data by energy sector stakeholders			
	Improve access and accessibility to weather/climate data for energy sector stakeholders			
Building institutional capacity and knowledge networks	Review current levels of awareness and knowledge of climate change within key institutions; Implement initial capacity building program			
	Continued dissemination and knowledge sharing on climate change impacts and responses by the energy sector (in Bulgaria and internationally)	<ul style="list-style-type: none"> Provision of public information regarding resources, state, and plans for development of electricity generation networks (2013–2020): €1.5 million Information campaigns/trainings for construction/building engineers and households to increase awareness of requirements for nearly zero energy buildings, new materials, practices and technologies: €0.15 million 		<p>Republic of Bulgaria, Ministry of Environment and Water. (2012). Third National Action Plan on Climate Change for the Period 2013-2020. Sofia.</p> <p>http://www4.unfccc.int/nap/Documents%20NAP/Third%20National%20Action%20Plan%20for%20the%20Period%202013-2020.pdf</p>