Background Paper: Development and Evaluation of Power Supply Options for Kosovo

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This background paper was prepared by a team from the consulting firm DHInfrastructure and reviewed by World Bank staff. The Government of Kosovo has requested the Bank for a Partial Risk Guarantee to support its proposed power generation project called Kosovo Power Project. Consistent with World Bank guidelines that seek to balance development needs with climate change concerns, an External Expert Panel is currently assessing whether the proposed project meets the “Development and Climate Change: A Strategic Framework for the World Bank Group” criteria.

This background paper was commissioned by the World Bank as one of many analytical inputs to the Expert Panel’s deliberations. This background paper consolidates many analytical reports and models the projected use of the installed capacity of all power supply options for Kosovo to meet energy consumption and peak demand until 2025. This paper includes consideration of the environmental externalities associated with each option and reviews several combinations of energy alternatives for meeting daily and seasonal variations in demand.

Table of Contents

Tables

Figures

Appendices

Executive Summary

Purpose of this report

The Government of Kosovo has requested World Bank support, in the form of a partial risk guarantee (PRG), for a new, coal-fired independent power project (IPP). World Bank support for coal-fired projects requires that full consideration be given to other viable alternatives and their economic costs, as compared to the coal-fired alternative.

Previous studies sponsored by the European Commission, the World Bank and other donors, concluded that Kosovo's lignite-fired power generation was the least cost option for the entire region to meet its energy supply and security needs. Other studies, conducted by the Government with the help of a broad spectrum of donors, supported this conclusion, but a systematic comparison and evaluation of the costs of the alternatives had not yet been presented in any single document.

This paper therefore analyzes the cost of the alternatives available to Kosovo for meeting energy consumption and peak demand until 2025 and presents a consolidated review. The analysis includes consideration of the environmental externalities associated with each option.

Historical electricity consumption and peak demand

Electricity consumption and peak demand in Kosovo grew more than 90 percent between 2000 and 2010. Electricity consumption grew at an average annual rate of 6.7 percent, and peak demand at an average annual rate of nearly 6 percent.

Frequent load shedding has constrained peak demand and muted the seasonal (winter) and daily peaks. The transmission system operator, KOSTT has estimated that, during 2001-2007, annual electricity demand would have been 300-700 GWh higher in the absence of load shedding. KOSTT shed an estimated 200-400 GWh between 2009 and 2010.

Most electricity demand in Kosovo is residential (approximately 63 percent in 2010) followed by industry. Technical and non-technical losses in the network remain high, together representing roughly 40 percent of gross electricity consumption.

Existing supply

Kosovo's power system has total installed electricity generation capacity of nearly 1,524 MW, with about 920 MW as net operating capacity. Most of the generation comes from two thermal power plants Kosovo A and Kosovo B, with net operating capacity ranging between 840 and 900 MW.

Kosovo A—the largest and oldest power plant—is unreliable and inefficient. Two of its units, A1 and A2, are out of operation and units A3-A5, though overhauled during 2006-08, remain unreliable and operate well below their installed capacity. Today, the total available capacity from Kosovo A is about 350 MW. The Kosovo B plant, although newer than Kosovo A, continues to have mechanical and electrical problems that result in frequent forced outages of both of its units. These units also have been derated due to damage to the turbine rotors and deterioration of the operating condition of other critical components. The net capacity of Kosovo B is about 540 MW for the entire plant.

Imports of electricity via regional interconnections have been important to Kosovo over the past decade. Net imports have ranged between 5 and 17 percent of total annual consumption since 2001.[1] The volume of imports is constrained by availability of surplus generation in exporting countries, interconnection capacity, and cost. The interconnection with Serbia cannot be relied on, and the availability of electricity from Albania for trading or exchange depends on hydrological conditions.

Future demand growth

This study derives a forecast of gross demand for electricity in Kosovo in which growth averages 4.6 percent per year during the 2010-2025 time period ("the planning period") and peak demand grows at an average of 4.2 percent during the same period. This forecast is driven primarily by projected GDP growth and the estimated increase in the electricity tariff to Kosovo's consumers that would be required eventually to cover the economic costs of meeting the forecast growth in power demand as new supply capacity is brought online. The IMF's latest forecast of GDP growth at 4.5 percent[2] is used for modeling growth in power demand from 2011 to 2025.

The forecasts assume that technical and non-technical losses will be reduced over time. More specifically, technical losses are assumed to decline from 16.6 percent of gross energy supplied in 2010 to 8.0 percent in 2025. Non-technical losses are assumed to be reduced from 24 percent to 5 percent at a uniform rate over the 5 years from 2013 to 2018.[3] It is also assumed that the reduction in non-technical losses will reduce demand, as customers reduce consumption of the kWh for which they pay.

A portion of load would be most economically served by the lignite plant—a base load plant—and another portion of load by higher cost peaking plants. An analysis of the supply-demand balance (see Section 3 of the report) shows that Kosovo needs about 950 MW of new, firm capacity by 2017. This need grows to about 1000 MW by 2019 and

[1] KOSTT, Long-term Energy Balance for Kosovo 2009-2018, August 2008.

[2] The IMF forecast real GDP growth for the period 2012 to 2016 averages 4.5 percent (IMF Country Report No. 11/210, July 2011).

[3] The year 2013 is chosen for the beginning of the reduction of non-technical losses on the assumption that the planned privatization of the electricity distribution system in mid-2012 will introduce the commercial discipline required to achieve this reduction.

about 1500 MW by 2025.

The supply options

Kosovo's electricity supply options are constrained by a limited variety of energy sources for power generation. Lignite is the only abundant domestic fuel for power generation. Some potential for renewable energy (RE) generation exists, but it cannot provide the firm capacity Kosovo needs.

-Energy efficiency

As numerous studies have shown, Kosovo has considerable potential to improve energy efficiency by reducing technical and non-technical losses on the supply side, and reduce demand. Reductions in non-technical losses will reduce consumption of electricity because unmetered households use considerably more electricity than those that are metered. Addressing theft and non-payment for consumption of electricity by metered households would reduce demand, and will also have the important effect of increasing the revenues of the power utility (since a large proportion of non-technical 'losses' are actually electricity that is consumed but not paid for). Government is making progress in these areas. The Law on Energy Efficiency has been adopted and a draft National Energy Efficiency Plan for the period 2010-18 has been prepared. Some donors have grant-funded projects for improvement in energy efficiency of public buildings. This study assumes uptake of energy efficiency measures in its demand forecast and consequent sensitivity analysis.

-Thermal

The options for thermal generation are:

- **Lignite.** Domestic lignite reserves are estimated to amount to 12.5 billion tons, of which 10.9 billion tons are exploitable.[4] The proposed Sibovc mine (in the Kosovo basin), which has been deemed the most acceptable option from economic, social and environmental perspectives, has sufficient lignite to supply existing generation facilities to the end of their operational life as well as supplying the proposed 600 MW of generation for forty years.
- **Natural Gas.** Kosovo does not have any gas resources or a gas transmission system.[5] The closest connecting points for a gas pipeline are in Skopje, Macedonia,and Niš, Serbia.[6] However, given demand for gas in Macedonia and the limited capacity of Macedonia's current pipeline, it would be necessary to bring gas to Pristina from Bulgaria. The seasonality of gas demand and geopolitical considerations (Kosovo will have to negotiate a gas supply contract with the single gas supplier in the region, Gazprom

[4] MEM, Energy Strategy 2009-18, pp.6-10 and p.48

[5] A gas pipeline once did exist, in the former Yugoslavia, between a coal gasification facility in Kosovo and an industrial consumer in Macedonia. KEK owns the old pipeline and right of way along the route.

[6] Given the cost of developing a pipeline, consideration has been given only to a base load gas-fired plant. Smaller peaking gas-fired plants have not been included in the analysis.

of Russia) would make it extremely difficult to negotiate a gas supply agreement in the near-term.

- **Fuel Oil.** All liquid fuels in Kosovo are currently imported by rail or road from Macedonia.[7] A fuel oil plant could be supplied via this route or conceivably by road from the Albanian port of Durres.

- Renewables

The options for renewable energy (RE) generation are:

- **Hydro.** The only specific plan for a moderately-sized hydro plant in Kosovo is for the Zhur plant, to be located southwest of Prizren in the area of the Prizren and Sharr municipalities. Plant capacity will be about 305 MW, expected to produce approximately 400 GWh of electricity per year under average hydrological conditions. Studies have also identified 18-20 sites for small hydro plants, with a combined capacity of about 64 MW, producing 294 GWh per year under average hydrological conditions.
- **Wind.** Fewer than 2 MW have been installed to date in Kosovo, and the potential for new wind capacity appears to be limited. A 2010 study funded by Swiss Renewable Energy and Energy Efficiency Promotion in International Cooperation and carried out by consultants NEK Technologies, concluded that there were very few areas with wind speeds exceeding 6 m/s a minimum needed for commercial potential in the region.
- **Solar PV.** A study by consultants Mercados has estimated solar PV potential of 77 MW, but achievable only at very high costs.
- **Biogas and biomass.** Manure-based biogas from livestock and biomass from forestry products and residues are possible sources of distributed (not grid connected) generation in Kosovo. However, it is important to consider that the feedstock for such generation is currently in high demand for alternative uses (wood for heating, and manure for fertilizer).

-Imports

Kosovo is also critically dependent on imports to meet seasonal and daily peaks. However, imports are affected by the geopolitical factors constraining the availability of transmission capacity, by the energy supply-demand balance in the Balkans, and by the financial capacity of KEK to fund imports from tariffs collected and that of the government to fund it from the budget. A new 400 kV transmission line to Albania is expected to be commissioned by the end of 2013, boosting transfer capacity in each direction by roughly 500 MW. A new 400 kV connection to Macedonia is also planned, which will boost transfer capacity in each direction by an additional 500 MW.

The best mix of generation for Kosovo

Kosovo needs a mix of both base load and peaking capacity in order to meet its demand reliably and at lowest cost. This will inevitably mean that it needs a mix of the supply options named above—both thermal

[7] Macedonia has a refinery, connected by pipeline to Greece.

and renewables—and not any single option by itself.

Hydro and renewables can provide some of this firm capacity; it is assumed that 305 MW of firm capacity (used during peak demand) could be supplied by the Zhur hydropower plant; another 170 MW of firm capacity can be supplied by other renewables (small hydro, wind, biomass and biogas). Even if all of this renewable capacity could be built by 2017[8], there would be a remaining gap for firm base-load capacity which averages about 600 MW in the period 2017-19, and grows to about 1,000 MW by 2025. Firm base-load capacity can only be provided by fossil-fuel fired thermal options, as nuclear is not feasible and the neighboring countries are supply-constrained and unable to provide firm capacity.

The least cost supply mix

Alternative power supply plans for Kosovo must include a mix of base load and peaking capacity, and a mix of thermal and renewable energy generating capacity. This study therefore assumes that the following plants will be built with all three options for thermal generation:

- The 305 MW Zhur hydropower plant, which has a large storage facility and will serve as a peaking plant
- 395 MW of installed renewable capacity (providing roughly 170 MW of firm capacity), and
- Approximately 600 MW thermal.

The thermal options considered are: a 600 MW lignite plant, a 575 MW CCGT natural gas plant, and a 575 MW CCGT plant running on fuel oil. The analysis reported in this study concludes that the power supply plan based on new lignite plant is the least cost thermal option for Kosovo.

Importantly, the least cost supply plan assumes significant reduction in technical and non-technical losses and improvement in end-use efficiency. Recent achievements of KEK in reducing non-technical losses and improving collections are an indication of the potential for accelerating loss reduction on privatization of electricity distribution and supply.

Sensitivity analysis

The lignite option is the least expensive thermal option, even when the relatively higher environmental costs are priced in. This option also appears to be able to withstand fairly wide deviations in the assumptions made about changes in demand, capacity utilization, capital costs, fuel costs, global environmental costs that include price of carbon forecast by International Energy Agency in its 2011 World Energy Outlook.

[8] RE capacity will be developed gradually by multiple investors and is therefore assumed to be spread uniformly over the planning period (2011-2025).

The lignite plan (coupled with Zhur and other renewables, as described above) is least cost even under a much lower forecast average growth rate of the gross demand for electricity of 2.9 percent per year during the 2010-2025 time period. This scenario is driven by an assumed GDP growth rate of 3.0 percent per year. This lower demand growth only slightly reduces the cost advantage of the lignite plan.

Higher environmental costs reduce the cost advantage of lignite over gas, but CO_2 prices would need to stay 55 percent above the medium-term forecasts of the International Energy Agency (IEA) for carbon to bring gas at par with lignite option. The cost of lignite surpasses the cost of gas if the cost per ton of CO_2 is 55 percent higher than assumed in the base case (€23.25/tCO_2 instead of €15/ tCO_2), and is 55 percent higher than the IEA forecast for each year thereafter (reaching a level of €35.02/tCO_2 by 2020 and €40.44/tCO_2 by 2025).

Higher costs for building and operating the lignite plant will also reduce its advantage, over gas, but such costs would have to increase substantially. Lignite fuel costs would need to increase by 70 percent or the price of gas decrease by 15 percent before the gas option becomes equivalent to the lignite option in total supply cost. Construction costs of the lignite plant could increase 25 percent while keeping the construction costs of gas plant constant before the gas option becomes equivalent. Construction costs overall (for all types of plant) could increase by 45 percent before the cost of the gas option nears that of the lignite option.

1 Introduction

The Government of Kosovo has requested World Bank support, in the form of a partial risk guarantee (PRG), for a new, coal-fired independent power project (IPP). The World Bank Group has appointed a panel of experts to assess whether the proposed project meets the six screening criteria under which the World Bank can support coal-based power generation projects.

The six criteria, as described in the World Bank Group's Strategic Framework for Development and Climate Change, are the following:

- There is a demonstrated developmental impact of the project, including improving overall energy security, reducing power shortage or increasing access for the poor;
- Assistance is being provided to identify and prepare low carbon projects;
- Energy sources are optimized, looking at the possibility of meeting the country's needs through energy efficiency (both supply and demand) and conservation;
- After full consideration of viable alternatives to the least cost (including environmental externalities) options, and when the additional financing from donors for their incremental cost is not available;
- Coal projects will be designed to use the best appropriate available technology to allow for high efficiency and, therefore, lower GHG emissions intensity;
- An approach to incorporate environmental externalities in project analysis will be developed.

This paper analyzes the alternatives available to Kosovo for meeting its power demand, including the environmental externalities of each alternative. Previous studies sponsored by the European Commission, the World Bank, and other donors concluded that Kosovo's lignite-fired power generation was the least cost option for the entire region to meet its energy supply and security needs. Other studies, conducted by the Government with the help of many donors, supported this conclusion. However, a systematic comparison and evaluation of all the alternatives was not presented in a single document for easy comparison; hence, this background paper was commissioned. Appendix Box **A.1** lists some of the principal studies used in this analysis.[9] A more detailed list of studies and references are listed at Appendix G.

[9] Appendix G contains a more complete list of some of the studies consulted and referred to extensively in this report.

Appendix Box A.1: Principal Studies Reviewed for this Analysis

CESI, EIMV, Ramboll Oil and Gas, and Rheinbraun Engineering Und Wasser GMBH (consortium), Energy Sector Technical Assistance Project (ESTAP) Kosovo, Final report, June 2002

KOSTT, Generation Adequacy Plan (2009-15), October 2008

KOSTT, Generation sizing in view of the technical and commercial requirements of Kosovo Power system, February 2010

KOSTT, Long-term Energy Balance for Kosovo 2009-2018, August 2008

KOSTT, Transmission Development Plan (2010-19), May 2010

Ministry of Energy and Mining, Energy Strategy of the Republic of Kosovo for the Period 2009-2018, September 2009

Ministry of Energy and Mining, Statement of Security of Supply for Kosovo, June 2010

Parsons Brinckerhoff and PriceWaterhouseCoopers, Lignite Power Technical Assistance Project Generation Planning and Unit Sizing Report, March 2010

Parsons Brinckerhoff and PriceWaterhouseCoopers, Lignite Power Technical Assistance Project Unit Sizing Report, April 2010

Pöyry, CESI and DECON (consortium), Studies to Support the Development of new Generation Capacities and Related Transmission, Prepared for Kosovo UNMIK, November 2007

PwC Consortium, Regional Balkans Infrastructure Study – Electricity (REBIS) and Generation Investment Study (GIS), December 2004 and update in January 2007.

The remainder of this paper is organized as follows:

- Section 2 provides a brief overview of the characteristics of electricity supply and demand in Kosovo over the past decade
- Section 3 describes future expectations about demand until 2025
- Section 4 identifies the supply options Kosovo has available
- Section 5 identifies which options can be combined to meet expected demand in Kosovo until 2025
- Section 6 concludes with an analysis of which of the plans, identified in Section 5, best meets Kosovo's needs at lowest cost.

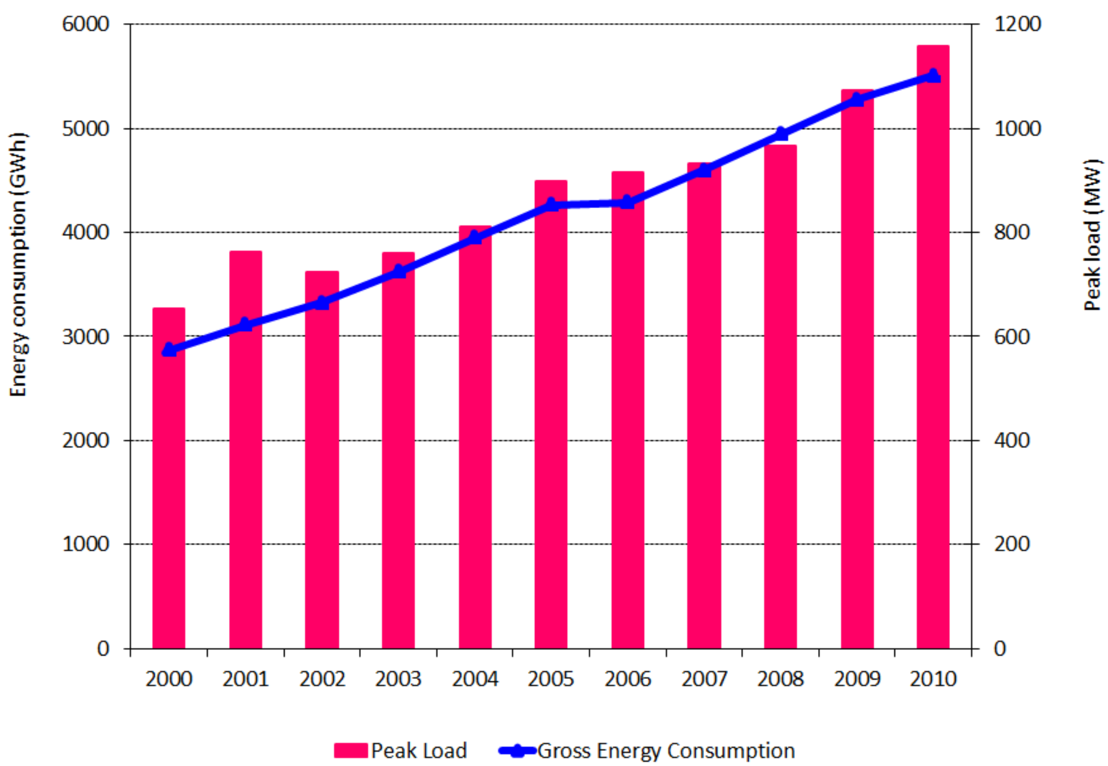
2 The Current Demand-Supply Balance in Kosovo

This section provides an overview of the demand-supply balance in Kosovo. Section 2.1 describes the characteristics of historical demand in Kosovo. Section 2.2 describes the characteristics of the existing generating plants, and transmission and distribution lines available to serve demand.

2.1 Electricity Demand

Electricity consumption and peak demand in Kosovo increased by more than 90 percent between 2000 and 2010; peak increased nearly 90 percent. Electricity consumption grew at an average annual rate of 6.7 percent, and peak demand at an average annual rate of nearly 6 percent. Figure 2.1 shows the trend.

Figure 2.1: Historical Consumption and Peak Demand in Kosovo



Source: Lignite Power Technical Assistance Project (LPTAP) Office, Kosovo and KEK

Load shedding and outages

Frequent load shedding and unplanned outages have constrained demand growth and muted the seasonality of demand. Power System Operator KOSTT sheds load during peak periods, when domestic generation and imports are insufficient to meet demand. KOSTT has estimated that, during 2001-2007, annual electricity demand would have been 300-700 GWh higher in the absence of load shedding. In 2009 and 2010, load shedding is estimated as 373 and 205 GWh, respectively.[10] Unplanned outages are the result of faults at all segments of the network: generation, transmission and distribution.[11]

Tariffs

Current tariffs charged to customers are not cost reflective: for the most part, household consumers are subsidized by non-household users. Household tariffs as a whole are estimated to be roughly 20-30 percent below the suppliers' total financial costs, whereas some industrial tariffs significantly exceed the cost reflective level.[12] Moves to more cost reflective tariffs will affect the demand by different consumer categories with the impact (as discussed in the next section) depending on consumers' price elasticity of demand. Kosovo currently has eight tariff groups reflecting different voltages of off-take and volumes of consumption. Tariffs for most metered, high-voltage customers are two-part tariffs (in other words, they have fixed and variable components). Tariffs for all metered customers differ by season, and by day for (high voltage and some residential) customers who have time-of-use meters. Tariffs for residential customers reflect an increasing block schedule, with higher tariffs on higher volumes of consumption. Unmetered residential customers pay a fixed monthly fee based on their estimated monthly consumption. Appendix Table F.1 presents the current electricity tariff schedule in Kosovo.

Load shape

Kosovo's electricity consumption follows a winter peaking pattern. Load factors have historically ranged between 50 and 60 percent, but the seasonality of demand has been muted, and load factors overstated because of planned and unplanned outages. Figure 2.2 shows a load duration curve and annual consumption pattern for 2010.

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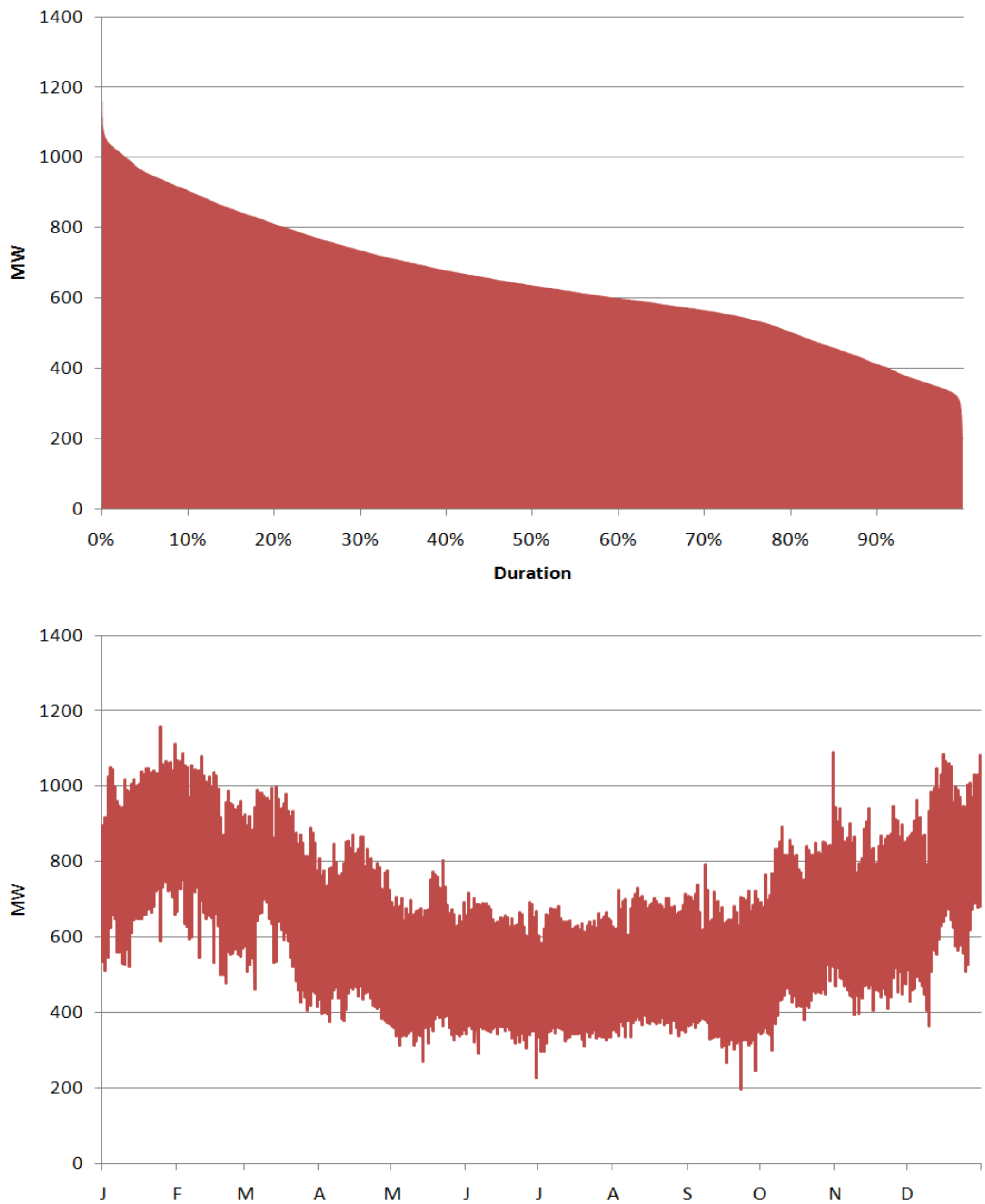
[10] Energy Regulatory Office, *Statement of Security of Supply for Kosovo (Electricity, Natural Gas and Oil),* July 2011

[11] KOSTT, *Generation Adequacy Plan (2009-15),* October 2008.

[12] The term "financial costs" is used to distinguish from "economic costs" which are the basis for the analysis in Section 5 and the sensitivity analysis in Section 6

Figure 2.2: Load Duration Curve and Seasonality of Demand (2010)



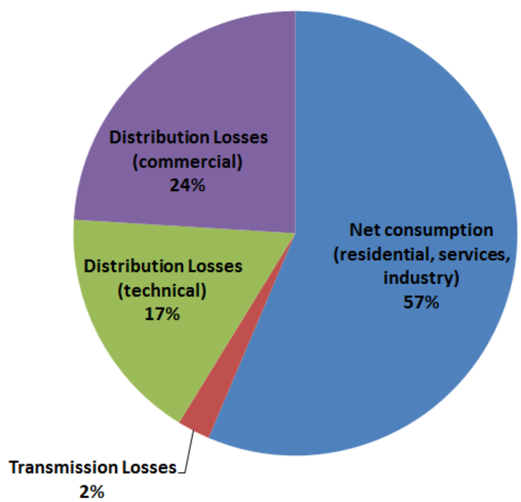
Source: Spreadsheets provided by KOSTT

Composition of demand

Most metered electricity demand in Kosovo is residential (approximately 63 percent in 2010), followed by industry. Technical and non-technical distribution losses together represent more than 40 percent of total electricity generated. Non-technical losses have been reduced in recent years, from roughly 30 percent in 2006 to 24 percent in 2010. Losses in 2010 totaled roughly 2,000 GWh. The current District Heating system in Pristina and Gjakova, if not operated properly, can also load the power system with an additional demand of 70-100 MW during winter.[13]

Reductions in non-technical losses will reduce consumption of electricity because unmetered households have been shown to use considerably more electricity (in some cases nearly double that of metered households).[14] Addressing theft and non-payment for consumption of electricity by metered households would reduce demand and would have the important effect of increasing the revenues of the power utility (because a large proportion of non-technical 'losses' are actually electricity that is consumed but not paid for).

Figure 2.3: Composition of Gross Electricity Consumption (2010)



Source: Energy Regulatory Office, Security of Supply for Kosovo (Electricity, Natural Gas and Oil), July 2011

[13] This 70-100 MW of load was not included in the demand forecasts developed in Section 3

[14] CESI, EIMV, Ramboll Oil and Gas, and Rheinbraun Engineering Und Wasser GMBH (consortium), *Energy Sector Technical Assistance Project (ESTAP) Kosovo, Final report,* June 2002 ("ESTAP") (Prepared for the UN Interim Administration Mission in Kosovo UNMIK)

2.2 Electricity Supply

Kosovo's power system has total installed electricity generation capacity of nearly 1,524 MW, with about 920 MW as net available capacity.[15] The majority of the generation comes from two thermal power plants, Kosovo A and Kosovo B, with total installed capacity of 800MW (available 350 MW) and 678 MW (available 500-540 MW) respectively. A minority share comes from two hydro power plants, Ujmani and Lumbardhi, with installed capacities of 35MW and 8.3 MW respectively (see Table 2.1).

However, not all this installed capacity is available. Kosovo A—the largest and oldest power plant—is very unreliable and inefficient. Two of its units, A1 and A2, are out of operation and units A3-A5, although overhauled during 2006-08, remain unreliable and operate well below their installed capacity. Today, the total capacity from Kosovo A is 350 MW. The entire plant is planned to be decommissioned in 2017.

The Kosovo B plant, although newer than Kosovo A, continues to have mechanical and electrical problems that result in frequent forced outages of both units. These units have reduced active power output due to damage to the turbine rotors and deterioration of the operating condition of other critical components, thus reducing the net capacity to about 500-540 MW for the entire plant.

Taking into account these issues, the net operating capacity of the Kosovo power system is about 920 MW. In an effort to mitigate issues with the existing generation plant, the Kosovo B power plant is scheduled to undergo major rehabilitation to i) improve the emissions control system and bring it in compliance with EU standards, and ii) improve its operating efficiency and reliability.

In order to meet EU requirements, Kosovo B units will have to be equipped with emission reduction equipment, repair of the existing electrostatic precipitators, and a means of reducing fugitive dust from the lignite and ash handling systems. Regarding the operating efficiency, the rehabilitation of the turbine generation and other technical improvements are expected to result in an increase in unit net capacity up to 309 MW each or 618 MW for the entire power plant (bringing it to the original design net capacity of the plant).

[15] The net operating capacity ranges between 840 to 900 MW of thermal capacity and net available hydroelectric capacity is about 42 MW

Table 2.1: Characteristics of Electricity Generation Plants in Kosovo

Plant name	Fuel	Installed capacity (MW)	Net Dependable Capacity[16] (MW)	Production (GWh 2010)	Commissioned	Useful life (Retirement)
Kosovo A	Lignite					
Unit A1		65			1962	Out of operation
Unit A2		125			1964	Out of operation
Unit A3		200			1970	
Unit A4		200			1971	
Unit A5		210			1975	
Total Kosovo A		**800**	**345-370[17]**	**1740**		**2017**
Kosovo B	Lignite					
Unit B1		339			1983	
Unit B2		339			1984	
Total Kosovo B		**678**	**500-540**	**3271**		**2027-30**
Ujmani	Hydro	35	32	114*		2033
Unit 1		17.5			1983	
Unit 2		17.5			1983	
Lumbardhi	Hydro	8.8	8.0	42		
Other	**Hydro**	**2.1**	**2.07**			
Total		**1,523.9**	**887-952**			

*(80-90 with average inflows)

Sources: Poyry Power Market Review, ERO Security of Supply for Kosovo 2011

[16] The power level that a unit can sustain during a given period, less any capacity (MW) utilized for that unit's station service or auxiliary loads.

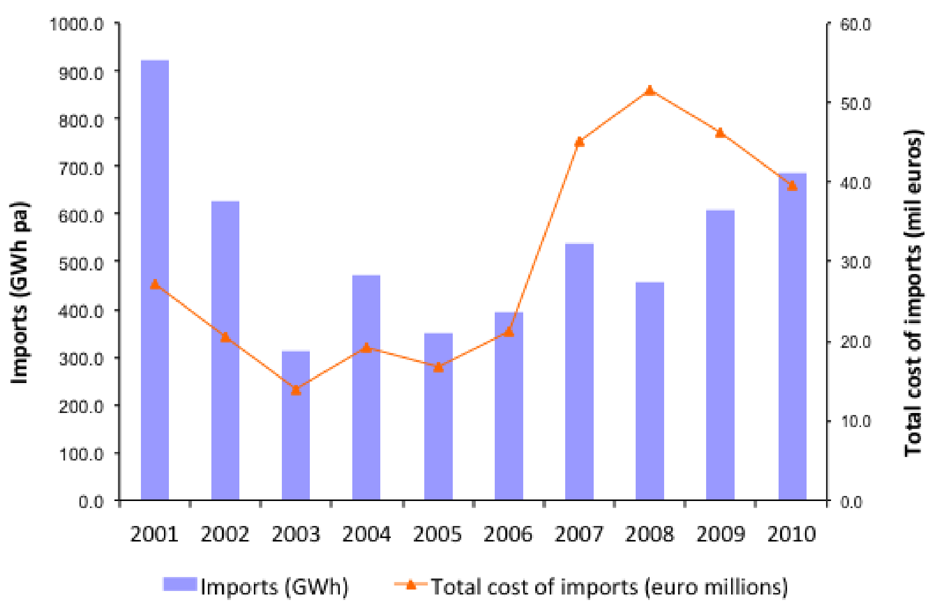
[17] Though actual available capacity is in excess of 300MW, Kosovo A3 and A4 cannot currently be operated simultaneously. With the operating constraint, net available capacity is roughly 230 MW.

Abundant good quality lignite is the only significant domestic source of primary energy currently used for electricity production. With the exception of the plants described above and a number of smaller hydro plants, there is almost no electricity production from other energy sources in Kosovo.

Imports

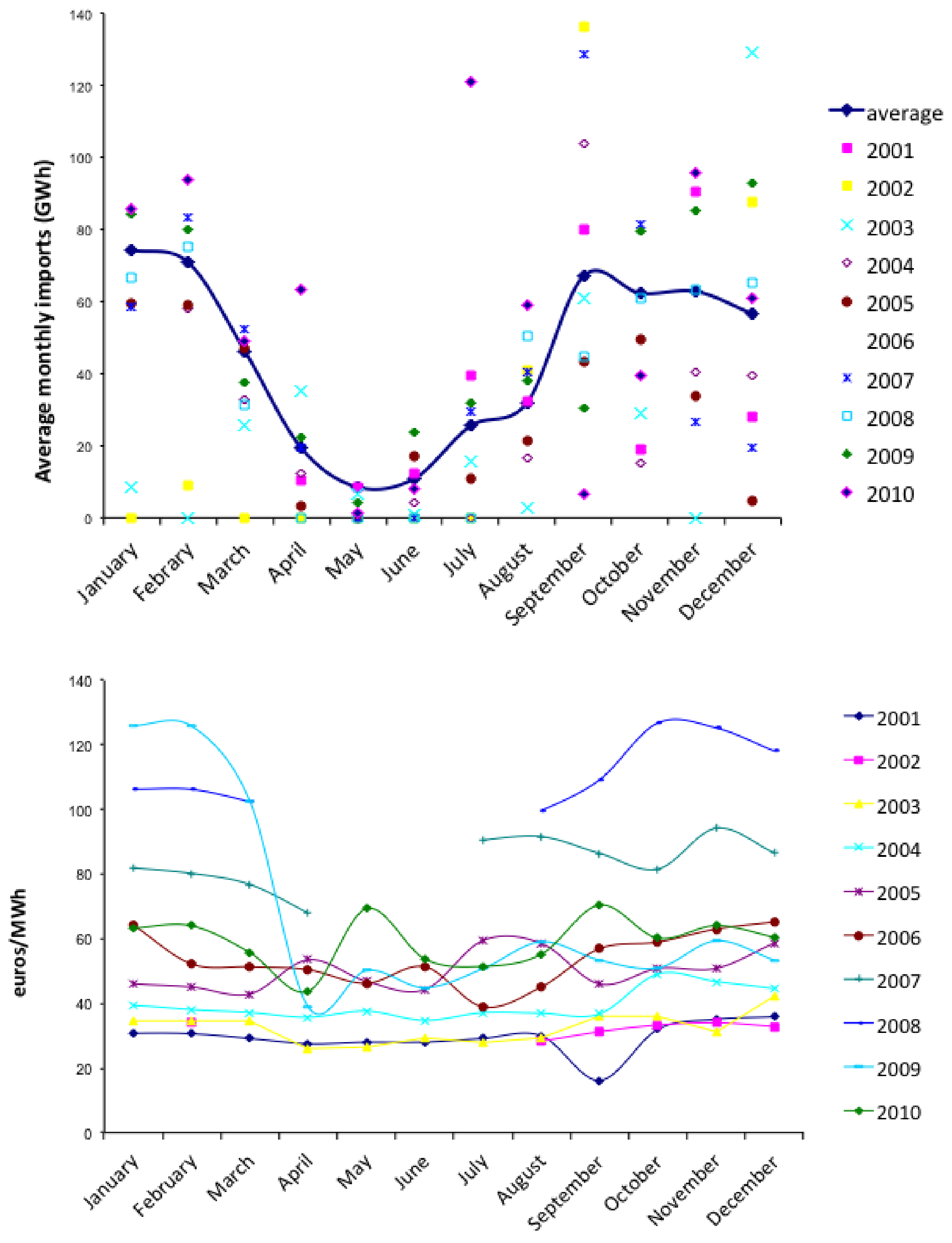
Imports of electricity via interconnections have been important to Kosovo over the past decade. Net imports in Kosovo have ranged between 5 and 17 percent of total annual consumption since 2001, with wide variation both between and within years (seasonality) as shown in Figure 2.4 and Figure 2.5. Kosovo has contracts for energy exchange with Albania. Average import prices per MWh have ranged substantially during this period, between €30 and €113. The price of exports by Kosovo (not shown) ranged from €30 to €40 per MWh during the same time period. The volume of imports is constrained by availability of surplus generation in exporting countries, interconnection capacity, and cost. For example, interconnection with Serbia cannot be relied upon and availability of electricity from Albania depends on hydrological conditions there. In terms of cost constraints, imports are limited by the financial ability of KEK to fund the purchases given high levels of non-technical losses.[18] The total cost of electricity imports has approximately doubled in the past five years. However, unit prices have declined since 2008 as a result of a fall in demand in the region due to the global financial crisis.

Figure 2.4: KEK Electricity Imports and Cost 2001-10



[18] MEM, *Energy Strategy for the Republic of Kosovo for the Period 2009-2018*, September 2009. Onp.44, it states that "the amount of imported electricity will depend from [sic] its consumption control, and primarily from elimination of commercial losses."

Figure 2.5: Seasonality in Electricity Imports and Prices 2001-10



The curves above reflect the fact that imports generally cease in summer months when demand in Kosovo is lower.

3 Future Demand-Supply Balance in Kosovo

Forecasts of electricity demand had been prepared under the Energy Sector Technical Assistance Project (ESTAP) in 2002 and updated by a consulting group led by Pöyry in 2007.[19] At the time the ESTAP study was prepared, the lack of reliable time series data on electricity consumption prevented a conventional approach to demand modeling. The approach therefore used projections of technical characteristics of electricity end-uses from 2002 levels. The 2007 update of the forecast simply extrapolated ESTAP's approach. Another, more recent long-term demand forecast is presented by KOSTT in its Transmission Development Plan (2010-19).[20] Although the forecast mentions that various economic and technical factors have been taken into account, including forecast economic growth, potential industrial development, and envisaged reduction in technical and non-technical losses, the forecast was affected by the lack of accurate economic data.

In the absence of detailed and accurate data on the structure of end-use demand and the key economic drivers, the available demand forecasts all suffer from deficiencies. Demand forecasts therefore need to be periodically updated to account for actual behavior of economy and the consumers.

Given the substantial changes in Kosovo since 2002, extrapolating the ESTAP/Pöyry forecasts further would not provide a credible forecast of power demand. The technical basis on which those forecasts were based has changed substantially since the post-conflict years. In addition, actual consumption for the last five years has turned out to be closer to their High Growth scenarios than to the base demand scenario, in part due to slower rates of loss reduction, implementation of demand-side management measures, and tariff adjustments to cost-recovery levels.

Therefore, for the purpose of this analysis, an electricity demand forecast (for the period to 2025) based on a demand growth function driven by electricity price and Gross Domestic Product (GDP) has been prepared. The forecast represents a first order estimate of how electricity demand will develop over the medium- to long-term under projected economic conditions.

[19] *ESTAP,* June 2002; Pöyry, CESI and DECON (consortium), *Studies to Support the Development of new Generation Capacities and Related Transmission,* Prepared for Kosovo UNMIK, November 2007

[20] KOSTT, *Transmission Development Plan (2010-19)*, May 2010

3.1 Basic Forecasting Methodology

The methodology for deriving a forecast of the economically efficient level of demand for electricity over the long term is based on the following relationship between power demand growth and real income growth rate and real electricity price growth rate, assuming a constant elasticity power demand equation:

> The rate of growth of demand is equal to the rate of growth of prices times the price elasticity plus the rate of growth of income times the income elasticity. This is expressed formally as:
>
> $d = p*b + g*a$
>
> where:
>
> d = annual average rate of growth of demand
>
> a = income elasticity (positive)
>
> g = growth of real income between successive forecast periods
>
> b = price elasticity of demand (negative)
>
> p = change of real power prices between successive forecast periods.

For the purpose of using this model, the forecast period is the calendar year and estimates of price elasticity and income elasticity of power demand in Kosovo were generally derived from ESTAP's analysis. The approach taken to deriving these estimates is set out in Appendix A and is summarized below.

- A constant price elasticity of electricity demand equal to -0.20 for total Kosovo consumption when the average electricity tariff level across consumer tariff groups is changed.
- A specific price elasticity of electricity demand equal to -0.40 for the reduction in consumption brought about by the reduction in non-technical losses (mainly for unpaid consumption by households).
- A constant income elasticity of electricity demand equal to +1.31.

The resulting first order end-use electricity demand forecast model for year $n+1$ is:

$$D_{n+1} = D_n*(1-0.40*p_{n+1} + 1.31*g_{n+1})$$

> where D_n is the end-use energy demand in year n of the forecast period and D_{n+1} is the end-use energy demand in year $n+1$, p_{n+1} is the projected change of real power prices between years n and $n+1$, g_{n+1} is the projected growth of real income between years n and $n+1$, and n equals one in 2011.

The demand for electricity derived with this model is the forecast unconstrained end use consumption without reduction of losses from the present level. This forecast demand is then transposed into the **gross energy sent out to the power network from power generation plants needed to supply forecast unconstrained end use**

consumption with scheduled reduction in non-technical losses. This amendment takes account of assumptions about reductions in technical and non-technical losses.

The incorporation of price elasticity and income elasticity effects is carried out in the following three-stage process.

- In the first stage, which is described above, the value for income elasticity is combined with the forecast growth in GDP, but no change is assumed in the average electricity tariff in real price terms. This part of the analysis produces the **preliminary base case demand forecast**.
- In the second stage, the economic cost of supplying this forecast demand is computed according to the methodology described in Section 6.1. These costs include the local socio-economic costs imposed by atmospheric emissions (NO_X, SO_X, ash, etc.) from burning fossil fuels to generate electricity in Kosovo. These costs exclude the price of carbon dioxide and the costs of constructing and operating the high-cost renewable supply options.
- In the third stage, **the economic base case power demand forecast** is derived with electricity prices that reflect the level of the economic cost of supplying the preliminary base case forecast demand. When this economic cost is substantially greater than the current average electricity tariff – taken to be equal to the average level in force in Kosovo during the year 2010 – the difference between the two measures provides an estimate of the increase in electricity prices from the current level required to estimate the demand for electricity that is consistent with economic efficiency principles. When this price increase is large, it is modeled in affordable annual steps over a long period, which in practice is by 2025. The power demand model is rerun with the estimated increase in electricity price combined with the value for price elasticity of electricity demand, as well as with the value for income elasticity combined with the forecast growth in GDP.

The economic base case forecast is the forecast used for evaluating the power supply options.

3.2 Forecast of Electricity Consumption (GWh)

The preliminary base case demand forecast was computed from the demand model utilizing an assumption of 4.5 percent per annum real GDP growth from 2011 to 2025.[21] Under these assumptions, electricity consumption in Kosovo would grow at an average of 4.6 percent per annum over the period to 2025. Appendix A shows the annual forecast, year-by-year, and how it was derived.

The measure of economic cost used for this analysis is **the long run average incremental cost (LRAIC),** which is defined in Appendix A**.**

[21] This assumption was made based on the IMF forecast real GDP growth for the period 2012 to 2016, which averages 4.5 percent (IMF Country Report No. 11/210, July 2011).

The LRAIC for the preliminary base case is estimated to be €0.080 per kWh sent out from generation plants to the power network (see Appendix Table A.5).

This estimate of economic cost of supply is compared with the average tariff charged in 2010, as described above. Hence the LRAIC has to be converted to the equivalent cost per kWh billed.

- Assuming the actual level of technical losses in 2010 of 16.6 percent of the total energy sent out to the power network and to direct consumers, and incorporating an acceptable allowance on efficiency grounds of 5 percent for non-technical losses that the power supplier has to cover from billed revenues, this economic cost of supply is equivalent to €0.103 per kWh billed in constant 2011 price terms.
- According to KEK, in 2010 they billed €201.3 million for total billed consumption of 3,496 GWh, which indicates that KEK's average tariff was €0.0576 per kWh billed.[22]
- The estimated LRAIC is therefore 78 percent more than the average tariff in 2010. This difference can be bridged by a series of 4.2 percent annual increases on the average tariff level in constant 2011 price terms starting in 2012 and running to 2025, on the basis described above. These prices reflect economic costs in order to derive the economically efficient demand. They do not reflect financial costs or tariffs needed to recover financial costs, which differ from economic costs.

Hence **the economic base case demand forecast** is derived with 4.2 percent annual increases in the power price and a price elasticity of demand equal to –0.2, combined with the a value of +1.31 for income elasticity and annual growth in real GDP of 4.5 percent per during the planning period.

The effect of introducing the price elasticity of demand effect is to reduce the forecast gross energy sent out requirement in 2020 from 8,819 GWh to 8,208 GWh, or 6.93 percent of the former. The corresponding reduction in 2025 is from 11,488 GWh to 10,274 GWh, or 10.57 percent of the former amount. Under this base case, demand is forecast to grow on average at 4.6 percent per year from 2010 to 2025.

The sources for such significant reductions in demand were identified in the ESTAP study. By far the largest source is improved efficiency of space heating in houses and offices. The feasibility of achieving this efficiency improvement can be shown in principle by updating ESTAP's projections as follows. Electricity consumption for space heating in Kosovo appeared to be about 1,800 GWh in 2010, and could increase to

[22] Kosovo's current electricity tariff is low compared to the average electricity price for all users in Southeast European Countries in the second semester of 2011, which are as follows (Euro cents per kWh): Albania - 8.66; Bosnia and Herzegovina - 6.35; Bulgaria - 8.26; Croatia - 10.76; Macedonia - 8.00; Montenegro - 6.89; Romania - 9.22; Serbia 6.86; Kosovo - 5.74. (Source: The Energy Regulators Regional Association (ERRA)'s website http://www.erranet.org).

around 2,900 GWh in 2025. Assuming that the long-term improvement in heating efficiency should be around 35 percent of the current level and that this level could be attained by 2025, the long-term potential saving in electricity consumption for space heating would be around 1,000 GWh in 2025. This would account for about four-fifths of the reduction in demand in that year from the projected increase in electricity prices under the economic base case demand forecast. The other one-fifth could be obtained from improved efficiency for other electricity uses, energy conservation, and fuel substitution.

A sensitivity case for the comparison of power supply plans is conducted at a low economic case demand forecast, in which the forecast growth in GDP is reduced to 3.0 percent per year from the 4.5 percent per year used in the base case. This lower GDP growth is combined with the price increase used for the base case to produce this low case, under which demand is forecast to grow on average at 2.9 percent per year from 2010 to 2025

Appendix A shows the derivation of these three demand forecast cases using the methodology described above. Table 3.1 summarizes these cases.

Table 3.1: Summary of Power Demand Forecast Cases

	Gross energy to supply forecast unconstrained end-use consumption with scheduled reduction in non-technical losses (GWh)				
	Year	**2010**	**2015**	**2020**	**2025**
		actual	**forecast**	**forecast**	**forecast**
Preliminary Base Case Demand Forecast		5,271	7,114	8,819	11,488
annual growth of gross energy supply			6.18%	4.39%	5.43%
Economic Base Case Demand Forecast		5,271	6,890	8,208	10,274
annual growth of gross energy supply			5.51%	3.56%	4.59%
Low Economic Base Case Demand Forecast		5,271	6,527	7,075	8,058
annual growth of gross energy supply			4.37%	1.62%	2.64%

Table 3.2 shows the various demand forecasts discussed at the beginning of this section. for comparison with the base case and low case economic demand forecasts shown in Table 3.1. In 2015, the end year for most of the previous forecasts, the economic base case forecast used for this study is almost the same as KOSTT's forecast. The low

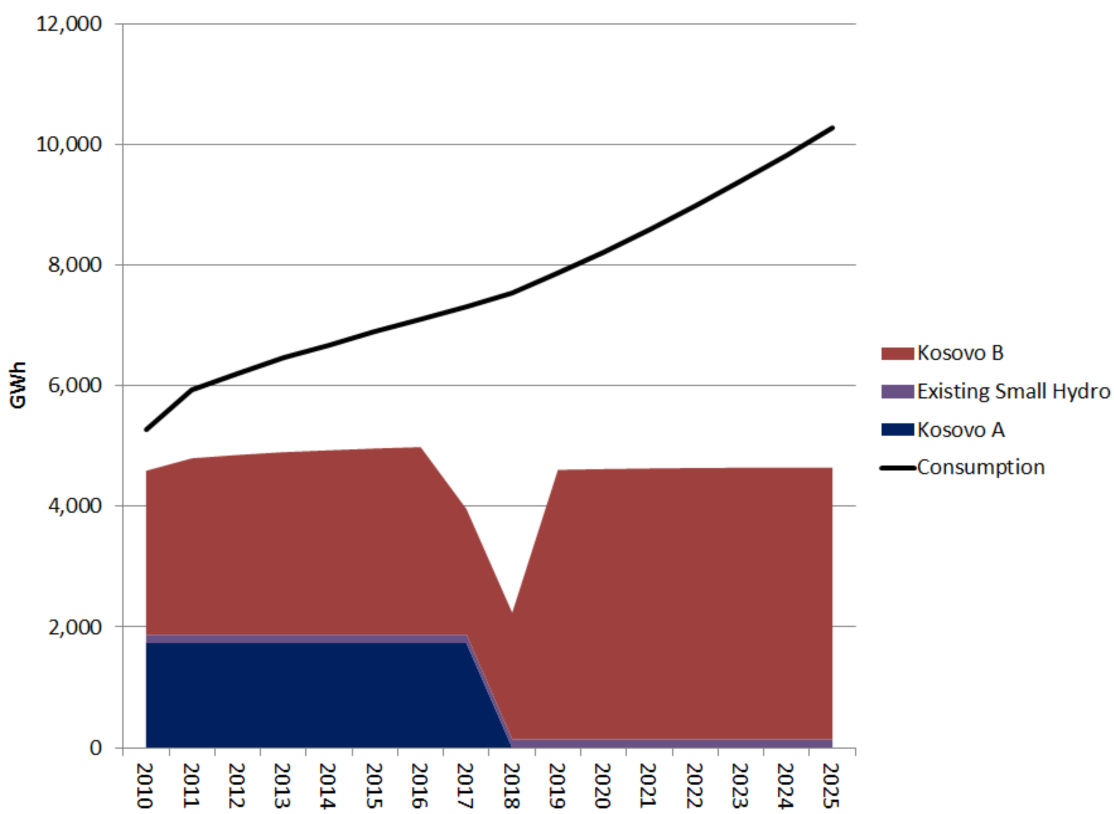
economic forecast used for sensitivity analysis in this study lies within the range of demands for the previous forecasts.

Table 3.2: Previous Demand Forecasts

Electricity demand	2005	2006	2007	2008	2009	2010	2015	2020	2025
ESTAP Study-Base Case	3,586					4,272	5,137		
ESTAP Study-High Case	3,769					4,988	6,519		
Povry Study	4,562		4,966			5,136	5,696	6,219	
KOSTT						5,700	6,800		
Energy Strategy						5,226	6,295		
Actual consumption	4,266	4,285	4,597	4,944	5,275	5,506			

Figure 3.1 shows the forecast gap between consumption (as per the economic base case in Table 3.1) and available domestic supply over the period to 2025. The dip in supply in the 2017-2019 period reflects the rehabilitation planned for Kosovo B.

Figure 3.1: Future Generation Gap (GWh)



3.3 Forecast of Peak Demand (MW)

The unconstrained system peak demand was estimated based on power system load factors derived by ESTAP for the situation where measures to reduce technical and non-technical losses are implemented. A projected annual system load factor of 0.545 from 2015 is based on ESTAP's projected factors for the modeling case where measures to reduce non-technical losses are assumed to be implemented.

Under the assumption that such measures are implemented over five years, the forecast values for system peak load are as shown in Table 3.3. The forecast gap between peak demand and available peak supply is shown in Figure 3.2. Under the base case assumptions, peak demand growth is forecast at approximately 4.2 percent per annum between 2010 and 2025.

Table 3.3: Summary of Forecasts of Peak Demand on the Kosovo Power System

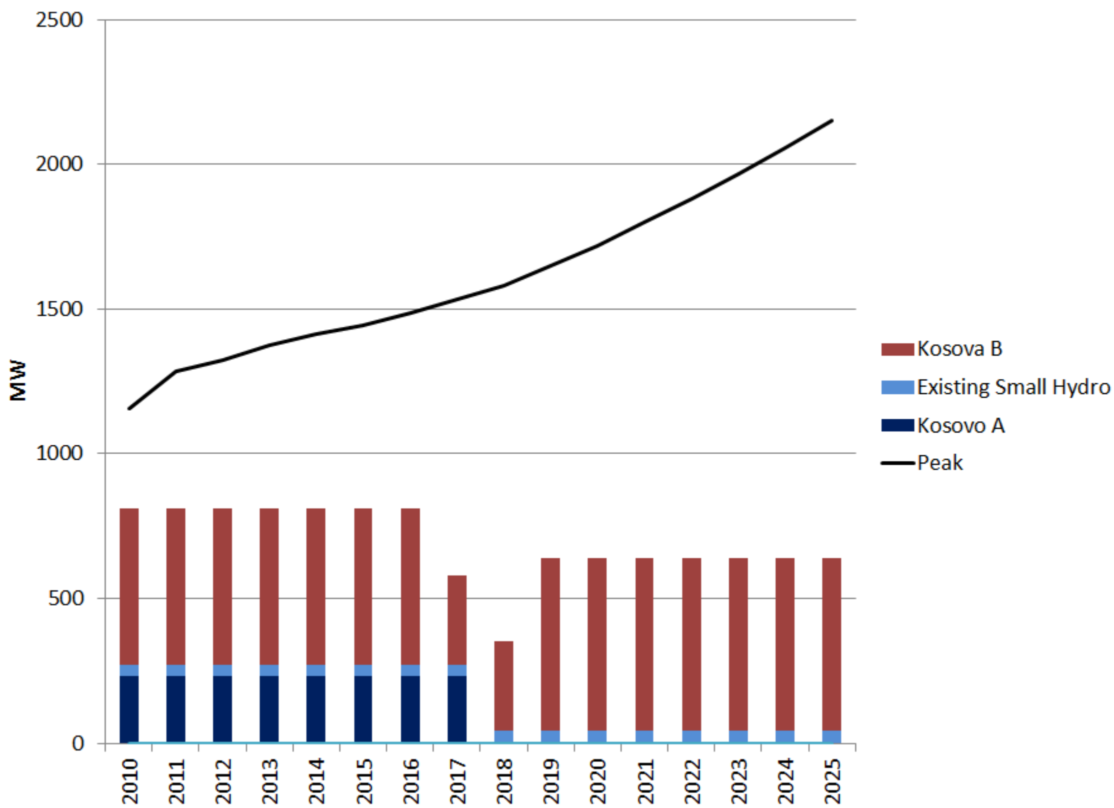
	Projected unconstrained system peak demand (MW) (based on generated energy to supply forecast unconstrained consumption)			
Year	**2010**	**2015**	**2020**	**2025**
	Actual	**forecast**	**forecast**	**forecast**
Economic Base Case Demand Forecast	1,158	1,443	1,719	2,152
annual growth of peak system demand		4.50%	3.56%	4.59%
Low Economic Base Case Demand Forecast	1,158	1,367	1,482	1,688
annual growth of peak system demand		3.38%	1.62%	2.64%

Figure 3.2 shows the anticipated gap between forecast peak demand and available domestic generation from existing capacity, using the economic base case forecast.[23] [24]

[23] Electricity imports are excluded from these figures. The role of potential for electricity imports to meet demand is considered Section 4.

[24] For both figures, Kosovo A is assumed to go off line by 2018.

Figure 3.2: Peak Demand-Supply Gap

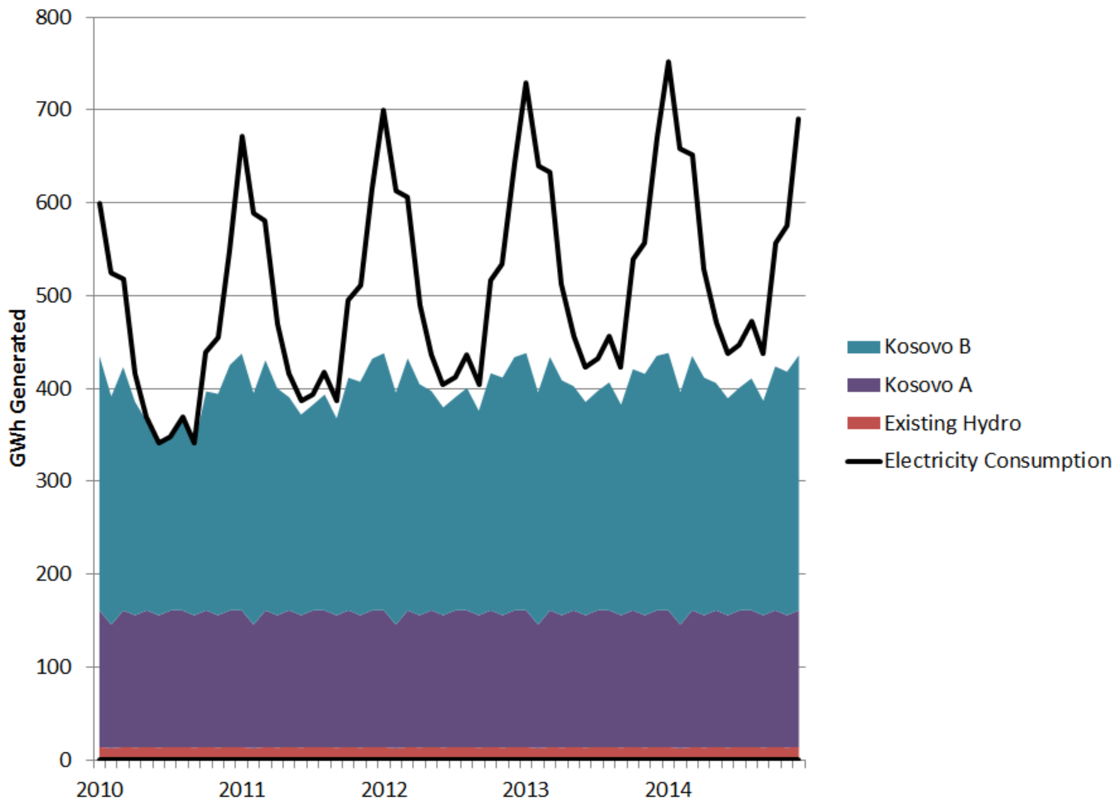


As Figure 3.2 shows, Kosovo's needs for new firm capacity are: 950 MW by 2017 (after Kosovo A has retired), 1200 MW in 2018 (when one Kosovo B unit is out of service), 1000 MW in 2019 and about 1500 MW in 2025. Hydro and renewables can provide some of this firm capacity; it is assumed that 305 MW of firm capacity (used during peak demand) could be supplied by the Zhur hydropower plant; another 170 MW of firm capacity can be supplied by other renewables (small hydro, wind, biomass and biogas). Even if all of this new renewable capacity could be built by 2017[25], there would be a remaining gap for firm base-load capacity which would average about 600 MW in the period 2017-19, and grow to about 1,000 MW by 2025. Firm base-load capacity can only be provided by fossil-fuel fired thermal options, as nuclear is not feasible and the neighboring countries are supply-constrained and unable to provide firm capacity.

Figure 3.3 shows generation and demand by month until 2015, indicating Kosovo's large gap during its winter peaks. This gap is typically filled with imports, and when imports are not available, load shedding must be implemented.

[25] RE capacity will be developed gradually by multiple investors and is therefore assumed to be spread uniformly over the planning period (2011-2025).

Figure 3.3: Demand and Generation Forecast by Month, 2010-2015



4 Power Supply Options

Kosovo's electricity supply options are constrained by its limited variety of domestic energy resources. As noted above, lignite is the only domestic fuel for power generation. Some additional potential for renewable energy (RE) generation exists, but is limited and can be costly to develop; also, it does not provide firm capacity to ensure that demand will be satisfied. The potential for additional imports may exist as transmission links are expanded with neighboring countries, but are ultimately limited by the tight demand-supply balance in the region.

4.1 Overview of the Options

The options for new generation in Kosovo are the following:[26]

- **Lignite.** Several alternate configurations, technologies, and sites have been considered for a new lignite plant in Kosovo. Domestic lignite reserves are estimated to amount to 12.5 billion tons of which 10.9 billion tons are exploitable.[27] The proposed Sibovc mine (in the Kosovo basin), which has been deemed the most acceptable option from economic, social, and environmental perspectives, has sufficient lignite to supply existing generation facilities to the end of their operational life as well as supplying the proposed 600 MW of generation for forty years. Lignite-fired options for Kosovo include i) subcritical or supercritical pulverized coal plants with flue gas desulphurization (FGD), or ii) subcritical or supercritical circulating fluidized beds (CFBs).

  The feasibility of using carbon capture and storage (CCS) with the new lignite plant was also considered. The Bid Documents for Kosovo C include requirements for the bidder to assess the CCS option to comply with European Union Directives. The Kosovo C plant could be designed to be "CCS-ready" so it could be retrofitted with post-combustion CCS when CCS technology matures and is required. Based on the most recent studies on CCS, such an addition would reduce the plant efficiency by 9.8 percentage points and increase the capital costs by 82 percent. It would also add approximately €68 million per year in operating and maintenance costs. The benefits of CCS would be a 90 percent reduction of CO_2 emissions and a corresponding reduction of the CO_2 externality costs. If on-going technological developments are successful, it is possible that these estimates will be improved (e.g., lower efficiency penalty and costs). However, the results of most CCS demonstration projects planned and implemented in various countries are expected to be available in the 2015-2020 timeframe; development of commercial scale CCS technology would depend on

[26] We did not consider options which seemed unrealistic for obvious reasons of resource availability (for example, tidal power) or because of other obvious barriers that would likely prevent the option from advancing to a pre-feasibility study stage (nuclear power, which for geopolitical reasons, cost reasons and internal political reasons we deemed a very unlikely choice).

[27] MEM, Energy Strategy 2009-18, pp.6-10 and p.48

the outcome of demonstration projects and may take even longer. Therefore, any prediction of performance improvements and cost reductions are speculative.

- **Natural gas.** Kosovo does not have any natural gas resources or a gas transmission system.[28] Importing gas for power generation would require extending existing pipelines from Skopje, Macedonia, or from Niš, Serbia, to connect to Pristina and the power plant locations of Obiliq.[29] However, given the current and projected demand for gas in Macedonia and the limited capacity of Macedonia's current pipeline, it would be necessary to bring gas to Pristina from Bulgaria. Moreover, fueling a gas plant would require purchases of gas that would require substantial foreign exchange outlays for Kosovo. In addition to the pipeline, natural gas supply contracts need to be secured; this is not impossible, but it is difficult due to the relatively low demand and the seasonality of demand. A World Bank/KfW South East Europe Gasification Study (October 2007)[30] also analyzed the economics of bringing gas into Kosovo, concluding that it may be viable to supply industrial and commercial load and build gas distribution networks in Pristina and Mitrovica. The assessment was part of the proposed Energy Community Gas Ring project that would connect up to seven countries in South Eastern Europe (SEE). The study concluded that it would not be financially viable to establish a bulk gas transmission line for any country in the region other than Romania due to the small size of markets, but that it might be possible to consolidate the demand of the SEE region, including for power generation, to make gas infrastructure viable or to build spurs off major transmission lines that would cross the SEE region to supply Western Europe. However, Kosovo cannot depend on these proposals in the medium-term.
- **Fuel Oil.** All liquid fuels in Kosovo are currently imported by rail or road from Macedonia.[31] A fuel oil plant could be supplied via this route or conceivably by road from the Albanian port of Durres. As with the gas plant, purchases of fuel oil would require substantial foreign exchange outlays.
- **Hydro.** The only specific plan for a moderately-sized hydro plant in Kosovo is for the Zhur plant, to be located southwest of Prizren in the area of the Prizren and Sharr municipalities. Plant capacity will be about 305 MW, expected to produce approximately 400 GWh of electricity per year under average hydrological conditions. Due to its high storage capacity, it would be operated as a peaking

[28] A gas pipeline once did exist, in the former Yugoslavia, between a coal gasification facility in Kosovo and an industrial consumer in Macedonia. KEK owns the old pipeline and right of way along the route.

[29] Given the cost of developing a pipeline, consideration has been given only to a base load gas-fired plant. Smaller peaking gas-fired plants have not been included in the analysis.

[30] Economic Consulting Associates/Penspen/Energy Institute Hrvoje Pozar, *South East Europe: Regional Gasification Study (Draft Final Report),* October 2007

[31] Macedonia has a refinery, connected by pipeline to Greece.

station. This project has been under consideration since the 1980s. Construction is expected to take 6 years.[32]

Studies have also identified 18-20 sites for small hydro plants, with a combined capacity of 64 MW, producing 294 GWh per year under average hydrological conditions. The Government of Kosovo's policy is to develop small HPPs with private sector investment by licensing the right to use water for power generation and ERO has developed an Authorization Procedure for construction of such plants. Feed-in tariffs also apply to small HPPs.

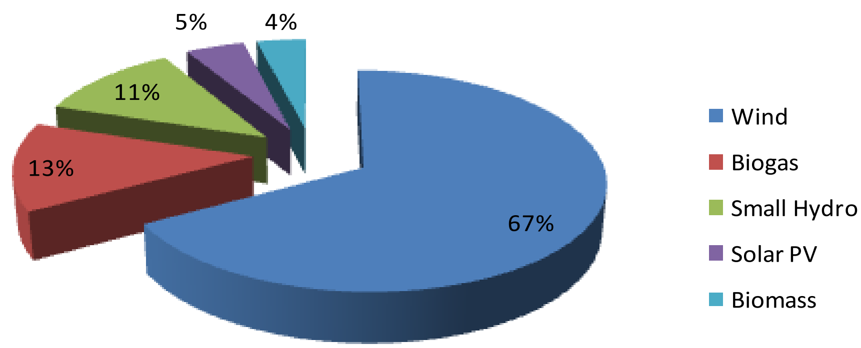
- **Wind.** Maps of wind resources are in progress in Kosovo and some wind monitoring has been undertaken by private investors. Fewer than 2 MW have been installed to date. Mercados[33] estimated, on the basis of a top-down assessment of resource availability, wind generation potential of more than 2000 GWh per year, equivalent to more than 1,000 MW of installed capacity with a capacity factor of 25 percent. A 2010 study funded by Swiss Renewable Energy and Energy Efficiency Promotion in International Cooperation and carried out by consultants NEK Technologies, concluded that there were very few areas with wind speeds exceeding 6 m/s, a minimum needed for commercial potential in the region. The report concluded that the wind resources in Kosovo are moderate at best. It is possible that a more rigorous wind mapping could reveal pockets of high wind sites in complex terrain, but the utilization of these resources could easily be constrained by space and access issues. Further, Kosovo's small system would be unlikely to be able to absorb more than about a quarter of that total technical wind potential, given requirements for reliable operation of the power system. Without greater regional integration, the installed capacity potential for wind will be limited by the availability of firm imports, domestic hydro for storage, and ramping characteristics of thermal plants—all of which are required for "firming" non-dispatchable RE capacity like wind.
- **Solar PV.** No solar maps have yet been produced for Kosovo, though limited measurements are available for some cities. Mercados estimates solar PV potential in the medium term of only 160 GWh per year, equivalent to about 77 MW of installed capacity, with a capacity factor of 22-25 percent.
- **Biogas and biomass.** Manure-based biogas from livestock is available in many parts of Kosovo, and there is some potential for this to be converted into gases to drive turbines or gas engines. Mercados estimated a medium-term potential of 430 GWh per year for biogas, based on top down assessments (a total of roughly 80 MW, with a capacity factor of 60 percent). However, it should be pointed out that the energy resource is spread throughout the country and it

[32] MEM and Elektroprojekt Consulting Engineers, *Review of HPP Zhur Feasibility Study*, October 2008 (presentation)

[33] Mercados Energy Markets International, *Kosovo - Regulatory Framework for RES – Procedures and Methodology for RES Electricity Pricing Task 1 Report*, May 2009.

would be difficult to bring it to a centralized facility. Biomass in the form of forestry products and residues is also a possible source of electricity generation. Mercados estimated a medium-term potential of 120 GWh/year. However, it is important to consider that most of the feedstock for biomass is from wood, and to some extent from agricultural and livestock waste (straw and manure, which is then converted into biogas). These potential feedstocks are in high demand for alternative uses (wood for heating and manure for fertilizer) and are costly to collect and transport to a central location.

Figure 4.1: Breakdown of Mercados' Estimate of RE Potential by 2020



Source: Mercados Energy Markets International (2009)

- **Other sources of generation.** Data available to date suggests that geothermal energy is not viable due to low water and soil temperatures.[34] There are some commercial projects underway to heat houses using 100 meter deep boreholes and heat pumps. These projects are being implemented in the International Village near Pristina but do not involve generation of electricity with geothermal steam.
- **Imports.** Imports are affected by the geopolitical factors constraining the availability of transmission capacity, by the energy supply-demand balance in South East Europe region, and by the financial capacity of KEK to fund imports from tariffs collected and that of the government to fund it from the budget. Kosovo's transmission system is interconnected to the transmission systems of Serbia, Montenegro, and Macedonia via 400kV lines, and to Albania via a 220kV line. As noted in Section 2, net imports in Kosovo have ranged between 5 and 17 percent of total annual consumption during the past 10 years, and their

[34] European Commission Liaison Office to Kosovo, Lot No. 4 Assessment Study of Renewable Energy Resources in Kosovo, main report, July 2008, p.7.

availability from Albania is seasonal, with greater availability in the winter months, and highly sensitive on hydrological conditions from year-to-year. Imports are scheduled on a day-ahead basis and are purely energy imports, not capacity.

A new 400 kV transmission line to Albania is expected to be commissioned by the end of 2012, boosting transfer capacity in each direction by roughly 500 MW. A new 400 kV connection to Macedonia is also planned that will boost transfer capacity in each direction an additional 500 MW. This could help increase power trade with Albania to exchange Albania's peaking hydro with Kosovo's off-peak thermal generation, which would mean higher capacity utilization of Kosovo's thermal power plants. However, during winter when the region faces concurrent peak demand this exchange can get constrained. Over the long-term, Kosovo's import potential will likely also be constrained by the growing supply deficit in the region. Most countries in the region are net importers, and only few are building new plants. Romania, Bulgaria, Bosnia and Herzegovina are net exporters, but their excess power is declining as new plants, such as the Belene nuclear plant in Bulgaria, are delayed indefinitely. The World Energy Council foresees a shortage of 10,000 GWh per year in the South East Europe region over the period 2011-2015.

- **Energy efficiency.** As various studies have shown, Kosovo has considerable potential to improve energy efficiency. Government is making progress in this area. The Law on Energy Efficiency[35] has been adopted and a draft National Energy Efficiency Plan[36] for the period 2010-18 has been prepared. Progress to date includes establishing and funding a number of programs that might reasonably be expected to result in EE gains, for example:
  - Setting targets for EE and identifying and pursuing the measures that will be implemented to achieve the targets
  - Committing substantial funding for public awareness campaigns promoting EE, and to EE loan schemes
  - Undertaking, during 2010, a comprehensive survey to assess energy consumption by sector including the status of EE
  - Training and certification of energy auditors (commenced during 2010, more than 50 auditors have been certified)
  - Introducing technical regulations on building energy performance

[35] The Law on Energy Efficiency will align with the acquis on energy labelling, ecodesign, energy performance of buildings and energy end-use efficiency, and is also intended to provide the legal basis for establishing an energy efficiency agency and to lay down the procedures for setting up an energy efficiency fund to promote projects on energy efficiency and renewable energy sources.

[36] The Kosovo Energy Efficiency Plan (KEEP) prepared by Kosovo's Ministry of Economic Development represents Kosovo's first long-term energy efficiency plan. It covers the period from 2010 till 2018.

- Promoting efficient fuel substitution, for example, increasing the use of LPG for space heating and cooking, undertaking a feasibility study into converting part of Kosovo B to cogeneration, in order to expand Pristina's district heating scheme
- Retrofitting a few public buildings through pilot projects (60 schools with EC funding) as technical demonstrators of energy efficiency improvements.

4.2 Suitability of the Options for Meeting Demand

As shown in Figure 3.1 and Figure 3.2, Kosovo will have a substantial gap between available domestic supply and peak demand, and between generation and annual consumption. Daily and seasonal peaks are currently met through a combination of imports and load shedding. The suitability of any of the generation options to meet demand depends on: i) the quantity of reliable capacity that can be built and ii) how quickly the new capacity can be built.

Capacity Needed to Meet Demand

As noted in Section 3, Kosovo will need about 950 MW of new, firm capacity by 2017. This need grows to about 1000 by 2019 and about 1500 MW by 2025. A combination of renewable and thermal plant can be used to fill this gap.

The entire technical potential of the renewables described in Section 4.1 includes more than 1,000 MW of new capacity, but because hydropower in Kosovo has low capacity factors (16 percent for Zhur and roughly 50 percent for the smaller hydroelectric plants described above), and other renewables (PV and wind) are intermittent, only about 350-400 MW of the capacity could be assumed to be available for meeting daily and seasonal peaks. Moreover, as shown in Section 4.3, a portion of the renewable energy generation capacity is available only at a very high cost. Due to feed-in-tariffs the renewable are considered as "must-run" plants in the evaluation of options.

Timing of the Plants

In terms of commercial operation of the various plants, it is assumed – for the sake of comparison – that all of them will come on line at the same time (2017). However, project planning and construction may take more or less time, depending on the requirements of each option:

- The lignite plant is expected to take 5-6 years from procurement to operation. Parsons Brinkerhoff/PricewaterhouseCoopers have suggested a construction period of approximately 48 months for the lignite plant but additional time is needed for planning, permitting, financing, procurement, and contacting. The beginning of operations of a lignite plant is dependent on mine development, which is expected to take several years but can be operational before the plant is ready for commissioning.
- The natural gas plant can be built in 4 years (on a stand-alone basis), but negotiating a gas supply contract and building a gas pipeline is going to be very

challenging for Kosovo. It is assumed that the gas plant and associated pipeline could be available by 2017, but this outlook is very optimistic.

- The oil plant is similar to the gas plant in terms of design and construction and could be completed in 4 years. Transporting of oil is a major challenge (whether it is transported from Macedonia or Albania), but no new infrastructure is required as oil can be transported by train or road transport.

Photovoltaic and other smaller RE generation options could be built more quickly (some PV, biomass and biogas in under a year) but this capacity will be scattered throughout the country, and whether it gets built or not depends on private sector initiative to develop it. No single investor is likely to develop all of the RE capacity all at once. Instead, it is likely to be built gradually, over time, by multiple investors. As such, the analysis assumes that new RE capacity is spread uniformly over the planning period.

4.3 Costs of the Options

Table 4.1 summarizes the capital, operating and environmental costs of the thermal energy generation options described above. A discounted cash flow model was used to produce estimates of the Levelized Electricity Cost (LEC), assuming a 10 percent (economic) opportunity cost of capital.

For each thermal option, global and local environmental costs were included as operating expenses. Global environmental costs include the cost of carbon dioxide (CO_2) emissions, priced according to recent forecasts by the International Energy Agency.[37] Local environmental costs include the costs of NO_X, SO_X and particulate emissions, as well as various other local pollutants, harmful to human health. These costs were taken from the results of ECOSENSE dispersion modeling commissioned by the World Bank. The ECOSENSE model relied extensively on data from the European Commission's ExternE project (www.externe.info).[38]

[37] Though carbon prices have recently registered a steep decline and are currently about €6/ton, this study assumes that in the medium-term prices may rise. Therefore, the study assumes €15/tonne as starting point, then growing in pace with the IEA forecast to roughly €23/tonne by 2025, and €26/tonne by 2030.

[38] ECOSENSE is a model which uses epidemiological studies to assess the human health impact of power plant pollution. It is developed and maintained by the University of Stuttgart. The results are summarized in the World Bank Project Appraisal Document on the Lignite Power Technical Assistance Project, from September 13, 2006 (Report No. 35430-XK). For more information on the project's social and environmental impact, see the Strategic Environmental and Social Assessment - Kosovo C (E1367, Vol. 3)

Table 4.1: Estimated Costs of Thermal Supply Options

		Lignite[39]	Natural Gas	Fuel Oil	Imports[40]
Costs					
Capital costs of the plant (kW Net)	(€/kW)	1,994	859	859	
Total O&M (including fuel)	(€/MWh)	20.22	64.14	132.93	85.00[41]
Fuel costs	€/ weight or volume	10.5/ ton	300/tcm	900/MT	
	€/kWh	0.012	0.060	0.128	
Non-fuel variable O&M	€/kWh	0.005	0.003	0.003	
Fixed O&M	€/kW-year	25.92	10.84	13.00	
Global Environmental Costs	(€/MWh)	15.30	5.40	8.10	12.03
Local Environmental Costs	(€/MWh)	3.50	0.60	1.30	
LEC, including externalities	(€/MWh)	81.42	89.78[42]	161.45	97.03
LEC, excluding externalities	(€/MWh)	50.05	79.64	145.85	85.00
Operating characteristics					
Plant capacity	MW (gross)	600	575	575	NA

39 Assumes 2x300MW circulating fluidized bed (CFB) subcritical units, with the technical and cost specifications identified in the following documents: Parsons Brinckerhoff and PricewaterhouseCoopers, *Generation Planning and Unit Sizing* Report, March 2010 (which considered unit size and technology); and KOSTT, *Generation Sizing in View of the Technical and Commercial Requirements of the Kosovo Power System*, February 2010.

40 Imports are treated as a thermal generation option because generating capacity used by Kosovo's neighbors includes thermal generation in their energy mix and therefore has associated environmental costs. In calculating the global environmental costs of imports, we have used a grid emissions factor which is an average of the grid emissions factors of major exporters in the region (Albania, Bulgaria, Montenegro and Serbia, and Romania). The source used was MWH consultants, *Electricity Emission Factors Review* (Produced for the European Bank for Reconstruction and Development (EBRD)), 2009.

41 Based on the work by Mercados (Mercados Energy Markets International, *Kosovo - Regulatory Framework for RES – Procedures and Methodology for RES Electricity Pricing Task 1 Report*, May 2009.)

42 The LECs for the gas plant (with and without externalities) include the cost of a new 268 kilometer, 20 inch diameter gas pipeline from Sofia to Pristina, via Skopje. Our estimate was based on a survey of the cost per kilometer of other pipelines in the SEE region. We used a benchmark cost of approximately €375,000 per kilometer (total cost of the pipeline was estimated at roughly €100 million).

	MW (net)	560	560	560	NA
Thermal efficiency	(% LHV net)	38.2	57	50	NA
Carbon content of fuel	g CO_2/ kWh[43]	1020	360	540	NA
Asset life	years	40	30	30	NA

The levelized cost calculations in Table 4.1 are based on an assumption that all the thermal plant options have a capacity factor of 85 percent. However, this capacity factor is not used in the power system analysis (scenarios), where the utilization factor is estimated on the basis that the available generating units are dispatched in merit order of increasing variable O&M costs including fuel cost.

The difference between the value of LEC that includes externalities and the value of LEC that excludes externalities represents the cost to Kosovo of the externalities assumed for this analysis (local socio-economic costs of emissions from thermal power plants, carbon price, high-cost local renewables). In the case of lignite-fuelled thermal power generation, this difference amounts to more than 60 percent of the LEC that excludes externalities. In the case of gas-fired thermal power generation, however, this difference amounts to only 13 percent of the LEC that excludes externalities.

The costs of RE generation were based on the Mercados study and updated where the estimates of the Mercados study seemed out of line with current costs. The study estimated the potential for RE electricity generation of 3.3 TWh per year by 2020. Some of this potential can only be realized at very high costs: the first 3.1 TWh can be achieved at an average cost of €65-130 per MWh, but beyond that level the inclusion of solar PV and the more costly biomass plants cause a steep increase in cost of supply. Figure 4.2 shows the supply curve developed by Mercados. We have updated it to reflect a 10 percent economic opportunity cost of capital.

[43] Based on gross generating capacity.

Figure 4.2: RE Supply Curve Developed by Mercados

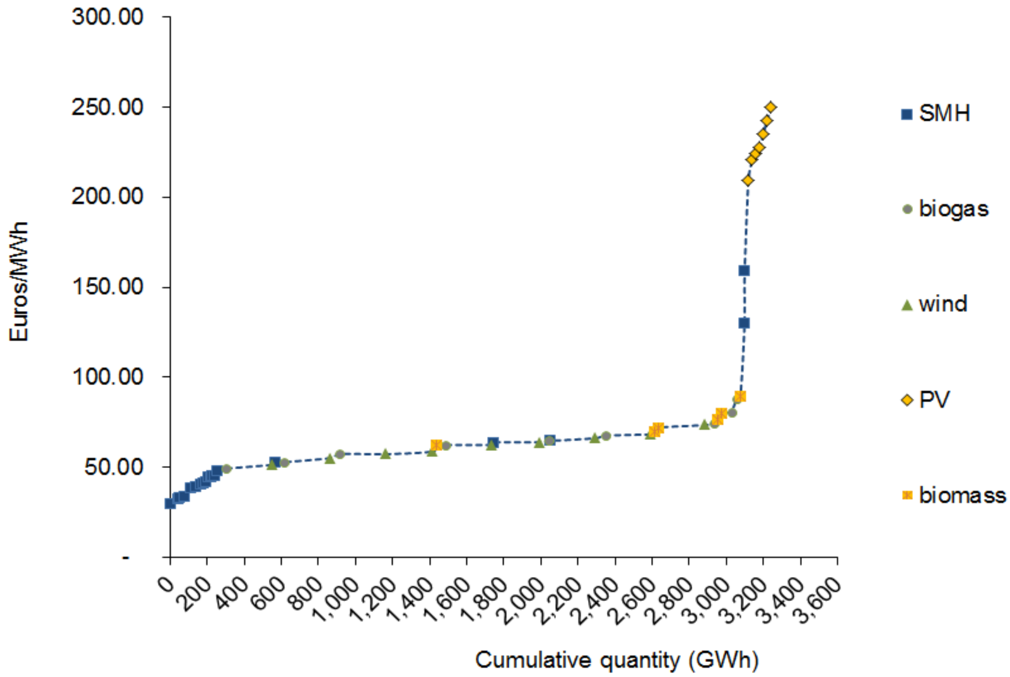


Table 4.2 summarizes the costs of renewable energy options. For each of the renewable energy options, a "capacity penalty" has been added. The capacity penalty reflects the lower reliability of certain types of generation. It effectively reflects the cost of standby power required to "firm up" the renewable energy capacity.

Table 4.2: Estimated Costs of Renewable Energy Supply Options[44]

		Zhur	Small Hydro	Wind	Photo-voltaic	Biogas	Biomass
Costs							
Capital Costs of Plant	(€/kW)	941	1,170	1,133	4,053	2,735	3,501
Capital Costs of Additional T&D investment required[45]	€ millions		9.6	2.2			
Operating Costs	(€/MWh)	16.78	11.70	10.68	19.68	36.43	24.60
Capacity Penalty	(€/MWh)	0	4.18-9.67	7.84-18.14	8.04-18.59	3.27-7.56	2.61-6.05
LEC with capacity penalty[46]	(€/MWh)	96.40	57.78-63.27	108.93-119.23	259.54-270.09	94.22-98.51	93.62-97.06
LEC without capacity penalty	(€/MWh)	96.40	53.60	101.09	251.50	90.95	91.01
Operating characteristics							
Plant Capacity	(MW)	305	64	1027	78	82	21
Utilization (capacity) factor assumed	(%)	16	53	25	24	60	65
Asset life		50	20	20	20	20	20

A range of capacity penalties is shown for each plant in Table 4.2 because the value of the penalty depends on which type of standby (thermal) capacity is assumed. The capacity penalty will be lower if computed with respect to plants with relatively inexpensive capacity (gas or fuel oil) and higher if computed with respect to plants with relatively more expensive capacity (lignite). The capacity penalty is used only in the development of the supply curves and the screening curve analysis and is a rough approximation of the actual requirements of renewables. In the power system planning analysis (scenarios), the capacity penalty is not used as the model analyzes each scenario and adds the required capacity to meet the demand.

[44] Costs reflect the weighted average costs of Mercados' estimates for all plants shown in the curve on Figure 4.3. This is for a 5 Km 20-30 kV line

[45] Assumes that a transmission investment of €37.500 will be needed to serve each MW of new small hydro or wind capacity, since these are distributed resources. T&D costs are included for the sake of clarity and completeness but do not have a significant impact on the comparison of options.

[46] The LECs are a weighted average cost of all plants considered technically viable by Mercados. The analysis in Section 4 considers a smaller package of economic renewables (along the flat portion of the supply curve).

Figure 4.3 through Figure 4.5 show the supply curve for the renewable energy potential identified by Mercados, and the adjustments for capacity penalties. The lines indicating the cost of thermal generation have been similarly adjusted to reflect the costs of environmental externalities identified above. The figures differ in the avoided cost of generation assumed. Figure 4.3 assume that the avoided cost of generation is set by a lignite plant. Figure 4.4 and Figure 4.5 show the same, assuming, that gas and fuel oil plants, respectively, set the avoided cost.

The economically optimal amount of renewable generation can be found at the intersection of the renewable energy supply curve—adjusted for availability—and the avoided cost of thermal generation—adjusted for the cost of environmental externalities.

Figure 4.3: Optimal Renewables Generation with Lignite Setting Avoided Cost

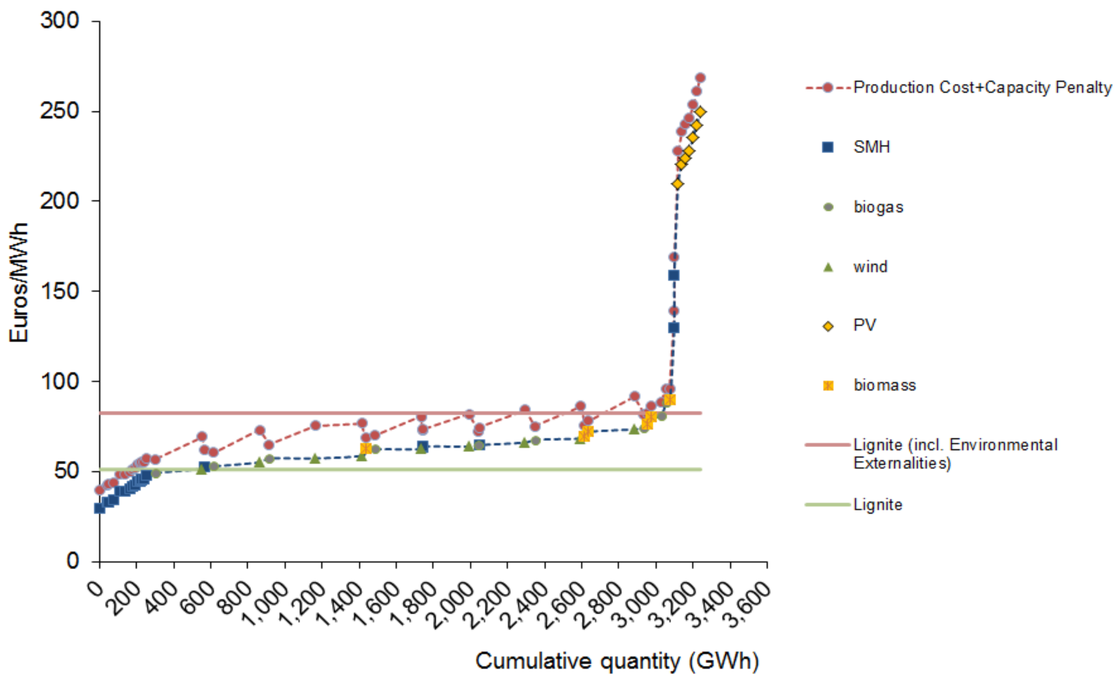


Figure 4.4: Optimal Renewables Generation with Gas Setting Avoided Cost

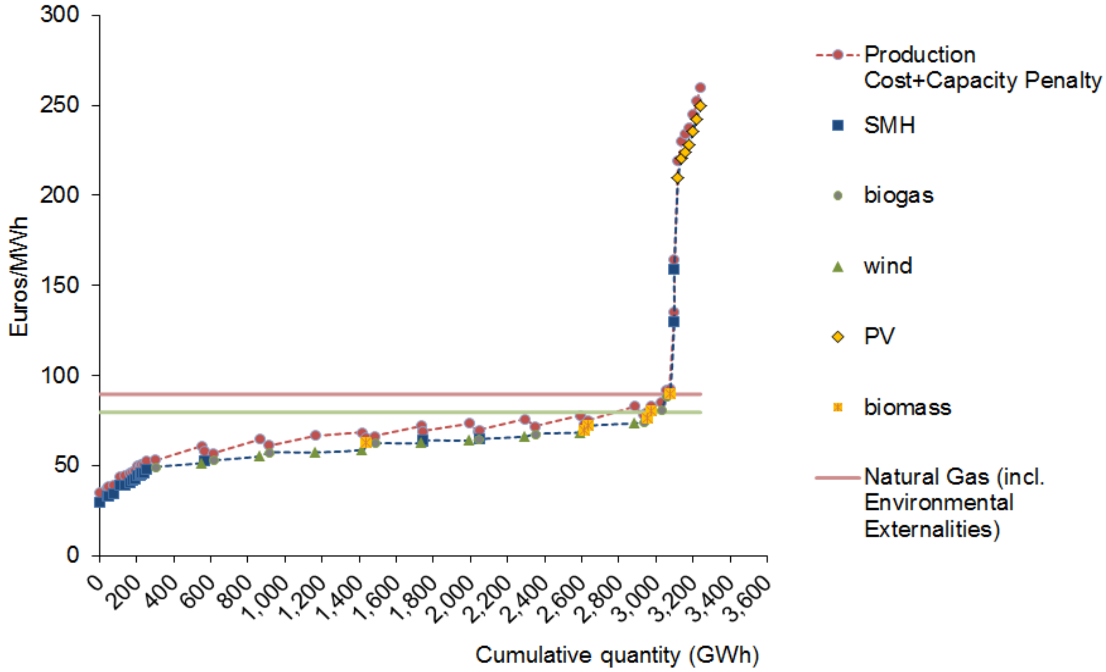


Figure 4.5: Optimal Renewables Generation with Fuel Oil Setting Avoided Cost

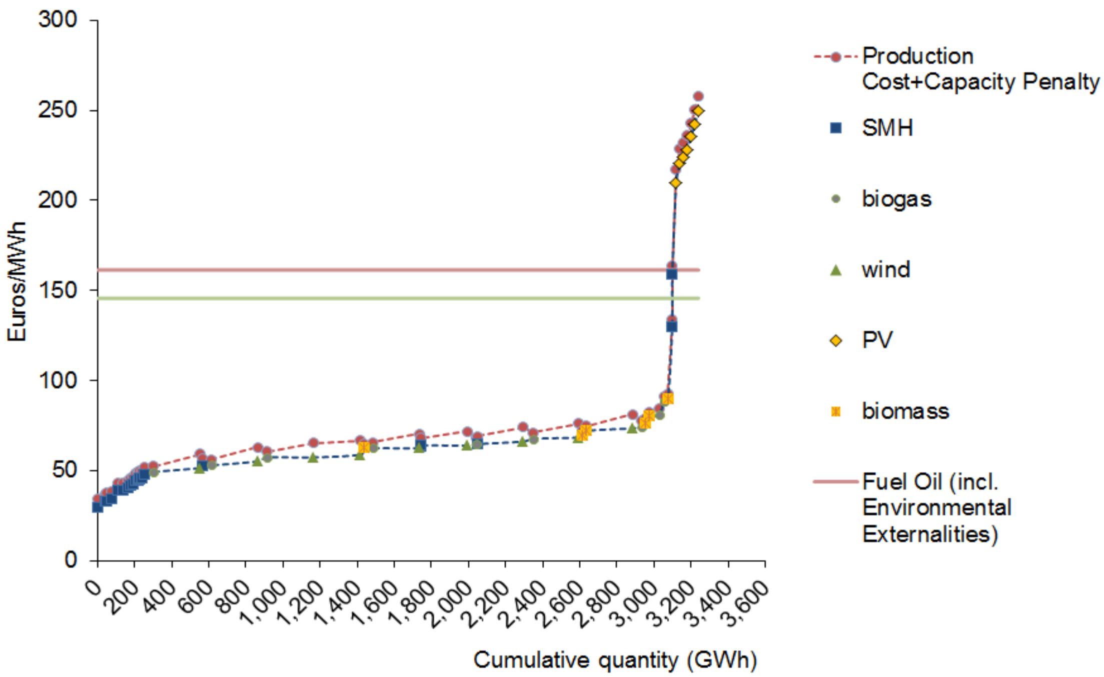
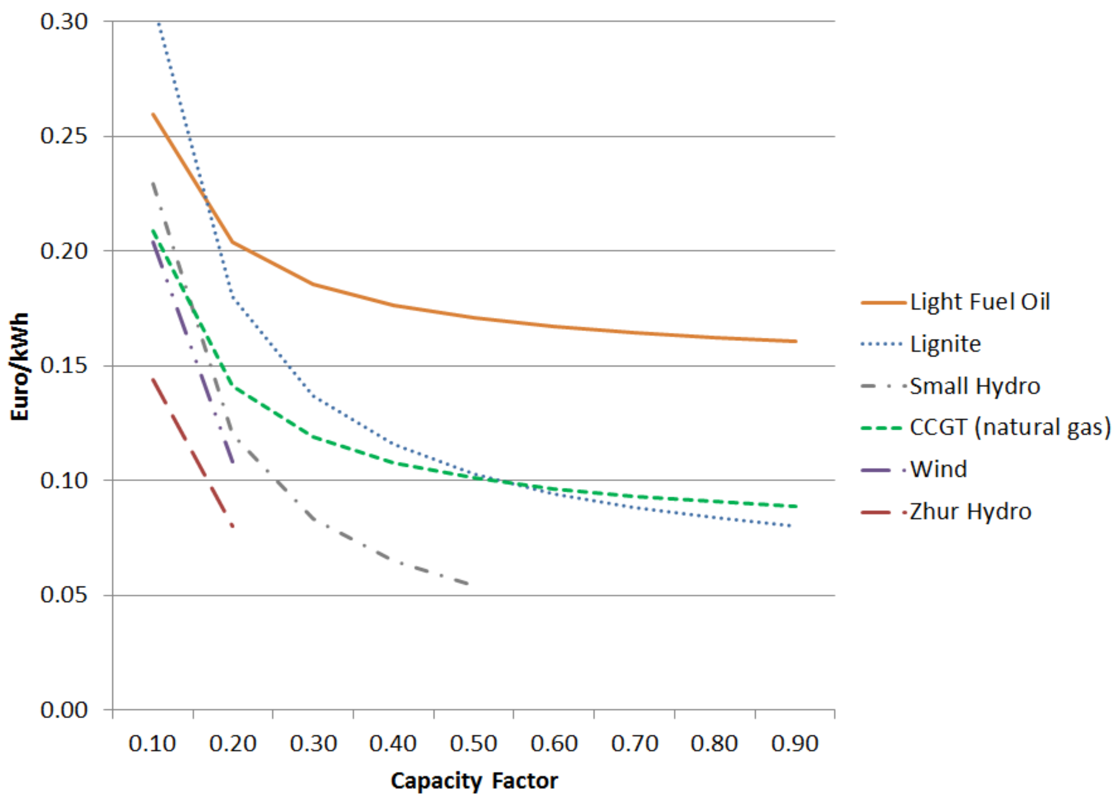


Figure 4.6 compares the LECs of the various generation options described above. The LECs for the thermal plants include global and local environmental externalities. The levelized energy costs (LECs) shown for the thermal plants correspond to an 85 percent utilization factor, or load factor. Lower load factors would mean higher LECs, as capital costs of the plant would have to be spread out over fewer units of production (kWh). Lower utilization factors mean higher LECs; higher utilization factors mean lower LECs. The LEC curves show that, for utilization factors above 50-55 percent, the lignite plant is the least expensive option.

Figure 4.6: Comparison of Levelized Energy Costs



5 Alternative Power Supply Plans for Kosovo

The alternative power supply plans for Kosovo must include a mix of base load and peaking capacity, and a mix of thermal and renewable energy generating capacity. As noted in Section 3, Kosovo will need about 950 MW of new, firm capacity by 2017. This need grows to about 1000 by 2019 and about 1500 MW by 2025. A combination of renewable and thermal plant can be used to fill this gap.

Because most of the renewable energy potential is non-dispatchable, expansion of Kosovo's generation capacity based only on renewables is not a feasible option for meeting power demand fully and reliably. In other words, a system dispatcher would not always be able to depend on its availability during peak load hours. At least some thermal standby generation is necessary for "firming" supply.

Any of the thermal options described in Section 4 could be built large enough to fill the demand gap on their own, but the availability of some economically viable renewable energy capacity (most of the gently sloping portion of the supply curve shown in Figure 4.2) justifies building at least some small hydro and wind plants.[47] All of the alternative supply options for Kosovo therefore include 395 MW installed renewable energy generating capacity (providing roughly 170 MW of firm capacity) in addition to the 305 MW Zhur hydropower plant.

Even assuming that all of this new renewable capacity could be built by 2017, the remaining gap for firm base-load capacity would average about 600 MW in the period 2017-19, and grow to about 1,000 MW by 2025. The thermal options considered to fill this gap are a 600 MW lignite, gas, and fuel oil plant, respectively. As noted above, Kosovo needs more than this to meet peak demand in 2018, but we assume that some peak demand will be met through imports or through the construction of new renewable, as it has in the past. This study also uses the 600 MW size range because it is consistent with recommendations of earlier studies on the optimal size of a new lignite plant.[48] This allows for easier comparison of the planned lignite plant to other generation options. This analysis further assumes that:

- Kosovo A is retired in 2017 and the new thermal plant comes online the same year.
- Kosovo B is rehabilitated between 2017 and 2018 (inclusive). During the rehabilitation period, only one of the two units is available and Kosovo B's net available capacity is assumed to be average 300 MW. After rehabilitation, its net available capacity is assumed to be 618 MW. However, Flue Gas

[47] None of the photovoltaic capacity is economically viable under any of the alternatives.

[48] PWC/PB, *Generation Planning and Unit Sizing Report*, March 2010

Desulphurization (FGD) is expected to reduce further the capacity of each unit by roughly 10 MW and net available capacity to 598 MW.[49]

- The same package of RE generation is combined with each thermal alternative.
- This includes:
  - The 305 MW Zhur hydropower plant. This plant is commissioned in 2017 (at an assumed load factor of 16 percent). The plant is assumed to have a capacity credit of 100 percent, since it has considerable storage, and is assumed to be used to serve only the highest 16 percent hours of demand during any given year.[50]
  - Roughly 60 MW of new, small hydropower generation is installed in 2015, with a capacity factor of 53 percent. This represents nearly all of the small hydropower potential identified by the Mercados study, with the exception of a few higher cost plants on the vertical portion of the supply curve shown in Figure 4.2.
  - Roughly 250 MW of new wind generation is gradually installed between 2016 and 2021, with a capacity factor of 25 percent, and a capacity credit of 10 percent. These are very optimistic assumptions for wind, given what is currently known (as described in Section 4) about average wind speeds in Kosovo. At this pace of expansion, wind power will represent about 14 percent of Kosovo's peak load by 2021.
  - Roughly 20 MW of new biomass and 70 MW of new biogas generation are installed between 2022 and 2023. Such installations would not likely be grid connected, but could be used to absorb some demand which otherwise must be served by the grid. This assumption is also quite optimistic for biomass and biogas, given the feedstock constraints described in Section 4.
- The new 400kV lines, to Albania and Macedonia, increase import capacity as described in Section 4. The base case supply scenario assumes that the 400kV line to Albania is commissioned in 2012, and the line to Macedonia is commissioned in 2018.
- Renewables are contracted on the basis of a feed-in tariff and are therefore dispatched first in KOSTT's merit order.

[49] Kosovo B is proposed to be rehabilitated between 2017 and 2018. Each Unit will be taken out of service for eight months. The first unit will be taken out of service from March 2017 to October 2017 and the second from March 2018 to October 2018. A 2010 USAID feasibility study for the rehabilitation estimated that gross output was expected to be 604 MW net. However, KEK has said that, after rehabilitation, it does not expect to be able to run the units above their original design capacity.

[50] A capacity credit is a measure of a generator's expected contribution to meeting peak demand. Capacity credits for thermal plants are assumed to be equal to operable capacity. In the case of HPP Zhur, a capacity credit of 1 is assumed on the basis that it has substantial storage.

The analysis does not consider imports as an option which can provide firm capacity due to the tight supply-demand balance in the region and because electricity in the region is currently traded on an energy-only basis. Imports will undoubtedly remain important for meeting energy needs and peak demand until substantial new capacity is installed. In the absence of substantial new flexible hydro capacity in Kosovo (other than the Zhur plant), imports will also remain necessary for managing system frequency and providing reserves, as well as for enabling the integration of intermittent renewable technologies. However, long-term supply contracts for firm capacity would be needed to consider electricity imports as a stand-alone supply option.

Figure 5.1 and Figure 5.2 show how the alternatives are used to meet consumption and peak requirements for the 2010-2025 time period. Appendix E contains the generation assumed for each plant, by year, in a tabular format.

Figure 5.1: Generation and Consumption with new Thermal Plant + RE

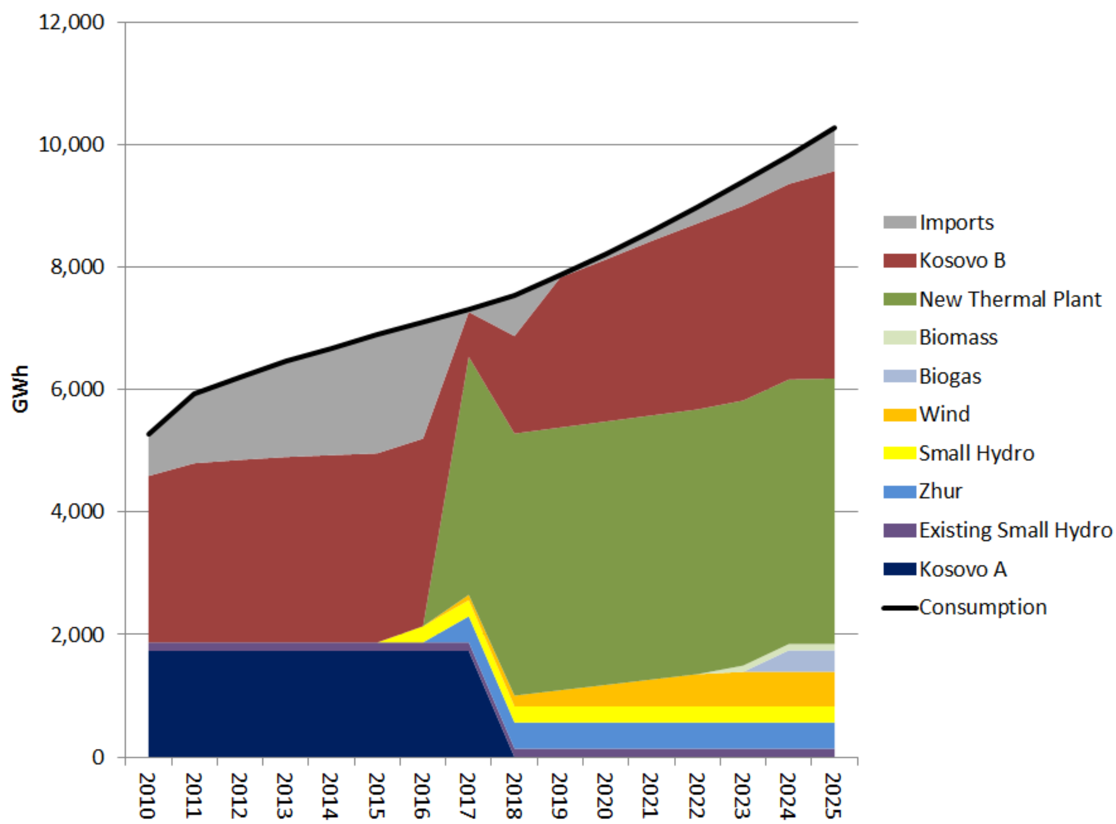
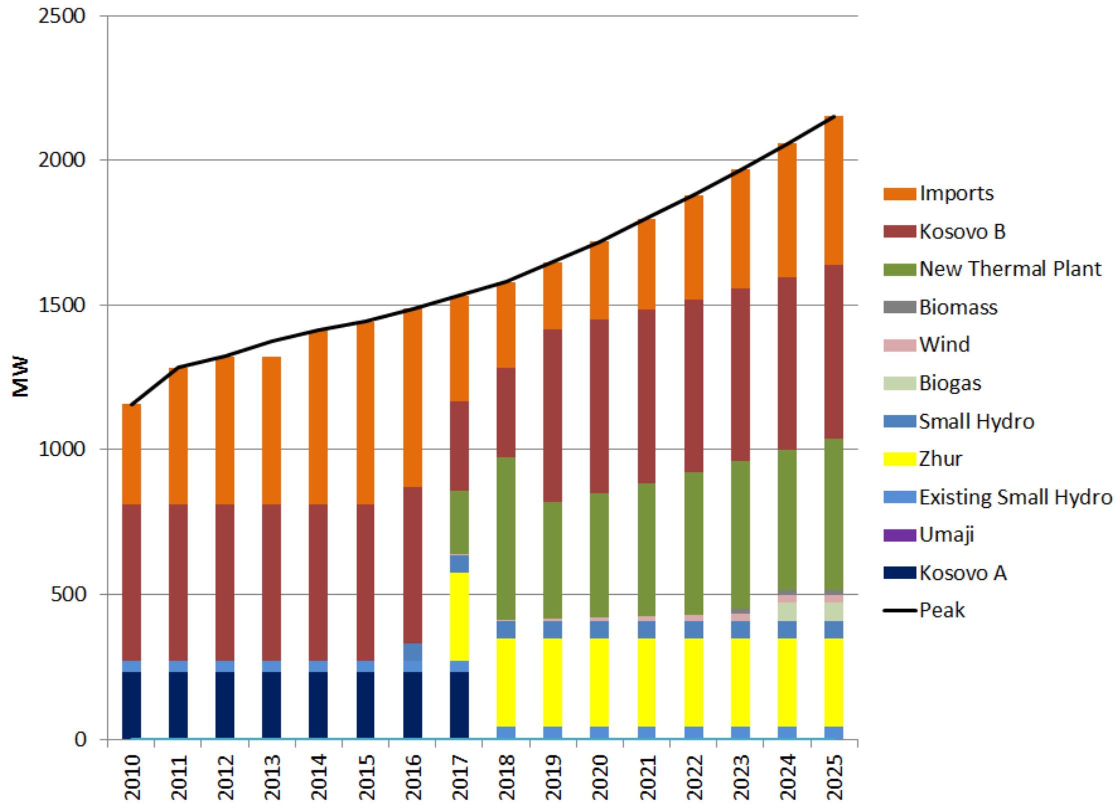
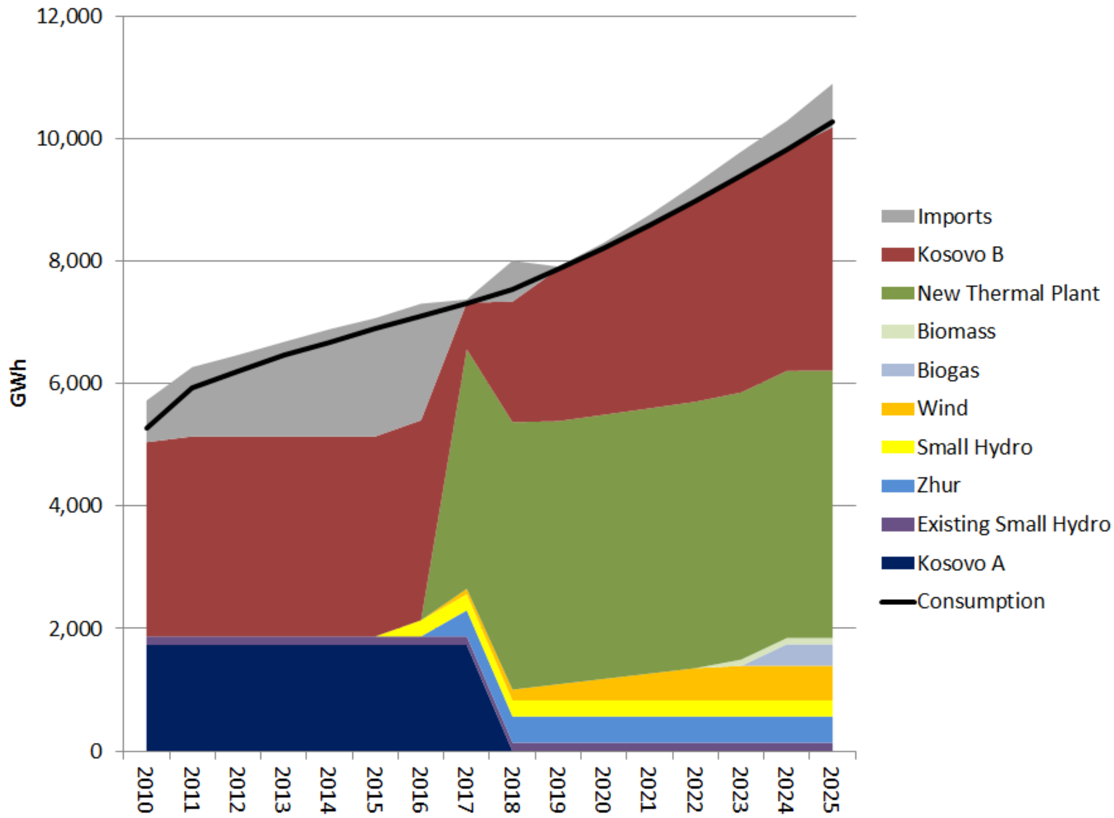


Figure 5.2: Lignite+RE—Peak Demand and Capacity to Meet Peak with new Thermal Plant + RE



The figures above do not show energy exported. Kosovo is a net importer but has a swap or "banking" arrangement with Albania under which it pays for some of its electricity imports with export to Albania. Figure 5.3 shows generation required to reimburse Albania for imports. The figure shows that, to honor the banking arrangement Kosovo's plants must run at higher capacity factors than is required to serve only domestic load (Figure 5.1).

Figure 5.3: Generation and Consumption with New Thermal Plant and Energy Banking with Albania



5.1 Cost of the Alternatives

The Lignite+RE option is the least cost option for Kosovo, when capital and operating costs are discounted at Kosovo's economic cost of capital. The next section examines how this cost advantage withstands different assumptions about changes in input prices and demand.

Table 5.1 summarizes the present value of the costs of each option. The values in the table below include the costs of local and global externalities.

Table 5.1: Summary of Present Values (PVs) of the Costs of Alternative Power Supply Plans[51]

		Lignite+RE	Gas+RE	Fuel Oil+RE
	(€ Millions)			
New Thermal Plant		1,995	2,192	3,941
Kosovo A		417	417	417
Kosovo B		1,618	1,618	1,618
Existing Hydro		28	28	28
Zhur		238	238	238
Small Hydro		84	84	84
Wind		176	176	176
Biogas		87	87	87
Biomass		28	28	28
Imports		863	863	863
Total		5,542	5,739	7,488

Appendix D contains additional details on the calculation of the NPVs for each alternative.

[51] Assumes a run-out period until 2050.

6 Identifying the Least-Cost Supply Plan

In economic terms, the best power supply plan is the one that allows Kosovo to meet its electricity supply needs at lowest economic cost to the provider and consumer, where such costs include the costs of environmental damage associated with each thermal power supply option. As described in Section 5, the choice of the best supply plan depends principally on the fuel for thermal power generation.

As shown in Section 5, lignite is the fuel for the least expensive thermal option available to Kosovo, even when the relatively higher global and local environmental externalities for this fuel are included. The Lignite + RE plan is lowest cost under the demand forecast developed in Section 3 and the cost estimates developed in Section 4. Section 3 gives details of this case.

In this Section, we test the robustness of this finding to fairly wide deviations in the assumptions about forecast power demand, generation plant capacity utilization, generation plant construction costs, fuel costs for power generation, and global environmental costs associated with the use of these fuels. We do this by assessing the changes in those assumptions that would render the lignite option less attractive than other options analyzed in Section 5. In most cases (because the gas alternative is the next cheapest option after the lignite alternative), this means looking for the assumptions regarding the categories of costs (but not about forecast power demand) that would make the Gas + RE plan less expensive than the Lignite + RE plan on a net present value basis.

The following six sensitivity cases are analyzed and compared to the base (reference) case analyzed in Section 5.

- Using a lower demand forecast based on lower projected GDP growth.
- Switching level of environmental costs in terms of carbon dioxide emissions price that raises the cost of power from lignite-fueled generation plant higher than the cost of power from gas-fired generation plant.
- Switching level of construction cost only for lignite-fueled generation plant that raises the cost of power from this plant higher than the cost of power from gas-fired plant.
- Switching levels of construction costs for thermal generation plants for the three fuels, which raise the cost of power from the lignite-fueled generation plant higher than the cost of power from gas-fired generation plant.
- Switching level of lignite fuel cost that raises the cost of power from lignite-fueled generation plant higher than the cost of power from gas-fired plant with the base case price for natural gas.
- Switching level of natural gas fuel cost that lowers the cost of power from gas-fired generation plant below the cost of power from lignite-fueled plant with the base case price for lignite.

6.1 Demand Sensitivities

The LEC curves in Section 4 show that a lignite plant is the lowest cost choice thermal option at capacity utilization factors above 50-55 percent. Lower-than-expected demand would reduce the capacity utilization factor of the lignite plant, reducing its cost advantage over other generation options.

To understand the impact of variations in such demand, a sensitivity case was developed for lower demand, reflecting lower GDP growth. The low growth case reflects a projected real GDP growth rate of 3 percent per annum from 2013 (compared to 4.5 percent per annum in the base case).

The impact of lower demand is to reduce overall system costs (for all options) because of lower operating costs and imports requirements.[52] The reduction in demand also narrows very slightly the cost advantage of lignite as compared to natural gas and fuel oil, because it reduces the capacity factor of the new lignite plant from 81 percent to 80 percent.[53] Under this scenario Kosovo B's utilization factor, drops from 55 percent to 33 percent (post rehabilitation).

Table 2.1 compares the costs of the three alternative thermal power supply plans under the low growth scenario.

[52] We assume for the sake of simplicity that the reduction in demand is achieved at no CAPEX cost. In other words, if the reduction in demand is achieved through energy efficiency measures, those measures are assumed to be costless.

[53] We do not show here the impact of higher demand, as the effect would be the opposite, to raise the overall costs of supply, but improve the cost advantage of lignite over the other options (because it improves the capacity factor).

Table 6.1: Summary of NPVs of Alternative Power Supply Plans with Lower Demand Growth[54]

		Lignite+ RE	Gas+ RE	Fuel Oil+ RE
	(€ Millions)			
New Thermal Plant		1,964	2,141	3,838
Kosovo A		417	417	417
Kosovo B		1,321	1,321	1,321
Existing Hydro		28	28	28
Zhur		238	238	238
Small Hydro		84	84	84
Wind		176	176	176
Biogas		87	87	87
Biomass		28	28	28
Imports		552	552	552
Total		4,903	5,080	6,777

Figure 6.1 and Figure 6.2 show dispatch required to serve load and meet peak demand under the low demand scenario.

[54] Assumes a run-out period until 2050.

Figure 6.1: Generation and Consumption with new Thermal Plant + RE and lower demand growth

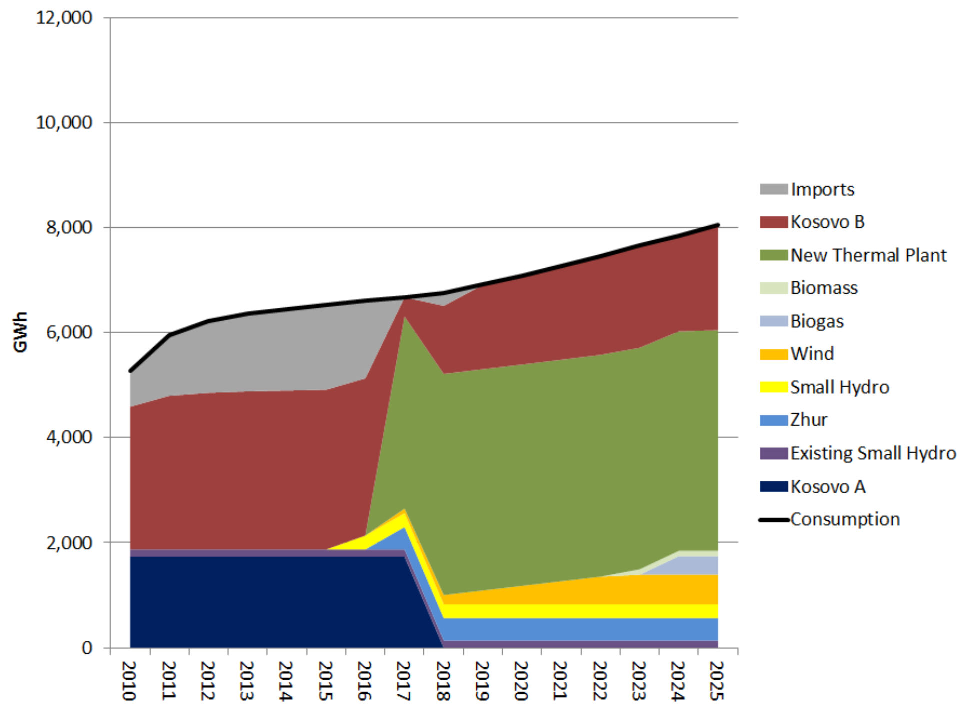
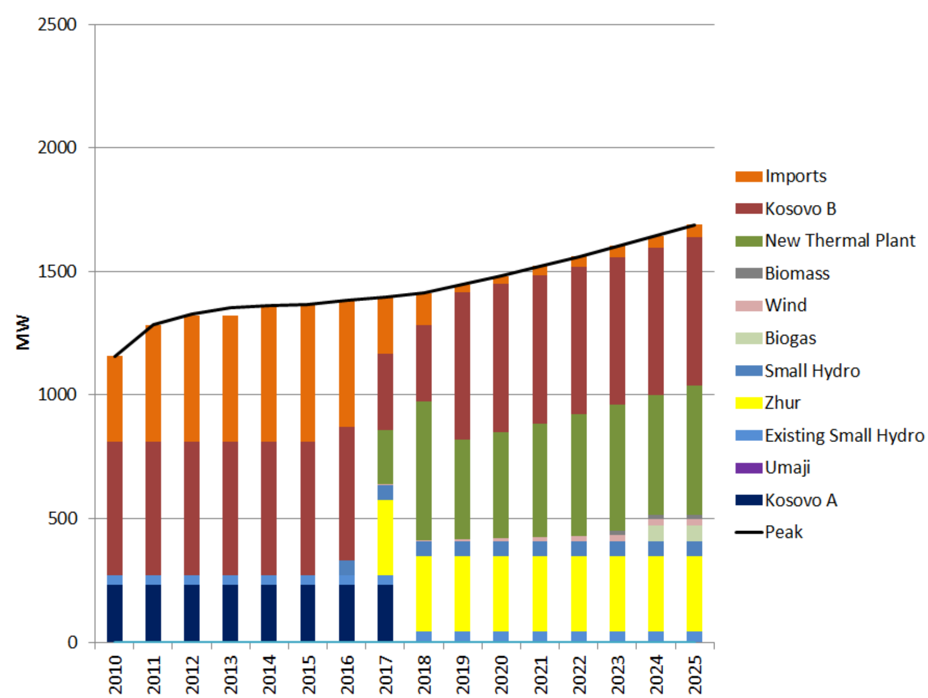


Figure 6.2: Lignite+RE—Peak Demand and Capacity to Meet Peak with new Thermal Plant + RE and lower demand growth



6.2 Environmental Cost Sensitivities

Higher global or local environmental costs make Kosovo's renewable energy generating potential look more economically viable and reduce a lignite plant's cost advantage over the other thermal generation options. Lower environmental costs have the opposite effect, reducing the amount of renewable potential that is economically viable and increasing a lignite plant's cost advantage over the other thermal options.

The cost of lignite surpasses the cost of gas if the cost of tCO_2 is 55 percent higher than assumed in the base case (€23.25/tCO_2 instead of €15/ tCO_2), and is 55 percent higher than the IEA forecast for each year thereafter (reaching a level of €35.02/tCO_2 by 2020 and €40.44/tCO_2 by 2025). Table 6.2 below shows the effect of higher carbon price assumptions on the costs (in net present value terms) of the alternative plans.

Table 6.2: Summary of NPVs of Alternative Power Supply Plans—IEA CO_2 Forecast + 55 percent

		Lignite+ RE	Gas+ RE	Fuel Oil+ RE
	(€ Millions)			
New Thermal Plant		2,326	2,309	4,117
Kosovo A		514	514	514
Kosovo B		1,990	1,990	1,990
Existing Hydro		28	28	28
Zhur		238	238	238
Small Hydro		84	84	84
Wind		176	176	176
Biogas		87	87	87
Biomass		28	28	28
Imports		923	923	923
Total		6,402	6,385	8,193

6.3 Construction Cost Sensitivities

The analysis also considered the implications of changes in construction costs on the alternative supply plans. Higher construction costs for lignite-fueled generation plants will obviously reduce the cost advantage of the Lignite + RE plan. Table 6.3 shows that the construction cost of the lignite-fueled generation plant could increase by as much as 25 percent (from $1.1 billion to $1.4 billion) before the construction cost of the Gas + RE plan becomes the lowest cost in terms of NPV.

Table 6.3: Summary of NPVs of Alternative Power Supply Plans—Construction Costs of Lignite Plant Increase by 25 percent

		Lignite+ RE	Gas+ RE	Fuel Oil+ RE
		(€ Millions)		
New Thermal Plant		2,198	2,192	3,941
Kosovo A		417	417	417
Kosovo B		1,618	1,618	1,618
Existing Hydro		28	28	28
Zhur		238	238	238
Small Hydro		84	84	84
Wind		176	176	176
Biogas		87	87	87
Biomass		28	28	28
Imports		863	863	863
Total		5,744	5,739	7,488

Increases in construction costs, however, would most likely affect all construction in Kosovo. It is therefore unlikely that the construction costs for a lignite plant increase while construction costs for the other options remain constant. Construction costs could also increase for other technologies. This would make the more capital-intensive technologies (lignite plants and renewable) less economically attractive than the less capital-intensive technologies (gas and fuel oil). Table 6.4 shows the impact of changes in all plant construction costs on the economic attractiveness of the Lignite + RE plan versus the alternative Gas + RE plan. The table shows that the construction costs could increase by 45 percent for all technologies before the Lignite + RE plan approaches the cost of the Gas + RE plan.

Table 6.4: Summary of NPVs of Alternative Power Supply Plans—Increase in Construction Costs for All Plants of 45 percent

		Lignite+ RE	Gas+ RE	Fuel Oil+ RE
		(€ Millions)		
New Thermal Plant		2,360	2,338	4,087
Kosovo A		417	417	417
Kosovo B		1,725	1,725	1,725
Existing Hydro		28	28	28
Zhur		327	327	327
Small Hydro		121	121	121
Wind		252	252	252
Biogas		126	126	126
Biomass		41	41	41
Imports		863	863	863
Total		6,267	6,246	7,995

6.4 Fuel Cost Sensitivities

Higher lignite costs or lower natural gas or fuel oil costs could also reduce the cost advantages of the Lignite+RE plan. Table 6.5 shows that lignite costs would need to increase 70 percent (from €10.5/ton to €17.17/ton) before the NPV of the Lignite + RE plan surpasses the NPV of the Gas + RE plan.

Table 6.5: Summary of NPVs of Alternative Power Supply Plans—Lignite Costs increase by 70 percent

		Lignite+ RE	Gas+ RE	Fuel Oil+ RE
		(€ Millions)		
New Thermal Plant		2,203	2,192	3,941
Kosovo A		566	566	566
Kosovo B		1,899	1,899	1,899
Existing Hydro		28	28	28
Zhur		238	238	238
Small Hydro		84	84	84
Wind		176	176	176
Biogas		87	87	87
Biomass		28	28	28
Imports		863	863	863
Total		6,180	6,169	7,918

Table 6.6 shows the impact on the natural gas option of a 15 percent reduction in natural gas cost, from €300/tcm to €255/tcm. The Gas + RE plan approaches the cost of the Lignite + RE plan at these prices.

Table 6.6: Summary of NPVs of Alternative Power Supply Plans—15 percent reduction in Natural Gas Cost

		Lignite+ RE	Gas+ RE	Fuel Oil+ RE
	(€ Millions)			
New Thermal Plant		1,995	1,971	3,469
Kosovo A		417	417	417
Kosovo B		1,618	1,618	1,618
Existing Hydro		28	28	28
Zhur		238	238	238
Small Hydro		84	84	84
Wind		176	176	176
Biogas		87	87	87
Biomass		28	28	28
Imports		863	863	863
Total		5,542	5,518	7,016

6.5 Summary of Sensitivities

The Lignite + RE plan shows to be lowest cost despite fairly wide variations in assumptions about forecast power demand, generation plant capacity utilization, generation plant construction costs, fuel costs for power generation, and global environmental costs (including cost of carbon at prices forecast by International Energy Agency) associated with the use of these fuels.

Table 6.7 summarizes the results of the sensitivity analysis.

Table 6.7: Summary of Sensitivity Analysis[55]

	Base Case	Sensitivity	Base Case PV of Lignite + RE Plan	Base Case PV of Gas + RE Plan	PV of Lignite + RE plan with sensitivity	PV of Gas + RE plan with sensitivity
Demand	4.5 percent GDP growth	3% GDP growth	5,542	5,739	4,903	5,080
Cost of CO_2	IEA forecast	IEA forecast + 55%	5,542	5,739	6,402	6,385
Construction Costs of Lignite Plant	€1.1 Billion	25% increase to €1.4 Billion	5,542	5,739	5,744	5,739
Construction Costs of All Plants		45% increase for all plants	5,542	5,739	6,267	6,246
Lignite Fuel Costs	€10.5	70% increase to €17.77/ Ton	5,542	5,739	6,180	6,169
Gas Fuel Costs	€300/tcm	15% decrease to €255/tcm	5,542	5,739	5,542	5,518

[55] The analysis does not consider the Fuel Oil+RE option further because the Gas+RE plan is the next lowest cost alternative after Lignite+RE

Appendix A. Power Demand Forecast Model

Basic forecasting methodology

Since this analysis of power supply options is carried out in economic terms, the forecast of power demand used for this analysis should reflect the demand for electricity that is consistent with economic efficiency principles. In practice, this demand is the estimated quantity of electricity that consumers would consume if they had to pay a price that fully covers the economic cost of supplying the amount of electricity consumed by them. This approach does necessarily predict that electricity prices will actually equal this economic cost of supply. But if these prices do differ from the economic cost, then the amount of electricity consumed would not equal the economically efficient level of consumption. If the price were below the economic cost, consumption would exceed the economically efficient level, and this difference would impose an economic cost on society (a “deadweight loss” in economic terms).

The methodology for deriving a forecast of the economically efficient level of demand for electricity over the long-term is based on the following relationship between power demand growth and real income growth rate and real electricity price growth rate, assuming a constant elasticity power demand equation:

> The rate of growth of demand is equal to the rate of growth of prices times the price elasticity plus the rate of growth of income times the income elasticity. This is expressed formally as:
>
> $d = p*b + g*a$
>
> where:
>
> d = annual average rate of growth of demand
>
> a = income elasticity (positive)
>
> g = growth of real income between successive forecast periods
>
> b = price elasticity of demand (negative)
>
> p = change of real power prices between successive forecast periods.

For the purpose of using this model, the forecast period is the calendar year and estimates of price elasticity and income elasticity of power demand in Kosovo were generally derived from ESTAP’s analysis, as set out below.

The demand for electricity derived with this model is the forecast unconstrained end use consumption without reduction of losses from the present level. This forecast end use consumption is then transposed into **the gross energy sent out to the power network from power generation plants needed to supply forecast unconstrained end use consumption with scheduled reduction in non-technical losses**. This amendment takes account of assumptions about reductions in technical and non-technical losses and for shortfalls in generation as a result of load shedding.

The incorporation of price elasticity and income elasticity effects is carried out in the following three-stage process.

- In the first stage, which is described in the paragraph before this one, the value for income elasticity is combined with the forecast growth in GDP, but no change is assumed in the average electricity tariff in real price terms. This part of the analysis produces the **preliminary base case demand forecast**.
- In the second stage, the economic cost for Kosovo of supplying this forecast demand is computed according to the methodology described in Section 6.1. These costs include the local socio-economic costs imposed by atmospheric emissions (NO_X, SO_X, ash, etc.) from burning fossil fuels to generate electricity in Kosovo. These costs exclude, however, the price of carbon dioxide because the benefit from incurring this cost is a global good, and the costs of constructing and operating the high cost renewable supply options are excluded because they cannot form part of the economically least-cost means for supplying the forecast power demand. The Zhur hydropower project and renewable energy projects are included because they can be fitted into a cost-effective power supply expansion plan.
- In the third stage, **the economic base case power demand forecast** is derived with electricity prices that reflect the level of the economic cost of supplying the preliminary base case forecast demand.. When this economic cost is substantially greater than the current average electricity tariff – taken to be equal to the average level in force in Kosovo during the year 2010 – the difference between the two measures provides an estimate of the increase in electricity prices from the current level required to estimate the demand for electricity that is consistent with economic efficiency principles. When this price increase is too large to implement over a short period without causing serious economic and social difficulties for electricity consumers, the increase is modeled in affordable annual steps over a long period. In practice, the electricity price used for forecasting power demand increases steadily to reach the level of the economic cost of power supply by the time that all of the planned new power supply capacity is installed and operational, namely by 2025. The power demand model is rerun with the estimated increase in electricity price combined with the value for price elasticity of electricity demand, as well as with the value for income elasticity combined with the forecast growth in GDP.

The economic base case forecast is the forecast used for evaluating the power supply options.

Price elasticity of demand

Price refers to the average level of power tariffs faced by electricity end users in Kosovo. Price elasticity can be derived for each sector as follows, based on information from ESTAP:

- For industrial and service consumer categories[56], price elasticity = -0.30
- For the household sector, price elasticity was estimated by comparing annual consumption per household for houses without meters with annual consumption per household for houses with meters[57]. The price elasticity of households that were newly connected to meters in 2000 and 2005 were calculated as follows:
  - For year 2000 = - (7554 – 4500) / 7554 = -0.40.
  - For 2005 = - (9000 – 4856) / 9000 = -0.46.

  i.e. the price elasticity for the household sector trends upwards from -0.40 to -0.46 between 2000 and 2005.

Based on ESTAP's forecast reductions in consumption levels from the removal on non-technical losses for the three consumer sectors[58] the weighted average price elasticity for all sectors is:

- - 0.38 in 2000
- - 0.41 in 2005
- - 0.40 in 2010
- - 0.39 in 2015.

On the basis of these values, a specific price elasticity of electricity demand equal to -0.40 is assumed for the reduction in consumption brought about by the reduction in non-technical losses (mainly for unpaid consumption by households).

A constant price elasticity of electricity demand equal to -0.20 is assumed for total Kosovo consumption when the average electricity tariff level across consumer tariff groups is changed.[59] This possibility was not envisaged in ESTAP's analysis.

Income elasticity of demand

Estimating income elasticity from ESTAP data means determining the value for income elasticity that would have produced ESTAP's forecast average demand growth rate (2000-15) in the demand forecasting model **d = -0.40*p + a*g**, under ESTAP's implicit assumption of no change in the electricity price.[60]

In the case where the modeling assumed that measures to reduce non-technical losses were implemented, the forecast average consumption growth rate for 2000-2015 was

[56] *ESTAP Kosovo Final Report, June 2002* Module A, p.97

[57] *ESTAP Kosovo Final Report, June 2002* Module A, Table 5.5, p.75. The "Assumption 2 case" shows projections for these consumer categories from 2000 to 2005 on the basis that all households will be metered by 2005.

[58] *ESTAP Kosovo Final Report, June 2002,* Module A, Table 7.4, p.122

[59] This value of price elasticity of total electricity demand for all consumption sectors is a typical reference value.

[60] The value for price elasticity of demand based on ESTAP's analysis, namely –0.40, is the appropriate value for deriving the income elasticity of demand because this derivation is based on ESTAP's analysis.

4.37 percent per annum[61], and the projected growth in GDP over the same period was 6.4 percent per annum[62].

Substituting these values in the demand model results in income elasticity:

$$a = (4.37 + 0.40*10.0)/6.4 = 1.31$$

Hence the demand forecast model for the base year 2010 is:

$$d = -0.40*p + 1.31*g$$

The resulting first order end-use electricity demand forecast model for year $_{n+1}$ is:

$$D_{n+1} = D_n*(1-0.40*p_{n+1} + 1.31*g_{n+1})$$

where D_n is the end-use energy demand in year *n* of the forecast period, D_{n+1} is the end-use energy demand in year *n*+1, p_{n+1} is the projected change of real power prices between years *n* and *n*+1, g_{n+1} is the projected growth of real income between years *n* and *n*+1, and *n* equals one in 2011.

Incorporating assumptions about loss reduction

The demand for electricity derived in the previous section with this model is the forecast unconstrained end use consumption without reduction of losses from the present level. This forecast demand is then amended to take account of assumptions about reductions in technical and non-technical losses and for shortfalls in generation as a result of load shedding.

Technical losses (TL*n* in year *n*) on electricity generated in Kosovo are projected separately as a percent of net energy transmitted in Kosovo (energy generated in Kosovo *plus* imports *less* exports) in each year *n*. This model assumes that technical losses are reduced from the actual level of 16.6 percent of gross energy supplied in 2010 to 8.0 percent in 2025.

Non-technical losses in year *n* (NTL_n) are assumed to be reduced to 5 percent at a uniform rate over the 5 years from 2013 to 2018. The year 2013 is chosen for the beginning of the reduction of non-technical losses on the assumption that the planned privatization of the electricity distribution system in mid-2012 will introduce the commercial discipline required to achieve this reduction.

The resulting model for forecast demand for generated energy to supply demand in year *n*, is:

$$E_n = d_n/(1-TL_n)$$

Forecast billed consumption in year *n* is:

$$B_n = d_n - NTL_n$$

[61] *ESTAP Kosovo Final Report, June 2002*, Module A, Table 5.38, p.103

[62] *ESTAP Kosovo Final Report, June 2002* Module A, Table 5.35, p.100

The final equation set out above can be used, together with the information specified below, to derive a first-order forecast of billed electricity consumption for the period 2010 to 2025. Addition of base year data into the demand forecast model.

The demand forecast model is calibrated as follows to reflect actual data for Kosovo:

- 2010 actual (base year) consumption[63]: 4,591 GWh
- 2010 actual gross energy supplied to the power network[64]: 5,506 GWh
- 2010 technical losses[65]: 16.6 percent of generation at beginning of forecast period
- 2010 non-technical losses[66]: 20 percent of total generated energy (i.e. in 2010 this would equal 5,506 x 0.20 = 1,101 GWh
- 2010 actual generation shortfall through load shedding[67]: 205 GWh
- 2010 generation required to supply demand including all losses: 5,506 + 205 = 5,711 GWh
- Reduction in gross energy by removing non-technical losses: 0.40 x 1,101 = 440 GWh, treating these losses as unpaid consumption (assuming a price elasticity of demand, as above, of 0.40)

2010 gross energy to supply unconstrained end-use demand for electricity at the prevailing tariff: (4591/(1-0.166) + 205-440) = 5271 GWh (i.e. 2010 actual consumption plus foregone consumption from load shedding plus technical losses less the reduction in consumption by removing non-technical losses)

Forecast real GDP growth rate for the medium planning scenario: 4.5 percent.

Forecast change in power tariffs in real price terms: Initially an assumption of no change over the forecast period is used, with this assumption reviewed in a second iteration by comparing the current average tariff with the LRAIC of the least cost power development plan (from the analysis in Section 4). If the current tariff is significantly lower than the LRAIC, the demand forecast is recalculated assuming a steady increase in the tariff up to LRAIC, using the value for price elasticity of electricity demand derived above and then the least-cost power development plan is re-estimated under the revised demand forecast.

---

[63] Data provided by KEK (file "Power system data 2008_2010.doc"). This is a combination of consumption paid at the electricity tariff and unpaid consumption categorized as non-technical losses. The 2010 level is constrained by actual load shedding. The forecast levels assume no supply constraints and hence no un-served demand on the power system.

[64] Data provided by KEK (file "Power system data 2008_2010.doc").

[65] Data provided by KEK

[66] Data provided by KEK (file "Power system data 2008_2010.doc").

[67] KOSTT, *Generation Adequacy Plan (2009-15),* October 2008

Forecast of Electricity Consumption (GWh)

The preliminary base case demand forecast. This forecast is computed from the demand model utilizing assumptions of 4.5 percent per annum growth in GDP but no increase in electricity price during the planning period.[68] Under these assumptions, electricity consumption in Kosovo would grow at an average of 5.3 percent per annum over the period to 2025. This derivation is shown in Appendix Table A.1. A year-by-year forecast is shown in Appendix Table A.6.

Appendix Table A.1: Derivation of the Preliminary Base Case Demand Forecast

year	**2010** actual	**2015** forecast	**2020** forecast	**2025** forecast
Actual end use consumption in 2010 incl. NTL (GWh)	4,591			
Actual end use consumption in 2010 incl. shed load (GWh)	4,762			
Forecast unconstrained end use consumption without reduction of NTL under the demand model (GWh)		6,341	8,444	11,244
Annual growth of end use consumption		5.9%	5.9%	5.9%
Technical losses (percent of generation)	16.6%	13.0%	10.0%	8.0%
Gross energy to supply unconstrained end use consumption without reduction of NTL (GWh)	5,711	7,289	9,382	12,222
Annual growth of generated energy		5.00%	5.2%	5.4%
NTL (percent gross energy – actual in 2010)	20.0%	14.0%	5.0%	5.0%
NTL – gross energy (GWh)	1,101	1,020	469	611
Reduction in gross energy by removing NTL (GWh)	440	175	563	733
Reduction in consumption by removing NTL (GWh)	367	152	507	675
Gross energy to supply forecast unconstrained consumption with scheduled reduction in NTL (GWh)	5,271	7,114	8,819	11,488
Annual growth of gross energy supply		6.2%	4.4%	5.4%
Forecast unconstrained end use consumption with scheduled reduction in NTL (GWh)	4,395	6,189	7,937	10,569

[68] The IMF forecast real GDP growth for the period 2012 to 2016 averages 4.5 percent (IMF Country Report No. 11/210, July 2011).

The economic cost for Kosovo of supplying this forecast demand is derived in terms of **the long run average incremental cost (LRAIC),** which is defined in the box below**.**

Appendix Box A.1: Definition of LRAIC

LRAIC is the ratio of (the discounted present value of the stream of incremental supply costs) to (the discounted present value of the stream of incremental energy supplied or consumed). The discount period runs from the first year of the planning period (2011) to the final year of the runout period (2050). The annual values used for the runout period are the costs and energy values for the final year of the planning period (2025).

The term "incremental" refers to the increase in the amount of energy supplied or costs incurred for the whole power system in a year during the planning period over the amount of energy supplied or costs incurred in the first year of the planning period.

The use of incremental costs reflects the principle of using only presently uncommitted costs and benefits in economic analysis. Past and presently firmly committed expenditures and benefits therefrom are excluded from this analysis.

For economic analysis, the discount rate used is the estimated opportunity cost of capital to Kosovo, assumed to be 10 percent.

The LRAIC for the preliminary base case in the first stage of this analysis is estimated to be €0.080 per kWh sent out from generation plants to the power network (see table headed "Derivation of LRAIC for Lignite + RE Plan based on the Preliminary Base Case Demand Forecast and Economic Costs to Kosovo" located at the end of this appendix).

This estimate of economic cost of supply is compared with the average tariff charged in 2010, as described above. Hence the LRAIC has to be converted to the equivalent cost per kWh billed.

- Assuming the actual level of technical losses in 2010 of 16.6 percent of total energy sent out to the power network and to direct consumers[69], and incorporating an acceptable allowance on efficiency grounds of 5 percent for non-technical losses that the power supplier has to cover from billed revenues, this economic cost of supply is equivalent to €0.103 per kWh billed.
- According to KEK, in 2010 they billed €201.3 million for total billed consumption of 3,496 GWh, which indicates that KEK's average tariff was €0.0576 per kWh billed.
- The estimated LRAIC of is therefore 78 percent more than the average tariff in 2010.

[69] This level of 16.6 percent is based on data provided by KEK for total network technical losses as a proportion of total gross consumption in KEK's terminology in 2010, which is equivalent to total energy supplied to the power system. Alternatively, these losses could be expressed as a proportion of KEK's gross consumption in the network, in which case the total technical losses amount to 20.1 percent.

This difference can be bridged by a series of 4.2 percent annual increases on the average tariff level starting in 2012 and running to 2025, on the basis described above. These prices reflect economic costs in order to derive the economically efficient demand. They do not reflect financial costs or tariffs needed to recover financial costs, which differ from economic costs.

Hence **the economic base case demand forecast** is derived with 4.2 percent annual increases in the power price and a price elasticity of demand equal to -0.2, combined with the a value of +1.31 for income elasticity and annual growth in real GDP of 4.5 percent during the planning period. Appendix Table A.2 shows the derivation of the base case economic demand forecast, using the methodology described above. This derivation is shown in Appendix Table A.1. A year-by-year forecast is shown in Appendix Table A.7.

Appendix Table A.2: Derivation of the Economic Base Case Demand Forecast

year	**2010** actual	**2015** forecast	**2020** forecast	**2025** forecast
Actual end use consumption in 2010 incl. NTL (GWh)	4,591			
Actual end use consumption in 2010 incl. shed load (GWh)	4,762			
Forecast unconstrained end use consumption without reduction of NTL under the demand model (GWh)		5,043	7,859	10,055
Annual growth of end use consumption		5.22%	5.1%	5.1%
Technical losses (percent of generation)	16.6%	13.0%	10.0%	8.0%
Gross energy to supply unconstrained end use consumption without reduction of NTL (GWh)	5,711	7,060	8,732	10,930
Annual growth of generated energy		4.33%	4.34%	4.59%
NTL (percent gross energy – actual in 2010)	20%	14%	5%	5%
NTL – gross energy (GWh)	1,101	988	437	546
Reduction in gross energy by removing NTL (GWh)	440	169	524	656
Reduction in consumption by removing NTL (GWh)	367	147	472	603
Gross energy to supply forecast unconstrained consumption with scheduled reduction in NTL (GWh)	5,271	6,890	8,208	10,274
Annual growth of gross energy supply		5.51%	3.56%	4.59%
Forecast unconstrained end use consumption with scheduled reduction in NTL (GWh)	4,395	5,994	7,387	9,452

The effect of introducing the price elasticity of demand effect is to reduce the forecast gross energy sent out requirement in 2020 from 8,819 GWh to 8,208 GWh, or 6.93 percent of the former. The corresponding reduction in 2025 is from 11,488 GWh to 10,274 GWh, or 10.57 percent of the former amount. Under this base case, demand is forecast to grow on average at 4.6 percent per year from 2010 to 2025.

A sensitivity case for the comparison of power supply plans is conducted at a low economic case demand forecast, in which the forecast growth in GDP is reduced to 3.0 percent per year from the 4.5 percent per year used in the base case. This lower GDP growth is combined with the price increase used for the base case to produce this low case. Appendix Table A.3 presents the derivation of this low case demand forecast. A year-by-year forecast is shown in Appendix Table A.8.

Appendix Table A.3: Derivation of the Economic Low Case Demand Forecast

year	**2010** actual	**2015** forecast	**2020** forecast	**2025** forecast
Actual end use consumption in 2010 incl. NTL (GWh)	4,762			
Actual end use consumption in 2010 incl. shed load (GWh)	4,762			
Forecast unconstrained end use consumption without reduction of NTL under the demand model (GWh)		5,818	6,774	7,886
Annual growth of end use consumption		4.09%	3.09%	3.09%
Technical losses (percent of generation)	16.6%	13.0%	10.0%	8.0%
Gross energy to supply unconstrained end use consumption without reduction of NTL (GWh)	5,711	6,687	7,526	8,572
Annual growth of generated energy		3.21%	2.39%	2.64%
NTL (percent gross energy – actual in 2010)	20%	14%	5%	5%
NTL – gross energy (GWh)	1,101	936	376	429
Reduction in gross energy by removing NTL (GWh)	440	160	452	514
Reduction in consumption by removing NTL (GWh)	367	140	406	473
Gross energy to supply forecast unconstrained consumption with scheduled reduction in NTL (GWh)	5,271	6,527	7,075	8,058
Annual growth of gross energy supply		4.37%	1.62%	2.64%
Forecast unconstrained end use consumption with scheduled reduction in NTL (GWh)	4,395	5,678	6,367	7,413

The effect of reducing the GDP growth rate to 3 percent per year is to reduce the forecast gross energy sent out requirement in 2020 from 8,208 GWh to 7,075 GWh, or 13.8 percent of the former. The corresponding reduction in 2025 is from 10,274 GWh to 8,058 GWh, or 21.6 percent of the former amount. Under this low forecast case, demand is forecast to grow on average at 2.9 percent per year from 2010 to 2025.

Appendix Table A.4 summarizes these three demand forecast cases.

Appendix Table A.4: Summary of Power Demand Forecast Cases

	Gross energy to supply forecast unconstrained end-use consumption with scheduled reduction in non-technical losses (GWh)				
	year	**2010**	**2015**	**2020**	**2025**
		actual	**forecast**	**forecast**	**forecast**
Preliminary Base Case Demand Forecast		5,271	7,114	8,819	11,488
annual growth of gross energy supply			6.18%	4.39%	5.43%
Economic Base Case Demand Forecast		5,271	6,890	8,208	10,274
annual growth of gross energy supply			5.51%	3.56%	4.59%
Low Economic Base Case Demand Forecast		5,271	6,527	7,075	8,058
annual growth of gross energy supply			4.37%	1.62%	2.64%

Appendix Table A.6 through Appendix Table A.8 show the year-by-year demand forecasts derived for the preliminary base case, economic base case, and low economic base case.

Appendix Table A.5: Derivation of LRAIC for Lignite+RE Plan based on the Preliminary Base Case Demand Forecast and Economic Costs to Kosovo

Year	Thermal Costs (a)				Renewables Costs (a)					-	Total	Energy sent out (MWh)	Annual Increments relative to 2011	
	New Lignite	Kosovo A	Kosovo B	Older Hydro	Zhur	Small Hydro	Wind	Bio-gas	Bio-mass	Imports			Costs	Energy
	(€ Millions)												(€ million)	(GWh)
2011	0.00	55.04	72.86	3.79	0.00	0.00	0.00	0.00	0.00	96.20	227.90	5,928,217	0.0	0.0
2012	0.00	55.04	74.24	3.79	0.00	0.00	0.00	0.00	0.00	116.38	249.46	6,230,170	21.6	302.0
2013	334.99	55.05	75.36	3.79	57.40	22.97	0.00	0.00	0.00	137.93	687.49	6,535,777	459.6	607.6
2014	279.16	55.05	76.13	3.79	57.40	22.97	11.70	0.00	0.00	160.76	666.96	6,840,160	439.1	911.9
2015	223.33	55.05	76.88	3.79	57.40	22.97	23.40	0.00	0.00	181.09	643.91	7,114,288	416.0	1,186.1
2016	223.33	55.05	277.53	3.79	57.40	25.73	35.10	0.00	0.00	183.47	861.40	7,390,082	633.5	1,461.9
2017	151.30	55.05	231.19	3.79	64.43	2.76	46.97	0.00	0.00	10.51	566.00	7,675,738	338.1	1,747.5
2018	102.22	0.00	49.98	3.79	7.03	2.76	47.31	0.00	0.00	83.17	296.27	7,971,538	68.4	2,043.3
2019	102.47	0.00	74.88	3.79	7.03	2.76	47.82	0.00	0.00	11.94	250.68	8,384,806	22.8	2,456.6
2020	102.70	0.00	79.61	3.79	7.03	2.76	41.77	0.00	0.00	21.91	259.56	8,819,897	31.7	2,891.7
2021	102.92	0.00	84.04	3.79	7.03	2.76	30.91	0.00	19.70	36.82	287.96	9,298,503	60.1	3,370.3
2022	103.11	0.00	87.85	3.79	7.03	2.76	20.22	56.84	19.70	56.53	357.82	9,803,272	129.9	3,875.1
2023	103.23	0.00	91.01	3.79	7.03	2.76	9.50	56.84	22.06	78.88	375.11	10,335,644	147.2	4,407.4
2024	103.17	0.00	91.83	3.79	7.03	2.76	5.35	68.78	2.36	93.69	378.76	10,897,136	150.9	4,968.9
2025	103.33	0.00	95.43	3.79	7.03	2.76	6.00	11.94	2.36	129.22	361.85	11,489,350	134.0	5,561.1
					PV @ 10% to 2025 of the runout period 2026-2050 at 2025 total costs:						€ 3,284.6	million	€ 1,216.0	50,478.6
Note a: Construction, fuel and O&M costs														
					PV @ 10% to 2011 of total costs 2012-2025 plus runout period:						**€ 4,316.52**	**million**	**€ 2,142.48**	**26,636.77**
												LRAIC @10% =	**€ 0.080**	**/kWh sent out**

Appendix Table A.6: Year-by-Year Derivation of the Preliminary Base Case Demand Forecast

Preliminary Base Case Demand Forecast	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
	Actual	Forecast														
Actual end use consumption in 2010 inc. non-technical losses (GWh)	4591															
Actual end use consumption in 2010 inc. shed load (GWh)	4762															
Projected real GDP annual growth rate (%)		4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Projected annual real change in average price of billed electricity (%)		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Forecast unconstrained end use consumption without reduction of non-technical losses under the demand model (GWh)		5043	5340	5655	5988	6341	6715	7111	7530	7974	8444	8942	9469	10027	10618	11244
annual growth of end use consumption (%)						5.9					5.9					5.9
Technical losses (% generation)	16.6	15.0	14.5	14.0	13.5	13.0	12.4	11.8	11.2	10.6	10.0	9.6	9.2	8.8	8.4	8.0
Gross energy to supply unconstrained end-use consumption without reduction of non-technical losses(GWh)	5711	5933	6246	6575	6923	7289	7665	8062	8480	8919	9382	9891	10428	10994	11592	12222
annual growth of generated energy (%)						5.0%					5.2%					5.4%
Non-technical losses (% gross energy - actual in 2010)	20.0	20.0	20.0	20.0	17.0	14.0	11.0	8.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Non-technical losses - gross energy (GWh)	1101	1187	1249	1315	1177	1020	843	645	424	446	469	495	521	550	580	611
Reduction in gross energy by reducing non-technical losses (GWh)	440	0	0	0	83	175	276	387	509	535	563	593	626	660	696	733
Reduction in consumption by reducing non-technical losses (GWh)	367	0	0	0	72	152	242	341	452	478	507	537	568	602	637	675
Gross energy to supply forecast unconstrained end use consumption with scheduled reduction in non-technical losses (GWh)	**5271**	**5933**	**6246**	**6575**	**6840**	**7114**	**7389**	**7675**	**7971**	**8384**	**8819**	**9298**	**9803**	**10335**	**10896**	**11488**
annual growth of gross energy supply						6.18					4.39					5.43
Forecast unconstrained end use consumption with scheduled reduction in non-technical losses (GWh)	4395	5043	5340	5655	5916	6189	6473	6769	7078	7495	7937	8405	8901	9425	9981	10569

Appendix Table A.7: Year-by-Year Derivation of the Economic Base Case Demand Forecast

Economic Base Case Demand Forecast	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
	Actual	Forecast														
Actual end use consumption in 2010 inc. non-technical losses (GWh)	4591															
Actual end use consumption in 2010 inc. shed load (GWh)	4762															
Projected real GDP annual growth rate (%)		4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Projected annual real change in average price of billed electricity (%)			4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Forecast unconstrained end use consumption without reduction of non-technical losses under the demand model (GWh)		5043	5298	5565	5846	6142	6452	6778	7121	7481	7859	8256	8673	9111	9572	10055
annual growth of end use consumption (%)						5.2					5.1					5.1
Technical losses (% generation)	16.6	15.0	14.5	14.0	13.5	13.0	12.4	11.8	11.2	10.6	10.0	9.6	9.2	8.8	8.4	8.0
Gross energy to supply unconstrained end-use consumption without reduction of non-technical losses(GWh)	5711	5933	6196	6471	6759	7060	7366	7685	8019	8368	8732	9132	9552	9990	10449	10930
annual growth of generated energy (%)						4.3					4.3					4.6
Non-technical losses (% gross energy - actual in 2010)	20.0	20.0	20.0	20.0	17.0	14.0	11.0	8.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Non-technical losses - gross energy (GWh)	1101	1187	1239	1294	1149	988	810	615	401	418	437	457	478	500	522	546
Reduction in gross energy by reducing non-technical losses (GWh)	440	0	0	0	81	169	265	369	481	502	524	548	573	599	627	656
Reduction in consumption by reducing non-technical losses (GWh)	367	0	0	0	70	147	232	325	427	449	472	495	520	547	574	603
Gross energy to supply forecast unconstrained end use consumption with scheduled reduction in non-technical losses (GWh)	5271	5933	6196	6471	6678	6890	7100	7316	7538	7866	8208	8584	8979	9391	9822	10274
annual growth of gross energy supply						5.51					3.56					4.59
Forecast unconstrained end use consumption with scheduled reduction in non-technical losses (GWh)	4395	5043	5298	5565	5776	5994	6220	6453	6694	7032	7387	7760	8153	8564	8997	9452

Appendix Table A.8: Year-by-Year Derivation of the Low Economic Base Case Demand Forecast

Low Economic Base Case Demand Forecast	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
	Actual	Forecast														
Actual end use consumption in 2010 inc. non-technical losses (GWh)	4591															
Actual end use consumption in 2010 inc. shed load (GWh)	4762															
Projected real GDP annual growth rate (%)		4.6	4.6	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Projected annual real change in average price of billed electricity (%)			4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Forecast unconstrained end use consumption without reduction of non-technical losses under the demand model (GWh)		5049	5311	5475	5644	5818	5998	6183	6374	6571	6774	6983	7198	7421	7650	7886
annual growth of end use consumption (%)						4.1					3.1					3.1
Technical losses (% generation)	16.6	15.0	14.5	14.0	13.5	13.0	12.4	11.8	11.2	10.6	10.0	9.6	9.2	8.8	8.4	8.0
Gross energy to supply unconstrained end-use consumption without reduction of non-technical losses(GWh)	5711	5940	6211	6366	6525	6687	6847	7010	7178	7350	7526	7724	7928	8137	8351	8572
annual growth of generated energy (%)						3.2					2.4					2.6
Non-technical losses (% gross energy - actual in 2010)	20.0	20.0	20.0	20.0	17.0	14.0	11.0	8.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Non-technical losses - gross energy (GWh)	1101	1188	1242	1273	1109	936	753	561	359	367	376	386	396	407	418	429
Reduction in gross energy by reducing non-technical losses (GWh)	440	0	0	0	78	160	246	336	431	441	452	463	476	488	501	514
Reduction in consumption by reducing non-technical losses (GWh)	367	0	0	0	68	140	216	297	382	394	406	419	432	445	459	473
Gross energy to supply forecast unconstrained end use consumption with scheduled reduction in non-technical losses (GWh)	5271	5940	6211	6366	6446	6527	6600	6674	6747	6909	7075	7261	7452	7649	7850	8058
annual growth of gross energy supply						4.4					1.6					2.6
Forecast unconstrained end use consumption with scheduled reduction in non-technical losses (GWh)	4395	5049	5311	5475	5576	5678	5782	5886	5991	6176	6367	6564	6767	6975	7191	7413

Appendix B. Additional Assumptions Used in Cost Estimates

Appendix Table B.1 lists the sources used as the basis for assumptions about plant costs and operating characteristics.

Appendix Table B.1: Specific Assumptions Used for New Plant Costs and Operating Characteristics

	Source	Assumptions
Lignite	PWC valuation of Kosovo B	Capital cost, O&M costs, fuel costs
	PWC/PB	Plant efficiency
Zhur Hydro	Review of Zhur Feasibility Study by Eletropojekt (2009) for MEM	All assumptions
Renewables (except Zhur)	Mercados (2010)	All assumptions
CCGT (natural gas)	Updated Estimates of Power Plant Capital and Operating Costs. Table 1. US Department of Energy, Energy Information Administration. 2010	O&M costs
	Study on Equipment Prices in the Power Sector. World Bank/ESMAP. 2008.	Capital costs
	IMF Primary Commodity Prices (2011) (http://www.imf.org/external/np/res/commod/index.aspx (Table 3)	Fuel cost
CCGT (light fuel oil)	Based on assumptions for natural gas CCGT. Non-fuel (fixed and variable) O&M costs of the fuel oil plant were increased by 20 percent to arrive at the costs for the fuel oil plant. The same capital costs were used.	All assumptions except fuel cost
	Review of global bunker prices indices, 2011	Fuel cost
All plants	ECOSENSE dispersion model as summarized in the World Bank Project Appraisal Document on the Lignite Power Technical Assistance Project, from September 13, 2006 (Report No. 35430-XK)	Emissions rates (global and local), and cost of emissions

Appendix C. Approach to Supply Modeling

A Microsoft Access database was created to simulate the dispatch of Kosovo's electricity system to meet demand. The model simulated an hourly dispatch of plants required to meet demand from 2010 through 2025.

Creating the demand curve

An hourly demand curve from KOSTT was used as the basis for the initial load shape. Demand in each hour of each day of each year was multiplied by the compound electricity consumption growth forecasted (using the methodology described in Appendix A) through 2015. In other words, the load shape and load factor are assumed to remain constant until 2015. The load curve was reshaped for the 2015 forecast period to reflect the fact that the forecasts 2010-2015 show slower growth in peak load than in gross generation.

Peak load and electricity consumption are assumed to grow at the same pace from 2015 through 2025. The load shape for 2015 is therefore used from 2015-2025. As for the period 2010 through 2014, demand in each hour of each day of each year was multiplied by the compound electricity consumption growth forecasted.

Creating the supply curve

The supply curve was created using the plants in Appendix Table C.1 and Appendix Table C.2. Appendix Table C.1 shows the plants existing in the system as of 2010. Appendix Table C.2 shows the plants added after 2010, and their date of entry and exit during the planning period (in other words, the time frame covered by the model). Maximum utilization factors were chosen based on known technical specifications of the plants (see Appendix B for references).

As Appendix Table C.1 shows, wind capacity is phased in, over time, in seven increments. Transmission capacity is gradually increased as new transmission lines to Albania (in 2013) and Macedonia (in 2019) are completed.

Appendix Table C.1: Existing Sources of Supply in 2010

Plant Name	Dependable Capacity (MW Net)	Maximum Utilization Factor[70]	First Year of Operation (in the planning period)	Last Year of Operation (in the planning period)
Existing small hydros (Ujmani, Lumbardhi, and others)	42.07	0.36	2010	2025
Kosovo B before rehab	500	0.75	2010	2017
Kosovo A	230[71]	0.86	2010	2017
Cross-border transmission capacity	510	NA	2010	2012

[70] This is a limit placed on the production of each plant, during each hour, for the purpose of determining a level of annual generation which is consistent with the plant's net dependable capacity (as defined in Section 2). This limit applies to generation only, not to availability during peak periods.

[71] Net capacity is 345 MW but because Kosovo A3 and A4 cannot be operated simultaneously, a lower figure has been used.

Appendix Table C.2: Additions to Kosovo's System after 2010

Plant Name	Dependable Capacity (MW Net)	Maximum Utilization Factor[72]	First Year of Operation (in the planning period)	Last Year of Operation (in the planning period)
Biogas	67	0.60	2024	2025
Biomass	18	0.65	2023	2025
Cross-border transmission capacity 2013-2018	910	NA	2013	2018
Cross-border transmission capacity after 2018	1435	NA	2019	2025
Kosovo B after rehab	598[73]	0.86	2019	2025
Kosovo B during rehab	300	0.75	2017	2018
New CCGT (alternative to oil or lignite)	560	0.89	2017	2025
New Fuel Oil (alternative to gas or lignite)	560	0.89	2017	2025
New Lignite Plant (alternative to oil or gas)	560	0.89	2017	2025

[72] This is a limit placed on the production of each plant, during each hour, for the purpose of determining a level of annual generation which is consistent with the plant's net dependable capacity (as defined in Section 2). This limit applies to generation only, not to availability during peak periods.

[73] The net available capacity is expected to be 618, but Flue Gas Desulphurization is expected to reduce the capacity of each unit by roughly 10 MW.

Plant Name	Dependable Capacity (MW Net)	Maximum Utilization Factor[72]	First Year of Operation (in the planning period)	Last Year of Operation (in the planning period)
Small Hydro	60	0.53	2016	2025
Wind1	40	0.25	2017	2025
Wind2	40	0.25	2018	2025
Wind3	40	0.25	2019	2025
Wind4	40	0.25	2020	2025
Wind5	40	0.25	2021	2025
Wind6	40	0.25	2022	2025
Wind7	17	0.25	2023	2025
Zhur	305	0.16	2017	2025

Other operating constraints

Certain renewable energy generators had seasonal or dispatching constraints that were also reflected in the model:

- Seasonality of small hydro. The dispatch of small hydroelectric plants (assumed to come into operation in 2016) during the year is shaped according to estimates of monthly inflows to select small hydro sites from a 2006 DANIDA study.[74]
- Capacity credits for annual system peaks. A capacity credit is a measure of a generator's expected contribution to meeting peak demand. Wind plants were assigned capacity credits of 10 percent, meaning that, during an annual system peak, only 10 percent of the installed wind capacity could be assumed to be available to meet peak. Small hydro plants were assigned capacity credits of 53 percent, which is equal to their system load factor and roughly equal to the

[74] Albanian Association of Energy and Environment for Sustainable Development (AAEESD), *Prefeasibility Study for Identification of Water Resources and Their Utilisation Through Small Hydro Power Plant on Kosovo: Final Report,* May 2006

availability of small hydro plants during the months in which Kosovo's annual peak occurs. All other plants were assigned capacity credits of 100 percent.[75]

Appendix Table C.1: Monthly Dispatch of Small Hydroelectric Plants

Month	MW of small hydro capacity available in any hour during the month
January	28.45
February	36.31
March	34.74
April	55.16
May	60.00
June	41.20
July	16.88
August	8.88
September	11.85
October	16.32
November	25.06
December	27.54

Dispatching Supply to Meet Demand

Plants were generally dispatched in order of increasing variable cost (the plants with the lowest variable costs are dispatched first; the plants with the highest variable costs last). However, renewable generation was given priority over thermal generation (dispatched before thermal generation), under the assumption that renewable energy generators will have feed-in tariffs which gives KOSTT the incentive to dispatch them first regardless of cost.

For each hour of each day of the planning period, the plants that were in-service during that year and season were added to the supply curve until supply equaled demand.

[75] Because it has substantial storage capacity, the Zhur plant was also assigned a capacity credit of 100 percent, but because of its low availability is assumed to serve peak loads only (the highest 16 percent of demand hours in any given year).

Availability of capacity to meet annual system peak demand was calculated separately, applying the additional operating constraints indicated above for renewable energy generators. The capacity available from any plant to meet peak was assumed to be equal to the net dependable capacity shown in Appendix Table C.2.

Appendix D. Computation of the Present Values of Generation Options under the Base Case

Appendix Table D.1: Present Values of the Lignite+RE Plan (Base Case)

Year	Thermal				Renewables						Total Cost (€ million)
	Lignite	Kos A	Kos B	Older Hydro	Zhur	Small Hydro	Wind	Biogas	Biomass	Imports	
2011	0.00	90.62	132.90	3.79	0.00	0.00	0.00	0.00	0.00	107.26	334.56
2012	0.00	92.11	137.81	3.79	0.00	0.00	0.00	0.00	0.00	126.63	360.34
2013	334.99	93.66	142.50	3.79	57.40	22.97	0.00	0.00	0.00	147.48	802.79
2014	279.16	95.27	146.66	3.79	57.40	22.97	11.70	0.00	0.00	168.01	784.97
2015	223.33	96.96	151.02	3.79	57.40	22.97	23.40	0.00	0.00	186.37	765.24
2016	223.33	98.71	354.01	3.79	57.40	25.73	35.10	0.00	0.00	184.45	982.52
2017	228.80	100.53	242.35	3.79	64.43	2.76	46.97	0.00	0.00	4.97	694.62
2018	192.51	0.00	83.12	3.79	7.03	2.76	47.31	0.00	0.00	65.26	401.78
2019	196.79	0.00	122.82	3.79	7.03	2.76	47.82	0.00	0.00	3.84	384.84
2020	201.21	0.00	133.46	3.79	7.03	2.76	41.77	0.00	0.00	8.38	398.40
2021	204.58	0.00	144.67	3.79	7.03	2.76	30.91	0.00	19.70	15.81	429.25
2022	208.03	0.00	155.50	3.79	7.03	2.76	20.22	56.84	19.70	26.65	500.51
2023	211.37	0.00	164.37	3.79	7.03	2.76	9.50	56.84	22.06	39.46	517.19
2024	214.10	0.00	167.49	3.79	7.03	2.76	5.35	68.78	2.36	47.08	518.74
2025	218.14	0.00	179.50	3.79	7.03	2.76	6.00	11.94	2.36	71.60	503.11
					PV @ 10% to 2025 of 25 year runout period 2026-2050 at 2025 total costs:						4,566.8
					PV @ 10% to 2011 of total costs 2012-2025 plus runout period:						**5,542.01**

Appendix Table D.2: Present Value of the Gas+RE Plan

Year	Thermal				Renewables						Total Cost (€ million)
	Gas	Kos A	Kos B	Older Hydro	Zhur	Small Hydro	Wind	Biogas	Biomass	Imports	
2011	0.00	90.62	132.90	3.79	0.00	0.00	0.00	0.00	0.00	107.26	334.56
2012	0.00	92.11	137.81	3.79	0.00	0.00	0.00	0.00	0.00	126.63	360.34
2013	0.00	93.66	142.50	3.79	57.40	22.97	0.00	0.00	0.00	147.48	467.80
2014	174.77	95.27	146.66	3.79	57.40	22.97	11.70	0.00	0.00	168.01	680.58
2015	174.77	96.96	151.02	3.79	57.40	22.97	23.40	0.00	0.00	186.37	716.69
2016	174.77	98.71	354.01	3.79	57.40	25.73	35.10	0.00	0.00	184.45	933.97
2017	337.79	100.53	242.35	3.79	64.43	2.76	46.97	0.00	0.00	4.97	803.61
2018	308.43	0.00	83.12	3.79	7.03	2.76	47.31	0.00	0.00	65.26	517.69
2019	310.56	0.00	122.82	3.79	7.03	2.76	47.82	0.00	0.00	3.84	498.62
2020	312.72	0.00	133.46	3.79	7.03	2.76	41.77	0.00	0.00	8.38	509.90
2021	314.52	0.00	144.67	3.79	7.03	2.76	30.91	0.00	19.70	15.81	539.19
2022	316.31	0.00	155.50	3.79	7.03	2.76	20.22	56.84	19.70	26.65	608.80
2023	317.82	0.00	164.37	3.79	7.03	2.76	9.50	56.84	22.06	39.46	623.64
2024	318.25	0.00	167.49	3.79	7.03	2.76	5.35	68.78	2.36	47.08	622.89
2025	320.61	0.00	179.50	3.79	7.03	2.76	6.00	11.94	2.36	71.60	605.58
					PV @ 10% to 2025 of 25 year runout period 2026-2050 at 2025 total costs:						5,496.91
					PV @ 10% to 2011 of total costs 2012-2025 plus runout period:						**5,738.87**

Appendix Table D.3: Present Value of the Fuel Oil+RE Plan

Year	Thermal				Renewables						Total Cost (€ million)
	Fuel Oil	Kos A	Kos B	Older Hydro	Zhur	Small Hydro	Wind	Biogas	Biomass	Imports	
2011	0.00	90.62	132.90	3.79	0.00	0.00	0.00	0.00	0.00	107.26	334.56
2012	0.00	92.11	137.81	3.79	0.00	0.00	0.00	0.00	0.00	126.63	360.34
2013	0.00	93.66	142.50	3.79	57.40	22.97	0.00	0.00	0.00	147.48	467.80
2014	144.23	95.27	146.66	3.79	57.40	22.97	11.70	0.00	0.00	168.01	650.04
2015	144.23	96.96	151.02	3.79	57.40	22.97	23.40	0.00	0.00	186.37	686.15
2016	144.23	98.71	354.01	3.79	57.40	25.73	35.10	0.00	0.00	184.45	903.43
2017	612.26	100.53	242.35	3.79	64.43	2.76	46.97	0.00	0.00	4.97	1,078.07
2018	622.34	0.00	83.12	3.79	7.03	2.76	47.31	0.00	0.00	65.26	831.61
2019	625.97	0.00	122.82	3.79	7.03	2.76	47.82	0.00	0.00	3.84	814.02
2020	629.60	0.00	133.46	3.79	7.03	2.76	41.77	0.00	0.00	8.38	826.79
2021	632.72	0.00	144.67	3.79	7.03	2.76	30.91	0.00	19.70	15.81	857.39
2022	635.80	0.00	155.50	3.79	7.03	2.76	20.22	56.84	19.70	26.65	928.28
2023	638.28	0.00	164.37	3.79	7.03	2.76	9.50	56.84	22.06	39.46	944.11
2024	638.57	0.00	167.49	3.79	7.03	2.76	5.35	68.78	2.36	47.08	943.20
2025	642.73	0.00	179.50	3.79	7.03	2.76	6.00	11.94	2.36	71.60	927.71
					PV @ 10% to 2025 of 25 year runout period 2026-2050 at 2025 total costs:						8,420.83
					PV @ 10% to 2011 of total costs 2012-2025 plus runout period:						**7,487.99**

Appendix E. Generation Forecast by Plant

Appendix Table E.1: Generation Forecast—Thermal+RE, Base Economic Demand Case

Year	Kosovo A	Kosovo B	New Thermal Plant	Existing Hydros	Zhur	Small Hydro	Wind	Biogas	Biomass	Imports	Total Dispatched	Deficit/ Surplus
	(GWh)											
2010	1,732	2,717	-	140	-	-	-	-	-	681	5,271	(0.22)
2011	1,733	2,924	-	140	-	-	-	-	-	1,132	5,928	(4.86)
2012	1,733	2,980	-	140	-	-	-	-	-	1,331	6,183	(13.21)
2013	1,733	3,026	-	140	-	-	-	-	-	1,543	6,442	(30.16)
2014	1,733	3,056	-	140	-	-	-	-	-	1,749	6,678	(0.00)
2015	1,733	3,087	-	140	-	-	-	-	-	1,931	6,891	(0.00)
2016	1,733	3,063	-	140	-	264	-	-	-	1,902	7,101	(0.00)
2017	1,733	731	3,885	140	426	264	88	-	-	51	7,317	0.00
2018	-	1,590	4,278	140	426	264	175	-	-	666	7,538	0.00
2019	-	2,446	4,289	140	426	264	263	-	-	39	7,866	0.00
2020	-	2,644	4,299	140	426	264	350	-	-	85	8,209	0.00
2021	-	2,848	4,310	140	426	264	438	-	-	159	8,585	0.00
2022	-	3,036	4,321	140	426	264	526	-	-	267	8,979	0.00
2023	-	3,176	4,326	140	426	264	563	-	102	394	9,392	0.00
2024	-	3,191	4,317	140	426	264	563	352	102	468	9,823	0.00
2025	-	3,386	4,334	140	426	264	563	352	102	708	10,275	0.00

Appendix Table E.2: Generation Forecast—Thermal+RE, Low Economic Demand Case

Year	Kosovo A	Kosovo B	New Thermal Plant	Existing Hydros	Zhur	Small Hydro	Wind	Biogas	Biomass	Imports	Total Dispatched	Deficit/Surplus
	(GWh)											
2010	1,732	2,717	-	140	-	-	-	-	-	681	5,271	(0.22)
2011	1,733	2,925	-	140	-	-	-	-	-	1,137	5,935	(5.02)
2012	1,733	2,983	-	140	-	-	-	-	-	1,343	6,198	(14.02)
2013	1,733	3,011	-	140	-	-	-	-	-	1,461	6,344	(22.14)
2014	1,733	3,025	-	140	-	-	-	-	-	1,549	6,447	(0.00)
2015	1,733	3,042	-	140	-	-	-	-	-	1,613	6,527	(0.00)
2016	1,733	2,994	-	140	-	264	-	-	-	1,470	6,601	(0.00)
2017	1,733	369	3,654	140	426	264	88	-	-	1	6,674	0.00
2018	-	1,297	4,209	140	426	264	175	-	-	237	6,748	0.00
2019	-	1,606	4,211	140	426	264	263	-	-	0	6,909	0.00
2020	-	1,682	4,213	140	426	264	350	-	-	0	7,075	0.00
2021	-	1,776	4,217	140	426	264	438	-	-	1	7,261	0.00
2022	-	1,875	4,221	140	426	264	526	-	-	1	7,453	0.00
2023	-	1,935	4,217	140	426	264	563	-	102	2	7,649	0.00
2024	-	1,824	4,178	140	426	264	563	352	102	2	7,851	0.00
2025	-	2,005	4,199	140	426	264	563	352	102	7	8,058	0.00

Appendix F. Electricity Tariffs in Kosovo as of 2010

Appendix Table F.1: Current Electricity Tariffs in Kosovo

Tariff Group	Voltage of Supply	Tariff Elements	Unit	Time of Day	High Season Tariffs	Low Season Tariffs
0	110 kV	Standing (customer) charge	Euros/customer/month		83.83	
		Standing (Demand) charge	Eurocents/kWh		5.59	5.59
		Active Energy (P)	Eurocents/kWh	High Tariff	6.49	1.92
			Eurocents/kWh	Low Tariff	2.7	1.58
		Reactive Energy (Q)	Eurocents/kVArh		0	0
1	35 kV	Standing (customer) charge	Euros/customer/month		11.08	
		Standing (Demand) charge	Eurocents/kWh		5.81	5.81
		Active Energy (P)	Eurocents/kWh	High Tariff	6.79	2.94
			Eurocents/kWh	Low Tariff	3.59	2.65
		Reactive Energy (Q)	Eurocents/kVArh		0.66	0.66
2	10 kV	Standing (customer) charge	Euros/customer/month		4.58	
		Standing (Demand) charge	Eurocents/kWh		5.01	5.01
		Active Energy (P)	Eurocents/kWh	High Tariff	7.61	3.39
			Eurocents/kWh	Low Tariff	4.1	3.09
		Reactive Energy (Q)	Eurocents/kVArh		0.66	0.66
3	0.4 kV Category I (Large reactive power consumers)	Standing (customer) charge	Euros/customer/month		2.58	
		Standing (Demand) charge	Eurocents/kWh		2.91	2.91
		Active Energy (P)	Eurocents/kWh	High Tariff	8.45	4.69
			Eurocents/kWh	Low Tariff	5.33	4.43
		Reactive Energy (Q)	Eurocents/kVArh		0.66	0.66
4	0.4 kV Category	Standing (customer) charge	Euros/customer/month		2.92	

Tariff Group	Voltage of Supply	Tariff Elements	Unit	Time of Day	High Season Tariffs	Low Season Tariffs
	II	Active Energy	Eurocents/kWh	Single Tariff	10.41	6.73
				High Tariff	12.53	8.21
		Active Energy (P)	Eurocents/kWh	Low Tariff	6.26	4.1
5	0.4 kV (domestic, 2 rate meter)	Standing (customer) charge	Euros/customer/month		2.08	
		Active Energy for consumption				
		<200 kWh/month	Eurocents/kWh	High Tariff	4.64	3.33
			Eurocents/kWh	Low Tariff	2.33	1.66
		200-600 kWh/month	Eurocents/kWh	High Tariff	6.43	4.6
			Eurocents/kWh	Low Tariff	3.22	2.31
		>600 kWh/month	Eurocents/kWh	High Tariff	9.33	6.68
			Eurocents/kWh	Low Tariff	4.66	3.35
6	0.4 kV (domestic 1-rate meter)	Standing (customer) charge	Euros/customer/month		2.08	
		Active Energy for consumption				
		<200 kWh/month	Eurocents/kWh	Single Tariff	4.14	2.96
		200-600 kWh/month	Eurocents/kWh	Single Tariff	5.73	4.1
		>600 kWh/month	Eurocents/kWh	Single Tariff	8.31	5.96
7	0.4 kV (domestic unmetered)	Estimated consumption <200 kWh/month	Euros/customer/month		21.5	
		Estimated consumption 200-600 kWh/month	Euros/customer/month		38.92	
		Estimated consumption >600 kWh/month	Euros/customer/month		65.58	
8	Public Lighting	Standing (customer) charge	Euros/customer/month		2.92	
		Active Energy	Eurocents/kWh	Single Tariff	8.42	8.42

Source: Energy Regulatory Office of Kosovo

Appendix G. Principal Studies Reviewed for this Paper

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