CLEAN DEVELOPMENT MECHANISM
PROJECT DESIGN DOCUMENT FORM (CDM-PDD)
Version 02 - in effect as of: 1 July 2004)

CONTENTS

Annexes

SECTION A. General description of project activity

A.1 Title of the project activity:

Improved Efficiency in Power System Generation through Advanced SCADA Control Systems and Related Energy Management Protocol in Azerbaijan

A.2. Description of the project activity:

Azerenerji, the state-owned power generation and transmission company will install an advanced Supervisory Control and Data Acquisition system (SCADA) including energy management software. This SCADA system will replace the ad hoc dispatch system currently used that causes inefficient use of the existing generation capacity. In the current system, significant fuel is wasted with generating capacity operating at a less than optimal efficiency. This is because the job of matching load with demand is done mostly by guess work with little access to critical information. The SCADA system and associated software will provide timely information and system analysis to allow operators to quickly match load with demand in a manner that optimizes generation efficiency. This will reduce fuel waste, improve the efficiency of generation and reduce carbon emissions. Additionally, the SCADA system will enable Azerenerji to improve its voltage profile and reduce technical losses in its transmission system. With improved data and control, Azerenerji will:

- reduce its fuel consumption per kWh produced by its thermal plants
- reducing technical losses saving additional fuel
- reduce carbon emissions over the baseline case

There is an extensive overview of the Azerbaijan electricity system prepared for the EBRD and Azerenerji by Burns and Roe in Appendix 5.

A.3. Project participants:

Azerenerji (Azerbaijan, Ratified 28, September 2000)
World Bank Carbon Finance Unit

A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

Azerbaijan electricity generation units

A.4.1.1. Host Party(ies):

Azerenerji

A.4.1.2. Region/State/Province etc.:

This project will cover the entire electricity grid of Azerbaijan

A.4.1.3. City/Town/Community etc:

The headquarters of Azerenerji is located in Baku.

A.4.1.4. Detail of physical location, including information allowing the unique identification of this project activity (maximum one page):

This project will encompass all of the existing thermal capacity of Azerenerji. This includes 7 power plants with a total of 27 generating units.

A.4.2. Category(ies) of project activity:

Category 3 – Energy Efficiency

A.4.3. Technology to be employed by the project activity:

Supervisory Control and Data Acquisition system (SCADA) and related Energy Management Protocol.

A.4.4. Brief explanation of how the anthropogenic emissions of anthropogenic greenhouse gas (GHGs) by sources are to be reduced by the proposed CDM project activity, including why the emission reductions would not occur in the absence of the proposed project activity, taking into account national and/or sectoral policies and circumstances:

This project will enable the same amount of electricity to be generated for less fossil fuel input, which will reduce CO2 emissions. By far, the most likely scenario, without the SCADA project would be for Azerenerji to continue to dispatch power as it currently does. This scenario would lead to continued waste of fossil fuels as generating units are brought online and operated at less than the optimal efficient scenario and technical transmission losses remain high. There is no national or sectoral policy which requires or even encourages optimization of generation dispatch. In fact, national policy provides significant disincentives for this project, particularly in the area of fuel subsidies to the utility (this is described in Section B.3).

A.4.4.1. Estimated amount of emission reductions over the chosen crediting period:

Approximately 2.5 million tonnes over ten year period

A.4.5. Public funding of the project activity:

No public funding from an Annex One country will be involved.

SECTION B. Application of a baseline methodology

B.1. Title and reference of the approved baseline methodology applied to the project activity:

No approved methodology exists for this project, so the project developers are proposing a new methodology entitled '*Improved Efficiency of Electrical Power System Generation through Advanced SCADA Control Systems and Associated Energy Management Protocol*'.

B.1.1. Justification of the choice of the methodology and why it is applicable to the project activity:

The methodology proposed captures the emission reductions of the project by determining the efficiency of the thermal generation per kWh delivered through the transmission system at a particular operating point before and after the project. It captures total kilocalories saved and then calculates fuel savings and CO2 reductions associated with the efficiency improvements. It makes this calculation hourly to ensure an accurate comparison between actual and baseline conditions.

B.2. Description of how the methodology is applied in the context of the project activity:

The project is designed to improve the system-wide efficiency of the Azerbaijan electricity system by better utilizing the generation capacity and reducing transmission line losses through better management data and tools. The SCADA system and associated software will decrease the cumulative kcal per unit of electricity generated and delivered through the transmission system up to the distribution system. This will happen because load is being better managed to maximize the efficiency of generation from all the power plants in the grid; in addition, the I^2R losses can be minimized by better utilizing the existing transmission system. The efficiency factor of total kWh delivered to metered distribution points per total kcal expended (kcal/kWh) is used because it captures (a) improvements in efficiency at both the generation point and (b) reduction in lines losses resulting from the SCADA system and associated software. This efficiency ratio will be measured at each level kWh of delivery in the baseline year so that it can be compared to data in the project year at the same point of delivery.

In order to ensure the accuracy of the emission reductions, the baseline will change on an annual basis based on the given CO2 content of the fuel and will be measured on an hourly basis to allow Azerenerji to compare the thermal-system efficiency at a given amount of kWh delivered to the transmission system from the baseline year with the improved efficiency of the system at the same demand point in the project year.

Azerenerji's hydro load and any new thermal generation brought on after the initiation of the project will not be included in order to isolate the direct effect of the project on fossil fuel use and be extremely conservative. In order to isolate the fossil fuel production from other sources, the Azerenerji will define the delivered amount used in this calculation by taking the total electricity delivered measured at the end points of the transmission system and subtract any non-thermal generation and any units installed or significantly rehabilitated after the start of the project measured at point of generation. Since many of Azerenerji's generating units use both mazut and natural gas for combustion, the methodology will account for changes in fuel throughout a given year using the hourly kgCO2/kcal figure which will be determined by the average CO2 content per kcal of fuel based on type and relative quantities of fuels used.

The baseline emissions for year x is determined for each hour in year x by multiplying the power supplied to the end of the transmission system for that hour measured in kWh by the average efficiency of the thermal units in the baseline for that same demand point measured in kcal/kWh. The sum of this calculation performed for all the hours in a given year is a measure of the total kilocalories that would have been expended in the project year given the same level of efficiency in the generation as the baseline year. This number is then multiplied by the carbon coefficient for the project year measured in kg CO2/ kcal to get a total carbon emissions in year x for the baseline scenario.

B.3. Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered CDM project activity:

Dispatch systems are responsible for determining how the demand on a given electricity grid is going to be met by the various generation units connected to the grid. Given that most grids operate with a wide variety of plants with different generation methods, capacities and efficiencies, the overall efficiency of operation of the entire system will be determined by how efficient the grid's dispatch system operates. Optimizing an electricity grid's dispatch system will allow the generating units to operate under closer to optimal conditions thereby increasing their efficiency and reducing input consumption per kWh produced. In the case of thermal power plants, the reduction of inputs can be directly translated into fossil-fuels saved per kWh produced.

In a very simplistic example with four generating units of equal engineered capacity, if the dispatch system can allow the two most efficient generating units to operate at 100% capacity rather than having four generating units operating at 50% capacity the same kWh will likely be produced using significantly less fuel.

Additionally, Azerenerji currently faces significant technical losses in its transmission system since it cannot accurately manage its voltage profile. The SCADA system will help reduce some of these technical losses.

SCADA systems when utilized in conjunction with a power dispatch system can greatly optimize the operation of the entire system. The data collection and the real-time control systems that are typical of modern SCADA systems and associated energy management software can allow operators to determine the most efficient combination of generation options at under every operation condition.

The project can also be shown to be additional, using a version of the EB's Additionality Test tool outlined in the proposed baseline methodology:

Step 0. Preliminary screening based on the starting date of the project activity: Because this project will start after 2005, there will be no need to start the crediting period prior to our seeking registration as a CDM project.

Step 1. Identification of alternatives to the project activity consistent with current laws and regulations

Alternative #1: Additional Generation Capacity Would be Built: Before Azerenerji was presented the overview of the SCADA project, their initial assessment was that they simply needed additional generation capacity to meet growing demand. This scenario would be the most likely situation if the utility had access to investment capital. But as described below, the utility is in poor financial condition.

Alternative #2: Azerenerji would try to undertake this project anyway without CDM. This seems unlikely given the barriers to implementation that are described in the Barriers Analysis.

Alternative #3: The continuation of the current situation. Without the SCADA system, Azerenerji would continue to dispatch electricity generation on an ad hoc basis. This would mean a continuation of blackouts, unmet demand, and wasted fuel. This is the most likely scenario given the financial health of the utility.

Alternative #4: Azerenerji could meet any current shortfall and growing demand by importing additional supplies. This option seems unlikely based on the transmission limitations that would involve significant investments in new transmission lines to overcome. Imported power is also expensive and unreliable in this region.

Alternative # 3 is determined to be the baseline scenario since it is least likely to be hindered by existing barriers described below.

Sub-step 1b. Enforcement of applicable laws and regulations: All four alternatives would comply with Azerbaijani law.

Step 2. Investment analysis: This step is not used.

Step 3. Barrier analysis: This project would not be implemented without the involvement of CDM due to the following barriers. These barriers described below would not prevent the most likely option, Alternative #3 – continuation of the current situation.

Financial/Investment Barriers: Although SCADA systems are not huge capital investments compared to new power generation, their design, installation and operating can require tens of millions of dollars – a substantial first-cost for a power company with poor cash-flow.

Azerenerji currently does not have basic cost recovery for its expenses. Like most utilities in the former Soviet Union, electricity prices are highly-subsidized with many consumers paying only a portion of the true market value of the power. Non-payment is also rampant. These two facts mean that the utility does not have a secure enough cash flow for financing capital investments. Azerenerji would have great difficulty, therefore, going to commercial lenders to get credit and make capital investments. Further complicating matters is the fact that energy efficiency is poorly understood by the financial community in general and specifically in the local credit market. The main asset generated by this project is energy savings, which makes this project a harder sell to bankers. To date, no commercial bank has been willing to undertake this project for Azerenerji. The World Bank's involvement as the main source of credit for the project, due in significant part to the risk-mitigating potential (for the Bank) of the carbon revenue, highlights the project's lack of commercial viability.

Barrier Effects:
Proposed CDM Project: As described above, Azerenerji's financial situation hinders its access to credit markets and the fact that the project's return relies on energy savings as a key asset created further impedes commercial viability of the project.
Alternative #1- Investment in new generation would likely face similar barriers in terms of Azerenerji's financial position, but since a power plant is a very clear asset it would not face the same discrimination afforded to energy efficiency investments.
Alternative #2- The impact of this barrier would be very similar to Alternative #1.
Alternative #3- Despite the existence of this barrier, Azerenerji could still chose to do nothing.

Lack of Financial Incentive to Invest in Energy Efficiency: Currently, perverse subsidies exist in payments made to and from Azerenerji that would inhibit most energy efficiency projects including this one from taking place without CDM. The current subsidy is based completely on fuel used. Azerenerji does not fully recover costs. In order to maintain service without going bankrupt the Azerbaijani government provides tax relief to the fuel supplier – the Azeri State Oil Company – in exchange for eliminating fuel payments from Azerenerji. This means that investments made to reduce fuel consumption will not provide the same benefits that would occur if the Azerenerji actually paid for all its fuel. New power projects that would require additional fuel resources will look significantly better than they should when compared to energy efficiency projects.

Barrier Effects:
Proposed CDM Project- Reduces the incentive for Azerenerji to invest in energy efficiency over new generation capacity
Alternative # 1- Since true fuel costs are not part of the current investment equation for Azerenerji, new generation project will look abnormally attractive.
Alternative #2- The project undertaken without CDM would likely face the same barrier as the proposed project, but would not have the advantage of CDM revenues to help overcome the barrier.
Alternative #3- This barrier would not hinder the company from operating as usual, but as demand increases and efficiency decreases, the subsidy will become a larger drag on Azerbaijan's finances.

Technology Barriers: To install and utilize the SCADA system will require a significant upgrade in the existing capacity of Azerenerji. While the technical staff of Azerenerji has been convinced that an investment SCADA is in their best interests, they do not have adequate financial resources to provide the required training. SCADA systems are very specialized tools, requiring a highly-trained team capable of

operating and maintaining the system. Currently, no such capacity exists in Azerenerji. This SCADA system will be the first of its kind in the country. Previously the electricity grid dispatch has been operated using telephones and operator's best guesses.

Barrier Effects:
Proposed CDM Project: Lack of proper training on a SCADA system could lead to a poorly installed and operated system, undermining the potential savings. CDM revenues can provide Azerenerji with both the resources and incentive to ensure their staff is properly trained to make best use of the energy efficiency potential of the SCADA system. The more optimal the use of the system, the more CERs can be generated, providing that incentive. There has already been a significant amount of education required to overcome the uncertainty, lack of familiarity and perceived risk associated with this type of project

Alternative #1- The existing staff is properly trained to operate generation facilities and might need very limited training to operate new capacity.
Alternative #2- This option would face the same barrier as the CDM project, but not have the resources or incentive to over come the barrier.
Alternative #3- This barrier would not hinder the company from operating as usual.

Step 4: Common Practice Analysis: This SCADA system is a first of its kind in the Azerbaijani electricity system. In the last several years, Azerenerji has invested in new generation capacity by retrofitting generation units within thermal power plants that had severely lagged in terms of efficiency. No investments have been made in recent year in upgrading the dispatch system. It is operated much the same way it was 20 years ago. No similar projects to the proposed CDM project activity are occurring in the country. Evidence of the lack of common-practice will be presented to the DOE upon project validation in the form of letters from the utility and various World Bank funded studies of the country's electricity sector.

Step 5. Impact of CDM registration

Alternative #1 is a real option and may go ahead in addition to the SCADA project, although less additional capacity will be required due to the increase in efficiency of the existing capacity from this project. (Any addition in capacity would require substantial investment and thus some gradual improvement in revenue generation). Any new capacity will be positively affected by the SCADA system as well even though this project does not seek to claim credit for these improvements.

Impact of CDM to Overcome Barriers-
Barrier #1- The additional CDM revenues from the project improves the return on investment and can help overcome the perception that energy efficiency does not create a real asset. In this case, the World Bank has included the potential CDM asset as part of its internal loan review process to help overcome these perceptions. It also may act as a hedge against the currency risk involved in borrowing money in dollars, getting revenue in local currency and having to repay some of the purchases in Euro.

Barrier#2- The CDM revenue earned by this project could help distinguish this project in the decision making process of Azerenerji management as it decides whether to move forward with this approach or pursue additional generation capacity. In discussion on the project the potential of CDM revenues has garnered significant attention of senior management of Azerenerji and the Ministry of Industry and Energy. Parts of this project have been proposed before, but have not

made it through the decision-making process of senior management while new capacity projects have made it through. The implementation of this project is gaining acceptance in part due to the revenue, visibility, and partners (World Bank) the CDM has brought.

Barrier #3- Azerenerji will have both the incentive and means – via the CDM revenues – to pay for the critical on-going training required for its staff to install, maintain, and operate the SCADA system at optimal levels.

Barrier #4- The perceived risk of investing in a first of its kind project in Azerbaijan is muted somewhat by the involvement and additional revenue brought by the World Bank as a purchaser for the CDM credits. Power generation projects that the management of Azerenerji has more experience with have made it through the decision making process, while this type of system energy efficiency project will be a first of its kind with all the perceived risk attached to its implementation.

B.4. Description of how the definition of the project boundary related to the baseline methodology selected is applied to the project activity:

The proposed baseline methodology calls for the project boundaries to be set at the thermal generation units in operation at the start of the project and the distribution system and the transmission system. This project includes only those thermal plants in operation at the start of the project. It will also drops out any plants that undergo major renovations that would change the efficiency rate of the generation units. Meters linked to the SCADA will be placed at every transmission termination point and at each generation unit to ensure the integrity of the boundary data.

B.5. Details of baseline information, including the date of completion of the baseline study and the name of person (s)/entity (ies) determining the baseline:

A feasibility study was undertaken by Kevin James of Quality Tonnes and Lasse Ringius of the World Bank to gauge the emission reduction potential of this project based on current data. The complete baseline study is not planned until after the installation of advanced meters in the year prior to the installation of the full SCADA system. Azerenerji and a consulting company to be determined will be responsible for this study.

SECTION C. Duration of the project activity / Crediting period

C.1 Duration of the project activity:

C.1.1. Starting date of the project activity:

January 1, 2008

C.1.2. Expected operational lifetime of the project activity:

20 years

C.2 Choice of the crediting period and related information:

C.2.1. Renewable crediting period

C.2.1.1. Starting date of the first crediting period:

NA

C.2.1.2. Length of the first crediting period:

NA

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

January 1, 2008

C.2.2.2. Length:

10 years

SECTION D. Application of a monitoring methodology and plan

D.1. Name and reference of approved monitoring methodology applied to the project activity:

A new monitoring methodology entitled, '*Improved Efficiency in Electrical Power System Generation through Advanced SCADA Control Systems and Associated Energy Management Protocol', is being proposed for this project.*

D.2. Justification of the choice of the methodology and why it is applicable to the project activity:

No current methodology covers this type of project so this methodology is being proposed because it can quantify the emission reductions resulting from the improved electricity system performance in this proposed project resulting from the implementation of a more advanced monitoring and control system.

D.2. 1. Option 1: Monitoring of the emissions in the project scenario and the baseline scenario

D.2.1.1. Data to be collected in order to monitor emissions from the project activity, and how this data will be archived:

There will be no project emissions from installing a SCADA system.

ID number *(Please use numbers to ease cross-referencing to D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment

D.2.1.2. Description of formulae used to estimate project emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

There will be no project emissions from installing a SCADA system.

D.2.1.3. Relevant data necessary for determining the baseline of anthropogenic emissions by sources of GHGs within the project boundary and how such data will be collected and archived :

ID number *(Please use numbers to ease cross-referencing to table D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment

A-1	*Generation efficiency data given level of kWh delivered through transmission system*	Azerenerji *Measured at each thermal generation unit*	*Kcal/kWh*	*m*	*Constant and averaged for each project year*	*100%*	*electronic*	*The SCADA system will gather and archive this data*
A-2	*Total Delivered electricity through the transmission system*	Azerenerji *Measured at each thermal generation unit*	*KWh output*	*m*	*annual*	*100%*	*electronic*	*The SCADA system will gather and archive this data*
A-3	*Carbon content of fuel used*	Azerenerji *Measured at each thermal generation unit*	*Kg CO2/Kcal and kg CO2 per liter,m3, etc.*	*m*	*Constant with an annual figure*	*100%*	*electronic*	*The SCADA system will gather and archive this data in cases where better data exists, IPCC data may be used to determine carbon content for fuels.*
A-4	*Heat content of fuel used*	Azerenerji	*Kcal/liter of fuel oil (Mazut)or Kcal/m3 of natural gas (Russian or Azeri)*	*m*	*Constant*	*100%*	*electronic*	*Each fuel will have a known energy content per unit*
A-5	*Total amount of each fuel type used*	Azerenerji	*Liters of fuel oil or m3 of gas, , etc.*	*m*	*hourly*	*100%*	*electronic*	*The SCADA system will gather and archive this data*
A-6	*Total amount of non-fossil fuel based generation*	Azerenerji *Measured at generation site*	*kWh*	*m*	*hourly*	*100%*	*electronic*	*The SCADA system will gather and archive this data*

A-7	*Total Amount of electricity generated from new or significantly upgraded Fossil Fuel generation*	Azerenerji *Measured at generation site*	*kWh*	*m*	*hourly*	*100%*	*electronic*	*The SCADA system will gather and archive this data*
A-8	*Carbon Emissions Factor*	*Derived from data in A-3,A-4,A-5*	*Kg CO2/kWh*	*c*	*hourly*	*100%*	*electronic*	*The SCADA system will gather and archive this data*

D.2.1.4. Description of formulae used to estimate baseline emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

The project is designed to improve the system-wide efficiency of the electricity system by better utilizing the generation capacity and reducing line losses through better management data and tools. The Supervisory Control and Data Acquisition (SCADA) and related energy management software system will allow the cumulative kcal per unit of electricity generated and delivered through the transmission system up to the distribution system to decrease. This will happen because load is being better managed to maximize the efficiency of generation from all the power plants in the grid; in addition, the I^2R losses can be minimized by better utilizing the existing transmission system. The efficiency factor of total kWh delivered to metered distribution points per total kcal expended (kcal/kWh) is used because it captures (a) improvements in efficiency at both the generation point and (b) reduction in lines losses resulting from the SCADA system. This efficiency ratio will be measured at each level kWh of delivery in the baseline year so that it can be compared to data in the project year at the same point of delivery.

For example, in the baseline year .3 million kcal/MWh are required to deliver 1000 MWh to the terminal points of the transmission system. If in the post-project year to deliver the same amount of electricity to the end of the transmission system only takes .291million kcal/MWh, it will be clear there has been a three percent efficiency improvement in the system's ability to deliver 1000MWh. This improvement will result from some combination of reduced line losses and increased generation efficiency due to the SCADA system.

In order to ensure the accuracy of the emission reductions, the baseline will change on an annual basis based on the given CO2 content of the fuel and will be measured on an hourly basis to allow the project developer to compare the thermal-system efficiency at a given amount of kWh

delivered to the transmission system from the baseline year with the improved efficiency of the system at the same demand point in the project year.

Renewable loads and new thermal generation brought on after the initiation of the project will not be included in order to isolate the direct effect of the project on fossil fuel use and be extremely conservative. In order to isolate the fossil fuel production from other sources, the project developer will define the delivered amount used in this calculation by taking the total electricity delivered measured at the end points of the transmission system and subtract any non-thermal generation and any units installed or significantly rehabilitated after the start of the project measured at point of generation. The methodology will account for changes in fuel throughout a given year using the hourly $kgCO_2/kcal$ figure which will be determined by the average CO_2 content per kcal of fuel based on type and relative quantities of fuels used.

The baseline emissions for year x is determined for each hour in year x by multiplying the power supplied to the end of the transmission system for that hour measured in kWh by the average efficiency of the thermal units in the baseline for that same demand point measured in kcal/kWh. The sum of this calculation performed for all the hours in a given year is a measure of the total kilocalories that would have been expended in the project year given the same level of efficiency in the generation as the baseline year. This number is then multiplied by the carbon coefficient for the project year measured in kg CO_2/ kcal to get a total carbon emissions in year x for the baseline scenario.

Baseline Emissions in year x equals

$$\sum_{i_x=1}^{8760} (D_{i\ year\ x} * kcal/kWh_{Di\ year\ 0}) * kgCO_2/kcal_{i\ year\ x}$$

Where
i = Given hour in a year
Di=Total fossil fuel generated electricity delivered in kWh at given hour i where total fossil-based electricity equals total measured electricity delivered through the transmission system minus the total non-fossil generation measured at the site of generation
$Kcal/kWh_{Di\ year\ 0}$ = an efficiency factor for the fossil fuel based load at the given delivered amount in hour i (Di) as found in the baseline year
Year x= given project year being compared to baseline
Year 0= baseline year

D. 2.2. Option 2: Direct monitoring of emission reductions from the project activity (values should be consistent with those in section E).

This Option is not selected -- D.2. 1. Option 1 was selected

D.2.2.1. Data to be collected in order to monitor emissions from the project activity, and how this data will be archived:

ID number *(Please use numbers to ease cross-referencing to table D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment

This Option is not selected -- D.2. 1. Option 1 was selected

D.2.2.2. Description of formulae used to calculate project emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.):

This Option is not selected -- D.2. 1. Option 1 was selected

D.2.3. Treatment of leakage in the monitoring plan

There is no leakage anticipated from this project. The SCADA installation is not a large, capital-intensive project with substantial environmental impacts (like power plant construction). In terms of dispatch efficiency, the environmental gains should only be positive. In other words it is not expected that dispatch efficiency improvements would lead to greater fossil fuel use or inefficiencies in any other part of the grid.

D.2.3.1. If applicable, please describe the data and information that will be collected in order to monitor leakage effects of the project activity

ID number *(Please use numbers to ease cross-referencing to table D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment

NA

D.2.3.2. Description of formulae used to estimate leakage (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

There is no leakage anticipated from this project. The SCADA installation is not a large, capital-intensive project with substantial environmental impacts (like power plant construction). In terms of dispatch efficiency, the environmental gains should only be positive. In other words it is not expected that dispatch efficiency improvements would lead to greater fossil fuel use or inefficiencies in any other part of the grid.

D.2.4. Description of formulae used to estimate emission reductions for the project activity (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

The project is designed to improve the system-wide efficiency of the electricity system by better utilizing the generation capacity and reducing line losses through better management data and tools. The Supervisory Control and Data Acquisition (SCADA) and related energy management software system will allow the cumulative kcal per unit of electricity generated and delivered through the transmission system up to the distribution system to decrease. This will happen because load is being better managed to maximize the efficiency of generation from all the power plants in the grid; in addition, the I^2R losses can be minimized by better utilizing the existing transmission system. The efficiency factor

of total kWh delivered to metered distribution points per total kcal expended (kcal/kWh) is used because it captures (a) improvements in efficiency at both the generation point and (b) reduction in lines losses resulting from the SCADA system. This efficiency ratio will be measured at each level kWh of delivery in the baseline year so that it can be compared to data in the project year at the same point of delivery.

For example, in the baseline year .3 million kcal/MWh are required to deliver 1000 MWh to the terminal points of the transmission system. If in the post-project year to deliver the same amount of electricity to the end of the transmission system only takes .291million kcal/MWh, it will be clear there has been a three percent efficiency improvement in the system's ability to deliver 1000MWh. This improvement will result from some combination of reduced line losses and increased generation efficiency due to the SCADA system.

In order to ensure the accuracy of the emission reductions will be measured on an hourly basis to allow the project developer to compare the thermal-system efficiency at a given amount of kWh delivered to the transmission system from the baseline year with the improved efficiency of the system at the same demand point in the project year.

Renewable loads and new thermal generation brought on after the initiation of the project will not be included in order to isolate the direct effect of the project on fossil fuel use and be extremely conservative. In order to isolate the fossil fuel production from other sources, the project developer will define the delivered amount used in this calculation by taking the total electricity delivered measured at the end points of the transmission system and subtract any non-thermal generation and any units installed or significantly rehabilitated after the start of the project measured at point of generation. The methodology will account for changes in fuel throughout a given year using the hourly kgCO2/kcal figure which will be determined by the average CO2 content per kcal of fuel based on type and relative quantities of fuels used.

The emissions for year x is determined for each hour in year x by multiplying the power supplied to the end of the transmission system for that hour measured in kWh by the average efficiency of the thermal units measured in kcal/kWh. The sum of this calculation performed for all the hours in a given year is a measure of the total kilocalories that have been expended in the project year. This number is then multiplied by the carbon coefficient for the project year measured in kg CO2/ kcal to get a total carbon emissions in year x. This should equal the combined total of each fossil fuel consumed multiplied by the relevant CO2 emissions factor for that fuel.

Actual Emissions in year x equals

8760

$$\sum_{i_x=1} (D_{i\ year\ x} * kcal/kWh_{Di\ year\ x}) * kgCO2/kcal_{i\ yearx}$$

Where
i = Given hour in a year
Di=Total fossil fuel generated electricity delivered in kWh at given hour i where total fossil-based electricity equals total measured electricity delivered through the transmission system minus the total non-fossil generation measured at the site of generation
$Kcal/kWh_{Di\ year\ x}$ = an efficiency factor for the fossil fuel based load at the given delivered amount in hour i (Di) as found in the project year
Year x= given project year being compared to baseline

This should equal

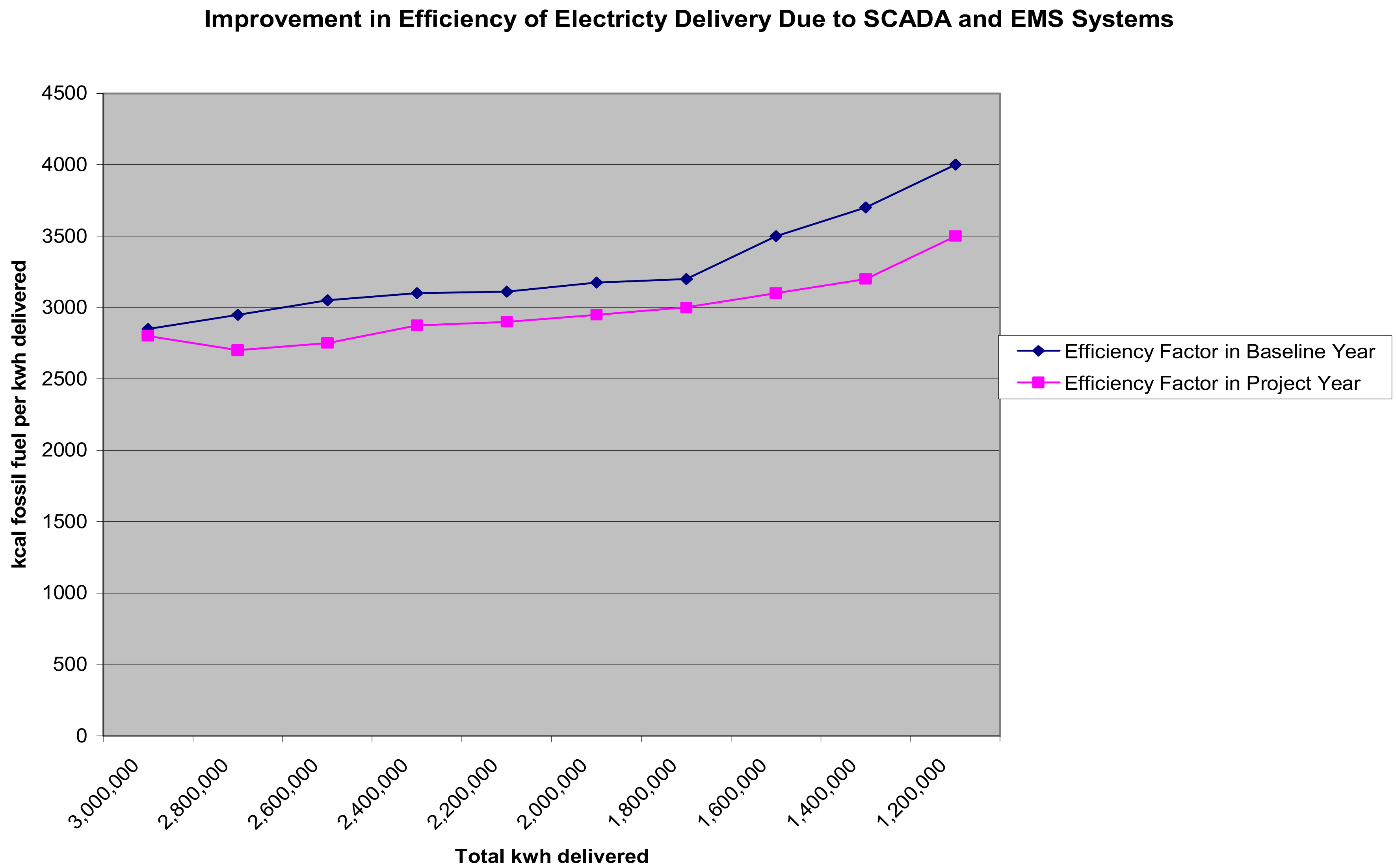
$$\sum_{Fuel_x=1}^{n} \left(\text{total kcal fuel}_x \text{ consumed in year x} * kgCO2/kcal_{fuelx}\right)$$

Where
$Fuel_x$ = the types of fossil fuel used in year x
Year x = project year
n= number of different fossil fuels consumed

The emissions reductions are simply calculated as the difference between Baseline Emissions calculated for year x and Actual Emissions calculated for year x.

Baseline $Emissions_x$ – Actual $Emissions_x$ = Emissions $Reductions_x$

The following is a demonstration of the use of the formulas using a small subset of hypothetical data. In an actual case there would be a population of 8760 data points for each hour of the baseline year and actual year. Actual data will be provided to the DOE upon project validation.


Improvement in Efficiency of Electricty Delivery Due to SCADA and EMS Systems
kcal fossil fuel per kwh delivered
4500
4000
3500
3000
2500
2000
1500
1000
500
0
3,000,000
2,800,000
2,600,000
2,400,000
2,200,000
2,000,000
1,800,000
1,600,000
1,400,000
1,200,000
Total kwh delivered
Efficiency Factor in Baseline Year
Efficiency Factor in Project Year

Hr of year x	**A** Delivered electricity to transmission system kWh	**B** Non-Fossil Power generated in kWh	**C** Generation from units not on line at the start of the project kWh	$D_{i\ year\ x}$=A-B-C Total fossil delivered to transmission system from existing project sources	Efficiency factor in year x Kcal/kWh delivered through transmission lines	Efficiency factor in base line year for same Di Kcal/kWh delivered through transmission lines	Kg CO2 / kcal* At hour i in year x
140	2,500,000	500,000	100,000	1,900,000	3000	3200	250
141	2,000,000	500,000	100,000	1,400,000	3200	3700	230
142	1,700,000	200,000	100,000	1,400,000	3200	3700	230
143	1,500,000	200,000	100,000	1,200,000	3500	4000	200

* Equals sum of all CO2 emitted by fuel burned divided by total fuel consumption in kcal in the given hour.

Baseline Emissions in year x equals

$$\sum_{i_x=1}^{8760} (D_{i\ year\ x} * \ kcal/kWh_{\ Di\ year\ 0})* \ kgCO2/kcal_{\ i\ year\ x}$$

Where i= 140
$D_{i\ year\ x}$ = 1,900,000 kWh
Kcal/kWh $_{Di\ year\ 0}$ = 3200 kcal/kWh
kgCO2/ kcal $_{i\ year\ x}$ =.000250 kg CO2/ kcal

= (1,900,000* 3200) * .000250 = 1,520,000 kg CO2 - The formula call for this equation to be done for every hour in year x and the outcomes totaled. In this case we will use the formula for just one hour and compare the same hour in the actual project case.

Actual Emissions in year x equals

$$\sum_{i_x=1}^{8760} (D_{i\ year\ x} * kcal/kWh_{Di\ year\ x}) * kgCO2/kcal_{i\ yearx}$$

Where i= 140
$D_{i\ year\ x}$ = 1,900,000 kWh
Kcal/kWh $_{Di\ year\ x}$ = 3000 kcal/kWh
kgCO2/ kcal $_{i\ year\ x}$ =.000250 kg CO2/ kcal

= (1,900,000* 3000) * .000250 = 1,425,000 kg CO2

Baseline Emissions$_x$ – Actual Emissions$_x$ = Emissions Reductions$_x$
1,520,000 kg CO2 -1,425,000 kg CO2 = 95,000 kg

This means the project eliminated 95,000 kg of emissions that would have been emitted in the baseline case without the efficiency gains at hour 140 in year x. If we had followed the formula we would have tabulated the savings for each hour over the whole year.

D.3. Quality control (QC) and quality assurance (QA) procedures are being undertaken for data monitored		
Data *(Indicate table and ID number e.g. 3.-1.; 3.2.)*	Uncertainty level of data (High/Medium/Low)	Explain QA/QC procedures planned for these data, or why such procedures are not necessary.
A-1	*L*	*The SCADA system will provide highly accurate data.*
A-2	*L*	*The SCADA system will provide highly accurate data*
A-3	*L*	*Based on sales data that can easily be tested or IPCCC defaults*
A-4	*L*	*Based on specifications at delivery can be easily tested*
A-5	*L*	*Based on delivery and sales data*
A-6	*L*	*The SCADA system will provide highly accurate data*

A-7	*L*	*The SCADA system will provide highly accurate data*
A-8	*L*	*Data will be calculate using highly accurate data from SCADA system and IPCCC defaults as appropriate*

D.4 Please describe the operational and management structure that the project operator will implement in order to monitor emission reductions and any leakage effects, generated by the project activity

The SCADA system will be designed to monitor the emissions reductions.

D.5 Name of person/entity determining the monitoring methodology:

Kevin James
Quality Tonnes

Lasse Ringius
World Bank

SECTION E. Estimation of GHG emissions by sources

E.1. Estimate of GHG emissions by sources:

There will be no project emissions from installing a SCADA system.

E.2. Estimated leakage:

NA

E.3. The sum of E.1 and E.2 representing the project activity emissions:

Zero additional emissions from project activities.

E.4. Estimated anthropogenic emissions by sources of greenhouse gases of the baseline:

Year	2008	2009	2010	2011	2012	2012	2014	2015	2016	2017
Total Anticipated Tonnes of CO_2- Baseline	11,695,325	11,695,325	11,695,325	11,695,325	11,695,325	11,695,325	11,695,325	11,695,325	11,695,325	11,695,325
Total Estimated Actual TonnesCO_2 – Post Project Additional Tonnes CO_2 Emitted in the Baseline Above the Post –Project Year	11,461,418. 233,907	11,461,418 233,907	11,461,418. 233,907	11,461,418. 233,907	11,461,418. 233,907	11,461,418 233,907	11,461,418 233,907	11,461,418 233,907	11,461,418 233,907	11,461,41 233,907

* Estimates for project years using best available data for current years extrapolated over the course of the project. Better quality baseline data from newly installed advanced meters will precede full installation of the SCADA system by one year. For the purposes of this PDD, we will assume a 2% gain in efficiency, but all the data will be validated and verified according to UNFCCC procedures.

E.5. Difference between E.4 and E.3 representing the emission reductions of the project activity:

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Total Anticipated Tonnes of CO_2 Reductions	233,907	233,907	233,907	233,907	233,907	233,907	233,907	233,907	233,907	233,907

Estimates for project years using best available data for current years extrapolated over the course of the project. Better quality baseline data from newly installed advanced meters will precede full installation of the SCADA system by one year.

E.6. Table providing values obtained when applying formulae above:

THERMAL

						Baseline		Post Project Estimate 2005	
	Kcal/MWh 2004 (In units of 100,000)	Estimated Improvement (In units of 100,000)	Kcal/MWh 2005 (In units of 100,000)	total generation in 2005 (MWh)	kgCO2/kcal (10^{-6})	kgCO2/MWh	total kgCO2	kgCO2/MWh	total kgCO2
Azerbaijan Thermal Power Plant									
1	2.5166376	0.050333	2.466305	1,427,648.0	237.4703	597.626686	853,200,542.8	585.6741521	836,136,532
2	2.888387	0.057768	2.830619	1,204,132.0	237.4703	685.906127	825,921,517	672.1880049	809,403,086.7
3	2.7853869	0.055708	2.729679	744,627.0	237.4703	661.446663	492,531,044.2	648.2177295	482,680,423.3
4	2.6950655	0.053901	2.641164	1,165,894.0	237.4703	639.998013	746,169,843.1	627.1980525	731,246,446.3
5	3.5806144	0.071612	3.509002	510,115.0	237.4703	850.289576	433,745,466.9	833.2837842	425,070,557.6
6	2.7250382	0.054501	2.670537	1,363,733.0	237.4703	647.115639	882,492,951.5	634.1733261	864,843,092.5
7	2.6444721	0.052889	2.591583	1,039,457.0	237.4703	627.983583	652,761,931.2	615.4239113	639,706,692.5
8	2.506952	0.050139	2.456813	1,562,451.0	237.4703	595.326644	930,168,709.5	583.4201107	911,565,335.3
total	2.7162894	0.054326	2.661964	9,018,060.00	237.4703	645.038059	5,816,991,916	632.1372975	5,700,652,077
Ali-Bayramli									
1	3.1340098	0.062680	3.071330	500,238.0	290.0181	908.919568	4,546,761,06.6	890.7411762	445,582,584.5
2	3.4512191	0.069024	3.382195	587,656.0	290.0181	1000.91601	588,194,296.5	980.8976859	576,430,410.5
3	2.6816141	0.053632	2.627982	818,863.0	290.0181	777.716626	636,843,369.7	762.1622937	624,106,502.3
4	3.1868865	0.063738	3.123149	721,123.0	290.0181	924.254768	666,501,370.8	905.7696723	653,171,343.4
5	3.0024709	0.060049	2.942421	658,299.0	290.0181	870.770906	573,227,616.5	853.3554876	561,763,064.1
6	3.100014	0.062000	3.038014	596,188.0	290.0181	899.06017	536,008,884.8	881.0789668	525,288,707.1
7	3.0088618	0.060177	2.948685	900,295.0	290.0181	872.624382	785,619,368.4	855.1718948	769,906,981
total	3.0526904	0.061054	2.991637	4,790,353.66	290.0181	885.33547	4,241,070,004	867.6287603	4,156,248,604
Shimal									
1									
2									
total	1.5859064	0.031718	1.554188	2066151.5	329.4356	522.454026	1,079,469,191	512.0049459	1,057,879,807
Baku									
1									
2									
total	2.4816828	0.049634	2.432049	668,230.50	336.3566	834.730389	557,792,305.1	818.0357811	546,636,459
					Total Tonnes CO2		11,695,324.52		11,461,418.03

Totals

Total Tonnes CO2 Emissions in baseline case (based on 2005 data)	11,695,325
Total Actual (estimated) Tonnes CO2 Emissions (based on 2005 data)	11,461,418
Emissions reductions (based on 2005 data)	233,907

* Note: There is not enough accurate data at this point to use the formulas provided to calculate CO2 emissions reductions. Instead the data that is available was used to estimate the potential emission reductions. Azerenerji is currently planning on installing the appropriate meters to start collecting data based on the submission of this PDD.

Year	Emissions Reductions
1	233,907
2	233,907
3	233,907
4	233,907
5	233,907
6	233,907
7	233,907
8	233,907
9	233,907
10	233,907
Total	2,339,070

SECTION F. Environmental impacts

F.1. Documentation on the analysis of the environmental impacts, including transboundary impacts:

The environmental impacts of this project are likely to be only positive. The installation of a SCADA system is benign in terms of environmental impacts and the reduced fuel consumption will only have a positive environmental impact by reducing CO2 emissions and other criteria air pollutants such as NOx, SOx, and particulate.

F.2. If environmental impacts are considered significant by the project participants or the host Party, please provide conclusions and all references to support documentation of an environmental impact assessment undertaken in accordance with the procedures as required by the host Party:

NA

SECTION G. Stakeholders' comments

G.1. Brief description how comments by local stakeholders have been invited and compiled:

Azerenerji and the Ministry of Industry and Energy have both been involved in the development of this project. An initial stakeholders meeting was held and the World Bank has required additional meetings before the implementation of the project. There are not likely to be any groups negatively affected by the installation of a SCADA system.

G.2. Summary of the comments received:

All parties were supportive of the proposed project.

G.3. Report on how due account was taken of any comments received:

NA

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

Organization:	Azerenerji ASC	World Bank Carbon Funds
Street/P.O.Box:	10, Academician A. Alizade str.	1818 H St. NW
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City:	Baku	Washington
State/Region:		DC
Postfix/ZIP:	370005	20433
Country:	Azerbaijan Republic	USA
Telephone:	(+994 12) 4984184	202-473-6381
FAX:	(+994 12) 4984117	202-522-7432
E-Mail:	abdulkhalik@azerenerji.com	lringius@worldbank.org
URL:	http://www.azerenerji.com/	www.carbonfinance.org
Represented by:	Abdulhalik Heydarov	Lasse Ringius
Title:	Chief Specialist	Senior Environmental Specialist
Salutation:	Mr.	Mr.
Last Name:	Heydarov	Ringius
Middle Name:		
First Name:	Abdulhalik	Lasse
Department:	Engineering	Carbon Finance Business
Mobile:		
Direct FAX:	(+994 12) 4984117	202-522-7432
Direct tel:	(+994 12) 4984184	202-473-6381
Personal E-Mail:	abdulkhalik@azerenerji.com	lringius@worldbank.org

Annex 2

INFORMATION REGARDING PUBLIC FUNDING

No Annex 1 public funding is being used for this project.

Annex 3

BASELINE INFORMATION

Key Variables/Parameters	Data Source
Total fossil fuel generated electricity delivered in kWh at given hour where total fossil-based electricity equals total measured electricity delivered through the transmission system minus the total non-fossil generation measured at the site of generation	Based on logged data
Kcal/kWh an efficiency factor for the fossil fuel based load at the given delivered amount of electricity in a given hour as found in the baseline year	Based on measured and logged data
kgCO2/kcal	Measured through logged data of fuel consumption by type in project year.

The first step of this project once approved will be to install appropriate meters and gather the data required to accurately establish the baseline.

Annex 4

MONITORING PLAN

ID number *(Please use numbers to ease cross-referencing to table B.7)*	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment

A-1	*Generation efficiency data given level of kWh delivered through transmission system*	*Measured at each thermal generation unit at each level of kWh delivered*	*Kcal/ kWh*	*m*	*hourly*	*100%*	*electronic*	*The SCADA system will gather and archive this data*
A-2	*Total Delivered electricity through the transmission system*	*Measured at each end point of the transmission system and totaled*	*kWh*	*m*	*hourly*	*100%*	*electronic*	*The SCADA system will gather and archive this data*
A-3	*Carbon content of fuel used*	*Measured quantities for each fuel from delivery specifications or IPCCC*	*Kg CO2/ Kcal and kg CO2 per liter, m3, etc.*	*m*	*constant*	*100%*	*electronic*	*The project developer will gather and archive this data in cases where better data exists, otherwise IPCC data may be used to determine carbon content for fuels.*
A-4	*Heat content of fuel used*	*Measured or from delivery specifications*	*Kcal/ liter of fuel oil, Kcal/ m3 of gas, kcal/tonne of coal etc.*	*m*	*Constant*	*100%*	*electronic*	*Each fuel will have a known energy content per unit*
A-5	*Total amount of each fuel type used*	*Measured at each thermal generation unit*	*Liters of fuel oil or m3 of gas, etc.*	*m*	*hourly*	*100%*	*electronic*	

A-6	*Total amount of non-fossil fuel based generation*	*Measured at generation site*	*kWh*	*m*	*hourly*	*100%*	*electronic*	*The SCADA system will gather and archive this data*
A-7	*Total Amount of electricity generated from new or significantly upgraded Fossil Fuel generation*	*Measured at generation site*	*kWh*	*m*	*hourly*	*100%*	*electronic*	*The SCADA system will gather and archive this data*
A-8	*Carbon Emissions Factor*	*Derived from data in A-3,A-4,A-5*	*Kg CO2/ kWh*	*C*	*hourly*	*100%*	*electronic*	*The SCADA system will gather and archive this data*

- - - - -

The first step once the project is approved is to install the proper meters to accurately develop the baseline and the annual data requirements for the monitoring plan.

Appendix 5
Electricity Sector Overview of Azerbaijan

*taken from a Burns and Roe Enterprises report Prepared for Azerenerji and the EBRD.

CURRENT CONDITION OF THE AZERBAIJAN ELECTRIC POWER SUPPLY SECTOR

Capacity/Demand Balance

The power-generation resource mix in Azerbaijan is composed of gas/mazut-fired thermal generating stations and hydroelectric generating stations. Of the roughly 5 GW of existing dispatchable capacity, over 80 percent of the capacity is thermal and the remaining is hydroelectric.

Little investment has been made in Azerbaijan generation assets in the past decade. Much of the system has fallen into a state of disrepair due to the inattention to facility maintenance. The bulk of the system was built during the Soviet era and is in generally poor condition. Minimal public investment and maintenance have occurred since independence, and shortages are frequent. The decline in the sector was tied to the country's economic condition in the mid-1990s. In addition, artificially low power prices and non-payment by customers resulted in little funds available to support the grid. It is also true that the majority of the existing power plants in the system are advanced in their technical life, which in recent years resulted in retiring considerable amount of capacity in power plants at Baku and Gandja. The Sumgait Power plant has been put on a reserve stand-by due to high costs to operate and maintain, and due to lack of demand for coproduced steam. Two of these three facilities are located in the eastern portion of the country closer to the load centers.

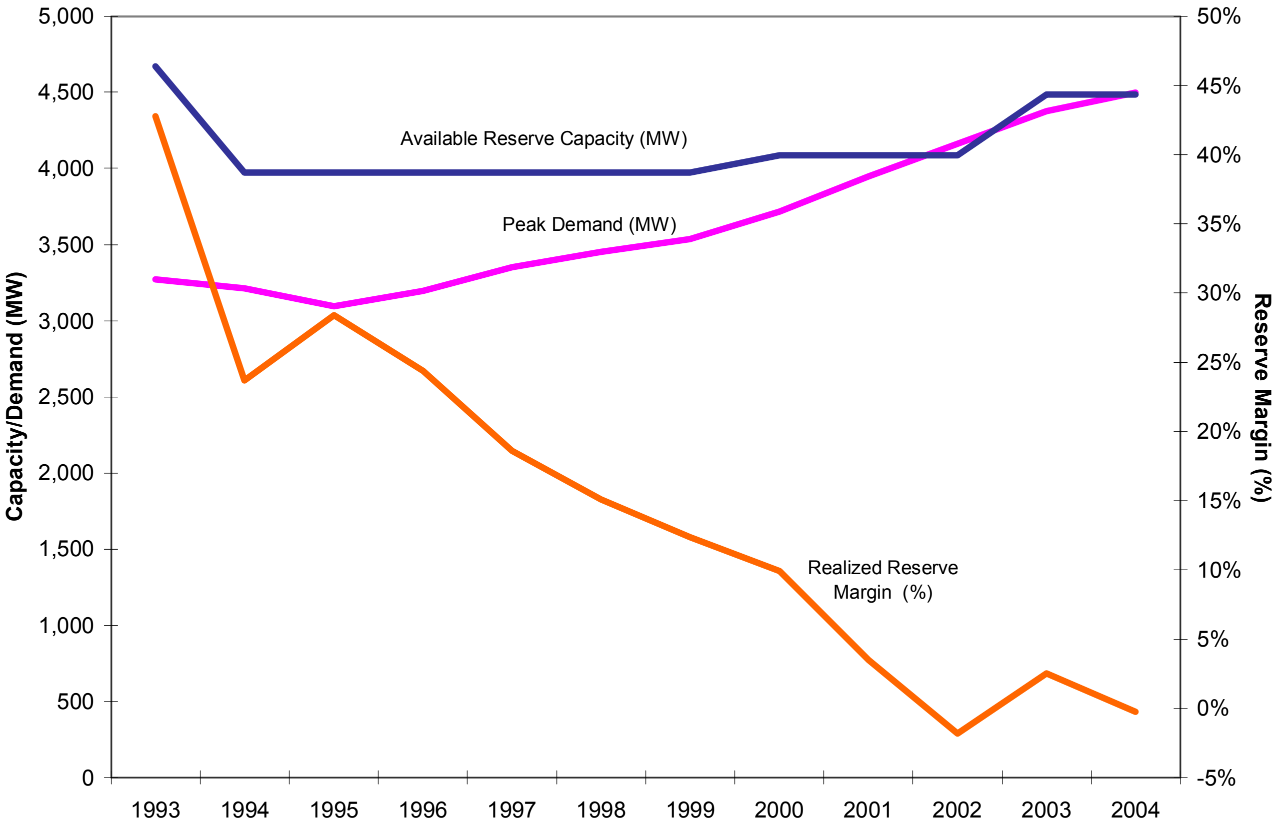
In recent years, the international donor community has provided the capital input necessary to undertake expansion of the generation capability and to restore aging facilities. In 2000 and 2001, the Yenikend and Mingechaur hydroelectric plants were completed or significantly upgraded, adding more than 400 MW to the power grid. The 400 MW Severnaya gas-fired combined cycle power plant began operation in late 2002. Azerenerji has numerous additional options to further develop the country's generation capacity or to supplement capacity at existing facilities that are considered in the Least Cost Planning study presented in this Report.

In addition to internal resources, Azerbaijan can import or export power to several neighboring countries. The design of the system in the Soviet era relied heavily on the exchange of power across regions (Georgia, Azerbaijan, Russia and Armenia in particular) and tended to centrally locate the power plants in order to serve the import and export functions. As such, the Azerbaijan system has a relatively broad network that extends outside of the load centers and offers a fair amount of opportunity for expansion, but unfortunately offers distant placement of power generating facilities from the load. After the collapse of the Soviet Union, the bulk of Azerbaijan's generating capacity was located in the western portion of the country while the majority of the consumption was in the eastern part. Now as an independent country, Azerbaijan cannot rely heavily on cross-border transmission interconnections for various reasons including political and economic issues. Firm commitments for cross-border exchange transactions have been relatively limited. Other than the purchases from Russia over a 320 MW transmission line, no long-term agreements are in place or anticipated. One of the key issues confronting Azerbaijan power sector planners is how to counteract the regional supply and demand imbalance created by the previous integrated regional plan. Also contributing to the limited cross-border transactions are socio-political issues between Azerbaijan and Armenia regarding the Nagorno-Karabakh Region.

Within Azerbaijan, the transmission grid spans most areas of the country and is capable of serving all the major load areas. However, the transport of power from generation sources in the west to load centers in the east is subject to high losses on the transmission system and the reliability of the network is low. In addition, the maintenance on the transmission network has been limited (as it has on power plants) such that the network has been subject to frequent breakdowns. The analysis considers each distribution region with the exception of Nakhchivan, which is not included in this analysis.

Capacity Balance

Exhibit 1
Estimated Historical Capacity Balance at Peak



The capacity balance within a given area is determined by two main contributing factors: 1) peak demand[1]; and 2) the capacity available to supply peak demand reliably. Ideally, a system should have in place enough capacity in the form of internal capacity or firm imports to not only supply peak demand, but to also ensure a certain level of reliability by maintaining capacity above the peak requirement. This additional capacity frequently is called the reserve margin capacity and is intended to account primarily for risk of generation outages and demand fluctuations that may occur at peak. Planning reserve margins are driven by reliability goals that take into account the system composition. Several general rules of thumb that are applicable to reserve margins are:

[1] The highest electric requirement occurring in a given period.

- The less reliable existing supply, the greater reserve margins should be.
- The smaller a system, the greater reserve margins should be.
- The less well interconnected to neighboring regions, the greater reserve margins should be.
- The less diverse the regional supply mix, the greater reserve margins should be.
- The greater the size of largest plant relative to the peak load, the greater the reserve margins should be.
- The more non-dispatchable resources, such as run-of-river hydro in the system, the greater the reserve requirement.
- As economies grow, the value of lost load increases, and reserve margins should be higher.

Taking these concepts into account, the planning reserve margin for Azerbaijan should be high, certainly above 20 percent. However, as seen in Exhibit 1, the current reserve margin in Azerbaijan, based on available capacity, is essentially non-existent. Hence, the system is not reliable at peak load conditions. This is evidenced by the numerous outages and unserved energy that have occurred in Azerbaijan during the last ten years. Expected increases in peak demand, due to economic recovery and program goals, will put a high strain on the system in upcoming years and significant investment is required to serve peak demand reliably.

Energy Balance

As mentioned above, frequent instances of outages and unserved energy have occurred within Azerbaijan. Exhibit 2 presents the historically served peak demand and electrical energy requirements on the system. As can be seen, there were significant declines in electrical energy use beginning in the early 1990s. This drop does not reflect a drop in the typical demand levels required by consumers, but rather reflects drops in electrical energy use associated with the inability to serve all consumer requirements. Electrical energy use dropped nearly 5,000 GWh (over 20%) from maximum levels reached in the late 1980s. This represents a significant decline in the service provided to the local populations. Although this decline is also tied to economic downturn and loss of industrial activity, electrical heating demands actually increased during this period putting upward pressure on the energy requirements. The level of unserved energy estimated in the 2004 market is slightly above 1600 GWh per year or roughly 6 percent of total energy demand.

Exhibit 2
Historical Peak Demand, Energy Consumption and Sales

Year	Peak Demand (MW) Note 1		Gross Electrical Energy (GWh) Note 1		Load Factor (Note 1)		
	MW	% Growth	GWh	% Growth	%	GWh	% Growth
1986	3,410	-	21,903	-	73.3	17,047	-

1987	3,776	10.7	22,478	-1.9	68.0	17,453	2.4
1988	3,733	-1.1	22,987	2.3	70.3	17,931	2.7
1989	3,818	2.3	22,773	-0.9	68.1	17,950	0.1
1990	3,676	-3.7	21,452	-5.8	66.6	17,116	-4.6
1991	3,921	6.9	21,613	0.8	62.9	17,507	2.3
1992	3,513	-10.4	19,042	-11.9	61.9	15,290	-12.7
1993	3,365	-4.2	19,037	0	64.6	14,566	-4.7
1994	3,213	-4.5	17,758	-6.7	63.1	13,644	-6.3
1995	3,098	-3.6	16,957	-4.5	62.5	12,974	-4.9
1996	3,195	3.2	17,006	0.3	60.8	13,276	2.3
1997	3,350	4.9	17,451	2.6	59.5	12,968	-2.3
1998	3,452	3.0	18,145	4.0	60.0	14,263	10.0
1999	3,536	2.4	18,816	3.7	60.7	15,002	5.2
2000	3,719	5.2	19,097	1.5	58.6	15,608	4.0
2001	3,712	6.2	21,088	10.4	64.9	16,162	3.5
2002	3,950	6.4	23,029	3.3	66.6	18,301	11.6
Note 1: On a gross generation basis; i.e. inclusive of power station consumption and transmission and distribution losses.							

Source: JSC Azerenerji.

In order to reliably serve both energy and peak demand requirements, Azerbaijan needs to develop a plan that will consider:

1. Implementation of "must do" (i.e., emergency) rehabilitation projects to existing facilities that serve the most urgent needs of the system.

2. Implementation of upgrade and rehabilitation measures in the short term (i.e., before the time when new capacity can be built) will improve both capacity and energy generation balances.

3. Implementation of a new power plant construction plan that will introduce modern efficient technologies, sited closer to the demand centers, that will gradually replace the aging, less efficient existing units.

Generation

Responsibility for the production and transmission of electric energy in the Republic of Azerbaijan rests with the State owned Azerenerji Joint Stock Company. In addition to electric supply, Azerenerji is also responsible for the production and supply of thermal energy (both hot water and process steam) to certain industries and to district heating companies.

Selected performance characteristics of Azerenerji's existing thermal and hydroelectric power plants are presented on Exhibits 3 and 4, respectively.

The Azerenerji's electric power system has a total installed design capacity of about 5,562 MW of which about 4,607 MW is thermal and about 955 MW is hydroelectric. During 2001, the power system experienced a maximum demand of 3,950 MW.

Today, Azerbaijan finds itself in a situation where about 80 percent of its generating capacity is located in the western part of the country, while 70 percent of its load occurs in the eastern part of the country on the Apsheron Peninsula. As a consequence of this, fuel is transported several hundred kilometers from the Apsheron Peninsula to the 2,400 MW Azerbaijan Power Plant (Azgres) and the 1,100 MW Ali Bayramli Power Plant and bulk power is then wheeled back to the Apsheron Peninsula. While the eastern and western parts of Azerbaijan are connected by two 500 kV transmission lines (one of which is operated at 330 kV) they experience significant losses and frequent interruptions in service.

Though the design capacity of Azerenerji's generating assets is about 5,562 MW, actual available capacity is only about 4,535 MW. The design capacity has been derated for several reasons, in particular, the age of generating units, inadequate funds to procure spare parts and non-performance of required maintenance. Today more than 35% of Azerenerji's generating capacity is over 30 years old. Another factor which has had a significant adverse impact on the performance (both capacity and heat rate) of thermal generating plants is that natural gas supply for power generation has declined in recent years necessitating increased use of mazut for power generation. While essentially all of the thermal generating units can fire both natural gas and heavy fuel oil, their performance on heavy fuel oil has been particularly poor.

The following sections provide a description of the existing thermal and hydroelectric power facilities.

Thermal Power Plants

Azerenerji operates seven thermal generating plants comprised of a total of 27 units (See Exhibit 3).

The following paragraphs describe the existing thermal power plants and the main problems encountered at these plants:

I.

a. Azerbaijan Power Plant (Azgres)

II.

The Azerbaijan Power Plant is the largest generating plant in the country, located near the city of Mingechaur, approximately 280-km west-northwest of Baku. The plant consists of eight (8) 300 MW supercritical units that are designed to fire both natural gas and mazut. The units at this plant were installed between 1981 and 1990 and are among the youngest and most efficient thermal units in Azerenerji's supply system.

The performance of the plant has degraded in recent years due to extensive mazut firing, improper design and insufficient funds for maintenance and repair. Some of the problems affecting the performance of the plant include: corroded regenerative air heater elements, defective LP and IL/LP last stage steam turbine blading and plugged boiler screen tubes. Moreover, the station is experiencing significant cooling water problems. As a consequence of these and other problems, the station design capacity of 2400 MW has been derated by about 400 MW and the average full load unit heat rate has increased by approximately 20 percent, from a design value of 2290 kcal/kWh to about 2780 kcal/kWh.

b. Ali Bayramli Power Plant

The 1100 MW Ali Bayramli Power Plant is located in the town of Ali Bayramli approximately 110-km southwest of Baku. The plant consists of seven natural gas/mazut fired generating units. The first four units, installed in 1962 and 1963 have a design rating of 155 MW, whereas the last three units, installed in 1966 and 1967 have a design rating of 160 MW.

The performance of the plant has been poor due to extensive mazut firing, age, improper design and lack of maintenance and replacement parts. At present, the plant has been derated from 1100 MW to about 800 MW and the average full load heat rate has increased by about 26 percent, from a design value of 2530 kcal/kWh to about 3,190 kcal/kWh. Some of the major problems affecting efficiency, capacity and availability of the plant include:

- worn and leaking electric generator hydrogen coolers
- plugged condenser tubes due to fouling and erosion
- corrosion of the regenerative air heaters due to mozut luriary
- sealing of high pressure feedwater heater tubes

c. Severnaya Power Plant

The Severnaya Power Plant is located on the north coast of the Apsheron Peninsula approximately 40 km northeast of Baku. Unit No. 7 is a 150 MW (design) natural gas fired unit. The unit is currently 43 years old, having been commissioned in 1960. The effects of aging, boiler fouling due to the mazut firing with inoperable sootblowers, and condenser fouling and erosion due to the quality of circulating water, have resulted in a significant degradation of performance. Consequently, the unit capacity has been derated from 150 MW to 80 MW and its full load heat rate has increased from a design value of 2350 kcal/kWh to 3690 kcal/kWh. Azerenerji plans to retire unit No. 7 at the end of 2003.

Also on the Severnaya Plant site, Azerenerji commissioned the 400 MW gas fired Severnaya Combined Cycle Unit No.1 in November 2002. This unit was constructed with financing provided by the Japan Bank for International Cooperation (JBIC). This unit is the most efficient unit in the country with a design efficiency of nearly 57%.

d. Baku 1 Combined Heat and Power Plant (Cogeneration)

Baku 1 Combined Heat and Power Plants is located on the outskirts of Baku on the south shore of the Apsheron Peninsula. Baku 1 consists of two (2) 53 MW (nominal) gas-fired gas turbine cogeneration units. Unit No. 1 was placed in service in October 2000 and Unit No. 2 was placed in October 2001. Each unit consists of an ABB GT8 gas turbine that exhausts to an HRSG. Only the second unit at Baku 1 is equipped with a by-pass stack.

The plant provides process steam to the Azneftyag (SOCAR) refinery, a textile factory and to other process heat users in Baku. While each unit has a design capacity of 53

MW, the units have been limited to a maximum output of 45 MW owing to a design problem with the fuel gas compressor that is currently in the process of rectification by the manufacturer.

The main problem affecting operations at the Baku 1 CHP Plant is that, because of the absence of traveling screens at the plant water intake and strainers on the pump suctions, debris is entering the plant water system. While the absence of intake screens does not impact rated capacity or efficiency, if could adversely impact availability/reliability.

e. Sumgait 1 and 2 Combined Heat and Power Plant

Sumgait 1 and 2 Combined Heat and Power (CHP) Plants are located approximately 40-km north-northwest of Baku. The two CHP plants are separated by a distance of about 2km. Both plants were designed to provide export steam for nearby chemical plants that are no longer in operation.

Operations at Sumgait 1 (230 MW nominal) consist of four boilers, three 60 MW condensing/extraction steam turbines and one 50 MW backpressure steam turbine. The steam turbines were placed in service between 1959 and 1962 and are, therefore, more than forty years old.

Operations and Sumgait 2 (220 MW nominal) consist of five boilers, two 60 MW condensing/extraction steam turbines and two 50 MW backpressure steam turbines. The steam turbines were placed in service between 1966 and 1972 and are, therefore, all more than thirty years old.

Both Sumgait 1 and 2 CHP Plants were shut down and placed on standby reserve in February 2002 due to their very high fuel consumption (heat rate of 20,500-23,400 kJ/kWh) resulting from the absence of any export steam demand. The boilers fire mazut and gas. Primarily due to the absence of process heat demand, the maximum combined capacity of both Sumgait CHP 1 and 2 is limited to between 100 and 120 MW.

Exhibit 3
Selected Performance Characteristics
Azerenerji's Existing Thermal Plants

Unit Name	Capacity Type	Online Year	Full Load Heat Rate (kWh)	Fixed O&M ($/MWh)	Variable O&M ($/MWh)	Design Capacity (MW)	Available Capacity (MW)	Fuel Type
Azgres Power Plant (1)								
Unit 1	Steam	1981	11,131	26.0	0.47	300	245	Gas/Oil
Unit 2	Steam	1982	11,131	26.0	0.47	300	245	Gas/Oil
Unit 3	Steam	1983	11,131	26.0	0.47	300	245	Gas/Oil
Unit 4	Steam	1984	11,131	26.0	0.47	300	245	Gas/Oil
Unit 5	Steam	1985	11,131	26.0	0.47	300	245	Gas/Oil
Unit 6	Steam	1986	11,131	26.0	0.47	300	245	Gas/Oil
Unit 7	Steam	1989	10,734	26.0	0.47	300	270	Gas/Oil
Unit 8	Steam	1990	10,734	26.0	0.47	300	270	Gas/Oil
Azgres Power Plant (2)								
Unit 1	Steam	1962	13,012	26.3	0.30	155	128	Gas/Oil
Unit 2	Steam	1962	13,012	26.3	0.30	155	128	Gas/Oil
Unit 3	Steam	1963	13,012	26.3	0.30	155	128	Gas/Oil
Unit 4	Steam	1963	13,012	26.3	0.30	155	128	Gas/Oil
Unit 5	Steam	1986	12,172,	26.3	0.30	160	128	Gas/Oil
Unit 6	Steam	1987	12,172	26.3	0.30	160	127	Gas/Oil
Unit 7	Steam	1988	12,172	26.3	0.30	160	127	Gas/Oil
Baku 1								
GT 1	CHP Thermal	2000	7,404	8.8	1.23	53	53	Gas
GT 2	CHP Thermal	2001	7,404	8.8	1.23	53	53	Gas
Shimal (Severnaya) (4)								
CC!	Combined Cycle	2002	6,056	23.6	1.05	400	400	Gas
Unit 7	Steam	1960	14,650	- -	- -	150	80	Gas/Oil
Sumgait 1								
08	CHP Thermal	1959	17,719	22.9	5.02	60	**(3)**	Gas/Oil
09	CHP Thermal	1960	17,719	22.9	5.02	60	**(3)**	Gas/Oil
10	CHP Thermal	1961	17,719	22.9	5.02	60	**(3)**	Gas/Oil
11	CHP Thermal	1962	17,719	22.9	5.02	60	**(3)**	Gas/Oil
Sumgait 2								
1	CHP Thermal	1966	22,476	19.8	2.81	60	**(3)**	Gas/Oil
2	CHP Thermal	1967	22,476	19.8	2.81	50	**(3)**	Gas/Oil
3	CHP Thermal	1971	22,476	19.8	2.81	60	**(3)**	Gas/Oil
4	CHP Thermal	1972	22,476	19.8	2.81	50	**(3)**	Gas/Oil

(1) Azgres unit heat rates and available capacities reflect average values for Units 1-6 and 7-8.
(2) Ali Bayramli units heat rates and available capacities reflect average values for units 1-4 and 5-7.

(3) Both Sumgait 1 and 2 are currently in reserve shutdown due to the lack of process steam demand and the station's very high heat rates. Emergency capacity from these stations is limited to 100-120 MW.

(4) Shimal Unit 7 is planned for the end of 2003.

Hydroelectric Power Plants

The main waterway on which Azerbaijan's hydroelectric plants have developed is the Kura River. This river, which is more than 1500 km long, originates in Turkey flows through parts of Georgia, traverses Azerbaijan and drains into the Caspian Sea. At present, Azerenerji operates four hydroelectric plants along the river. The following sections describe Azerenerji's existing hydroelectric plants. Selected performance characteristics of the existing hydroelectric plants are presented in Exhibit 4.

Exhibit 4
Performance Characteristics of The Existing Hydroelectric Plants

Name	River	Purpose	Year of Commission	Installed Capacity (MW)	Available Capacity (MW)	Number of Units	Fixed O&M ($/kW-yr)	Variable O&M ($/MWh)
Shamkhir	Kura	Power, Irrigation, Fishing, Water Supply	1981/1982	380.0	380	2	5.0	0.22
Mingechaur	Kura	Power, Irrigation, Fishing, Water Supply	1953/1955 (1)	409	409	6	6.0	0.3
Yenikend	Kura	Power, Irrigation, Fishing, Water Supply	2000/2002	150	150	4	5.0	0.15
Varvara	Kura	Power	1956/1957	16.5	6.3	3	14.3	0.07

(1) Units 5 and 6 were reconstructed in 1999, Unit 2 in 2000 and Unit 4 in 2001.

a. Shamkhir Hydroelectric Power Plant

Shamkhir is the uppermost plant on the Kura River. The facility was completed in 1982 and houses two 190 MW Kaplan turbines with vertical-shaft synchronous generators.

The design head is 47.5 m. The annual energy expected from the facility is 830 GWh, which gives a plant factor of 24%. The actual average power production from 1986 to 2002 is reported to be 772 GWh. The catchment area at the dam site is 40,500 kM^2 and the average annual inflow is 315 m^3/s. The crest length of the embankment dam is 1,700 m with a maximum height of 70m. The reservoir ensures the long-term regulation and has a useful volume of 1,420 million m^3.

The major operational problem is the turbine discharge ring in Unit 1. The discharge ring had been incorrectly installed. A portion of the ring became dislodged in 1989 when the unit was in operation and caused significant damage to the turbine. The discharge ring was replaced, but for some reason to a different profile. Since that time, the ring has been a constant problem. Plates on the discharge ring have had to be replaced and on three occasions the runner blades were returned to the manufacturer for refinishing.

b. Mingechaur Hydroelectric Power Plant

The Mingechaur plant was commissioned in 1955 and for many years was the largest source of peak power in the whole Transcausican power system. The maximum height of the earth fill dam is 80 m, the crest length is 1,500m. The reservoir has a useful volume of 9,000 million m^3, which ensures yearly regulation of the river for power generation, flood control, and irrigation. The installed capacity is 360 MW (6 x 60 MW units). The turbines are the Francis type, which operate under a maximum gross head of 65 m.

c. Varvara Hydroelectric Power Plant

The Varvara plant is immediately downstream of the Mingechaur dam. The purpose of the plant, which was commissioned in 1958, is to re-regulate the outflows from the Mingechaur station on a daily basis and satisfy the needs of the irrigation system. The plant has three 5.5 MW units, giving a plant capacity of 16.5 that have a design head of 5.5m. It was reported that the units are capable of generating 6.3 MW.

The annual generation from the plant from 1987 to 2002 is reported to be 76 GWh, giving a plant capacity factor of 52.4%. The expected annual energy is 90 GWh, a plant capacity factor of 62%.

The plant was commissioned in 1955 and still utilizes its original equipment. The station was left in disrepair after the fall of the FSU and was not rehabilitated until 1993. Because of the present state of the equipment, this station warrants a complete renovation including the switchyard equipment. It is reported that when three units are fully operational, water is still discharged over the spillway. Therefore, it is evident that the capacity could be increased according to a previous study (See Ref.15). The hydro-mechanical components and civil structures of the plant are all in need of refurbishment. As only a little of half of the available flow passes through the hydro plant, there may also be an opportunity to augment the plant or replace it with a larger installation to bring the total capacity to about 25-30 MW. This plant will always remain a base load plant and its rehabilitation and expansion should be evaluated as such.

d. Yenikend Hydroelectric Power Plant

The Yenikend plant was planned during Soviet times as a four unit project (4 x 37.5 MW). Construction began in 1984 but was interrupted in 1990 due to financing problems. The first three units were ultimately completed in 2000 and unit 4 was commissioned in March of 2003.

The project includes a 27.5 m high, 2900 m long zoned earthfill embankment dam, with a concrete lined upstream face to protect against erosion. The powerhouse is located in the dam embankment and houses four 37.5 MW horizontal bulb units, which have an operating head range of 12.5 to 18.5 m, and two step up transformers. The concrete spillway is located to the left of the powerhouse and has four 11 m wide chutes capable of passing a 1 in 100 probable flood.

Transmission System

Azerbaijan used to be part of the Transcaucasus Interconnected Power System and, therefore, its generation capacity was installed in the center of the electric load. Subsequent to the collapse of the Former Soviet Union, Azerbaijan was left with a situation in which large distances between its generation and load centers need to be crossed using an extensive high voltage transmission network. This network consists of:

- 250 km of 500 kV single circuit lines
- 1204 km of 330 kV single circuit lines
- 115 km of 220 kV double circuit lines
- 1054 km of 220 kV single circuit lines
- 2210 km of 110 kV single circuit lines
- 1 substation 500/330/220 kV
- 1 substation 500/330 kV
- 3 substations 330/220/110 kV
- 6 substations 330/110 kV
- 10 substations 220/110 kV

The transport of energy from generating plants in the West to the load centers in the East results in considerable losses. The reliability of the transmission lines is very low due to pollution that results in frequent breakdowns and due to winds that can blow up to 40 m/sec.

Transmission links to Georgia have been disconnected while those to Dagistan in Russia remain active. Currently, talks are underway to reconnect the power systems of Azerbaijan, Georgia and Russia. A 57 km, 230 kV transmission line is under construction to facilitate exchange of power with Iran. Both Turkey and Iran have interconnections to Nakhichevan to provide power to this region that is isolated from the mainland due to hostilities with Armenia. At present, there are no direct links to Turkey.

Central Dispatch Center

The electrical system is controlled by a Central Dispatch Center (CDC) located in Azerenerji's head office building in the capital city of Baku. The CDC was built in 1945. It was designed to control the distribution of electricity produced at power plants and transmitted by the main 110 kV, 220 kV, 330 kV and 500 kV high voltage transmission lines. The hardware in the CDC for the information collection system has deteriorated over the last ten years. The de-multiplexing equipment RPT-80, Remote Terminal Units RTU, the telecommunication devices and the computer software are all of obsolete design. It is impossible to find spare parts for the equipment. The data processed by these devices have higher relative errors and the information generated is unreliable and inaccurate. The computer operating system is slow and does not have enough memory. The CDC does not meet the requirements of a modern on-line energy Supervisory Control and Data Acquisition system (SCADA). Therefore, full potential of the CDC cannot be realized in economic dispatch of power generation.