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CLIMATE VULNERABILITY ASSESSMENTS

An Assessment of Climate Change Vulnerability, Risk, and Adaptation in Albania's Power Sector

FINAL REPORT

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ESMAP MISSION

The Energy Sector Management Assistance Program (ESMAP) is a global knowledge and technical assistance trust fund program administered by the World Bank and assists low- and middle-income countries to increase know-how and institutional capacity to achieve environmentally sustainable energy solutions for poverty reduction and economic growth.

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TABLE OF CONTENTS

FIGURES

TABLES

BOXES

SYNOPSIS

Many countries are increasingly vulnerable to destructive weather events—floods, droughts, windstorms, or other parameters. The vulnerability is driven in part by climate but also by countries' sensitivity to events exacerbated by past practices, socioeconomic conditions, or legacy issues. The degree to which vulnerability to weather affects the countries' economies is driven by their coping or adaptive capacities.

Seasonal weather patterns, weather variability, and extreme events can affect the production and supply of energy, impact transmission capacity, disrupt oil and gas production, and impact the integrity of transmission pipelines and power distribution networks. Climate change also affects patterns of seasonal energy demand. It is important to explore these vulnerabilities for the energy sector given its major contribution to economic development, the long life span of energy infrastructure planning, and the dependence of energy supply and demand on weather.

This report showcases a pilot vulnerability, risk, and adaptation assessment undertaken for Albania's energy sector to raise awareness and initiate dialogue on energy sector adaptation. A bottom-up, stakeholder-based, qualitative/semi-quantitative risk-assessment approach is used to discuss and identify risks, adaptation measures, and their costs and benefits. It draws on experience and published guidance from the United Kingdom and Australia, as well as existing research and literature. The climate vulnerability assessment framework puts stakeholders at the heart of the decision-making process and involves:

- Climate risk screening of the energy sector to identify and prioritize hazards, current vulnerabilities, and risks from projected climate changes out to the year 2050.

- Identification of adaptation options to reduce overall vulnerability.

- A high-level cost benefit analysis of key physical adaptation options.

This pilot assessment demonstrates an approach that can be used to help countries and energy sector stakeholders develop policies and projects that are robust in the face of climatic uncertainties, and assist them in managing existing energy concerns as the climate changes. It identifies key direct risks to energy supply and demand and options for adaptation to establish where to focus subsequent in-depth analyses. It also identifies additional research needed to better understand the implications of extreme climatic events for the energy sector as well as potential indirect impacts—such as possible adaptation actions in the agriculture sector that may affect energy supply.

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Finally, the team would like to dedicate this report to Antonio (Tony) Lim who passed away in October 2009. Tony was a tireless campaigner for climate change and carbon finance at the World Bank who worked diligently to bring better appreciation for and attention to climate issues and challenges, particularly in the energy sector.

ACRONYMS

AKBN	National Agency for Natural Resources
AR4	The Fourth Assessment Report of the IPCC, released in 2007
CAPEX	Capital expenditure
CO_2	Carbon dioxide
CAT-DDO	Catastrophe Risk Deferred Draw-down Option
CBA	Cost–benefit analysis
CCGT	Combined cycle gas turbine power plant
CCSA	Climate change scenario for Albania
CSP	Concentrated solar power
ECA	Europe and Central Asia
ECMWF	European Centre for Medium-range Weather Forecasting
EIA	Environmental Impact Assessment
EMI	European meteorological institution
EMP	Environmental Management Plan
ERE	Energy Regulatory Authority
ESIA	Environmental and Social Impact Assessment
ESMAP	Energy Sector Management Assistance Program
EUCOS	EUMetNet Composite Observing System
EUMetSat	European Organisation for the Exploitation of Meteorological Satellites
GCM	General circulation model / Global climate model
GIS	Generation Investment Study
GIS	Geographical information system
GHG	Greenhouse gas
IEWE	Institute of Energy, Water, and Environment
IPCC	Intergovernmental Panel on Climate Change
KESH	Korporata Energjitike Shqiptare, Albanian Electricity Corporation
LHPP	Large hydropower plant
LNG	Liquefied natural gas
METE	Ministry of Economy, Trade and Energy
NES	National Energy Strategy
NHMS	National hydrometeorological service
NMS	National meteorological Service
OPEX	Operating expenditure
OST	Transmission System Operator
RCM	Regional climate model
REBIS	Regional Balkans Infrastructure Study
SEE	South Eastern Europe
SHPP	Small hydropower plant (less than 15 MW)
SRES	Special Report on Emissions Scenarios
SST	Sea surface temperature
SWOT	Strengths, weaknesses, opportunities and threats analysis
T&D	Transmission and distribution
TAP	Trans-Adriatic Pipeline
TFESSD	Trust Fund for Environmentally and Socially Sustainable Development
TPP	Thermal power plant
UKCIP	UK Climate Impacts Programme
UNFCCC	United Nations Framework Convention on Climate Change
WB	World Bank
WBG	World Bank Group
WMO	World Meteorological Organization

EXECUTIVE SUMMARY

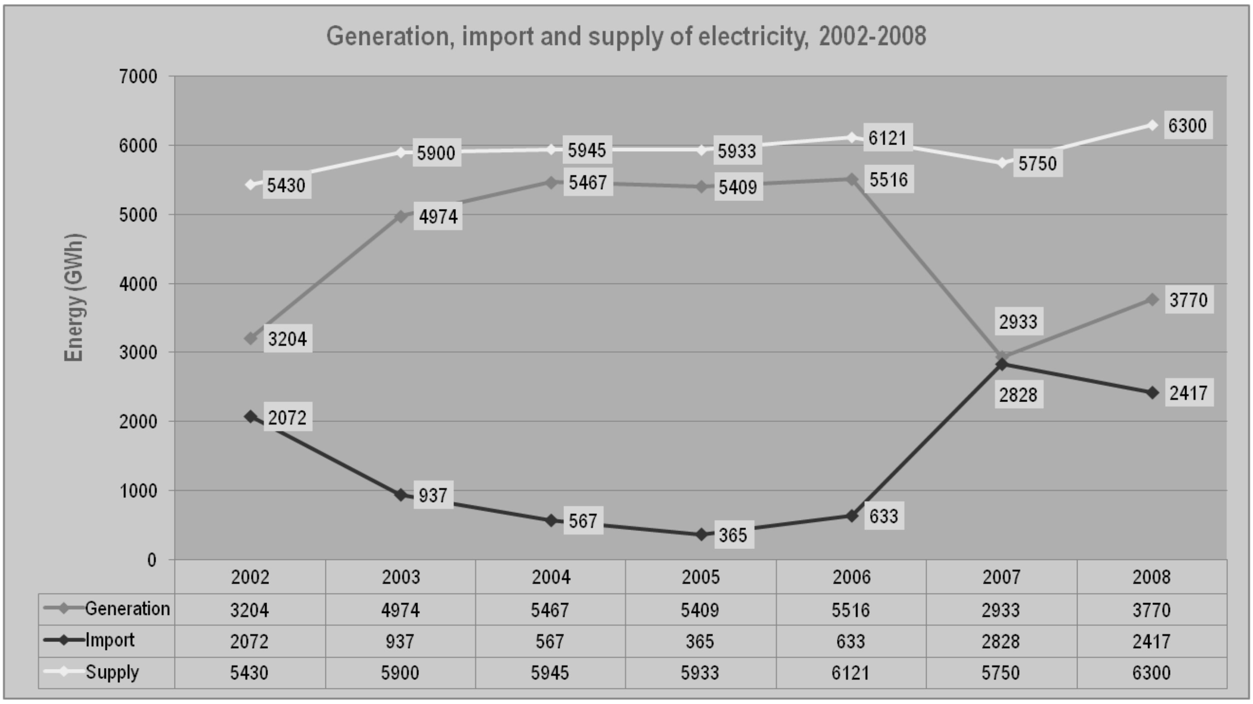
Albania's Energy Sector and Climate Change

Albania's water resources are a national asset, with hydropower from the River Drin currently providing about 90 percent of domestic electricity. As climate change mitigation targets and legislation are tightened, and with other countries struggling to reduce their greenhouse gas emissions, Albania's green production capability is an increasingly important national and regional asset. However, such a high dependence on hydropower also brings challenges. Albania finds it difficult to meet energy demand and maintain energy supply. The country's rainfall, on which its hydropower depends, is among the most variable in Europe. Hydropower production varies between about 2,900GWh in very dry years to twice that amount in very wet years.

Coupled with this, Albania has limited regional electricity interconnections at present, and imports are expensive. There are also significant inefficiencies in domestic energy supply, demand and water use. Technical losses in the transmission network were 213GWh in 2008 (3.3 percent), an improvement on losses in 2006 (which were 256GWh or 4 percent). Technical and commercial losses from the distribution system amounted to 1,927GWh (33 percent) in 2008. From 10 percent to 20 percent of water resources are lost in the irrigation system. All these factors have compounded to create frequent load shedding and consequent impacts on Albania's economic development. Figure 1 clearly shows lower domestic power production linked to low rainfall in the period 2002 to 2008, with resultant associated high energy imports. It is worth noting that, even with imports, load shedding has still been required, so the energy supply data in Figure 1 do not represent the true energy demand.

Efforts are underway to address these challenges and improve resource use efficiency: In 2008, for the first time, no load shedding was programmed and there has been a recent decision in Albania to eliminate load shedding from 2009 onward, along with a commitment to provide a 24-hour electricity supply. As well as reductions in losses from the transmission system, losses from the distribution system were reduced by 5.5 percent in 2008 compared to 2007. The efficiency of water use in energy generation is influenced by long-term reductions in efficiency (due to aging of assets) and more-recent management actions to improve water use efficiency. In 2007 and 2008, inflows to Fierze Reservoir were similar (approximately 4,120,000,000 m^3) but power generation in 2008 was 29.4 percent higher than in 2007. This was because high water levels were maintained in the reservoir in 2008, and there was better optimization between electricity import and domestic production. This improvement is reflected in a metric known as *specific consumption* (m^3 of water consumed per kWh of electricity generated). Specific consumption in 2007 was 1.40 m^3/kWh, whereas in 2008 it improved to 1.04 m^3/kWh. The new Dam Safety Project (funded by the World Bank) is reviewing investments in the Drin and Mati River Cascades, including investments in bathymetry and hydrology.

However, unless prompt action is taken, climate change looks set to worsen Albania's energy security over the medium to long term. This study estimates that a reduction in runoff of 20 percent by 2050 driven by climate change could lead to 15 percent less electricity generation from Albania's large hydropower plants (LHPPs) and 20 percent less from small hydropower plants (SHPPs). At the same time, increases in extreme precipitation events could lead to increased costs for maintaining dam security. Other energy assets are not immune from climate impacts. Rising sea levels and increased rates of coastal erosion will threaten energy assets in the coastal region. Rising air temperatures are also estimated to reduce the efficiency of TPPs by about 1 percent by 2050. If river-water cooled TPPs were developed in future, these would be affected by changes in river flows and higher river temperatures, further reducing their efficiency. Efficiency losses of 1 percent by 2050 are also estimated for transmission and distribution networks. Owing to uncertainties in current and future wind speeds, estimates of changes in wind power generation cannot be made. Solar energy production in Albania may, however, benefit from projected decreases in cloudiness—it is estimated that output from solar power could increase by 5 percent by 2050.



	2002	2003	2004	2005	2006	2007	2008
Generation	3204	4974	5467	5409	5516	2933	3770
Import	2072	937	567	365	633	2828	2417
Supply	5430	5900	5945	5933	6121	5750	6300

Figure 1: Generation, import, and supply of energy in Albania from 2002 to 2008 (ERE, 2008)

Energy demand is also related to climatic conditions. Higher temperatures due to climate change will reduce demand for space heating, particularly in winter, but will increase demand for space cooling and refrigeration in hotter months.

The seasonality of Albania's supply–demand imbalance will become increasingly critical: As summer demand rises along with temperatures, hydropower production in summer looks set to be most affected by reduced rainfall. At the same time, demand for agricultural irrigation will rise, further competing with water demand for small hydropower.

Adapting to climate variability and change will become increasingly important for the Albanian energy sector. KESH, Korporata Energjitike Shqiptare, the Albanian Electricity Corporation, is currently privatizing the country's energy sector. (The distribution system has recently been privatized, with the Czech company, CEZ, being the private sector operator.) As awareness of climate issues is accelerating globally, concerns about unmanaged climate risks and their impacts on the financial performance of the energy sector could make Albania less attractive to foreign energy investors.

This study provides high-level assessments of climate risks and adaptation options for Albania's energy sector, drawing on existing research and literature. It identifies key direct risks to energy supply and demand and options for adaptation in order to establish where subsequent more in-depth analyses should be focused. Additional research is recommended to better understand the implications of extreme climatic events for the energy sector and of changes in seasonality in energy supply and demand, as well as potential indirect impacts—for instance, due to the adaptation actions that may be taken in the agriculture sector, which may affect energy supply.

Recommendations for Building Climate Resilience of the Energy Sector

Given the challenges above, how could Albania best manage its future security of energy supply in the face of a changing climate?

Albania's recent draft National Energy Strategy (NES) sets out a so-called *active scenario,* which aims to improve energy security. It looks out to the medium term (the year 2019) and describes plans to diversify the energy system, by encouraging development of renewable energy generation assets (solar, small hydropower plants, wind, and biomass) and thermal power plants. It does not consider climate change impacts on energy security on these timescales. Yet, as already described, over the longer time horizons of this study (out to the year 2050) these assets will be increasingly affected by climate change. The draft NES's active scenario notes the importance of new electricity interconnection lines to facilitate Albania's active participation in the South East Europe energy market. But the wider region will also be affected by climate change—about one quarter of the region's electricity is generated by hydropower plants, and regional summer energy demand will rise along with temperatures and due to economic development. This could increase import prices and reduce supply, so these interconnections may not help Albania maintain energy security unless regionwide coping strategies are devised. The draft NES active scenario also emphasizes the need for improved energy efficiency through greater use of domestic solar water heating, improved building standards, lower-energy appliances, and alternative heating sources other than electricity. These energy-efficiency measures are increasingly critical as the climate changes, and Albania must provide financial incentives to promote their uptake. But, based on experience from other countries, implementing them in a timely manner will be a significant challenge.

Even if the measures in the draft NES active scenario were extrapolated to 2050 and fully implemented, this study estimates that, due to climate change impacts on supply and demand, Albania would still have a supply–demand gap. The estimated net shortfall due to climate change is on the order of 350 GWh per year by 2030, equivalent to power generation from a 50 MW thermal power plant. By 2050, the shortfall rises to 740 GWh per year (105 MW), or 3 percent of total demand. As previously noted, this disguises a more significant impact on energy security due to changing seasonal demand and production, with summer peak demand increasing when hydropower production is at its lowest.

So, what are the critical actions that Albania could take now to improve energy security now and in the future?

First, Albania could increase its investment in, and coordination of, meteorological, hydrometeorological and hydrological monitoring, modeling, and forecasting. These capabilities have been considerably eroded in recent decades due to lack of investment and poorly coordinated institutional arrangements. The current poor state of monitoring networks and forecasting capability prevent optimal use of water resources and operation of hydropower plants today—though some recent optimization improvements have been made. By exploiting better data on reservoir use, margins, and changes in rainfall and runoff, it should be possible to improve further the management of existing reservoirs. Investments in monitoring and forecasting would have other benefits, helping the agriculture and transportation sectors and the general population, while building resilience to climate change. Albania could develop (in-country) or obtain (from elsewhere) weather and climate forecasts appropriate for energy-sector planning, from short-range forecasts (1 to 3 days ahead) and medium-range forecasts (3 to 10 days ahead), to seasonal forecasts and regional downscaled climate change projections. Short-range and medium-range forecasts should be made available to decision makers with adequate lead time to help in optimizing the operation of the energy system. This could be supported by better interaction between meteorological/hydrometeorological experts and energy-sector decision makers. Drawing on this information, energy-sector stakeholders could work in partnership with water users in the agricultural sector to undertake climate risk assessments that are integrated across these sectors and could devise agreed strategies for managing shared water resources. Regional cooperation across South East Europe on sharing of monitoring data and forecasts could also be strengthened, especially in relation to shared watersheds (Drin, Vjosa). Albania could work in partnership with neighbors on regional studies on climate risks and their implications for energy security, prices and trade. These studies will help to build understanding of the extent to which the whole region will be affected in the same way at the same time by climatic events such as droughts, and how best to manage such regional risks.

Second, there are enormous opportunities for Albania to close its supply–demand gap through improved energy efficiency and demand-side management. While this is recognized in the draft NES active scenario, more emphasis and progress could be made on this issue. The large technical and commercial losses in the distribution system could be reduced and demand-side management could be improved through, for example, improved bill collection and establishment of cost-recovery tariffs (amending energy subsidies that are distorting market signals). Such actions are vital for many reasons—fiscal, economic, and as part of good governance. The recent privatization of the distribution system provides a driver for this. Similarly, the losses from the water irrigation system could be tackled and greater emphasis placed on improving the management of reservoirs, and on coordinating actions for more-efficient water resource use in every sector. The Ministry of Agriculture, Food and Consumer Protection has made significant progress recently in reducing irrigation losses from agriculture in some parts of Albania, and this work could usefully be scaled up across the country. In the face of climate change, the imperative for efficient and sustainable use of water resources is increasing.

Thirdly, Albania could review its technical standards and planning/contractual processes for all energy infrastructure, and upgrade them where needed to ensure that assets can withstand climate variability and projected climate change impacts over their lifetimes. For new assets, consideration of climate variability and change could be addressed through site selection decisions, environmental impact assessments, tariffs, incentives, contracts and public–private partnerships. Similarly, upgrading and rehabilitation of existing assets could build in assessments of, and resilience to, climate change impacts. For instance, it may be possible to increase water storage in existing reservoirs at a reasonable cost, to dampen the effects of seasonal variations in runoff. Emergency Contingency Plans (ECPs) for hydropower plants could also be reviewed and upgraded where needed, to take account of expected increases in precipitation intensity due to climate change. Power producers and local authorities may also need to improve their capacities to implement ECPs, ensuring that they provide sound mechanisms for monitoring weather and its influence on river flows and reservoir levels, as well as communication with downstream communities and contingency plans for evacuation.

Finally, climate change emphasizes the imperative (recognized in the draft National Energy Strategy active scenario) for Albania to increase the diversity of its energy supplies—both through increased regional energy trade and through developing a more diverse portfolio of domestic generation assets, ensuring that these are designed to be resilient to climate change. For example, Albania could structure Power Purchase Agreements including off-take arrangements and power-swap agreements that recognize the complementarities between the different countries' energy systems. For this study, a high-level cost–benefit analysis (CBA) has been undertaken to estimate the relative costs and benefits to Albania of increased energy trade and different types of domestic energy generation, to supply the shortfall in Albania's electricity that is attributed to climate change impacts (350 GWh per year by 2030, and 740 GWh per year by 2050) that remains after full implementation of an extrapolated NES active scenario to 2050. The CBA included the following options:

- Import of electricity
- Upgrading of existing large hydropower plants
- Upgrading of existing small hydropower plants
- New large hydropower plants
- New small hydropower plants
- New thermal power plants
- New wind farms
- New concentrated solar power plants (CSPs)

The performance of these options has been assessed, using parameters confirmed as important by energy-sector stakeholders in Albania. As well as financial parameters (capital and operational costs), environmental factors including water value, greenhouse gas emissions, and other emissions and ecosystem values were seen as relevant in choice among energy asset options. In terms of social parameters, disturbance to people and property was also assessed in the CBA. Using these parameters, the sustainability of the various options was ranked.

Figure 2 presents the net present value (NPV) results in current (2010) U.S. dollar terms for each of the options tested, under a base case set of assumptions. According to the CBA, the most economic options for Albania are upgrade of existing LHPPs and SHPPs, followed by development of new SHPPs and thermal power plants (the latter assumed to be gas-fired and shown as CCGTs in Figure 2). An alternate thermal power option could be the use of supercritical pulverized coal technology. While not considered in detail in the CBA, this option would lead to greater GHG emissions and water usage than a gas-fired thermal power facility, and would be less sustainable. Nevertheless, it would likely still be the fourth most-sustainable option.

Sensitivity analyses were undertaken, to test the sensitivity of these options to varying discount rates and values of greenhouse gas emissions. These confirmed that upgrading existing LHPPs and SHPPs were the most economic options. For discount rates in the range 2 percent to 20 percent, the relative ranking of the top two options does not change, with the "Upgrade existing LHPP" option returning the greatest NPV over all discount rates, followed by "Upgrade existing SHPP." However, when the discount rate is larger than 16.2 percent, thermal power plants (CCGTs) become marginally more attractive than "New SHPP." Thermal power plants have higher operating costs, but the effects of future operating costs on their NPV are diminished at higher discount rates. In addition, as the discount rate increases, import of electricity becomes a relatively more attractive option, though it remains NPV-negative across all discount rates examined.

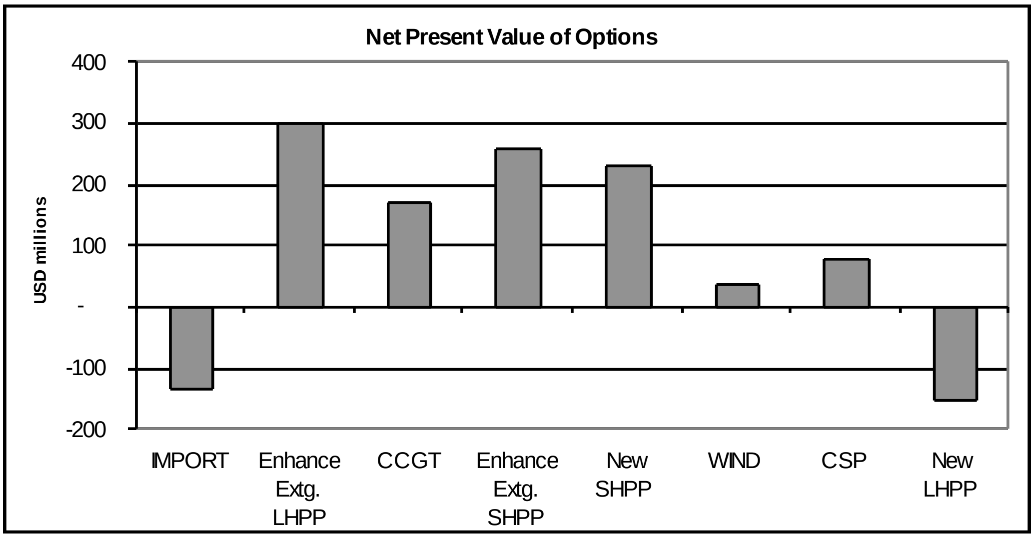


Figure 2: Net Present Value of diversification options, using base case assumptions

In relation to the effects on the options of varying the price of CO_2 and other greenhouse gases (GHGs), as expected, the economics of the renewable assets are insensitive to this parameter. Clearly, those options that are sensitive to increasing GHG value are thermal power plants (CCGTs) and import of electricity (assumed generated using CCGTs). The higher the value placed on carbon dioxide and other GHGs, the more unfavorable thermal power plants and electricity imports become in relative terms. However, domestic thermal power plants remain NPV-positive up to the highest value tested, US$100 per tonne of GHG.

In conclusion, there are several critical actions that Albania could take now—namely, improving meteorological and hydrometeorological monitoring, modeling, and forecasting, and improving energy efficiency, demand-side management, and water-use efficiency. These will help manage existing climate variability better and will build the country's resilience to climate change. Albania is on the brink of a significant adaptation opportunity: major investments in new energy assets are underway or being planned. Integrating adaptation measures into these can help ensure their climate resilience. As the electricity system is privatized, it is possible to consider how to structure incentives for adaptation; there could be opportunities for cost sharing between government and the private sector. According to the CBA, upgrades to existing LHPPs and SHPPs are the most economic options for Albania to fill the climate change-induced energy gap that will emerge over the period 2030 to 2050. For development of new assets and upgrade of existing assets, the earlier that climate risks and resilience are considered, the greater the opportunities to identify financially and economically efficient solutions that will build the robustness of the energy system for coming decades.

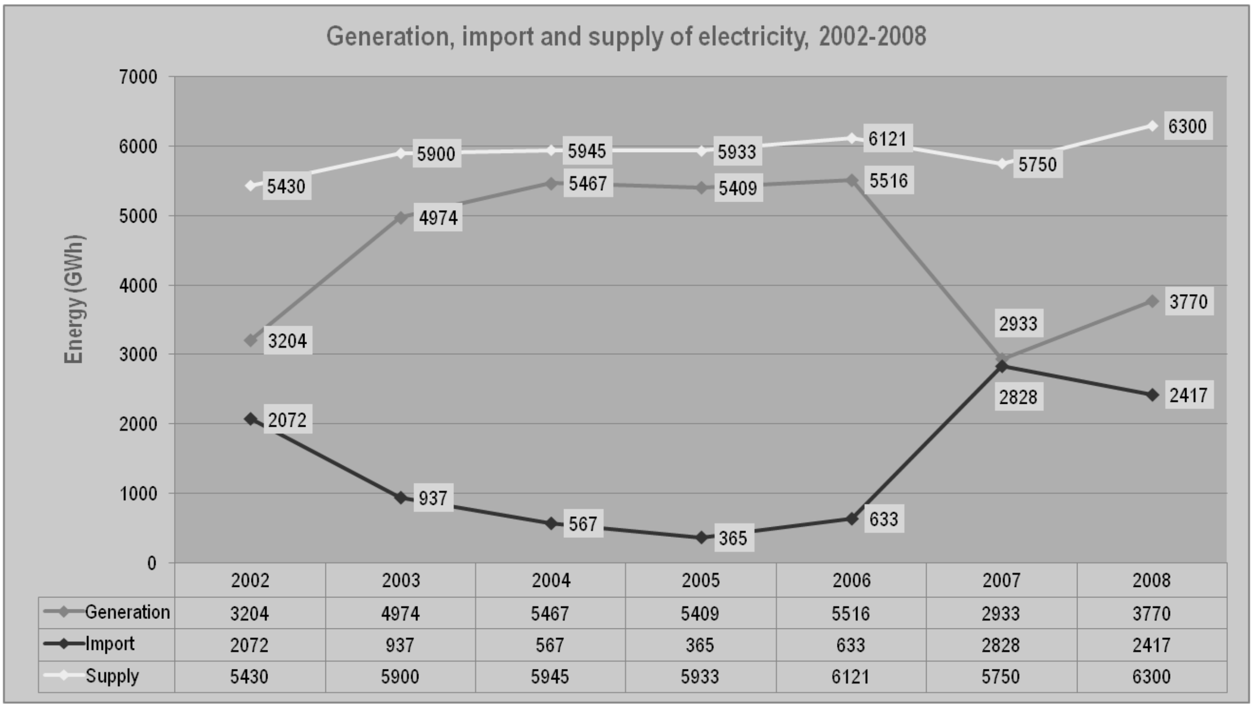
PËRMBLEDHJE EKZEKUTIVE

Sektori i energjisë në Shqipëri dhe ndryshimet klimatike

Burimet ujore të Shqipërisë janë një pasuri kombëtare, ku energjia hidrike nga lumi Drin siguron rreth 90% të energjisë elektrike të prodhuar në vend. Ndërkohë që synimet dhe legjislacioni për zbutjen e ndryshimeve klimatike bëhen më shtrënguese, dhe kur vendet e tjera mundohen të ulin shkarkimet e gazeve serë, aftësia e Shqipërisë për prodhim "të gjelbër" është një vlerë kombëtare dhe rajonale gjithnjë dhe më e rëndësishme. Megjithatë, një varësi e tillë e lartë tek energjia hidrike sjell dhe sfida. Për Shqipërinë është e vështirë të plotësojë kërkesën për energji elektrike dhe të ruajë nivelin e furnizimit me energji. Sasia e reshjeve të shiut në vend, nga të cilat varet dhe energjia hidrike, janë nga më të ndryshueshmet në Europë. Prodhimi i energjisë hidrike luhatet nga rreth 2,900 GWh në vitet shumë të thata deri në rreth dyfishin e kësaj sasie në vitet që janë jashtëzakonisht të lagështa.

Përveç kësaj, Shqipëria ka aktualisht numër të kufizuar interkonjeksionesh rajonale për energjinë elektrike dhe importet janë të shtrenjta. Gjithashtu, ka inefiçencë të lartë si në anën e furnizimit vendas me energji elektrike dhe në kërkesë, ashtu dhe në përdorimin e ujit. Humbjet teknike në rrjetin e transmetimit në vitin 2008 ishin 213GWh (3.3%), një përmirësim në krahasim me humbjet e vitit 2006 (të cilat ishin 256GWh ose 4%). Humbjet teknike dhe tregtare nga sistemi i shpërndarjes shkonin në 1,927GWh (32.7%) në vitin 2008. Ndërmjet 10% dhe 20% e burimeve ujore humbasin në sistemin e ujitjes. Të gjithë këta faktorë janë grumbulluar dhe shkaktojnë ndërprerje të shpeshta të energjisë dhe pasoja me ndikim në zhvillimin ekonomik të Shqipërisë. Figura 1 tregon qartësisht që ulja e prodhimit vendas të energjisë elektrike është e lidhur me uljen e sasisë së reshjeve në periudhën nga viti 2002 deri në vitin 2008, me një rezultante të shoqëruar me rritje të importeve të energjisë. Ja vlen të vihet në dukje që, edhe me importet, janë nevojitur ndërprerje në furnizimin me energji elektrike, kështu që të dhënat e furnizimit me energji në Figurën 1 nuk përfaqësojnë kërkesën e vërtetë për energji.

Po bëhen përpjekje për të adresuar këto sfida dhe për të përmirësuar eficencën e përdorimit të burimeve: Në vitin 2008, për të parën herë, nuk janë programuar ndërprerje të energjisë elektrike dhe ka patur një vendim të kohëve të fundit në Shqipëri për të eliminuar ndërprerjet për shkak të mbikgarkesës nga viti 2009 dhe më tej, së bashku me një angazhim për të siguruar një furnizim me energji 24 orë. Ashtu si uljet e humbjeve nga sistemi i transmetimit, edhe humbjet në sistemin e shpërndarjes u ulën me 5.5% në vitin 2008, krahasuar me vitin 2007. Eficenca e përdorimit të ujit gjatë prodhimit të energjisë elektrike ndikohet dhe nga uljet historike në eficencë (për shkak të vjetërimit të aseteve) si nga dhe veprimet menaxhuese më të fundit që synojnë të përmirësojnë eficencën e burimeve ujore. Në vitet 2007 dhe 2008, prurjet në rezervuarin e Fierzës ishin shumë të ngjashme (rreth 4,120,000,000 m^3) por prodhimi i energjisë elektrike në vitin 2008 ishte 29.4% më i lartë se në vitin 2007. Kjo erdhi si shkak i ruajtjes në nivele të lartat të ujit në rezervuar në vitin 2008, dhe optimizimit më të mirë ndërmjet importimit dhe prodhimit të brendshëm të energjisë elektrike. Ky përmirësim pasqyrohet në një element të njohur si *konsumim specifik* (m^3 ujë të konsumuar për kWh energji elektrike të prodhuar). Konsumi specifik në vitin 2007 ishte 1.40 m^3/kWh, ndërsa në vitin 2008 u përmirësua deri në 1.04 m^3/kWh. Projekti i ri mbi Sigurinë e Digave (financuar nga Banka Botërore) po shqyrton investimet në kaskadat e lumenjve Drin dhe Mat, përfshirë dhe investimet në batimetri dhe hidrologji.



	2002	2003	2004	2005	2006	2007	2008
Generation	3204	4974	5467	5409	5516	2933	3770
Import	2072	937	567	365	633	2828	2417
Supply	5430	5900	5945	5933	6121	5750	6300

Figura 1: Prodhimi, importimi dhe furnizimi me energji elektrike në Shqipëri nga viti 2002 në 2008 (ERE, 2008)

Megjithatë, po të mos ndërmerren veprime të menjëhershme, ndryshimet klimatike duket që do ta përkeqësojnë sigurinë e energjisë në Shqipëri në afat të mesëm dhe të gjatë. Ky studim vlerëson se një reduktim 20% në rrjedhje deri në vitin 2050 i nxitur nga ndryshimet klimatike mund të çojë në 15% më pak prodhim të energjisë elektrike nga hidrocentralet e mëdha të Shqipërisë (HECM) dhe 20% më pak nga hidrocentralet e vogla (HECV). Në të njëjtën kohë, rritjet në ngjarjet ekstreme të reshjeve mund të çojnë në rritjen e shpenzimeve për ruajtjen e sigurisë së digave. Edhe asetet e tjera të energjisë nuk janë të imunizuara nga ndikimet klimatike. Rritja e niveleve të detit dhe rritja e shkallës së erozionit bregdetar do të kërcënojnë asetet e energjisë në zonat bregdetare. Temperaturat në rritje të ajrit vlerësohen gjithashtu që do të zvogëlojnë efikasitetin e TEC-ve me 1% deri në vitin 2050. Nëse në të ardhmen do të ndërtohen TEC-e që ftohen me ujin lumenjve, këto do të ndikohen si nga ndryshimet në sasinë e rrjedhës së lumenjve ashtu dhe nga temperaturat më të larta të ujit të lumit, duke zvogëluar më tej efikasitetin e tyre. Humbjet e efikasitetit prej 1% deri në vitin 2050 janë parashikuar edhe për rrjetet e transmetimit dhe shpërndarjes. Për shkak të paqartësive mbi shpejtësinë e erës si atë aktuale dhe në të ardhmen, nuk mund të bëhen vlerësime mbi ndryshimet në prodhimin e energjisë elektrike me anë të erës. Megjithatë, prodhimi i energjisë diellore në Shqipëri mund të përfitojë nga zvogëlimi i parashikuar në mbulimin me re – është llogaritur që prodhimi nga energjia diellore mund të rritet me 5% deri në vitin 2050.

Kërkesa për energji elektrike është e lidhur edhe me kushtet klimatike. Temperaturat më të larta për shkak të ndryshimeve klimatike do të ulin kërkesën për ngrohjen e hapësirave, veçanërisht në dimër, por do të rrisin kërkesën për ftohje hapësirash dhe përdorim frigoriferik në muajt më të nxehtë.

Sezonaliteti i çekuilibrit furnizim-kërkesë të Shqipërisë do të bëhet gjithnjë e më kritik: ndërkohë që kërkesa gjatë verës rritet së bashku me temperaturat, prodhimi i energjisë hidrike në verë duket do të jetë më i prekuri nga reduktimi i sasisë së reshjeve. Në të njëjtën kohë, kërkesa për ujitje në bujqësi do të rritet, duke konkuruar më shumë me kërkesën për ujë të hidrocentraleve të vogla.

Adaptimi me ndryshueshmërinë dhe ndryshimin e klimës do të bëhet gjithnjë e më i rëndësishëm për sektorin energjetik shqiptar. KESH-i, Korporata Elektorenergjitike Shqiptare, është aktualisht duke privatizuar sektorin e energjisë të vendit. (Sistemi i shpërndarjes është privatizuar kohët e fundit, ku kompania çeke CEZ është operatori privat i sektorit). Ndërkohë që ndërgjegjësimi mbi kërcënimet e klimës po përshpejtohet në nivel global, shqetësimet në lidhje me rreziqet e pamenaxhuara të klimës dhe ndikimet e tyre mbi performancën financiare të sektorit të energjisë mund ta bëjnë Shqipërinë më pak tërheqëse për investitorët e huaj të energjisë.

Ky studim jep vlerësime të nivelit të lartë mbi rreziqet klimatike dhe mundësitë për tu përshtatur për sektorin energjitik të Shqipërisë, duke u mbështetur në kërkimet dhe literaturën ekzistuese. Ai identifikon rreziqet kryesore të drejtpërdrejta për furnizimin dhe kërkesën për energji elektrike dhe mundësitë për tu përshtatur, si dhe paraqet ku duhet të përqendrohen më shumë analizat e mëtejshme më të thella. Rekomandohen kërkime shtesë për të kuptuar më mirë implikimet e ngjarjeve ekstreme klimatike për sektorin e energjisë dhe të ndryshimeve në sezonalitetin e furnizimit dhe kërkesës për energji elektrike, si dhe ndikimet e mundshme të tërthorta – për shembull, për shkak të veprimeve përshtatëse që mund të merren në sektorin e bujqësisë, dhe të cilat mund të ndikojnë në furnizimin me energji.

Rekomandimet për krijimin e elasticitetit klimatik të sektorit energjitik

Duke patur parasysh sfidat e mësipërme, si mund të menaxhojë më mirë Shqipëria në të ardhmen sigurinë e furnizimit me energji përballë një klime që po ndryshon?

Draft-strategjia e fundit Kombëtare e Energjisë (SKE) e Shqipërisë përcakton një të ashtuquajtur ‘skenar aktiv’, i cili synon të përmirësojë sigurinë e energjisë. Ai mbulon periudhën afat-mesme (deri në vitin 2019) dhe përshkruan planet për të diversifikuar sistemin energjitik, duke nxitur ndërtimin e aseteve për prodhimin e energjisë të rinovueshme (diellore, hidrocentrale të vogla, era dhe biomasa) dhe termocentraleve. Ajo nuk merr parasysh ndikimet e ndryshimeve klimatike mbi sigurinë e energjisë në këto periudha kohore. Megjithatë, siç përshkruhet dhe më lart, përgjatë shtrirjeve më të gjata kohore të këtij studimi (deri në vitin 2050) këto asete do të ndikohen gjithnjë e më shumë nga ndryshimet klimatike. Skenari aktiv i draft- SKE-së vë në dukje rëndësinë e linjave të reja të interkonjeksionit të energjisë elektrike për të lehtësuar pjesëmarrjen aktive të Shqipërisë në tregun e energjisë të Europës Jug-Lindore. Por dhe rajoni më i gjerë gjithashtu do të ndikohet nga ndryshimet klimatike – rreth një e katërta e energjisë elektrike të rajonit prodhohet nga hidrocentralet, dhe kërkesa rajonale për energji gjatë verës do të rritet së bashku me temperaturat dhe për shkak të zhvillimit ekonomik. Kjo mund të rrisë çmimet e importit dhe të zvogëlojë furnizimin, kështu që këto interkonjeksione mund të mos e ndihmojnë Shqipërinë të ruajë sigurinë e energjisë nëse nuk hartohen strategji përballuese për gjithë rajonin. Skenari aktiv i draft SKE-së gjithashtu thekson nevojën për të përmirësuar efiçencën e energjisë nëpërmjet rritjes së përdorimit më të madh shtëpiak të ngrohjes së ujit me energji diellore, përmirësimin e standarteve të ndërtimit, përdorimin e pajisjeve shtëpiake që përdorin pak energji dhe burimet alternative për ngrohje përveç energjisë elektrike. Këto masa të efiçencës së energjisë janë gjithmonë e më kritike ndërkohë që klima ndryshon, dhe Shqipëria duhet të ofrojë nxitje financiare për të bërë të mundur përdorimin e këtyre masave. Por, duke u bazuar në përvojën e vendeve të tjera, zbatimi i tyre në kohë do të jetë një sfidë e rëndësishme.

Edhe në qoftë se masat në skenarin aktiv të draft SKE-së që shtrihet deri në vitin 2050 do të zbatohen plotësisht, ky studim vlerëson se, për shkak të ndikimeve të ndryshimeve klimatike mbi kërkesën dhe ofertën, Shqipëria ende do të ketë një hendek furnizim-kërkesë. Mungesa e parashikuar neto për shkak të ndryshimit të klimës është rreth 350 GWh në vit deri në vitin 2030, e barabartë me prodhimin e energjisë nga një termocentral 50 MW. Deri në vitin 2050, mungesa rritet në 740 GWh në vit (105 MW), ose 3% e kërkesës totale. Siç u theksua dhe më lart, kjo fsheh një ndikim më të rëndësishëm për sigurimin e energjisë për shkak të ndryshimit të kërkesës dhe të prodhimit sezonal, me rritjen e kërkesës pik të verës në kohën që prodhimi i energjisë hidrike është në nivelin e tij më të ulët.

Pra, cilat janë veprimet kritike që Shqipëria mund të ndërmarrë tani për të përmirësuar sigurinë e energjisë tani dhe në të ardhmen?

Së pari, Shqipëria mund të shtojë investimin e saj, dhe koordinimin e monitorimit, modelimit dhe parashikimit meteorologjik, hidrometeorologjik dhe hidrologjik. Këto aftësi janë shkatërruar në mënyrë të konsiderueshme në dekadat e fundit për shkak të mungesës së investimeve dhe rregullimet institucionale të koordinuara dobët. Gjendja e keqe aktuale e rrjeteve të monitorimit dhe aftësive parashikuese pengojnë përdorimin optimal të burimeve ujore dhe funksionimin e hidrocentraleve sot – megjithëse, siç vihet në dukje më lart, janë bërë disa përmirësime të kohëve të fundit për optimizimin. Duke shfrytëzuar të dhëna më të mira mbi përdorimin e rezervuarëve, kufijve dhe ndryshimeve në sasinë e reshjeve dhe rrjedhjeve, do të jetë e mundur të përmirësohet më tej menaxhimi i rezervuarëve ekzistues. Investimet në monitorim dhe parashikim të motit do të kishin përfitime të tjera, duke ndihmuar edhe sektorët e bujqësisë dhe transportit dhe popullatën në përgjithësi, si edhe ndërtimin e elasticitetit ndaj ndryshimeve klimatike. Shqipëria mund të zhvillojë (në vend) ose të marrë (nga vende të tjera) parashikimet e motit dhe klimës të përshtatshme për planifikim në sektorin e energjisë, duke mbuluar parashikimet në periudhë afat shkurtër (1-3 ditë përpara), parashikimet në periudhë afat mesme (3-10 ditë), parashikimet sezonale si dhe parashikimet rajonale të ndryshimit të klimës me shkallë të zvogëluar. Parashikimet për periudhë afat shkurtër dhe afat mesme duhet të jenë në dispozicion të vendim-marrësve në kohë reale, për të ndihmuar në optimizimin e funksionimit të sistemit energjitik. Kjo mund të mbështetet nëpërmjet bashkëveprimit më të mirë ndërmjet ekspertëve meteorologjikë/hidrometeorologjikë dhe vendim-marrësve në sektorin e energjisë. Duke u mbështetur në këto të dhëna, palët e interesuara të sektorit të energjisë mund të punojnë në partneritet me përdoruesit e ujit në sektorin e bujqësisë, për të ndërmarrë vlerësime të rrezikut të klimës që janë të integruara në të gjithë këta sektorë dhe të hartojnë strategji të pranuara për të menaxhuar burimet ujore të përbashkëta. Duhet gjithashtu të forcohet bashkëpunimi rajonal në të gjithë Europën Juglindore për shkëmbimin e të dhënave të monitorimit dhe parashikimeve, veçanërisht në lidhje me pellgjet ujëmbledhës të përbashkëta (Drin, Vjosa). Shqipëria mund të punojë në partneritet me fqinjët në studime rajonale mbi rreziqet klimatike dhe implikimet e tyre për sigurinë, çmimet dhe tregtinë e energjisë. Këto studime do të ndihmojnë për të ndërtuar të kuptuarit nëse i gjithë rajoni do të ndikohet në të njëjtën mënyrë, e në të njëjtën kohë nga ngjarjet klimatike të tilla si thatësira, dhe cila është mënyra më e mirë për të menaxhuar rreziqe të tilla rajonale.

Së dyti, ekzistojnë mundësi shumë të mëdha për Shqipërinë për të mbyllur hendekun e saj furnizim-kërkesë përmes përmirësimit të efiçencës së energjisë dhe menaxhimit të anës së kërkesës. Megjithëse kjo është e pranuar në skenarin aktiv të draftit të SKE-së, duhet t'i vihet më shumë theksi dhe të bëhet përparim në këtë çështje. Mund të reduktohen humbjet e mëdha teknike dhe tregtare nga sistemi i shpërndarjes, si dhe mund të përmirësohet menaxhimi i kërkesës përmes mbledhjes së përmirësuar të faturave dhe vendosjes së tarifave që mbulojnë kostot (duke ndryshuar subvencionet e energjisë të cilat po deformojnë sinjalet e tregut).

Veprime të tilla janë jetike për shumë arsye – fiskale, ekonomike dhe si pjesë e qeverisjes së mirë. Privatizimi i fundit i sistemit të shpërndarjes siguron një shtysë për këtë. Në mënyrë të ngjashme, humbjet nga sistemi i ujitjes mund të trajtohen dhe të vihet më shumë theksi në përmirësimin e menaxhimit të rezervuarëve, dhe në bashkërendimin e veprimeve për përdorimin më efiçent të burimeve ujore në çdo sektor. Ministria e Bujqësisë, Ushqimit dhe Mbrojtjes së Konsumatorit ka bërë përparim të ndjeshëm kohët e fundit në reduktimin e humbjeve gjatë ujitjes në bujqësi në disa pjesë të Shqipërisë, dhe kjo punë mund të shkallëzohet në mënyrë të dobishme në të gjithë vendin. Përballë ndryshimeve klimatike, po rritet domosdoshmëria për përdorim efiçent dhe të qëndrueshëm të burimeve ujore.

Së treti, Shqipëria mund të rishikojë standardet e saj teknike dhe proceset planifikuese/ kontraktuese për të gjithë infrastrukturën energjitike, dhe për t’i përmirësuar ato ku të jetë e nevojshme për të siguruar që asetet mund të përballojnë ndryshueshmërinë klimatike dhe ndikimet e parashikuara të ndryshimeve klimatike gjatë jetës së tyre. Për asetet e reja, shqyrtimi i ndryshueshmërisë dhe ndryshimeve të klimatike mund të trajtohet përmes vendimeve mbi përzgjedhjen e vendndodhjes, vlerësimeve të ndikimit në mjedis, tarifave, stimujve, kontratave dhe partneritetit publik-privat. Në mënyrë të ngjashme, përmirësimi dhe rehabilitimi i aseteve ekzistuese mund të përfshijë vlerësimet, dhe elasticitetin, ndaj ndikimeve të ndryshimeve klimatike. Për shembull, mund të jetë e mundur të rritet ruajtja e ujit në rezervuaret ekzistuese me një kosto të arsyeshme, për të zbutur efektet e variacioneve sezonale në rrjedhje. Planet e emergjencave të paparashikuara (PEP) për hidrocentralet duhet gjithashtu të shqyrtohen dhe përmirësohen aty ku është e nevojshme, për të marrë parasysh rritjet e pritshme në intensitetin e reshjeve si shkak i ndryshimeve klimatike. Prodhuesit e energjisë dhe autoritetet lokale mund të kenë gjithashtu nevojë për të përmirësuar kapacitetet e tyre për të zbatuar PEP, duke siguruar që ato japin mekanizma të shëndoshë për monitorimin e motit dhe ndikimin e tij në prurjet e lumenjve dhe nivelet e rezervuarëve, si dhe komunikim me komunitetet që banojnë poshtë rrjedhës dhe planet e emergjencës për evakuim.

Së fundmi, ndryshimet klimatike theksojnë domosdoshmërinë (e pranuar në skenarin aktiv të draftit të Strategjisë Kombëtare të Energjisë) për Shqipërinë, për të rritur diversitetin e furnizimeve me energji – si nëpërmjet rritjes së tregtisë rajonale të energjisë ashtu dhe nëpërmjet zhvillimit të një portofoli më të shumëllojshëm të aseteve prodhuese vendase, duke siguruar që këto të jenë projektuar në mënyrë që të jenë elastikë ndaj ndryshimeve klimatike. Për shembull, Shqipëria mund të strukturojë Marrëveshjet e Blerjes së Energjisë duke përfshirë edhe rregullimet e marrjes dhe marrëveshjet e këmbimit të energjisë, të cilat njohin plotësimet ndërmjet sistemeve të energjisë të vendeve të ndryshme. Për këtë studim, është ndërmarrë një analizë e nivelit të lartë të kosto-përfitimeve (CBA) për të llogaritur kostot dhe përfitimet relative për Shqipërinë të tregtisë së rritur të energjisë dhe llojet e ndryshme të prodhimit vendas të energjisë, për të furnizuar (mbuluar) mungesën e energjisë elektrike të Shqipërisë që i atribuohet ndikimeve të ndryshimeve klimatike (350 GWh në vit deri në vitin 2030, dhe 740 GWh në vit deri në vitin 2050) dhe që mbetet pas zbatimit të plotë të skenarit aktiv të SKE të shtrirë (ekstrapoluar) deri në vitin 2050. CBA përfshin mundësitë e mëposhtme:

- përmirësimin e hidrocentraleve të mëdha ekzistuese,
- përmirësimin e hidrocentraleve të vogla ekzistuese,
- hidrocentrale të reja të mëdha,
- hidrocentrale të reja të vogla,
- termocentrale të reja,

- impiante të reja të erës, dhe
- impiantet e reja të energjisë së përqëndruar diellore (CSP).

Performanca e këtyre alternativave është vlerësuar, duke përdorur parametrat që janë konfirmuar si të rëndësishme nga aktorët kryesorë të sektorit të energjisë në Shqipëri. Ashtu si dhe parametrat financiare (shpenzimet kapitale dhe operative), faktorët mjedisorë duke përfshirë vlerën e ujit, gazet me efekt serrë dhe shkarkimet e tjera dhe vlerat e ekosistemit u panë si të rëndësishëm në zgjedhjen midis alternativave të aseteve të energjisë. Përsa i përket parametrave sociale, u vlerësua shqetësimi i njerëzve dhe pronës në CBA. Duke përdorur këto parametra, u rendit qëndrueshmëria e alternativave të ndryshme.

Figura 2 paraqet rezultatet e Vlerës së Tanishme Neto (Net Present Value – NPV) në terma aktuale (2010) në USD për secilin nga alternativat e testuara, bazuar në një grup supozimesh si rast bazë. Sipas CBA, alternativa më ekonomike për Shqipërinë është përmirësimi i HECM dhe HECV ekzistuese, e ndjekur nga ndërtimi i HECV të reja dhe termocentraleve të reja (treguar në Figurën 2 si 'CCGT' – turbina gazi me cikël të kombinuar). Një opsion alternativ i energjisë termike mund të jetë përdorimi i teknologjisë superkritike me qymyr të pluhurizuar. Megjithëse nuk shqyrtohet me hollësi në CBA, kjo alternativë mund të ketë shkallë më të lartë të shkarkimeve të gazrave me efekt serrë dhe të përdorimit të ujit krahasuar me një termocentral me gaz, si dhe do të jetë më pak i qëndrueshëm. Megjithatë, ka të ngjarë të jetë zgjedhja e katërt më e qëndrueshme e grupit të alternativave.

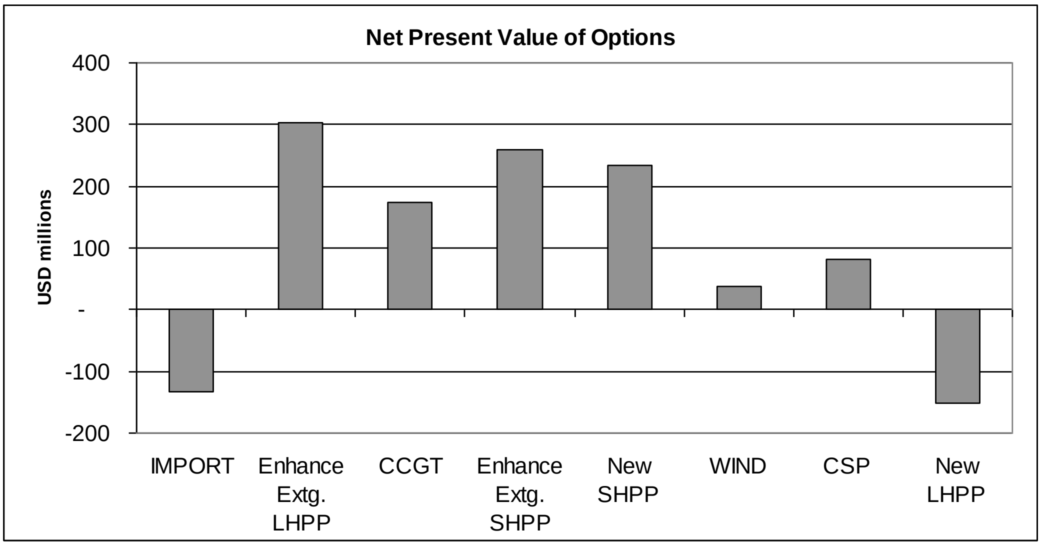


Figura 2: Vlera e Tanishme Neto e alternativave të diversifikimit, duke përdorur supozimet e rastit bazë

Janë ndërmarrë analizat e ndjeshmërisë, për të provuar sa të ndjeshme janë këto opsione në nivele të ndryshme zbritjeje dhe vlera të ndryshme të shkarkimeve të gazeve serë. Ato konfirmuan se përmirësimi i HECM dhe HECV ekzistuese ishin alternativat më ekonomike. Për normat e zbritjes (discount rates) nga 2% deri 20%, renditja relative e dy opsioneve kryesore nuk ndryshon, ku alternativa "Përmirësimi i HECM" shfaqi NPV më të madhe nga të gjitha normat e zbritjes, e ndjekur nga "Përmirësimi i HECV ekzistues". Megjithatë, kur norma e zbritjes është më e madhe se 16,2%, termocentralet (CCGT – turbina gazi me cikël të kombinuar) bëhen pak më tërheqëse se sa "HECV të reja". Termocentralet kanë kosto të larta operative, por efektet e kostove të ardhshme operative mbi NPV e tyre zvogëlohen në nivele më të larta zbritjeje. Përveç kësaj, me rritjen e normave të zbritjes, importimi i energjisë elektrike bëhet një alternativë relativisht më tërheqëse, edhe pse ai mbetet me NPV negative në të gjitha normat e zbritjes që janë ekzaminuar.

Në lidhje me ndikimet mbi opsionet e ndryshme të ndryshimit të çmimit të CO_2 dhe gazeve të tjera me efekt serë (GHG), siç pritej, ekonomia e aseteve të rinovueshme është e pandjeshme ndaj këtij parametri. Është e qartë që ato opsione që janë të ndjeshme ndaj vlerës në rritje të GHG janë termocentralet (CCGT) dhe importimi (supozohet të jetë prodhuar duke përdorur CCGT). Sa më e lartë të jetë vlera e vendosur mbi dioksidin e karbonit dhe GHG-të e tjera, aq më të pafavorshme bëhen termocentralet dhe importimi në terma relative. Megjithatë, termocentralet vendase mbeten me NPV pozitive deri në vlerën më të lartë të testuar, me 100 USD për ton GHG.

Në përfundim, ekzistojnë disa veprime të rëndësishme që Shqipëria mund të ndërmarrë tani – përkatësisht, përmirësimin e monitorimit, modelimit dhe parashikimit meteorologjik dhe hidrometeorologjik, dhe përmirësimin e efiçencës së energjisë, menaxhimin e anës së kërkesës dhe përdorimin efiçent të ujit. Këto do të ndihmojnë për të menaxhuar më mirë ndryshueshmërinë ekzistuese të klimës, dhe do të krijojnë elasticitetin e vendit ndaj ndryshimeve klimatike. Shqipëria është në prag të një mundësie të rëndësishme përshtatshmërie: investime të mëdha në asetet e reja energjitike janë duke u zhvilluar ose duke u planifikuar. Integrimi i masave të adaptimit në to mund të ndihmojë sigurimin e elasticitetit të tyre ndaj klimës. Ndërkohë që sistemi i energjisë elektrike është është privatizuar, është e mundur të shqyrtohet se si të strukturohen stimujt për adaptim; mund të ketë mundësi për ndarjen e shpenzimeve ndërmjet qeverisë dhe sektorit privat. Sipas CBA, përmirësimi i HECM dhe HECV ekzistuese është opsioni më ekonomik për Shqipërinë për të mbushur hendekun e energjisë të shkaktuar nga ndryshimet klimatike, i cili do të shfaqet gjatë periudhës nga viti 2030 deri në 2050. Për zhvillimin e aseteve të reja dhe përmirësimin e aseteve ekzistuese, sa më herët të merren në konsideratë rreziqet dhe elasticiteti klimatik, aq më të mëdha do të jenë mundësitë për të identifikuar zgjidhje me efiçencë financiare dhe ekonomike që do të krijojnë qëndrueshmërinë e sistemit të energjisë për dekadat e ardhshme.

1. OVERVIEW

Energy security is a key concern in Albania, which relies on hydropower for about 90 percent of its electricity production. While renewable energy resources like hydropower play a fundamental role in moving the world towards a low-carbon economy, they are also vulnerable to climatic conditions. Climate variability already affects Albania's energy production to a considerable extent, and climate change is bringing further challenges.

This report summarizes work conducted in partnership with stakeholders in Albania's energy sector and other closely related sectors. It aimed to build greater understanding of the climate risks faced by the energy sector and of priority actions that could be taken to reduce vulnerabilities. It addressed the following question:

> ***"How can Albania best manage its future security of energy supply in the face of a changing climate?"***

Best is defined as "an optimal balance between financial, environmental and social objectives."

The work involved:

- Climate-risk screening of the energy sector to identify and prioritize hazards, current vulnerabilities
- Estimating the impacts of projected climate changes on energy supply and demand out to the year 2050
- Identifying adaptation options to reduce overall vulnerability
- A high-level cost–benefit analysis of key physical adaptation options

The analysis was intended to raise awareness among stakeholders and provide high-level (semi-quantitative) assessments of risks and adaptation options for Albania's energy sector, drawing on existing research and literature on climate change and its impacts. It aimed to identify key risk areas and options for adaptation, to establish where subsequent more in-depth analyses should be focused. Additional research would help to improve understanding of the implications of extreme climatic events, which are addressed only briefly in this study. There may also be significant indirect impacts that could be better understood through integrated cross-sectoral assessments—for instance, the effects on energy supply of the adaptation actions that may be taken in the agriculture sector. The recommended next steps to further refine and improve the evidence base for adaptation planning are described in Section 6.

It is intended that this assessment will help support the Albanian government and other energy-sector stakeholders in developing policies and projects (future energy assets) that are robust in the face of climatic uncertainties, and will also assist them in managing existing energy concerns, as the climate changes.

Box 1: Development and climate change at work

The World Bank Group's (WBG) operational response to climate change is articulated in *Development and Climate Change: A Strategic Framework for the World Bank Group*, a framework prepared at the request of the Development Committee during the WBG's 2007 Annual Meetings and endorsed a year later. Six action areas are identified to support the specific needs and priorities of World Bank clients:

1. Support climate actions in country-led development processes.
2. Mobilize additional concession and innovative finance.
3. Facilitate the development of market-based financing mechanisms.
4. Leverage private sector resources.
5. Support accelerated development and deployment of new technologies.
6. Step up policy research, knowledge, and capacity building.

Supporting tools for adaptation and actions with mitigation co-benefits are linked to each action area. The focus is on improving knowledge and capacity, including learning by doing. The framework sets measurable indicators to track implementation performance over fiscal years 2009 to 2011.

(Adapted from: Development and Climate Change, A Strategic Framework for the World Bank Group, World Bank, 2008a).

The analysis has been co-funded by the Energy Sector Management Assistance Program (ESMAP), the Trust Fund for Environmentally and Socially Sustainable Development (TFESSD) and the World Bank. It fits within the broader context of the World Bank's Strategic Framework on Development and Climate Change (see Box 1).

1.1. METHODOLOGICAL APPROACH

The overall approach for undertaking the analysis followed a risk-based framework for decision-making on climate change adaptation, applying guidance published in the UK (Willows and Connell, 2003) and Australia (Broadleaf Capital International and Marsden Jacob Associates, 2006). An annotated version of the framework is shown in Figure 3.

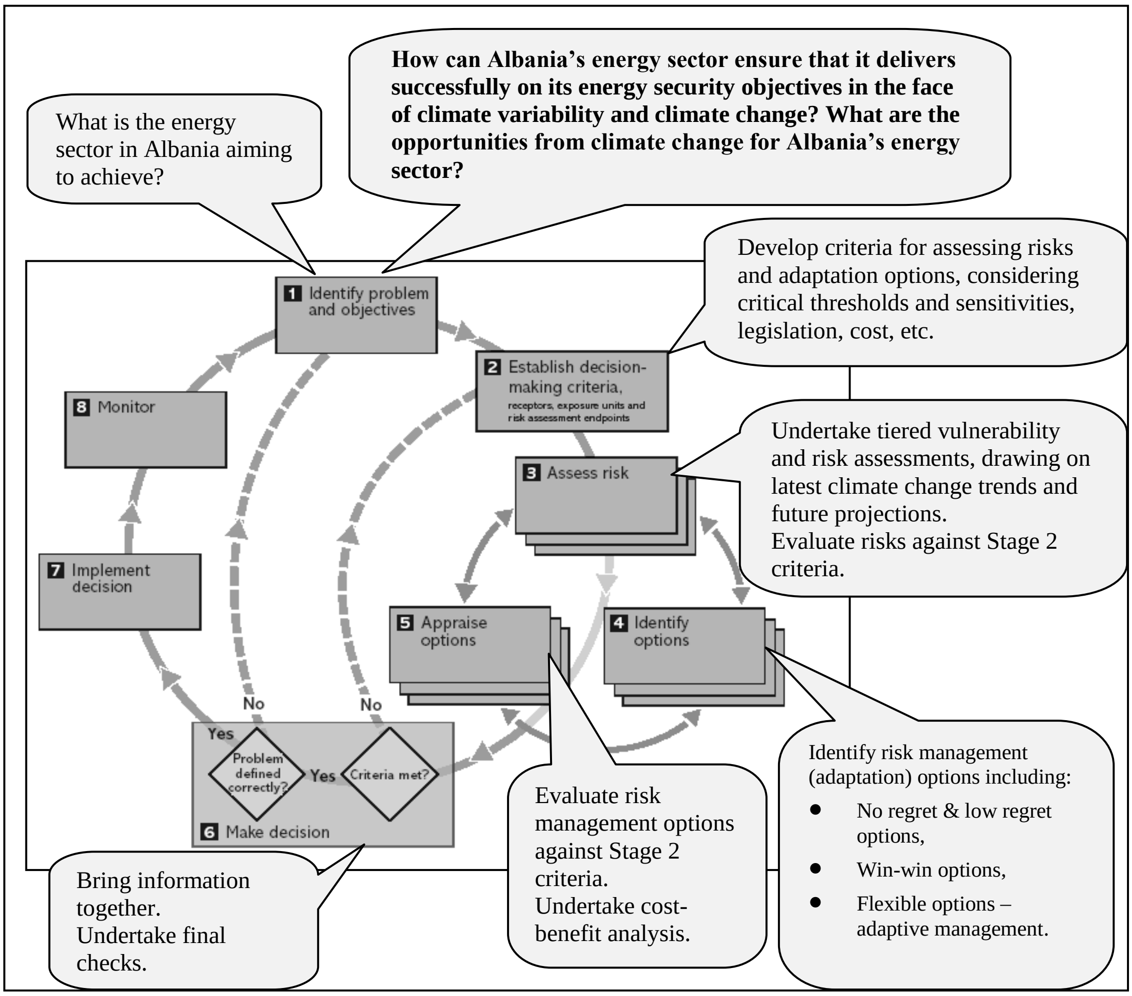
The framework puts stakeholders at the heart of the decision-making process. It starts by working with stakeholders to define their objectives and success criteria, and maintains their involvement through the stages of climate vulnerability assessment, risk assessment, and risk management (adaptation planning).

The assessment was intended to deliver a high-level (semi-quantitative) analysis covering the entire energy sector. It identifies key issues related to Albania's energy security in the face of climate variability and change, and demonstrates where subsequent in-depth analyses should be focused.

Delivering the assessment involved the following activities that are described further in Annex 1:

- Review Albania's energy sector strategies, energy assets and energy demand projections.
- Review and build on work conducted for Albania's First National Communication to the United Nations Framework Convention on Climate Change (Islami *et al.*, 2002).
- Analyze observed climatic conditions and data on future climate change for Albania.
- Use Geographical Information System (GIS) to map Albania's energy assets overlaid with data on climate change.

- Conduct a hands-on vulnerability assessment and development of SWOT[1] analyses, with energy-sector stakeholders in Albania, through a workshop and series of meetings.
- Review and assess Albania's meteorological and hydrometeorological capacity, monitoring networks and forecasting, and assess information exchange between hydrometeorologists and energy-sector decision makers.
- Analyze climate risks for regional electricity markets in South East Europe.
- Review literature and expert analyses to develop risk ratings and high-level semi-quantitative assessments of climate change risks to energy security.
- Identify adaptation options to address climate-related vulnerabilities and risks, along with agreement on the objectives and parameters for the cost–benefit analysis, through a second workshop and meetings with energy sector stakeholders in Albania.
- Conduct a desk-based high-level cost–benefit analysis (CBA).



What is the energy sector in Albania aiming to achieve?

How can Albania's energy sector ensure that it delivers successfully on its energy security objectives in the face of climate variability and climate change? What are the opportunities from climate change for Albania's energy sector?

Develop criteria for assessing risks and adaptation options, considering critical thresholds and sensitivities, legislation, cost, etc.

Undertake tiered vulnerability and risk assessments, drawing on latest climate change trends and future projections.
Evaluate risks against Stage 2 criteria.

Identify risk management (adaptation) options including:
- No regret & low regret options,
- Win-win options,
- Flexible options – adaptive management.

Evaluate risk management options against Stage 2 criteria.
Undertake cost-benefit analysis.

Bring information together.
Undertake final checks.

Figure 3: The UKCIP risk-based decision-making framework for climate change adaptation, modified for use in this assignment (Willows and Connell, 2003).

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[1] Strengths, Weaknesses, Opportunities and Threats

1.2. STRUCTURE OF THIS REPORT

This report presents the outcomes of the assessment just described. The remainder of this report is set out as follows:

Section 2 describes the context for this assessment, covering the Albanian energy sector, observed and projected climatic conditions and Albania's adaptive capacity.

Section 3 outlines the climatic vulnerabilities, risks, and opportunities facing Albania's energy sector.

Section 4 describes the key adaptation options identified for managing climate risks to the energy sector.

Section 5 provides the cost–benefit analysis of physical adaptation options.

Section 6 sets out next steps for improving the climate resilience of Albania's energy sector.

Section 7 includes references and lists of annexes and appendices.

Annex 1 describes the methodological approaches to each stage of the assignment.

Annex 2 provides the background and rationale for the prioritization of climate-related risks.

Annex 3 provides tables of cross-cutting adaptation options, as well as options for each asset type.

Annex 4 describes the weather and climate information needs for energy sector management, covering design, operations and maintenance.

Annex 5 gives further details on the approach to the cost–benefit analysis.

Annex 6 gives further details on recommended actions to improve the climate resilience of the energy sector.

Annex 7 is a spreadsheet providing the scenarios of Albania power supply and demand from 2003 to 2050, which were applied in the cost–benefit analysis.

Annex 8 estimates impacts of climate change on large hydropower plants in Albania.

Annex 9 estimates impacts of climate change on energy generation in Albania, excluding large hydropower plants.

Annex 10 includes a glossary of key terms.

2. CONTEXT

2.1 EXISTING ENERGY SECTOR CONTEXT IN ALBANIA

Overview of Albania's Energy Sector

Albania has been struggling for some time to meet energy demand and maintain energy security. This is largely as a result of the country's current dependence on hydropower as almost the sole means of electricity production, coupled with a lack of investment in other energy assets. The situation has developed in a process of radical change since the beginning of Albania's economic transition in the early 1990s. At that time, the country was virtually 100 percent electrified and a net exporter of electricity within the region. After an initial decline in industrial production and ensuing reduced energy demand during the early transition period, the demand for energy rose by 10 percent per year from 1992 to 2000, making Albania a net energy importer by 1998 (World Bank, 2008). However, demand rose by less than 1 percent per year from 2000 to 2006, possibly in part linked to regional events but probably also partly due to increases in electricity prices, reductions in network losses and improvements in collections (World Bank, 2008). Poor-quality supply also meant that some consumers switched permanently to alternative sources of energy (Kaya, Z., pers. comm.).

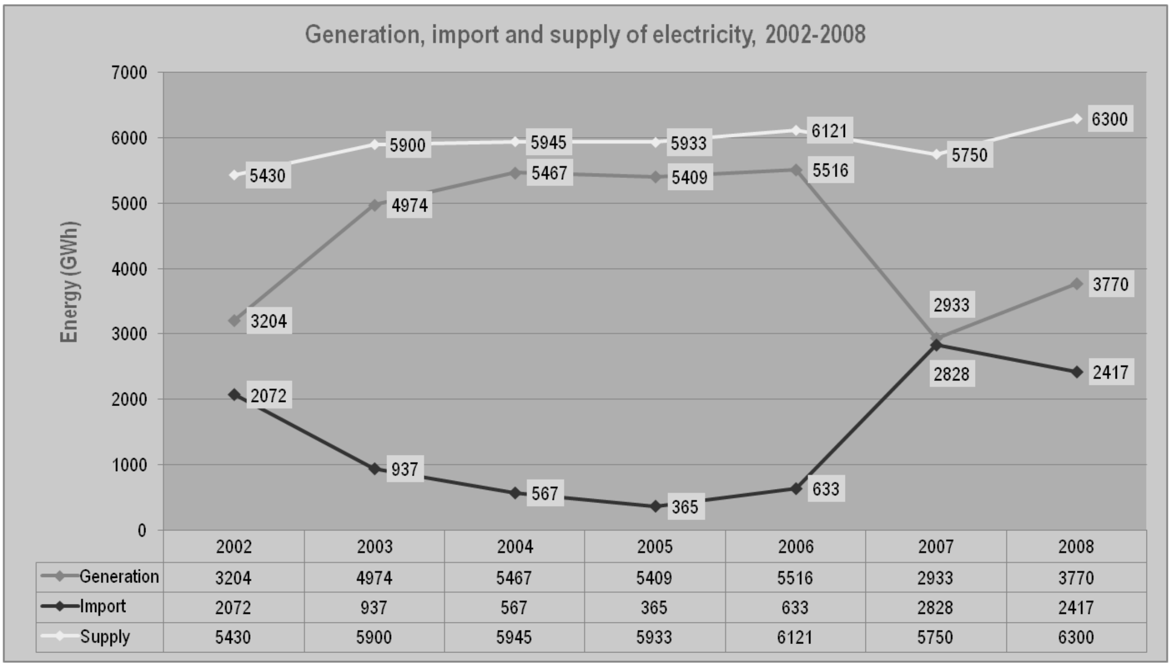
The outdated technologies used in many branches of the economy, as well as old equipment and standards applied in households and the services sector, mean that Albania is a country with low energy consumption per capita, but with high energy intensity (Government of Albania, 2007).

Due to increasing consumer demand and insufficient quantity of electrical power produced in the country, it is almost certain that electricity imports in the near future will continue to be essential to maintain a secure power supply (Government of Albania, 2007). However, financial and transmission constraints have restricted the amount of energy imports to date, resulting in load shedding (power cuts) that has had adverse economic and social effects. In addition, because of a worsening electricity shortage in the South East Europe region more generally, import prices have risen to unusually high levels, and KESH, the Albanian Electricity Corporation, has occasionally been unable to buy imports even when it has the funds to pay for them (World Bank, 2008).

Figure 4 depicts the relationship between electricity production in Albania and imports. Hydropower production ranges from below 2,900 GWh in very dry years to as much as 5,800 GWh in abnormally wet years (World Bank, 2008).

Efforts are underway to address these challenges and improve resource use efficiency: In 2008, for the first time, no load shedding was programmed and there has been a recent decision in Albania to eliminate load shedding from 2009 onward, along with a commitment to provide a 24-hour electricity supply. As well as reductions in losses from the transmission system, losses from the distribution system were reduced by 5.5 percent in 2008 compared to 2007. The efficiency of water use in energy generation has also improved, due to better monitoring and management. In 2007 and 2008, inflows to Fierze Reservoir were very similar (approximately 4,120,000,000 m^3) but power generation in 2008 was 29.4 percent higher than in 2007. This was because high water levels were maintained in the reservoir in 2008, and there was better optimization between electricity import and domestic production. This improvement is reflected in a metric known as *specific consumption* (m^3 of water consumed per kWh of electricity generated). Specific consumption in 2007 was 1.40 m^3/kWh, whereas in 2008 it improved to 1.04 m^3/kWh.

Climate risks already affect all asset types in the energy sector to varying degrees and, unless the risks are proactively managed, future climate change is likely to further degrade the inefficiencies already present in the system. Furthermore, the wider South East Europe region may also experience similar challenges, as highlighted in Box 2 (Ponari *et al*., 2009).



	2002	2003	2004	2005	2006	2007	2008
Generation	3204	4974	5467	5409	5516	2933	3770
Import	2072	937	567	365	633	2828	2417
Supply	5430	5900	5945	5933	6121	5750	6300

Figure 4: Generation, import, and supply of energy in Albania from 2002 to 2008 (ERE, 2008).

Albania's Draft National Energy Strategy and Recent Regulatory Reforms

The draft recent National Energy Strategy (NES) recognizes that problems with energy security have had an impact on the development of economic activity in the country, as well as on levels of living comfort (Government of Albania, 2007). The main aim of the draft NES, which looks out to 2019, is to guarantee a safe supply of energy to support the sustainable economic development of the country. To that end it has outlined key issues to address the growing challenges facing Albania regarding energy supply and demand, including the following main objectives (Government of Albania, 2007):

- Improving energy security through the diversification of the energy system and construction of new generation assets and inter-connection lines
- Encouraging development of renewable energy generation assets (solar, small hydropower stations, wind, biomass) to maximize use of local resources
- Opening up the domestic electricity market and actively participating in the regional market, in the framework of the Community Energy Treaty of South-Eastern European Countries, based on the requirements of the European Union for reforming the electrical power sector (Directive 54/2003 of EU)

The regulatory licensing process for energy assets has recently been altered. The Power Sector Law has assigned the Regulatory Licensing Authority, ERE, the role of regulating the electricity system and issuing licenses for electricity production, while permission to construct new energy production facilities is granted by the Ministry of Economy, Trade and Energy (METE). In the past year, regulations have been developed related to the 2008 amendment of the law on renewables, which aimed to harmonize Albanian practice with EU directives, as well as to speed up and manage the approval process for renewable concessions. The revised approval process covers authorization of wind, biomass, other renewables, and thermal power plants. Small hydropower plants are covered by the Law on Concessions.

Albania's Energy Assets

A brief overview of the existing and planned energy assets in Albania is useful for understanding the extent to which high dependence on hydropower, low diversity in the energy system, and inefficient grid systems constitute the main reasons for Albania's poor energy security.

Large Hydropower Plants

Hydropower from three large hydropower plants (LHPPs) on the River Drin account for about 90 percent of electrical power produced within Albania, utilizing the country's plentiful water resources (Government of Albania, 2007). The remaining domestic generation is mainly from the two LHPPs on the Mati River Cascade. These five LHPPs have a combined installed capacity of 1.45GW (see Figure 5):

Drin River Cascade:

- Fierza—4 × 125 MW with annual production of about 1,800 GWh, built in the 1970s and modernization completed in 2006
- Koman—4 × 150 MW, with annual production of about 2,000 GWh, built in the 1980s
- Vau i Dejes—5 × 50 MW, with annual production of about 1,000 GWh, built in the 1960s

Mati River Cascade:

- Ulza—25 MW, producing about 120 GWh, commissioned in 1958
- Shkopeti—25 MW, producing about 94 GWh per year, commissioned in 1970

A further LHPP is installed on the Bistrica River, with 25MW installed capacity.

Recognizing the importance of the main five LHPPs to Albania and the wider South Eastern Europe Energy Community, the World Bank has provided credit of US$35.3 million to Albania for a dam safety project, which will contribute to safeguarding them, improve their operational efficiency, and enhance the stability of power supply for the regional electricity market (World Bank, 2008b).

The Ministry of Economy, Trade and Energy (METE) estimates that there is capacity for about 3,200MW of additional hydropower power plants within Albania (Tugu, 2009). A number of large hydropower plant projects are being considered or are in progress:

Box 2: Regional electricity markets in South Eastern Europe and climate risks

At present, hydropower is about 30 percent of electricity production across South Eastern Europe (SEE) as a whole, though the relative contributions of hydropower, fossil fuel combustion and nuclear power vary considerably from country to country (Table 1). This diversity in sources of electrical power is becoming a strength, as countries in the region have subscribed to the Energy Community Treaty, which aims to create a regional energy market compatible with the internal energy market of the European Union.

Table 1: Electricity production in South Eastern Europe in 2006, as % of total

Country	Hydropower	Fossil fuel combustion	Nuclear
Albania	98	2	0
Bosnia and Herzegovina	44	56	0
Bulgaria	9	48	43
Croatia	49	51	0
Greece	10	88	0
Kosovo	0	100	0
FYR Macedonia	24	77	0
Montenegro	59	41	0
Romania	29	62	9
Serbia	30	70	0
TOTAL SEE	24	65	10

(World Bank, 2009a; International Energy Agency, 2009). Note: Grey highlights a dependence above 50 percent.

Across the region, electricity demand is expected to grow considerably over coming decades. Expansion of hydropower could make a significant contribution toward meeting future demand: as the cost of fossil fuels rise, hydropower is increasingly cost-effective. Excluding Croatia, which does not plan to develop further hydropower, SEE has an unexploited potential of about 22,000 MW of hydropower capacity (annual generation of about 73,000 GWh). However, regional development of hydropower sources and regional trading do not necessarily help to manage energy security risk: climate trends can affect shared transboundary waters and regionwide energy demand in the same way, at the same time.

Future energy prices in South Eastern Europe will be sensitive to climate change, in part because hydropower is exposed to climate risk. An assessment of the sensitivity of energy prices to availability of water for hydropower for the years 2010 and 2015, undertaken in the Regional Balkans Infrastructure Study, Electricity (REBIS) and Generation Investment Study (GIS), indicated that the marginal production cost for a unit of energy could be 15 percent to 50 percent higher in a dry year than in a wet year (PricewaterhouseCoopers LLC and Atkins International, 2004). REBIS assumed that the region might be wet or dry as a whole. In fact, climate patterns within SEE are complex, and a regional approach to managing climate risk for the energy sector could potentially be devised. Research undertaken in Brazil (Pereira de Lucena et al., 2009) has demonstrated that climate risk to Brazil’s hydropower facilities is buffered by the fact that they are located across several partly uncorrelated hydrological regimes. Drawing on Brazil’s experience, it would be very helpful to understand whether all South Eastern Europe’s watersheds face wet or dry years or seasons at the same time, or whether it is possible that careful selection of an ensemble of hydropower investments could help to diversify risk.

(Ponari et al, 2009).

Vjosa River:

- Kalivaci HPP is under construction.
- A study on the hydropower potential of the Vjosa is being prepared by KESH and is expected to lead to further concessions soon.

Drin River Cascade:

- Verbund (Austria) have been granted a concession for Ashta HPP and construction is expected to start shortly.
- Scavica HPP is currently under tender.

Devolli River Cascade:

- A concession has been granted to EVN (Austria).

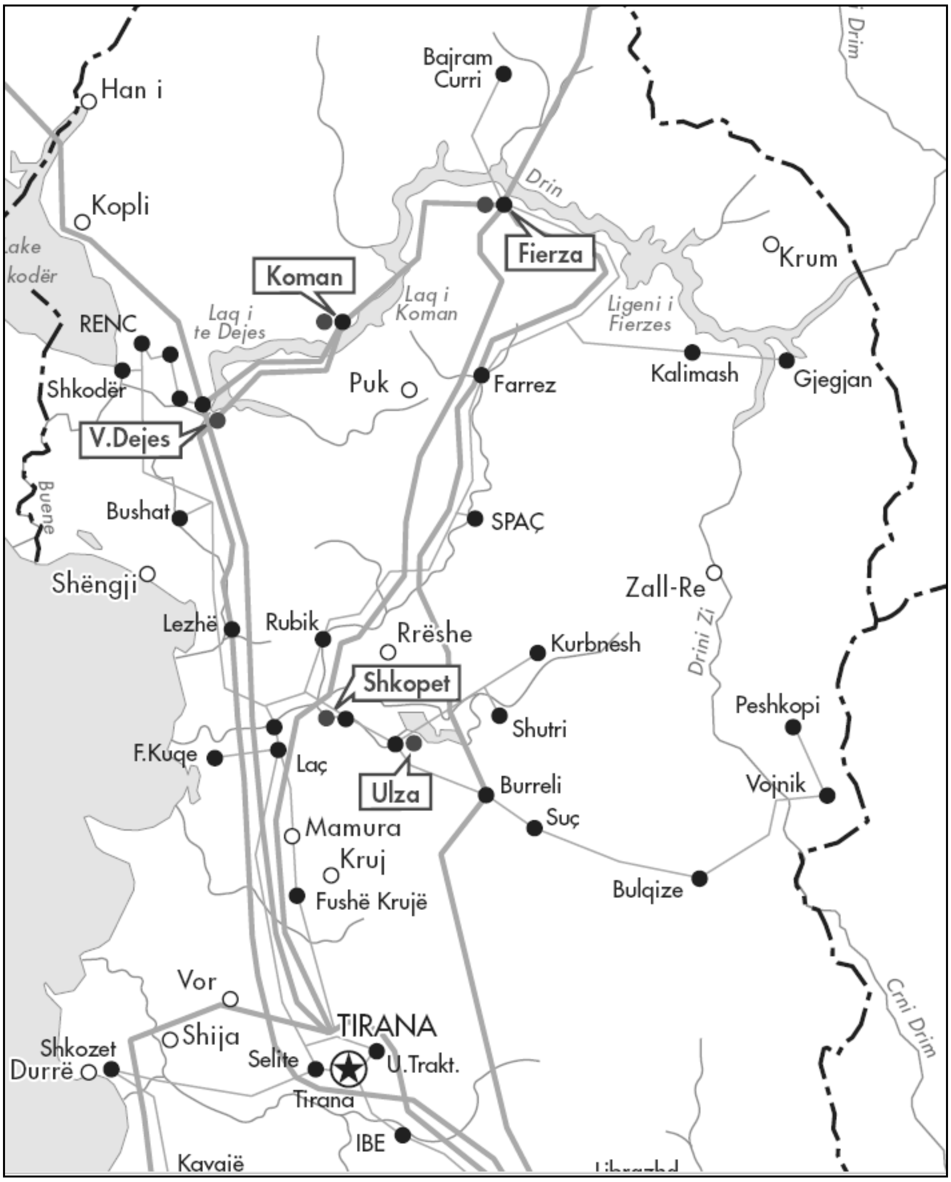


Figure 5: Locations of the five large hydropower plants that provide about 90 percent of Albania's domestic electricity production (World Bank, 2008b).

Small Hydropower Plants (less than 15 MW capacity)

Small hydropower plants (SHPPs) are defined in Albanian law as plants with capacity up to 15MW, in line with EU norms. While there are 84 existing SHPPs, only about 20 privately owned SHPPs are operating at present. Most of these are in need of rehabilitation.

Since the passage of the General Concession Law on December 18, 2006, by the Albanian Parliament, an additional 50 new concessions were granted to small hydropower plant (SHPP) owners in Albania. A feed-in tariff for SHPP is a major incentive for new investments.

Thermal Power Plants

The only thermal power plant (TPP) currently operating in Albania is at Fier. The plant operates on heavy fuel oil produced by the Ballsh oil refinery, and available capacity has only about 20MW capacity. Due to its low fuel efficiency and associated high operating costs, the plant is used for only a few days every year (World Bank, 2008). It is currently being rehabilitated.

The commissioning of the 100 MW seawater-cooled Vlore TPP (due to commence full operation in January 2010) will add about 760 GWh (15 percent) per year of domestic production. Additional large TPP projects are also being considered or taken forward, including a 250MW combined cycle gas turbine (CCGT) power plant at Fier as part of the planned LNG terminal and a coal-fired TPP at Porto Romano (1000MW) that could export some of its electricity to Italy (Hoxha, 2009).

Renewables

Currently, apart from hydropower, there are no industrial-scale renewable assets in operation in Albania (World Bank, 2008). The lack of investment in other assets to diversify the energy system plays an important role in the current challenges Albania is faced with in terms of energy security.

Several wind projects are under discussion or development, including plans for a joint wind/biomass project in Lezhe District and close to Vlore (Karaburun Peninsula). Some seven wind licenses have been issued to date, which would provide 1 million kWh installed capacity (2-2.2 billion kWh per year of production). These will likely export some of the electricity they generate to Italy. Solar and geothermal are not currently foreseen for industrial-scale power generation purposes. However, they are considered useful for heating in the domestic, public, and services sectors.

Electricity Transmission System

The transmission system consists of 122 km of 400 kV, 1128 km of 220 kV, 34.4 km of 150 kV, and 1216 km of 110 kV lines. There is a 400 kV interconnection to Greece (Elbasan to Kardia), a 220 kV interconnection to Montenegro (Vau i Dejes to Podgorica) and a 220 kV interconnection to Kosovo (Fierze to Prizren). There is also a 150 kV interconnection with Greece (Bistrice 1 to Igumenice). The 220 kV transmission network serves to interconnect the three LHPPs on the Drin River and the existing Fier TPP, with the major load centers of Tirana-Durres, Elbasan, Burreli, and Fier (World Bank, 2008). The existing transmission grid does not yet have enough capacity to allow for full regional energy trade with Albania's neighbors, but it is generally in good condition, as most transmission lines are either new or have been upgraded (Acclimatise *et al.*, 2009a). The expected completion in 2010 of a 400 kV transmission interconnection between

Tirana and Podgorica and a subsequent 400 kV transmission interconnection to Kosovo will relieve the transmission constraint on importing electricity.

Some new interconnection lines are underway (see Figure 6) such as Tirana–Elbasan (AL), a 400 kV line which is due to be finished in 2010, and the interconnection line Tirana (AL)–Prishtina (KS), also 400 kV, which is under development and for which construction is expected to start in 2010. An interconnection of Albania with Italy with DC lines is in an early stage of development, but no details are available yet. Other particularly important regional interconnection updates are given as below (Electricity Coordinating Center Ltd and Energy Institute ”Hrvoje Požar,” 2004):

The priorities until the year 2010 are as follows:

- Ugljevik (BA) to S. Mitrovica (SER)
- C. Mogila (BG) to Stip (MK) (under construction)
- Florina (GR) to Bitola (MK)
- Maritsa Istok (BG) to Filipi (GR)
- Ernestinovo (HR) to Pecs (HU)
- Filipi (GR) to Kehros to Babaeski (TR)
- Bekescaba (HU) to Nadab (Oradea) (RO)

The priorities for the period 2010 and 2015 are:

- Zemlak (AL) to Bitola (MK) 2010/15
- Nis (SER) to (Leskovac) to Vranje to Skopje (MK) 2010/15

These projects are broadly supported by decision makers in the region, as well as the EU, because they will help with the creation of a regional energy market in SEE, facilitating smooth integration into the EU internal electricity market by 2010.

Under the Athens Memorandum of November 2002,[2] the countries in the region made commitments toward a common energy policy, including gradual liberalization of power markets, restructuring of energy companies, maintenance of cost-recovery tariffs, adoption of tariff methodologies and technical codes for network access, enforcement of payments, introduction of social safety nets, and setting-up of independent regulators to scrutinize third-party network access.

The subsequent treaty establishing the Energy Community in South East Europe comprises a number of market design elements in electricity. The European Commission notes that this European market design is “not based on one single concept, but has rather evolved from different regional designs” harmonized through the Florence process involving existing EU Member States (European Commission, 2005).

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[2] The 2002 Athens Memorandum relates to electricity, whereas the 2003 Memorandum relates to gas.

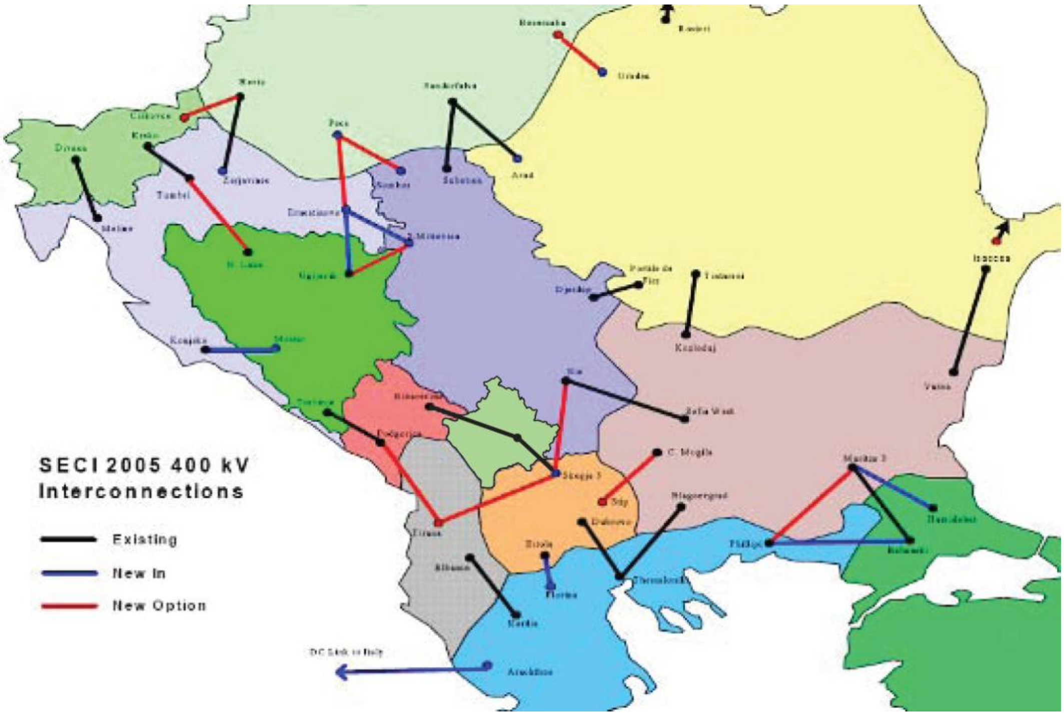


Figure 6: Existing and candidate interconnections in the region (Cerepnalkovski *et al*., 2002).

Electricity Distribution System

The distribution grid is considerably weaker and more inefficient than the transmission system. Commercial losses (i.e., electrical power taken from the network illegally) constitute the main losses from the distribution grid and have led to KESH being unable to invest in maintenance and rehabilitation of the system (World Bank, 2008). Commercial losses amounted to 760 GWh (13.4 percent) in 2008 and carry a considerable economic cost to KESH (Government of Albania, 2007).

Although city distribution networks are generally in good condition, there are significant parts of the distribution grid that need upgrading, especially those serving rural and mountain communities, many of which do not have secure energy supplies (Acclimatise *et al*., 2009a).

The recent privatization of the distribution system to CEZ will see new investment, as well as efforts to curb total losses from the grid, with targets to reduce total losses (technical and commercial) to 15 percent at the end of 2014, down from a value of about 33 percent in 2008 (CEZ Regulatory Statement, 2008).

Oil, Gas, and Coal Production Facilities

The main areas where oil is produced are Patoz Marinza, Cakran-Mollaj, Ballsh-Hekal, Gorisht-Kocul, and Kucova. Bankers Petroleum currently produces about 600kt/yr of oil, about 75 percent of Albania's domestic production, approximately half of which is for export markets. The remainder is mainly produced by Albpetrol. Bankers Petroleum has plans to reactivate some existing wells, which could more than double national production in the next three to four years. It should be noted that there is a significant legacy of contaminated land around the oil production facilities at Patos Marinza, which is recognized by the EU as an environmental hotspot (UNEP, 2000).

Albania has two oil refineries. The main refinery is at Ballsh (producing 1 m bbl/yr of heavy fuel oil, low grade diesel (8 API) and bitumen), and a second at Fier produces about 0.5 m bbl/yr.

While Albania has both on- and off-shore gas reserves, none are currently being exploited.

There are no current oil and gas pipeline connections to regional markets, though there are a number of proposals including the TAP (Trans-Adriatic Pipeline) and the Balkans Gas Ring.

In addition, an LNG terminal is proposed in the Fier Region.

The coal industry in Albania is small. Most mines have been shut down, while those at Memalija and Mborje-Drenova are still operating but at reduced capacity. Waste minerals, stored in enrichment facilities near mines, present a contamination risk.

2.2 CLIMATE IS CHANGING

Causes and Effects of Global Climate Change

According to the Intergovernmental Panel on Climate Change Fourth Assessment Report (IPCC AR4), warming of the climate system is unequivocal, and most of the observed increase in global average temperatures since the mid-twentieth century is very likely due to emissions of greenhouse gases, such as carbon dioxide, from human activities. Eleven of the twelve years from 1995 to 2006 rank among the twelve warmest years in the instrumental record of global surface temperature (since 1850).

Carbon dioxide concentrations in the atmosphere are higher now than at any time during the past 650,000 years, with human activities already having increased concentrations by one-third compared to preindustrial levels (see Figure 7). By the middle of the twenty-first century, concentrations are likely to be double preindustrial levels.

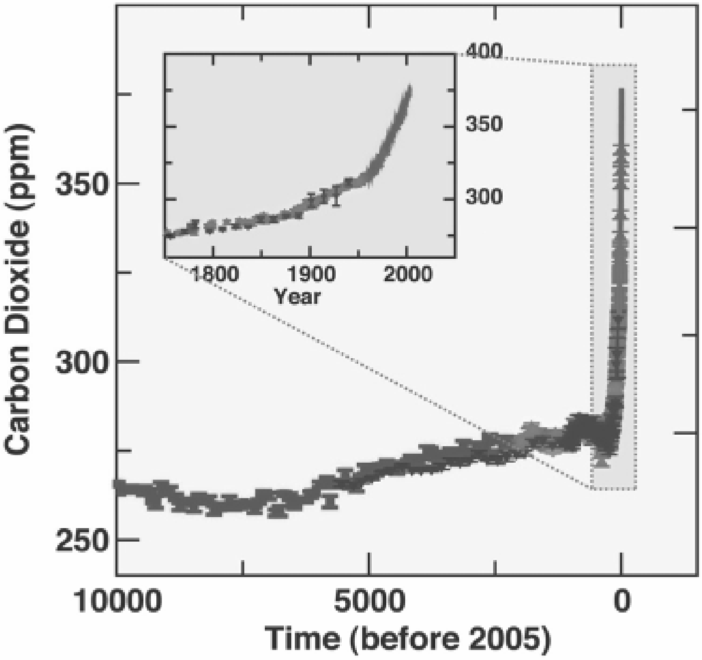


Figure 7: Increases in concentrations of carbon dioxide in the atmosphere from 10,000 years before present to the year 2005 (IPCC, 2007).

Figure 8 shows the temperature changes that have occurred globally from 1970 to 2004. Large parts of the northern hemisphere land mass have seen increases over this period of up to 2°C. Changes in snow, ice, and frozen ground have increased the number and size of glacial lakes and increased ground instability in mountain and other permafrost regions. Some hydrological systems have also been affected through increased runoff and earlier spring peak discharge in many glacier- and snow-fed rivers and effects on thermal structure and water quality of warming rivers and lakes. In terrestrial ecosystems, spring events are occurring earlier and plants and animals are shifting poleward and upward in altitude, in response to warming. Of the more than 29,000 observational data series that show significant change in physical and biological systems, more than 89 percent are consistent with the direction of change expected as a response to warming.

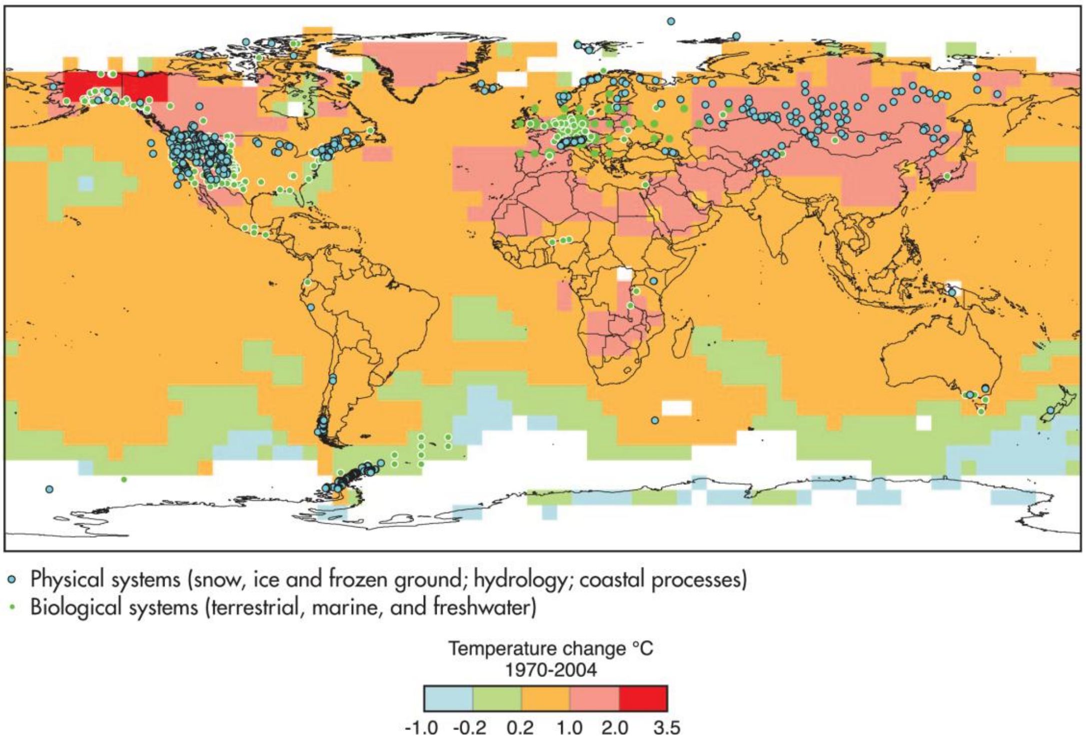


Figure 8: Observed changes in climate, physical and biological systems (IPCC, 2007).

Baseline Climatic Conditions and Observed Trends in Albania's Climate

In general, temperatures in Albania showed a decreasing trend from 1961 until the mid-1980s, but temperatures have been increasing since then. In the last 15 years, a positive temperature trend has been observed at almost all of Albania's meteorological stations. Since the 1980s, the numbers of very hot days (when temperatures exceeded 35°C) has increased, whereas the numbers of very cold days (with temperatures below –5°C) has decreased (Bruci, 2008).

In general, over the period from 1961 to 1990, annual precipitation across Albania decreased by about 1 percent. The decreasing trend was statistically significant for the Ishmi River basin, in the downstream basin of the Mati River, and in the upper part of the Vjosa River basin. In the northern Albanian Alps, a slight positive trend in precipitation was observed, but this was not statistically significant (Bruci, 2008).

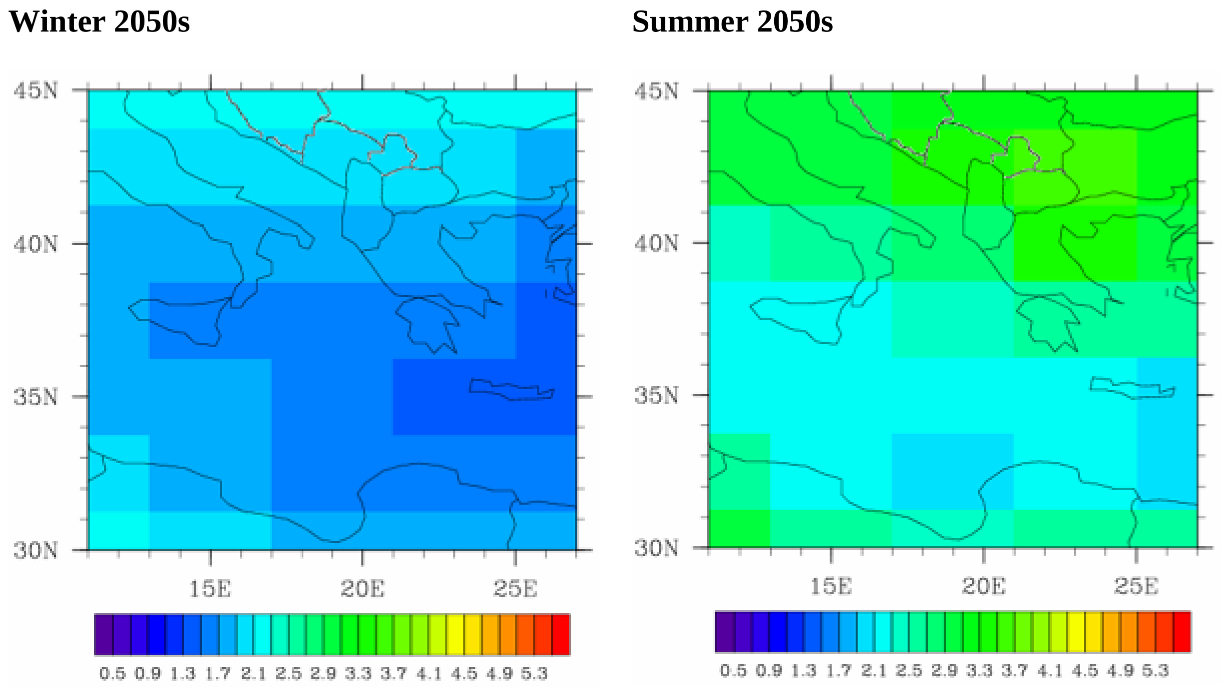
Sea levels have risen in the Mediterranean, though by less than in the neighboring Atlantic sites during the period 1960 to 2000. However, decadal sea level trends in the Mediterranean are not always consistent with global values, in particular for the 1990s, during which the Mediterranean has seen sea level rise of up to 5 mm per year compared to the global average (Marcos and Tsimplis, 2008).

Climate Change Scenarios for Albania and the Wider South Eastern Europe Region

Climate change scenarios for Albania and the wider region over coming decades are summarized as follows. Further details are provided in Acclimatise, 2009. These scenarios are taken from nine of the most up-to-date global climate models (GCMs) used in the Intergovernmental Panel on Climate Change Fourth Assessment Report (IPCC, 2007), for a range of greenhouse gas emissions scenarios (see Box 3).

Temperature

According to the scenarios, annual average temperatures are expected to increase by about 1°C to 2°C by the 2020s and 3°C by the 2050s (see Figure 9). The greatest temperature increases are expected to occur in summer months (June to August).


Winter 2050s

Summer 2050s

Figure 9: Projected increases (averaged across nine IPCC AR4 global climate models) in winter and summer temperatures across South East Europe by the 2050s compared to the 1961 to 1990 average, under the A2 emissions scenario (Acclimatise, 2009).

Precipitation

Although precipitation projections are generally inconsistent among global climate models, the eastern Mediterranean is one region for which most global models produce a similar result, which is one of drying over the course of the twenty-first century. Models indicate reductions in annual average precipitation for Albania of approximately 5 percent by 2050, and decreased summer precipitation of about 10 percent by the 2020s and 20 percent by 2050 (see Figure 11).

This drying, coupled with the marked increase in temperature noted above, would lead to reduced runoff and increased wild-fire risk.

Box 3: Climate change modeling and greenhouse gas emissions scenarios

Modeling of future climate conditions is undertaken by meteorological agencies around the world using models of the climate system that have been developed over many decades. These models, known as general circulation models (GCMs) or global climate models, are validated in current practice by tests of how well they are able to simulate climate conditions that have occurred over the last 100 years or so and through international climate model intercomparison experiments. While these models provide data at a coarse spatial scale (typically 2.5^o x 2.5^o), they indicate the future climatic conditions that countries could experience over coming decades.

For some regions and countries, regional climate models (RCMs) have also been developed, providing better-resolved projections of future climates, typically at about 50 km × 50 km spatial resolution.

To project changes in future climate conditions, scenarios of future greenhouse gas (GHG) and other emissions are fed into the GCMs. Because there are uncertainties about the amounts of emissions that will be released in the future, a range of emissions scenarios are used. At present, most GCMs have been run using the SRES emissions scenarios (Nakićenović and Swart, 2000), and these underpin the recent assessments of future climate published by the Intergovernmental Panel on Climate Change (IPCC, 2007).

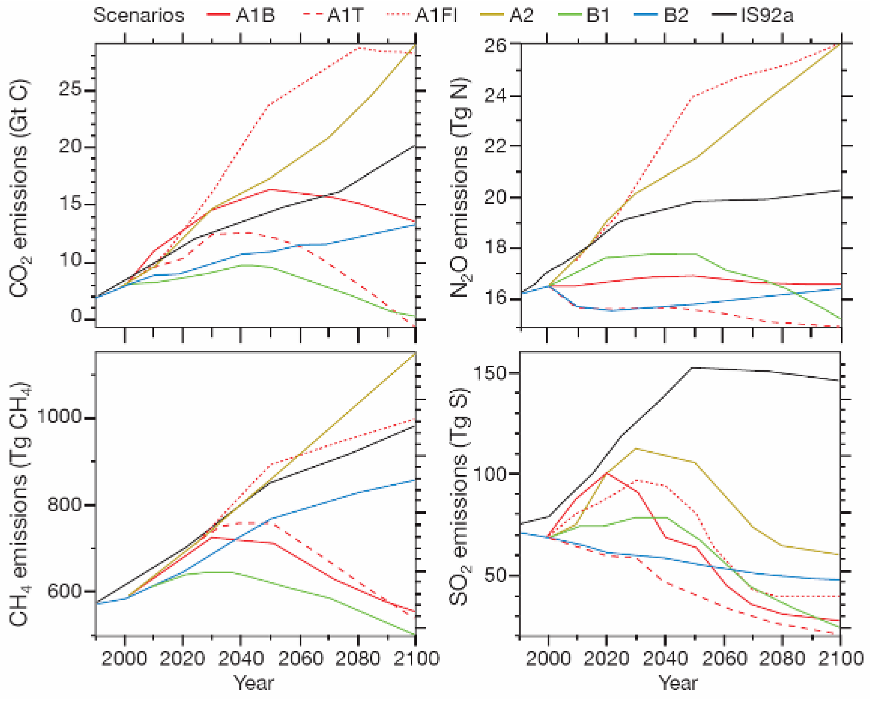
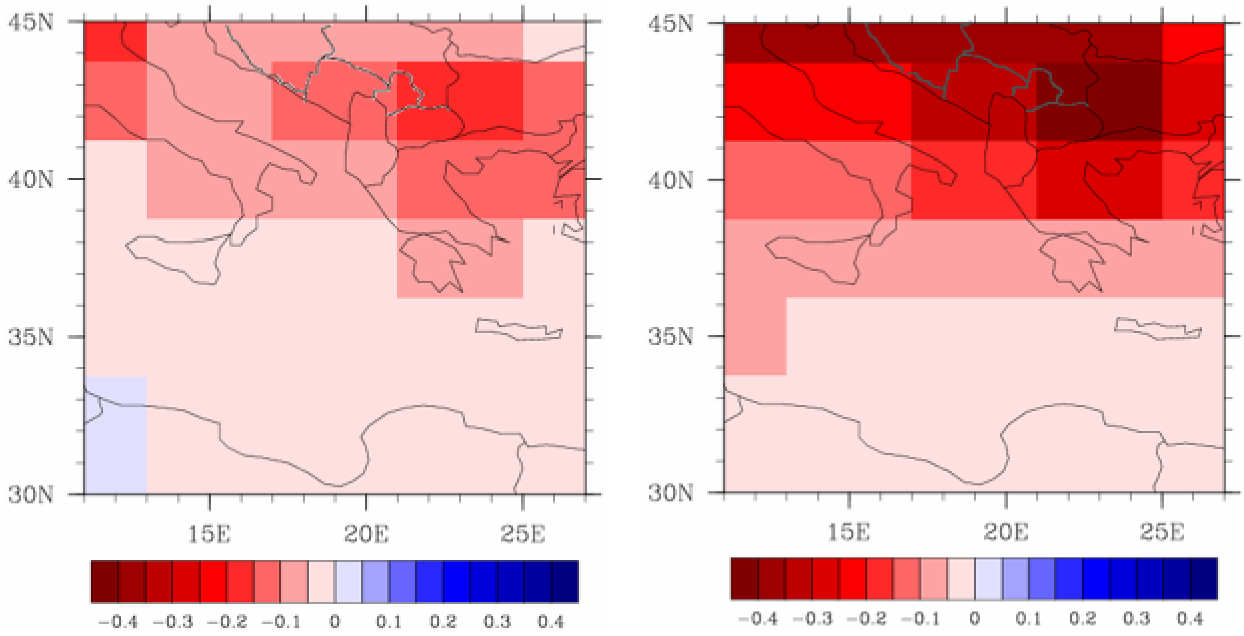
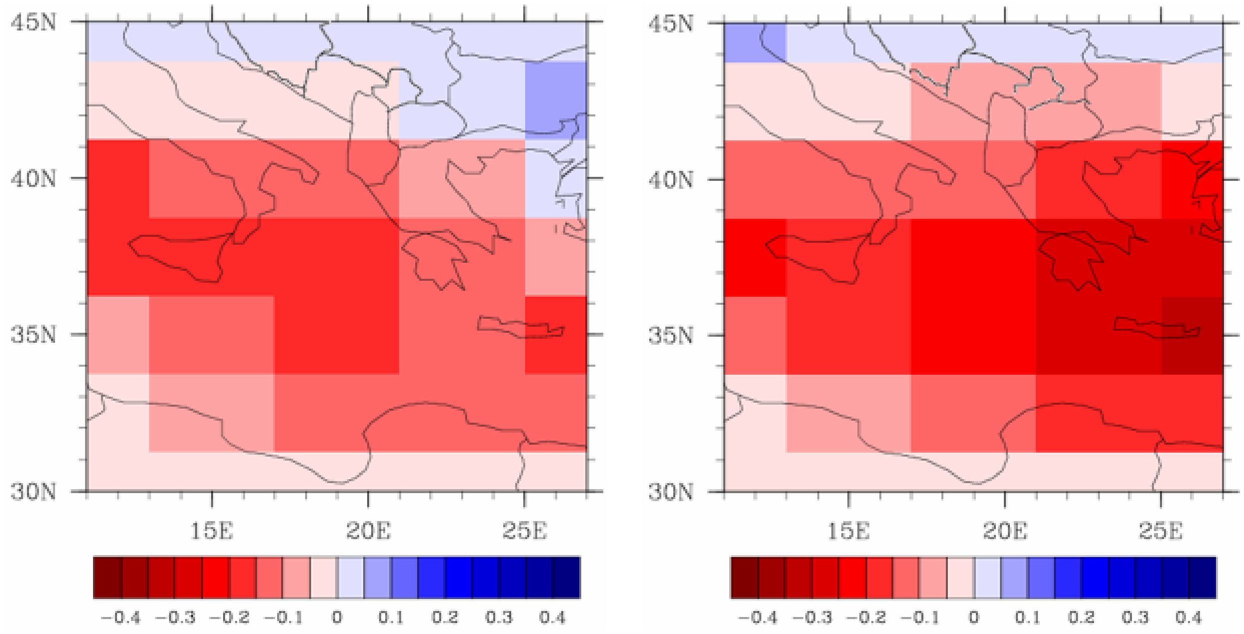


Figure 10: Man-made emissions of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and sulphur dioxide (SO_2) for six SRES scenarios (Nakićenović and Swart, 2000). The IS92a scenario from the IPCC Second Assessment Report in 1996 is also shown for comparison.



Summer 2020s **Summer 2050s**



Winter 2020s **Winter 2050s**

Figure 11: Projected changes averaged across nine IPCC AR4 global climate models in summer and winter precipitation (mm/day) across South East Europe by the 2020s and 2050s compared to the 1961 to 1990 average, under the A2 emissions scenario. (Acclimatise, 2009)

Table 2 summarizes projected trends in future precipitation in Albania drawn from nine GCMs. Summers are projected to be drier in the 2020s by six of the nine models presented, with one model showing wetter summers and two models indicating a mixed signal. None of these models projects a wetter summer by the 2050s. Eight of the nine models presented show drier summers and one model shows a mixed signal.

The nine models show less agreement concerning winter precipitation change: by the 2020s, four of the nine models indicate drier winters, three show wetter winters and one shows a mixed signal. A similar situation is seen in the 2050s, where five of the nine models indicate drier winters and four show wetter winters. The risk of uncertainty is heightened by the consideration that most of Albania's precipitation occurs in the winter months.

Table 2: Summary of Albanian Scenarios for Changes in Precipitation (compared to 1961 to 1990 baseline) by Number of Global Climate Models (Acclimatise, 2009)

Model trend in future precipitation compared to baseline	**Number of models**			
	2020s summer	**2020s winter**	**2050s summer**	**2050s winter**
Dry	6	4	8	5
Wet	1	3	0	4
Mixed	2	2	1	0
Ensemble mean	Dry	Dry	Dry	Dry

Wind Speed, Relative Humidity, Cloudiness

Projections of future changes in wind speed are viewed with low confidence as hindcasts appear to have weak skill; as it happens the selected climate models show little change in wind speed. Relative humidity and cloudiness are projected to decrease slightly in future over the year as a whole, with decreases being greatest in summer, in association with decreased rainfall. Climate change scenarios indicate a reduction in cloudiness of 6 percent to 8 percent by the 2050s in summer and a reduction of 0 percent to 3 percent in winter.

Sea Surface Temperature and Sea Level Rise

Sea surface temperatures (SSTs) throughout the eastern Mediterranean are projected to increase by about 1°C in the 2020s and 2°C by the 2050s. Sea levels are also projected to rise, due to thermal expansion of the oceans and melting of ice, leading to increased flood and erosion risks in coastal areas.

Extreme Events

There has been concern that climate change may bring a change in the frequency of magnitude of extreme climatic events—for instance, more-intense heavy rainfall events and a lengthening of dry periods. According to some models, Albania is projected to be highly affected by changes in extreme events, compared to other countries in Europe and Central Asia (ECA) (World Bank, 2009a). It is second only to Russia in terms of projected increases in extremes, as indicated in Figure 12.

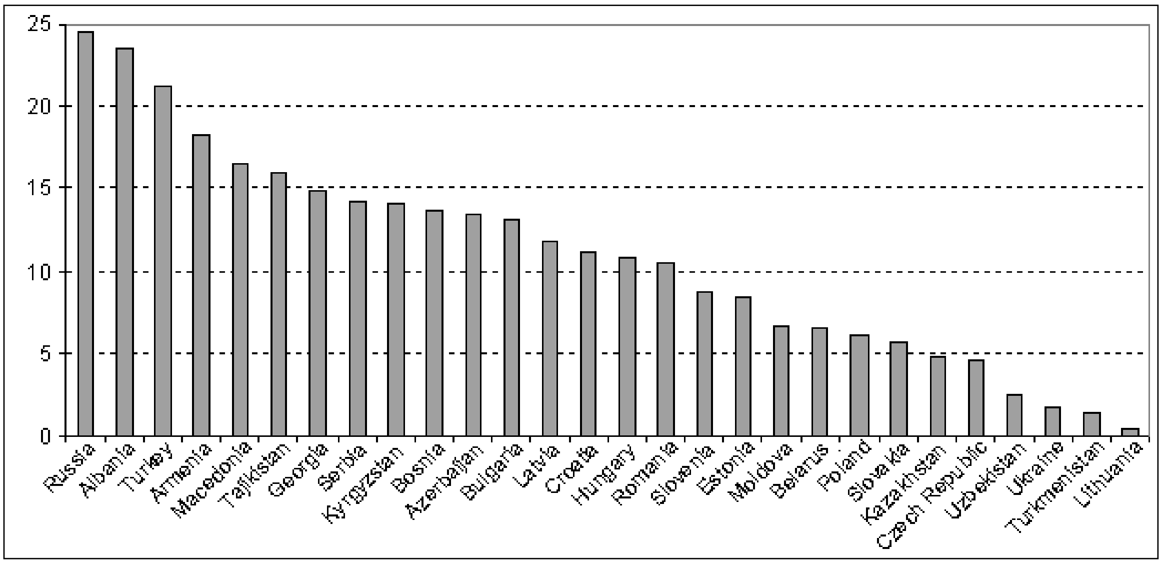


Figure 12: The ECA countries likely to experience the greatest increases in climate extremes by the end of the twenty-first century (Baettig *et al*., 2007 *in:* World Bank, 2009b). (The index combines the number of additional hot, dry, and wet years; hot, dry, and wet summers; and hot, dry, and wet winters projected over the 2070–2100 period relative to the 1961–1990 period. As such, countries already experiencing substantial variability and extremes are less likely to rank highly on this index.)

Uncertainties and Limitations in Scenarios of Future Climate Change

Scenarios of future changes in climatic conditions for a given location have a number of uncertainties and limitations that need to be borne in mind by users of the information:

1. Different general circulation models (GCMs) show different projected future climate conditions, because the models vary in the ways that they represent the atmosphere, land, and sea, and the interactions between them. It is therefore important to use a range of GCMs to assess the importance of the differences among the selected models. In general, agreement among the nine models presented concerning changes in temperature is good, while there is less agreement among these models concerning precipitation changes. The agreement among these models concerning precipitation changes in the eastern Mediterranean is better than it is for some other areas of the world. Model agreement for changes in wind conditions is weaker.

2. GCMs are usually run at a coarse spatial scale (typically $2.5^{o} \times 2.5^{o}$). Locally, the same models could project different trends if undertaken at higher resolution, , particularly in areas where the topography is very variable or in coastal locations. *Downscaling* from GCMs using Regional Climate Models (RCMs) or statistical methods identifies these variations. To be sure, if the parent GCMs are themselves in poor agreement, downscaling does not resolve the differences.

3. As noted in Box 3, there are uncertainties about the amounts of greenhouse gas emissions that will be released in the future, so a range of emissions scenarios should be explored. In practice, for the near term (2020s) this uncertainty makes little difference as, on these timescales, the climatic changes that will result from greenhouse gas emissions have already been built into the climate system due to past emissions. For the 2040s onwards, however,

projections based on different emissions scenarios start to diverge and by the end of the century, there are large differences between them.

4. GCMs project changes in average seasonal or annual climate conditions, but do not provide ready information on changes in extreme climatic events, such as heavy downpours of rain, which may have significant impacts.

These issues are explored in further detail in Acclimatise (2009). Ideally, the quantified estimates of climate change impacts on Albania's energy assets provided in Section 3 should be provided as *ranges* of potential future changes, to capture uncertainties. For instance, hydrological assessments of changes in runoff affecting large and small hydropower plants should make use of a wide range of climate models and emissions scenarios (and indeed hydrological models), using downscaling methods to provide data at the catchment scale. This depth of analysis was beyond the scope of the current study and is an area for future research.

2.3 ALBANIA'S LOW ADAPTIVE CAPACITY

Managing the risks for Albania's energy sector from changing climatic hazards appropriately will require analysis and forward planning by government and private energy sector players, to establish optimal adaptation strategies for existing and new energy infrastructure.

Figure 13 illustrates the breakdown of three different factors that drive ECA countries' vulnerability to climate change, which indicates that Albania suffers from relatively high exposure and sensitivity to climate change, coupled with a relatively low adaptive capacity to offset these vulnerabilities. Among ECA countries, Albania is second only to Tajikistan in this vulnerability rating.

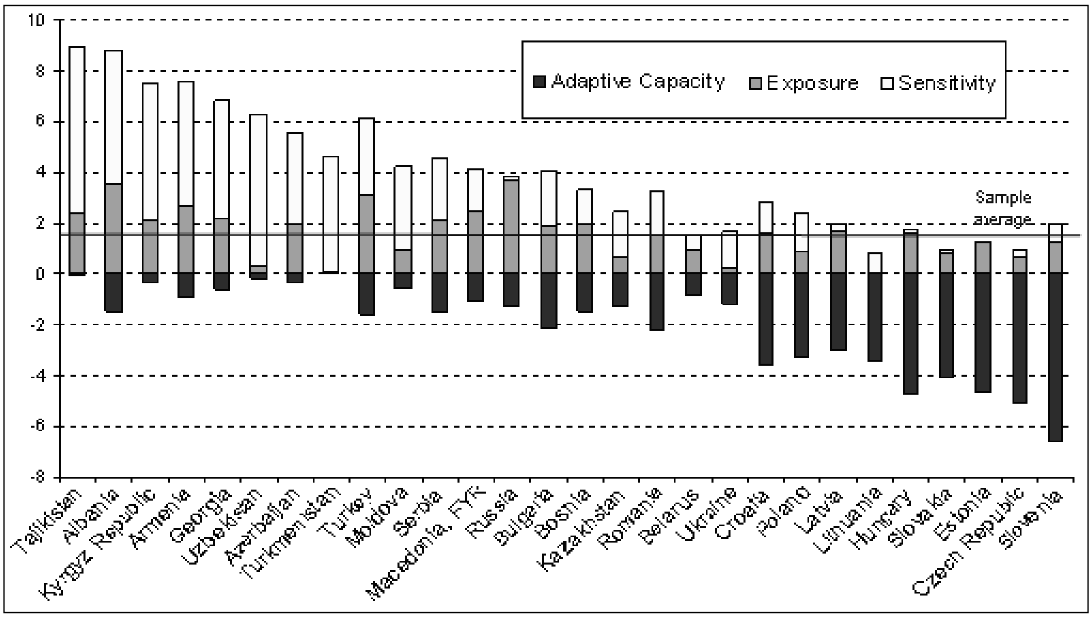


Figure 13: The drivers of vulnerability to climate change (Fay and Patel, 2008 in: World Bank, 2009b).

Albania's current low adaptive capacity is mainly due to its inefficient and wasteful use of water and energy resources, weak regional interconnections, and the poor state of national hydrometeorological services.

Inefficient Use of Water Resources

The management of water resources is a key issue for Albania, given its dependency on hydropower and the use of water for irrigating agriculture. Responsibilities for water resource management are fragmented; many water bodies are involved in its use and oversight[3]. Lack of a comprehensive inventory of water resources and a weak institutional framework for their management, compounded by climate change, means that the country risks increasing water crises in the future (World Bank, 2003). It is estimated that some 10 percent to 20 percent of Albanian water resources are lost in the irrigation system (Fantozzi, 2009). As outlined in Section 2.1, efforts are underway to change this, and the efficiency of water use in energy generation has improved recently. Furthermore, some areas of agricultural land in Albania have been equipped with efficient irrigation systems in the last couple of years.

Weak Regional Interconnections, Technical and Commercial Losses and Inefficient Use of Energy

As just highlighted, although the power transmission grid has been recently upgraded, the interconnections between Albania and its neighboring countries are currently weak and constrain energy import and export. Technical losses in the power transmission network in 2008 were 213GWh (3.3 percent) (ERE, 2008). In 2008, technical and commercial losses from the distribution system amounted to 33 percent, though there are strong targets to reduce this as part of the privatization of the distribution system (CEZ Regulatory Statement, 2008). Demand-side energy efficiency is also currently low, and the draft National Energy Strategy includes objectives and measures to tackle this issue (Government of Albania, 2007). Increased demand and insufficient quantity of electrical power produced in the country make it likely that imports will be essential in the near future to ensure a steady supply of power (Government of Albania, 2007).

Deficiencies in Hydrometeorological Services

The energy sector is one of the economic sectors most affected by weather, and most dependent on weather and climate information (Ebinger *et al*., 2009). The currently depreciated and poor state of the national weather and hydrological monitoring network places a significant constraint on Albania’s ability to monitor and forecast in support of secure energy (Hancock and Ebinger, 2009).

Coupled with low funding and the poor state of National Meteorological Services (NMS) and National Hydrometeorological Services (NMHS) is the high weather dependence of the Albanian economy—about 65 percent of Albania’s GDP is estimated to be weather dependent, the highest among eight ECA countries assessed (IBRD & HMI, 2006; Tsirkunov *et al*., 2007; Hancock, Tsirkunov and Smetanina, 2008 *in:* Ebinger *et al*., 2009).

Financial constraints are at the heart of the issue behind the poor state of the Albanian national meteorological services (NMS) and national hydrometeorological services (NHMS) (HMI & IBRD, 2006; Hancock and Ebinger, 2009; Ebinger *et al*., 2009). A comparison of Albania with seven other ECA countries reveals that it has the lowest investment in annual NMS and NHMS

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[3] Water management is the responsibility of the National Water Council established under Law 8093 on Water Reserves (March 21, 1996, as amended). Responsibilities are also allocated to River Basin Councils under a decision of the Council of Ministers Nr 2 "Establishment of River Basin Councils" (June 21, 2006, as amended). Further responsibilities and tasks are allocated to Organizations of Water Users under Law 8518 on "Irrigation and Drainage" (July 30, 1999, as amended).

funding, totalling $440,000, or only 0.01 percent of average annual GDP (Tsirkunov *et al*., 2007; Hancock, Tsirkunov and Smetanina, 2008 *in:* Ebinger *et al*., 2009). The percentage of weather equipment that has been completely depreciated is about 60 percent, and there is an increasing need for modernization in all departments, especially for replacing aging equipment and observation stations (IBRD & HMI, 2006). Insufficient funding also limits the consistency and availability of national hydrological and meteorological datasets. Although comprehensive, digitized datasets exist up until 1990, thereafter the information is much more patchy and data are generally only digitized up until 2000 (Hancock and Ebinger, 2009).

KESH is now working with weather and climate experts and is planning to install a network of river-level sensors and a system for collecting regional weather forecasts. With this information, managers will be able to forecast the level of the Drin more accurately, timing the filling and releasing of water from reservoirs, to maximize energy generation while maintaining dam security. However, more could be done; Albania is not fully exploiting the benefits of weather forecasting. The Institute of Energy, Water, and Environment (IEWE) does not provide 1 to 3 day forecasts of precipitation and runoff applicable to the needs of KESH, because the meteorological and hydrological stations operated by IEWE do not report daily; many transmit observations by postal mail. The monitoring network also has serious gaps: there are neither upper-air stations nor radar in the network, despite the necessity of these for forecasting and for assessment of rainfall that has occurred. Furthermore, Albania does not currently subscribe to quantitative precipitation forecasts 3 to 10 days ahead, which are available from organizations such as the European Centre for Medium-range Weather Forecasting (ECMWF).

The lack of coordination among the three agencies charged with weather monitoring and forecasting is a further key factor behind the weak national capacity of Albania's NHMS (Hancock and Ebinger, 2009). The Military Weather Service, the Institute for Energy, Water and Environment (which operates within the University of Tirana), and the National Air Traffic Agency currently do not cooperate effectively, and thus each remains short of data and resources needed for its mandate (Hancock and Ebinger, 2009). Furthermore, Albania does not currently share meteorological and hydrological data effectively with its neighbors with whom it shares watersheds, even though this could help to reduce uncertainties about inflows into its reservoirs. This further limits its abilities to engage effectively in regional energy trading.

The incidence and impact of natural disasters over the last decades provides another proxy for vulnerability to current climate (World Bank, 2009b). As depicted in Figure 14, this suggests that Albania is among the most vulnerable countries in ECA. Existing climate risks and extreme events are not generally well monitored, understood or managed.

Unless improvements are made, Albania's ability to cope successfully with changing climate risks will be severely constrained by its low adaptive capacity.

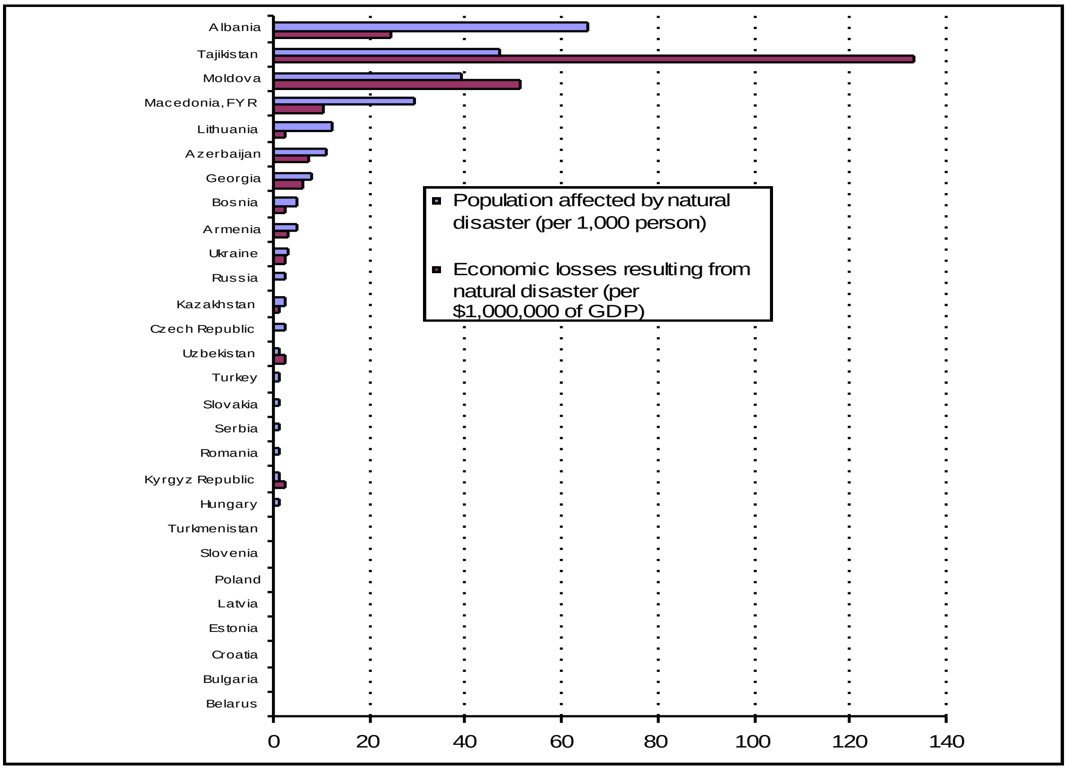

Figure 14: Impact of natural disasters in ECA, 1990–2008 (EM-DAT, Centre for the Research on the Epidemiology of Disasters, Université Catholique de Louvain, no date *in:* World Bank, 2009b).

3. CLIMATIC VULNERABILITIES, RISKS, AND OPPORTUNITIES FOR ALBANIA'S ENERGY SECTOR

This section highlights the climate-related vulnerabilities, risks and opportunities for Albania's energy sector, based on the outcomes of the stakeholder-led and desk-based analyses described in Annex 1. A SWOT (strengths, weaknesses, opportunities and threats) analysis developed with stakeholders (see Acclimatise *et al*., 2009a) helped to highlight key current vulnerabilities in the energy system, some of which have already been emphasized in earlier sections of this report. An overview of the specific vulnerabilities for each asset type is summarized in this section.

Looking forward, the risks identified from climate variability and climate change, in the absence of adaptation, are highlighted in Table 3. Some of these risks affect the energy sector in general, such as the impacts of climate change on demand for electricity; others are associated with specific energy asset types. The components of each risk (probability of hazard and magnitude of consequence) are shown on the risk maps in Annex 2, Tables A2-3 and A2-4. It is important to note that the consequence of a particular risk may be manifest in many different ways: there may be financial loss, impacts on energy security, environmental or social impacts, or perhaps a reputational consequence for Government. The risks for each asset type are outlined in Table 3, with further detail provided in Acclimatise *et al*. (2009a).

Table 3: Summary of Climate Risks before Adaptation

Risk Code No.	**Description of risk**	**Magnitude of risk before adaptation**	**Asset class affected**
1	Higher peak demand in summer due to higher temperatures could lead to lack of capacity.	Extreme	All
2	Less summer electricity generation from hydropower facilities due to reduced precipitation and runoff could reduce energy security.	Extreme	LHPP / SHPP
3	EU Carbon trading schemes add cost to thermal power generation.	Extreme	TPP
4	Changes in seasonality of river flows (including more rapid snowmelt due to higher winter temperatures) combined with mis-management of water resources could decrease the operating time for SHPPs, resulting in decreased production.	Extreme	SHPP
5	Increased CAPEX / OPEX due to climate change could lead to reduced shareholder value.	Extreme	All
6	Higher peak summer demand across the region could increase import prices and reduce supply.	Extreme	All
7	Paucity of hydromet data makes it difficult to manage water resources and optimize operation of hydropower plants.	Extreme	LHPP / SHPP
8	Sea level rise could lead to increased coastal erosion, potentially affecting coastal infrastructure such as ports for oil export.	High	Oil Production & other coastal infrastructure
9	Lack of data (impact of climate change on wind patterns) creates uncertainty about optimal sites / design for generation using wind.	High	Wind

Risk Code No.	**Description of risk**	**Magnitude of risk before adaptation**	**Asset class affected**
10	Climate change increases risk of competition between water users.	High	SHPP, LHPP & river-cooled TPP
11	Dry periods followed by heavy downpours of rain would exacerbate soil erosion from agricultural land, leading to increased sedimentation and reduced output from SHPP and LHPP.	High	LHPP / SHPP
12	Mal-adapted infrastructure design if climate change not built-in could lead to reduced operation / efficiency of assets.	High	All
13	Changes in extreme precipitation lead to higher costs for maintaining dam operations / security.	High	LHPP
14	Changing temperature, ground conditions and extreme precipitation could increase contamination risks associated with oil and coal mining facilities, potentially leading to increased risk of contamination of local water courses.	High	Oil and Coal Production
15	Reduced precipitation and increased temperatures can affect environmental performance of river water-cooled TPP abstracting and discharging water into local water courses.	High	TPP
16	Transmission and distribution losses increase due to summer temperature rise resulting in higher effective demand and reduced energy security.[4]	High	Transmission & Distribution
17	Concerns about unmanaged climate risks causes Albania to be less attractive to foreign investors.	Moderate	All
18	Changes in extreme precipitation and wind lead to transmission disruption.	Moderate	Transmission & Distribution
19	Loss of productivity for thermal plants due to higher air and water temperatures and / or reduced ability to abstract and discharge cooling water.	Moderate	TPP
20	Increases in landslips due to heavy rains resulting from climate change could increase the risk of loss of integrity for gas pipelines.	Low	Gas
Note: The *magnitude of risk* rating system presented here is described in Annex 2, Tables A2.1 and A2.2			

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[4] Losses in the transmission network are already relatively high, due to the configuration of the electricity network. The main sources of power generation are in the north of the country, while the main electricity consumers are located in central and southern Albania.

3.1 CROSS-CUTTING ISSUES

Current Vulnerabilities

As highlighted in earlier sections, energy security has been a major concern in Albania for some years. This is particularly prominent in relation to electricity distribution systems and hydropower plants: Unstable power supplies and lack of access to electricity in some rural communities are constraining economic development, and the productivity of both large and small hydropower plants has been affected by droughts in recent years, leading to frequent load shedding.

Many of Albania's existing energy assets are aged and have seen insufficient investment. They are operating inefficiently or, in some cases, not at all. Technical and commercial losses of energy are a major cause for concern and energy demand is poorly managed. While energy trade could help with energy security, limited interconnectivity with neighboring countries prevents robust trade at present.

Other vulnerabilities related to Albania's low adaptive capacity were discussed in Section 2.3.

Risks and Opportunities

Rising temperatures associated with climate change, together with economic development, are set to increase energy demand in summer, when the water available for hydropower plants is lowest, threatening future energy security. The same effect on demand is likely to occur across South Eastern Europe, which could increase costs of importing electricity. There will however be benefits in terms of reduced heating demand in Albania during warmer winters.

For existing, unadapted energy assets, climate change seems set to reduce efficiencies and increase operating costs (OPEX). Capital expenditure (CAPEX) will be needed to retrofit existing assets so they can cope with new climatic conditions. Private developers of energy assets also have concerns about climate risks.

However, Albania is also on the brink of an exciting opportunity: as highlighted in Section 2.1, major investments in new energy assets are underway or being planned. Integrating adaptation measures into concession agreements, contracts, site selection, and design decisions for these new facilities could help ensure their climate resilience. As KESH privatizes the energy system, it could consider how to structure incentives for adaptation; there could be opportunities for cost sharing between Government and the private sector on adaptation actions. The earlier that climate risks and adaptation are considered, the greater the opportunities to identify financially efficient solutions to build the robustness of the energy system for coming decades.

3.2 LARGE HYDROPOWER PLANTS

Current Vulnerabilities

The output from large hydropower plants is vulnerable to variability in the runoff that feeds their reservoirs. In turn, runoff is affected both by seasonal precipitation and temperature (including the timing of snowmelt). Figure 15 clearly depicts lower production from Albania's LHPPs (shown in blue), linked to low rainfall in the period 2000 to 2002, and resultant associated high-energy imports. Planning for new LHPPs draws on river gauge data gathered for a year prior to application. However, rating curves linking river level to discharge have not been updated. As the calibration is likely to have changed as a result of natural and man-made erosion of riverbeds, river flow remains uncertain in most basins other than the Drin and to some extent the Mati. This lack of information constrains Albania's ability to plan effectively for new assets that are robust to changing climate risks.

Extreme rainfall can also cause spillover at LHPPs and threaten dam security. As outlined in Section 2.1, the World Bank has provided credit to Albania for a dam safety project (World Bank, 2008b) for Albania's five LHPPs, aimed at safeguarding them from dam failure and improving their operational efficiency.

Current levels of sedimentation of LHPP reservoirs are unknown but may be significant.

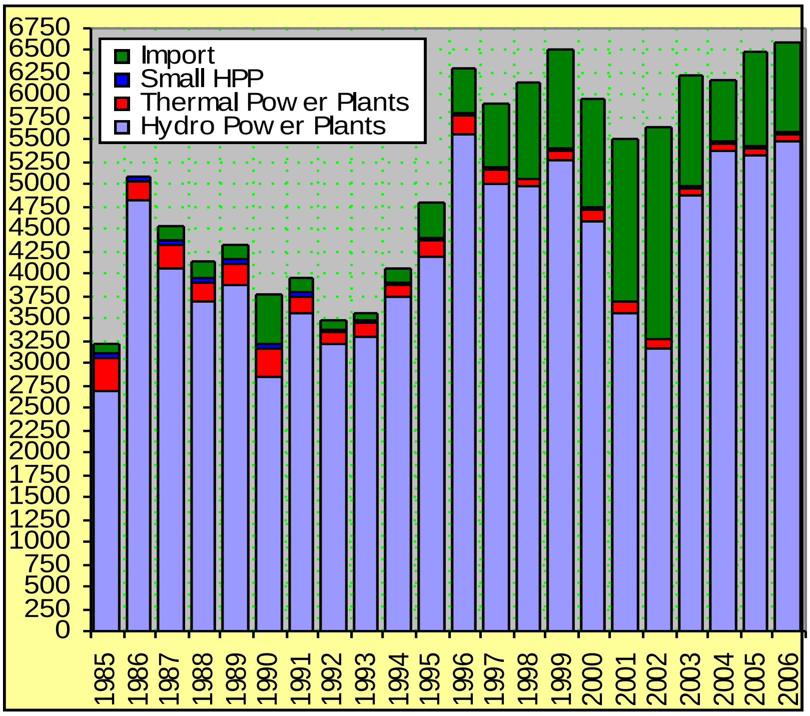

Figure 15: Annual Energy Profile for Albania from 1985 to 2006 in GWh (Islami, 2009).

Risks and Opportunities

As outlined in Section 2.2, the climate change models examined in this study are in good agreement that Albania and the wider eastern Mediterranean region will experience decreases in summer precipitation, projected to be about 20 percent by the 2050s. The models examined are in weaker agreement about the direction of change in winter precipitation (i.e., whether it will increase or decrease) although increases in temperature (which are mutually consistent) will mean that snowmelt occurs more rapidly and evapotranspiration increases. Even if winter precipitation amounts increase in the future, lack of reservoir storage and turbine selection adapted to past hydrology may impose limits on the ability of hydropower facilities to harness increased winter river flows and energy may be wasted through spillover. Furthermore, while seasonal changes can be managed to some extent by improved reservoir management (and indeed this is beginning to be achieved by KESH), this is impeded by the country's lack of hydrometeorological capacity, as outlined in Section 2.3.

Climate change is also projected to increase the intensity of rainfall, which can cause higher spillover at hydropower facilities, put increased pressure on dam reservoirs, and cause landslips. Communities and land close to large dams may be exposed to increased risk of flooding. Increased intensity of precipitation events can also lead to upstream soil erosion and greater siltation of hydropower reservoirs.

As a consequence of these risks, unless risks are proactively managed, climate change is anticipated to impact negatively on the financial performance of LHPPs, leading to loss of revenue and increased OPEX and CAPEX.

High-level Quantitative Estimate of Climate Change Impact on LHPP Production by 2050

An in-depth approach to quantifying the impacts posed by climate change for hydropower plants would involve hydrological modeling using downscaled climate change scenarios, and subsequent modeling of the impacts of changes in river flows on hydropower plant output. Such analysis is beyond the scope of this analysis; instead, to develop high-level quantitative estimates, the following information and data were used:

- Rainfall-runoff modeling of the relationships between projected changes in climate (precipitation and temperature) and changes in river flows for several catchments Albania (Islami *et al*., 2002; Bogdani and Bruci, 2008; Islami and Bruci, 2008).
- A correlation of annual average inflows to Fierze hydropower plant on the Drin Cascade (Annex 8) and consequent electricity generation, together with a similar correlation for power production from LHPPs on the Mati River (Islami and Bruci, 2008).
- Recent research undertaken in Brazil, which used regional climate modeling data to project impacts on output from Brazil's hydropower plants (Andre *et al*., 2009; Schaeffer *et al*., 2009).

Rainfall-runoff modeling undertaken for the Drin, Mati and Vjosa River basins using climate change projections for temperature and precipitation indicates reductions in runoff in these catchments of about 20 percent by 2050 (Islami *et al*., 2002; Bogdani and Bruci, 2008; Islami and Bruci, 2008). It should be noted that this is an approximate estimate, based on a small number of global climate models and hydrological models. As highlighted in Section 2.2, a wide range of models and greenhouse gas emissions scenarios better represents uncertainties, but it was beyond the scope of the current study to undertake new hydrological assessments. Furthermore, climate change is expected to lead to increased rainfall intensity and longer dry periods, which will affect runoff and hence hydropower production. Again, analysis of the implications of these changes, while they may be important, is beyond the scope of this assessment and is an area for future research.

Correlations were developed for both the Drin and Mati Rivers of the relationship between river flows into the reservoirs and electricity production (Connell, 2009; Islami and Bruci, 2008). These are shown in Figures 16 to 18. These correlations indicate that, as a first estimate, if the flows on the Drin and Mati Rivers declined by 20 percent, electricity generation would fall by about 15 percent. This estimate has been applied in the cost–benefit analysis presented in Section 5. Further information on how this estimate was derived is provided in Annex 8.

It is worth noting that Albania's hydropower managers have recently begun to improve their operations to better manage drought risks to production. Working with weather and climate experts, they are planning to expand the network of river-level sensors and rain gauges, and a system for collecting regional weather data. Using this information, managers will be able to forecast the level of the Drin more accurately, timing the filling and release of water from reservoirs so they can draw the most energy from the system without endangering dams that may collapse if the water level rises to over-top dam height.

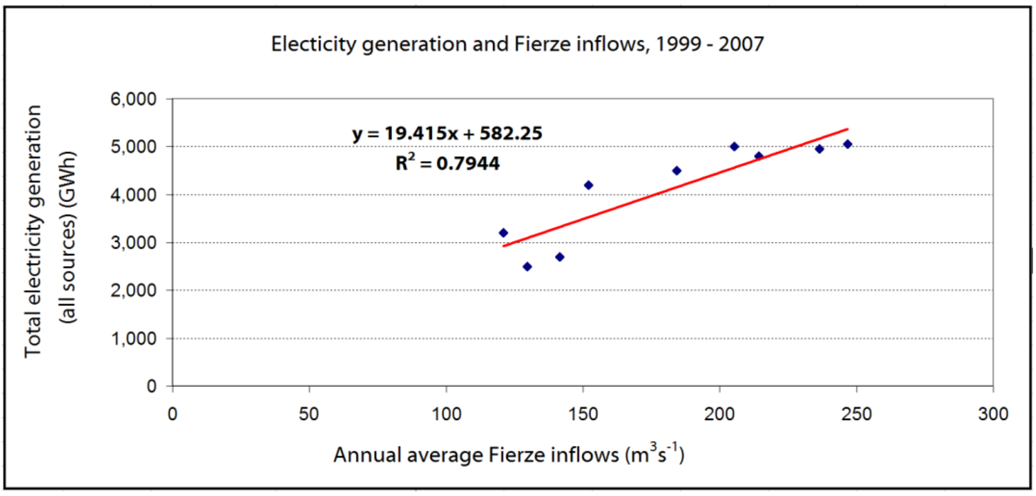

Figure 16: Relationship between Drin River flow and electricity production at Fierze (Annex 8).

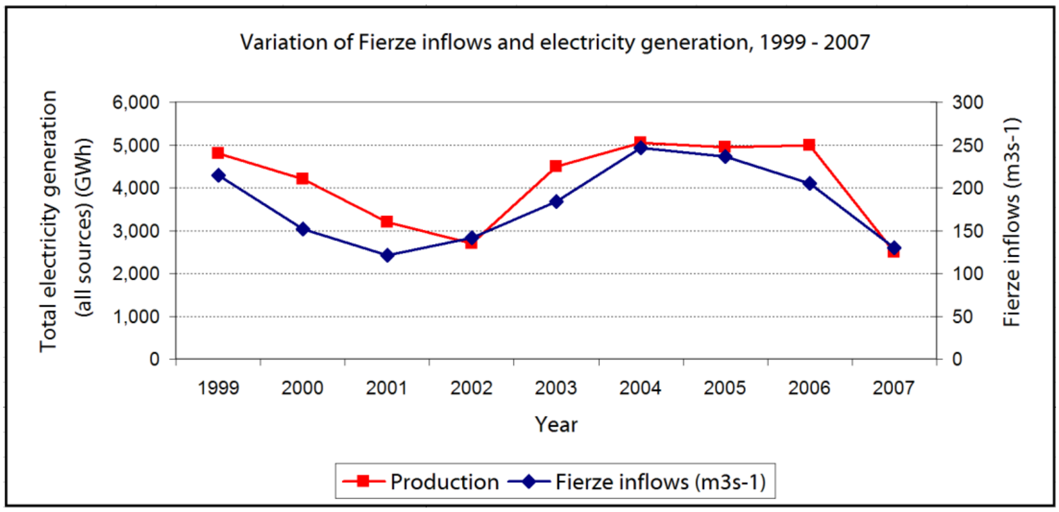

Figure 17: Variation of Fierze inflows and electricity generation, 1999 to 2007 (Annex 8).

3.3 SMALL HYDROPOWER PLANTS (SHPP)

Current Vulnerabilities

Existing small hydropower plants in Albania have generally been constructed to serve local communities and sized accordingly. In that sense, they are not necessarily in the best locations or sized optimally for river flows. Many are being rehabilitated, so they will recommence operation in their current locations. As with LHPPs, the key climatic vulnerabilities for SHPPs relate to variability in precipitation and temperature, through their impacts on runoff.

During three consecutive years of drought in Albania (2005, 2006, 2007), some SHPPs were unable to produce the needed power to feed into the grid or even to supply their local communities on a sustainable basis, reducing the total power available. Annual operating periods of some SHPP facilities have reduced in recent years from 8 months to 4, linked to less snow (Acclimatise *et al*., 2009a).

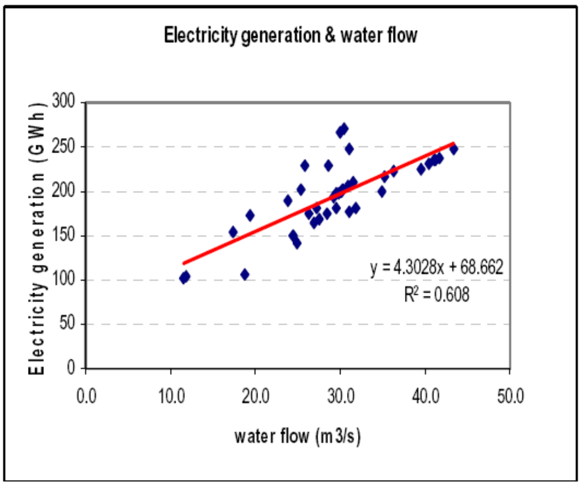

Figure 18: Relationship between Mati River flow and electricity production from Ulëza and Shkopeti HPP (Islami and Bruci, 2008).

Risks and Opportunities

Because SHPPs do not have reservoirs, their performance is linked essentially to the intensity and duration of precipitation. They will therefore be affected by any future decreases in annual average and summer precipitation amounts. Snow affects SHPP production by slowly releasing stored water as it melts, and consequently SHPPs are particularly sensitive to more-rapid snowmelt due to higher winter temperatures.

The irrigation needs of agriculture take precedence over energy production in Albania, so SHPPs could also be affected by farmers' adaptation strategies in response to climate change—namely the need to increase irrigation (World Bank, 2009c). At present, agricultural irrigation is undertaken for about three to four months per year in summer, often in the daytime, when energy demand is lower, thus reducing the chance of conflicts over water use. Energy demand is currently at a maximum in winter. However, as already noted, rising temperatures will cause shifts to greater energy demand in summer, potentially bringing farmers and SHPP owners into conflict over water use, unless actions are taken to manage this. The need for agricultural irrigation in Albania cannot currently be easily forecast before or during the irrigation season, making forward planning by SHPP owners very difficult. Furthermore, water delivery to farmers is not organized in automated delivery schemes that follow defined basin modeling so it is not possible to maximize its effectiveness. However, large areas of agricultural land in Albania have been equipped with efficient irrigation systems in the last couple of years, which has had a dramatic effect on reducing water use in these areas.

Additionally, minimum flow requirements are in place to protect river ecology, so potential lower flows due to climate change could affect the flow available for SHPP utilization. Climate change is also anticipated to lead to increased risks of siltation for SHPPs, when combined with deforestation and poor watershed management, affecting asset performance.

High-level Quantitative Estimate of Climate Change Impact on SHPP Production by 2050

Assumption of a one-to-one relationship between changes in river flows and SHPP power output leads to projection of a 20 percent reduction by 2050, according to the projected decrease in runoff estimated for LHPP generation in the previous section (Annex 9). This estimate has been applied in the cost–benefit analysis presented in Section 5. It is noted that there could be significant indirect impacts of climate change on SHPPs, due to the adaptation actions that may be taken in the agriculture sector. For instance, farmers' demands for irrigation water will increase due to higher temperatures. Hence, the 20 percent reduction may be an underestimate. Assessments of such indirect impacts were beyond the scope of this assessment but could usefully be addressed in additional cross-sectoral climate change risk assessments.

Box 4 overleaf summarizes some of the interlinkages between water resources, energy security, and food security.

3.4 THERMAL POWER PLANTS (TPPS)

Risks and Opportunities

As outlined in Section 2.1, Albania is developing thermal power plants to improve energy security. Optimal TPP performance is slightly vulnerable to climate change impacts, mostly with regards to operating efficiency: rising temperatures have a modest impact on gas turbine performance, and the availability and temperature of cooling water can also affect operations.

Currently, the TPP assets under development or in discussion (at Vlore Port, Fier and Porto Romano) are to be cooled by sea water. However, if Albania were to consider developing river-water-cooled TPPs, then the impacts of climate change on river flows and water temperatures could have significant effects on their operation in warmer, drier months. There could then be insufficient river flow to meet cooling requirements, and abstractions could be prevented for periods of time by regulations designed to protect river ecology during low flows. Thermal power plants in the United States have been subjected to such constraints on a number of occasions during recent droughts (Karl *et al*., 2009).

The Vlore TPP is located near Vlore Port. The Vlore plant has raised the elevation of the site by 2 m above sea level due to its proximity to the Vlore floodplain (Maire Engineering, 2008). Further modifications have been made to equipment installed on site. Nevertheless, it is not possible to estimate in this assessment how much more frequently, if at all, the site might flood in the future due to climate impacts due to limited available information on the reason for the site elevation decision.

In general, coastal energy assets may be significantly affected by rising sea levels and coastal erosion and this should be an important consideration in the siting of future TPPs.

High-level Quantitative Estimate of Climate Change Impact on TPP Efficiency by 2050

The authors estimated the efficiency (output) reduction for TPP based on engineering expertise at 1 percent by 2050, associated with the impacts of rising temperatures.

Box 4: Climate change, water resources, energy, and food security in Europe and Central Asia (ECA)

Rising temperatures and changing hydrology are already affecting forestry and agriculture in many countries in ECA. The region's natural resilience and adaptive capacity have been diminished by the Soviet legacy of environmental mismanagement and the pursuit of economic growth carried out with blatant disregard to the environment. This is evident in agriculture where poor management of soil erosion, water resources, pest control, and nutrient conservation increases the sector's vulnerability to climate change. Inadequate capital investment and watershed management have led to significant water losses and reduced the productivity of irrigation systems as well as hydropower generation capacity.

Over time, the impact of global warming, other nonclimatic factors (such as inefficient use of water), legacy issues and the continuing unsustainable demand will exacerbate water stress in Europe and Central Asia. Global warming will negatively affect water systems in some parts, as reduced precipitation and high evaporation rates decrease water availability for agriculture and hydropower production alike.

ECA countries are expected to help offset the projected decline in world food production due to decreasing agriculture yields in lower latitudes due to climate change. However, there are important caveats: the projected gap between potential and actual yields in ECA is 4.5 times higher than the potential increase in agricultural production from climate change by 2050. Unless current inefficiencies in the agricultural sector are addressed, food insecurity in the region will become a major development concern. The inability of Kazakhstan, Russia, and Ukraine to close the productivity gap and respond to recent crop price increases does not bode well for their capacity to adapt to and benefit from climate change.

Going forward, improved water resource management and better-performing water utilities and energy systems will help reduce climate vulnerability. Gains from improved agricultural practices, including adaptation measures such as better water resource management, could outweigh projected negative impacts. Energy security considerations will be integral to the long-term investment decisions on water resource allocation. Albania currently derives 90 percent of its energy from (both large and small) hydropower plants; plants that are feeling the effect of weather variability and are likely to see further declines in runoff and energy production into the future (estimated at 15 percent and 20 percent respectively by 2050, as outlined in this section of the report). It is a complex picture. Agricultural demand for irrigation water is seasonal and subject to significant variability. Timing is also critical. Today, water demand for agricultural use is low during periods of peak energy demand (winter and night-time) and high when energy needs drop (summer and daytime). But winter demand for energy is expected to drop with climate change and daytime summer demand to rise with increasing temperature and cooling demand.

(World Bank, 2009d)

3.5 WIND POWER

Risks and opportunities

As outlined in Section 2.1, Albania currently has no industrial wind power generation facilities, although it is holding discussions about developing them and seven licenses have been issued. The wind resources of Albania are uncertain. Until recently, the wind field maps available could draw only on data measured at 10 m height above ground (as per World Meteorological Organization standards adhered to by Albania's national measuring stations), rather than the height where the turbines would be located. Especially in Albania's mountainous terrain, there is no consensus model for extrapolation from the measured field to the wind field of interest. These considerations have made wind farm development vulnerable to climate uncertainties that can affect design and operational parameters. Recognizing this, a Wind Energy Resources Assessment for Albania has been conducted by the Italian Ministry for the Environment, Land and Sea, which has resulted in a map of average wind speed for Albania that is an improvement on past data availability. If changes in wind speed and/or direction were to occur, however, reoptimization of the design and operation of wind energy facilities would be could be needed to ensure that installed turbines did not slip out of their optimal operating band.

High-level quantitative estimate of climate change impact on wind power by 2050

The climate change projections are very uncertain with respect to wind, and the data that are available for Albania indicate little or no change. The cost–benefit analysis in Section 5 has therefore assumed no change.

3.6 POWER TRANSMISSION AND DISTRIBUTION

Current vulnerabilities

As outlined in Section 2.1, the power transmission system was recently upgraded, aligning with EU standards, and ongoing investments are focusing on improving regional interconnectivity. Technical losses in the transmission network in 2008 were 213GWh (3.3 percent) (ERE, 2008).

The distribution grid already presents clear climatic vulnerabilities and has high technical and commercial losses (about 33 percent in 2008). Although city networks are generally in good condition, there are significant parts of the distribution grid that need upgrading, especially those serving rural and mountain communities, who already do not have secure energy supplies due to the deterioration of the grid. In periods of high winter precipitation, snow and ice can cut off distribution lines. Repair crews have difficulties repairing damaged networks due to difficult road conditions and local authorities may not always have the resources and expertise to repair damage quickly. High winds can also cause damage to power lines. The capacity of communities to cope with interruptions to supply of power (and other services) is highly dependent on the level of economic development. For instance, small businesses may not have backup generators. Even if the effect of intermittent power can be managed with the use of backup generators, there is an additional capital and operating cost in use of such generators.

Risks and opportunities

Owing to the recent technical upgrades of the transmission system, its performance is not expected to be significantly affected by projected changes in temperature and precipitation. However, it is worth noting that, at present, EU standards do not account for climate change, and the technical specifications may require review in the years to come. Indeed, the EU Adaptation White Paper refers to the need to review and update EU regulations in the light of climate change projections (European Commission, 2009).

Rising temperatures due to climate change will gradually erode the efficiency of the transmission and distribution systems, by reducing the ability of transmission lines to lose heat to their environment.

If climate change leads to increased winter precipitation, damaging events could occur more frequently unless the distribution grid is upgraded, with consequent worsening social impacts. Because projections of future changes in wind are highly uncertain, it is not possible to say with any confidence whether damage to power lines from these events will happen more often. However, increased intensity of precipitation could lead to greater incidence of landslips, affecting distribution lines in hill terrain.

High-level Quantitative Estimate of Climate Change Impact on Transmission and Distribution Efficiency by 2050

Using engineering expertise, the efficiency reduction for transmission and distribution has been estimated as 1 percent by 2050, the consequence of rising temperatures.

3.7 Energy Demand

Current Vulnerabilities

Energy demand is not managed effectively at present, with old, inefficient equipment and standards being applied in households and the services sector. Many houses have inadequate insulation, leading to wasteful use of energy. Furthermore, electrical power is often the main source of energy for heating. Commercial losses are significant, running at 13.4 percent in 2008 (ERE, 2008).

Risks and Opportunities

The most significant impacts of climate change on energy consumption are likely to be the effects of higher temperatures on the use of electricity and the direct use of fossil fuels for heating in Albania. Higher temperatures are likely to affect the following major electric end uses:

• Space heating	Energy demand for space heating will decline
• Air conditioning	Energy demand for space cooling will increase
• Water heating	Energy demand for water heating will decline slightly
• Refrigeration	Energy demand for refrigeration will increase

Of these end uses, air conditioning and space heating are those most likely to be significantly affected by climate change in Albania, since both are functions of indoor-outdoor temperature differences. Compounded by the anticipated reduction in availability of hydropower in summer, this could exacerbate energy security difficulties. There are opportunities, however: climate change is expected to shorten the cold season and reduce the severity of cold weather events, reducing energy demand for heating.

Quantitative estimates of climate change impacts on energy demand are described in Section 5.2.

3.8 Oil, Gas, and Coal Production

Current Vulnerabilities

Although Albania’s oil production facilities are not considered to be directly vulnerable to climate risks to any great extent, the ability to import LPG or to export crude oil products depends on shipping ports. At present, extreme weather can delay ships arriving into Vlore Port by one to two days, although wider channels being opened at Vlore Port in summer 2009 will reduce this problem. Furthermore, it is understood that the port has a transgressive geological structure though current rates of erosion are not well understood (Acclimatise, 2009a).

Oil production facilities at Patoz Marinza are one of five European hotspots for contaminated land (UNEP, 2000). Pollution carried via drainage channels into the Gjanica River, which is heavily contaminated by oil operations, and contamination pathways are affected by climatic influences on ground conditions.

The Ballsh oil refinery is vulnerable to electricity disruptions: it relies on the grid, and if a power cut lasts more than an hour, financial losses estimated at $100,000 or above can occur (Acclimatise *et al*., 2009a).

The existing low-pressure gas pipelines from Fier and Ballsh have experienced loss of integrity in the past, due to landslips at valley crossings after storms and heavy downpours. These risks are seen as minimal, however, when compared to the risk of sabotage.

Albania's coal industry is small, employing only about 200 people at present (Acclimatise *et al*., 2009a). Coal is stored outdoors, sometimes on slopes, and is therefore vulnerable to heavy rainfall, which can lead to loss of product and also ground and water contamination.

Risks and Opportunities

Higher temperatures are not anticipated to affect oil production facilities significantly. Indeed, there may be a slight positive effect of warming temperatures on their cost profile.

However, unless steps are taken to adapt new and existing port developments, port operators could face increased risk of flooding and storm damage, with consequent service disruption for oil producers and increased operating costs. Furthermore, it is not clear whether the new design for Vlore Port takes into account projections of rising sea levels, but, given the fact that the coastline is eroding, increased risk of coastal erosion is a potential cause for concern.

The existing problems with contaminated land and watercourses at Patos Marinza could be exacerbated if, as projected, climate change brings increased summer droughts. The consequent changes in ground conditions could create new pathways for pollutants, which would then flush through into water courses during heavy downpours, worsening an already difficult situation.

The low-pressure gas pipelines from Fier and Ballsh could see increased risk of landslips, associated with projected increased incidence of heavy downpours as a result of climate change.

The main climate change impacts on Albania's limited coal facilities are also likely to result from heavy downpours of rain, which could lead to increased loss of product and increased risks of ground and water contamination.

As outlined in Section 1, the focus of this assessment is on how Albania can best manage its future security of energy supply in the face of climate change. Given that oil, gas, and coal production assets are not key factors in Albania's energy security, impacts on these assets were not taken forward as part of the cost–benefit analysis. However, it is clear from the analysis outlined in this section that oil, gas, and coal production are vulnerable to changing climate risks, and the issues identified here merit further consideration by the decision makers responsible for these activities.

4. IDENTIFICATION OF ADAPTATION OPTIONS FOR MANAGING RISKS TO ALBANIA'S ENERGY SECTOR

The key cross-cutting climate risks and opportunities related to energy security identified in the previous section are that, over time:

- Annual energy demand may decline slightly (an estimated reduction approximately 0.1 percent per year, see Section 5.2).
- Winter energy demand will reduce and summer peak demand will increase.
- Energy supply from existing assets will decline, particularly in summer, leading to a shortage in supply that would have to be filled to ensure energy security.

Adapting to climate change, to reduce vulnerabilities and risks and take advantage of opportunities, will be increasingly important for the Albanian energy sector. Stakeholders provided input on adaptation options applicable to the Albanian energy sector through a workshop and series of meetings (Acclimatise *et al*., 2009b).

Detailed descriptions of the potential adaptation options, including cross-cutting actions and individual actions for each energy asset class, are summarized in Annex 3, Tables A3.1 to A3.8.[5] The adaptation option tables highlight which options are *no-regret*, *low-regret*, *win-win*, and *flexible* (see Box 5 for definitions of these terms). These kinds of options are particularly useful in devising decision strategies in the face of uncertainties about the future.

In essence, the adaptation options fall into three main groups:

1. **Informational actions** including: gathering and sharing additional meteorological and hydrometeorological data; analysis and modeling of catchments that may be suitable for hydroelectric power generation; working with neighboring countries to understand regional risks from climate change and their implications for regional energy trading; further research on climate change impacts through downscaling of global climate model data; and researching the impacts of changing seasonal conditions and extreme climate events. Many of these options are considered to be *no-regret* options. As such, it is considered that undertaking these options would prove beneficial for a wide range of reasons, whatever the extent of future climate change. Stakeholders in Albania should consider the no-regret options as a priority. No further analysis has been conducted for these options, though further details on one vital no-regret option, namely improved monitoring and forecasting of weather and climate, are provided in Box 6, Annex 4 and Hancock and Ebinger (2009).

2. **Institutional actions** including: reviewing, upgrading, and enforcing design codes to require new assets to take account of climate change; and reviewing the government prioritisation policy for resources such as water in the face of climate change. It is anticipated that many of these adaptation options would be subject to regulatory impact assessment prior to being introduced. Therefore, no further assessment of these options has been carried out in this report. However, further details are provided in Box 7, on weather coverage and insurance instruments that could help mitigate the anticipated losses associated with climate variability and extreme events.

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[5] Note that the adaptation options numbers listed in the Risk Register below (Table 5) correspond to the adaptation option numbers in Tables A3-1 to A3-8.

3. **Physical/technical actions**: A number of potential *engineering* adaptation options have been identified, including: amendments to the way existing LHPPs are operated; upgrades of existing assets to optimize performance and minimize decline in power generation due to climate change; and construction of new and diversified power generation assets.

Box 5: Categorization of adaptation options for robust decision making under conditions of high uncertainty, with some examples

No regret: Measures that deliver benefits that exceed their costs, whatever the extent of climate change, e.g.:
- Investment in energy demand management
- Preparing for questions about adaptation from government, investors, analysts, lenders, lawyers
- Funding baseline climate monitoring and regional climate models
- More holistic approaches to water cycle management in water-constrained locations

Low regret: Low cost measures with, potentially large benefits under climate change, e.g.:
- Allowing for heavier rainfall when designing new drainage system—make drainage pipes wider; use Sustainable Drainage Systems which allow rainfall to percolate into the ground, reducing runoff

Win-win: Measures that contribute to climate adaptation and also deliver other benefits, e.g.:
- Creation of salt-marsh habitat provides flood protection for coastal areas and also contributes to nature conservation objectives

Flexible approaches/'Adaptive management: Keeping open / increasing options that will allow additional climate adaptation in future, when the need for adaptation and performance of different adaptation measures is less uncertain, e.g.:
- Flood management: Allow for future increases in defence height by making foundations wider and deeper, but do not build higher defence immediately

Avoid maladaptive actions: Some actions will make it more difficult to cope with climate change risks, e.g.:
- Inappropriate development in a flood risk area

The Risk Register presented in Table 5 summarizes the main climate-related risks before and after adaptation, demonstrating how effective the adaptation actions could be in reducing risks. It also summarizes the adaptation actions that could help to manage each risk. In developing the risk-severity ratings after adaptation, it has been assumed that the adaptation actions would be fully implemented. However, we add a note of caution: as mentioned in Section 2.3, Albania has low adaptive capacity, which means that implementing these actions would require considerable effort, coordination and, in some cases, funding.

Some 20 risks are identified in Table 5. The risks falling into each risk severity category before and after full implementation of adaptation measures are outlined in Table 4. (For further details on the risk categories, refer to Annex 2, Tables A2.1 and A2.2.)

As can be seen in Annex 2 (Tables A2.3 and A2.4), for a given risk, the adaptation options considered could lead to a decrease in the likelihood of occurrence of a hazard and/or a decrease in the magnitude of its consequence.

Table 4: Number of Risks in Each Risk Severity Category, Before and After Adaptation

	Number of Risks in Category	
Risk Severity Category	**Before Adaptation**	**With Full Implementation of Adaptation Measures**
Extreme	7	0
High	9	6
Moderate	3	5
Low	1	9

For most of the “extreme” risks, the key adaptation options include: diversification of energy into other forms of generation than hydroelectric power, working with neighboring countries to understand regional risks and implications for regional energy trading, and improved data collection and modeling to enable hydropower plant design and operation to be optimized.

Diversification of assets was also seen by most stakeholders engaged during this assessment as a critical step for the Albanian energy sector. With this in mind, the high-level cost–benefit analysis element of this assessment, presented in Section 5, has focused on looking at a diverse range of asset classes that may be utilized to adapt to climate risks to supply and demand. The economic cost–benefit analysis presented here is thus an example of a process that Albania could use as it evaluates adaptation options. A more in-depth analysis, appropriate for the magnitude and costs of the challenges presented by climate change, would consider a larger variety of options and explore the costs and benefits in greater detail.

Box 6: A vital ‘no-regrets’ option for Albania—improved monitoring and forecasting of weather and climate

As outlined in previous sections, hydropower provides about 90 percent of domestic electricity in Albania. This buffers national economic development from fossil fuel price shocks and will help Europe as a whole to meet its targets for reduction of greenhouse gas emissions. However, Albania’s dependence on renewable energy sources makes it vulnerable to the weather, especially because the rainfall on which Albania’s hydropower depends is among the most variable in Europe. Albania’s vulnerability has been highlighted in recent drought years (e.g., 2002 and 2007).

Improved weather monitoring and forecasting could bolster Albania’s energy security, enabling planning for water shortages, guiding the optimal tradeoffs among various water users in times of shortage, and supporting management of reservoirs to extract the largest amount of energy per unit of flow. However, Albania’s national weather-monitoring network was damaged in the civil struggles of the 1990s and has been only partly rehabilitated. Many stations and hydroposts are heavily depreciated, and telecoms do not support the data reporting frequency that efficient management of hydropower requires. As a result, the network that records rainfall, temperatures, and river levels is sparse and reports very little information in real time. Rainfall and runoff could be qualitatively forecast to three days if modest resources were invested in obtaining and tuning models; but in part because computing capacity is extremely weak, Albania uses the model output of neighboring countries, which is not verified in detail nor continuously re-tuned to Albania’s conditions. Longer lead-time forecasts to seven days could be obtained from the European Centre for Medium-range Weather Forecasting to support national forecasts and planning; although these are low-resolution they would provide valuable guidance on regional water availability. Currently, Albania is not a full subscriber and has only limited access. Seasonal forecasting via statistical models is having increasing success in some regions of the world, but good success in Albania would need to draw on digitized historical data, which is not available because much of Albania’s historical data is not in digital form. Watershed models and maps of national climate could be updated to support planning for the future, but today they provide only weak guidance because they are out of date.

Wind farms, also of potential interest to Albania, are also weather-dependent. Their optimal design depends on knowledge of the distribution of wind speeds; currently, a verified map of the wind resource for Albania does not exist. Management of the transmission and distribution system can also be made more robust. Power is generated in the Drin cascades of northern Albania while most consumers are concentrated in the south, so the country’s transmission and distribution system necessarily involves long transmission lines, exposed to severe weather. Repairs of inevitable occasional damage would be more rapid if Albania were able to monitor severe weather, pinpointing lightning strikes, heavy winds, and the other sources of damage. Finally, better weather forecasting would enable Albania to make the most of its natural resources by improving the accuracy of demand forecasts that build on knowledge of upcoming temperature and cloudiness to assess demand for electricity.

As outlined in Section 2.2, climate projections from a range of climate models are in good agreement about the extent of future increases in temperature for the South Eastern Europe region and they are also in general agreement that future summer precipitation would decrease. They are valuable as a source of qualitative information about the patterns of regional climate trends but further downscaling would provide more localised data for energy asset management. It would be helpful to determine whether several more-robust projections of changes in Albania’s precipitation could be identified through a review of correlation of modeled baseline climates against observed historical precipitation patterns, and to focus on downscaling an ensemble of these.

All these functions are very weak in Albania today: monitoring, modeling, and forecasting. Albania’s former strengths in this area could be revived and expanded to bolster its energy security, which is so strongly linked to its variable climate. As the climate changes, Albania is likely to see changes in the availability of renewable energy sources. Increased skill in monitoring and forecasting the weather that measures out these resources would enable Albania to adapt flexibly and rapidly to trends on all time scales.

(Further insights on this topic are provided in Annex 4 and Hancock and Ebinger (2009).

Box 7: Weather risk management through weather coverage and insurance instruments

Albania's economy is weather sensitive and vulnerable to man-made and natural disasters; some avoidable. In the past 33 years, 62 percent of disasters were hydrometeorological in origin and in the past decade alone there have been 2 significant periods of drought, 45 major landslips, and 3,767 forest fires. Projected changes in climate—rising temperatures and reduced precipitation—could compound already adverse impacts on fiscal stability and macroeconomic performance, businesses, and households.

Albania is taking steps to address its vulnerability through a US$9.16 million (equivalent) Disaster Risk Management and Adaptation Project approved by the World Bank's Board in May 2008 (effective June 2009). This project supports:

- Capacity building for emergency response and strengthening of disaster risk mitigation planning
- Provision of accurate, tailored hydrometeorological forecasts and services to weather sensitive sectors (agriculture, energy, water resource management etc.)
- Development of building codes that address seismic risk
- Development of private catastrophe risk insurance for households, small and medium enterprises

Lending and technical assistance programs could be complemented by weather coverage and insurance instruments that could help mitigate the anticipated losses associated with climate variability and extreme events. Weather coverage is an emerging market instrument that pays on the basis of a measurable weather event and does not require individualized loss assessment (as in the case of more traditional insurance). Customized weather coverage is being used by hydroelectric utilities in Australia, the United States, India, and Canada to do the following (WeatherBill 2009):

- *Stabilize revenues* and protect against income loss due to precipitation or temperature fluctuations affecting power generation.
- *Control costs* associated with power purchases to address supply shortages arising from weather related events (e.g., below average precipitation).
- *Manage cash reserves*, for example to ensure that reserve funds are not required to cover operating costs when budgets are stressed due to successive drought years.

Such instruments can be accessed on the insurance market. The World Bank Group (WBG) also offers a range of services to mitigate the impacts of disasters and weather events:

- **Catastrophe Risk Deferred Draw-down Option (CAT DDO)**, a deferred development policy loan offering IBRD eligible countries immediate liquidity up to US$500 million or 0.25% of GDP (whichever is less) if they suffer a natural disaster.
- **Sovereign Budget Insurance**, advisory services to help countries access the international catastrophe reinsurance markets on competitive terms; currently used by 16 Caribbean countries as parametric insurance against major hurricanes and earthquakes.
- **Insurance Linked Securities**, a multi-country catastrophe bond to poll the risks of several countries and transfer the diversified risk to capital markets is under development. WBG has experience in working with Mexico to transfer earthquake risk to investors through such mechanisms (2006).
- **Catastrophe Property Insurance**, to create competitive insurance markets and increase catastrophe insurance penetration.
- **Indexed Based Weather Derivatives.** In Malawi the World Bank provided intermediation services on an index-based weather derivative. If precipitation falls below a certain level, a rainfall index reflects the projected loss in maize production, and payout is made when production falls significantly below historic averages.

(World Bank, 2008a; World Bank; 2009b; WeatherBill Inc, March 27, 2009.)

Table 5: Risk Register (For details on the rating system presented here (labeled 1 to 5 and A to E), see Annex 2, Tables A2.1 and A2.2)

Rank	Risk Description, Event and Consequence	Risk Severity Before Adaptation					Adaptation Actions	Risk Severity After Adaptation				
			Consequence		Likelihood	Risk Level Before Adaptation			Consequence		Likelihood	Risk Level After Adaptation
1	Higher peak demand in summer due to higher temperatures could lead to lack of capacity.	**5**	Catastrophic	**A**	Almost Certain	*Extreme*	Develop shared understanding of region-wide climate risks to energy security; increase energy trade; supply diversification; supply and demand side management / efficiency; optimize current generation; make new energy assets climate resilient (Adaptation Options: 1, 7, 10 to 15).	**2**	Minor	**D**	Unlikely	*Low*
2	Less summer electricity generation from hydropower facilities due to reduced precipitation and runoff could reduce energy security.	**5**	Catastrophic	**A**	Almost Certain	*Extreme*	Optimize current water and power generation management system, implement engineering adaptations as part of dam rehabilitation, amend and implement design standards to take account of climate change, diversify power generation, contingency planning such as insurance back-up and / or regional trading (Adaptation Options: 7, 16 to 23).	**3**	Moderate	**C**	Moderate	*High*

Rank	**Risk Description, Event and Consequence**	**Risk Severity Before Adaptation**					**Adaptation Actions**	**Risk Severity After Adaptation**				
			Consequence		**Likelihood**	**Risk Level Before Adaptation**			**Consequence**		**Likelihood**	**Risk Level After Adaptation**
3	EU Carbon trading schemes add cost to thermal power generation.	**4**	Major	**A**	Almost Certain	*Extreme*	Diversify asset portfolio so that thermal power remains a small contributory element; seek ways to offset carbon emission costs through regional / global trading (Adaptation option: 7).	**3**	Moderate	**C**	Moderate	*High*
4	Changes in seasonality of river flows (including more rapid snowmelt due to higher winter temperatures) combined with mismanagement of water resources could decrease the operating time for SHPPs, resulting in decreased production.	**4**	Major	**A**	Almost Certain	*Extreme*	Collect and analyze hydromet data for existing and potential basins; require climate change aspects to be considered in designs and upgrades of new and existing facilities, work with other users (particularly in the agriculture sector) to reduce potential future competition for water resources; consider insurance, upgrade existing facilities to optimize generation (Adaptation options: 24 to 30).	**2**	Minor	**C**	Moderate	*Moderate*

Rank	Risk Description, Event and Consequence	Risk Severity Before Adaptation					Adaptation Actions	Risk Severity After Adaptation				
			Consequence		Likelihood	Risk Level Before Adaptation			Consequence		Likelihood	Risk Level After Adaptation
5	Increased CAPEX / OPEX due to climate change could lead to reduced shareholder value.	**4**	Major	**B**	Likely	*Extreme*	Diversify assets; require consideration of climate change in contracts for new energy assets; regional interconnections and explore potential financial risk management products (Adaptation Option: 7).	**3**	Moderate	**B**	Likely	*High*
6	Higher peak summer demand across the region could increase import prices and reduce supply.	**3**	Moderate	**A**	Almost Certain	*Extreme*	Develop shared understanding of region-wide climate risks to energy security; diversify assets, regional interconnections and explore potential financial risk management products (Adaptation Option: 1, 7).	**3**	Moderate	**C**	Moderate	*High*
7	Paucity of hydromet data makes it difficult to manage water resources and optimize operation of hydropower	**4**	Major	**A**	Almost Certain	*Extreme*	Collect, model and analyze hydromet data (Adaptation Options: 1, 2, 16, 17, 24, 25).	**2**	Minor	**D**	Unlikely	*Low*

Rank	Risk Description, Event and Consequence	Risk Severity Before Adaptation					Adaptation Actions	Risk Severity After Adaptation				
			Consequence		Likelihood	Risk Level Before Adaptation			Consequence		Likelihood	Risk Level After Adaptation
	plants.											
8	Sea level rise could lead to increased coastal erosion potentially affecting energy assets in the coastal region such as ports for oil export.	**3**	Moderate	**C**	Moderate	*High*	Research impacts of rising sea levels on coastal zone, implement design codes with climate change taken into account, identify assets at risk, include climate resilience in new design and rehabilitation of existing assets (Adaptation Options: 3, 6, 8, 31, 33, 34, 36).	**2**	Minor	**D**	Unlikely	*Low*
9	Lack of data (impact of climate change on wind patterns) creates uncertainty about optimal sites / design for generation using wind.	**3**	Moderate	**C**	Moderate	*High*	Collect appropriate wind data and complete mapping; research and monitoring of climate change impact on wind; incorporate climate change assessment in design requirements (Adaptation options 37, 38, 39).	**1**	Insignificant	**E**	Rare	*Low*

Rank	**Risk Description, Event and Consequence**	**Risk Severity Before Adaptation**					**Adaptation Actions**	**Risk Severity After Adaptation**				
			Consequence		**Likelihood**	**Risk Level Before Adaptation**			**Consequence**		**Likelihood**	**Risk Level After Adaptation**
10	Climate change increases risk of competition between water users.	**3**	Moderate	**B**	Likely	*High*	Collect and analyze data, raise awareness of competing interests, and work together, particularly with agricultural water users (Adaptation Options 1, 2, 4, 5).	**3**	Moderate	**D**	Unlikely	*Moderate*
11	Dry periods followed by heavy downpours of rain would exacerbate soil erosion from agricultural land, leading to increased sedimentation and reduced output from SHPP and LHPP.	**3**	Moderate	**B**	Likely	*High*	Monitor and assess sedimentation risk, rehabilitate existing assets, work with other stakeholders to manage future risks (Adaptation Options: 17, 19, 25 and 27).	**3**	Moderate	**D**	Unlikely	*Moderate*

Rank	Risk Description, Event and Consequence	Risk Severity Before Adaptation					Adaptation Actions	Risk Severity After Adaptation				
			Consequence		Likelihood	Risk Level Before Adaptation			Consequence		Likelihood	Risk Level After Adaptation
12	Mal-adapted infrastructure design if climate change not built-in could lead to reduced operation / efficiency of assets.	**3**	Moderate	**B**	Likely	*High*	Monitor impact of climate change on dam security and look to financial risk management products to spread the risk (Adaptation Options: 17, 21).	**2**	Minor	**D**	Unlikely	*Low*
13	Changes in extreme precipitation lead to higher costs for maintaining dam operations / security.	**3**	Moderate	**B**	Likely	*High*	Monitor impact of climate change on dam security and look to financial risk management products to spread the risk (Adaptation Options: 17, 21).	**3**	Moderate	**C**	Moderate	*High*

Rank	Risk Description, Event and Consequence	Risk Severity Before Adaptation					Adaptation Actions	Risk Severity After Adaptation				
			Consequence		Likelihood	Risk Level Before Adaptation			Consequence		Likelihood	Risk Level After Adaptation
14	Changing temperature, ground conditions and extreme precipitation could increase contamination risks associated with oil and coal mining facilities, potentially leading to increased risk of contamination of local water course.	**3**	Moderate	**B**	Likely	*High*	Assess likely impact of climate change, plan contingency for any proposed / necessary intervention, (Adaptation Options: 48 to 51).	**3**	Moderate	**C**	Moderate	*High*
15	Reduced precipitation and increased temperatures can affect	**2**	Minor	**B**	Likely	*High*	Monitor river flows and emissions to ensure abstractions and discharge do not damage river and avoid negative impacts by considering impact of climate	**2**	Minor	**C**	Moderate	*Moderate*

Rank	Risk Description, Event and Consequence	Risk Severity Before Adaptation					Adaptation Actions	Risk Severity After Adaptation				
			Consequence		Likelihood	Risk Level Before Adaptation			Consequence		Likelihood	Risk Level After Adaptation
	environmental performance of river water-cooled TPP abstracting and discharging water into local water courses.						change in design of future assets (Adaptation Options: 33 and 36).					
16	Transmission and distribution losses increase due to summer temperature rise, resulting in higher effective demand and reduced energy security.	**1**	Insignificant	**A**	Almost Certain	*High*	Reduce existing technical losses (e.g., insulation of cables, undergrounding of critical cables, consider DC rather than AC for long lines), manage commercial losses (e.g., tariffs and metering), amend and implement design standards to take account of climate change for new / upgraded infrastructure (Adaptation Options: 3, 12, 14).	**1**	Insignificant	**C**	Moderate	*Low*

Rank	**Risk Description, Event and Consequence**	**Risk Severity Before Adaptation**					**Adaptation Actions**	**Risk Severity After Adaptation**				
			Consequence		**Likelihood**	**Risk Level Before Adaptation**			**Consequence**		**Likelihood**	**Risk Level After Adaptation**
17	Concerns about unmanaged climate risks cause Albania to be less attractive to foreign investors.	**3**	Moderate	**D**	Unlikely	*Moderate*	Further data collection and research on potential impacts of climate change in Albania; ensure regulations require climate change assessment to be implemented in design (Adaptation Options 4 to 9)	**2**	Minor	**D**	Unlikely	*Low*
18	Changes in extreme precipitation and wind lead to transmission disruption.	**2**	Minor	**C**	Moderate	*Moderate*	Further assess possible risks to the network, transfer risk to partners with expertise to manage the issues, develop contingency plans (Adaptation Options 41 to 46).	**2**	Minor	**D**	Unlikely	*Low*
19	Loss of productivity for thermal plants due to higher air and water temperatures and / or	**1**	Insignificant	**B**	Likely	*Moderate*	Collect and analyze data to identify issues, understand and manage existing risks, avoid risk to new assets by considering at design stage (Adaptation options: 32, 34, 36).	**1**	Insignificant	**C**	Moderate	*Low*

Rank	Risk Description, Event and Consequence	Risk Severity Before Adaptation					Adaptation Actions	Risk Severity After Adaptation				
			Consequence		Likelihood	Risk Level Before Adaptation			Consequence		Likelihood	Risk Level After Adaptation
	reduced ability to abstract and discharge cooling water.											
20	Increases in landslips due to heavy rains resulting from climate change could increase the risk of loss of integrity for gas pipelines.	**2**	Minor	**E**	Rare	*Low*	Monitor integrity of existing low pressure pipelines due to landslips after heavy downpours and review and upgrade design codes to ensure assets are climate-resilient (Adaptation Options: 49 and 50).	**2**	Minor	**E**	Rare	*Low*

5. COST–BENEFIT ANALYSIS OF ADAPTATION OPTIONS

5.1 OBJECTIVE OF THE COST–BENEFIT ANALYSIS

Based on discussions with stakeholders it was agreed that a high-level economic cost–benefit analysis would be an appropriate method of examining options to manage the risks and vulnerabilities to Albania's energy security in the face of climate change. Having subsequently considered the impacts of climate change on energy security further, and given that diversification of power generation assets was identified as a key adaptation option, stakeholders agreed that the objective for the cost–benefit analysis be refined to address the following question:

> "What is the optimal technology (power generation asset) to supply the shortfall in electricity that is directly caused by climate change?"

Implicit in the word *optimal* in this question is the delivery of sustainable development. Also implicit is the time period over which options should be considered. During discussions with stakeholders, it was suggested that a 30-year period should be considered, however this was later refined to 40 years (up to 2050) to tie in with climate modeling timeframes and a notable threshold date.

5.2 ASSESSMENT OF SHORTFALL IN FUTURE POWER GENERATION DUE TO CLIMATE CHANGE

To assess the range of energy generation technologies that could be used, it is first necessary to identify what shortfall in power generation may result from climate change in Albania. The calculations and projections below use as their starting point the most recent draft National Energy Strategy (NES, Government of Albania, 2007). The draft National Energy Strategy presents two scenarios, passive and active (described in Box 8 overleaf), and considers the medium-term period out to the year 2019. Since the present assessment has a longer time horizon than the draft NES, extending out to 2050, a number of assumptions have been made to build supply and demand projections beyond the timescales of the NES. These assumptions are detailed in Annex 8.

Step 1. Supply–Demand Projections Excluding Climate Change

In discussions undertaken during the workshops and subsequent meetings, stakeholders highlighted that it was important to assess the impacts of climate change over a long planning horizon; therefore, a time period from 2010 to 2050 was selected. But the draft NES for Albania only provides projections for power supply and demand for the medium-term, from 2003 to 2019.

Therefore, as part of this assessment, the projected power demand described in the draft NES was extrapolated beyond 2019 for each of the two demand-side scenarios that the draft NES presents:

- The passive scenario, which involves no energy demand control or energy efficiency measures)

- The active scenario, which includes implementation of energy efficiency measures such as residential property insulation standards and installation of domestic solar water heating

The extrapolation of demand projections beyond the timeframe of the draft NES was based on Albanian energy-expert opinion (Islami, 2009) and corresponds to annual growth rates in demand of 2.8 percent initially, declining to 2.1 percent by 2050, in the passive projections; and 2.2 percent declining to 1.8 percent in the active projections. These demand growth projections are illustrated in Figure 19 and are detailed in full in Annex 8.

From these demand projections, potential energy supply curves were generated that would meet demand. Electricity typically cannot be stored but, rather, is produced instantaneously; in that sense, supply and demand projections are the same line. Reconciliation is achieved as follows: detailed supply projections are based on known potential energy assets included within the draft NES, plus additional energy assets known to be under discussion within the Albanian energy sector, plus energy imports at the level that achieves demand–supply balance without load shedding (after 2013, when the draft NES predicts load shedding will cease). The use of imported energy represents the demand that cannot be addressed with domestic sources.

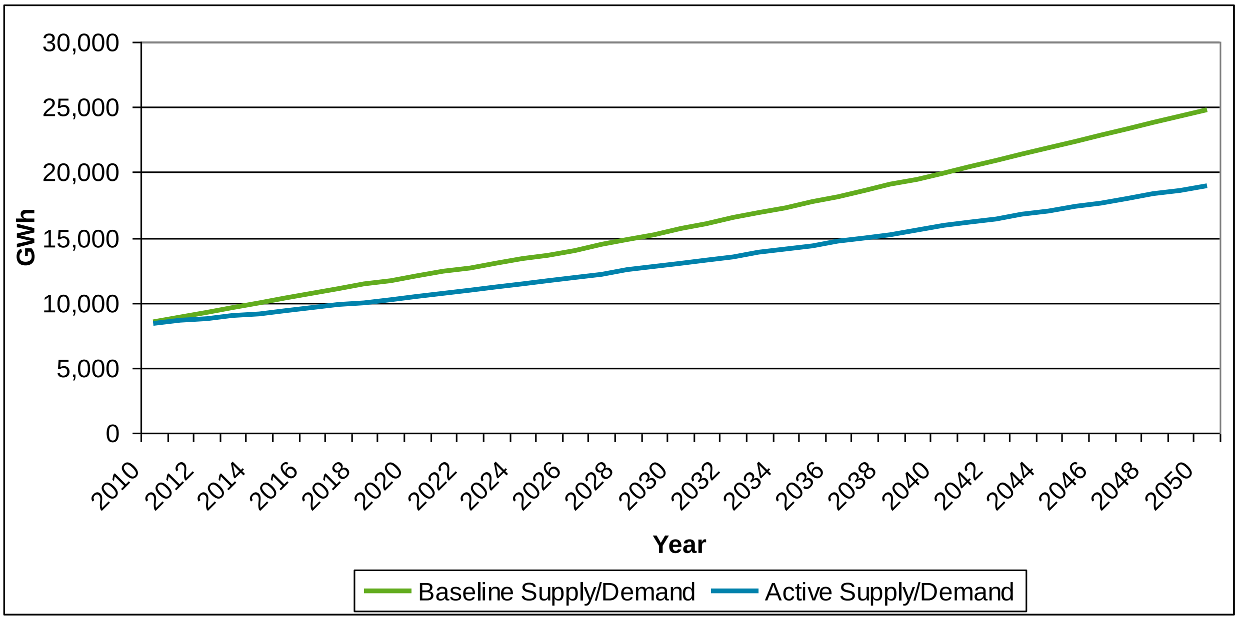

Figure 19: Projected electricity supply/demand for Albania from 2010 to 2050

Step 2. Superimposing the Impacts of Climate Change on Supply–Demand Projections

Based on the climate change risks identified for Albania (see Section 3, Annex 8 and Annex 9), the active-scenario projections of supply and demand were modified. Section 3 highlighted the anticipated impacts of climate change:

- Demand side:
  - Summer cooling of residential and commercial properties will increase due to rising summer temperatures.
  - Winter heating of residential and commercial properties will decrease as winter temperatures rise.

- Based on analysis of the above effects and combining these two phenomena results in an estimated net effect of a reduction in annual demand of approximately 0.1 percent per year. It is noted that this annual decrease may disguise a more significant impact on energy security due to changing seasonal demand, with the summer peak demand increasing and potentially becoming a greater controlling factor than current winter peak demand (see Section 5.7 for more information on seasonality of impacts).

Box 8: Active and passive scenarios in the draft National Energy Strategy, 2007

The draft National Energy Strategy uses two future scenarios (passive and active) to project Albania's electricity supply and demand up until 2019. Both projections are based on economic growth in Albania of +5 percent GDP per year.

The passive-scenario projection assumes the preservation and development of the present situation in terms of supply and demand for energy in all sectors of the local economy. It projects continuation of electrical power consumption as the dominating source of energy for space heating and water heating in the households and services sector. This projection assumes that a considerable part of the future demand for electrical power shall be covered by extension of the thermal generating capacities (based on marine petroleum, solar, fuel oil, and imported natural gas) and hydropower energy.

The active-scenario projection assumes efforts to address the supply–demand imbalance that is expected to arise under a passive scenario. It assumes the following objectives:

- Improving supply security
- Improving energy efficiency
- Diversification of energy resources
- Use of renewable resources
- Real pricing of electrical power
- Implementation of the regional electricity market
- Environment protection

The active-scenario projection assumes a focus on improving energy efficiency through:

- Greater use of domestic solar water heating
- Improved building standards (insulation, windows etc.)
- Lower energy appliances
- Alternative heating sources other than use of electricity

Although the active scenario envisions efforts intended to address current energy security concerns, many of the actions included in the active scenario would also help to build resilience to the impacts of climate change. The projections made underthe active scenario are dependent on the successful implementation of the measures outlined above, which will be challenging. For the elements of the cost–benefit analysis involving the active-scenario projections, it has been assumed that these measures are implemented as described in the draft NES.

- Supply side:
  - Reduce annual precipitation and increases in temperature, leading to lower runoff and less hydropower generation. As outlined in Section 3, the impact of climate change on large hydropower plants is estimated as reduction of their generation by 15 percent by 2050. For small hydropower plans, the reduction is estimated as 20 percent by 2050.

    - Reduce efficiency of thermal power plants and also transmission and distribution networks. The efficiency reduction has been estimated as 1 percent for TPPs by 2050, associated with rising temperatures. This estimate does not take into account any impact on efficiency of thermal power plant operations due to environmental management associated with cooling water discharge. Vlore TPP will be cooled using seawater, and it is considered unlikely that its operations would need to change for discharge to the marine environment. (However, if Albania develops river- or lake-cooled TPPs in the future, these risks could be significant.) Losses from transmission and distribution networks are also estimated as 1 percent by 2050.
    - The projected reduction in cloudiness would mean that the output of solar power plants would increase in the future. As outlined in Section 3, it is estimated that an increase of 5 percent would occur by 2050.

The resulting predicted net reductions in supply (shortfall in power generation) due to climate change are on the order of 580 to 740 GWhrs/annum (2 percent to 3 percent of total power demand) by 2050, based on the extrapolated passive- and active-scenario projections respectively. Interestingly, the shortfall caused by climate change in the active-scenario projection is greater than that in the passive-scenario projection. This is because the active-scenario projection assumes greater demand-side efficiency measures, less reliance on GHG-emitting thermal plants, and a greater share of generation burden placed on hydropower plants, which are more affected by climate change than other sources of electricity. However, an aspect that should not be overlooked is the fact that many of the actions proposed as part of the active scenario represent adaptation options: energy efficiency measures, diversification of assets, and regulatory reform. Ensuring implementation of these measures would be an important part of a strategy for Albania to manage climate-related risks and vulnerabilities to the energy sector. As climate change impacts take effect in Albania, these “adaptive-active” scenario options will have increasing value. However, the benefits evident in the active-scenario projection are predicated on successful implementation of energy efficiency measures, asset diversification, and other measures mentioned in the draft NES.

As can be seen in Figure 20, the active- and passive-scenario projections track together over the time period considered, with the energy shortage due to climate change slightly higher in the active scenario than that in the passive scenario. As already mentioned, the draft National Energy Strategy projections end at 2019. From 2020 onward, the shortage is projected using a different methodology and a number of technologies are assumed either to come online or increase output. This is the reason for the inflection in the active scenario line at 2020. (See Annex 7 for further details.)

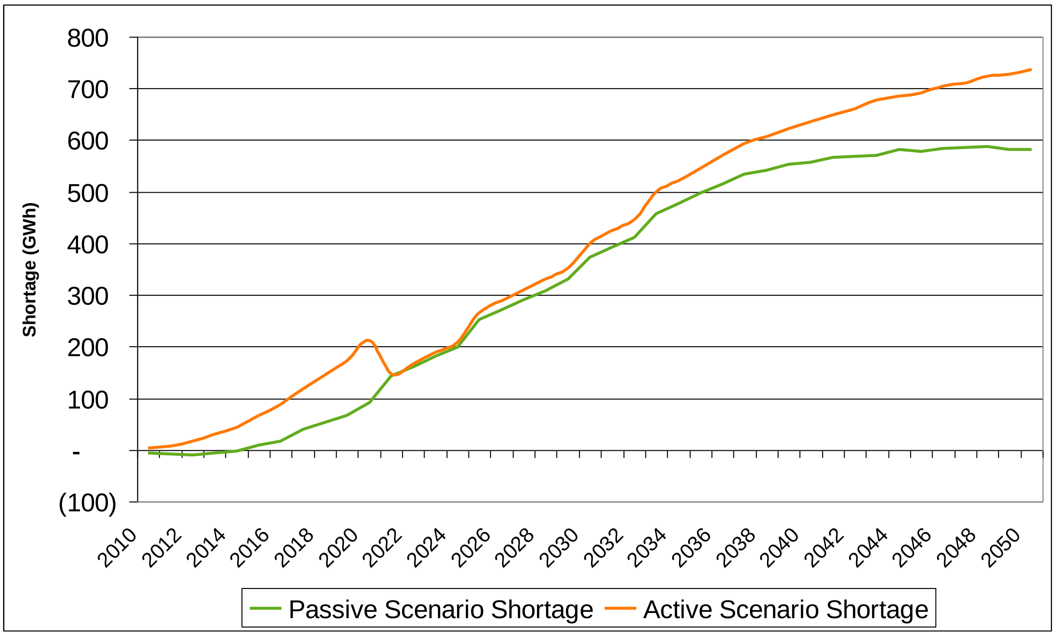

Figure 20: Electricity shortage due to climate change

Superimposing the impacts of climate change on the annual supply–demand projections reflects only part of the potential threat that Albania's energy sector faces from climate change. There is a question regarding how the energy system will work during critical periods (very hot or dry periods) and whether more-significant impacts may emerge under some circumstances that are beyond the annual-average shortfall projected in Figure 20. For example, the shortfall projected does not take account of the limited capacity for storage of water in reservoirs that serve LHPP assets. If, due to climate change, runoff that fills the reservoirs comes in shorter, more-extreme periods of wet weather that requires water to be spilled, followed by long dry periods and shortage of water, the power generation from LHPPs could be less than projected above. This issue is discussed further in Section 5.7. A recent study in Brazil indicated that where power production was calculated based on projected annual-average rainfall/runoff data, climate change would result in a 3 percent drop in power generation. When the same analysis was conducted using more detailed seasonal data, it was projected that the drop in firm power production could be as much as 30 percent (Schaeffer *et al.*, 2009). At this stage, there are insufficient hydrometeorological and climatological data available for Albania to enable an estimate of future subannual rainfall and power-generation relationships. However, this could be researched further by policy makers and technical managers.

5.3 OPTIONS TO MEET THE PROJECTED POWER SHORTFALL DUE TO CLIMATE CHANGE IMPACTS

Having identified potential future shortfall in electricity supply due to climate change, and noting that some measures that contribute to building climate resilience are already contained within the active-scenario projection, this assessment looks at the costs and benefits of options for diversification of Albania's electricity supply.

Before discussing these options, it is worth noting briefly the significant benefits of improving energy efficiency. The Asian Development Bank estimates that if 1 million incandescent light bulbs were replaced with compact fluorescent lamps (CFLs) at a cost of about $1.5 million, electricity demand would be reduced by about 50 MW. It estimates that the cost of building a new 50 MW power station would be at least $50 million, and that operating costs would add another $2 million to $3 million per year. This demonstrates how cost-effective energy efficiency measures can be, and further strengthens the argument for ensuring that the energy efficiency measures in the draft NES are implemented.

For the cost–benefit analysis, eight reasonable and practicable technology-based options (asset types) for filling the electricity shortfall were identified during the workshops. These selected options are described in order of increasing estimated capital cost. Assumptions relating to the parameters that were used to assess each option in the CBA are also outlined:

1. **Import.** The import of electricity from neighboring countries is considered to be a realistic potential option. There is a premium associated with the cost of this power and prices fluctuate on a daily basis. To assess the environmental and social effects associated with this option in the CBA, only those global impacts that could potentially affect Albania were considered. Water usage and emissions for this option were considered to be the same as for the combined cycle gas turbine option. Impacts on ecosystems and disturbances to people and property were not considered, as it was assumed that the regulatory authority in the generating country has already taken these into account. It has been assumed that all imported electricity is produced using combined cycle gas turbine (CCGT) technology, although it is recognized that a range of electricity generation technologies are used in South Eastern Europe (see Box 2, Section 2.1), including nuclear power, hydropower, other renewables, and GHG-emitting thermal plants fueled by coal.
2. **Use combined cycle gas turbine (CCGT) technology.** A new-build CCGT-based power plant would use natural gas, which is cleaner than coal but has several disadvantages, such as dependence on foreign sources of fuel and relatively high GHG emissions in comparison with renewable technologies such as hydropower. Supercritical pulverized coal technology was not considered in detail in the CBA, but if supercritical pulverized coal technology were used instead of a gas-fired CCGT, it would have different environmental costs: it has approximately 200 percent of the water usage and 220 percent of the GHG emissions of CCGT. CCGT is clearly the more sustainable thermal option in spite of costing approximately 10 percent more than coal on a levelized basis.
3. **Improve/update existing large hydropower plants (LHPPs).** There is some capacity for improvement in existing large hydropower assets, including actions such as optimizing data collection and usage, reservoir/dam maintenance and reservoir management.
4. **Improve/update existing small hydropower plants (SHPPs).** Many of the small hydropower assets in Albania are old, and technology and design have improved considerably since they were installed. In many cases, improvements such as optimizing turbine operation with respect to varying river flow regimes, widening intake and outfall channels, resizing turbines/plant, and improving connections to the transmission network are possible.
5. **Install new small hydropower plants (SHPPs).** There are a number of unexploited sites where new run-of-river hydropower plants could be sited. These smaller plants generally serve smaller communities and could be connected to local distribution networks as well as the national transmission grid.
6. **Develop wind power.** At this stage, there is no wind-power electricity generation in Albania, although, as outlined in Section 2, a number of potential projects are currently under consideration in Albania’s coastal areas.

7. **Use concentrated solar power.** Concentrated solar power (CSP) captures solar energy through a large array of mirrors, directing light toward a brine solution or other thermal receptor that converts the solar energy into electricity. There are currently no CSP plants in Albania. However, there are several located in the Mediterranean region in areas with similar solar characteristics to those of Albania.
8. **Install new large hydropower plant (LHPP).** This option represents the building of a completely new dam and reservoir to exploit the remaining generation potential in Albania's hydrological system.

In undertaking the CBA, potential constraints on the implementation of technologies have been considered:

- It is considered that, subject to approval, there are no physical constraints on the number of thermal power plants that could be installed.
- With respect to wind power, there are insufficient data at present on wind speeds in Albania at turbine operating heights. However, it is assumed that there is adequate wind potential for the purposes of the CBA.
- In the case of CSP, technology is developing in this area and a number of stakeholders felt that this technology might become more feasible in the future, perhaps by 2040 and beyond. Aspects considered in relation to current use of CSP were:
    - I. The technology is relatively new.
    - II. The capital costs are higher compared to other technologies.
    - III. There is not enough operating experience accrued worldwide to provide real data for operating and maintenance costs.
    - IV. It involves higher technological, schedule and financial risks.

  It is expected that by 2040 the capital costs for CSP would be comparable with other technologies and sufficient experience worldwide would be developed that would reduce the current risks associated with CSP. For the purposes of the CBA, best estimates of technology costs (CAPEX and OPEX) have been used in the analysis, though it is recognized these may be reduced if/when the technology advances.
- With respect to hydropower, much more data are available. METE stated during meetings that the current estimate of Albania's hydropower generation capacity is 3,200MW total for LHPP and SHPP (Tugu, 2009). Of this, there is currently 1,445MW of LHPP and 15MW SHPP installed capacity. The future supply projections developed in this assessment are based on development of a further 1,150MW LHPP and 390MW SHPP, thus giving a total installed capacity of 3,000MW by 2050. These values are estimated before the impact of climate change has been taken into account, which it is predicted would reduce hydropower potential in Albania. Therefore, there may be a significant physical constraint on further potential capacity for hydropower generation, beyond those facilities already included in the future projections. However, given the uncertainty surrounding total potential for hydropower generation in Albania, and that estimates may be substantially modified if additional basin hydrometeorological data and modeling were available, further development of both LHPPs and SHPPs have been considered for the purposes of the CBA.

Importantly, to compare the costs and benefits of all the different assets on a like-for-like basis, a quantity of power was chosen, 350 GWh, which could meet the estimated climate change-induced shortage for 20 years. All of the generation capacity is not required at once, but rather the need increases over the assessment period. Some assets would probably not be able to fill the entire gap from beginning to end. Additionally, the assets under study have different expected periods of service. Twenty years represents a period of time for which energy needs could be met by the technologies under consideration. For the second 20 years to 2050 (the timescale under consideration for climate change risks in this assessment), the additional generation needs could be reexamined. This analysis thus considers what could be done in the immediate future, providing guidance as to what may be good options.

It is important to note that the use of a normalized quantum of a particular asset that could provide 350 GWh per year is hypothetical and a simplification, in the sense that installing this amount of capacity may be unrealistic in most cases. For instance, economies of scale dictate that a 50 MW thermal plant (which would provide about 350 GWh) would generally be less feasible on a financial basis than a larger unit. Furthermore, to complete a high-level CBA, it has been necessary to make broad assumptions about the specific locations where future assets may be sited and also of the various options, their costs, and their impacts on society and the environment. In addition, it should be noted that the options would themselves be susceptible to climate change. The most notable impacts would be on the SHPP and LHPP options, as these are most sensitive to climate change (see Sections 3.3 and 3.2), though the efficiency of TPP is also slightly reduced as temperatures rise (see Section 3.4). In contrast, there may be benefits for future solar power production due to reduced cloud cover in summer in the future (see Section 2.2). Since the available cost and benefit data are relatively high-level, further analysis of these impacts on the options is not included in the scope of the CBA. Thus, the options considered in this assessment are generic and indicative rather than definitive. However, it is considered useful and informative to undertake a high-level CBA for these technologies, to provide an indication of what the key issues are, and to identify where further data could be used to reduce uncertainty or confirm a chosen course of action.

The eight power technology options were evaluated on the basis of eight parameters that were determined based on the outcome of workshops and discussions with stakeholders. Parameters were chosen that reflect sustainable-development performance aspects—that is, financial, social, and environmental aspects of the different options. The parameters selected are detailed next.

5.4 BENEFIT CATEGORIES/PARAMETERS USED IN THE COST–BENEFIT ANALYSIS

In a complete economic analysis, the benefits of a given course of action are compared to the cost. Actions that result in a net overall positive benefit to society as a whole are deemed *economic* and sustainable.

The approach for this analysis is to attempt to capture the maximum likely benefits and dis-benefits (i.e., costs) that would accrue to both the power producers (private benefits/dis-benefits) and to society (external benefits/dis-benefits), for each of the various alternatives being assessed. To do this, a conservative approach (from the economic point of view) has been adopted, with each external (societal) monetizable benefit valued using a method that would tend to overstate (rather than understate) the benefits. In addition, a qualitative examination of some likely nonmonetizable benefits is also included. Thus, in the CBA, likely costs are compared with conservatively high benefits, or disbenefits, as the case may be. In adopting this approach, the report is biasing the economic analysis toward the societal position. This is advantageous because it assures that the external perspective is fully considered and valued, and helps to deflect any possible criticism that the analysis favours the proponent.

The parameters/potential benefits considered are summarized next and described in more detail in Annex 5.

Financial Parameters

Financial parameters reflect a number of key issues identified at the workshops. An obvious issue is the cost per unit of electricity produced. Although social and environmental aspects are also important, the cost of producing electricity plays heavily on the viability of a given asset type. Loss of production is also reflected in the financial parameters, specifically revenue from electricity sold. The possibility that an asset type may not be able to fill the electricity shortage is included in the model by virtue that it would have lower associated electricity revenue.

1. **Capital Expenditure.** Capital expenditure is the financial expense required during the construction of the plant. It represents investment in the fixed assets that are used to generate electricity. The value of land is also included in capital expenditure figures.
2. **Operating Expenditure.** Once the plant has been built, ongoing expenditure is required to keep the plant operating. These costs comprise spares, maintenance, fuel, and other ongoing costs required to keep the plant operating. Operating expenses vary depending on asset type and depend on factors such as the location of the asset (more isolated assets are more expensive to supply) and the age of the technology (newer technologies are often more expensive to maintain).
3. **Electricity Revenue.** The revenue received through the sale of produced electricity represents both the value of the production of the electricity and its contribution to macroeconomic activity. Electricity revenue is based on the stated market price of 8.23 Lek per kWh (USD 0.085 per kWh) (Tugu, 200). This parameter also represents a portion of the benefits to the economy through a contribution to GDP.

Environmental Parameters

In the workshops environmental parameters were also identified as high priority issues to be taken into account when deciding which type of power assets to build. Greenhouse gases, other emissions, water and ecosystems were included as parameters in the CBA. In addition to determining a base case monetary value for these parameters, a potentially realistic maximum (high case) monetary value for these parameters was also determined, as shown in Table 6.

1. **Value of water.** Water in many forms (as a resource, in precipitation, in storms) is a key factor in the risks associated with climate change. In Albania especially, where a large proportion of electricity generation is based on water flows, it is important to account for water usage and availability when looking at the different generation options. In this economic CBA, the base value of water was based on the rate charged to an enterprise consumer in Albania, 90 Lek per m^3 (USD 0.93 per m^3). This price is based on information from Tirana Municipality (2006). It is noted that, other than for concession costs for new small hydropower plants, hydropower generators do not currently have to pay for water that they use. However, inclusion of this value in the analysis takes account of the fact that there may be cost in the future, as water becomes more highly valued by society.
2. **Carbon dioxide and other greenhouse gases (GHGs).** CO_2 is the well-known greenhouse gas that is traded in markets around the world. The base value used in this analysis was based

on the European Trading Scheme market spot price, €15.80 per tonne (USD 21.55 per tonne) (11 May 2009). Other studies, such as the Stern Review (Stern, 2006), use detailed models to project the cumulative economic impact of additional units of GHG, called the social cost of carbon (SCC), estimated at approximately USD 75 per tonne $CO_{2\text{-}e}$. This value was used in the evaluation of the high case (see Table 6). Other emissions that were considered were particulate emissions and NO_x. After research, none of the generation asset types were determined to have significant emissions of particulate matter, so it was not monetized or explicitly included in the model. There are limited emissions of NO_x from the CCGT plant option, and these emissions were valued at USD 62 per tonne based on the U.S. EPA auction of NO_x emissions permits. Due to the limited scope of the study, some GHG emissions were not included. The GHG emissions caused by the decomposition of organic matter during the creation of a reservoir for a large hydropower plant and emissions during transportation of materials for construction of the various generation assets are two examples.

3. **Value of ecosystems (loss of ecological services).** Building a power plant on a greenfield site destroys or converts ecosystems to other uses. For the CBA, it was assumed that hydropower plants were built in mountainous ecosystems and all other asset types were constructed in coastal ecosystems. Based on published studies, the ecosystem services for the mountains were valued at USD 30 per hectare (UNEP, 2001) and coastal ecosystems were valued at USD 117 per hectare (Department of Natural Resources, 2004). The analysis included loss of ecological resources, specifically the loss of mountainous or coastal ecosystems, due to clearing associated with activities directly related to the power generation options being considered.

Social Parameters

The economic CBA takes into account an aspect of social concerns through a parameter that describes the overall disturbance to people and property caused by new constructions. There were several other social aspects identified as important in the workshops that could not be generalized and therefore were not included within the scope of this high level analysis; examples are impacts on tourism, recreational benefits of some asset types (e.g., reservoirs) and political implications of constructing a new power asset in a region or area where public dissatisfaction is high.

1. **Disturbance of people and property.** This aspect has been valued using an approach that has been previously widely used for assessing the disturbance from wind farms (Ladenberg, 2001). This value was pro-rated for the other asset types based on the population density of the area and the footprint of the asset at hand. It is clear that there are other disturbances, such as recreational benefits, and importantly for Albania, impacts on tourism. This is an area for further study when more information about specific proposals is available. Other important aspects are mentioned below.
2. **Discount rate.** In economics, it is common to assume that having something now is worth more than getting it in the future. This is the basis for interest on bank accounts. To account for the fact that expenditure today precludes other uses of the money, a discount is applied to future cash flows. The amount of this discount rate has an effect on the present value of future cash flows. In this assessment, a base discount rate of 4.5 percent has been used. This discount rate has been adopted as the base value following discussion with the World Bank's energy economist in Albania. The value is higher than the social discount rate used in other developed European economies (e.g., the United Kingdom uses 3.5 percent) and reflects the higher potential growth rates that a developing economy, such as Albania's, may experience.

The choice of discount rate can be contentious, especially in the context of environmental and social benefits that occur many years in the future. Whereas environmental benefits for future generations may not be considered as less valuable than the same benefits for the current generation, in the context of purely financial investments, such as savings accounts, benefits now are much more highly valued than later benefits. This causes a divide between the discount rate used for public projects and the private discount rate used by investors when making investment choices. The power sector necessarily combines a number of stakeholders with interests in both the private financial and the public social/environmental performance of investments. A project that is attractive from a purely private financial point of view may not be interesting from a public point of view (or vice versa). Therefore, for this assessment the impact of discount rate on the outcome of the CBA is explored through sensitivity analysis, to understand the effects that discount rate assumptions may have on the relative performance of different options.

Important Aspects for Further Study

As many parameters as feasible have been included within the scope of the high-level CBA assessment. However, it is important to note that there are several important aspects that either could not be included or were not included to the full extent possible in principle.

Water, by nature of its multiple forms and uses, is a particularly complicated aspect to consider in policy decision making. In future studies, the alternative possible uses of water (e.g., irrigation) should be considered. There are also nonuse and ecological values to consider. Not every use of water accrues all of these values. For instance, using water to cool a turbine through evaporation precludes its use for irrigation, whereas water that has passed through a hydropower turbine may still be available of downstream irrigation.

Each asset type will have a different impact on the surrounding ecosystems. Furthermore, different locations will have different types of ecosystems of different values. Outside a highly-general study, greater ecosystem impact information is required to consider properly the full costs and benefits of various options.

Broader economic impacts are also important. Again, across various assets, the exact impact that constructing a given facility will have on gross domestic product and employment will depend on the number of people that particular facility takes to operate, the type of training required and the legal structure of the operating company. Although these effects could only be superficially covered in this assessment, they are suited for inclusion in a more detailed and specific future study.

Vulnerability to natural disasters and increased climatic vulnerabilities is another parameter that was identified as important at the workshops, but has only been incorporated in the CBA through sensitivity testing (see Section 5.6). Further study could expose potentially-critical hidden vulnerabilities that would need to be incorporated into policy decisions.

A summary of the base case and high case parameter values used in the CBA is presented in Table 6.

Table 6: Base Case and High Case Parameter Value Assumptions

Benefit Category	**Units**	**Base (USD)**	**High (USD)**
Value of water	m^3	0.93	3.00
Carbon dioxide and other GHG emissions	Tonne	21.55	75.00
NO_x emissions	Tonne	62.00	80
Value of ecosystem (mountain)	/ha/yr	30	200
Value of ecosystem (coastal)	/ha/yr	117	200
Disturbance of people and property	/hh/km^2/yr	1.82	5.00

5.5 RESULTS OF THE COST–BENEFIT ANALYSIS

Given the financial, environmental and social base values discussed in the previous section, the results of the CBA for the base values only are presented below. The charts (Figures 21 and 22) provide the net present value (NPV) results in current (2010) U.S. dollar terms for each of the technology options under consideration.

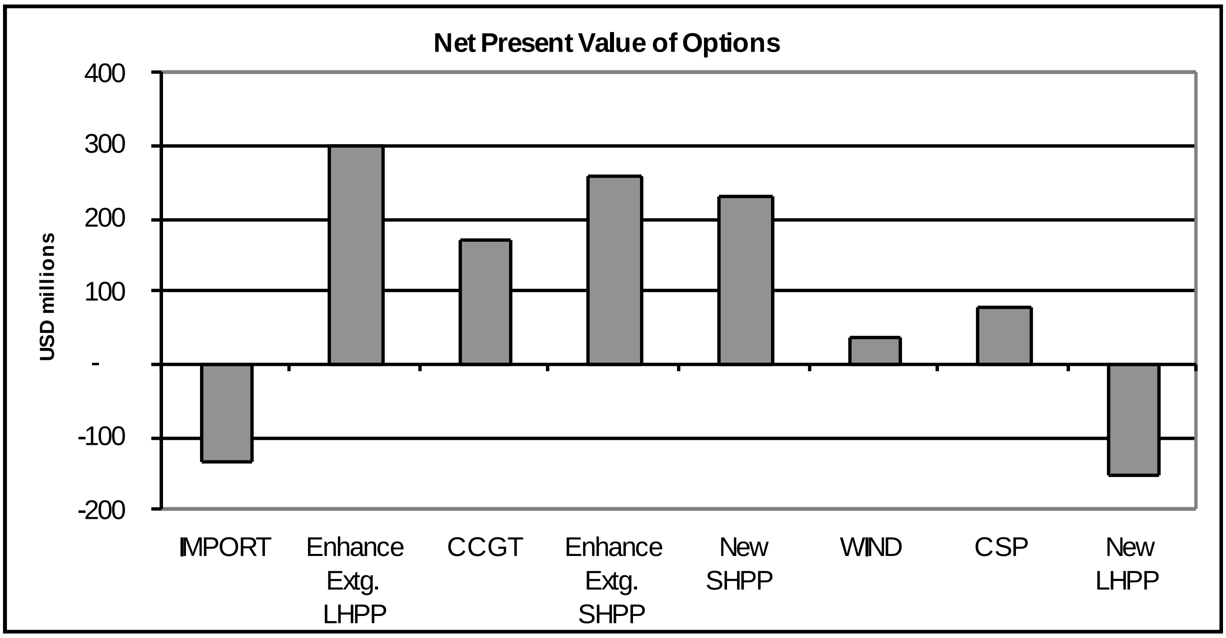

Figure 21: NPV using base case assumptions

Figure 22 illustrates the NPV results broken down by each internal and external parameter value.

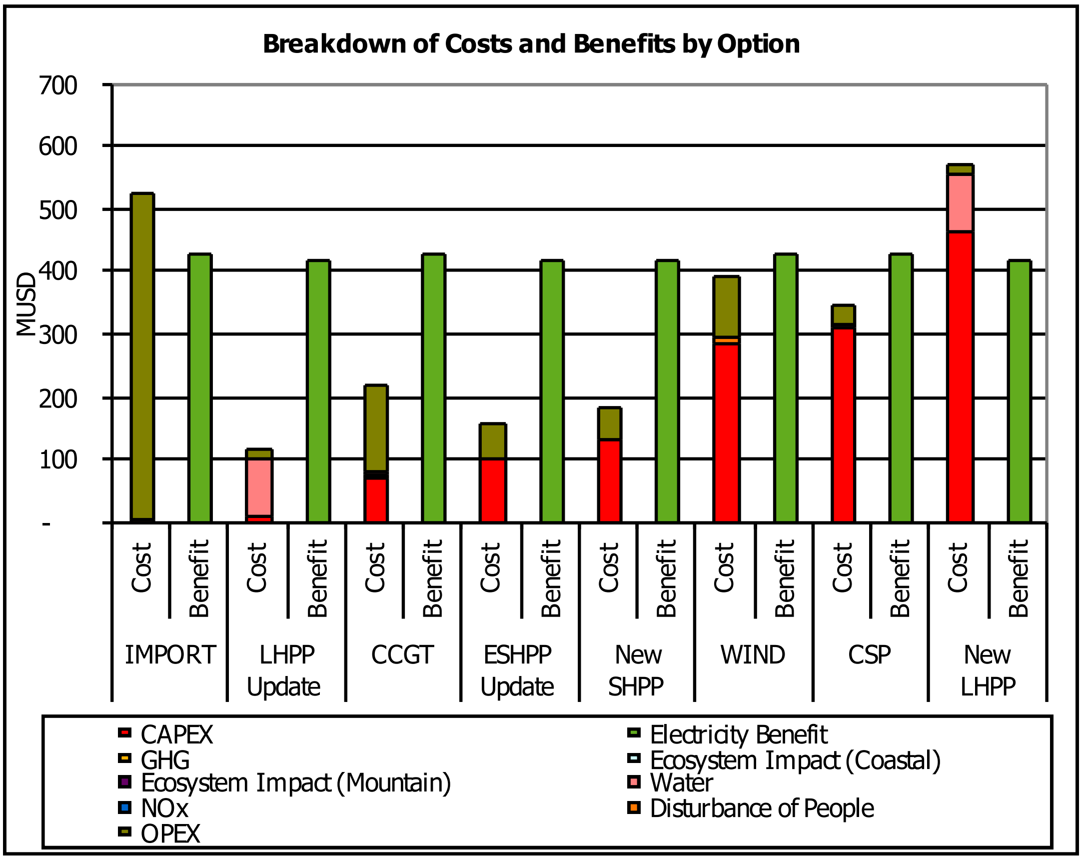

Figure 22: Breakdown of NPV of options by parameter

The options are sorted from greatest to least capital expenditure, going from left to right. In general, options with an NPV less than zero are not considered economic/sustainable. Options with an NPV greater than zero are economic/sustainable. The higher the NPV the more sustainable is the option. The three most-sustainable options identified are as follows:

1. Enhancements to existing large hydropower assets
2. Enhancements to existing small hydropower assets
3. The building of new small hydropower plants

Within the scope of this CBA, two options appear unsustainable within the context (i.e., to fill the future shortfall in electricity supply due to the impacts of climate change) and boundaries of this assessment, namely: building new large hydropower plants, and importing power. However, in this particular analysis the relative ranking of the options is more important than the specific NPV of any particular option. Due to the high-level nature of this analysis, other possible benefits that may be very relevant when considering a specific project have not been considered. In a detailed analysis phase, careful consideration of all possible benefits may well mean that the two unsustainable options may, in fact, be sustainable in certain contexts. This is especially important to note in the case of "New LHPP." Although in the context of this analysis the net present value is below the breakeven point (zero), this should not imply that the options should never be undertaken. Nevertheless, these results provide useful information by way of illustrating a high-level comparison of the options.

The breakdown chart in Figure 22 shows that by far the biggest costs are capital expenditure (CAPEX) and operating expenditure (OPEX). This is unsurprising, as most of the options are based on renewable fuels, which have fewer external costs than traditional generation asset types such as coal-fired power plants. The nonrenewable option, CCGT, is a low-carbon source of energy and thus also has limited environmental impact.

Importing electricity has the biggest operating expenditure, because the electricity is purchased from the regional grid, and thus, the price reflects recapture of foreign capital expenditures, operating expenditures, and the profits of the other generating assets. However, this should not be taken as evidence that imports do not play an important role in Albania's energy mix. This assessment is concentrating only on the shortage due to climate change, which is one piece of a larger energy context. Imports are sometimes necessary to fill short-term shortages and avoid load shedding. Furthermore, this analysis was based on a one-time snapshot of market prices, where import cost is higher than domestic sales revenue in Albania. In reality, there are a number of measures that could help manage the cost of imports. Financial tools such as options or long-term contracts could hedge against price movements and keep imports viable for appropriate uses. However, the results of this analysis suggest that for the gap caused by climate change, another source of electricity may be preferable.

As mentioned in Section 5.3, supercritical pulverized coal technology was not considered in detail in the CBA. A cursory analysis based on general knowledge of the relationship between the cost, GHG emissions, and water usage of supercritical coal and CCGT technologies indicates that although coal technology is less sustainable than CCGT, it ranks relatively the same amongst all the other options. That is, it would likely be the fourth most sustainable option behind the three options just identified.

5.6 SENSITIVITY ANALYSIS

Any CBA analysis of this type is inherently subject to uncertainty. Cost estimates provided are to ±30 percent accuracy, and the valuation and estimation of benefits is subject to even larger changes, as discussed in Annex 5. However, the aim of the analysis is not to reveal "absolutes" in terms of dollars, but better and worse decisions overall, when comparing the range of possible decisions that could be made.

From this perspective, sensitivity analysis is important because it allows the overall conclusions of the analysis to be tested across a wide range of parameter inputs. If a decision is favourable or economic over a wide range of parameter inputs, compared to other possible decisions, then despite the overall uncertainty in the actual dollar figures, the decision can safely be identified as superior to the alternative options. This is particularly useful when considering the sustainability of options. By definition, sustainability is concerned with the future, which is inherently uncertain. By varying key input parameters over a wide but reasonable range, the implications of a range of possible futures can be examined.

The overall sensitivities are presented in the *tornado* chart in Figure 23. The sensitivities are normalized so the most sensitive option/parameter combination is 1.0 and less-sensitive options/parameter combinations have shorter lines, with values less than 1.0.

The parameter to which every option is sensitive is the electricity benefit, which is the value to the producer and society for use of electricity. GHG and water value is significant for large hydropower options, and GHG emission costs are significant for CCGT and import options.

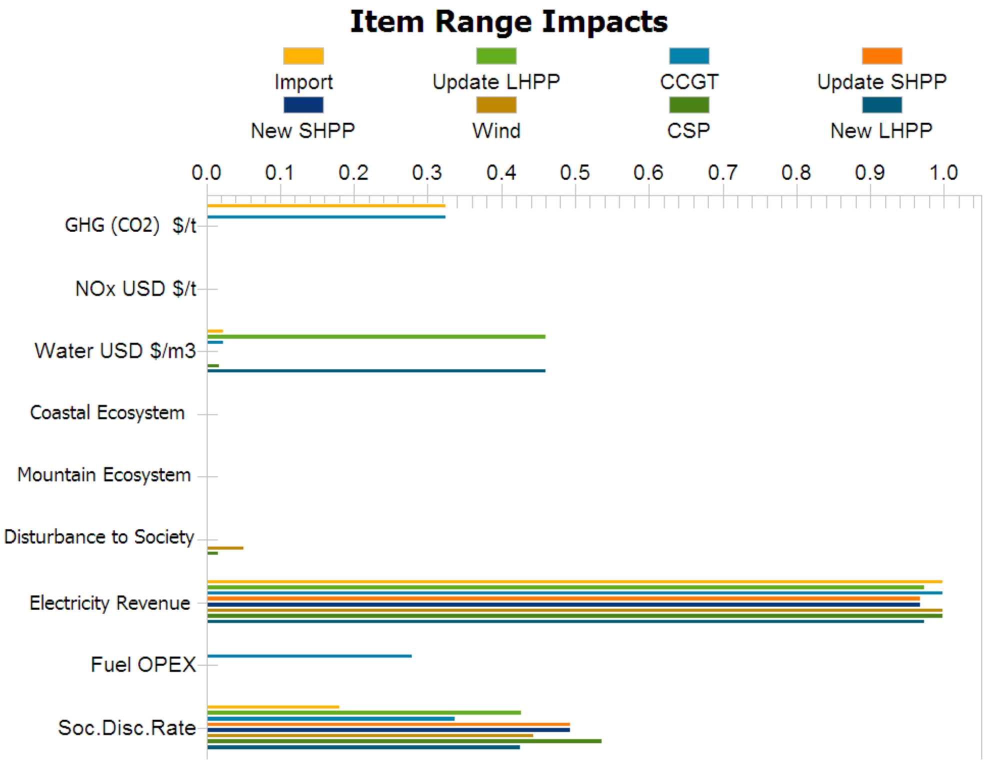

Figure 23: Tornado chart showing sensitivity of NPV for each option to variations in the values of each parameter

One possible parameter case, using the high-case values summarized in Table 6, is presented in Figures 24 and 25. In this case, the values of water, carbon dioxide and other GHGs, and fuel for the CCGT are increased to represent a high scenario under the effects of climate change.

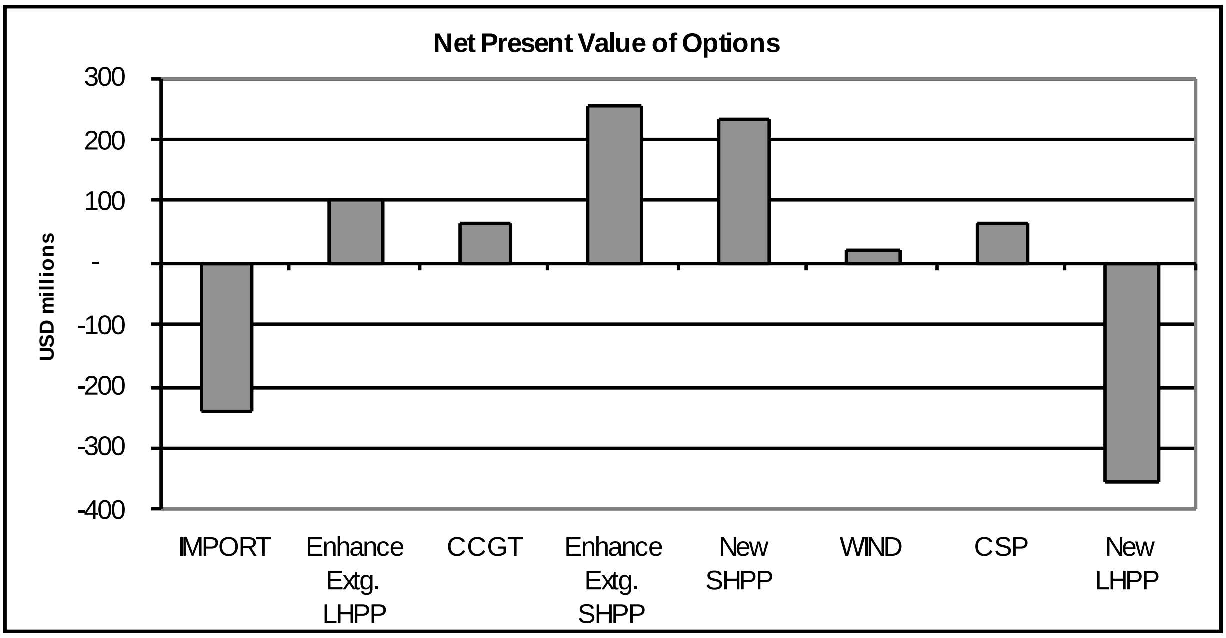

Figure 24: Net present value of options under high parameter assumptions

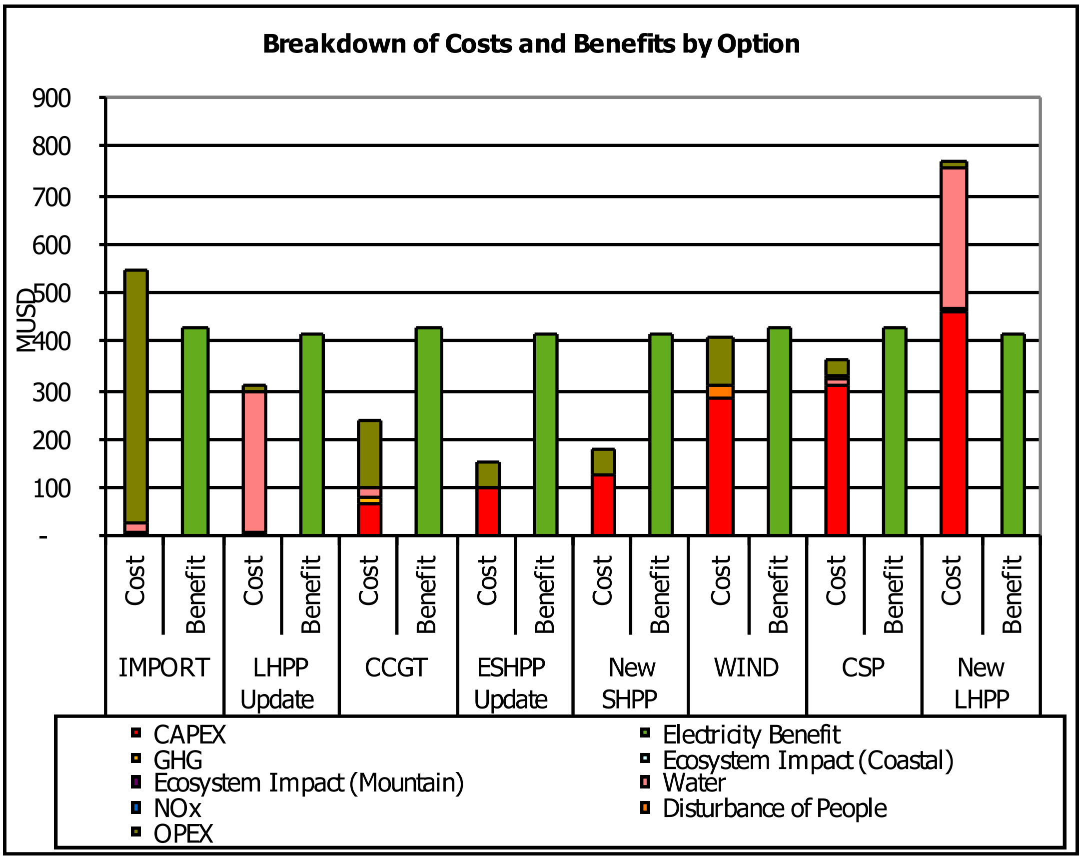

Figure 25: Breakdown of costs and benefits, high parameter case

The value of water primarily affects the large hydropower assets. Dams increase the surface area by which water can evaporate, causing water losses. With a higher value of water, the water usage of the large hydropower assets becomes a greater issue to society as a whole, and therefore this option becomes less attractive.

Increase in the value of CO_2 and other GHGs and fuel for the CCGT creates a marked decrease in the viability of the CCGT option. Increasing the value for CO_2, fuel costs, and water is akin to making the assumption that these commodities are going to be increasingly valuable in the future under climate change. It should be noted that although Albania is not yet subject to a carbon trading system such as that adopted in the European Union (EU), it is important that the pricing of carbon is taken into account now, as Albania aims for inclusion in the EU, so in the future explicit GHG emission levies may apply. The reaction of the CCGT option in this analysis to this change in parameter values suggests that further study is warranted when considering CCGT.

In this high-parameter case, small hydropower and updating existing hydropower are still viable options, and solar power begins to show relative advantages as well. These renewable options are not as vulnerable to fluctuations in fuel costs, increases in the value of CO_2 and other GHGs, or increases in the value of water.

Another set of parameters was designed to explore the effect that increasing frequency of extreme events may have on the availability of electricity from various sources. The primary source of risk is the vulnerability of power transmission assets to wind and lightning strikes. Although transmission lines are generally designed to withstand storms, repairing lines that are more remote is more difficult, meaning that assets that require longer transmission distances, such as hydropower and import, are more vulnerable. To set up this scenario, a penalty was placed on long-distance transmission assets—that is, all hydropower assets and the import option. For the base value, it was assumed that in the second 20 years of the analysis, these assets are unable to supply the needed power for one week per year, due to extreme events. By adjusting this factor up and down, the significance of this effect on the relative ranking of the options is revealed. The results of this extreme event scenario are illustrated in Figure 26.

It can be seen that the effects on the ranking of options are relatively minor, in spite of the effect having an approximately USD$8 million penalty. This indicates that in spite of the increased risk, the other parameters are more important to the relative ranking. It is important to note that this is based on the assumptions made, and that further study may reveal cases where transmission vulnerability may be an important consideration.

A more-significant effect was investigated; i.e., long transmission assets being put out of service for a month per year. Depending on the availability of resources in Albania and the remoteness of the terrain, this effect is a possibility. Figure 27 shows the results of one month of shortage for long transmission assets for every year of the final 10 years of the assessment period. However, interestingly, even when the long transmission assets are further penalized and are taken out of service for a month every year, the effect is not enough to change the conclusions of this high-level CBA analysis.

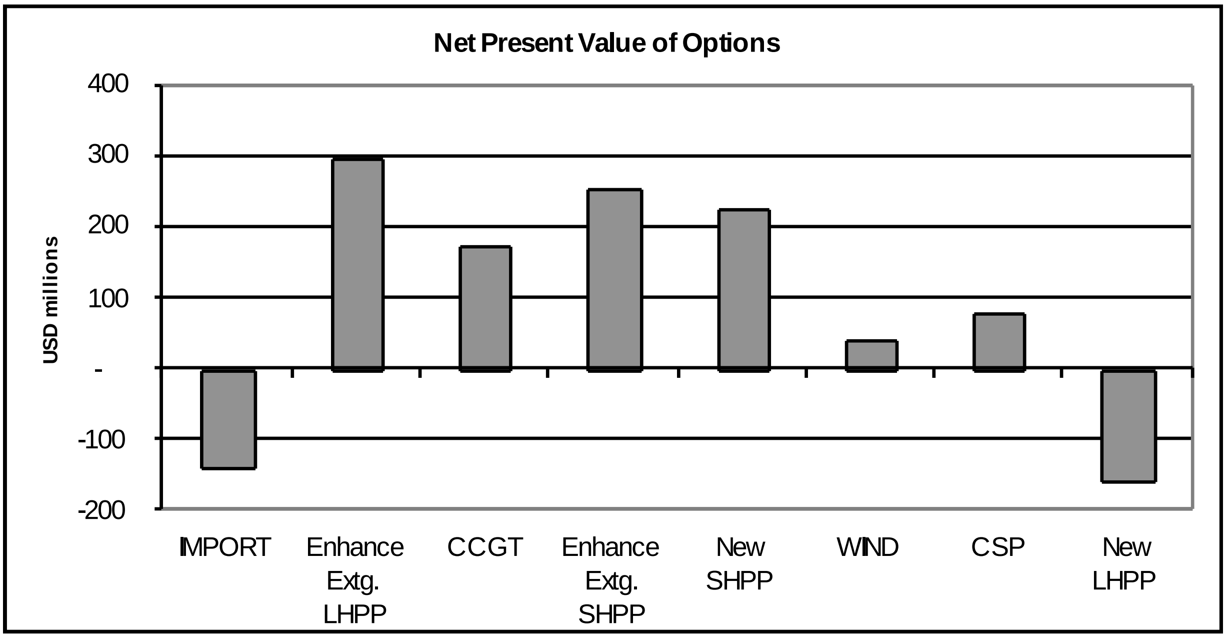

Figure 26: Costs vs. benefits for the extreme storm case (1 week per year outages)

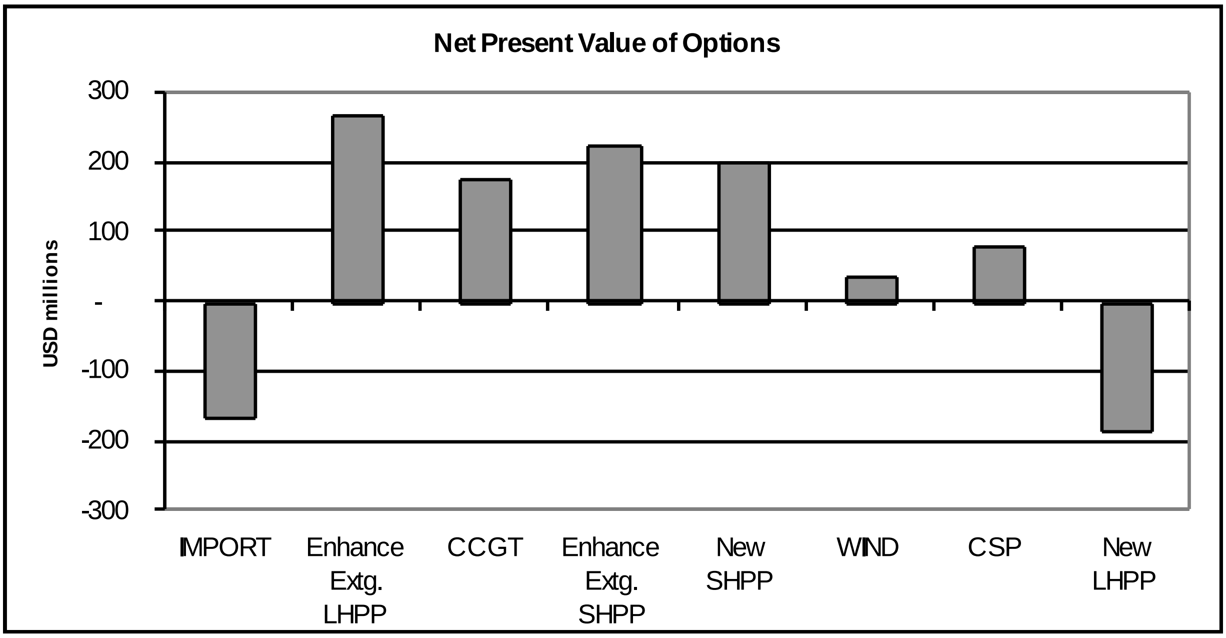

Figure 27: Costs vs. benefits for the extreme storm case (1 month per year outages)

A final case illustrates the effect that length of time can have on the analysis, whereby the timeline is extended from 20 years to 50 years (see Figure 28). All base-case parameter values are used. It should be noted that many of the assets would not last until 2050 without extensive reinvestment. However, this case illustrates the consequences of the time and discount rate assumptions.

Under this scenario, all options except import (discussed above) have greater value to society because they are providing value for a longer period of time. Eventually, the ongoing benefits outweigh the one-off investment costs.

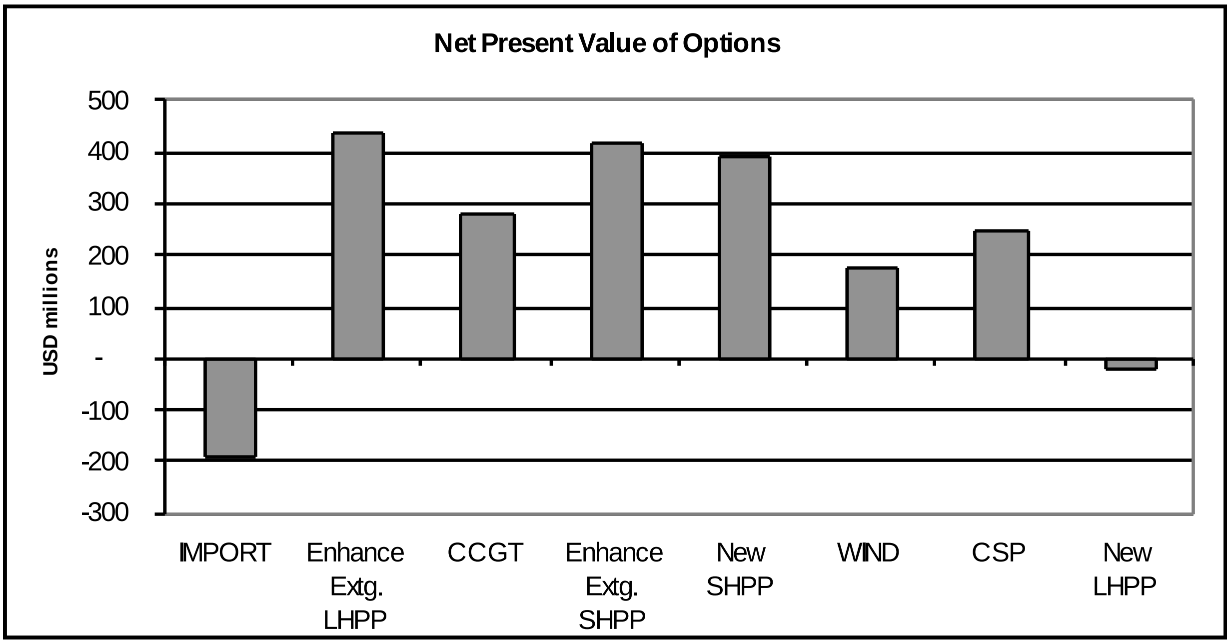

Figure 28: Costs vs. benefits for 50-year duration analysis

Figure 29 presents the sensitivity of the various options to changes in the discount rate in the range 0 percent to 20 percent. The NPV is represented by the vertical axis and the discount rate increases along the horizontal axis from left to right.

The chart illustrates that in general, over a range of different discount rates that would typically be used for public decision making, the relative ranking of the options does not change, with the "Update LHPP" option returning the greatest NPV. However, as the discount rate increases toward ranges that represent typical investment thresholds for private investors, "Import" becomes a relatively more attractive (though still NPV-negative) option. Additionally, when the discount rate is larger than 16.2 percent "CCGT" becomes marginally more attractive than "New SHPP." "CCGT" has higher operating costs. However, the effect of the future operating costs on "CCGT" in comparison with "New SHPP" is such that NPV for "CCGT" is diminished at higher discount rates.

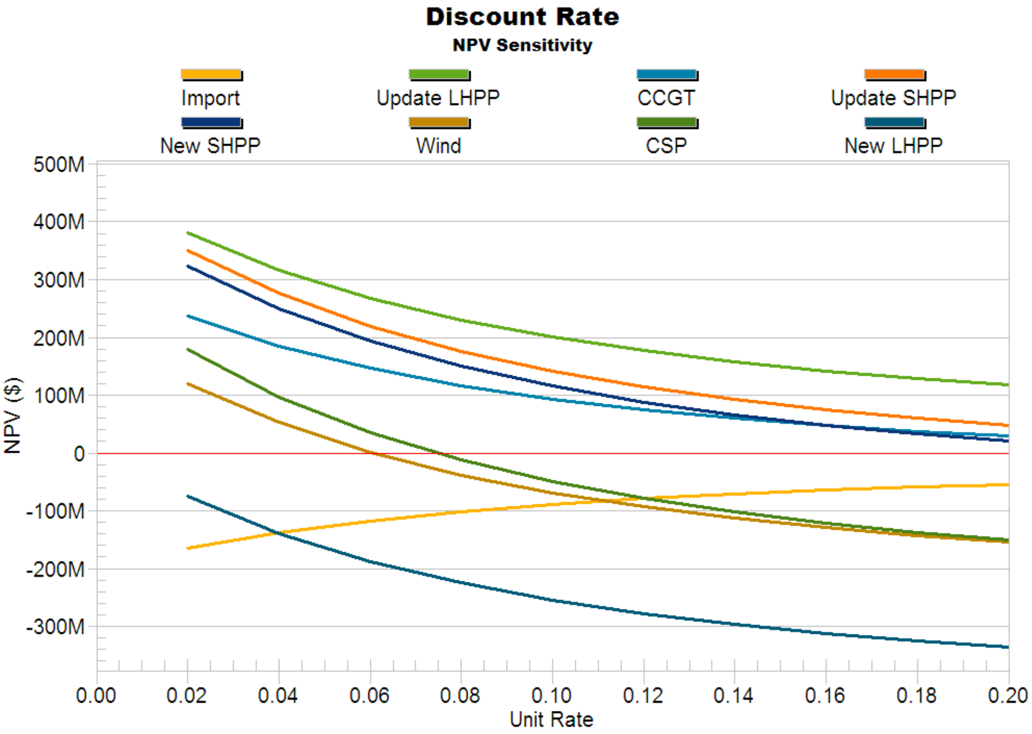

Figure 29: Sensitivity of options to discount rate

Another interesting parameter for the sensitivity analysis is the value of carbon dioxide and other GHGs. Varying the CO_2 price over a range of values is illustrated in Figure 30.

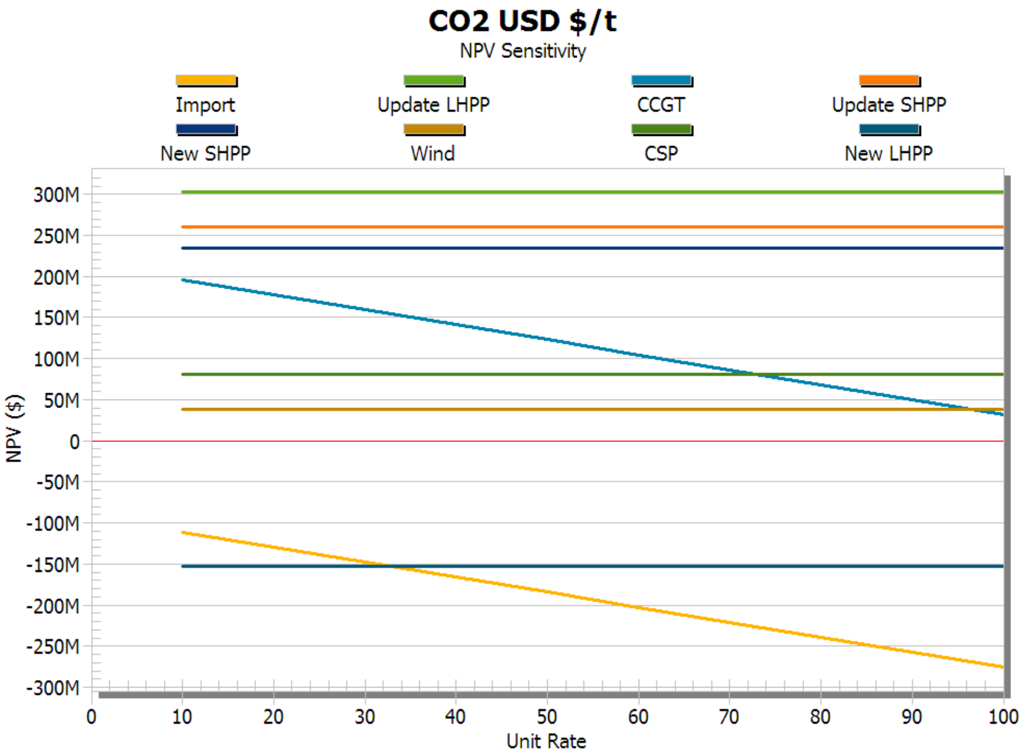

Figure 30: Sensitivity of options to carbon dioxide and other GHGs

As expected, the economics of a group of renewable assets are generally insensitive to the value of carbon dioxide and other GHGs. Those options that are sensitive to increasing value are “CCGT” and “Import” (the latter assumed to be generated via CCGT), due to the fact that they both use fossil fuels. The higher the value placed on carbon dioxide and other GHGs, the more unfavorable the “Import” and “CCGT” options become in relative terms.

The sensitivity of the options to water value is shown in Figure 31. The LHPP options exhibit the largest sensitivity to the value of water. “New LHPP” remains the least favorable option under conditions where the value of water is greater than USD 0.71/m^3. However, even at lower values (down to zero) “New LHPP” does not become favorable in comparison to any of the other options except “Import.” The value of water also has a large impact on the relative attractiveness of “Update LHPP”; the higher the value of water, the more appealing are alternative options.

As mentioned already, due to the high-level nature of this analysis, other possible benefits that may be very relevant when considering a *specific* project have not been considered.

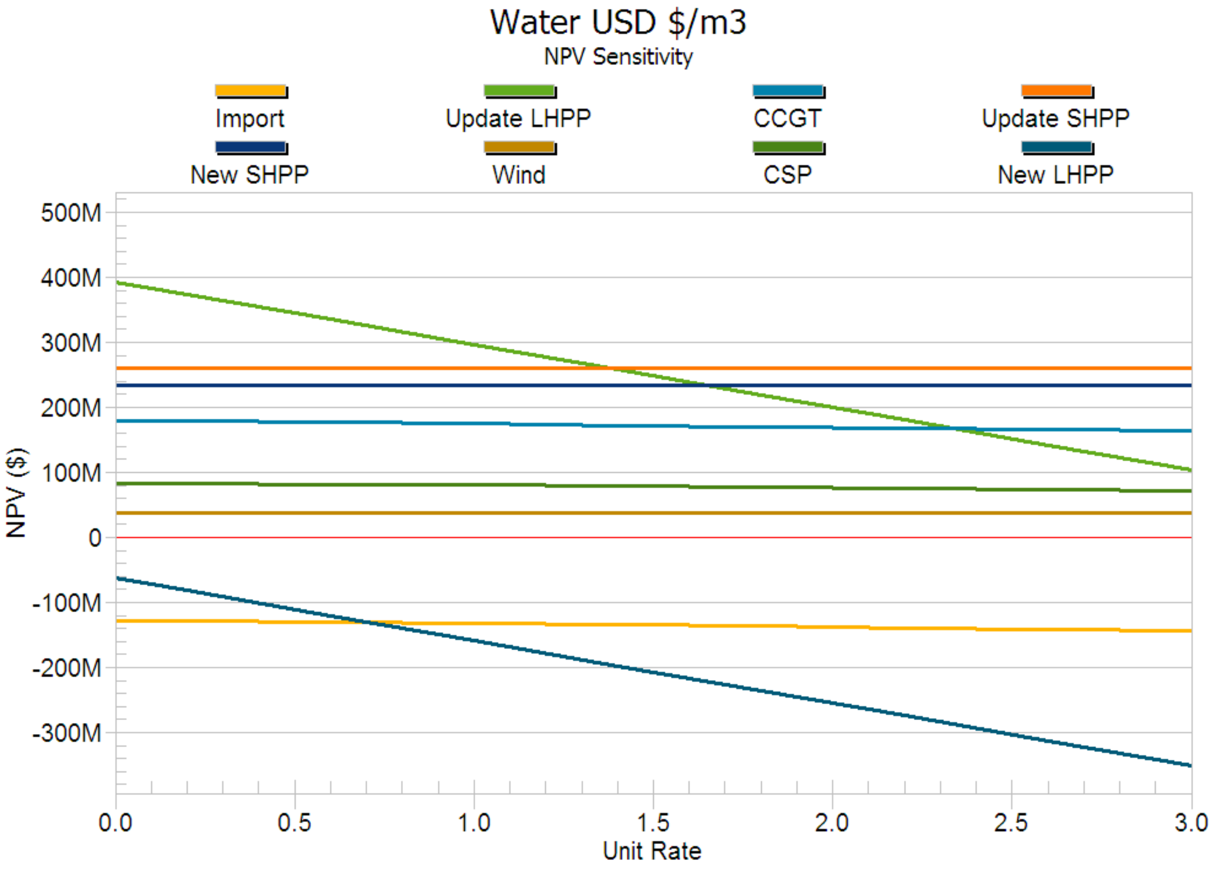

Figure 31: Sensitivity of options to the value placed on water

5.7 USING THE RESULTS OF THE COST–BENEFIT ANALYSIS TO SUPPORT DECISIONS TO MANAGE THE ALBANIAN ENERGY SECTOR IN THE FACE OF CLIMATE CHANGE

The high-level cost–benefit analysis examined eight options to provide equivalent power generation of 350 GWh per year for the next 20-year planning horizon, where existing technology and current asset life span remains most relevant. This analysis therefore ranks the options based on a common measure. On the one hand, it is recognized that the projected shortfall in energy supply due to the impacts of climate change will gradually increase over time, and that some technical options are more flexible in their implementation and may be more economic where an incremental increase in supply capacity is preferred (e.g., gradual implementation of small hydroelectric or wind power schemes). On the other hand, it may be considered that larger plants built early in the planning period may provide additional returns. These considerations could be examined in further detail by future studies, but are beyond the scope of the current assessment.

In addition, to fill the projected energy shortfall, the CBA indicates that the most economic/ sustainable options to consider are enhancing existing small and large hydropower schemes and development of new small hydropower schemes. However, it is recognized that there may be a limit to the amount of additional hydropower generation capacity within Albania. METE estimates that there is capacity for only 3,200 MW installed HPP in Albania (Tugu, 2009), and there may be insufficient additional capacity, beyond that used in the projections for supply to 2050, to accommodate all additional requirements due to climate change. Therefore the results of the CBA could be used to some extent to prioritize adaptation measures, starting initially with upgrading existing facilities, moving on to exploiting remaining small hydroelectric power opportunities, before consideration of other assets that may be less economic/sustainable.

Important Notes

As noted above, this analysis addresses only a small part of the larger context of the effects of climate change on Albania's energy sector. Additionally the high-level nature of the assessment means that in specific situations the results of a CBA could be different. Several constraints and limitations on the CBA are worth mentioning.

First, the environmental and social effects of the construction phase for energy assets were not considered; only the financial aspects. Although the construction of a power plant is a resource-intensive undertaking, it is difficult to make a general qualification about social and environmental impacts without studying a specific project. For instance, in some cases the construction of an equivalent capacity hydropower facility may cause more CO_2 emissions than constructing a thermal power plant, especially during the construction of a dam. However, in other cases—for instance, if a thermal plant were sited in an environmentally valuable area—its construction may have the greater impact.

Another issue that is not addressed directly in this economic cost–benefit assessment, but that would need to be addressed in further analysis, is the political and business climate in Albania. This includes factors such as Albania's ability to attract investment funds and obtain necessary permitting.

Many of the effects of climate change are seasonal in nature, though this analysis does not account for this, as the available data on seasonal water flows and energy production are sparse. However, it is worth noting the range of effects climate change may have on seasonal performance of energy assets, in particular HPPs. Not only may climate change affect the quantity of precipitation at any given period of the year, climate change may also influence the timing of changes. For instance, it was noted by Albanian energy sector stakeholders that existing SHPPs rely on runoff generated by spring and summer melting of the snow pack in the mountains. This runoff extends the period that the SHPP are able to operate. Although insufficient data were available for this assessment to determine the possible changes in snowmelt, it is anticipated that the timing and rate of spring melt may increase runoff and the risk of spillover of LHPP dams, which means that less water would be available for power generation if reservoirs were not sized adequately.

To provide some illustration of the seasonal effects associated with power generation in Albania, historical monthly river flow rates into the Fierze Reservoir on the Drin River and power generation in the Drin Cascade were reviewed. Seasonal variations were examined for a relatively wet year (2006, Figure 32) and a relatively dry year (2007, Figure 33), from datasets provided by KESH. It should be noted that the *flow rate* presented on the graphs is the rate of inflow into Fierze reservoir and that the power generation—Drin total is the combined power generation for Fierze, Koman, and Vau i Dejes hydropower plants. The demand data presented are the demand that was met, and not necessarily the demand that may have existed if there had been unrestricted supply (i.e., had there been no load shedding, demand might have been greater).

Although it is recognized that operation of dams and power generation from hydropower plants is potentially complex, a number of observations about the potential impacts of seasonality and possible future climate change impacts can be made based on these data.

Figure 32 (wet year) indicates that river flows are highly seasonal, with the winter and spring months having the greatest flow. In the wet year, power generation is more correlated with river flows than in the dry year. Generation appears to be independent of demand, as throughout the year demand exceeds generation, except for a short period during the spring.

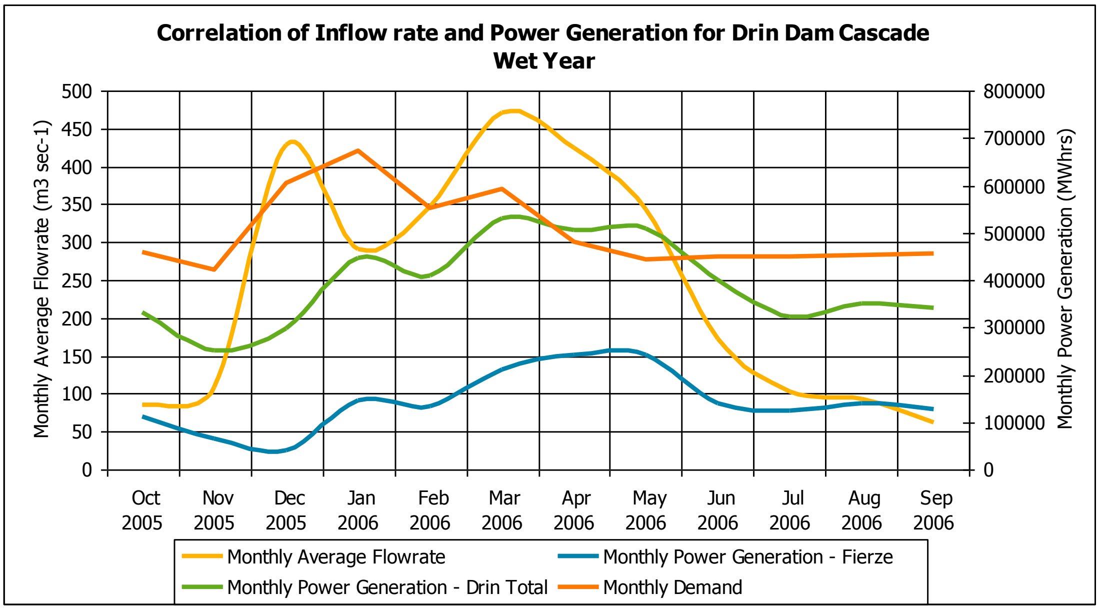

Figure 32: Rainfall and Drin Dam Cascade generation in a wet year (October 2005 to September 2006)

Figure 33 shows a dry year. Seasonal variations are still apparent but are much less well defined. Generation is also less correlated with flow rate, and again generation appears to be independent of demand. At the beginning of the period examined (October 2006), generation increases, almost in anticipation of the increased flow rate seen in November and December. However, generation quickly levels off to a much lower level than in the corresponding months of the wet year.

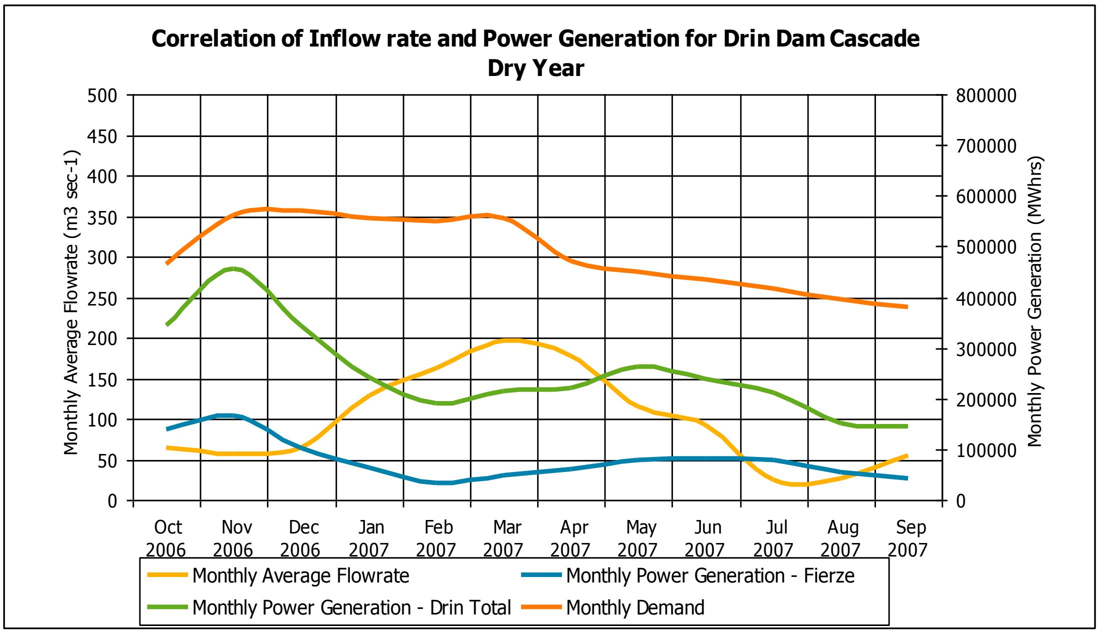

Figure 33: Rainfall and Drin Dam Cascade generation in a wet year (October 2006 to September 2007)

Interpretation of this limited dataset indicates that, as expected, hydroelectric power generation is seasonal and strongly influenced by runoff. When the potential power generation is calculated by dividing the inflow rate by the efficiency factor that KESH reports for the Fierze dam (1.04 m^3/kW in 2008) (Stojku, 2009), it is seen that potential power generation of the Drin cascade closely follows the seasonal pattern, with periods of excess and periods of deficit. This is as expected for a dam storage facility. The climate change projections indicate that future summers will become drier in Albania, runoff from snow melt may occur more rapidly and earlier, and summer energy demand will increase. As a result, these seasonal fluctuations will likely become more pronounced and may negatively impact Albania's energy security. It is therefore important to consider these aspects when interpreting the need for diversification of assets and the conclusions of the cost–benefit analysis. Future studies would be useful, to examine in more detail the seasonal effects on energy security associated with climate change.

6. NEXT STEPS TO IMPROVE THE CLIMATE RESILIENCE OF ALBANIA'S ENERGY SECTOR

Given the risks and adaptation actions highlighted in the previous sections, there are a number of steps that could be considered to build the resilience of Albania's energy sector to cope with climatic variability and change. Many of these are no-regrets actions that would improve Albania's energy security even without climate change, and some are included in the draft National Energy Strategy active scenario. Many others are generally low cost, though clearly where financial resources are constrained, even low-cost measures could be difficult to fund. They fall into the three categories outlined in Section 4:

1. Informational
2. Institutional
3. Physical / technical

The steps, along with suggested timescales for *commencing* them, are as outlined next. Further details on these actions are provided in Annex 6. The annex highlights which actions are no-regrets and which are already included in the draft National Energy Strategy active scenario.

In Year 1, Albania could consider:

- Improving meteorological and hydrometeorological monitoring, modeling and forecasting capabilities, and communicating that information effectively to energy sector stakeholders, to support energy sector planning and management
- Further research on climate change impacts on the energy sector, through downscaling of global climate model outputs, and researching the impacts of changes in seasonal climate conditions and extreme climatic events
- Initiating dialogue and research with partners in South Eastern Europe to develop a shared understanding of regional risks from climate change to energy security, and to discuss the implications for energy prices and trade
- Mapping out detailed plans to address issues in Years 2 to 5 and onward

In Year 2, emphasis could be placed on beginning to develop policy, regulatory and other management options to manage climate risks, including:

- Improving and exploiting data on reservoir use, margins and changes in rainfall and runoff, to improve operational management of existing reservoirs
- Developing incentives for energy efficiency measures to reduce demand
- Enforcing measures to reduce technical and commercial water and energy losses
- Engaging with water users in the agricultural sector, to devise agreed strategies for managing shared water resources
- Incorporating assessments and management of climate risks into energy sector contracts, environmental impact assessments and other policy instruments for new facilities
- Developing tariffs and incentives to promote climate resilience of energy assets

- Structuring Power Purchase Agreements with neighboring countries that take account of climate change risks
- Reviewing and upgrading Emergency Contingency Plans
- Investigating weather coverage and insurance instruments

In Year 5, progress could be made in the following areas:

- Ensuring that new energy investments and rehabilitation of existing assets are building in resilience for projected climate changes
- Diversifying energy asset types, taking account of climate change
- Reducing technical and commercial losses from the transmission and distribution network
- Demonstrating progress on demand-side energy efficiency
- Having improved regional interconnections in place, and ensuring that regional partners have a shared plan in place for regional energy security in the face of climate change
- Testing Emergency Contingency Plans
- Ensuring that the measures commenced in Years 1 and 2 are making progress and being implemented successfully

As noted, a number of these actions are already recognized by the government or identified for action, and are described in the draft National Energy Strategy's "active" scenario (Government of Albania, 2007). Nevertheless, they have been highlighted here because they contribute to improving climate resilience.

7. REFERENCES, ANNEXES, AND APPENDICES

Acclimatise. (2009). Climate change projections for Albania. Acclimatise, UK.

Acclimatise, WorleyParsons, and World Bank. (2009a). World Bank workshop on climate risks and vulnerabilities of Albania's energy sector: Workshop 1 Report. 10 March 2009, Tirana International Hotel, Tirana, Albania.

Acclimatise, WorleyParsons, and World Bank. (2009b). World Bank workshop on climate change vulnerability and adaptation assessment of Albania's energy infrastructure: Workshop 2 Report. 21-23 April 2009, Tirana International Hotel, Tirana, Albania.

Bogdani Ndini, M., and Bruci, E. (2008). Assessment of climate change impacts on water resources in the Vjosa Basin, Institute of Energy, Water and Environment. Tirana, Albania.

Broadleaf Capital International and Marsden Jacob Associates. (2006). Climate Change Impacts & Risk Management A Guide for Business and Government. Australian Greenhouse Office, Department of the Environment and Heritage, Australian Government, Canberra, Australia.

Bruci, E. (2008). Climate variability and trends in Albania. IWE, Tirana Polytechnic University, Tirana, Albania.

Bruci, E. (2009). Climate variability and expected changes in Albania. Presentation at World Bank workshop on climate risks and vulnerabilities of Albania's energy sector. 10 March 2009, Tirana International Hotel, Tirana, Albania.

Cerepnalkovski, T., Miller, P., Bajs, D., Majstrovic, G., Mijailovic, S., Vukovic, M., Rusanov, N. and Gamov, N. (2002). SECI Regional Transmission Planning Study.

CEZ and OSHH. (2009). Annex 11: Regulatory Statement (English).

Department of Natural Resources and Parks, King County, Washington. (2004). Ecological Economic Evaluation: Maury Island, King County, Washington.

Ebinger, J., Hancock, L., and Tsirkunov, V. (2009). Weather/Climate Services in Europe and Central Asia: A key tool for energy sector adaptation to climate change. In: Troccoli, A. (ed), Management of Weather and Climate Risk in the Energy Industry, NATO Science Series, Springer Academic Publisher, forthcoming.

Electricity Coordinating Center Ltd. and Energy Institute ”Hrvoje Požar.“ (2004). Generation Investment Study: Transmission network checking, Draft Report, Zagreb.

Energy Regulator of Albania (ERE). (2008). Annual report. Situation of Energy Sector and activity of ERE for 2008.

European Commission. (2005). South East Europe Electricity options paper, 5 December 2005.

European Commission. (2009). White Paper. Adapting to climate change: Towards a European framework for action. Brussels, Belgium.

E.U. (2006). European Market Price, 5 Feb 2006. www.pointcarbon.com.

Fantozzi, G. pers. comm. (2009). World Bank, Washington, D.C., USA.

Greenley, D. A., Walsh, R. G., and Young, R. A. (1982). Option Value: Empirical Evidence from a Case Study of Recreation and Water Quality: Reply. *Quarterly Journal of Economics*, **100** (1): 294–299.

Government of Albania, National Energy Strategy (Draft), 2007.

hHancock, L., and Ebinger, J. (2009). Weather/climate data and the energy sector in Albania. World Bank, Washington, D.C., USA.

Hardisty, P. E. (2005). The Economics of Environmental Protection: A Middle East Oil and Gas Industry Perspective. *Middle East Economic Survey*, **48** (28): 26–30.

Hardisty, P. E., and Ozdemiroglu, E. (2005). The Economics of Groundwater Remediation and Protection. New York: CRC Press.

Hoxha, F., KESH. pers. comm. (2009). Meetings held as follow-up to Workshop 2 on Climate Change Vulnerability and Adaptation Assessment of Albania’s Energy Infrastructure, April 2009.

International Bank for Reconstruction and Development and Hydrometeorological Institute. (2006). Annex 5.5: Assessment of Economic Benefits of Hydrometeorological Services in Albania (Interim Report).

International Energy Agency. (2009). Statistical database at www.iea.org.

IPCC. (2007). Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.). Cambridge and New York: Cambridge University Press, 996 pp.

Islami, B., Kamberi, M., Demiraj, E., Fida, E. (2002). The First National Communication of the Republic of Albania to the United Nations Framework Convention on Climate Change (UNFCCC). Ministry of Environment, Republic of Albania.

Islami, B., and Bruci, E. (2008). Impacts of Climate Change to the Power Sector and Identification of the Adaptation Response Measures in the Mati River Catchment’s Area.

Islami, B. (2009). Current understanding of vulnerabilities of Albania’s power sector (demand and supply sides) to climate risks. Presentation at World Bank workshop on climate risks and vulnerabilities of Albania's energy sector. 10 March 2009, Tirana International Hotel, Tirana, Albania.

Karagiannis, Ioannic, Petros, C., and Soldatos, G. (2008). Water desalination cost literature: review and assessment. *Desalination*, **223**, pp 448–456.

Karl, T. R., Melillo, J. M., and Peterson, T.C. (eds.). (2009). Global Climate Change Impacts in the United States. Cambridge: Cambridge University Press.

Kaya, Z. Kurum International. pers. comm. (2009). Meetings held as follow-up to Workshop 2 on Climate Change Vulnerability and Adaptation Assessment of Albania's Energy Infrastructure, April 2009.

KESH, pers. comm. (2008). Meeting at KESH headquarters within scope of project preparation.

Ladenburg, J., and Dubgaard, A. (2007). Willingness to pay for reduced visual disamenities from offshore wind farms in Denmark. *Energy Policy*, Elsevier, **35** (8), pp 4059–4071.

Le Goffe, P. (1995). The Benefits of Improvements in Coastal Water Quality: A Contingent Approach, *Journal of Environmental Management* **45** (4), pp. 305–317.

Maire Engineering. (2008). EPC of a Combined Cycle Power Plant at Vlore: Environmental Protection Plan (EPP).

Marcos, M., and Tsimplis, M. N. (2008). Coastal sea level trends in Southern Europe. Geophysical Journal International, **175**, 70–82.

Nakićenović, N., and Swart, R. (eds.). (2000). Special Report on Emissions Scenarios. A Special Report of Working Group III of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 599 pp.

Pereira de Lucena, A. F., Szklo, A. S., Salem, A., Schaeffer, R. de Souza, R. R., Borba, B. S. M. C., da Costa, I.V.L, Junior, A.O.P., da Cunha, S. H. F. (2009). The vulnerability of renewable energy to climate change in Brazil, Energy Policy, **37**: 879–889.

Ponari, A., Ebinger, J., Lim, A. C., and Hancock, L. (2009). Regional Electricity Markets in South Eastern Europe: Weather and Climate Risk. World Bank, Washington, D.C., USA.

PricewaterhouseCoopers LLC and Atkins International. (2004). Regional Balkans Infrastructure Study (REBIS)—South East European Generation Investment Study (GIS). Undertaken for the European Commission within the scope of the European Union's CARDS programme—Contract No. 52276.

Schaeffer, R. de Souza, Szklo, A. S., and Lucena, A. (2009). Climate Change and Energy Security in Brazil: Understanding the Impact of Climate Change on the Energy Sector. Presentation at World Bank Energy Week 2009.

Stojku M., KESH. pers. comm. (2009). Meetings held as follow-up to Workshop 1 on Climate Risks and Vulnerabilities of Albania's Energy Sector, March 2009.

Stern, N. (2006). Review on the Economics of Climate Change, H.M. Treasury, UK. http://www.sternreview.org.uk.

Sutherland, R. J., and Walsh, R. G. (1985). Effect of Distance on the Preservation Value of Water Quality. *Land Economics.*

Tugu, F., METE. pers. comm. (2009). Meetings held and information sent related to Workshop 2 on Climate Change Vulnerability and Adaptation Assessment of Albania's Energy Infrastructure, April 2009.

Tirana Municipality. (2006). Water Supply Services Brochure. www.tirana.gov.al.

UK Environment Agency. (2000). Research and Development Paper P279.

UNEP. (2000). Post-conflict environmental assessment—Albania. United Nations Environment Programme, Switzerland.

UNEP. (2001). The Value of Forest Ecosystems.

Wade, N. M. (2001). Distillation Plant Development and Cost Update. *Desalination*, **136**, pp 3-12.

WeatherBill Inc. (2009). Protecting Profits with Weather Coverage, New Solutions for Hydroelectric Companies and Water Districts, March 27, 2009.

Willows, R. I., and Connell, R.K. (eds.) (2003). Climate adaptation: Risk, uncertainty and decision-making. UKCIP Technical Report. UKCIP, Oxford, UK.

World Bank. (2003). Water Resources in Europe and Central Asia: Volume II. Country and Water Notes and Selected Transboundary Basins. Washington, D.C., USA.

World Bank. (2008a). Development and Climate Change, A Strategic Framework for the World Bank Group.

World Bank. (2008b). Project Appraisal Document on a Proposed Credit in the amount of SDR 21.7 million (US$35.3 million equivalent) to Albania for a Dam Safety Project (Phase 5) in support of the South East Europe APL Program. World Bank.

World Bank. (2008c). The World Bank Group's Catastrophe Risk Financing Products and Services, July 2008.

World Bank. (2009a).World Development Indicators. World Bank, Washington, D.C., USA.

World Bank. (2009b). Project Appraisal Document on a Proposed Loan in the Amount of Eur 2.0 million (US$3.0 million equivalent) and a Proposed credit in the amount of SDR 3.8 million (US$6.16 million equivalent) to Albania for a Disaster Risk Mitigation and Adaptation Project, May 23, 2009, Report No. 43380-AL.

World Bank. (2009c). Climate Change and Agriculture: Albania Country Note (Draft for Discussion). Washington, D.C., USA.

World Bank. (2009d). Adapting to Climate Change in Europe and Central Asia. Washington, D.C., USA.

ANNEX 1: METHODOLOGICAL APPROACH TO THE ASSESSMENT

A1.1 ANALYSIS OF OBSERVED CLIMATIC CONDITIONS AND DATA ON FUTURE CLIMATE CHANGE

A considerable amount of research has been undertaken by climate experts in Albania to describe observed climatic conditions and trends, and this research was utilized in this assessment to provide a context for the existing vulnerabilities of the energy sector and as a baseline against which climate change will be felt (Bruci, E. 2008; Bruci, E. 2009).

To understand potential future changes in climate for Albania and South East Europe more generally, data from nine global climate models (GCMs) that formed part of the Intergovernmental Panel on Climate Change Fourth Assessment report (IPCC AR4) were evaluated (Acclimatise, 2009). Projections of changes in the following climate variables were developed and mapped:

- Temperature
- Precipitation
- Wind speed
- Relative humidity
- Cloudiness
- Sea surface temperature
- Sea level rise

It should be noted that most global climate models operate at a coarse spatial resolution ($2.5^o \times 2.5^o$ is typical) that is insufficiently detailed for risk assessments and adaptation planning in small countries. As a result, methods have been developed to downscale the climate information to finer resolution, though these have only been applied in a small number of locations and often only provide results for the end of the century. In the absence of coordinated efforts to undertake climate downscaling for Albania, the global models, when studied at the regional scale, offer the best currently available guide to future Albanian climate conditions.

It is clear that Albania would benefit from additional investment in downscaling of large-scale global climate models to scales of more relevance to river basin planning.

A1.2 GEOGRAPHICAL INFORMATION SYSTEM (GIS) MAPPING

To provide a visual tool to facilitate discussions at Workshop 1, graphics presenting climate change data were input into a GIS, to provide an overlay of climatic hazards against energy assets. These maps were developed in both ArcGIS and GoogleEarth. A sample of the GIS output is shown in Figure A1.1. The complete output is available and has been provided to energy sector stakeholders in Albania.

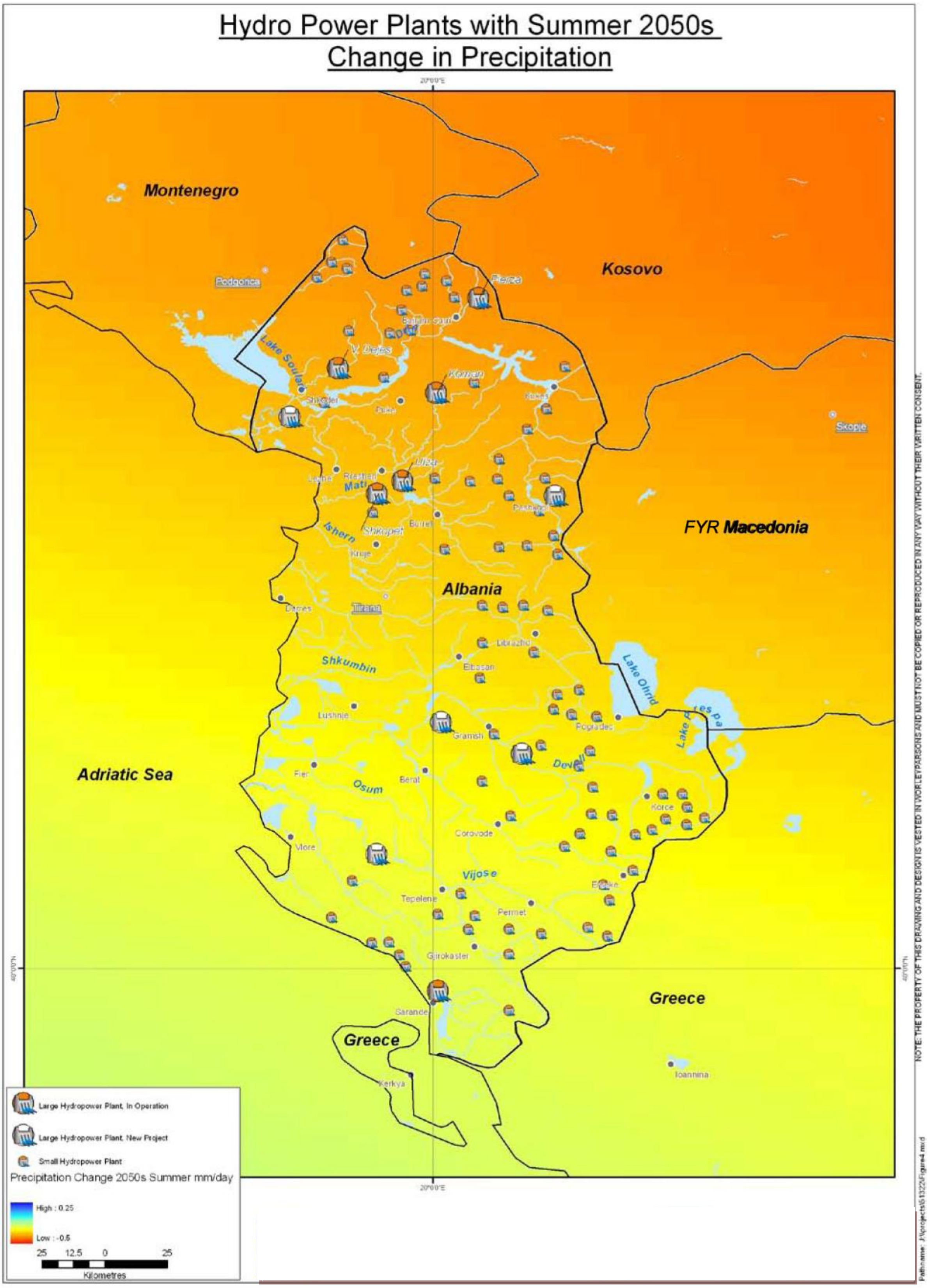

Figure A1.1: Sample GIS output.

A1.3 WORKSHOP 1: HANDS-ON VULNERABILITY, RISK, AND SWOT ANALYSES WITH ENERGY SECTOR STAKEHOLDERS IN ALBANIA

A first workshop discussed climate risks and vulnerabilities of Albania's energy sector, leading to the development of SWOT (strengths, weaknesses, opportunities and threats) analyses (Acclimatise *et al*., 2009a). It was held on March 10, 2009, and brought together more than 60 key stakeholders in Albania's energy sector, including government ministries and agencies, utilities and corporations, private companies, expert consultants, university academics and NGOs, as well as energy sector experts from the World Bank and other international organizations. The objective of the workshop was to develop a shared understanding among these stakeholders of the climate risks and vulnerabilities of Albania's energy sector.

The workshop was opened by Ms. Camille Nuamah (World Bank), Dr. Suzana Guxholli (Council of Ministers), and H. E. Lufter Xhuvelli (Minister of Environment, Forests and Water Administration).

Plenary sessions were followed by four breakout group discussions on various aspects of Albania's energy sector that could be vulnerable to climate risks:

1. Hydropower plants and energy demand
2. Other forms of energy generation: thermal power plants and renewable energy
3. Electricity transmission and distribution and small hydropower plants
4. Fossil fuel supply and transmission / transportation

Each of these working groups focused their discussions around three key areas:

1. Overall strategies and objectives for Albania's energy sector
2. Climatic vulnerabilities of existing and planned energy sector assets
3. Climate change risks

A Business Risk Pathways Model was used in the workshop to help facilitate working group discussions. This took the form of a diagram presenting the linkages between changing climate hazards and their consequences for the performance of the energy sector (Figure A1.2). This tool was subsequently used to provide the criteria for assessing the significance of climate change risks to the energy sector (see Annex 2 for further details). Building on the outcomes of the workshop and meetings, SWOT analyses were developed for each of the breakout group themes.

Directly after the first workshop, meetings were held with energy-sector experts from government, the private sector, research and academic institutions and NGOs, at which the risks and vulnerabilities identified during the workshop were discussed in greater depth.

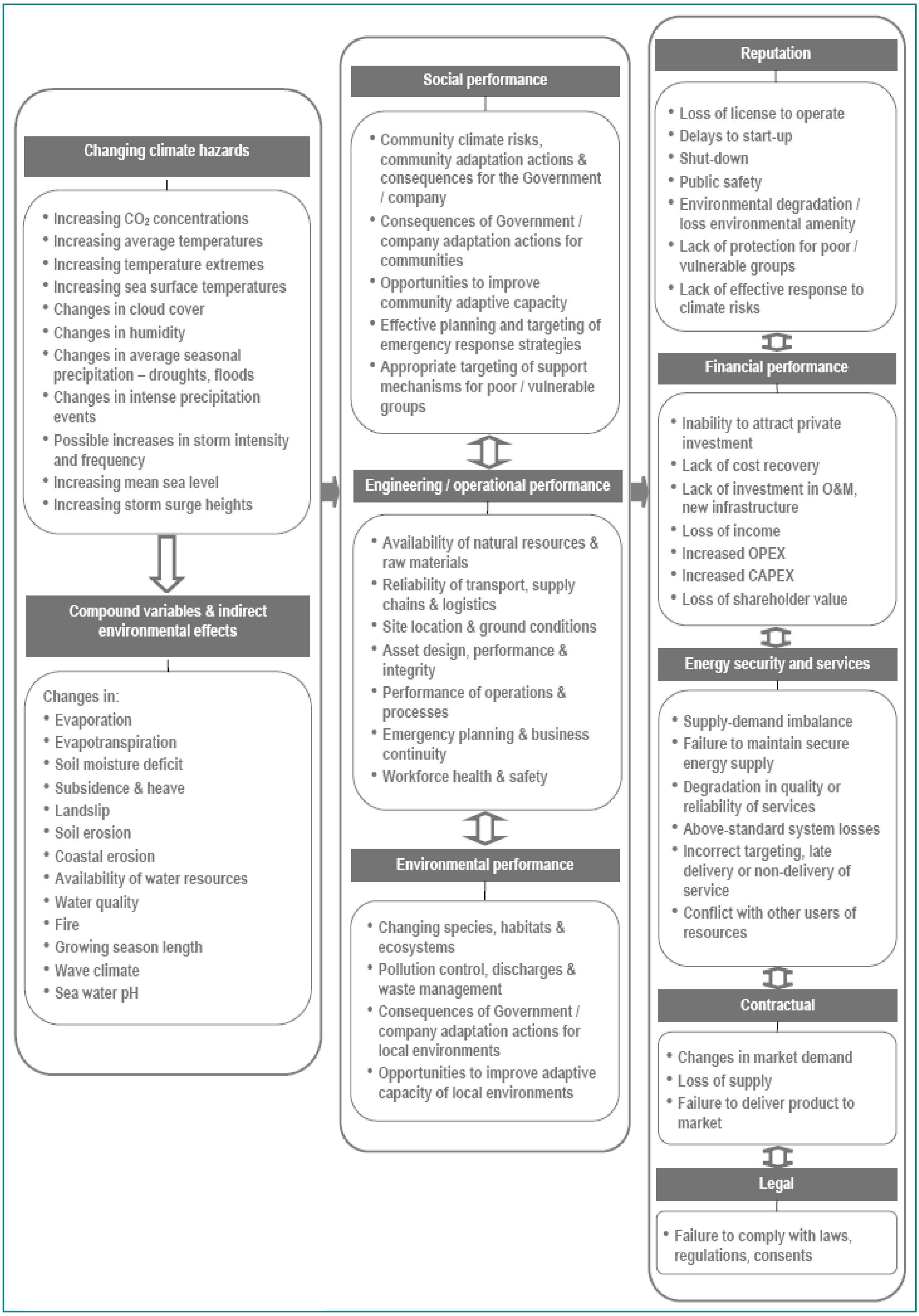

Figure A1.2: Acclimatise Business Risk Pathways Model, adapted for Workshop 1.

A1.4 ANALYSIS OF CLIMATE RISKS FOR REGIONAL ENERGY MARKETS IN SOUTH EAST EUROPE

Albania's draft National Energy Strategy (2007) places emphasis on Albania increasing energy trade with its neighbors in South East Europe as a way of helping with security of energy supply. Hydropower is widely used throughout the region, and the climate change projections indicate that the whole region could experience higher temperatures and reduced summer precipitation in future. However, it is not clear that all parts of the region would experience wet or dry seasons or years at the same time. A brief analysis of energy generation types across the region was undertaken, considering how climate risks could affect them and questioning whether careful selection of an ensemble of hydropower investments could help to diversify risk (Ponari *et al*., 2009).

A1.5 DEVELOPMENT OF HIGH-LEVEL QUALITATIVE AND QUANTITATIVE ASSESSMENTS OF CLIMATE CHANGE RISKS TO ENERGY ASSETS

While the first workshop and associated meetings were helpful in identifying the key risks and vulnerabilities of the energy sector, it was not possible within the time available at the workshops and meetings to develop high-level quantitative estimates of the risks to each energy asset type, nor was it achievable to evaluate the significance of each of the risks. These estimates were required as input to the CBA. Instead, high-level quantitative estimates of risk and risk ratings were developed based on engineering expertise and a review of relevant literature.

Estimating climate change impacts on hydropower plants and other energy assets

An in-depth approach to quantifying the impacts posed by climate change for large hydropower plants (LHPP) would involve hydrological modeling using downscaled climate change scenarios, and subsequent modeling of the impacts of changes in river flows on hydropower plant output. However, this approach would take considerable research effort and time, which is beyond the scope of this high-level assessment. Instead, quantitative estimates were developed drawing on the following information and data:

- Modeling of the relationships between changes in climate (precipitation and temperature) and changes in river flows for several catchments Albania (Islami *et al*., 2002; Bogdani and Bruci, 2008; Islami and Bruci, 2008)
- A correlation undertaken of annual average inflows to Fierze hydropower plant on the Drin Cascade (Annex 8) and consequent electricity generation, together with a similar correlation for power production from LHPP on the Mati River (Islami and Bruci, 2008)
- Recent research undertaken in Brazil, which used regional climate modeling data to project impacts on output from Brazil's hydropower plants (Pereira de Lucena *et al*., 2009; Schaeffer *et al*., 2009)

These information sources were analyzed and a paper was produced, providing a high-level estimate of climate change impacts on generation from LHPP (Annex 8). This estimate was subsequently used in the cost–benefit analysis.

Estimates of the climate change impacts on other energy assets were developed drawing on climatological and engineering expertise and on the relationships between climatic factors and asset performance (Annex 9). In some cases, the relationships between average climatic conditions and energy assets are straightforward and well-established in the engineering sector (e.g., impacts of increases in temperature on efficiencies of gas turbines).

It is worth noting again that it is not the purpose of this analysis to assess in detail all of the impacts of climate change on Albania's energy sector. Instead, this analysis provides high-level (semi-quantitative) assessments to identify key risk areas where subsequent more in-depth analyses could be focused. In particular, data are not available on future changes in extreme climatic events, which could have significant consequences for the sector. Furthermore, knowledge and data on the detailed design characteristics of Albania's energy assets, particularly in relation to proposed new assets, would be needed.

Evaluating the Significance of Risks

The significance of a risk is rated according to the probability of a hazard occurring and the magnitude of its consequence. A risk rating system for Albania's energy sector was developed using the tool presented in Figure A1.2. This rating system is detailed in Annex 2, Tables A2.1 and A2.2.

Drawing on the quantitative estimates described, and using expert judgement, a desk-based exercise was undertaken to assign a rating to each of the risks. These ratings were tested and revised in collaboration with stakeholders during the second workshop. The resultant risk maps are presented in Annex 2, Tables A2.3 and A2.4. Further detail is provided in Sections 3 and 4.

A1.6 WORKSHOP 2: ADAPTATION AND COST–BENEFIT ANALYSIS WITH ENERGY SECTOR STAKEHOLDERS IN ALBANIA

A second workshop and associated meetings, held on April 21–23, 2009, discussed adaptation measures to address the potential risks and vulnerabilities identified in the first workshop, and set out the framework for an assessment of their costs and benefits (Acclimatise *et al.*, 2009b). Workshop participants included a cross-section of more than 25 stakeholders from the government, key agencies and institutions, academia, the private sector and NGOs.

The second workshop involved five steps:

1. Agreeing the objective for the cost–benefit analysis of the energy sector
2. Confirming the key risks posed by climate change
3. Agreeing the boundaries / limits and constraints of the CBA
4. Identifying adaptation options to meet the objective
5. Discussing the range of parameters to be used to evaluate the performance of adaptation options in the CBA

The workshop agreed that the objective of the high-level CBA was to address the following question:

> *"How can we best manage Albania's future security of energy supply in the face of a changing climate?"*

Best was defined as "an optimal balance between financial, environmental and social objectives."

The workshop also agreed on the key adaptation option to be assessed as part of the CBA, namely, diversification of power generation assets. It was confirmed that the CBA would be a high-level assessment, utilizing readily available data and international normative valuations for selected aspects. Additional detailed study of external costs and benefits was excluded from the scope. Constraints associated with implementation of possible adaptation options were also discussed, such as the limits of potential capacity for additional hydropower in Albania and availability of fuel for thermal power plants, as well as key parameters that should be considered when undertaking the CBA, including costs of carbon dioxide emissions and economic value of water.

Directly after the workshop, further meetings were held with energy sector stakeholders from government, the private sector, research and academic institutions, and NGOs, during which the parameters for evaluating the adaptation options in the CBA were prioritized, and data on costs and benefits were obtained. In addition, a meeting was held with a group of engineering students, to consult on the assessment and hear their opinions about the most important parameters for the cost–benefit analysis.

Following from the workshop and meetings, the CBA approach and options to be assessed were further refined to provide the most value as an output from this assessment.

A1.7 HIGH-LEVEL COST–BENEFIT ANALYSIS (CBA)

As already outlined, during the second workshop, stakeholders discussed how the Albanian energy sector could be adapted to manage the potential risks to energy security from a changing climate. The CBA aimed to assess key sustainable development aspects (i.e., financial, social, and environmental aspects) that could be considered when assessing the optimal way in which adaptation could be implemented.

An economic model for assessing the benefits of environmental and social protection has been presented in Hardisty and Ozdemiroglu (2005). The WorleyParsons EcoNomics™ process that is based on this method was used. It explicitly describes and measures sustainability aspects in economic terms, by monetizing external costs and benefits and adding these to the conventional internal or private costs and benefits of a proposed project or action. Economic theory was then used to calculate the net present value (dollar value in today's money) of options that incur costs and benefits over a period of time (the planning horizon). This cost–benefit analysis approach is the basis upon which analyses of the adaptation options have been carried out (see Section 5). While the WorleyParsons EcoNomics™ process was used for this assessment, the approach is repeatable using standard methods.

A more detailed explanation of the CBA process is provided in Annex 5.

ANNEX 2 RISK ASSESSMENT BACKGROUND AND RATIONALE

Table A2.1: Scale for Assessing Likelihood of Occurrence of Hazard

Likelihood Category				
E	**D**	**C**	**B**	**A**
Rare	**Unlikely**	**Moderate**	**Likely**	**Almost certain**
Highly unlikely to occur	Given current practices and procedures, this incident is unlikely to occur	Incident has occurred in a similar country / setting	Incident is likely to occur	Incident is very likely to occur, possibly several times

OR

5% chance of occurring per year	20% chance of occurring per year	50% chance of occurring per year	80% chance of occurring per year	95% chance of occurring per year

Table A2.2: Scale for Assessing Magnitude of Consequence

	Magnitude of Consequence				
	1 - Insignificant	**2 - Minor**	**3 – Moderate**	**4 – Major**	**5 - Catastrophic**
Engineering / Operational	Impact can be absorbed through normal activity	An adverse event that can be absorbed with some management effort	A serious event that requires additional management effort	A critical event that requires extraordinary management effort	Disaster with potential to lead to shut down or collapse of the asset / network
Safety and Health	First aid case	Minor injury, medical treatment case with/or restricted work case	Serious injury or lost work case	Major or Multiple Injuries, permanent injury or disability	Single or multiple fatalities
Environment	• No impact on baseline environment • Localized to point source • No recovery required	• Localized within site boundaries • Recovery measurable within 1 month of impact	• Moderate harm with possible wider effect • Recovery in 1 year	• Significant harm with local effect • Recovery longer than 1 year • Failure to comply with regulations / consents	• Significant harm with widespread effect • Recovery longer than 1 year • Limited prospect of full recovery
Social	No impact on society	Localized, temporary social impacts	Localized, long-term social impacts	• Failure to protect poor or vulnerable groups • National, long term social impacts	• Loss of social license to operate • Community protests
Financial (for single extreme event or annual average impact)	<€100,000	€100k–€500k	€500k–€5m	€5m–€10M	>€10m
Energy Security: Lost Production / Load Shedding	Up to 1 hr	1 hr–3 hrs	3 hrs–12 hrs	12hrs–3 days	> 3 days
Reputation of Government / Political Context	Localized temporary impact on public opinion	Localized, short term impact on public opinion	Local, long-term impact on public opinion with adverse local media coverage	National, short-term impact on public opinion; negative national media coverage	National, long-term impact with potential to affect stability of government

Table A2.3: Risk Mapping (Before Adaptation)

				Consequence				
				Insignificant 1	Minor 2	Moderate 3	Major 4	Catastrophic 5
Likelihood	A	Almost Certain	95%	**16**		**6**	**3 4 7**	**1 2**
	B	Likely	80%	**19**	**15**	**10 11 12 13 14**	**5**	
	C	Moderate	50%		**18**	**8 9**		
	D	Unlikely	20%			**17**		
	E	Rare	5%		**20**			

Table A2.4: Risk Mapping (After Adaptation)

				Consequence				
				Insignificant 1	Minor 2	Moderate 3	Major 4	Catastrophic 5
Likelihood	A	Almost Certain	95%					
	B	Likely	80%			**5**		
	C	Moderate	50%	**16 19**	**4 15**	**2 3 6 13 14**		
	D	Unlikely	20%		**1 7 8 12 17 18**	**10 11**		
	E	Rare	5%	**9**	**20**			

Note: The risks are presented in the maps above using the "Risk Code No." noted on Table 3.

ANNEX 3: ADAPTATION OPTIONS

Table A3.1: Adaptation Options that Apply to All Energy Asset Classes

No.	**Adaptation Type**	**Potential Adaptation Actions Applicable to All Energy Asset Classes**	**Who could make it happen? Who would bear the cost? Would the action be acceptable to all stakeholders? What are the barriers or bottlenecks?**	**Is it a no-regret, low-regret or win-win option?**
Building Adaptive Capacity				
1	Research and analysis	• Climate risk assessments and cost-benefit analyses (CBA) could be further developed and incorporated into energy sector planning and asset design. • Higher resolution data on future climate variability and climate change for Albania and the wider South East Europe region could be developed • Develop more risk-based integrated climate change impact assessments, including cross-sectoral assessments exploring the interactions between water, agriculture, and energy. • Undertake research on the impacts of extreme climatic events on energy assets. • Keep track of new developments in climate change research of relevance to the energy sector. • Re-invigorate participation in World Meteorological Organization. • Join European Center for Medium-range Weather Forecasting. • Join EUMetnet, expand contribution to European consolidated observing system (EUCOS), prepare to join other European meteorological institutions (EMIs) and consider supporting EU COST. • Contribute research on climate change and support European Meteorological Society. • Work in partnership with South Eastern Europe region to develop shared understanding of climatic	• Would require funding and collaboration between policy makers / regulators and energy sector developers and operators as well as technical experts (e.g., climatologists, hydromet service providers). • Albania would need to collaborate with other national governments in the region.	**No-regret**

No.	Adaptation Type	Potential Adaptation Actions Applicable to All Energy Asset Classes	Who could make it happen? Who would bear the cost? Would the action be acceptable to all stakeholders? What are the barriers or bottlenecks?	Is it a no-regret, low-regret or win-win option?
		vulnerabilities and risks, and their implications for regional energy security, pricing and trade.		
2	Data collection and monitoring	• Monitor impacts of climatic factors on energy sector performance. • Continuously monitor and update regional weather and water resource availability. • Monitor and forecast regional energy demand and availability of shared energy from regional sources, and hydropower available within Albania that draws on shared resources (e.g., Lake Ohrid) that could be affected by upstream energy users. • Share weather monitoring and forecasting data between Institute or Energy, Water and the Environment, Military Weather Services and the National Air Traffic Agency. • Repair and adapt existing automated climate stations to provide continuous reporting, using for example solar panels to power them. • Share data regionally in return for regional information exchange. Data on precipitation and runoff could be shared with regional neighbors, given that Albania's rivers are shared with Greece, Macedonia and Kosovo. • Reestablish monitoring and analysis of the watersheds. At the moment, seasonality of the flow and its trends are unclear. Contingency planning could be less expensive if this information were available.	• Government (including Ministry of Environment), KESH and hydromet service providers. • Would require collaboration internationally. • Would need funding for participation in regional meteorological collaborative efforts, membership in, for instance, ECMWF, EUMetsat, EUMetnet and ICEED. • Funding would be a potential barrier, together with loss of hydromet capacity	**No-regret**
3	Changing or developing regulations, standards, codes, etc.	• Consider amending regulations to require developers to consider climate change in proposals and energy sector contracts • Develop tariffs and incentives to promote climate resilience of energy sector.	• METE, Ministry of Environment and ERE. • Barriers: would require developers to have access to information on climate change (above), and to be able to interpret this data (i.e. must be tailored to users); it would require regulators to be	**Low-regret**

No.	Adaptation Type	Potential Adaptation Actions Applicable to All Energy Asset Classes	Who could make it happen? Who would bear the cost? Would the action be acceptable to all stakeholders? What are the barriers or bottlenecks?	Is it a no-regret, low-regret or win-win option?
		• Consider amending regulations to capture climate change costs in energy price and the price of water. • Review and upgrade (as necessary) design codes for assets and infrastructure to support their climate-resilience. • Incorporate climate risk and adaptation assessment in Environmental and Social Impact Assessments for new energy facilities.	conversant with climate change risks and impacts and have capacity to assess submissions. • Enforcement of new codes for infrastructure could be an issue. Codes would need to be aligned with EU standards. • Costs of making new assets climate change resilient could be shared between Government and developers (KESH and private sector). • Would require high-level commitment and mechanisms for enforcement.	
4	Awareness-raising and organizational development	• Awareness of climate change and its impacts could be raised and championed in government on a multisector basis. • Committee or collaborative organization could be established to oversee action on climate resilience. • Capacity would need to be built in all sectors (public and private institutions). • Perceptions would need to be changed, so that climate change is not seen as simply an environmental issue.	• Government, regulators and other public bodies (universities). • Government would bear the cost. International adaptation funds or other international support could potentially be drawn upon. • Potential barriers: ownership, commitment, funding.	**No-regret**
5	Working in partnership	• Regional cooperation could be initiated to develop climate-resilient management plans for shared watersheds. • Energy-sector stakeholders and organizations dependent on the energy sector could work in partnership to understand climate change risks and develop adaptation measures. • Partnership working could help to avoid competition between different organizations' adaptation strategies.	• Joint initiatives involving the Government, energy industry, hydromet services, academics / research institutes, other users of water and energy and consumers. • It could be useful to establish whether there is an existing industry organization that could champion this. • National government could lead on engaging with national governments in the region.	**No regret**

No.	Adaptation Type	Potential Adaptation Actions Applicable to All Energy Asset Classes	Who could make it happen? Who would bear the cost? Would the action be acceptable to all stakeholders? What are the barriers or bottlenecks?	Is it a no-regret, low-regret or win-win option?
Delivering Adaptation Actions				
6	Accept impacts and bear (some) loss	• Consider establishing a process to ensure that future development design takes account of climate change effects. • Identify key assets at risk from climate change and plan for their future management.	• National government, operators (KESH and OST) and regulator (ERE).	**Low-regret**
7	Spread/share impacts	• Draft National Energy Strategy promotes diversification into TPP and other renewables, as well as regional energy trading, which could help provide improved energy security. • Regional energy trading could help to spread risks of climate-related disruptions to supply.	• The Albanian government would need to attract external private investors.	**No-regret**
		• Diversifying the location of energy assets could help avoid concentrating assets in at-risk locations.	• Government could set the strategy.	**Other**
		• Consider the use of weather insurance to cover potential risks. • Where available, consider using other financial products that lay-off risk, such as Alternative Risk Transfer mechanisms (ART) including risk bonds, futures, derivatives, swaps, and options.	• Operators (KESH, OST, private).	**Other**
8	Avoid negative impacts	• New energy assets could be designed to be climate-resilient. • Rehabilitation of existing assets could provide an opportunity to build in climate-resilience.	• Operators (KESH, OST, private). • Barriers: lack of awareness and information on which to act. • Costs and coordination issues would need to be considered.	**Low-regret**
		• Engineering solutions could improve efficiency of generation, transmission and distribution, and use of water and energy. • Contingency planning could support a response to increasing risk of heat waves and drought.	• Engineers, driven by government. • Government and operators.	**No-regret**
		• Consider location of new energy assets • Support implementation of improved design	• Government and operators.	**Low-regret**

No.	Adaptation Type	Potential Adaptation Actions Applicable to All Energy Asset Classes	Who could make it happen? Who would bear the cost? Would the action be acceptable to all stakeholders? What are the barriers or bottlenecks?	Is it a no-regret, low-regret or win-win option?
		standards for new assets		
		• Continue the existing efforts to improve efficient use of water resources in the agriculture sector, and reduce technical and commercial water losses.	• Government and farmers.	**Win-win**
9	Exploit opportunities	• Climate models are generally in good agreement over Albania regarding changes in temperature and summer precipitation, providing a useful basis for analysis of sensitivities of energy assets and development of climate resilience. • There is significant potential to improve energy efficiency (demand and supply side).	• Government could set standards for energy efficiency. • Barriers: funding and enforcement.	**No-regret**
		• Identify and consider developing energy technologies that are favored by future climate change conditions, e.g., increased solar potential due to increased sunshine hours.	• Asset developers (KESH and private sector.	**Low-regret**
		• TPP are not as climatically vulnerable as many other forms of energy generation.	• Government could set the strategy. • Delivered by operators (KESH and private).	**Other**

Table A3.2: Adaptation options—Energy Demand and Demand-side Energy Efficiency

No.	Adaptation Type	Potential Adaptation Actions for Energy Demand and Demand-Side Efficiency	Who could make it happen? Who would bear the cost? Would the action be acceptable to all stakeholders? What are the barriers or bottlenecks?	Is it a no-regret, low-regret or win-win option?
Building Adaptive Capacity				
10	Research and analysis	• Develop better understanding of the relationships between climate-related factors and energy demand. • Develop better understanding of the change in demand and change in residential and nonresidential sectors due to climate change. • Undertake cost–benefit analyses of adaptation	• Energy sector experts work with met / hydromet service providers.	**No-regret**

No.	Adaptation Type	Potential Adaptation Actions for Energy Demand and Demand-Side Efficiency	Who could make it happen? Who would bear the cost? Would the action be acceptable to all stakeholders? What are the barriers or bottlenecks?	Is it a no-regret, low-regret or win-win option?
		measures.		
11	Data collection and monitoring	• Monitor peak demand for space cooling in summer.	• METE and KESH.	**No-regret**
12	Changing or developing regulations, standards, codes, etc.	• Consider amending regulations, standards, codes of practice to ensure they are resilient to / take account of changing climatic conditions. • Support enforcement of regulations/ codes for energy efficiency in new buildings. • Consider use of tariff instruments to support energy efficiency and change consumer behaviour. Identify ways to regulate energy efficiency in existing buildings.	• Government and regulator. • . • Regulations/ codes would require alignment with EU standards. • Would require high-level commitment and mechanisms for enforcement. • Investment in existing building upgrades could be incentivized by government. • Enforcement of new codes could be an issue.	**Low-regret**
Delivering Adaptation Actions				
13	Accept impacts and bear (some) loss	• Be prepared for increase in summer energy demand for cooling.	• Government and energy sector operators (KESH and private)	**No-regret**
14	Avoid negative impacts	• Improve domestic, commercial, and industrial energy efficiency. • Tackle and reduce commercial losses, for instance through use of tariffs and incentives.	• Government, regulator, and CEZ. • Barriers: lack of funding to deliver energy efficiency measures, inertia whereby consumers are slow to make changes. • Incentives could be considered such as grants / rebates for energy efficiency measures.	**No-regret**
		• Install alternative fuel sources (other than electricity) for heating buildings.	• Building owners. • Barriers: insufficient service alternatives to electric power heating.	**Other**
15	Exploit opportunities	• Significant potential to improve energy efficiency.	• Government could provide incentives such as grants / rebates for energy efficiency measures.	**No-regret**
		• Higher solar radiation (due to projected less cloud cover with climate change) increases opportunities for domestic and commercial solar water heating. • Geothermal energy resources could be used for	• Building owners.	**Low-regret**

No.	Adaptation Type	Potential Adaptation Actions for Energy Demand and Demand-Side Efficiency	Who could make it happen? Who would bear the cost? Would the action be acceptable to all stakeholders? What are the barriers or bottlenecks?	Is it a no-regret, low-regret or win-win option?
		domestic and commercial heating and cooling. Geothermal energy is not climatically vulnerable and could potentially help increase climate resilience.		

Table A3.3: Adaptation Options—Large Hydropower Plants (LHPP)

No.	Adaptation Type	Potential Adaptation Actions for Large Hydropower Plants (LHPP)	Who could make it happen? Who would bear the cost? Would the action be acceptable to all stakeholders? What are the barriers or bottlenecks?	Is it a no-regret, low-regret or win-win option?
Building Adaptive Capacity				
16	Research and analysis	• Develop better understanding of the relationships between climate-related factors and the performance of LHPP assets. • Develop watershed-based hydromet data gathering to optimize operation of existing LHPP and characterize other potential basins for new LHPP. • Develop better understanding of impact of climate change on frequency and severity of drought and storm periods. • Study the feasibility of building pump and storage plants. • Explore opportunities to improve weather/ climate information services (seasonal forecasts, etc.) • Consider local downscaling of climate change scenarios benchmarked against past experience of climate and assess impacts on LHPP performance. • Develop more risk-based integrated climate change impact assessments to help optimize use of LHPP, including the impacts of extreme climatic events.	• Collaboration between policy makers/ regulators and energy sector developers and operators as well as hydromet service providers. • Barriers: lack of capacity of hydromet services (financial, human, institutional, etc.). • National government could work with other national governments to understand cross-border issues.	**No-regret.**

No.	Adaptation Type	Potential Adaptation Actions for Large Hydropower Plants (LHPP)	Who could make it happen? Who would bear the cost? Would the action be acceptable to all stakeholders? What are the barriers or bottlenecks?	Is it a no-regret, low-regret or win-win option?
		• Perform analysis looking at cross-sector and cross-border impacts of climate change in relation to water management for LHPPs.		
17	Data collection and monitoring	• Monitoring to focus on more vulnerable assets, e.g., existing and planned LHPP. • Monitor sedimentation of hydropower facilities to confirm operational lifetime aspects are correctly assessed in light of climate change, in the Drin cascade particularly. Sedimentation has not been measured for more than 40 years. • Monitor dam security.	• KESH and other operators could monitor impact of climatic factors. • KESH and the Large Dam Safety Board could examine sedimentation. • Limited historical topographical data may make sedimentation assessment difficult.	**No-regret**
18	Changing or developing regulations, standards, codes, etc.	• Consider amendments to regulations to require LHPP developers to consider climate change in proposals and energy sector contracts. • Consider amending design standards for LHPP to ensure assets are climate-resilient over their lifetimes. • Consideration how climate concerns could be built into long-term LHPP contracts. • Strengthen efforts to control illegal logging, which increases risks of soil erosion and consequent sedimentation of reservoirs. • Ensure that regulations on dam safety are implemented.	• Government and LHPP operators. • Costs would be borne by operators.	**Low-regret**
19	Working in partnership.	• Holders of existing and future hydromet data could work in partnership with LHPP operators.	• Hydromet data holders and LHPP operators. • Barrier: hydromet data may be viewed as a valuable asset and not willingly shared with other parties.	**No-regret**
Delivering Adaptation Actions				
20	Accept impacts and bear (some) loss.	• Be prepared for more frequent drought and storm events as well as changing hydrographic profiles for basins.	• LHPP operators.	**No-regret**
21	Spread/share impacts.	• Share cost of adapting existing assets.	• Government, utility operators.	**Other**

No.	Adaptation Type	Potential Adaptation Actions for Large Hydropower Plants (LHPP)	Who could make it happen? Who would bear the cost? Would the action be acceptable to all stakeholders? What are the barriers or bottlenecks?	Is it a no-regret, low-regret or win-win option?
22	Avoid negative impacts.	• Increase LHPP-installed capacity, ensuring that new assets are designed to be climate change-resilient. • Consider raising the dam crest on Fierze. • Consider increasing the capacity of spillways on Fierze and Komani dams. • Consider development of a pump storage scheme on Drin river cascade.	• Government, utilities. • Barriers: lack of awareness and information on which to act, costs, coordination. • Feasibility studies would be needed for all engineering adaptation options.	**Other**
		• Establish whether proposed locations for new LHPP would be sustainable in the face of climate change risks to water resources. • Improve existing asset efficiency through measure such as: clear / redesign trash racks, upgrade turbines and generators, replace equipment to reduce water losses (shut-off valves), improve apron below dams to reduce erosion, use improved hydromet data to optimize operation. • Strengthen contingency planning for operation during periods of extreme drought	• Government, utilities, and private developers.	**No-regret**
23	Exploit opportunities	• Rehabilitation of existing dams (options noted above).	• Government and utilities.	**No-regret**

Table A3.4: Adaptation Options—Small Hydropower Plants (SHPP)

No.	Adaptation Type	Potential Adaptation Actions for Small Hydropower Plants (SHPP)	Who could make it happen? Who would bear the cost? Would the action be acceptable to all stakeholders? What are the barriers or bottlenecks?	Is it a no-regret, low-regret or win-win option?
Building Adaptive Capacity				
24	Research and analysis	• Develop better understanding of relationship between snowfall, snowmelt and SHPP generation. • Develop higher resolution data on future snowfall and snowmelt projections. • Assess the future relationship between SHPPs and demand for water from other users (e.g., agriculture). • Develop watershed based hydromet data gathering to better inform future water use. • Explore opportunities to improve weather/ climate information services (e.g., seasonal forecasts). • Consider local downscaling of precipitation and temperature using an ensemble of GCMs, benchmarked against their ability to predict observed precipitation. • Develop more risk-based integrated climate change impact assessments, including the impacts of extreme climatic events. • Perform analysis looking at cross-sector and cross-border impacts in relation to water management.	• Collaboration between policy makers/ regulators and energy sector developers and operators as well as hydromet service providers. • Barriers: capacity of hydromet services (financial, human, institutional, etc.) • National government could collaborate with other national governments to understand cross-border issues.	**No-regret**
25	Data collection and monitoring	• Monitoring to focus on more vulnerable assets, e.g., existing and planned SHPP. • Monitor changes in snow and river flows for their impacts on SHPP production.	• Hydromet service providers and SHPP owners.	**No-regret**
26	Changing or developing regulations, standards, codes, etc.	• Consider amending regulations to require SHPP developers to consider climate change in proposals and energy sector contracts. • Consider amending design standards for SHPP to ensure they are climate-resilient over a facility's lifetime.	• Government, regulator (ERE) and SHPP owners.	**Low-regret**

No.	Adaptation Type	Potential Adaptation Actions for Small Hydropower Plants (SHPP)	Who could make it happen? Who would bear the cost? Would the action be acceptable to all stakeholders? What are the barriers or bottlenecks?	Is it a no-regret, low-regret or win-win option?
		• Consider how climate change could be built into long-term SHPP contracts. • Consider how regulations could support water resource allocation for energy generation as well as other users.		
27	Working in partnership	• Improve watershed management together with agricultural water users. Support delivery of medium-range (3 to 10 day) forecasts for farmers to build partnership, buffer potential conflicts over water availability and support coordination on water use.	• Hydromet service providers, farmers, and SHPP owners. • An institutional decision would be needed to support information flow to irrigation users.	**Win-win**
Delivering Adaptation Actions				
28	Spread/share impacts			
29	Avoid negative impacts	• Consider whether proposed locations for new SHPPs would be sustainable in the face of climate change risks to water resources and competition from other water users. • Improve management of water resources (e.g., reduce technical and commercial losses). • Improve efficiency of water use in agriculture sector (much progress on this has been achieved recently). • Contingency planning for operation during periods of extreme drought. • Improve efficiency and performance of existing SHPP through measures such as replacing old turbines, purchasing larger turbines or by replacing the turbine's runners with more efficient ones; increasing turbine name-plate output through a detailed hydrological study that would support to better usage of the flow; digging wider channels; replacing/rehabilitating other equipment (e.g., stop, control and shut-off valves). Generally,	• Regulator, OST, and SHPP developers. • Barriers: lack of awareness and information on which to act; costs and coordination; Access to finance for asset improvement sand new SHPP investments. • Review the use of guarantees to support the owners of SHPP in accessing capital.	**No-regret**

No.	Adaptation Type	Potential Adaptation Actions for Small Hydropower Plants (SHPP)	Who could make it happen? Who would bear the cost? Would the action be acceptable to all stakeholders? What are the barriers or bottlenecks?	Is it a no-regret, low-regret or win-win option?
		improvements could be achieved by replacing/ rehabilitating each piece of equipment in the SHPP. • Assess whether the transmission grids are able to carry power generated by SHPPs.		
		• Develop water storage capacity for SHPPs to support for longer periods of operation.	• Regulator (ERE) and SHPP owners, working with farmers.	**Low-regret**
30	Exploit opportunities	• Upgrade existing SHPP facilities. • SHPP could play a role in providing local electricity supply in remote areas, more prone to transmission failure during extreme climatic events that are predicted to increase.	• SHPP owners' association, METE, and AKBN. • Barriers: Feed-in tariff for existing SHPP is less than new SHPP; linking SHPP to the transmission system can take time.	**No-regret**

Table A3.5 Adaptation Options—Thermal (Fossil Fuel) Power Plants (TPP)

No.	Adaptation Type	Potential Adaptation Actions for Thermal Power Plants (TPP)	Who could make it happen? Who would bear the cost? Would the action be acceptable to all stakeholders? What are the barriers or bottlenecks?	Is it a no-regret, low-regret or win-win option?
Building Adaptive Capacity				
31	Research and analysis	• Develop risk-based integrated climate change impact assessments when siting and designing TPPs. For coastal facilities consider sea-level change and coastal storm surge in the assessment. For river-cooled TPP, assess flood risk and availability of cooling water and environmental impacts during periods of low flow or high temperatures.	• Would require collaboration between policy makers/ regulators and TPP developers and operators as well as technical experts; and funding. • Could assist in understanding and anticipating risks, and integration of risk management into sector operations. • Could take time to achieve international standards.	**No-regret**
32	Data collection and monitoring	• Monitor impacts of climatic factors on performance of TPP (e.g., reduction in efficiency during high-temperature periods) • If new TPP are river-water cooled, monitor river flows to ensure abstraction and discharges do not	• TPP operators	**No-regret**

No.	Adaptation Type	Potential Adaptation Actions for Thermal Power Plants (TPP)	Who could make it happen? Who would bear the cost? Would the action be acceptable to all stakeholders? What are the barriers or bottlenecks?	Is it a no-regret, low-regret or win-win option?
		damage the river water environment during periods of low flow.		
33	Changing or developing regulations, standards, codes, etc.	• Consider amending regulations to require TPP developers to consider climate change in proposals and energy sector contracts. • Review and upgrade (where necessary) design codes for TPP assets and associated infrastructure (buildings, pipelines, roads, etc.) to ensure their climate resilience. • Integrate climate risk assessment, including changes in sea level, storm surges and coastal erosion in the design of new coastal infrastructure.	• Regulator and TPP developers.	**Low-regret**
Delivering Adaptation Actions				
34	Accept impacts and bear (some) loss	• Assess potential impact, if any, of changing sea levels and coastal erosion on the proposed site for the Porto Romano TPP.	• Government, regulator and developer. • Barriers: information.	**No-regret**
35	Spread/share impacts	• Typically insurance for TPPs would cover usual risks such as earthquake, flood and fire. TPP developers could engage with insurers to discuss if risks could change as a result of rising sea levels and coastal erosion.	• TPP owners.	**Other**
36	Avoid negative impacts	• Consider whether proposed coastal locations for new TPP would be sustainable in the face of climate change risks (sea-level change, erosion). • If river-water-cooled TPP are considered in the future, ensure that their abstraction and discharge requirements would not adversely affect river environments, noting that river flows would likely decrease in the summer. Develop contingency plans to manage potential risks. • To manage the impacts of rising temperatures on TPPs, technical adjustments could be made. For example, condensers could be enlarged and/or cooling water flow rates could be increased.	• Government and TPP developers. • Barriers: lack of awareness and information on which to act; costs and coordination.	**No-regret**

Table A3.6: Adaptation Options—Other Renewable Energy Sources

No.	Adaptation Type	Potential Adaptation Actions for Other Renewable Energy Sources	Who could make it happen? Who would bear the cost? Would the action be acceptable to all stakeholders? What are the barriers or bottlenecks?	Is it a no-regret, low-regret or win-win option?
Building Adaptive Capacity				
37	Research and analysis	• Map wind resources, in the Karabun Peninsula and in other regions that are likely sites, to identify best locations and design for new wind turbines. • Map geothermal resources. • Undertake climate risk assessment and CBA of adaptation measures when planning and designing new renewable energy assets.	• Would require collaboration between policy makers/ regulators and renewable power developers and operators as well as technical experts. • Would assist with understanding and anticipating risks, and integration of risk management into sector operations. • Would require funding and commitment. • Could take time to reach international standards.	**No-regret**
38	Data collection and monitoring	• Monitor impacts of climate factors on renewable energy assets.	• Asset owners and meteorological service providers.	**No-regret**
39	Changing or developing regulations, standards, codes, etc.	• Consider amending regulations to require renewable power asset developers to consider climate change in proposals and energy sector contracts. • Review and upgrade (where necessary) design codes for renewable energy assets and associated infrastructure (e.g., buildings, pipelines, roads, etc.) to ensure that assets are climate-resilient.	• Government and regulator.	**Low-regret**
Delivering Adaptation Actions				
40	Exploit opportunities	• Decreased cloudiness due to climate change (particularly in summer) would benefit solar energy production.	• Households, commercial property owners • Developers of large-scale solar assets (e.g., CSP).	**Other**

Table A3.7 Adaptation Options—Electricity Transmission and Distribution

No.	Adaptation Type	Potential Adaptation Actions for Electricity Transmission and Distribution	Who could make it happen? Who would bear the cost? Would the action be acceptable to all stakeholders? What are the barriers or bottlenecks?	Is it a no-regret, low-regret or win-win option?
Building Adaptive Capacity				
41	Research and analysis	• Undertake climate risk assessment and CBA of adaptation measures when upgrading or developing new T&D systems. Critical climate data for design of T&D systems are minimum and maximum temperatures, and wind conditions.	• Would require collaboration between policy makers/ regulators and T&D developers and operators as well as technical experts. • Would assist with understanding and anticipating risks, and integration of risk management into sector operations. • Would require funding and commitment. • Could take time to reach international standards.	**No-regret**
42	Data collection and monitoring	• Monitoring to focus on more vulnerable assets, e.g., vulnerable areas of distribution system, and rural /remote areas. • Monitor effects on transmission losses due to higher temperatures.	• OST and CEZ.	**No-regret**
43	Changing or developing regulations, standards, codes etc	• Consider amending regulations, standards, codes of practice for T&D systems to ensure they are resilient to / take account of changing climatic conditions. • Re-assess the climate parameters used for design of existing transmission lines (e.g., frequency of extreme events).	• Government and regulator, drawing on information from meteorological service providers.	**Low-regret**
Delivering Adaptation Actions				
44	Accept impacts and bear (some) loss	• Accept slightly higher technical losses due to higher temperatures. Meet losses through extra generating capacity	• OST and CEZ.	**Other**
45	Spread/share impacts	• Privatization of distribution system passes risks to a private partner	• CEZ.	**Other**

No.	Adaptation Type	Potential Adaptation Actions for Electricity Transmission and Distribution	Who could make it happen? Who would bear the cost? Would the action be acceptable to all stakeholders? What are the barriers or bottlenecks?	Is it a no-regret, low-regret or win-win option?
46	Avoid negative impacts	• Examine costs and benefits of further upgrade of transmission and distribution system to account for lower efficiency in hotter weather. Considering the following options: • Insulating the lines • Underground cables (which makes them less susceptible to climatic conditions) in certain areas where uninterruptible supply is required • Use of DC instead of AC current (noting that this is expensive).	• OST and CEZ. • Barriers are lack of awareness and information on which to act; costs and coordination.	**Other**
		• Contingency planning for effects of high winds, lightning, ice loading on T&D systems.	• OST and CEZ.	**No-regret**
47	Exploit opportunities	• There is large potential to improve efficiency of the distribution system. The transmission grid has recently been upgraded to EU standards that should make it resilient to a wide range of climatic conditions. However, it is noted that EU standards have not yet taken on board climate change (though this will change in time, according to the EU Adaptation White Paper).	• OST and CEZ.	**No-regret**

Table A3.8: Adaptation Options—Fossil Fuel Supply and Transmission / Transportation

No.	Adaptation Type	Potential Adaptation Actions for Fossil Fuel Supply and Transmission/ Transportation	Who could make it happen? Who would bear the cost? Would the action be acceptable to all stakeholders? What are the barriers or bottlenecks?	Is it a no-regret, low-regret or win-win option?
Building Adaptive Capacity				
48	Research and analysis	• Undertake climate risk assessment and CBA of adaptation measures for existing and new fossil fuel resources.	• Would require collaboration between policy makers/ regulators and fossil fuel developers and operators as well as technical experts. • Would assist with understanding and anticipating risks, and integration of risk management into sector operations. • Would require funding and commitment. • Could take time to reach international standards.	**No-regret**
49	Data collection and monitoring	• Monitor changing ground conditions and concentrations of ground pollutants at Patos Marinza. • Monitor effects of sea level rise, storm surges and coastal erosion on coastal assets. • Monitor integrity of existing low pressure gas pipeline due to landslips after heavy downpours. • Monitor potential for pollution incidents due to heavy downpours at mines.	• Operators of oil, gas, and coal production facilities and Ministry of Environment.	**No-regret**
50	Changing or developing regulations, standards, codes, etc.	• Consider amending regulations to require developers of fossil fuel assets to consider climate change in proposals and contracts. • Review and upgrade (where necessary) design codes for fossil fuel assets and associated infrastructure (buildings, pipelines, roads, ports, etc.) to ensure that assets are climate-resilient.	• Government and regulators. • Asset owners. • Infrastructure owners.	**Low-regret**
Delivering Adaptation Actions				
51	Avoid negative impacts	• Identify whether contaminated land remediation would be effective / quick enough in light of climate change impacts.	• Operators of oil and coal production facilities and Ministry of Environment • Barriers: lack of awareness and information on which	**No-regret**

No.	Adaptation Type	Potential Adaptation Actions for Fossil Fuel Supply and Transmission/ Transportation	Who could make it happen? Who would bear the cost? Would the action be acceptable to all stakeholders? What are the barriers or bottlenecks?	Is it a no-regret, low-regret or win-win option?
		• Support contingency planning for legacy contaminated land e.g., effects of drought followed by heavy downpour leading to contamination and health risks. • Support contingency planning for effects of extreme precipitation on mine sites and associated pollution risk.	to act; costs and coordination.	
52	Exploit opportunities.	• Higher temperatures could have a slight beneficial impact on the cost profile at oil production facilities.	• Operators of oil production facilities could benefit.	**Other**

ANNEX 4: WEATHER / CLIMATE INFORMATION SUPPORT FOR ENERGY SECTOR MANAGEMENT

Table A4.1: Design and Operation of Energy Plants

This table has been extracted from Hancock and Ebinger (2009).

	Design		**Operations and Maintenance**	
	Current Resources	**Options to Improve**	**Current Resources**	**Options to Improve**
Large Hydropower Plants (LHPP)	For LHPP design, hydrological models and time series of flow are needed, but they are out of date.	Revise hydrological models, recommence measurements; digitize all available data.	For continuous optimization of reservoir levels, continuous awareness of water in the system and rain entering the system are needed. There is only a small network of river-level gauges in the Drin watershed. Radar assessments of ongoing precipitation would be useful; precipitation forecasts would be helpful. But there is no radar, and numerical precipitation forecasts are low resolution and not verified.	Expand river-level gauge network in Drin; initiate in Mati; and add rain gauges in both watersheds to indicate water entering the system (radar better). Identify best-skilled atmospheric models with respect to historical Albanian precipitation data. Downscale an ensemble of such to facilitate analysis of watersheds under climate change.
Small Hydropower Plants (SHPP)	For design of new SHPPs or to select which concessions are economically promising today, watershed models are needed, but those available date to 1990 or before, and rainfall statistics to 1990.	Undertake revision of hydrological models. Digitize rainfall data and make it publicly available. Improve monitoring.	To plan power generation and turbine management, operators have only low-resolution precipitation forecasts for the very near term. Forecasts are not routinely verified.	Highly resolved precipitation forecasts could be undertaken and could provide probabilistic information out to seven days. Rain gauges would indicate water entering the system (radar better). Not only for LHPPs but also for SHPPs would be useful to identify best-skilled atmospheric models with respect to historical Albanian precipitation data (and downscale an ensemble to facilitate analysis of watersheds under climate

	Design		Operations and Maintenance	
	Current Resources	**Options to Improve**	**Current Resources**	**Options to Improve**
				change).
Power Transmission and Distribution (T&D)	To devise distribution network protected against severe weather, climate data (minimum and maximum temperature and wind conditions) are needed, but what exists is old and much is not digitized.	Digitize the climate data and make it available publicly; strengthen monitoring.	To anticipate risks to network and undertake rapid repairs, storm forecasts and lightning detection are needed. But severe storms are not reliably forecast; no lightning detection network in place; no radar.	Initiate highly resolved probabilistic weather forecasts with verification to tune accuracy; initiate lightning detection to speed network repairs; undertake weather and radar monitoring to assess storms underway.
Thermal Power Plants (TPP)	To assess availability of cooling water for river or lake cooled TPPs, water temperatures, ambient air temperatures, and climate data are needed. Data up to 1990 are available; beyond that, data set is incomplete and hydrological models are old.	Revise hydrological models to show availability of cooling water; expand monitoring of rainfall to support ongoing revisions.	To assess adequacy and temperature of cooling water and ambient air temperatures, assessment of stream levels and rainfall entering the system are needed, but lacking. No radar. Forecasts needed, but these are low resolution and risky to use as they do not provide probabilistic information and are not verified.	Monitor rainfall entering the system to provide cooling water (radar, rainfall, stream levels); improve resolution of weather forecasts and provide probabilistic information.
Wind	To site and design wind generation plants, knowledge of wind speed distributions at turbine height is needed. But little data are available. Maps have been undertaken at low resolution, but their accuracy at turbine height is not known; data at turbine height have been taken in a few places but not long term.	Improve resolution of wind maps; add monitoring of wind at turbine height.	To anticipate wind extremes and assure security of infrastructure, wind forecasts are needed. But forecasts are at very low resolution, lack probabilistic information and are not verified.	Improve resolution of forecasts; add monitoring of wind at key altitudes; calibrate the forecasts.

	Design		**Operations and Maintenance**	
	Current Resources	**Options to Improve**	**Current Resources**	**Options to Improve**
Solar	To site large solar arrays, need data on irradiance and cloudiness. Satellite imagery could be used. Future cloudiness is not known but is generally projected by climate models to decrease in summer associated with decrease in precipitation; this is a skill gap in climate modeling.	Climatology of cloudiness assessed in more detail; assessment of model accuracy.	To anticipate solar power generation, cloudiness forecasts are needed, but these are available at low resolution and not verified.	Increase resolution of forecasts; include cloudiness in further detail.
Energy Demand	To forecast demand long-term, KESH has data on demand patterns in the past.	The widest possible range of climate projections covering natural effects as well as anthropogenic effects should be reviewed to understand the range of future demand possibilities linked to temperatures, cloudiness, etc.	To forecast demand day to day, forecasts of key demand variables (such as temperature, cloudiness) are needed, but these are available only at low resolution, without probabilistic information, and not verified.	Increase resolution of forecasts, provide probabilistic information, undertake verification and tuning.

ANNEX 5: FURTHER DETAILS ON APPROACH TO COST–BENEFIT ANALYSIS

This annex contains supplementary information to the cost–benefit analysis (CBA), outlined in Section 5. It includes the following sections:

- Methodology
- Framing workshop parameters summary
- Financial assumptions
- Benefits assessment and valuation
- Results summary
- Limitations

A5.1 METHODOLOGY

Assessment Process Overview

A structured process has been used to evaluate ways to address the shortage of energy generation predicted to be caused by climate change. This process involved the following steps:

1. Identify the issue or dilemma requiring assessment, followed by background data review and discussions.
2. Conduct a formalized workshop process, carried out with stakeholders to frame the assessment overall.
3. Collect data and pursue consultation.
4. Conduct economic CBA modeling.
5. Present results.

The key steps in this process are discussed in more detail next.

Theoretical Basis for the Assessment

An economic model for assessing the benefits of environmental and social protection has been presented in Hardisty and Ozdemiroglu (2005). Based on this CBA method, it is possible to explicitly monetize a number of relevant external costs and benefits, thereby allowing these costs and benefits to be added into the conventional internal or private (company or developer) costs and benefits of a proposed project or action. This model, described below in more detail, is the basis upon which the analysis of options has been carried out.

Benefits

Objective setting must consider the benefits of achieving a given objective. In economics, the overall objective of any decision is assumed to be the maximisation of human welfare over time. To compare the different benefit and cost streams over time, the process of discounting is used and amounts over time are expressed as present values. Economic analysis recommends the decision with the maximum net present value (NPV) (present value of net benefits, or benefits minus costs, over time) or the highest benefit cost ratio (BCR) (ratio of the present value of benefits to the present value of costs). Benefits of environmental protection can effectively be expressed as the “damages avoided” by undertaking that action.

Net Benefits

What is important in a decision-making process is the overall comparison of the costs of action, with the benefits of action; hence the term *cost–benefit* analysis. To find net benefits, we deduct the flow of costs from the flow of benefits.

Thus, the present value of the net benefits (NPV) (benefits minus costs) of the selected project or action in any year, *t*, is given by:

$$NPV = \sum_{0}^{T} \left[\frac{(B_p + B_x) - (C_p + C_x)}{(1+r)^T} \right]$$

Where NPV is the total social NPV of project p, B_p and C_p are the private or internal costs and benefits of the project, B_x and C_x are the external benefits and costs of the project respectively and r is the discount rate.

Valuation of Benefits

For the equation to be calculated, both the costs and benefits of each adaptation option must be estimated in a common unit. Economic analysis uses money as this common unit, based on what individuals are willing to pay, and what one would have to spend on the actions to supplement the shortfall in energy generation due to climate change.

The value of the environment or natural resources includes: as an input to production or consumption (direct use value); its role in the functioning of ecosystems (indirect use value); or its potential future uses (option value). In the case of water, for instance (a key consideration in this study), people may also value water and be willing to pay for its protection unrelated to their own use of the resource (nonuse values) but because of its benefits to others (altruistic value), for future generations (bequest value) and for its own sake (existence value). The sum of these different types of economic benefits or values is referred to as *total economic value* (TEV) in economic literature.

Private Benefits

If the analysis is undertaken from the perspective of the problem holder, only the costs and benefits that accrue to the problem holder are considered. This approach, which is a financial (as opposed to economic) analysis, uses market prices of costs and benefits, which include subsidies or taxes. Private discount rates are used, which are determined by the cost of capital or rates of return from alternative investments in the private sector. Private discount rates are generally higher than social discount rates. Financial analysis does not deal with environmental or other external social impacts. Table A5-1 presents a selection of typical private benefit categories.

Table A5.1: Private Benefit Categories—Examples

- Value of production realized from project or investment, from energy or water on-sale, for example
- Increased property value
- Elimination of corporate financial environmental liability
- Elimination of potential for litigation / prosecution (civil and criminal)
- Avoidance of negative public relations or even impact on company stock value
- Protection of a resource used as a key input to an economic process (e.g., water for irrigation or manufacture)
- Avoidance of exposure of on-site personnel to pollutants

A full economic analysis looks at those costs and benefits that accrue to society as a whole, and is therefore appropriate in helping to develop national policy. This includes costs and benefits to the project owner or state proponent as well as those to the rest of the society. The latter are also known as *external* costs and benefits (as they are external to the transactions in the market and hence not included in market prices) so long as they are not compensated by or paid to the problem holder. This different definition of costs and benefits requires them to be measured differently than in a financial (private) analysis.

The prices for marketed goods and services that are affected should no longer be market prices, but real or shadow prices. Shadow prices are estimated by subtracting (or adding) the subsidy and tax elements from (to) market prices. Subsidies and taxes are referred to as *transfer payments*—their payment does not cause a net change to the costs and benefits faced by the society as a whole but simply a transfer from one party to another within society. For example, litigation expenses are considered transfer payments. The proponent's costs for litigation become the benefits of the law firm, and hence cancel each other out when a social analysis is undertaken.

In practice, only some of the benefits identified during a CBA can be readily quantified and monetized. This is likely to include several of the key private benefits (such as land value). External benefits are less readily monetized, as there is often no market data that could be directly used for their estimation. Valuation methods applicable to problems of sustainable development include the following:

- *Actual market techniques*, where the good itself is priced on the open market as a saleable commodity. For example, water sold as drinking water has a price per unit volume, and land is bought and sold, and has a specific value, depending on location, zoning, and market conditions.
- *Surrogate market techniques,* in which a market good or service is found that is influenced by the externality that itself is not reflected in a market (or it is nonmarket). For example, water might be used to irrigate crops that are sold at market prices. The crop market in this example is a surrogate market and a proportion of the economic value of the yield is representative of the value of water as an input. This approach is especially useful when irrigation water is provided free or is subsidized resulting in lower prices than the water would have fetched in free markets in the absence of subsidies. If that water resource is polluted, another way to quantify the cost is to look at the expenditures people make to avoid the contamination damage (e.g., purchase of water filters or bottled water)—these markets act as a surrogate markets for the value of (clean) water.

- *Hypothetical market techniques* create hypothetical markets via structured questionnaires, which elicit individuals' willingness to pay (WTP) to secure a beneficial outcome or to avoid a loss, or their willingness to accept compensation (WTA) to forgo a beneficial outcome or to tolerate a loss. Among these stated preference techniques are contingent valuation and choice modeling.

WTP is a standard method used worldwide for estimating the economic value for goods and services for which no direct market exists. Economic valuations, transferred from a specific test group, location and subject and applied to other projects, are a common economic practice, known as Benefits Transfer, and a standard practice within WTP surveys.

In the process of undertaking a beneficial action, it is sometimes possible that secondary environmental impacts are produced by those actions, despite best attempts at mitigation. The economic value of these impacts should be included in the overall economic assessment. The costs of dealing with these effects (as a lower bound estimate), or the value of the damages that they cause, which are not borne by the problem holder, are termed *external costs of action* (Hardisty and Ozdemiroglu, 2005).

External costs of action (X) can be divided into two categories:

1. Planned or process-related external costs that cannot be mitigated against (X_{p})
2. Unplanned or inadvertent external costs (X_{up}), such that:

$$X = X_{\mathrm{p}} + (P \times X_{\mathrm{up}})$$

where P is the probability that the unplanned external cost will occur.

External costs of action could include production of greenhouse gases from energy-intensive solutions, production of other airborne pollutants such as NOx and SOx, and secondary impacts on water quality, biodiversity, or community.

Modeling

The CBA modeling is based on published methodologies (Hardisty and Ozdemiroglu, 2005; UK Environment Agency, 1999), and follows conceptual approaches espoused and approved by a number of government organisations worldwide.

A5.2 FRAMING WORKSHOP PARAMETERS SUMMARY

Table A5.2 presents the parameters that were identified in Workshop 2, their importance to stakeholders in Albania, and how they were or were not incorporated into the CBA.

The average ranking for each parameter is presented based on the opinions of workshop attendees and discussions with other stakeholders during meetings including: an industrial consumer, an academic, engineering students, and a World Bank economist. The rationale for inclusion or exclusion from the CBA is also noted.

A number of parameters were identified as areas for further study: value of water, value of ecosystems, disturbance of people and properties, impacts on tourism, GDP impacts, and vulnerability to natural disasters. In these cases, parameters could not be fully integrated into the study (typically because of a lack of data at the appropriate level of abstraction) but may be important for future policy making. One example is tourism. In the absence of a good basis for quantifying the benefits or dis-benefits that might arise in a “typical” power generation setting in Albania, the tourism parameter was not included in the current analysis. However, tourism is very important to the local economy, and it would enhance the value of the study if the impact on tourism of a particular policy choice were captured.

Table A5.2: Parameters for the CBA Discussed at Workshops and Meetings

Class	Parameters	Workshop Attendee Rating	Interpreted Rating of 20 Engineering Students	Industrial Consumer's Rating	Academic's Rating	World Bank Economist's Rating	Average Scores	Rank in Class	Parameter Adopted in Analysis	Comment/ Rationale for Monetization
Environmental	Value of water	3	3	2.5	1	1.5	2.2	2nd	Yes	This parameter is recognized as being very complex, as there are many 'goods and services' provided by water (e.g. ecosytem support, irrigation, human consumption, recreation). Detailed analysis of this parameter is beyond the scope of this study and therefore 'proxy' values are needed to capture this important aspect. The unit 'price' of water has been taken as the Albanian cost to consumer and sensitivity.
	Cabon dioxide and other GHG	3	1		2	3	2.3	1st	Yes	EU trading price and industry norms for operational emissions.
	Particulate matter	2	1		2	3	2	3rd	Yes	There are no significant emissions from any of the analyzed technologies so PM has not been explicitly included in the analysis.
	Nox, Sox	3	1		2	1	1.8	5th	Yes	Operational Nox incorporated in the analysis using industry norms and international market values.
	Value of ecosystems	1.5	1.5		2	3	2	3rd	Yes	Footprint of power plant and associated land take (e.g. estimate of reservoir land area). Assumptions made that mountainous terrain is principal forest ecosystem and lowland terrain is coastal (as per examples such as Vlore and Porto Romano).

Class	**Parameters**	**Workshop Attendee Rating**	**Interpreted Rating of 20 Engineering Students**	**Industrial Consumer's Rating**	**Academic's Rating**	**World Bank Economist's Rating**	**Average Scores**	**Rank in Class**	**Parameter Adopted in Analysis**	**Comment/ Rationale for Monetization**
	Non-use values	1	0.5			1	0.8	6th	No	This parameter is difficult to monetize without in depth study that is beyond the scope of this study.
Social	Recreation benefits	1	0			1	0.7	6th	No	Low priority and complex to analyze. Assessment considered to be beyond the scope of this study.
	Impacts on tourism	2	2				2	2nd	No	Although this was seem as a priority by stakeholders, there is insufficient information regarding the likely impacts of energy generation on tourism in Albania to enable meaningful analysis in this study. Further study could be undertaken to quantify and monetize this parameter.
	Disturbance of people and property	3	1	3		1	2	2nd	Yes	It is clear that there are other disturban ces such as community relocation. The necessary data to make a detailed assessment is lacking at this stage so a proxy has been used to approximate part of this aspect.
	Overall number of employees per MW generated/ job creation		1		1.5		1.3	5th	No	Low priority and partially accounted for in OPEX and GDP parameters.

Class	Parameters	Workshop Attendee Rating	Interpreted Rating of 20 Engineering Students	Industrial Consumer's Rating	Academic's Rating	World Bank Economist's Rating	Average Scores	Rank in Class	Parameter Adopted in Analysis	Comment/ Rationale for Monetization
	GDP/ econmic development	2	1			3	2	2nd	Yes	It is is recognized tht energy supply to consumers enables them to generate wealth in excess of the cost of electricity. An 'electricity benefit' factor has been incorporated in the analysis. However this is a constant factor for all approaches (as users would get the same benefit where ever the electricity was generated and thus the marginal difference between options is zero.
	Politics			2.5	3		2.8	1st	No	It is considered that the political process would utilize the output from the study to inform and support future decisions that are made. Therefore it is not appropriate to incorporate political views in the cost benefit analysis.
Financial	Cost per MW produced - CAPEX, OPEX	3	2	2	2.5	3	2.5	3rd	Yes	Industry norms and Albanian data.
	Efficiency (for every dollar in how much do you get out?)		1				1	6th	No	Efficiency is reflected in the CAPEX and OPEX to meet the required energy production (GWh).
	Land Value				3		3	1st	Yes	Land usage is reflected in the representaton of loss of ecosystem/ 'goods and services' that the land would otherwise provide.

Class	Parameters	Workshop Attendee Rating	Interpreted Rating of 20 Engineering Students	Industrial Consumer's Rating	Academic's Rating	World Bank Economist's Rating	Average Scores	Rank in Class	Parameter Adopted in Analysis	Comment/ Rationale for Monetization
	Reduction of liabilities (e.g. not paying penalties for turning off electricity)	3	1				2	4th	No	This parameter is captured in the assumption that all options being assessed would meet demand, and that the 'electricity benefit' factor captures this element to some extent.
	Investor/ funding agency confidence	3	1.5			1.5	2	4th	No	Considered by stakeholders as a low priority.
	Improved reputation	1	1				1	6th	No	Considered by stakeholders as a low priority.
	Loss in production	3	2			3	2.7	2nd	Yes	This is reflected in the 'electricity benefit' parameter.
	Vulnerability to natural disasters/ climatic vulnerabilities (e.g. landslide, seismic)							Not scored	Yes	This parameter has been captured by a sensitivity scenario within the analysis. This factor aims to represent the fact that large hydroelectric power generation is often in remote areas with long transmission lines to supply consumers in southern Albania.

A5.3 FINANCIAL ASSUMPTIONS

A summary of the overall capital expenditure (CAPEX) and operating expenditure (OPEX) (in real terms) for each option is shown in Table A5-3. OPEX is divided into non-energy operating expenditure and energy operating expenditure. This separation enables looking at an increase in energy (such as fuel) expenditure on a standalone basis in sensitivity analysis.

Table A5.3: CAPEX and OPEX Summary (U.S. Dollars, 2010)

Option	Description	Asset Size (MW)	CAPEX (USD $m)	OPEX (USD $m)- Non-energy	OPEX (USD $m)- Energy
1	Import	-	-	36	-
2	LHPP Update	78	14	1	-
3	CCGT	50	72	1	8
4	SHPP Update	88	106	4	-
5	New SHPP	88	132	4	-
6	Wind	130	286	7	-
7	CSP	88	311	2	-
8	New LHPP	78	468	1	-

CAPEX and non-energy OPEX values adopted are based on proprietary WorleyParsons data for industry norm (benchmark) values, data from purchased research databases to which WorleyParsons subscribes, and publicly available sources of information. Many local conditions may influence CAPEX, including: local policy and strategies, characteristics of local resources, and import chains. Non-energy operational costs depend on many local specifics as well, including: plant size, plant organizational structure, local legislation, and labor and material costs. Energy costs depend significantly on plant efficiency. Values used in the analysis were reviewed and adjusted in light of discussions with stakeholders in Albania and are considered to be sufficient for the purposes of this study. Values should be considered indicative only.

A5.4 BENEFITS ASSESSMENT AND VALUATION

Overview

In a complete economic analysis, the benefits of a given course of action are compared to the cost. Actions that result in a net overall positive benefit to society as a whole are deemed *economic*. In this section, the benefits applicable to this analysis are identified and valued.

The approach for this analysis is to attempt to capture the maximum likely benefits that would accrue to institutions (private benefits) and to society (external benefits), should various generation alternatives be enacted. To do this, a conservative approach (from the economic point of view) has been adopted; with each external (societal) monetizable benefit valued using a method that will tend to overstate (rather than understate) the benefits. In addition, a qualitative examination of some likely nonmonetizable benefits is also included.

Thus, in the CBA, likely costs are compared with conservatively high benefits, or disbenefits, as the case may be. In adopting this approach, the report is biasing the economic analysis towards the societal position. This is advantageous because it assures that the external perspective is fully considered and valued, and helps to deflect any possible criticism that the analysis favors the project proponent.

Scope and Basis of the Analysis

This analysis considers only the costs and benefits associated with the various options designed to provide enough electricity to supplement the expected supply shortfall caused by climate change. If an external asset is damaged by implementation of a particular option, this damage appears as a disbenefit (negative benefit). If the value of the asset is maintained as it is (undamaged), then there is no effect, and no benefit or disbenefit is created. So, for example, if a water resource is left intact, in place, the current ecological support and option values of the water remain, and there is no benefit or disbenefit included in the analysis. If forest, as another example, is cleared, a negative benefit (disbenefit) is included.

A5.5 BENEFIT/DISBENEFIT VALUATION

The following benefit categories have been considered in the analysis. These benefits are directly related to the Albanian energy sector and were included in the analysis based on the workshop proceedings.

Carbon Dioxide and Other Greenhouse Gases (GHGs)

Owing to concerns about the effects of greenhouse gas emissions on the Earth’s climate, caps have been set on the total amount of GHG emissions in given areas, such as the EU. Permits, which are permissions to emit a portion of the total allowable GHG emissions, are traded like other commodities in open markets. The market price represents the value of the emissions based on supply (the cap is initially set based on current scientific knowledge) and demand (the desired amount of emission reductions); a balance between the interests of the people as a whole and the individuals or groups who wish to emit GHG. A spot value from the European market was used in the analysis, a value for GHG at USD \$21.55 per tonne of CO_{2-e} (European Market Price, 11 May 2009). Other studies, such as the Stern Review (Stern, 2005), use detailed models to project the cumulative economic impact of additional unit of GHG, called the social cost of carbon (SCC), estimated at approximately USD\$75/t CO_{2-e}. This has been chosen as the ‘high case’ cost for this analysis. Firms may also strategically set an internal offset price based on their view of current markets and regulatory frameworks. The analysis calculated the GHG emissions associated with each option, and includes these costs over the range identified above.

Value of Water

The *total economic value (TEV) of water* can be broken down into three components: the direct use-value (used or potentially useable by humans); the ecological support value, and the option value (value to society from having the resource available at some time in the future to be used). Each option realizes different components, dependent on the final state of the water. In addition, the extent to which they are realized is dependent on the relative quality of the water resulting from the treatment level for each option. Within the sensitivity analysis, therefore, the TEV of water is varied around a base estimate of the value of water sold to enterprise users of USD\$0.93 / m^3 (90 Lek / m^3) (Tirana Municipality, 2006).

Given the scarcity of readily accessible water that could develop under climate change, the high unit value of water can be taken to be the cost of replacing a similar amount of fresh water. The replacement value of fresh water is considered to be equivalent to the current cost of desalination by conventional means, with a premium added for the external costs associated with GHG emissions resulting from the desalination process. Wade (2004) has reported that the cost of desalination varies between about US\$0.70/m^3 and US\$5.30/m^3, depending on the scale of the facility (larger capacity facilities produce water at lower unit costs). Karagiannis (2008) indicated costs from US\$1.60 for 2.70/m^3, with oil at US\$23/bbl. Costs in the order of US\$1.10/m^3 are typically used by government bodies and commercial operations. However, given the current high costs of fuel, for the capacity that would be required to replace the volumes of water discussed in this analysis, a value of US\$3.00/m^3 has been chosen.

Loss of Ecological Resources

Any options that involve significant land clearing to make way for power plants will cause direct ecological damage. For this analysis, it is assumed that these habitats would not otherwise have been destroyed or damaged. Valuation estimates for the surface ecology in the project area are provided by several sources, which provide estimates of the willingness-to-pay (see hypothetical market techniques in Section 5.1 of this Annex) for preservation of similar native vegetation (UNEP, 2001) of US\$30 ha/yr for mountain ecosystems and US\$117 per ha/yr (Ladenberg *et al*., 2007) for coastal ecosystems. For each option that involves land clearing, estimated impacted areas have been calculated.

Disturbance of People and Property

Construction of power plants can affect people and property in a negative way. For instance, given two houses that are exactly the same except that one is closer to a power plant, the one in the vicinity of a power plant will generally be cheaper. This reflects the value that people place on the possible health troubles (real or imagined), and the general preference for a natural view rather than neighboring a large industrial facility. The base value of this disbenefit was US \$1.82 /hh/ha/pa (Ladenburg, 2001). This value was prorated for the other asset types based on the population density of the area and the footprint of the asset at hand.

Electricity Financial Benefit

The revenue received through the sale of produced electricity represents both the value of the production of the electricity and its contribution to macroeconomic activity. The electricity revenue is based on the stated average energy price, to all consumers, of 8.23 Lek per kWh (US\$0.085 per kWh) (Tugu, 2009). To account for the fact that the climate change projections indicate that there will be less water available for hydropower electricity production, the electricity revenue from hydropower assets has been adjusted downwards as time progresses. The hydropower was adjusted downward on the basis of a total of a 15 percent decrease in generation capacity over the next 40 years, which is consistent with the projections based on climate modeling (Annex 8). It is applied on a cumulative yearly basis, with approximately 0.4 percent less capacity each year than the year before.

Benefits Summary

Based on information provided in Section 5, the range of expected values for each of the major benefit categories is provided below in Table A5.4. Each of the values in the table is based on a reference, as discussed in Section 5. As can be seen, the unit values for benefits vary over a considerable range. Base-case estimates have been deliberately chosen to reflect a reasonable value for the parameters and the 'high case' estimates aim to bracket the likely uppermost value, and also to provide an indication of the *likely future value trend*. It is highly probable that all environmental assets will steadily increase in value over time, given the increasing scarcity of these resources worldwide and the increasing demand for natural resources as the world population continues to grow. Despite this, the analysis presented does not assume any future increase in values, but holds the current values constant over time.

Table A5.4: Monetized Unit Benefit Values (U.S. Dollars)

Benefit Category	**Units**	**Base**	**High**
Value of water	m^3	0.93	3.00
Carbon dioxide and other GHGs	Tonne	21.55	75.00
NOx	Tonne	62.00	80
Value of ecosystems: mountain	/ha/yr	30	200
Value of ecosystems: coastal	/ha/yr	117	200
Disturbance to people and property	$/hh/km^2/yr$	1.82	5.00

A5.6 RESULTS SUMMARY

Benefits Realized by Each Option

Table A5-5 presents the net present value (NPV) in USD of the benefits (or disbenefits) accrued by each option.

Table A5.5: Benefits Realized by Each Option (U.S. Dollars, 2010)

	Environmental					**Social**
	GHG	**Ecosystem (coastal)**	**Ecosystem (mountain)**	**Value of water**	**NOx**	**Disturbance to people**
Import	-39,336,650			-4,809,838	-94,308	
LHPP Update				-89,551,619		
CCGT	-39,336,650	-3,371		-4,809,838	-94,308	-57,302
ESHPP Update						
New SHPP			-89,453			
Wind						-9,993,205
CSP		-593,244		-3,644,669		-3,325,316
New LHPP			-491,777	-89,551,619		-467,808

Present Value Benefits Calculation

The present value sum of benefits is calculated using the following formula, in the case of a uniform annual flow:

$$P = A\frac{(1+i)^N - 1}{i(1+i)^N} + C$$

where:

P = Present Value

i = discount

N = number of years

A = uniform series amounts (e.g., if the benefit is worth USD$100 / year)

C = one off benefit

The discount rate is an issue of controversy, with differing opinions on the value that should be used. In this study a base discount rate of 4.5 percent has been used as a base value. Variation in this discount rate is explored through sensitivity analysis. This base value for discount rate has been adopted following discussion with the World Bank's economist in Albania. The value is higher than the social discount rate used in other developed European economies (e.g., the United Kingdom uses 3.5 percent) and reflects the higher potential growth rates that a developing economy, such as Albania's, may experience. This discount rate is perturbed in the sensitivity analysis.

A5.7 LIMITATIONS

There are limitations to this analysis, largely the result of assumptions that are required to be made, and also due to the often-subjective nature of selections and appraisals that must be made by the user. The methodology presented in Hardisty and Ozdemiroglu (2005) depends necessarily on the expert input of the user. In reality, these are the same limitations inherent in most, if not all, such methodologies for economic analysis: they depend heavily on the assumptions made, the expertise and experience of the user and stakeholders. As such, this methodology is seen as a tool for deliberation over options with stakeholders, each of whom will tend to value various resources and potential risks slightly differently.

These tables contain the data for the charts presented in the results section in Section 5.

Table A5.6: Base-case Parameters Results (U.S. Dollars, 2010)

Financial				**Environmental**					**Social**	
	CAPEX	**OPEX**	**Electricity Benefit**	**GHG**	**Ecosystem (coastal)**	**Ecosystem (mountain)**	**Value of Water**	**NOx**	**Disturbance to People**	**NPV**
Import		-519,255,000	431,228,000	-39,337,000			-4,810,000	-94,000		-132
Update existing LHPP	-13,650,000	-13,833,000	420,148,000				-89,552,000			303
CCGT	-72,000,000	-140,062,000	431,228,000	-39,337,000	-3,000		-4,810,000	-94,000	-57,000	175
Update existing SHPP	-105,600,000	-51,875,000	417,824,000							260
New SHPP	-132,000,000	-51,719,000	417,824,000			-89,000				234
Wind	-286,000,000	-96,833,000	431,228,000						-9,993,000	38
CSP	-311,380,000	-31,816,000	431,228,000		-593,000		-3,645,000		-3,325,000	80
New LHPP	-467,000,000	-13,833,000	420,148,000			-492,000	-89,552,000		-468,000	-152

Table A5.7: High-case Parameters Results (U.S. Dollars, 2010)

Financial				**Environmental**					**Social**	
	CAPEX	**OPEX**	**Electricity Benefit**	**GHG**	**Ecosystem (coastal)**	**Ecosystem (mountain)**	**Value of Water**	**NOx**	**Disturbance to People**	**NPV**
Import		-519,255,000	431,228,000	-136,902,000			-15,516,000	-122,000		-241
Update existing LHPP	-13,650,000	-13,833,000	420,148,000				-288,876,000			104
CCGT	-72,000,000	-140,062,000	431,228,000	-136,902,000	-6,000		-15,516,000	-122,000	-157,000	66
Update existing SHPP	-105,600,000	-51,875,000	417,824,000							260
New SHPP	-132,000,000	-51,719,000	417,824,000			-596,000				234
Wind	-286,000,000	-96,833,000	431,228,000						-27,454,000	21
CSP	-311,380,000	-31,816,000	431,228,000		-1,014,000		-11,757,000		-9,135,000	66
New LHPP	-467,000,000	-13,833,000	420,148,000			-3,279,000	-288,876,000		-1,285,000	-355

ANNEX 6: FURTHER DETAILS ON OPTIONS TO IMPROVE THE CLIMATE RESILIENCE OF ALBANIA'S ENERGY SECTOR

Next steps

Actions marked with an asterisk (*) are *no-regrets* actions that could improve Albania's energy security even without climate change. Those marked with a cross (†) are included in the draft NES *active* scenario.

Informational

* Compile digital databases on historic and observed climatological and hydrological conditions. Provide free access on the Web to these data.

* Improve coordination of Albania's forecasting agencies (the Military Weather Services, Institute of Energy, Water and Environment and the National Air Traffic Agency), by sharing data, expertise, and financial strength to support better quality forecasting. These organizations could collectively engage with energy-sector stakeholders to understand their data needs to support management of the energy / climate interface.

* Upgrade Albania's weather and hydrological monitoring network, focusing most urgently on the Drin basin:

- Monitoring sites could be equipped with automatic devices able to record and transmit in real-time the key weather variables (rainfall, runoff, temperature, sunshine hours, wind speed, reservoir head, evaporation, turbidity, water equivalent of snow).
- Measure sedimentation in reservoirs, which has not been measured for 40 years.
- The data above could be collected by KESH and used in managing reservoirs for safety and energy production.
- Wind data are also required, measured at the height of wind turbines (80 to 100 m) to ensure wind farms are designed appropriately and will operate efficiently. Once these data are available, explore whether high wind speeds coincide with periods of lower rainfall, in which case wind power could provide a useful resource when generation from hydropower facilities is lower.

* Develop in-country or obtain weather and climate forecasts appropriate for energy-sector planning needs:

Short-range forecasts (1 to 3 days ahead) could be provided by IEWE—including weather products for energy demand forecasting (temperature, cloudiness), reservoir management (rainfall), safety and disaster management (heavy rainfall, high winds, lightning strikes)

- * Medium-range forecasts (3 to 10 days ahead) could be obtained by subscribing, for example, to the European Centre for Medium-range Weather Forecasting regional forecasts—particularly for use by KESH—to facilitate effective management of water reserves for hydropower generation
- * Seasonal forecasts (several months ahead) could be developed by IEWE from statistical models of teleconnections, using observed and historical data for application to energy-sector planning
- Climate change scenarios (years and decades ahead):
    - These should be at a spatial resolution suitable for river basin planning (e.g., 50 km × 50 km)
    - They should be developed by downscaling ensembles of outputs from global climate models (GCMs), which are provided by Met Agencies around the world, coordinated through the World Meteorological Organization.
    - The GCMs to be included in the ensemble should be those that are best able to

Next steps

Actions marked with an asterisk (*) are *no-regrets* actions that could improve Albania's energy security even without climate change. Those marked with a cross (†) are included in the draft NES *active* scenario.

simulate the observed (historic) precipitation.

* Consider providing free access to these data to energy-sector stakeholders. Short-range and medium-range forecasts should be available in real time via the Web.

Undertake further research on climate change impacts using downscaled climate change scenarios, researching the impacts of changes in seasonal conditions and extreme climatic events.

* Update watershed models and maps of Albania's climate to support planning for optimization of future hydropower assets.

* Join networks of experts working on climate and climate change issues; for instance, WMO, EUMetNet, and EUCOS.

* Create partnerships between weather, climate and hydrological experts, and energy-sector stakeholders to enhance dissemination of dissemination of information and to ensure that data providers understand user needs.

* Strengthen regional cooperation on sharing of weather/ climate information and forecasting and undertake research to develop shared understanding of regionwide climate change risks and their implications for energy security, energy prices and trade, including:

- Data exchange on historical and recent observed data
- Joint studies and monitoring activities with institutions in neighboring countries, especially in the two upper watersheds of the Drin and in the Vjosa watershed
- Regional studies to establish whether all South East Europe's watersheds are positively correlated (i.e., whether they experience wet or dry years or seasons at the same time, and whether wet and dry years correspond with cold and hot years):
  - If so, the existing and proposed hydropower assets in the region may be exacerbating the region's vulnerability to climate risks.
  - If not, it may be possible to undertake an investment strategy to diversify risk across the region.

* Work with regional partners to develop better knowledge of the linkages between energy prices and hydrological conditions in the face of climate change:

- Marginal costs of energy production are higher in dry years than wet years.
- Some data linking these factors are available for 2010 and 2015.
- Research should be undertaken to develop data out to 2020 and 2030, taking account of climate change projections.

* Improve understanding of current rates of coastal erosion and of the impacts of rising sea levels and storm surges on future erosion rates, for better management of coastal assets (e.g., TPP and port facilities).

* Learn from experience of energy-sector experts worldwide on managing current and future climate-related risks (e.g., hydropower experts in Brazil and EDF in France, both of whom have been researching these issues for some time).

* Monitor changing ground conditions and concentrations of pollutants at Patos Marinza.

Identify whether contaminated land remediation at Patos Marinza would be effective / quick enough in the light of climate change impacts and if not, develop additional management plans while rehabilitation is underway.

Next steps Actions marked with an asterisk (*) are *no-regrets* actions that could improve Albania's energy security even without climate change. Those marked with a cross (†) are included in the draft NES *active* scenario.
* Monitor potential for pollution incidents at coal mines due to heavy downpours.
***Institutional:* Managing current climatic variability and changes in average climatic conditions**
* Improve and exploit data on reservoir use, margins, and changes in rainfall and runoff to improve management of existing reservoirs.
*† Consider providing incentives for energy-efficiency measures to reduce demand.
* Support enforcement of measures to reduce technical and commercial losses of water.
* Work with water users in the agricultural sector to devise agreed strategies for managing shared water resources with owners of hydropower plants. This could draw on the outcomes of World Bank research investigating climate change impacts on agriculture in Albania. The outcomes of the research presented in this report and the agricultural assessments could be integrated to consider the cross-sectoral issues around water management.
*† Support enforcement of measures to reduce commercial losses from the power distribution system.
Incorporate robustness to climatic variability and climate change in regulations, design codes, energy-sector proposals, site selection decisions, environmental impact assessments, contracts, public-private partnerships for new energy assets and other policy instruments for new facilities.
Ensure that proposed locations for new LHPP will be sustainable in the face of climate change risks.
Assess use of tariffs and incentives to promote climate resilience of energy assets.
Consider amendment to regulations to capture climate change costs in energy prices and the price of water.
* Strengthen measures to control illegal logging that contributes to soil erosion and siltation of reservoirs.
Set up a committee to provide oversight and monitoring of progress on climate change adaptation.
***Institutional:* Managing climatic extremes**
Review and upgrade Emergency Contingency Plans (ECPs) for LHPPs, to take account of expected increases in precipitation intensity due to climate change, ensuring that they include: monitoring of precipitation; modeling of river flows; communication instruments and protocols for downstream communities; and plans for evacuation.
* Consider use of Power Purchase Agreements with neighboring countries and large energy users to assist Albania in coping with the impacts of extreme droughts on energy security. This would need to be supported by real-time data on regional runoff and precipitation (as outlined above), and could include: • Off-take arrangements with countries generating energy through less climatically vulnerable assets such as thermal power plants • Power swap agreements, whereby Albania could buy thermal energy from neighbors at low cost during off-peak hours at night while allowing its reservoirs to fill, then recoup the energy during the next day's peak load hours via a higher fall • Instituting formal arrangements with large energy users such that they agree to their electricity supply being cut off in an extreme situation, in return for which they pay less for electricity
* Investigate applicability of weather coverage and insurance instruments for energy-sector risk management.

Next steps

Actions marked with an asterisk (*) are *no-regrets* actions that could improve Albania's energy security even without climate change. Those marked with a cross (†) are included in the draft NES *active* scenario.

* Support development of contingency plans in collaboration with stakeholders for better management of extreme climatic events and ensure that resources could be mobilized effectively to respond to them.

* Ensure that regulations on dam security are enforced.

Physical / technical

Optimize existing energy assets:

- * Improve maintenance of existing assets, many of which were designed and constructed several decades ago.
- Check that the sizing of existing assets is robust to climate variability and projected changes in average climatic conditions and explore whether water storage could be increased at reasonable cost to help manage seasonal variations.
- Review old and/or inefficient equipment and identify cost-effective measures to improve efficiencies, such as:
    - Clearing / redesigning trash racks
    - Upgrading turbines and generators
    - Replacing equipment to reduce water losses (e.g., shut-off valves)
    - Improving aprons below dams to reduce erosion
    - Raising dam crest on Fierze
    - Increasing capacity of spillways on Fierze and Komani dams
    - Developing pump storage scheme on Drin river cascade
    - Digging wider channels for SHPPs

* Reduce losses:

- Reduce electricity transmission losses.
- Reduce losses of water—hold dialogues with stakeholders sharing watersheds to discuss losses and establish how best to work together to reduce them.
- † Improve demand-side energy efficiency through incentives (e.g., for insulation and energy efficient appliances) and enforcement.

Ensure new assets are resilient:

- For new assets at the design stage, review the robustness of design and site locations to climatic variability and projected climate change—including design of energy generation assets as well as associated infrastructure, such as port facilities.

*† Diversify energy generation asset types into non-hydropower renewables and thermal power plants, ensuring that site selection and design are resilient to climate change.

† Increase hydropower installed capacity, ensuring that new facilities are designed to cope with changing climate risks.

*† Provide better interconnections to facilitate regional energy trade.

*† Reduce energy demand and improve energy efficiency through greater use of domestic solar water heating, improved building standards, use of lower energy appliances, and use of alternative heating

Next steps Actions marked with an asterisk (*) are *no-regrets* actions that could improve Albania’s energy security even without climate change. Those marked with a cross (†) are included in the draft NES *active* scenario.
sources other than electricity.
Optimize transmission and distribution by reducing technical losses (e.g., insulation of cables, under grounding of critical cables, consider DC rather than AC for long lines).
*† Install alternative fuel sources (other than electricity) for heating buildings, such as solar water heaters, geothermal.

ANNEX 7: ALBANIA POWER SUPPLY DEMAND SCENARIO PROJECTIONS 2003 TO 2050

Table A7.1: Passive Scenario Projections 2003 to 2050

Installed Capacity in MW	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Existing HPPs	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445
SHPP	15	15	15	15	15	15	15	46	57	67	77	88	98	108
Bratila New HPP										75	75	75	75	75
Kalivaci New HPP									80	80	80	80	80	80
Ashta New HPP										44	44	44	44	44
Rehabilitation of Fier TPP	12	12	12	12	12	0	0	0	60	60	60	60	60	60
CCGT with distillate/natural gas							97	97	97	97	220	320	320	320
Devolli Cascade													100	100
Vjosa Cascade														
Skavica														
Wind PPs													20	25
Solar PPs														
Import - NTC							380	380	600	600	600	600	600	900
								143	294	423	556	667	797	812
Generation/Supply in MWh*000'	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Existing HPPs	4,888	5,325	5,274	5,410	2,900	4,000	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149
SHPP	20	25	30	45	80	102	143	185	226	268	309	351	392	434
Bratila New HPP	0	0	0	0	0	0	0	0	0	330	330	330	330	330
Kalivaci New HPP	0	0	0	0	0	0	0	0	356	356	356	356	356	356
Ashta New HPP	0	0	0	0	0	0	0	0	0	202	202	202	202	202
Rehabilitation of Fier TPP		76	77	87	55	0	0	0	390	390	390	390	390	390
CCGT with distillate/natural gas							226	679	679	679	1,540	2,240	2,240	2,240
Devolli Cascade	0	0	0	0	0	0	0	0	0	0	0	0	400	400
Vjosa Cascade	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Skavica	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wind PPs	0	0	0	0	0	0	0	0	0	0	0	0	54	68
Solar PPs	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Import - NTC	**4,908**	**5,426**	**5,381**	**5,542**	**3,035**	**4,102**	**4,518**	**5,013**	**5,800**	**6,374**	**7,276**	**8,018**	**8,513**	**8,569**
Import	1,295	747	1,018	1,058	3,865	3,302	3,186	3,124	2,746	2,584	2,143	1,907	1,779	2,084
	6,203	**6,173**	**6,399**	**6,600**	**6,900**	**7,404**	**7,704**	**8,137**	**8,546**	**8,958**	**9,420**	**9,925**	**10,293**	**10,653**
Load shedding	908	1,121	1,077	1,058	940	619	501	397	329	271	152	0	0	0
Demand in MWh '000	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Demand Baseline Scenario	7,111	7,293	7,476	7,658	7,840	8,023	8,205	8,533	8,875	9,230	9,571	9,925	10,293	10,653
Demand Active Scenario	7,111	7,293	7,476	7,658	7,840	8,023	8,205	8,388	8,570	8,752	8,935	9,117	9,342	9,567
Baseline Demand	7,111	7,293	7,476	7,658	7,840	8,023	8,205	8,533	8,875	9,230	9,571	9,925	10,293	10,653

Installed Capacity in MW	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Existing HPPs	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445
SHPP	119	129	140	150	165	180	195	210	225	240	255	270	285	300
Bratila New HPP	75	75	75	75	75	75	75	75	75	75	75	75	75	75
Kalivaci New HPP	80	80	80	80	80	80	80	80	80	80	80	80	80	80
Ashta New HPP	44	44	44	44	44	44	44	44	44	44	44	44	44	44
Rehabilitation of Fier TPP	60	60	60	60	60	60	60	60	60	60	60	60	60	60
CCGT with distillate/natural gas	420	420	420	420	520	520	620	620	620	620	620	620	750	750
Devolli Cascade	100	100	100	200	200	200	200	200	200	200	200	200	200	300
Vjosa Cascade	100	100	100	100	200	200	200	200	200	200	200	200	200	200
Skavica					150	150	150	150	350	350	350	350	350	350
Wind PPs	30	35	40	45	60	60	60	60	60	80	90	100	110	120
Solar PPs														
Import - NTC	900	900	900	900	900	900	900	900	900	1,200	1,200	1,200	1,200	1,200
	1028	1043	1059	1174	1554	1569	1684	1699	1914	1949	1974	1999	2154	2279
Generation/Supply in MWh*000'	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Existing HPPs	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149
SHPP	475	517	558	600	660	720	780	840	900	960	1,020	1,080	1,140	1,200
Bratila New HPP	330	330	330	330	330	330	330	330	330	330	330	330	330	330
Kalivaci New HPP	356	356	356	356	356	356	356	356	356	356	356	356	356	356
Ashta New HPP	202	202	202	202	202	202	202	202	202	202	202	202	202	202
Rehabilitation of Fier TPP	390	390	390	390	390	390	390	390	390	390	390	390	390	390
CCGT with distillate/natural gas	2,940	2,940	2,940	2,940	3,640	3,640	4,340	4,340	4,030	4,340	4,340	4,340	5,250	5,250
Devolli Cascade	400	400	400	800	800	800	800	800	800	800	800	800	800	1,200
Vjosa Cascade	410	410	410	410	820	820	820	820	820	820	820	820	820	820
Skavica	0	0	0	0	600	600	600	600	1,400	1,400	1,400	1,400	1,400	1,400
Wind PPs	81	95	108	122	162	162	162	162	162	216	243	270	297	324
Solar PPs	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Import - NTC	**9,733**	**9,789**	**9,843**	**10,299**	**12,109**	**12,169**	**12,929**	**12,989**	**13,539**	**13,963**	**14,050**	**14,137**	**15,134**	**15,621**
Import	1,292	1,568	1,854	1,726	252	501	58	322	105	63	369	686	104	43
	11,026	**11,356**	**11,697**	**12,025**	**12,361**	**12,670**	**12,987**	**13,312**	**13,645**	**14,027**	**14,419**	**14,823**	**15,238**	**15,665**
Load shedding	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Demand in MWh '000	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Demand Baseline Scenario	11,026	11,356	11,697	12,025	12,361	12,670	12,987	13,312	13,645	14,027	14,419	14,823	15,238	15,665
Demand Active Scenario	9,792	10,017	10,242	10,467	10,697	10,932	11,172	11,418	11,668	11,925	12,187	12,454	12,728	13,008
Baseline Demand	11,026	11,356	11,697	12,025	12,361	12,670	12,987	13,312	13,645	14,027	14,419	14,823	15,238	15,665

Installed Capacity in MW	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**
Existing HPPs	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445
SHPP	315	330	345	360	375	390	405	405	405	405	405	405	405	405	405
Bratila New HPP	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
Kalivaci New HPP	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
Ashta New HPP	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44
Rehabilitation of Fier TPP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CCGT with distillate/natural gas	900	900	900	900	1,100	1,100	1,100	1,100	1,200	1,200	1,300	1,300	1,300	1,500	1,500
Devolli Cascade	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
Vjosa Cascade	200	200	300	300	300	300	300	300	300	300	300	300	300	300	300
Skavica	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350
Wind PPs	130	140	150	160	170	180	190	200	210	220	220	220	220	220	220
Solar PPs										10	10	10	10	10	30
Import - NTC	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
	2394	2419	2544	2569	2794	2819	2844	2854	2964	2984	3084	3084	3084	3284	3304
Generation/Supply in MWh*000'	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**
Existing HPPs	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149
SHPP	1,260	1,320	1,380	1,440	1,500	1,560	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620
Bratila New HPP	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330
Kalivaci New HPP	356	356	356	356	356	356	356	356	356	356	356	356	356	356	356
Ashta New HPP	202	202	202	202	202	202	202	202	202	202	202	202	202	202	202
Rehabilitation of Fier TPP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CCGT with distillate/natural gas	5,850	6,300	6,030	6,300	6,875	7,029	7,579	7,700	8,400	8,400	9,100	9,100	9,100	10,500	10,500
Devolli Cascade	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
Vjosa Cascade	820	820	1,230	1,230	1,230	1,230	1,230	1,230	1,230	1,230	1,230	1,230	1,230	1,230	1,230
Skavica	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400
Wind PPs	351	378	405	432	459	486	513	540	567	594	594	594	594	594	594
Solar PPs	0	0	0	0	0	0	0	0	0	30	30	30	30	30	90
Import - NTC	**15,918**	**16,455**	**16,682**	**17,039**	**17,701**	**17,942**	**18,579**	**18,727**	**19,454**	**19,511**	**20,211**	**20,211**	**20,211**	**21,611**	**21,671**
Import	138	3	187	252	22	206	5	303	33	443	202	672	1,152	243	686
	16,056	**16,458**	**16,869**	**17,291**	**17,723**	**18,149**	**18,584**	**19,030**	**19,487**	**19,955**	**20,414**	**20,883**	**21,364**	**21,855**	**22,358**
Load shedding	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Demand in MWh '000	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**
Demand Baseline Scenario	16,056	16,458	16,869	17,291	17,723	18,149	18,584	19,030	19,487	19,955	20,414	20,883	21,364	21,855	22,358
Demand Active Scenario	13,268	13,533	13,804	14,080	14,361	14,649	14,942	15,240	15,545	15,856	16,142	16,432	16,728	17,029	17,336
Baseline Demand	16,056	16,458	16,869	17,291	17,723	18,149	18,584	19,030	19,487	19,955	20,414	20,883	21,364	21,855	22,358

Installed Capacity in MW	**2046**	**2047**	**2048**	**2049**	**2050**
Existing HPPs	1,445	1,445	1,445	1,445	1,445
SHPP	405	405	405	405	405
Bratila New HPP	75	75	75	75	75
Kalivaci New HPP	80	80	80	80	80
Ashta New HPP	44	44	44	44	44
Rehabilitation of Fier TPP	0	0	0	0	0
CCGT with distillate/natural gas	1,700	1,700	1,800	1,800	1,900
Devolli Cascade	300	300	300	300	300
Vjosa Cascade	300	300	300	300	300
Skavica	350	350	350	350	350
Wind PPs	220	220	220	220	220
Solar PPs	30	30	30	30	30
Import - NTC	1,200	1,200	1,200	1,200	1,200
	3504	3504	3604	3604	3704
Generation/Supply in MWh*000'	**2046**	**2047**	**2048**	**2049**	**2050**
Existing HPPs	4,149	4,149	4,149	4,149	4,149
SHPP	1,620	1,620	1,620	1,620	1,620
Bratila New HPP	330	330	330	330	330
Kalivaci New HPP	356	356	356	356	356
Ashta New HPP	202	202	202	202	202
Rehabilitation of Fier TPP	0	0	0	0	0
CCGT with distillate/natural gas	11,390	11,900	12,600	12,600	13,300
Devolli Cascade	1,200	1,200	1,200	1,200	1,200
Vjosa Cascade	1,230	1,230	1,230	1,230	1,230
Skavica	1,400	1,400	1,400	1,400	1,400
Wind PPs	594	594	594	594	594
Solar PPs	90	90	90	90	90
Import - NTC	**22,561**	**23,071**	**23,771**	**23,771**	**24,471**
Import	266	235	24	524	334
	22,827	**23,306**	**23,796**	**24,296**	**24,806**
Load shedding	0	0	0	0	0
Demand in MWh '000	**2046**	**2047**	**2048**	**2049**	**2050**
Electricity Demand Baseline Scenario	22,827	23,306	23,796	24,296	24,806
Electricity Demand Active Scenario	17,648	17,965	18,289	18,618	18,953
Baseline Demand	22,827	23,306	23,796	24,296	24,806

Table A7.2: Active Scenario Projections 2003 to 2050

Installed Capacity in MW	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Existing HPPs	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445
SHPP	15	15	15	15	15	15	15	46	57	67	77	88	98	108
Bratila New HPP										75	75	75	75	75
Kalivaci New HPP									80	80	80	80	80	80
Ashta New HPP										44	44	44	44	44
Rehabilitation of Fier TPP	12	12	12	12	12	0	0	0	60	60	60	60	60	60
CCGT with distillate/natural gas							97	97	97	97	220	220	220	220
Devolli Cascade													100	100
Vjosa Cascade														
Skavica														
Wind PPs													20	25
Solar PPs														
Import - NTC							380	380	600	600	600	600	600	900
TOTAL								143	294	423	556	567	697	712
Generation/ Supply in MWh ‘000														
Installed Capacity in MW	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Existing HPPs	4,888	5,325	5,274	5,410	2,900	4,000	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149
SHPP	20	25	30	45	80	102	143	185	226	268	309	351	392	434
Bratila New HPP	0	0	0	0	0	0	0	0	0	330	330	330	330	330
Kalivaci New HPP	0	0	0	0	0	0	0	0	356	356	356	356	356	356
Ashta New HPP	0	0	0	0	0	0	0	0	0	202	202	202	202	202
Rehabilitation of Fier TPP		76	77	87	55	0	0	0	390	390	390	390	390	390
CCGT with distillate/natural gas							226	679	679	679	1,540	1,540	1,540	1,540
Devolli Cascade	0	0	0	0	0	0	0	0	0	0	0	0	400	400
Vjosa Cascade	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Skavica	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wind PPs	0	0	0	0	0	0	0	0	0	0	0	0	54	68
Solar PPs	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Supply from IC	**4,908**	**5,426**	**5,381**	**5,542**	**3,035**	**4,102**	**4,518**	**5,013**	**5,800**	**6,374**	**7,276**	**7,318**	**7,813**	**7,869**
Import	1,295	747	1,018	1,058	3,865	3,302	3,186	2,978	2,441	2,107	1,507	1,799	1,529	1,698
Total Supply	**6,203**	**6,173**	**6,399**	**6,600**	**6,900**	**7,404**	**7,704**	**7,991**	**8,241**	**8,481**	**8,783**	**9,117**	**9,342**	**9,567**
Load Shedding	908	1,121	1,077	1,058	940	619	501	397	329	271	152	0	0	0
Demand in MWh ‘000														
Total Demand	7,111	7,293	7,476	7,658	7,840	8,023	8,205	8,388	8,570	8,752	8,935	9,117	9,342	9,567

Installed Capacity in MW	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Existing HPPs	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445
SHPP	119	129	140	150	165	180	195	210	225	240	255	270	285	300
Bratila New HPP	75	75	75	75	75	75	75	75	75	75	75	75	75	75
Kalivaci New HPP	80	80	80	80	80	80	80	80	80	80	80	80	80	80
Ashta New HPP	44	44	44	44	44	44	44	44	44	44	44	44	44	44
Rehabilitation of Fier TPP	60	60	60	60	60	60	60	60	60	60	60	60	60	60
CCGT with distillate/natural gas	220	220	220	220	220	220	320	320	320	320	320	320	320	320
Devolli Cascade	100	100	100	200	200	200	200	200	200	200	200	200	200	300
Vjosa Cascade	100	100	100	100	200	200	200	200	200	200	200	200	200	200
Skavica					150	150	150	150	350	350	350	350	350	350
Wind PPs	30	35	40	45	60	60	60	60	60	80	90	100	110	120
Solar PPs														
Import - NTC	900	900	900	900	900	900	900	900	900	1,200	1,200	1,200	1,200	1,200
TOTAL	828	843	859	974	1254	1269	1384	1399	1614	1649	1674	1699	1724	1849
Generation/ Supply in MWh '000														
Installed Capacity in MW	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Existing HPPs	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149
SHPP	475	517	558	600	660	720	780	840	900	960	1,020	1,080	1,140	1,200
Bratila New HPP	330	330	330	330	330	330	330	330	330	330	330	330	330	330
Kalivaci New HPP	356	356	356	356	356	356	356	356	356	356	356	356	356	356
Ashta New HPP	202	202	202	202	202	202	202	202	202	202	202	202	202	202
Rehabilitation of Fier TPP	390	390	390	390	390	390	390	390	390	390	390	390	390	390
CCGT with distillate/natural gas	1,540	1,540	1,540	1,540	1,540	1,540	2,240	2,240	2,240	2,240	2,240	2,240	2,240	2,240
Devolli Cascade	400	400	400	800	800	800	800	800	800	800	800	800	800	1,200
Vjosa Cascade	410	410	410	410	820	820	820	820	820	820	820	820	820	820
Skavica	0	0	0	0	600	600	600	600	1,400	1,400	1,400	1,400	1,400	1,400
Wind PPs	81	95	108	122	162	162	162	162	162	216	243	270	297	324
Solar PPs	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Supply from IC	**8,333**	**8,389**	**8,443**	**8,899**	**10,009**	**10,069**	**10,829**	**10,889**	**11,749**	**11,863**	**11,950**	**12,037**	**12,124**	**12,611**
Import	1,459	1,628	1,799	1,568	688	863	343	528	-81	61	236	417	604	396
Total Supply	**9,792**	**10,017**	**10,242**	**10,467**	**10,697**	**10,932**	**11,172**	**11,418**	**11,668**	**11,925**	**12,187**	**12,454**	**12,728**	**13,008**
Load Shedding	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Demand in MWh '000														
Total Demand	9,792	10,017	10,242	10,467	10,697	10,932	11,172	11,418	11,668	11,925	12,187	12,454	12,728	13,008

Installed Capacity in MW	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**
Existing HPPs	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445	1,445
SHPP	315	330	345	360	375	390	405	405	405	405	405	405	405	405	405
Bratila New HPP	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
Kalivaci New HPP	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
Ashta New HPP	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44
Rehabilitation of Fier TPP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CCGT with distillate/natural gas	435	435	435	435	550	550	550	550	700	700	700	700	800	800	800
Devolli Cascade	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
Vjosa Cascade	200	200	300	300	300	300	300	300	300	300	300	300	300	300	300
Skavica	350	350	350	350	350	350	350	350	350	350	350	350	350	350	350
Wind PPs	130	140	150	160	170	180	190	200	210	220	220	220	220	220	220
Solar PPs										10	10	10	10	10	30
Import - NTC	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
TOTAL	1929	1954	2079	2104	2244	2269	2294	2304	2464	2484	2484	2484	2584	2584	2604
Generation/ Supply in MWh ‘000															
Installed Capacity in MW	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**
Existing HPPs	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149	4,149
SHPP	1,260	1,320	1,380	1,440	1,500	1,560	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620	1,620
Bratila New HPP	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330
Kalivaci New HPP	356	356	356	356	356	356	356	356	356	356	356	356	356	356	356
Ashta New HPP	202	202	202	202	202	202	202	202	202	202	202	202	202	202	202
Rehabilitation of Fier TPP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CCGT with distillate/natural gas	3,045	3,045	3,045	3,045	3,300	3,850	3,850	3,850	4,200	4,550	4,900	4,900	5,600	5,600	5,600
Devolli Cascade	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
Vjosa Cascade	820	820	1,230	1,230	1,230	1,230	1,230	1,230	1,230	1,230	1,230	1,230	1,230	1,230	1,230
Skavica	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400
Wind PPs	351	378	405	432	459	486	513	540	567	594	594	594	594	594	594
Solar PPs	0	0	0	0	0	0	0	0	0	30	30	30	30	30	90
Supply from IC	**13,113**	**13,200**	**13,697**	**13,784**	**14,126**	**14,763**	**14,850**	**14,877**	**15,254**	**15,661**	**16,011**	**16,011**	**16,711**	**16,711**	**16,771**
Import	154	333	106	295	235	-115	91	363	291	195	130	421	17	318	564
Total Supply	**13,268**	**13,533**	**13,804**	**14,080**	**14,361**	**14,649**	**14,942**	**15,240**	**15,545**	**15,856**	**16,142**	**16,432**	**16,728**	**17,029**	**17,336**
Load Shedding	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Demand in MWh ‘000															
Total Demand	13,268	13,533	13,804	14,080	14,361	14,649	14,942	15,240	15,545	15,856	16,142	16,432	16,728	17,029	17,336

Installed Capacity in MW	**2046**	**2047**	**2048**	**2049**	**2050**
Existing HPPs	1,445	1,445	1,445	1,445	1,445
SHPP	405	405	405	405	405
Bratila New HPP	75	75	75	75	75
Kalivaci New HPP	80	80	80	80	80
Ashta New HPP	44	44	44	44	44
Rehabilitation of Fier TPP	0	0	0	0	0
CCGT with distillate/natural gas	900	900	1,000	1,000	1,100
Devolli Cascade	300	300	300	300	300
Vjosa Cascade	300	300	300	300	300
Skavica	350	350	350	350	350
Wind PPs	220	220	220	220	220
Solar PPs	30	30	30	30	30
Import - NTC	1,200	1,200	1,200	1,200	1,200
TOTAL	2704	2704	2804	2804	2904
Generation/ Supply in MWh '000					
Installed Capacity in MW	**2046**	**2047**	**2048**	**2049**	**2050**
Existing HPPs	4,149	4,149	4,149	4,149	4,149
SHPP	1,620	1,620	1,620	1,620	1,620
Bratila New HPP	330	330	330	330	330
Kalivaci New HPP	356	356	356	356	356
Ashta New HPP	202	202	202	202	202
Rehabilitation of Fier TPP	0	0	0	0	0
CCGT with distillate/natural gas	6,300	6,300	7,000	7,000	7,700
Devolli Cascade	1,200	1,200	1,200	1,200	1,200
Vjosa Cascade	1,230	1,230	1,230	1,230	1,230
Skavica	1,400	1,400	1,400	1,400	1,400
Wind PPs	594	594	594	594	594
Solar PPs	90	90	90	90	90
Supply from IC	**17,471**	**17,471**	**18,171**	**18,171**	**18,871**
Import	176	494	117	446	82
Total Supply	**17,648**	**17,965**	**18,289**	**18,618**	**18,953**
Load Shedding	0	0	0	0	0
Demand in MWh '000					
Total Demand	17,648	17,965	18,289	18,618	18,953

ANNEX 8: ESTIMATING IMPACTS OF CLIMATE CHANGE ON LARGE HYDROPOWER PLANTS IN ALBANIA

This Annex outlines the approach to estimating the impacts of climate change on large hydropower plants (LHPPs) in Albania. These estimates are required to make an initial assessment of climate change risks to Albania's energy sector, which will feed into the high-level cost–benefit analysis of adaptation options.

It was outside the scope of this vulnerability assessment to undertake hydrological assessments including climate change for Albania's LHPPs, and the data needed were not available to do this. The report therefore utilizes information from existing studies for Albania and other countries.

It is recognized that Albania could benefit from additional investment in hydrological and meteorological monitoring and research/assessments to understand these issues better.

A8.1 EXISTING AVAILABLE INFORMATION ON LHPPS AND CLIMATE CHANGE IMPACTS

The following information was reviewed linking climate change and hydropower production:

a. Work by IEWE (formerly HMI) at Tirana Polytechnic University for Albania's First National Communication to the UNFCCC
b. Recent work by IEWE on the Vjosa Basin in southern Albania
c. Recent work by IEWE on the Mati River catchment for Albania's Second National Communication
d. A correlation of annual average inflows to Fierze and electricity generation
e. Verbal information from the World Bank's Senior Energy Economist in Albania[6]
f. Roberto Schaeffer *et al.* (2009), recent assessment of climate change impacts on LHPP in Brazil[7]

These are reviewed in turn as follows.

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[6] Meeting with Demetrios Papathanasiou, Senior Energy Economist at the World Bank, on April 22, 2009.

[7] Reported in: Pereira de Lucena, A.F., Szklo, A.S., Salem, A., Schaeffer, R. de Souza, R.R., Borba, B.S.M.C., da Costa, I.V.L, Junior, A.O.P., da Cunha, S.H.F. (2009). The vulnerability of renewable energy to climate change in Brazil, *Energy Policy*, **37**: 879–889 and Roberto Schaeffer's presentation on the above at World Bank Energy Week 2009.

A8.2 ALBANIA'S FIRST NATIONAL COMMUNICATION

The range of projected climate changes for Albania presented in the 1NC[8] is shown in Table A8.1

Table A8.1 Climate Change Scenarios for Albania (CCSA)

Scenarios for Albania		**Time Horizon**		
		2025	**2050**	**2100**
Annual	Temperature (^{o}C)	0.8+1	1.2+1.8	2.1+3.6
	Precipitation (%)	-3.8+-2.4	-6.1+-3.8	-12.5+-6
Winter	Temperature (^{o}C)	0.8+1.0	1.3+1.8	2.13.7
	Precipitation (%)	-1.6+0	-1.8+0	-3.7+0
Spring	Temperature (^{o}C)	0.7+0.9	1.0+1.5	1.8+3.0
	Precipitation (%)	-2.7+-1.3	-3.6+-2.1	-7.4+-3.4
Summer	Temperature (^{o}C)	0.9+1.2	1.2+2.0	2.3+4.1
	Precipitation (%)	-0.8+-5.6	-20.0+-9.1	-27.0+-14.4
Autumn	Temperature (^{o}C)	0.9+1.1	1.1+2.0	2.1+3.8
	Precipitation (%)	-4.3+-3.4	-11.2+-2.1	-16.2+-8.6
Sea Level (cm)			20-24	48-61
Cloud Cover (%)		-1.3+-1.5	-2.6+-2.0	-4.6+-3.1
Wind Speed (%)		0.7	1+1.3	1.6+2.3

To assess the impact of climate change on the mean annual runoff, two models that relate runoff forming factors (annual sum of precipitation and mean annual evapotranspiration) to the long term mean annual runoff were used.

The 1NC states that: "*The models forecast a decrease in the long term mean annual runoff, respectively from –9.8 percent to –13.6 percent and from –6.3 percent to –9.1 percent, for 2025*" (see the black line in Figure A8.1).

According to Figure A8.1:

a. The projected climatic changes for 2050—that is, decreases in annual precipitation of –6.1 percent to –3.8 percent and temperature increases of +1.2 deg C to +1.8 deg C—translate into a decrease in annual runoff of about –15 percent by 2050.

b. The projected climatic changes for 2100—i.e. decreases in annual precipitation of –12 percent to –6 percent and temperature increases of +2.1 deg C to +3.6 deg C—result in a decrease in annual runoff of about –35 percent by 2100.

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[8] Islami, B., Kamberi, M., Demiraj, E., Fida, E. (2002). The First National Communication of the Republic of Albania to the United Nations Framework Convention on Climate Change (UNFCCC). Ministry of Environment, Republic of Albania.

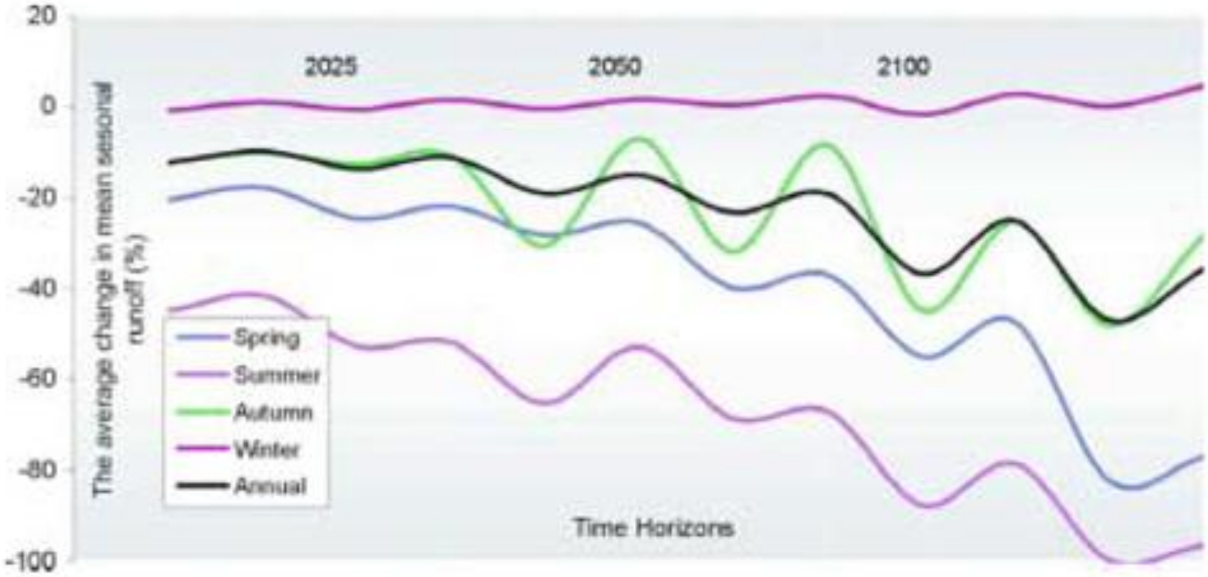

Figure A8.1: Average change in mean runoff according to CCSA for three time horizons: 2025, 2050, 2100

A8.3 ASSESSMENT OF CLIMATE CHANGE IMPACTS ON THE VJOSA BASIN

The assessment of climate change impacts on the Vjosa Basin[9] presented a slightly different set of climate change scenarios, with larger changes for Albania than the 1NC, as shown in Table A8.2.

Table A8.2: Climate Change Scenarios for Three Time Horizons: 2025, 2050, 2100

Scenarios for Albania		Time Horizon		
		2025	2050	2100
Annual	Temperature (°C)	0.8 to 1.1	1.7 to 2.3	2.9 to 5.3
	Precipitation (%)	-3.4 to -2.6	-6.9 to -5.3	-16.2 to -8.8
Winter	Temperature (°C)	0.7 to 0.9	1.5 to 1.9	2.4 to 4.5
	Precipitation (%)	-1.8 to -1.3	-3.6 to -2.8	-8.4 to -4.6
Spring	Temperature (°C)	0.7 to 0.9	1.4 to 1.8	2.3 to 4.2
	Precipitation (%)	-1.2 to -0.9	-2.5 to -1.9	-5.8 to -3.2
Summer	Temperature (°C)	1.2 to 1.5	2.4 to 3.1	4.0 to 7.3
	Precipitation (%)	-11.5 to -8.7	-23.2 to -17.8	-54.1 to -29.5
Autumn	Temperature (°C)	0.8 to 1.1	1.7 to 2.2	2.9 to 5.2
	Precipitation (%)	-3.0 to -2.3	-6.1 to -4.7	-14.2 to -7.7

A rainfall-runoff model was used to assess the impacts of these changes on Vjosa River runoff. The projected changes in runoff are shown in Figure A8.2.

The paper notes that during winter, precipitation feeding the Vjosa River falls as snow and that the presence of deep karst aquifers "*assure an abundant underground supply during the dry season.*"

According to Figure A8.2 which presents data drawn from that paper:

a. The projected climatic changes for 2050—that is, decreases in annual precipitation of –6.9 percent to –5.3 percent and temperature increases of +1.7

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[9] M. Bogdani Ndini and E. Demiraj Bruci, 2008

deg C to +2.3 deg C—translate into a decrease in annual runoff of about –18 percent to –25 percent by 2050.

b. The projected climatic changes for 2100—that is, decreases in annual precipitation of –16 percent to –9 percent and temperature increases of +2.9 deg C to +5.3 deg C—translate into a decrease in annual runoff for the Vjosa River in the range –30 percent to –47 percent by 2100.

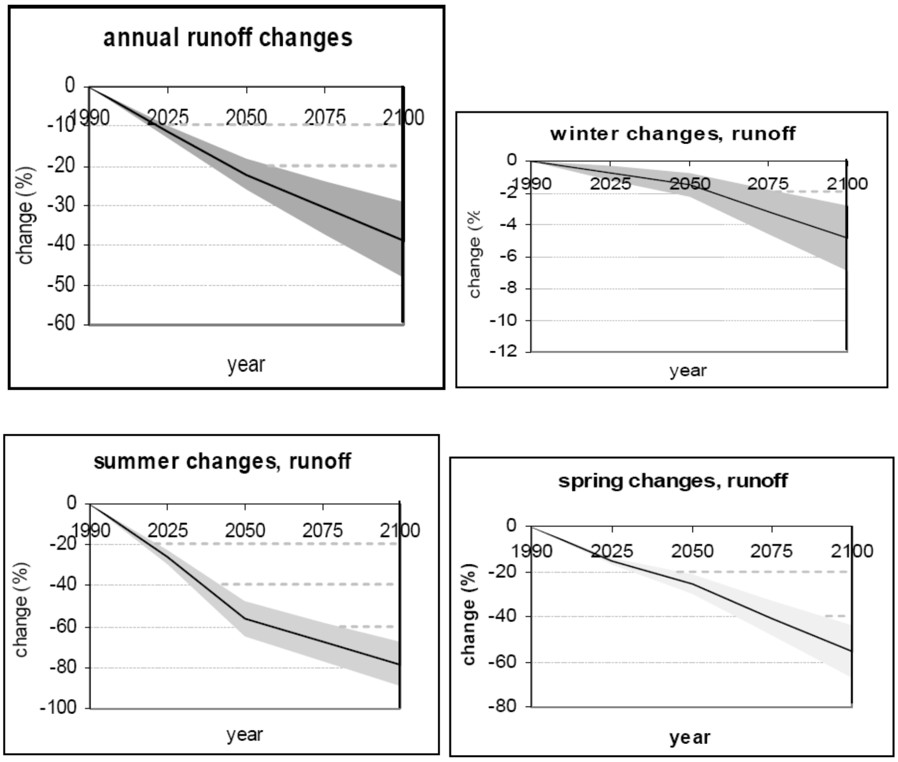

Figure A8.2 Projected Climatic Changes to 2100

A8.4 ASSESSMENT OF CLIMATE CHANGE IMPACTS ON THE MATI RIVER BASIN

The assessment of climate change impacts on the Mati River[10] presented the same set of climate change scenarios as the assessment of the Vjosa River (see Table A8.2).

The assessment states that "*snowfall is not a frequent phenomenon, even in the hilly part of the study area*" and notes that increasing temperatures will make snow in future even rarer.

According to Figure A8.3:

a. The projected climatic changes for 2050—that is, decreases in annual precipitation of –6.9 percent to –5.3 percent and temperature increases of +1.7 deg C to +2.3 deg C—translate into a decrease in annual runoff of about –18 percent to –25 percent by 2050.

b. The projected climatic changes for 2100—that is, decreases in annual precipitation of –16 percent to –9 percent and temperature increases of +2.9 deg C to +5.3 deg C—translate into a decrease in annual runoff for the Vjosa River in the range –30 percent to –47 percent by 2100.

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[10] B. Islami and E. Demiraj Bruci, 2008. Impacts of Climate Change to the Power Sector and Identification of the Adaptation Response Measures in the Mati River Catchment's Area.

Note that these are the same graphs as were presented above for the Vjosa River study.

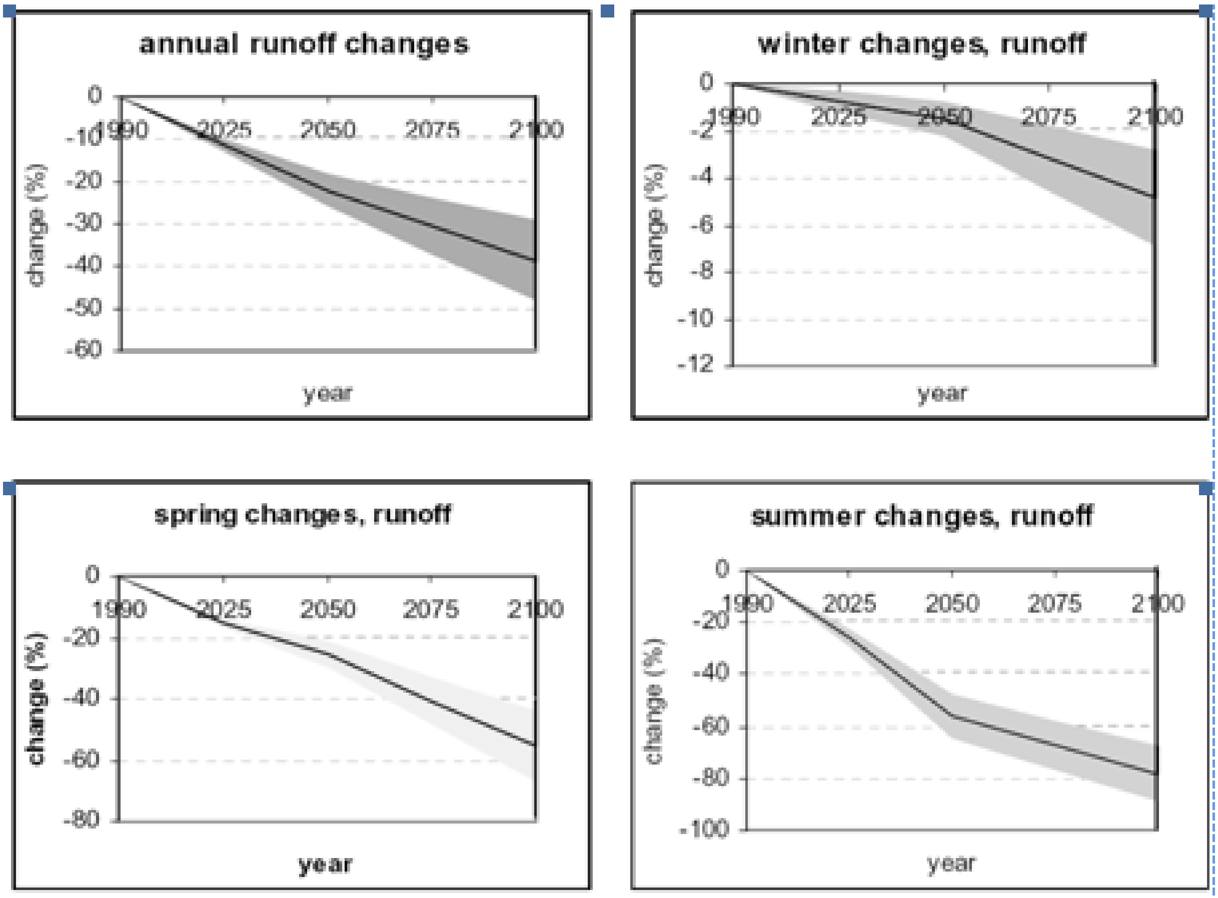

Figure A8.3 Expected changes in runoff, Mati catchment's area

This report states that there is a strong correlation between Mati River flow and power production from Ulëza and Shkopeti HPP, as shown in Figure A8.4 (taken from the report).

This graph implies that if the flow of the Mati River declined by 20 percent, electricity generation would fall by about 15 percent.

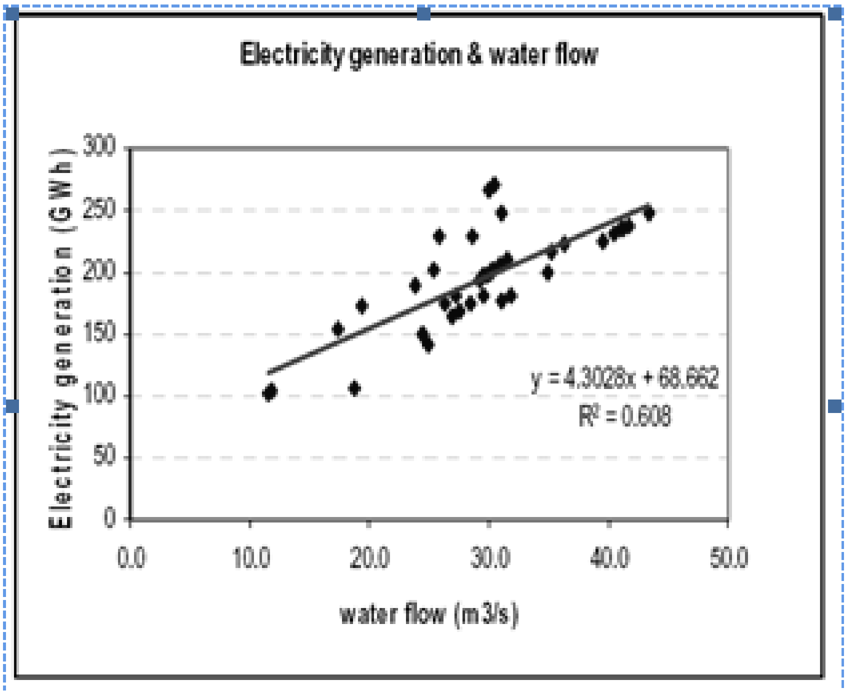

Figure A8.4: Relation of electricity production to river flow, MRCA

A8.5 CORRELATION OF ANNUAL AVERAGE INFLOWS TO FIERZE AND ELECTRICITY GENERATION

The World Bank office in Albania has provided Excel spreadsheets that include data on monthly and annual average inflows (m^3s^{-1}) to Fierze from 1948 to 2007, as well as annual energy generated (GWh) from all sources for the years 1999 to 2007.

A linear correlation of these data is provided in Figure A8.5. It indicates that a 20 percent fall in inflow leads to a reduction in energy generated of approximately 15 percent.

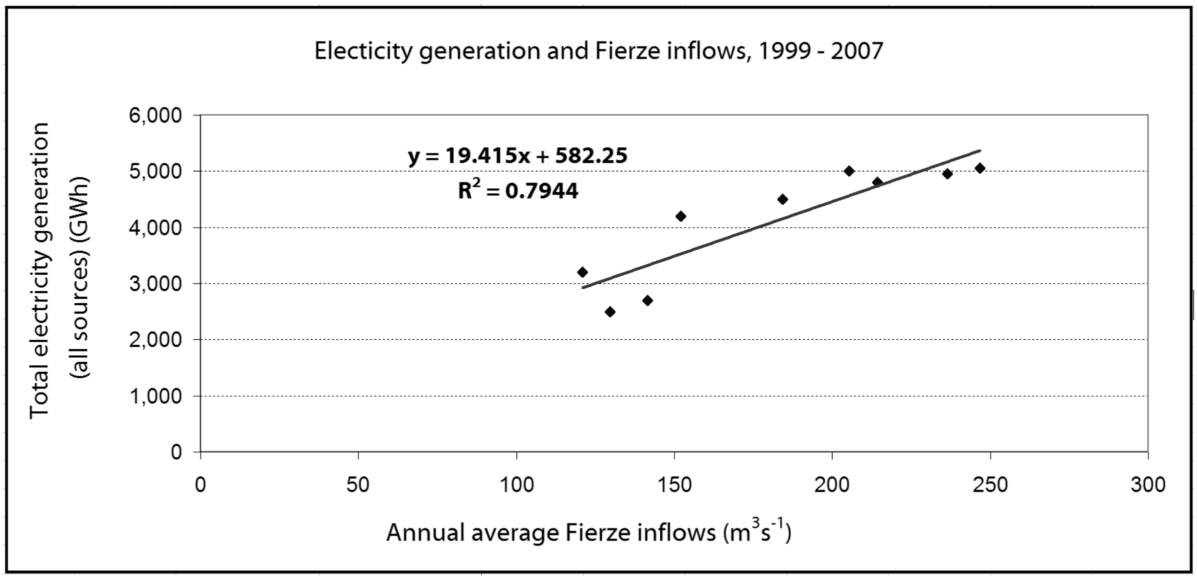

Figure A8.5: Electricity generation and Fierze inflows, 1999–2007

A8.6 VERBAL INFORMATION FROM THE WORLD BANK

The World Bank's Senior Energy Economist in Albania reported verbally that at Skavica a 20 percent reduction in precipitation translated into an approximate 20 percent reduction in HPP output.

A8.7 ASSESSMENTS OF LHPP IN BRAZIL

Research undertaken by Schaeffer and colleagues (Schaeffer, *et al*,.2009) used regional climate modeling for Brazil at 50 km × 50 km spatial resolution and on monthly timesteps to project impacts on LHPP.

First, projected changes in climate were used to generate perturbed river flows taking account of climate change. Then, using the SUISHI-O HPP operation simulation model, projected changes in HPP output were generated.

The projected changes in hydropower production for the period 2071 to 2100 are summarized in Table A8.3, (from Schaeffer *et al*., *op. cit.*)

Table A8.3: Results for Hydropower (Deviation from the Reference Projections) and Relative Participation of Each Basin in the Brazilian Hydropower System

Basin	Average Annual Flow		Average Power		Firm Power		Percent	
	A2 (%)	B2 (%)	A2 (%)	B2 (%)	A2	B2	Brazil	SINa
Parana River	-2.40	-8.20	0.70	-1.20			15.90	17.60
Grande	1.00	-3.40	0.30	-0.80			9.20	10.20
Paranaiba	-5.90	-5.90	-1.40	-1.90			10.20	11.30
Paranapanema	-5.00	-5.70	-1.40	-2.50			3.00	3.30
Parnaiba	-10.30	-10.30	-0.80	-0.70			0.30	0.30
Sao Francisco	-23.40	-26.40	-4.30	-7.70			8.50	9.40
Tocantins-Araguaia	-14.70	-15.80	-0.30	-0.30			15.80	17.60
Brazil (SIN)	**-8.60**	**-10.80**	**-0.70**	**-2.00**	**-1.58%**	**-3.15%**	**62.80**	**69.80**

a SIN – Sistema Interligado Nacional (Brazil Interconnected Electric Power System)

Schaeffer and colleagues state that in some of the river basins, reservoir management could go some way to mitigating the runoff changes in some basins, but not all: *"The Parana River, Paranaiba Basin, Paranapanema Basin and the Grande Basin—which all belong to the major Basin of Parana—show similar results. Besides the estimated negative average effect on flow, the seasonal variations in flow tend to be positive in the months when flow is increasing and negative in the months when it is falling. If this were the case, these power plants would face an earlier dry period, as well as an earlier start of the humid period. Given the not so relevant net annual results and the favourable seasonal pattern (higher flows in the beginning of the wet season), by adjusting the reservoir management in these existing power plants the estimated effects of GCC would be attenuated. The remaining basins all show an average negative impact on flow, especially the Sao Francisco Basin, where there is an installed hydroelectric capacity of 6.8GW. In that case, reservoir management would not be enough to compensate for the losses in the inflows to the hydropower plants."* (Schaffer et al., 2009),

A8.8 SUMMARY

The range of projected changes in annual climatic conditions, runoff, and hydropower production from the above studies are summarized in Table A8.4.

The research in Brazil indicates less severe impacts than the analyses above suggest for Albania, and Schaeffer and colleagues state that in Brazil reservoir management can compensate to some extent for reduced river flows.

According to this analysis, the high-level cost–benefit analysis for Albania uses an estimated decrease in annual hydropower output of 15 percent by 2050, associated with an average annual decrease of 20 percent in runoff. In addition, if possible, the CBA should test the sensitivity of these results to changes in annual power output in the range –20 percent to –5 percent.

Table A8.4: Projected Changes in Annual Climatic Conditions, Runoff, and Hydropower Production

Study	Change in annual average climatic conditions by 2050	Change in annual runoff by 2050 (%)	Change in annual hydropower output (%)
First National Communication	Precipitation: –6.1% to –3.8% Temperature: +1.2°C to +1.8°C	–15%	
Vjosa River	Precipitation: –6.9% to –5.3% Temperature: increases of +1.7°C to +2.3°C	–18% to –25%	
Mati River	Precipitation: –6.9% to –5.3% Temperature: increases of +1.7°C to +2.3°C	–18% to –25%	Figure A8.4 indicates that a 20% reduction in runoff would cause a reduction of 15% in power generation
Correlation of Fierze inflows and energy generation			A 20% reduction in inflows to Fierze is associated with a 15% reduction in power generation
Verbal information from World Bank			*“20% reduction in precipitation translates into a 20% reduction in HPP output”*
Schaeffer *et al.*		Parana River (2071–2100) –8.2% to –2.4% Sao Francisco (2071–2100) –26.4% to –23.4%	–1.2% to +0.7% –7.7% to –4.3%

ANNEX 9: ESTIMATING IMPACTS OF CLIMATE CHANGE ON ENERGY GENERATION IN ALBANIA, EXCLUDING LARGE HYDROPOWER PLANTS

This Annex outlines the estimates of climate change impacts on Albania's energy assets, excluding large hydropower plants[11], to be used in the cost–benefit analysis. It has been developed by considering the climate change projections for Albania and drawing on the authors' engineering expertise of the relationships between climatic factors and asset performance.

A9.1 SMALL HYDROPOWER PLANTS (SHPPS)

Assume a 1 to 1 relationship between reduced river flows and SHPP production, that is, a 20 percent reduction by 2050[12].

A9.2 THERMAL POWER PLANTS (TPPS)

Estimate a 0.5 percent reduction in TPP output associated with higher temperatures in 2020, rising to 1 percent in 2050.

A9.3 WIND

The climate change scenarios'[13] projections of changes in wind are low confidence and show little or no change. The report therefore assumes no change.

A9.4 DOMESTIC SOLAR HEATERS

The climate change scenarios[14] indicate a reduction in cloudiness as shown in Table A9.1.

Table A9.1 Range of Projected Changes Compared to 1961–1990 Baseline

	Range of projected changes compared to 1961–1990 baseline					
	2020s			**2050s**		
Climate variable	**Annual**	**Summer**	**Winter**	**Annual**	**Summer**	**Winter**
Cloudiness (%)	–4 to –1	–5 to –2	–2 to 0	–5 to –2	–8 to –6	–3 to 0

In summer, domestic solar heaters already provide all the required energy for water heating, so decreases in summer cloud cover will not act to reduce energy demand for water heating. In winter, however, this is not the case, so the report assumes that the winter water heating demand, taking account of climate change, should be reduced by 1 percent by the 2020s and 2 percent by the 2050s. For autumn and spring we suggest reduced demand of 1.5 percent by the 2020s and 3.0 percent by the 2050s.

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[11] For LHPP estimates see Annex 8.

[12] See Annex 8.

[13] Acclimatise. (2009). Climate change projections for Albania. Acclimatise, United Kingdom. (Jane, is this the elusive "CCSA"? If so the word here would be Scenarios? not projections)

[14] Ibid.

A9.5 CONCENTRATED SOLAR POWER

The report uses the data on decreases in cloudiness to estimate equivalent increases in output from concentrated solar power.

A9.6 TRANSMISSION AND DISTRIBUTION

The efficiency reduction for transmission and distribution is estimated as 1 percent by 2050, associated with rising temperatures.

ANNEX 10: GLOSSARY OF KEY TERMS

Adaptation Actions to reduce the vulnerability of natural and human systems to climate change effects. For instance, an adaptation action that can be taken to reduce the damaging effects of rising sea levels is to build higher sea defences. Various types of adaptation exist, e.g., anticipatory and reactive, private and public, and autonomous and planned.

Adaptive capacity The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

Baseline The reference against which change is measured, e.g., *baseline climate* is normally defined as the period 1961–1990.

Carbon dioxide (CO_2) CO_2 is a naturally occurring gas, and a byproduct of burning fossil fuels or biomass, of land-use changes and of industrial processes. It is the main greenhouse gas produced by man that is driving climate change.

CEZ CEZ Group, a privately owned Czech energy production group that has recently taken over management of Albania's power distribution system.

Climate change Climate change refers to any change in climate that lasts for an extended period, typically decades or longer, whether due to natural variability or as a result of human activity.

Climate hazards Climate variables that have consequences for the system being studied (in this case, Albania's energy sector). The main climate hazards to be discussed at the workshop are temperature, precipitation, relative humidity, sunshine, winds, sea level rise and extreme events such as storms.

Climate impacts The effects that climate hazards have on a given system (in this case, Albania's energy sector), such as reductions in rainfall have impacts on hydropower generation.

Climate variability Climate variability refers to variations in the average state of climate. Rainfall, for instance, has high natural variability, which makes it difficult to detect a climate change signal.

GCM General Circulation Model / Global Climate Model A computer-based numerical model of the climate system. GCMs are developed and run by climate modeling centers around the world and are used to project changes in climate.

Greenhouse Gases (GHGs) Greenhouse gases absorb and emit infrared radiation. This property causes the greenhouse effect. Water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and ozone (O_3) are the primary greenhouse gases in the earth's atmosphere.

Intergovernmental Panel on Climate Change (IPCC) The Intergovernmental Panel on Climate Change was formed in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP), and is the international advisory body on climate change.

Mitigation Actions to reduce man-made effects on the climate system. These include actions to reduce emissions of greenhouse gases (such as energy efficiency measures or the use of renewable energy resources), as well as actions to increase greenhouse gas sinks (such as planting forests).

Risk Risk is the product of the *likelihood (or probability) of an event* occurring and the *magnitude of its consequence*.

Scenario A plausible description of how the future may develop. Scenarios are not predictions or forecasts, but are useful to provide a view of the implications of actions.

Sensitivity Sensitivity is the amount by which a system is affected, either adversely or beneficially, by climate variability or climate change. For instance, the efficiency of gas turbines is sensitive to temperature. As temperatures rise, efficiency falls.

Special Report on Emissions Scenarios (SRES) To provide a basis for estimating future climate change, the IPCC prepared the Special Report on Emissions Scenarios in 2000. It provides 40 greenhouse gas and sulphate aerosol emission scenarios based on different assumptions about demographic, economic and technological factors. The emissions scenarios are fed into Global Climate Models, to project future changes in climate.

Threshold A property of a system where the relationship between the input and the output changes suddenly. For example, the height of a flood defence represents a critical threshold—if water levels exceed the defence height, flooding will occur. It is important to identify climate-related thresholds, as they indicate rapid changes in the level of risk.

Timeslice Projections of climate change are usually given for three timeslices—the 2020s, 2050s, and the 2080s. The projections are a 30-year average, centered on each of the given timeslices, (i.e., the 2020s is 2010–2039). Climate models cannot predict what the specific climate will be in any given year, due in part to the interannual variability of climate variables, so the projections are 30-year averages of future climate.

Uncertainty An expression of the degree to which a value is unknown (e.g., the future state of the climate system). Uncertainty can result from lack of information or from disagreement about what is known or even knowable.