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Update of the Power Sector Master Plan of Azerbaijan 2013 - 2025

FICHTNER

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Acronyms and Abbreviations

ADB	Asian Development Bank
AZN	Azerbaijani Manat
capex	capital expenditure
CHP	Combined Heat and Power Plant
CCGT	Combined Cycle Gas Turbine
e.g.	for example
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
HPP	Hydroelectric Power Plant
IEA	International Energy Agency
JICA	Japan International Cooperation Agency
JSC	Joint Stock Company
MIE	Ministry of Industry and Energy
MOF	Ministry of Finance
OECD	Organization for Economic Co-Operation and Development
OHL	Overhead Line
PP	Power Plant
PV	Photovoltaics
RE	Renewable Energy
REN	Regional Electricity Network
S/S	Substation
ST	Steam Turbine
TPP	Thermal Power Plant
SCADA	Supervisory Control and Data Acquisition
SHPP	Small Hydroelectric Power Plant
SIP	Self-carrying Insulated Wire
SOCAR	State Oil Company of the Azerbaijan Republic
TEPSCO	Tokyo Electric Power Services Co.

1. Executive Summary

The purpose of this report is to prepare an update of the Power Sector Master Plan for Azerbaijan as a reference document for decision makers and a contribution to the strategic framework for sector development.

Azerbaijan has an installed capacity of about 6,800 MW, with thermal power plants providing 90% of the capacity and hydropower plants 10%. These plants served a peak load of 3,850 MW and an energy demand of 20,621 GWh in 2012. Energy demand had dropped substantially following a drastic increase in tariffs in 2007, but since 2010 has been growing continuously again. Baku region is the main load center, accounting for over 40% of national demand. A 500 kV transmission backbone connects the Baku region with the large generation facilities in the Mingachevir region.

Master plans for the expansion of Azerbaijan's power sector were prepared by Mercados in 2010 and by TEPSCO in 2013. TEPSCO's master plan is based on plans of Azerenerji.

Fichtner reviewed these plans and provided updates of the key parameters, where required. The following main conclusions are drawn from the review and update:

(1) TEPSCO's demand forecast which is based on an earlier forecast by Azerenerji, links electricity demand to macroeconomic performance on an aggregate level, which is an internationally accepted procedure. As TEPSCO used actual demand data from 2011 as the basis for the forecast, an update to 2012 as the base year was necessary. The Consultant's update also considered the most recent GDP projections. According to the updated demand forecast, demand is projected to increase to around 35,000 GWh and 6,600 MW by 2025.

(2) The generation expansion plan in the TEPSCO study was found to be appropriate to match energy supply with the growing demand. It did, however, not consider the increased capacity of the existing system due to refurbishment of the largest plant, and Azerenerji's recent plans of delaying the Gobustan thermal power plant and constructing instead Yashma TPP with a lower capacity at a different location. Also it may have underestimated the reserve margin. The average available capacity is some 10% lower than the installed capacity, due to the intermittent operation of potential new solar and wind power plants, seasonality of small hydro power capacity and technical and operational limits to the availability of thermal plants. Thus the target reserve margin of 25% may not be achieved after 2020.

(3) Transmission from the largest power plants to the main load center relies on the 500 kV backbone transmission line. This represents a risk to the security of supply. Another critical issue is the 220 kV system in Baku, which cannot secure system stability in such a large load center. Azerenerji has already addressed the overreliance on the 500 kV backbone by

identifying a new location for the next large power plant to be built, but more activities are required to meet the security criteria. In principle, Azerenerji's plans for transmission expansion and reinforcement are appropriate to increase transmission capacities in line with the growing generation capacities and growing demand, but the plans need to be updated to integrate the implications of the changes in the generation expansion plan.

(4) Azerenerji's distribution system has been upgraded substantially in the recent past, and technical losses have been reduced, but a large part of the system is reaching the end of its technical lifetime and is in need of rehabilitation. Azerenerji's distribution plans were found to be appropriate to address the requirements of growing demand.

(5) The expansion plans of Mercados, TEPSCO and Azerenerji do not provide sufficient information on the costs of system expansion to establish an investment plan; in particular investment requirements resulting from the change in the plans for generation capacity additions still need to be identified.

The Consultant has identified a priority investment plan for the power sector and estimated the required funds, based on efficient generation technologies. A very rough preliminary cost estimate indicates that from 2014 until 2025

(i) capital expenditures for new generation capacity (not considering ongoing construction / rehabilitation and committed plants) are in the order of 2,750 million AZN;
(ii) the transmission system may require investments of around 1,200 million AZN;
(iii) the distribution system may require investments of around 4,570 million AZN;
(iv) the sector may thus require total capital expenditures in the order of 8,520 million AZN as priority investment.

Further investments beyond the priority measures, such as addition of renewable energy plants and further capacity additions to increase the reserve margin, would require additional funds of approximately 1,500 million AZN.

The Consultant's recommendations can be summarized as follows:

(1) Power system expansion in Azerbaijan should focus on priority investments, with a particular focus on the distribution sector at least in the short-term. Renovation and expansion of the distribution network should have priority, because the resulting reduction in distribution losses will have direct economic benefits. Measures in the industrially developed and highly populated regions (Baku, Sumgayit and Ganja) will have the greatest immediate effect.
(2) Priority investments in the generation sector comprise Yashma Thermal Power Plant, Agh Sheher Combined Heat and Power Plant in the years

2018-2020 and a number of Combined Cycle Power Plants in the period 2021-2025. Decisions on the short term priority investments must be taken at the soonest.

(3) Additional generation investments should be considered after 2020 to secure a sufficient reserve margin. A system would need at least another 500 MW, as previously envisaged before the postponement of Gobustan power plant.

(4) Combined cycle gas turbine plants should be considered in the future instead of the less efficient gas engines in order to reduce emissions and save gas for alternative uses, such as gas exports.

(5) Due to their intermittent nature, renewable energies like wind and solar have higher unit costs than conventional technologies and cannot as easily be integrated into the grid. They are therefore not included in the priority investments. Private sector participation is recommended as a potential alternative for the development of renewable energies.

(6) A detailed study on the transmission system should be carried out to update the information basis and to assess the implications of the changes in the generation expansion plan.

(7) In order to relieve the strain on the 500 kV backbone transmission line, it should be considered to construct a second circuit for the 500 kV line or a double circuit for the outer loop at 330 kV level connecting Baku, the large plants in Mingachevir and Imishli in the south of Azerbaijan.

2. Introduction

2.1 Objectives of the study

Fichtner ("the Consultant") was assigned by Asian Development Bank (ADB) to prepare an update on the Power Sector Master Plan for the country of Azerbaijan for the years 2013 - 2025. This report shall be a reference document for the Ministry of Finance of the Azerbaijan Republic and contribute to a strategic framework for the development of the energy sector. The study shall give an overview of the current situation in the generation, transmission and distribution sector, an outlook on the future electricity demand and an assessment of investment plans.

2.2 Sources of information

For that purpose the existing studies have been analyzed, in particular the following documents:

- Generation and Transmission Master Plan 2010-2025 prepared by Mercados in September 2010,
- Distribution System Master Plan 2010-2025 prepared by Mercados in September 2010,
- Study for Electric Power Sector in Azerbaijan – Final Report prepared by Japan International Cooperation Agency (JICA) and Tokyo Electric Power Services Co. (TEPSCO), henceforth referred to as "TEPSCO study".

Furthermore a series of workshops and interviews have been conducted during two local missions in Baku in May 2013 and July 2013 with responsible persons from the Ministry of Finance, namely Mr. A. Sharifov, the Minister of Finance, ADB, Azerenerji JSC and Baku Electric Grid JSC.

A set of data has been provided at the beginning of the project and also after the second local mission. Azerenerji JSC and Baku Electric Grid JSC have sent actual data upon request.

2.3 Scope of application

This study considers the whole country of Azerbaijan except for the Autonomous Republic of Nahkchivan, which is a self-supplying exclave with no direct interconnection to Azerbaijan in terms of electrical energy. Also the occupied territory in the Karabakh region is not included in the analysis as there is no data available. Figure 1 shows the supply areas of the regional electricity networks in Azerbaijan.

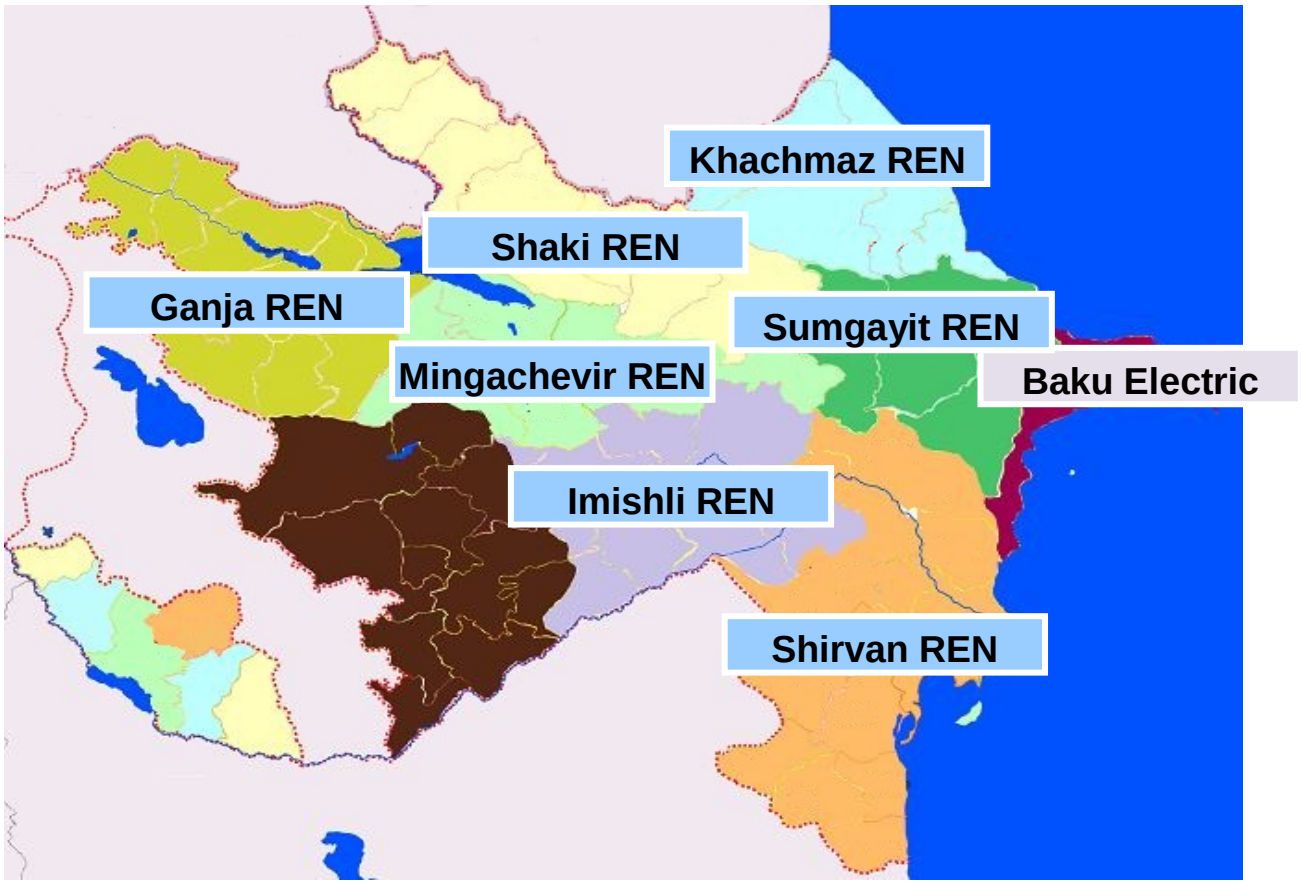

Figure 1: Regional Electricity Networks in the Republic of Azerbaijan

3. Current Status of the Power Sector of Azerbaijan

As a country with a strong economic infrastructure and rich natural resources, Azerbaijan is able to meet its energy demand completely through domestic generation. The energy policy mainly relies on the large oil and natural gas reserves and partly hydrological resources; the country is at present a net exporter of not only hydrocarbons, but also of electrical energy to its neighboring countries.

3.1 Sector institutions

The central executive body in the energy sector in Azerbaijan is the Ministry of Industry and Energy (MIE). The MIE is in charge of the implementation of national energy policy regulations and decrees. For price regulation and tariff methodology, the responsible authority is the Tariff Council.

The main actors in the Azeri electricity market are Azerenerji JSC and Baku Electric Grid JSC (Bakuelektrikshebeke), both 100% state-owned companies. Azerenerji is a vertically integrated enterprise, owner of all the generation capacity, except for some small private producers, and also the transmission system operator of the country. With its seven subsidiary grid companies Sumgayit, Ganja, Mingachevir, Shirvan, Imishli, Shaki and Khachmaz Regional Electricity Networks (REN), Azerenerji is also responsible for electricity distribution and sales in the whole country except for the Baku region and Nakhchivan Autonomous Republic.

In the capital and the surrounding region, Baku Electric Grid JSC operates the distribution grid and sells the electrical energy, which is completely purchased from Azerenerji at wholesale tariff, to its end customers. In the recent years, approximately 50-55% of the electricity generated by Azerenerji was bought by Baku Electric Grid and thus consumed in the Baku region. Table 1 shows the number and type of customers for each of the distribution regions.

Table 1: Electricity Customers in Azerbaijan as of July 2013

Electric Grid Company	Total	Households	Industry, Commercial & other
Baku	816,152	762,248	53,904
Sumgayit	217,975	186,686	31,289
Ganja	269,779	241,514	28,265
Mingachevir	242,792	192,004	50,788
Shirvan	271,334	248,649	22,685
Imishli	191,056	140,579	50,477
Shaki	162,657	145,794	16,863
Khachmaz	122,447	113,099	9,348
Total	**2,294,192**	**2,030,573**	**286,234**

3.2 Recent history of the Azerbaijani power sector

In the last decade, the power sector of Azerbaijan went through remarkable changes. The privatization of the distribution companies in 2002 did not bring the expected performance improvements for the power supply. On the contrary - when the responsibilities of the distribution sector were returned back to state-owned companies in 2006, the grid was found in a very poor condition. Excessively high losses had to be accepted and outages were frequent. Until 2007, peak demand could also not be fully met by domestic generation and electricity had to be imported, mainly from Russia. Through initial investment and rehabilitation activities done by Azerenerji and Baku Electric Grid, the quality of the power supply could be improved remarkably since then. Today distribution losses are at an average level of 10-11% and outages practically do not occur. But it should be noted that still a big part of the network is very old and in need of renovation. Also the rate of non-technical losses is still at a high level. Table 2 below outlines the technical and the commercial losses occurred in the distribution networks during the past years. The distribution grid is further described in Section 7 of this report).

Table 2: Network Losses in the Distribution NetworksAzerbaijan

Year	2009	2010	2011	2012
Azerenerji technical losses	12.1%	11.6%	11.2%	10.4%
Azerenerji commercial losses	10.3%	9.9%	11.0%	6.2%
Baku Electric Grid technical losses	12.6%	11.8%	11.0%	10.8%

Source: Azerenerji, Baku Electric Grid

3.3 Development of power consumption

The reform of electricity tariffs in 2007 was the reason for a serious change in the overall electricity consumption in the country. Basically the price for households was tripled and also the prices for industry and wholesale customers were raised drastically. It has to be assumed that this price increase led to higher awareness of the value of electricity and to a more efficient electricity use as the overall consumption in Azerbaijan declined and losses reduced for the following years.

The beginning of the installation of electronic meters in selected areas has had an impact on consumer behavior, too. Due to prepaid metering measures the collection rates have risen, in some areas even up to 100%.

Figure 2 summarizes the results from the consumption data given by the utilities and the different studies under review.

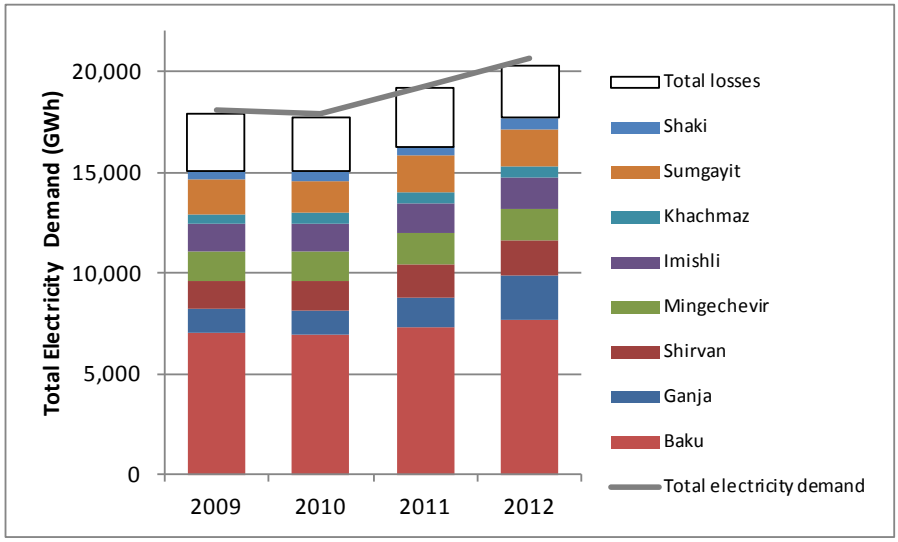

Figure 2: Total Electricity Consumption and Losses by Regions

After a slight decrease in 2010, electricity consumption has increased by 8.6% in 2011 and 5.7% in 2012, respectively. Since 2010, the demand is increasing again in the whole country so it can be said that these non-recurring effects are mainly absorbed by the system and the demand will further develop in a regular way according to the economic growth in Azerbaijan.

The region of Baku consumes large parts of the electricity provided compared to the country of Azerbaijan as a whole. However, increase of electricity consumption has been highest in the region of Ganja as can be seen from the graph above.

The regional distribution of the consumption for the year 2012 is illustrated in Figure 3 below.

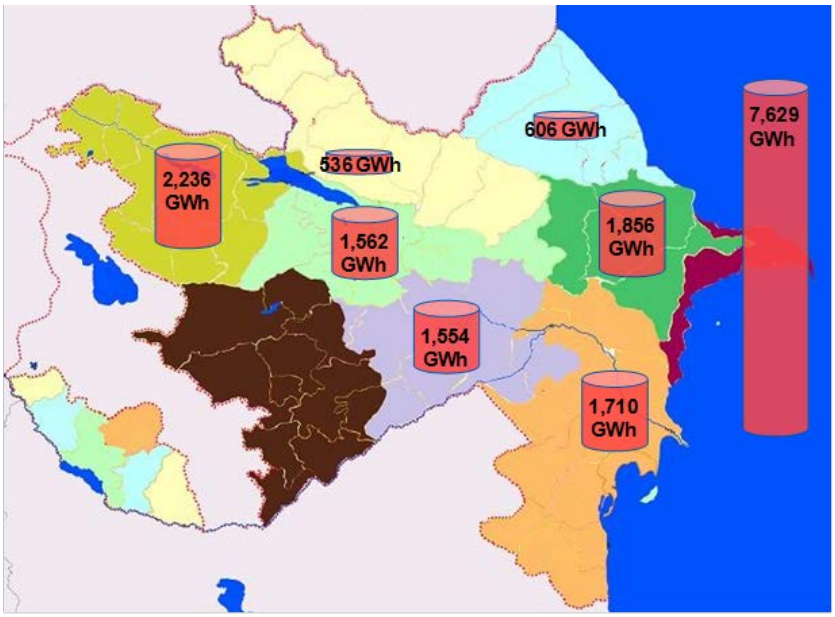

Figure 3: Regional Distribution of Consumption in Azerbaijan as of 2012

3.4 Future development of industry

The main driver for the energy demand is industry. At present, approximately 60% of the electricity generated in Azerbaijan is consumed by the industrial and commercial consumers. The Azerbaijani government has defined clear targets for economic growth. Diversifying the domestic economy to be more independent from the oil and gas sector will be one of the key aspects in the next years. The 2020 strategy aims to double the GDP per capita, mainly to be reached by activities beyond oil. The Sumgayit Technologies Park, 30 km northwest of Baku, is an exemplary project for this aim. 17 factories are already completed or will be built for the production of electrical and machine industry components. Today the electric industry of Azerbaijan is already capable of producing every component of the low- and medium-voltage grid locally. Other important industrial developments in this region are the Chemical Industrial Park, also in Sumgayit, or the construction of the new international sea port in Alat, 65 km southwest of Baku which will be the biggest port in the Caspian Sea.

It can be said that due to the growing industry concentrated in the Baku and Absheron area, the level of energy consumption in this key region, and also the importance of the grid stability will further grow in the future. Important events with international attention like the European Games in 2015, and big infrastructural projects like construction of roads, waterworks and the subway in Baku or the White City Project will further increase the importance of the region and also the power demand.

Besides the efforts of diversifying the economy, the oil and gas industry is growing as well. With the exploration of new gas and oil fields this sector will probably expand in the future and continue delivering the substantial contribution to the Azerbaijani economy.

4. Review and Update of the Power Demand Forecast

As an essential part of a system expansion plan, Azerbaijan's future electricity demand has to be projected in order to make the most viable and sound judgment on the sustainable development of the nation's electricity sector. In order to do so, the existing demand forecasts have been analyzed and compared in terms of methodology, applicability and relevance. Those studies have served as a basis for the study at hand and are therefore presented in brief below.

In particular, under review were the demand forecasts and studies prepared by Azerenerji (2013), Japan International Cooperation Agency (JICA) / Tokyo Electric Power Services Co. (TEPSCO) ("Study for Electric Power Sector in Azerbaijan" - 2013), Mercados ("Azerenerji Generation and Transmission Master Plan 2010-2025" - 2010, "Azerenerji Distribution System Master Plan 2010-2025" - 2010) and Baku Electric Grid distribution company (2013). Furthermore, relevant data comes from the IMF.

4.1 Review of existing forecasts

4.1.1 Azerenerji

The first demand forecast of Azerenerji which has been made available to the Consultant has been conducted in 2009 and covers the whole country of Azerbaijan. The demand forecast has been updated several times and the latest update has been provided by Azerenerji in August 2013. Projections have been made until the year 2017. Azerenerji has only prepared a base scenario. The growth rate in 2014 is assumed to be over 11.0% but decreasing to almost 5.0% at the end of the forecast period. The updated figures serve as a basis for the demand forecast presented in Section 4.2.

4.1.2 TEPSCO study ("Study for Electric Power Sector in Azerbaijan")

The "Study for Electric Power Sector in Azerbaijan" prepared by JICA and TEPSCO in 2013 includes a review of the demand forecast prepared by Azerenerji. Data for this review has been provided by the generation department of the Azerenerji Central Dispatch Center. Also three scenarios (central, high, highest case) with annual growth rates of 4%, 6% and 7% on average have been established by Azerenerji.

The latest demand forecast of Azerenerji as well as the review undertaken by TEPSCO is outlined in Figure 4 below.

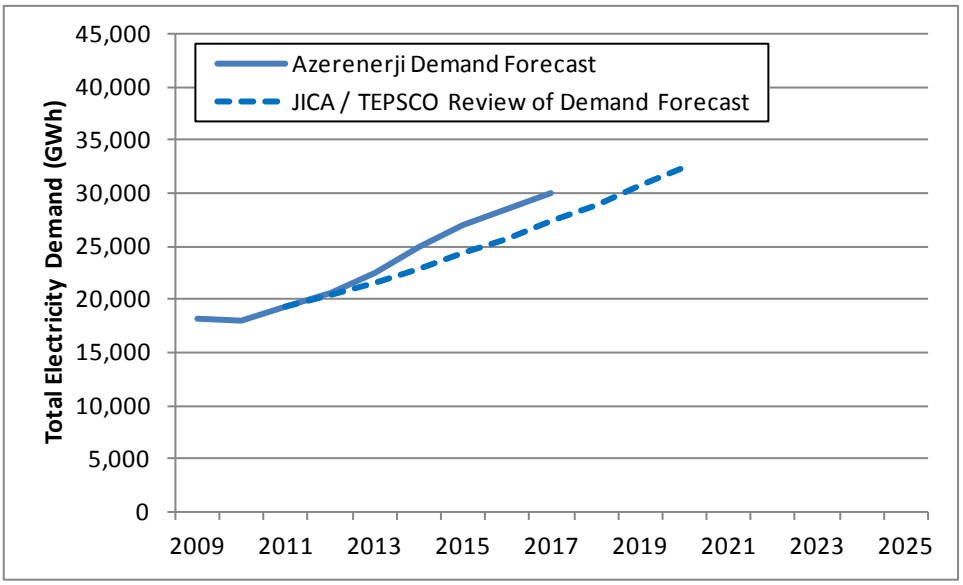

Figure 4: Azerenerji Demand Forecast and Review by JICA / TEPSCO

TEPSCO reviewed the demand forecast while calculating the future electricity demand taking into account the forecast itself provided by Azerenerji as well as different elasticity factors of electricity consumption to GDP. Elasticity factors link electricity demand to macroeconomic performance on an aggregate level. An elasticity factor of, e.g., 1.2 indicates that each 1% growth in GDP is accompanied by a 1.2% growth in demand.

The central case of the Azerenerji demand forecast matches almost the demand forecast calculated with an elasticity factor of 1.5. As outlined in the study, TEPSCO assumes that in future the elasticity factor will be higher than 1.0. This seems to be a reasonable assumption as the growth rates of electricity consumption exceeded GDP growth rates in the last two years. The TEPSCO study also mentions that the planning of Azerenerji is based on the central case. Therefore, the Consultant considers the review carried out by TEPSCO to be a reasonable approach.

4.1.3 Mercados study (“Azerenerji Generation and Transmission Master Plan 2010-2025”)

The study "Azerenerji Generation and Transmission Master Plan 2010-2025" prepared by Mercados in 2010 entails primarily the demand forecast provided by Azerenerji in 2010 for the country of Azerbaijan. As this demand forecast of Azerenerji stopped in 2019, Mercados maintained the last year’s growth rate of 5.1% constant for its forecast from 2020 onwards. No own methodology has been developed.

The Mercados demand forecast of the “Azerenerji Generation and Transmission Master Plan 2010-2025” study can be seen in Figure 5.

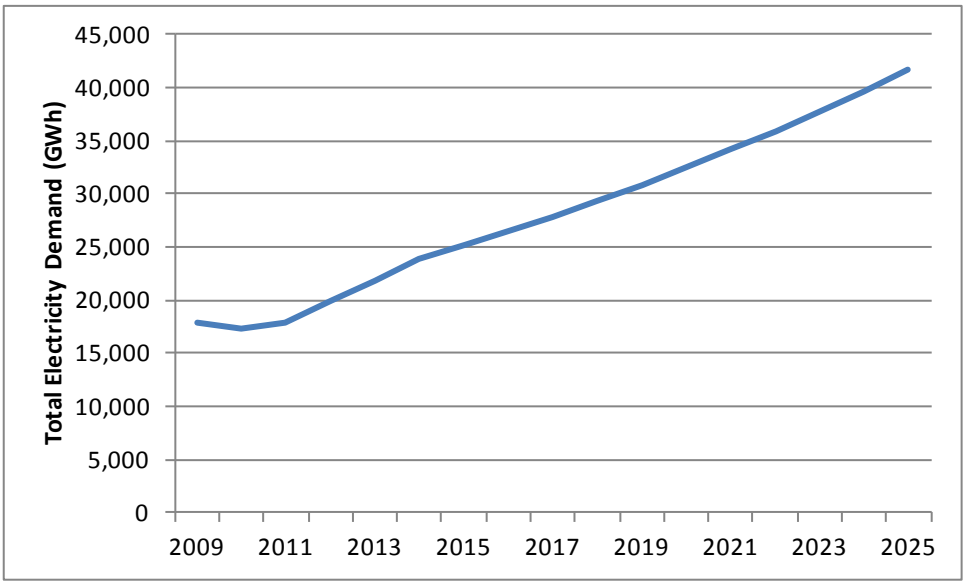

Figure 5: Mercados Demand Forecast for Transmission and Generation

4.1.4 Mercados study ("Azerenerji Distribution System Master Plan 2010-2025")

While conducting a demand forecast for Azerbaijan as a whole, Mercados also prepared demand forecasts for each of the seven distribution companies belonging to Azerenerji. Historical data for these forecasts has been provided by the several distribution companies for the years 2007 until 2009. For one part of the forecasting period (2010-2014) a technical forecast has been taken which includes information at an aggregated level for all distribution companies of Azerenerji. The growth rate of the individual demand forecasts after the year 2015 has been assumed to be the same for all distribution companies as it is for the whole country of Azerbaijan. The region of Baku has not been included in this study. Therefore, the summarized demand of the regions considered here cannot be compared directly with the demand forecast for the country itself.

Figure 6 summarizes the results of the demand forecast from the Mercados "Azerenerji Distribution System Master Plan 2010-2025".

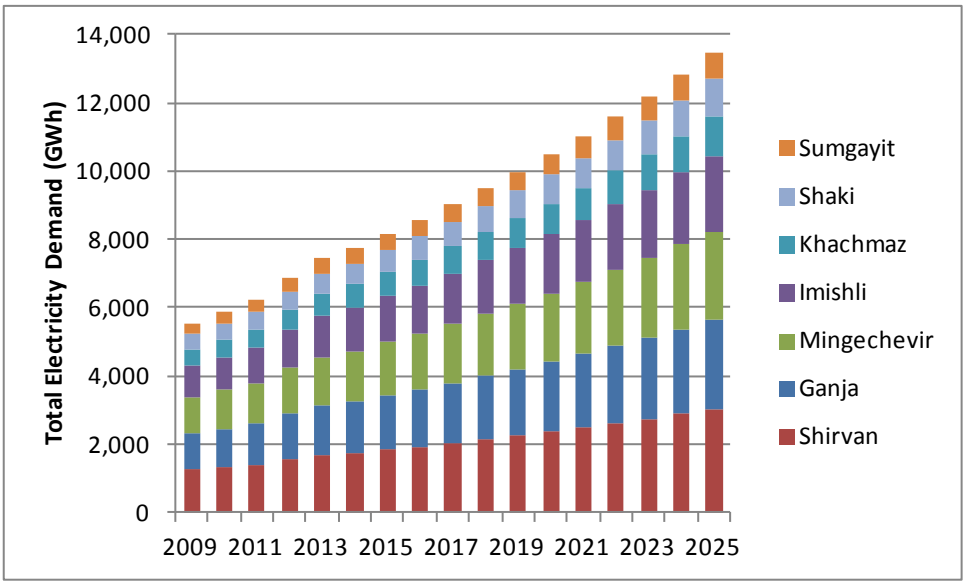

Figure 6: Mercados Demand Forecast for Distribution Companies

4.1.5 Baku Electric Grid

The distribution company Baku Electric Grid provided electricity consumption data starting in 2009 and its short term forecast spanning the years until 2016. The actual 2013 growth rate with almost 11.0% is considered to be quite high. Afterwards, however, growth rates are assumed to be more moderate in the range of 1.0%.

The historical consumption as well as the short term forecast until 2016 prepared by the distribution company of the Baku region is shown in Figure 7 below.

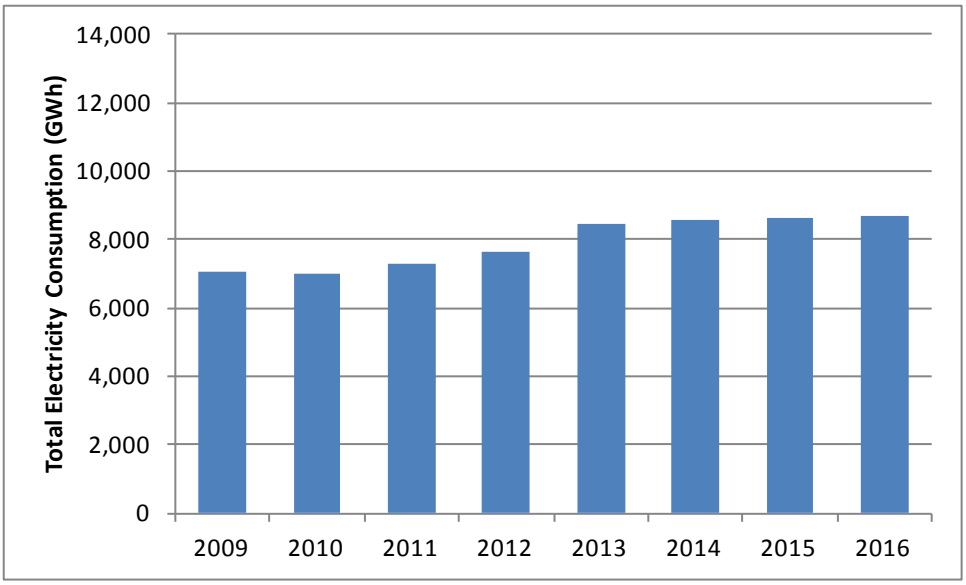

Figure 7: Baku Electric Grid Electricity Consumption and Forecast

As no demand forecast on a regional level will be prepared by the Consultant, the short term forecast of Baku Electric Grid will not be taken

into account. The consumption data has only been used for validation purposes when the consumption data of the different distribution companies plus distribution losses have been compared to the entire demand in the country as it is outlined in Figure 2 of Section 3.3.

4.2 Update of the power demand forecast

4.2.1 Data basis and assumptions

In general, the methodological assumptions presented at this stage, have been mainly a combination of assumptions founded in previous studies. The Consultant applied those on grounds of reasonability, applicability and presently relevant considerations. For the demand forecast at hand, the TEPSCO study (2013) and the demand forecast prepared by Azerenerji (2013) exhibited a good starting point due to their recent update and relevance.

The consumption data as taken from these sources is spanning a period of 4 years from 2009 until 2012, while the year 2012 served as a base year for the demand forecast. The forecast interval is between 2013 and 2025.

According to the TEPSCO study and according to actual data provided by Azerenerji the current load factor (i.e. the ratio of average load to peak load) on the Azerbaijan grid is around 0.6. In the following analysis this load factor of 0.6 will be maintained.

General macroeconomic indicators such as GDP and GDP growth have been retrieved from the 2013 IMF World Economic Outlook. The World Economic Outlook was important in two regards, one, as a data source and two, as an indication to where the IMF believes the economy of Azerbaijan to be heading. The GDP growth rate has been fallen from over 9.0% in 2009 to almost zero in 2011 and is increasing since this time again, which suggests a strong recovery and reflects improving public-sector efficiency and transparency. GDP in general is expected to continue to grow up to almost 6.0% until 2014 and, afterwards, to fluctuate around 4.0%. The IMF's World Economic Outlook only projects GDP growth rates until 2018. It has been assumed that GDP growth will remain constant at 4.0% thereafter. The following Table 3 summarizes GDP growth rates in the forecast period.

Table 3: GDP Growth Projections

Year	2013	2014	2015	2016	2017	2018	2019-2025
GDP growth	4.14%	5.84%	4.76%	3.45%	3.20%	4.00%	4.00%

4.2.2 Scenarios

It is necessary to assume certain scenarios when trying to forecast Azerbaijan's electricity demand. Therefore, the demand forecast has been subjected to a high and slow growth case.

The slow growth scenario is describing a future development which is characterized by an unfavorable social and economic performance of the country, such as changes in world market prices or reductions in FDI. As a result, GDP growth would be lower and less income would be available. This in turn would lead to a reduction of investments in energy infrastructure which would lead to less average electricity consumption due to a reduction of disposable income. In particular the slow growth scenario will be calculated with an elasticity factor of 0.8 which has been taken from the TEPSCO study.

The high growth scenario is describing a future development which is characterized by a favorable social and economic performance. Its underlying assumptions are a stable political situation and sound economic policy as well as performance. Resultantly, GDP growth would be higher and so would the available disposable income. Investments into the energy infrastructure would also be increased in that case. Furthermore, average electricity consumption would be higher throughout all sectors. In this scenario an elasticity factor of 1.5 will be used. That represents the figure which has been used in the TEPSCO study to verify the central case set up by Azerenerji.

4.2.3 Results

In the following graphs, the results of the demand forecast with respect to all scenarios established above are presented. Figure 8 depicts the results of the base case demand forecast for Azerbaijan as well as the high and low scenario forecasts.

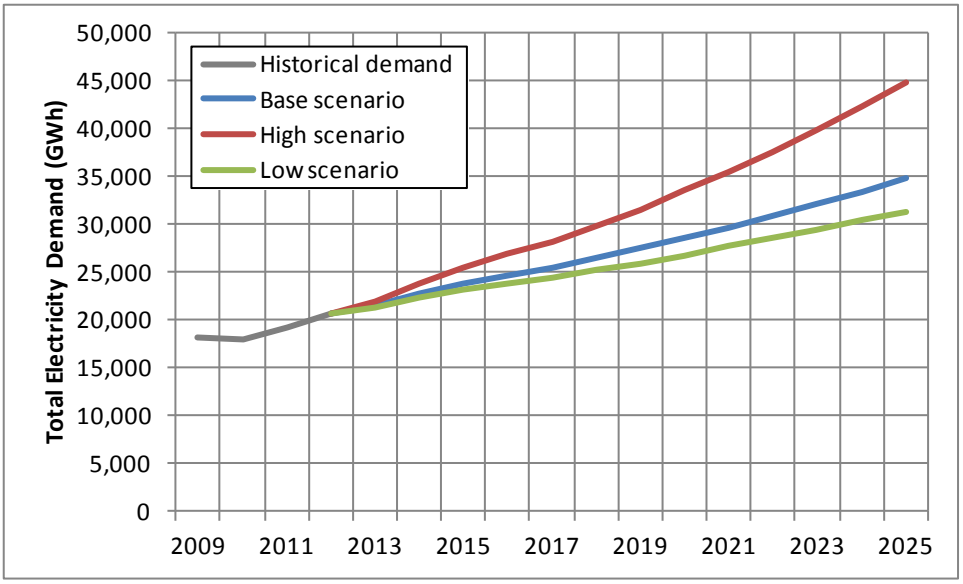

Figure 8: Total Electricity Demand in Azerbaijan

The figure above shows a smooth growth rate in electricity demand with slightly higher growth rates between 2013 and 2015. After 2018 the growth rate is held constant at 4.0%. Until 2025, total demand is increasing to 34,792 GWh within the base scenario. In the case of the low scenario total demand is expected to reach 31,389 GWh. The demand under the slow growth scenario is thus 10% lower than in the base case. Within the high growth scenario, it is expected that demand will reach a level of 44,839 GWh in 2025. In comparison to the base case, the high growth scenario implies a 29 % higher demand at the end of the forecast period.

The following Figure 9 below shows the load forecast including low and high growth scenario for Azerbaijan.

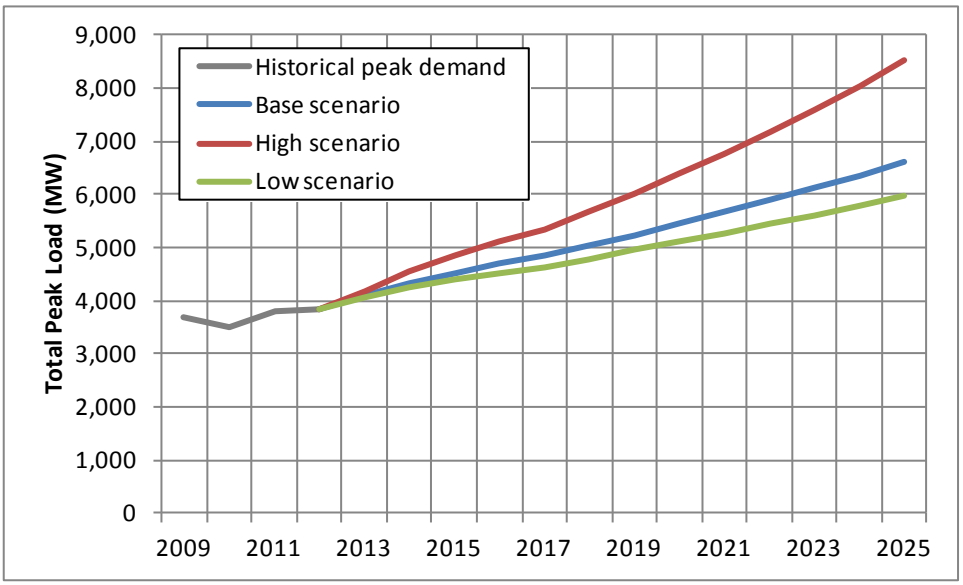

Figure 9: Development of the Peak Demand in Azerbaijan

The peak load in Azerbaijan increases to 6,619 MW in 2025 under the base scenario. Again the load forecast follows the same path as outlined by the demand forecast above, and the total load demand increases between 2013 and 2025 by a factor of 1.6. The slow and high growth scenarios sit 10% below and 29% above the base scenario, respectively.

5. Generation

5.1 Energy mix

For power generation the country of Azerbaijan relies to a high extent on its domestic oil & gas resources. Today approximately 90% of the electricity is generated in thermal power plants. The remaining part comes from hydroelectric power plants, which account for 10% of generation but 14% of installed generation capacity. Even though there are no vast hydropower resources in the country, there is still potential for small run-of-river type hydro power plants.

A big part of the more recently installed thermal power plants are modular gas engines. Experts from Azerenerji stated that these modular power plants were mainly acquired during the years from 2006, when Azerenerji faced serious problems with meeting the demand for peak power. Today this technology is favored for its part load behavior and for its capacity to supply peak power mainly in winter.

The fuel is purchased from SOCAR, the state-owned State Oil Company of the Azerbaijan Republic. The wholesale prices are determined by the Tariff Council at a level that makes thermal power generation profitable.

In Azerbaijan there is also a substantial potential for renewable energies especially wind power around the Caspian coast. This has already been recognized by the Azerbaijani government, who founded the State Agency on Alternative and Renewable Energy Sources in 2009 after a presidential decree was issued. Nevertheless there has been little implementation of wind power or other investments in renewable energies until now.

It is a clear aim of Azerbaijan to maintain self-sufficient in power supply, backed by the large hydrocarbon reserves, to enhance electricity trade with the neighboring countries and to increase activities in renewable energies in the near future.

5.2 Status of current power generation assets

Table 4 shows the current power generation assets that are all operated by Azerenerji. shows Azerenerji's current generation portfolio on the map. Further information is provided in **Annex 1**.

Table 4: Power Plants in Azerbaijan > 10 MW

Power Plant	Type	Installed Capacity as of 2013 (MW)	Annual Generation in 2012 (GWh)	Year of Com-missioning
Azerbaijan	Oil-fired ST	2,400,0 [1)]	8,126.4	1981-1990
Shirvan	Oil-fired ST	900.0	2,880.5	1962
Janub	CCGT	780.0	-	2013
Shimal	CCGT	400.0	2,019.5	2002
Sumgayit	CCGT	525.3	2,026.1	2008
Baku IEM	CHP	107.0	547.2	2001
Baku	Gas-Engine	104.4	572.1	2001
Astara	Gas-Engine	87.0	290.1	2006
Shaki	Gas-Engine	87.0	308.3	2006
Khachmaz	Gas-Engine	87.0	385.1	2006
Shahdagh	Gas-Engine	104.4	336.5	2009
Sangachal	Gas-Engine	299.2	1,463.7	2008
Thermal Power Plants		**5,881.3**	**18,955.5**	
Mingachevir HPP	HPP	401.6	755.6	1953
Shamkir HPP	HPP	380.0	632.3	1983
Yenikend HPP	HPP	150.0	277.7	2000
Varvara HPP	HPP	16.5	-	1956
Fizuli HPP	HPP	25.0	-	2012
Hydro Power Plants		**974.1**	**1,665.5**	
Total		**6,855.4**	**20,620.9**	

Source: Azerenerji

[1)] Modernization for Azerbaijan TPP is not considered in the table

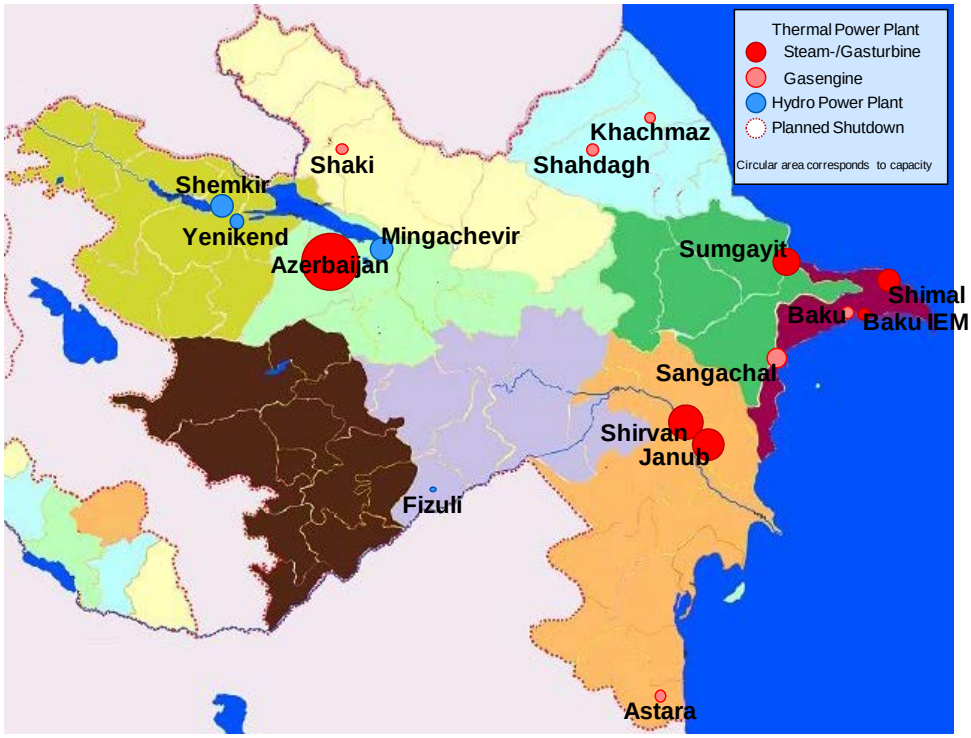

Figure 10: Current Power Plant locations in Azerbaijan (>25 MW)

The two oldest power plants Azerbaijan TPP and Shirvan TPP are also the biggest producers of electrical energy. Due to its age it is planned to shut down Shirvan TPP within the next months. The country's largest power plant Azerbaijan TPP was modernized recently. Amongst other activities, the capacity of the eight oil-fired units was increased from 300 MW to 330 MW each, which leads now to a total installed capacity of 2,640 MW for Azerbaijan TPP. Thus, the lifetime of this thermal power plant could be extended. The second unit of Janub CCGT is, according to information recently obtained by Azerenerji, completed as of 1st July 2013. This power plant shall replace Shirvan TPP and satisfy the load in the Absheron area. For this purpose also the second unit of Shimal CCGT, directly located in the Absheron peninsula, is under construction.

Azerenerji experts stated that a further 920 MW CCGT project is in pre-design phase. The location for this power plant was first determined to be in Gobustan, but newer considerations plan to construct it in Yashma, both potential project sites are also close to the load center of Baku and Absheron.

Currently the power consumption in Azerbaijan can fully be met by the domestic generation assets in the Azerenerji generation portfolio. The expansion plans consider the retirement of the oldest assets and also the proximity to the load center in the east. By commissioning new units in the eastern part of the country, also less energy has to be transmitted from Azerbaijan TPP, which will relieve the load flows in the 500 kV main transmission line. As long as this power plant is still in operation, Azerenerji aims to export the generated power to the neighboring countries, especially

to Turkey with its rapidly growing demand via Georgia, and thus gain extra profits for Azerenerji. It has to be noted, that this is profitable for the utility due to fuel procurement at regulated low prices from state-owned SOCAR. At current levels of international market prices for natural gas, the direct export of natural gas would be much more economic than the electricity export.

5.3 Review of existing generation master plan

The Generation Expansion Plan for 2013-2023 found in the Mercados study from 2010 was made using a computational model that selects a least cost option from a set of candidate power plants and network expansions considering transmission network configurations, hydrological flows and thermal generation.

The expansion plan comes to the conclusion that two 400 MW CCGT projects should be installed in 2014 additionally to the existing investment decisions. Also gas engines in the range of 1,000 MW shall be acquired in 2013. The remaining additions are mainly smaller hydro projects.

The TEPSCO study of 2013 provides a detailed long-term development plan for the power system that was developed together with Azerenerji. Besides the thermal power plants that are newly commissioned or will be commissioned soon (Janub, Shimal 2) this plan includes the Gobustan TPP (with 1,400 MW), renovation of Azerbaijan TPP from 2021, a series of future modular gas-engine power plants and various renewable energy projects, that are not described in detail with a total capacity of 400 MW in 2025. It is also not clearly stated whether the renovation of Azerbaijan TPP is planned at the same location and with the same technology (oil-fired steam turbine). According to recent statements by Azerenerji responsibles the power plant might be reconstructed as a more efficient CCGT plant and with half of the current capacity.

TEPSCO study closes its analyses with the recommendation to build a further CCGT unit at Gobustan site in 2020 (in total 1,800 MW). Table 5 shows the expansion plan from TEPSCO and Azerenerji for the period 2012-2025. Also the retirement plan for Shirvan and the various units of Azerbaijan TPP found in the study are considered in Table 5. Figure 11 shows the planned future generation portfolio on the Azerbaijan map.

Table 5: Azerenerji Expansion Plan 2012-2025 for Power Plants > 20 MW

Name	Type	Capacity (MW)	Year of Retire-ment	Year of Com-missioning
Janub 1	CCGT	390		2012
Janub 2	CCGT	390		2013
Temiz Sheher	Gas-Engine	40		2013
Shimal 2	CCGT	400		2014
Shirvan	Oil-fired ST	-900	2014	
Boyuk Shor	Gas-Engine	385		2015
Gobustan	CCGT	1,400		2018
Azerbaijan	Oil-fired ST	-600	2018	
Agh Sheher	CHP	300		2020
Azerbaijan	Oil-fired ST	-600	2020	
Azerbaijan	Oil-fired ST	600		2021
Aghjabedi	Gas-Engine	300		2022
Azerbaijan	Oil-fired ST	-300	2022	
Astara	Gas-Engine	200		2030
Khachmaz	Gas-Engine	200		2024
Azerbaijan	Oil-fired ST	600		2024
Azerbaijan	Oil-fired ST	-900	2024	
Sumgayit	CCGT	600		2025
TPP Additions		**5,805**		
TPP Retirement		**-3,300**		
Existing TPP Capacity in 2012		**5,116**		
Total TPP Capacity 2025		**7,621**		
Fizuli	HPP	25		2012
Small HPP	HPP	50		2014
Small HPP	HPP	50		2016
Small HPP	HPP	100		2019
Small HPP	HPP	100		2023
Samur	HPP	100		2023
Tovuz	HPP	200		2025
HPP Additions		**625**		
Existing HPP Capacity in 2012		**932**		
Total HPP Capacity 2025		**1,557**		
Renewable PP (wind, solar)	RE	50		2014
Renewable PP (wind, solar)	RE	50		2015
Renewable PP (wind, solar)	RE	50		2016
Renewable PP (wind, solar)	RE	50		2018
Renewable PP (wind, solar)	RE	100		2021
Renewable PP (wind, solar)	RE	100		2025
Total RE Capacity 2025		**400**		
Total Installed Capacity by 2025		**9,578**		

Source: TEPSCO, Azerenerji

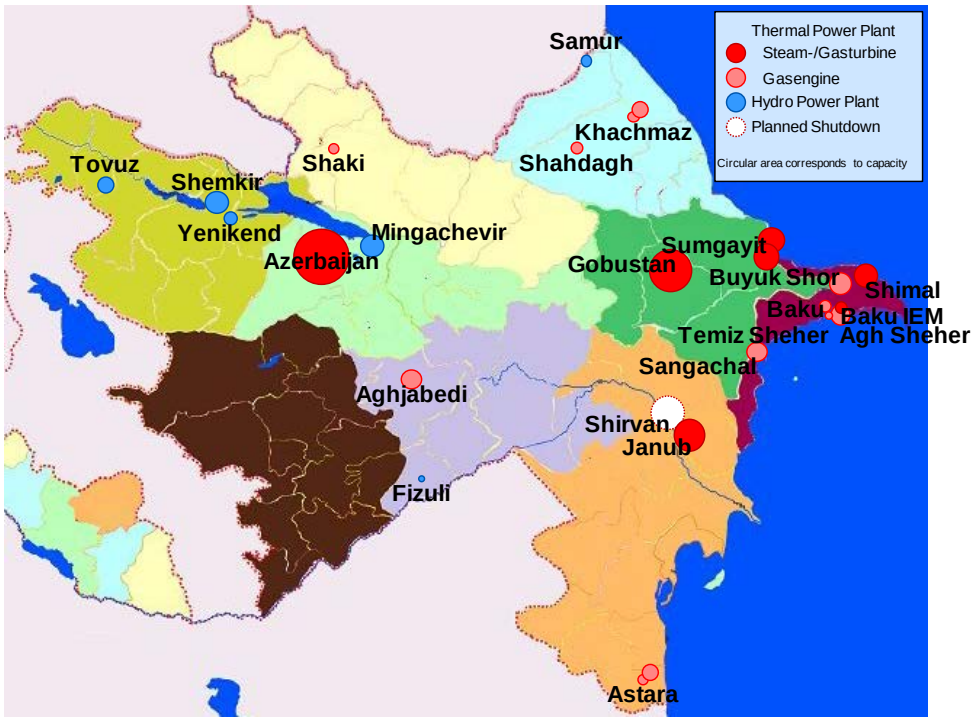

Figure 11: Azerenerji Expansion Plans for power generation 2013-2025

5.4 System expansion plan

For the purpose of a closer assessment of the Generation System Expansion plan, the Consultant adopts the expansion plan from TEPSCO and Azerenerji and updates it with the newest information available. The following aspects are considered:

- Refurbishment of Azerbaijan TPP (2,640 MW instead of 2,400 MW)
- Yashma 920 MW CCGT instead of Gobustan 1,400 MW CCGT.

The Gobustan CCGT which is included in Azerenerji's long-term power development plan as given in the TEPSCO study[1] is not an object of discussion at the moment according to Azerenerji experts; it is thereof replaced by the Yashma CCGT project. This has the impact on the total installed capacity to be 9,098 MW instead if 9,578 MW as in Table 5.

Not all of the installed capacity is available at all times. The assets have non-operating hours throughout the year (e.g. because of maintenance works) and also older units usually are not able to operate at the full capacity they had when newly commissioned due to deterioration. It is therefore the available capacity, not the installed capacity, that should be compared with the projected peak demand in the base scenario from Section 4.2. The estimated average rates for the available capacity are:

- 90% of the installed total capacity for new power plants (newly commissioned or up to 10 years old),

[1] Study for Electric Power Sector in Azerbaijan, Table 4.2.1

- 85% for power plants that are up to 20 years old,
- 80% for power plants older than 20 years,
- 80% for hydroelectric power plants,
- 30% for other renewable energies (wind, solar).

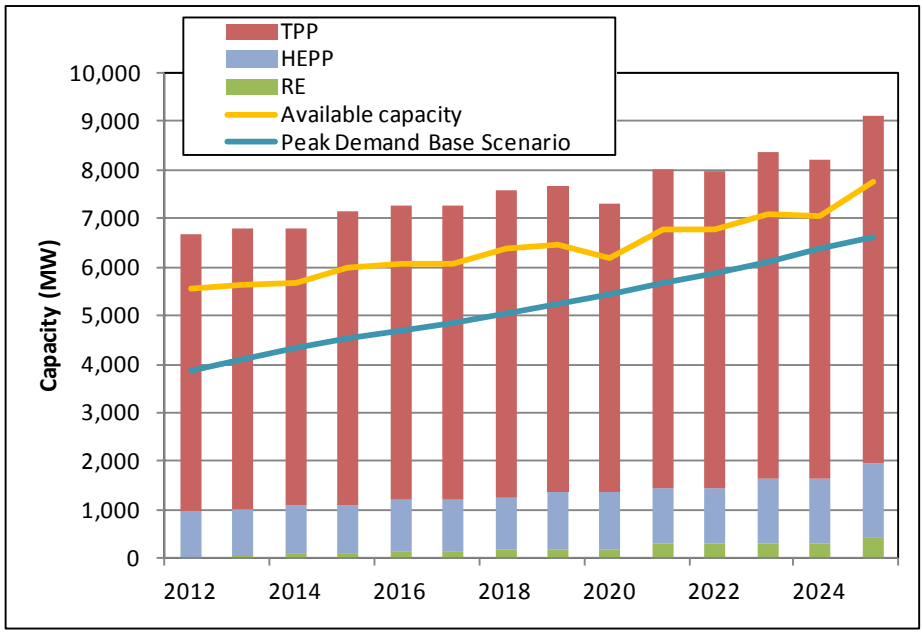

Figure 12: Supply-Demand Balance for Azerenerji 2012-2025

Figure 12 shows that the planned additions provide sufficient capacity to meet the projected peak demand and still leave a reserve for emergencies. However, the reserve margin - defined as the ratio of reserve to peak demand - decreases from 30% in 2013 to 21% in 2018 and falls below 20% by 2020. The reserve margin rates from 2012-2025 are shown for every second year in Table 6.

Table 6: Reserve Margin Rates for 2012-2025 for Base Case Scenario

Year	2012	2014	2016	2018	2020	2022	2025
Reserve margin	30.6%	23.5%	22.6%	21.0%	12.2%	13.1%	14.8%

According to the TEPSCO study, Azerenerji has a target reserve margin rate of 25% for the years of 2018-2023 and 20% for the years from 2024. For Azerbaijan these target rates are in a reasonable order according to the Consultants experience. Nevertheless, Table 6 shows that the calculated future rate falls below this value from 2014 and in 2020 it is only almost half of the target level. It has to be noted, that the base case scenario is regarded here. When the values of the high demand scenario are adopted for this analysis, the situation becomes even more critical with no reserve margin left from 2020 onwards.

Taking this into account, it can be said that, while the expansion plans of Azerenerji are generally in line with the growing demand, it is highly recommended to plan for building an additional power plant to be

commissioned in 2019/2020 in order to provide for an acceptable reserve margin. Such additional capacity was recommended in the TEPSCO study and considered in Azerenerji's expansion plan (1,400 MW Gobustan CCGT project) but according to the interviewed experts from Azerenerji's staff, the latest expansion plans focus on a project at a different location (920 MW Yashma CCGT). In the Consultant's view, an additional power plant should be considered to relieve the situation further, especially if electricity export is an objective in the future. This recommendation is consistent with TEPSCO's recommendation for installation of 1,800 MW at Gobustan).

5.5 Supply options

Due to its large hydrocarbon reserves, the country of Azerbaijan will also in the future rely mainly on thermal power plants for the power supply. Besides oil-fired steam turbines, which are used in the oldest power plants and more modern combined cycle gas turbines, Azerenerji has a high number of modular gas engine power plants. They were mainly ordered during the mid 2000s years when peak demand could not be satisfied domestically. In these years the power exchange balance was negative. Nowadays more electricity is exported than imported and problems with peak power production are not faced anymore. But still gas engine power plants in the range of 1,085 MW are included in the expansion plans of Azerenerji and TEPSCO for the upcoming 10 years.

A gas engine has lower capital cost than a CCGT, but higher operation costs, because its thermal efficiency is lower and therefore the engine consumes more fuel per kWh generated than the CCGT. In the context of the Azerbaijan power sector, with subsidized gas prices, the gas engine may prove to be the least cost solution, due to the much lower capital costs of a gas engine in combination with low fuel costs resulting from the subsidized gas price. But the uncertain development of future fuel costs should be an incentive to consider the options with the highest efficiencies at an early stage.

To stress this point, the Consultant calculated the economic benefits of increased adoption of CCGT technology, both, based on local gas prices for the utility (42 AZN/1000m³) and also compared to a gas price on the international market (238,56 AZN/1000m³). As mentioned above in Section 5.3, it is not clear at this stage, if the renovation of Azerbaijan TPP units will be done using the same technology or switch to CCGT. To outline the economic difference, Table 7 shows the annual economic benefits due to fuel savings when developing CCGT with typical unit sizes instead of steam turbines or gas engines.

Table 7: Estimated economic benefits by investments in CCGT per year

Measure	Effect	Savings
Replacement of old ST by CCGT	Higher efficiency (58% instead of 42%) – Fuel Savings	Replacement of 600 MW: • AZN 7.5 Million p.a. (local gas price) • AZN 42.7 Million p.a. (intl. gas price)
Development of CCGT instead of gas engines	Higher efficiency (58% instead of 42%) – Fuel Savings	Construction of 400 MW: • AZN 2.5 Million p.a. (local gas price) • AZN 13.7 Million p.a. (intl. gas price)

In a gas engine substantial energy is lost with the hot flue gas. This lost heat energy not only represents an economic loss, but also causes more emissions per MWh of power produced as compared to more efficient systems such as combined cycle power plants. In this context the efficient use of natural gas in power plants has also a remarkable effect on the carbon footprint of the country Azerbaijan. New CCGTs can replace old units and less efficient gas engine power plants. The level of greenhouse gases in Azerbaijan thus can be reduced or at least kept at the same level but with higher output of electrical energy.

From an economic point of view the cost savings on purchasing natural gas should be regarded. In cases where fuel gas is very cheap the short term economic loss associated with gas engine may not be a concern to the operator, but in the longer term impacts on both the environment and on a country's limited natural resources are also important considerations.

Therefore the Consultant would recommend to focus on highly efficient CCGTs instead of gas engine projects in the future. A typical CCGT unit size is relatively small in contrast to the installed capacity in Azerbaijan, so the Consultant does not see any difficulties from a system reliability point of view.

Despite its high potential, renewable energies are still on a very low level in Azerbaijan. This statement is not valid for hydroelectrical power which has historically a relatively strong position in the generation portfolio in Azerbaijan. But in terms of wind and solar power despite the intentions and support from political side the advancement is rather slow. The Consultant calculated levelized unit costs for renewable energies with typical values for investment and operating costs and hours of operation in Azerbaijan. The assumptions can be found in detail in **Annex 2**. As shown in Table 8**.**, CCGT when regarding the local procurement costs for the utility has by far the lowest costs per MWh. Even if the purchase price for fuel was at international market price level for the utility, CCGT would be a cheaper option than wind or PV power plants. The levelized unit costs for big HPPs are in a dimension, that is competitive with CCGT, but as stated above in Section 5.1, there is not an extensive hydrological capacity in the country and instead mainly small run-of-river HPPs will be developed in the future.

Table 8: Levelized unit costs for renewable energies and CCGT

Power Plant Technology	SHPP	HPP	PV	Wind	CCGT local	CCGT intern.
Levelized unit costs (AZN/MWh)	83.13	41.56	176.23	77.34	24.25	54.75

Despite the strong political will to support renewable energies, the extra costs linked to it have to be taken into consideration. A clear regulatory framework and the technical preconditions for integration of fluctuating renewable energies as well as the increase of the low feed-in tariffs to attract more private investors is recommended to be able to further enhance renewable energies in the future.

5.6 Investment requirements in the generation sector

Azerenerji's investment plan for the generation sector from the TEPSCO study is indicated in Table 9. Because of the expected growing demand in the upcoming years, the decommissioning of existing plants (Shirvan TPP, Azerbaijan TPP) and the aforementioned (Section 5.4) necessary capacity increase to have an adequate reserve margin, the Consultant recommends the construction of a new power plant based on CCGT technology, to be commissioned in 2019/2020, like the discussed Yashma project. Furthermore the Agh Sheher 300 MW combined heat and power plant (CHP) is a reasonable investment within the framework of the White City project in Baku, providing also district heating and thus increasing the efficiency by using also thermal energy.

In consideration of the budget restrictions, the Consultant has estimated the minimum investment requirements for capacity additions in the generation system until 2025. The investment plans for the (not specifically defined) renewable energy plants from Azerenerji's expansion plan until 2025 (approximately 1000 MW in total) are not regarded at this stage as they are costly and do not provide firm capacity. Concerning the hydropower projects only the 100 MW Samur HPP is considered in this estimation, as large HPPs contribute carbon-free electricity with lower specific costs than smaller HPPs.

The Consultant assumes that the Azerbaijan TPP will be replaced by more efficient CCGT units instead of oil-fired steam turbines, be it on the same location or (partly) at a different place, e.g. in the developing Absheron region. Further capacity additions will be needed from 2025 and it is also recommended that because of aforementioned reasons, these projects shall be based on CCGT technology instead of gas-turbines, that are no longer considered in the expansion plan. For that reason another 180 Million AZN is estimated to be invested in construction and development of power plant projects until 2025 where the location still has to be defined.

As shown in Table 9, capital expenditures could amount to about 1,250 million AZN until 2020 and over 2,750 million AZN until 2025. This estimate covers the cost for the minimum requirements in additional power plants up to 2025, with the exception of ongoing and committed plants for which financing is already secured. Given the considerable uncertainties associated with the long term expansion plan, the actual capex requirements could deviate considerably from this estimate.

The Consultant recommends to further develop small HPPs and introduce renewable energies even though it may not be cost-efficient. In order to relieve the burden on the state budget, this development can be achieved by attracting private investors.

Table 9: Tentative Cost Estimate of Capacity Additions

Year	Plant	Type	Capacity additions (MW)	Capex (million AZN)	Cumulated capex (million AZN)
2018	Yashma	CCGT	920	900	900
2020	Agh Sheher	CHP	300	350	**1,250**
2021	Azerbaijan	CCGT	600	585	1,835
2023	Samur	HPP	100	150	1,985
2024	Azerbaijan	CCGT	600	585	2,570
2025	Other CCGT Plant	CCGT	185	180	**2,750**
Total			**2,705**	**2,750**	

Source: Program for social-economic development of the regions of the Republic of Azerbaijan (2014-2018) for Yashma CCGT, Agh Sheher CHP and Samur HPP
Consultant's estimate based on $ 1,500/kW for HPP, $975/kW for CCGT - see

6. Transmission

6.1 Current transmission system

The current transmission system of Azerbaijan consists of 5 voltage levels starting from 110 kV up to 500 kV. Overhead transmission lines (OHL) have a total line length of more than 8,000 km, as shown in Table 10. There is a total of 18 major substations (S/S) from 220/100 kV to 500/330/220 kV, as detailed in Table 11. Both OHL and S/S are owned by Azerenerji. Further information on the transmission system is provided in **Annex 1**.

Table 10: High Voltage Overhead Lines in Azerbaijan

Voltage [kV]	Overhead Trans-mission Lines [no.]	Length [km]
500	3	477
330	19	1,280
230	1	31
220	20	1,243
110	273	5,157

Source: Azerenerji

Table 11: Major Substations in Azerbaijan

Voltage [kV]	No. of S/S	Name and Installed Capacity [MVA] of S/S
500/330/220	2	Absheron (801 MVA), Samukh (500 MVA)
330/110	5	Zavod (625), Ganja (125), Aghstafa (250), Khachmaz (360), Aghjibey (560 MVA)
330/230/110	1	Imishli (730)
330/220/110	1	Yashma (640)
220	1	Qabala (252)
220/110	9	Agsu (126), Masalli (188), Salyan (250), Sanaye (400), Hövsan (400), Nizami (250), Khirdalan (750), Müsfiq (750), Sangachal (250)

Source: Azerenerji

The data is taken from the final report of the "Study for Electric Power Sector in Azerbaijan" by JICA / TEPSCO in May 2013 but adjusted considering the information provided in Azerenerji's overall energy system diagram (2010) and "Information on 500, 330, 220 and 110 kV system-forming transmission lines" provided by Azerenerji. Some data from different documents are not consistent and could not be verified. As proposed by JICA / TEPSCO, the data should be updated and verified by an authorized team and Azerenerji during a more detailed study.

Based on a brief analysis of the network system the following issues should be considered:

- Transmission of bulk power from the main generation facilities with a total capacity of 3,300 MW (Azerbaijan TPP and Mingachevir HPP, and in addition Shamkir HPP and Yenikand HPP through Ganja S/S) to the main load center in the Baku region with a peak load of approximately 1,400 MW and a net demand of 7,629 GWh relies mainly on the 500 kV OHL which can be considered as the backbone of the system.
- Transmission of the bulk power through only one 500 kV circuit does not meet the security requirements (both N-1 and N-2 criteria)[2] for 500 kV voltage level. This will lead to instability in the Azerbaijan power system.
- Basing the transmission system of the Baku region on a voltage level of 220 kV is problematic, as shown in TEPSCO study. This voltage level cannot secure stable system behavior for a load center with a peak load of 1,400 MW in 2012 and a projected consumption of 9,000 GWh in 2020.

6.2 Review of expansion plans

In the "Program for social-economic development of the regions of the Republic of Azerbaijan (2014-2018)", which at present is awaiting governmental approval, Azerenerji defined a medium term expansion plan for their transmission network expansion and reinforcement. The expansion plan incorporates a number of recommendations made by JICA / TEPSCO in their study.

According to recent information by Azerenerji, the Gobustan TPP project will be postponed, and instead a TPP with the same generating capacity of 920 MW will be constructed within Yashma locality. The location has a substantial impact on the transmission network expansion within Absheron peninsula / Baku area.

As a consequence of changes in TPP priority a new detailed study is required, covering the whole area of Azerbaijan up to at least 2025. Several load forecast scenarios should be considered and several study cases verified, including the N-1 and N-2 criterion; several network configuration cases should be studied as well. In the absence of such a study, the Consultant can make only the following suggestions related to the Azerenerji reinforcement and expansion plans.

- Relieve the burden on 500 kV backbone Azerbaijan TPP / Mingachevir - Absheron; this recommendation has already been adopted by Azerenerji.
- Go with two different generation localities for the bulk supply of the Baku area, as recommended by TEPSCO.[3]

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[2] N-1 criterion: For multiple transmission lines delivering power to the same point, if one of the lines goes out of service, the remaining lines must be able to carry both the load they were carrying before the event, plus the load carried by the line that is out of service.
3 Study for Electric Power Sector in Azerbaijan, Section 8. The TEPSCO study analyzed alternative development patterns for four 450MW-class power units, in total 1,800MW. Case 2, which is supported by the Consultant, entails: "Installation of 2 units in 2018 in Gobustan, 2 more units will be installed in 2019 and in 2020, respectively, at sites other than Gobustan, and a 3rd unit will be installed in Gobustan depending on necessity in the future."

- Even if the burden on the 500 kV backbone is relieved, further reinforcement should be considered on a long term basis: either to build
  - another parallel 500 kV OHL or
  - another double circuit 330 kV OHL with twin conductor of approximately 400 mm² cross section depending on study calculations.
- It should be verified whether the planned new 330 kV OHL Azerbaijan TPP - Mingachevir HPP - Sulutepe S/S with appropriate transmission capacity can serve as the required reinforcement.
- Irrespective of finally selected and implemented generation plans as studied in JICA / TEPSCO report, an outer loop of 330 kV voltage level is recommendable.
- In addition to the above recommendations it is proposed that all 330 kV OHL forming the outer loop should be compact double circuit line either with twin or single conductor depending on the study results. In the first stage only one circuit can be installed and later a second one depending on the study recommendations.
- Double circuit 330 kV OHL is about 40-50% more expensive than single circuit, depending on the number of conductors per phase. They have, however, the benefit of avoiding corridor problems related to right of way and land acquisition which represent a risk for project implementation. In case that in the first stage only one circuit will be installed the capital investment in the first stage will be 10-15% lower.
- Further extension, reinforcement and rearrangement of 110 kV network will certainly be necessary. The recommended detailed study will identify which substation and OHL needs to be constructed or upgraded. Azerenerji’s "Program for social-economic development of the regions of the Republic of Azerbaijan (2014-2018)" already considers extension and reinforcement needs to a large extent, but the Consultant wants to underline the requirements in Absheron / Baku region resulting from the potential implementation of the 330 kV OHL outer loop.

In the long term the expected increase of energy trade with the neighboring countries and further exploitation of Azerbaijan's hydro potential - which is mainly located in the western part of the country - will require the 500 kV backbone. The Consultants’ recommendation to reinforce the 500 kV backbone or to construct a new 330 kV double circuit OHL is therefore justified.

6.3 Investment requirements in transmission network

In the Consultants’ view, the estimation of future investment requirements in the transmission network as given in Azerenerji's "Program for social-economic development of the regions of the Republic of Azerbaijan (2014-2018)" is realistic, but requires certain adjustments depending on the design recommendations and selected generation pattern related to the generation locality for the power supply to Baku load center.

The capital investments for the transmission projects (OHL and S/S of 110 kV and above) as listed in the "Program for social-economic development of the regions of the Republic of Azerbaijan (2014 - 2018)" amount to 1,540 million AZN. This amount includes the S/S and 330 and 220 kV OHL related to Gobustan TPP which is no longer considered in the medium term. When accounting for the changes in planned generation additions and the associated grid connections, the priority investment requirements may be approximately 1,000 million AZN.

In addition to these projects the major projects beyond 2018 are related to a second power plant as discussed in the TEPSCO study,[4] bringing the total generation capacity at Gobustan or other locations to 1,840 MW (2x920 MW). These projects require estimated investments of 190 million AZN, as shown in Table 12 (with contingencies around 200 million AZN). It should be mentioned that for both development patterns of the 1,840 MW assessed by TEPSCO, an identical outer loop is considered.

Thus, estimated priority investment requirements in the transmission network of Azerbaijan amount to:

- about 1,000 million AZN for expansion and reinforcement, plus
- about 200 million AZN for investments related to additional generation capacity.

Other necessary transmission projects all over Azerbaijan are not considered at this stage because a detailed system study as mentioned above is required to identify those projects and estimate their costs.

Table 12: Major Transmission Project beyond 2018

No.	Project name	Project description	Required funding (million AZN)
1	Second power plant S/S with necessary connections to the grid	220/110/10 kV S/S with 2x250 MVA capacity	45
2	330 kV DC OHL	Yashma - Sumgayit	7
3	330 kV DC OHL	Sumgayit - Hovsan	30
4	330 kV DC OHL	Hovsan - Puta	24
5	330 kV DC OHL	Puta - Sirvan	14
6	330 kV DC OHL	Azerbaijan TPP - Mingachevir HPP - Salutapa	70
Total			**190**

It should be noted that 330 kV DC OHL is foreseen at this stage to reinforce the backbone corridor as less expensive project but the study will define the most optimal option. The line connection is provisionally connected to the new 330/220 kV S/S.

[4] TEPSCO Study, Section 8, see also Footnote 3 above

7. Distribution

7.1 Description of distribution system

The electricity distribution in Azerbaijan is under the responsibility of the two state-owned companies Baku Electric Grid JSC, which operates the distribution grid in the capital region of Baku and its surrounding area, and Azerenerji JSC, who owns the distribution grids in the rest of the country operated by its seven regional subsidiary companies. The regional grid companies (including Baku Electric Grid) are responsible for 68 regions in total.

With approximately 50% of the total power consumption of the country, the Absheron peninsula with the capital Baku and the industrially developed Sumgayit, is the main load center in Azerbaijan (see also Figure 3). Due to growing industrialization in this region, this allocation is not expected to change. The country's second big city Ganja follows as the next big load center, especially if Mingachevir and Shamkir as further big cities in the greater area of Ganja, are included to this view.

In Azerbaijan the voltage level including and below 35 kV is considered as the distribution system. Voltages above that level are part of the transmission network. Although being solely responsible for distribution and sales in the Baku region, Baku Electric Grid also owns approximately 500 km of 110 kV cables and lines. The structure and the main characteristics of the distribution assets from Baku Electric Grid and Azerenerji are clustered and can be found in Table 13.

Table 13: Structure of the Distribution Networks in Azerbaijan

Component	Unit	Baku Electric Grid	Azerenerji
35 kV and 20 kV substation	pieces	136	430
10/6 kV transformers	pieces	3,785	17,920
20 kV and 35 kV distribution lines	km	1,570	4,046
6 kV and 10 kV distribution lines	km	7,200	29,126
0.4 kV distribution lines	km	5,000	56,776
0.4 kV SIP cables	km	11,251	6,000

According to the information gained from the interviews with the company representatives at Azerenerji and Baku Electric Grid and the available documents, it can generally be said, that the distribution network in Azerbaijan for now is reliable, as the most urgent renovation works have been done in the past since 2006, when the responsibilities for the electrical grids were transferred back to state-owned companies. Before that time, the private distribution companies obviously neglected necessary maintenance works and could not achieve any of the expected performance improvements from the privatization. As a consequence, frequent outages and supply interruptions, sometimes for a few hours a day, and also power

thefts were wide spread and more common. Through various investments and improvement projects by the Azerbaijani power companies, these negative effects have been reduced remarkably. No data or recordings for outages are available, neither from Azerenerji nor from Baku Electric Grid, but according to the interviewed experts, stability is not a problematic issue nowadays.

Nevertheless, the biggest part of the low voltage network, that mainly was built in Soviet times, is outdated and in need of renovation. This situation even becomes more critical, when the forecasted demand increase is taken into account. To meet the higher demand in the future, the present electricity network has to be in a good condition, and also well planned expansions into the regions with growing demand have to be implemented.

An indicator for the previously mentioned issue is the high rate of technical losses on the low voltage level as mentioned in Section 3 (see Table 2), especially when compared to other countries (see Table 14). These figures are highly correlated with the age structure and the efficiency of the distribution assets. Azerenerji reports that the low voltage infrastructure is corroded due to lacking investments, that transformers and conductors face overloads due to disorderly and inadequately designed structures and that there is a risk to not fully meet the increasing demand for power in the regions. When furthermore the non-technical losses and the transmission losses (approximately 3.9% in average for 2009 according to calculations with data from Azerenerji) are considered, obviously there is in total still a remarkable waste of resources due to inefficiencies.

Table 14: Electricity losses in comparable countries

Country	2009	2010
Azerbaijan	21.7%	20.3%
Georgia	12.6%	10.9%
Islamic Republic of Iran	15.6%	14.2%
Kazakhstan	8.2%	8.0%
Kyrgyzstan	29.9%	28.0%
Russian Federation	10.8%	10.1%
Turkey	14.9%	14.3%
Turkmenistan	13.1%	12.8%
Ukraine	11.9%	11.5%
European Union	6.1%	5.9%
World	8.6%	8.3%

Source: IEA Statistics – Electricity Information (transmission and distribution losses, includes pilferage)

To counter these tendencies, Azerenerji started reconstruction projects and modernization measures. With the area-wide installation of Smart Card meters in some pilot regions, collection rates reached almost 100% and helped building a power saving culture. Simultaneously old conductors were replaced by self carrying insulated wires (SIP), which also prevent electricity theft. At present approximately 25% of Azerenerji customers are

in possession of a smart meter. With the good results in the pilot projects Azerenerji is encouraged to expand those activities for the rest of the distribution grid.

Also Baku Electric Grid introduced remote-controlled smart meters especially in 'critical areas'. Constantly they are investing in renovation of its network structure. A big part of the network was installed during the last 2-5 years but the rest of the network has an age of 25-30 years. There are hardly any assets that were constructed in between this time. Many substations have recently been connected to a SCADA system and can be controlled centrally. It is expected that the whole distribution grid in Baku will be connected to SCADA within the next 2-3 years.

The reasonable investment plans and modernization activities of the Azerbaijani distribution companies should further be supported in the future.

7.2 Review of existing distribution master plan

The distribution system master plan prepared by Mercados in September 2010 was closer analyzed by the Consultant. The comments are as follows:

- The study includes the distribution grids operated by subsidiaries of Azerenerji; Baku Electric Grid is not part of the study and should not be disregarded in a master plan.
- On the basis of the data and the time available, Mercados uses an aggregated model. This is an acceptable approach but the determination of the parameters is arguable.
- Especially the formula used for determining requirements for new transformers and feeders does not seem appropriately deduced. This severely limits the validity of the final statements.
- The capital expenditure (capex) estimation concentrates mainly on expansion costs which are calculated on estimations that are difficult to reproduce. Renovation costs of the existing assets are not given sufficient attention.

The total capex, estimated by Mercados for investments in the distribution grids (excluding Baku region) up to 2025 are in an amount of 3.5 billion US$.

7.3 Investment requirements in the distribution sector

Based on the information available and the experiences and databases the Consultant will follow a simple and comprehensible approach to give a rough estimation on future investment requirements for Azerenerji owned distribution companies and for Baku Electric Grid Company. But it should be noted that this estimation cannot replace an in depth analysis of every single distribution grid, that would require a deeper examination of the distribution assets on a regional level.

The starting point is the overview of the main components of the Azerenerji's and Baku Electric Grid's distribution network from Table 13. From Baku Electric Grid information concerning the age structure has been submitted. A quick analysis of the data leads to the assumption that roughly 60% of the substations and transformers and 80% of the conductors can be considered as rather new and the remaining assets therefore need to be renewed within the next years. For Azerenerji such data is not available but in the document "Azerenerji Distribution Network Feasibility Study Text_Eng (14 01 2012).docx" it is stated that 40% of 10-6/0.4 kV substations, 80% of 0.4 kV distribution lines, 50% of 6-10 kV distribution lines and 90% of 35 kV distribution lines and substations need to be reconstructed. The SIP cables are considered as newly installed. The estimated number of transformers and substations and the length of lines and cables that are in need of renovation can be found in **Annex 3**.

As the demand (in the base case scenario) is growing by approximately 60% from 2013 to 2025 according to the demand forecast, this has to be considered in the design of the distribution network in terms of capacity increase. Hence, 60% of the current number and length of distribution assets is estimated to be installed additionally until 2025 for expansion (see also **Annex 3**). These numbers are added to the investments in need of renovation which leads to a total number for future investments in terms of lines/cables, substations and additional transformers.

With the market price assumptions from the Consultant's data base, the estimated overall investment costs including construction for the period from 2013-2025 amount to approximately 670 million AZN for Baku Electric Grid and 3,900 million AZN for Azerenerji, as shown in Table 15.

Table 15: Tentative Cost Estimate Distribution Networks in Azerbaijan 2012-2025

	Capital expenditure (million AZN)		
Network	**for renovation**	**for expansion**	**Total**
Baku Electric Grid	220	450	**670**
Azerenerji	2,100	1,800	**3,900**

Source: Consultant's estimations for average prices with 55,000 €/km for 35kV and 20 kV single circuit OHL, 35,000 €/km for 10kV and 6 kV single circuit OHL, 9,000€/km for 0.4kV area bundle cables and SIP cables, 17,000 €/set for 20/0.4 kV transformers, 2,000,000 €/set for a 35kV and 20kV substation (including transformers, switchgears, bays, panels). All prices include erection and transportation.

These are the rough estimations that consider the natural growth of the demand and with the grid necessary expansion and the renovation needs. It has to be pointed out that projects on 110 kV level as well as the installation of new meters are not included in this estimation. Special infrastructure projects (like e.g. White City, Construction of Baku Subway, Baku Olympic Stadium) are also not regarded here and would require a separate analysis.

As described in Section 7.1 the losses in the distribution network are remarkably high. According to calculations by the Consultant, a reduction

by only 1% of the technical losses would lead to an economic benefit of approximately 2.4 Million AZN per year when taking the annual consumption of the year 2012 and the subsidized local gas price into account. If the international market price for natural gas is taken as a basis, the profit would rise by 13.8 Million AZN. The Consultant estimates that a reduction of technical and commercial losses by 10% through rehabilitation of the network as well as further roll-out of smart meters and organizational improvements is realistic in the near term.

It is clear that because of budgetary restraints not all of Azerbaijan's distribution grids can be renovated and extended simultaneously. The necessary resources for investments have to be allocated in a rational way until 2014. The Consultant recommends that the industrially developed and highly populated regions, namely Baku, Sumgayit and Ganja, should be treated as priority regions as the country's wealth highly depends on these key areas and especially because they are by far the biggest power consumers. Thus the rehabilitation in the distribution network of Baku, Sumgayit and Ganja will have the highest economic benefits

8. Conclusions and Recommendation

The following conclusions can be drawn from the review and update of the Power Sector Master Plan:

The methodology for the demand projection of Azerenerji, as updated and extended by TEPSCO is sound. With an update of the base year data and of the GDP growth projections as the driving factor for demand, demand is now projected to reach around 5,440MW / 28,600 GWh in 2020 and 6,620 MW /35,000 GWh in 2025.

In order to meet this demand, about 3,000 MW of generation capacity have to be added. The planned retirement of over 3,000 MW increases the capacity to be added to over 6,000 MW. Additions of about 2,000 MW are already ongoing or committed and will be in service by 2015. Substantial additions are then planned in 2018 and 2020 with the 920 MW Yashma TPP and the 300 MW Agh Sheher CHP plant.

Initially Azerenerji had envisaged adding a number of gas engines instead of CCGTs because at the current gas prices these are the least cost solution for Azerbaijan. Considering the longer term impact of CO_2 emissions from gas engines on the environment and the impact on the country's limited natural resources, construction of CCGTs with higher efficiency and lower fuel consumption is, however, preferable.

Yashma TPP with 920 MW, Agh Sheher CHP with 300 MW and another 2,000 MW of CCGT over the period 2021-2025 are priority investments in the generation sector required to avoid a supply deficit in the medium term.

Considering the lead time of the projects, decisions on these priority investments need to be taken within the next years to ensure a timely commissioning. The timeline of investment decision and disbursements is provided in the prioritized investment plan for the power sector in Azerbaijan 2014-2025 in Table 16 below.

The planned priority additions provide sufficient capacity to meet the projected peak load. However, not all of the installed capacity will be constantly available, and when considering only the available capacity, the reserve margin drops below an acceptable level. It is therefore recommended to consider construction of additional power plants in order to reach the target reserve margin of 25%. Further additions will be necessary to allow energy export to neighboring countries.

In addition to the expansion of hydropower capacity, there is a political will for further integration of fluctuating renewable energies from wind and solar power. A clear regulatory framework and attractive tariffs are necessary to compensate the technical challenges and the higher generation costs.

The expansion plans for the transmission network as given in the TEPSCO study and Azerenerji's medium term plan are largely appropriate to match

energy supply with the growing demand, but require some adjustments to the changes in the location of the next large generation capacity additions. A study is required to identify the requirements for reinforcement and expansion of the grid. Even without this study it can be concluded that

- the burden on the 500 kV backbone from the major generation facilities to the main load center in Baku needs to be relieved; one option for this is to locate new generation capacity in a different area;
- further reinforcement should be considered either by a second parallel 500 kV line or another double circuit 330 kV line;
- further extension, reinforcement and rearrangement of 110 kV network will be necessary.

Priority investments in the transmission sector are the connections of Yashma TPP and the other priority generation plants, as well as reinforcement of the existing network, as shown in Table 16.

The distribution network of Azerenerji's regional subsidiaries is to a large extent outdated and in need of renovation. The resulting losses impose costs on the economy which could be avoided with a modernization program. A lot has been done in recent years with regard to modernization, introduction of SCADA system and smart meters, but in particular the low voltage lines still require substantial replacement and refurbishment. Furthermore, the projected increase in demand requires additional investments in the distribution grid to ensure the uninterrupted supply of customers.

The expansion and rehabilitation plans of Azerenerji and Baku Electric Grid should be supported and implemented promptly. Measures in the areas with the strongest industrial development and the highest population density in the country, i.e. especially Baku, Sumgayit and Ganja, should have the highest priority.

The expansion plans of Mercados, TEPSCO and Azerenerji do not provide sufficient information on the costs of system expansion to establish a sound year-by-year investment plan; in particular investment requirements resulting from the change in the plans for generation capacity additions still need to be identified. However, in order to provide a very rough indication of the funds required for system expansion until 2025, the Consultant has compiled preliminary cost estimates for priority generation capacity additions, transmission and distribution investments.

- The priority investment in generation capacity is estimated in the order of 2,750 million AZN until 2025. This amount does not include the ongoing and committed projects.
- The priority expansion and reinforcement of the transmission grid will require investments of approximately 1,000 million AZN plus further 200 million AZN for investments related to the second power plant recommended for bulk supply of Baku after 2020.

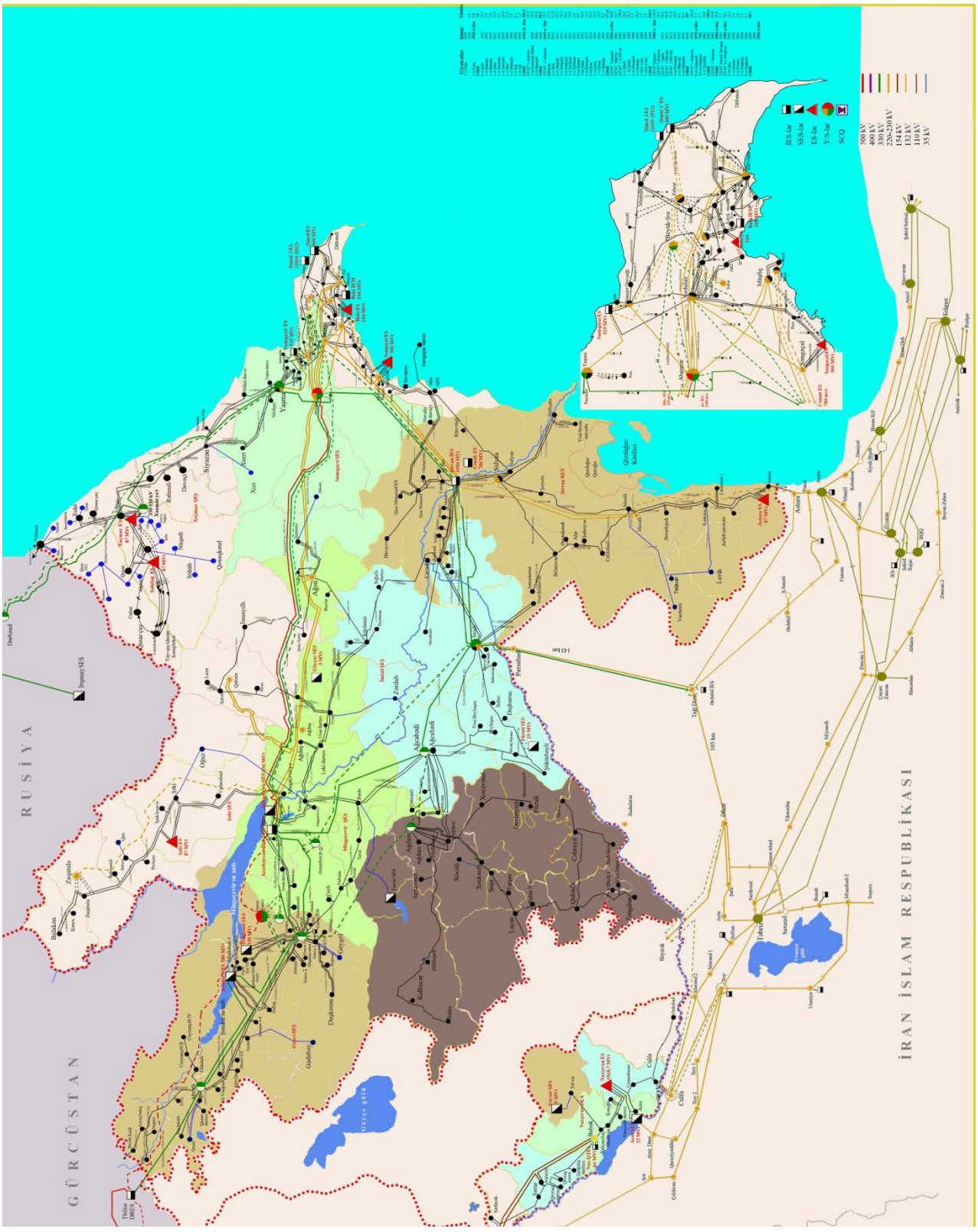
- The priority investments into the distribution network until 2025 are roughly estimated at 670 million AZN for Baku Electric grid and 3,900 million AZN for Azerenerji.
- In total, priority investments into the power sector until 2025 may require capital expenditures around 8,520 million AZN, as shown in Table 16 below.

Further investments beyond the priority measures, such as addition of renewable energy plants and further capacity additions to increase the reserve margin, would require additional funds of approximately 1,500 million AZN.

Table 16: Prioritized Investment Plan for the Power Sector in Azerbaijan 2014-2025

			2014	2015	2016	2017	2018	2019	2020	2021 - 2025	Total
Generation	Plant:	Yashma 920 MW									
	Activity:		Investment Decision		Construction	Construction	Construction COD				
	Disbursement:	AZN mln			100	400	400				
	Plant:	Agh Sheher CHP 300 MW									
	Activity:			Investment Decision				construction	construction COD		
	Disbursement:	AZN mln						175	175		
	Plant:	Other CCGT (~2000 MW)									
	Activity:				Investment Decision					construction COD	
	Disbursement:									1500	
	Total Generation	AZN mln	0	0	100	400	400	175	175	1500	**2,750**
Transmission	Yashma connection		Investment Decision			50					
	Connection of new plants				Investment Decision					200	
	Other Trans-mission projects	Activities	Annual Investment Decisions								
		Disbursement	100	100	100	100	100	100	100	250	
	Total Transmission	AZN mln	100	100	100	150	100	100	100	450	**1,200**
Distribution		Activities:	Prioritisation and annual investment decisions								
	Azerenerji	Rehabilitation	200	300	300	100	100	200	200	700	2,100
		Expansion	200	200	200	100	100	150	150	700	1,800
	Baku	Rehabilitation	30	30	30	30	30	30	30	10	220
		Expansion	50	50	50	50	75	75	50	50	450
	Total Distribution	AZN mln	480	580	580	280	305	455	430	1,460	**4,570**
	Grand Total	**AZN mln**	**580**	**680**	**780**	**830**	**805**	**730**	**705**	**3,410**	**8,520**

Annex 1: Power System of Azerbaijan



Annex 2: Assumptions for Calculating Levelized Unit Costs

Component	Unit	SHPP	HPP	PV	Wind	CCGT
Specific invest	US$/kW	3000	1500	1500	1500	975
O&M	% of CAPEX	2%	2%	2%	3%	
Fuel cost (local)	US$/MWh					5
Fuel cost (intl.)	US$/MWh					5
Efficiency	%					58%
Size	MW	3	50	1	10	450
Full operating hours	h	3500	3500	1500	2200	6000
Useful life	a	30	30	20	20	25
Discount rate	%	10%	10%	10%	10%	10%

Annex 3: Renovation and Expansion Needs in the Distribution Network in Azerbaijan

Component	Unit	Currently installed	% to be renewed	To be renewed	% ex-pansion	To be added	Total
Baku Electric Grid							
35 kV and 20 kV substation	pieces	136	40	54	60	82	136
10/6 kV transformers	pieces	3,785	40	1,514	60	2,271	3,785
20 kV and 35 kV distribution lines	km	1,570	20	314	60	942	1,256
6 kV and 10 kV distribution lines	km	7,200	20	1,440	60	4,320	5,760
0.4 kV distribution lines	km	5,000	20	1,000	60	3,000	4,000
0.4 kV SIP cables	km	11,251	-	-			
Azerenerji							
35 kV substation	pieces	430	90	387	60	258	645
10/6 kV transformers	pieces	17,920	40	7,168	60	10,752	17,920
35 kV distribution lines	km	4,046	90	3,641	60	2,428	6,069
6 kV and 10 kV distribution lines	km	29,126	50	14,563	60	17,476	32,039
0.4 kV distribution lines	km	56,776	80	45,420	60	34,066	79,486
0.4 kV SIP cables	km	6,000	-	-			