

Environmental Assessment Report

Summary Environmental Impact Assessment
Project Number: 43406
September 2009

AZE: Janub 760 MW Combined-Cycle Power Plant Project

Prepared by Cleaner Production & Energy Efficiency Center on behalf of Azerenerji Joint Stock Company of the Republic of Azerbaijan for the Asian Development Bank (ADB).

The summary environmental impact assessment is a document of the borrower. The views expressed herein do not necessarily represent those of ADB's Board of Directors, Management, or staff, and may be preliminary in nature.

CURRENCY EQUIVALENTS

(as of 28 September 2009)

Currency Unit	–	Azerbaijan new manta/s (AZN)
AZN1.00	=	\$1.242
\$1.00	=	AZN0.804

ABBREVIATIONS

ADB	–	Asian Development Bank
CO	–	carbon monoxide
CO ₂	–	carbon dioxide
DCS	–	digital control system
EU	–	European Union
GE	–	General Electric
HRSG	–	heat recovery steam generator
NO _x	–	nitrogen oxides
SO ₂	–	sulphur dioxide
S/S	–	substation

WEIGHTS AND MEASURES

C	–	Celsius (centigrade)
ha	–	hectare(s)
kg	–	kilogram(s)
kJ	–	kilo Joule(s)
kWh	–	Kilowatt-hour
kV	–	kilo Volt(s)
mg	–	milligram(s)
mm	–	millimeter(s)
MW	–	mega Watt(s)
MVA	–	mega Volt-Ampere(s)
s	–	second(s)
t	–	ton (metric) – 1,000 kg

NOTE

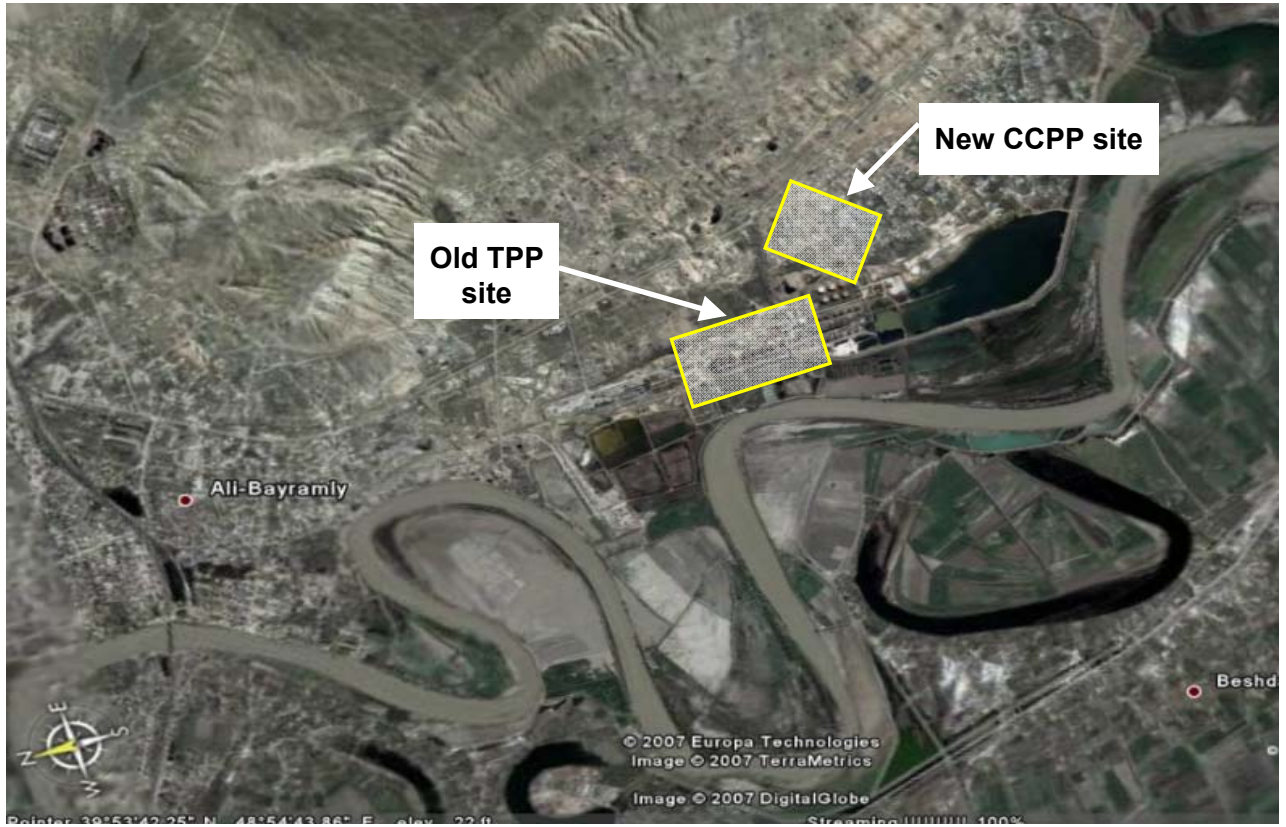
In this report, "\$" refers to US dollars.

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Map 1: Overview of the Project Site



I. INTRODUCTION

1. Government-owned Azerenerji Joint Stock Company (Azerenerji) is responsible for electricity production, transmission, and distribution in Azerbaijan. The company is planning to expand generating capacity and improve the efficiency of Azerbaijan's power system by constructing new power plants and upgrading old, inefficient plants.
2. In 1995, the ENERGO GROUP company prepared "Recommendations to the Government of Azerbaijan for Improvements of the Power Sector to 2010", supported by the Technical Assistance to the CIS countries (TACIS) Development Program for Azerbaijan. These recommendations formed the basis of the Republic Power System Development Plan up to 2010. Recommendations included reconstructing the second most important power plant in Azerbaijan, the 1,050 megawatts (MW) Shirvan Thermal Power Plant Limited (Shirvan), where the thermal generating units were constructed in 1962. Given the poor condition of Shirvan's thermal power units, it has been planned since 2002 by Azerenerji to gradually replace them with higher-capacity combined-cycle units.
3. As the first of the replacement plan, at the request of Azerenerji JSC, Alstom Power Company is constructing a new 240 MW combined-cycle units on a vacant site of the power plant. This is the initial stage of Shirvan reconstruction. After commissioning this unit, one of the old thermal power units will be taken out of operation. The cost of this project is about \$140 million and the repayment period for the investment will be 7 years. The subsequent plan involves replacement through construction of a total 760 MW combined cycle plant, Janub (Project)
4. The Government of Azerbaijan considers this power project to be of state importance and agrees to be its guarantor. Azerenerji, with the guarantee of the Government of Azerbaijan, has raised over half of the financing through commercial banks and now has requested the Asian Development Bank (ADB) to consider providing assistance to fill the financing gap for this Project that the second phase of commercial bank financing could not fulfil due to the global financial crisis.
5. Azerbaijan's energy system includes 10 thermal power plants and four hydro power plants. Total installed capacity in 2007 was 5,442 MW. Available power was 4,640 MW. Characteristics of Azerbaijan's power plants are outlined in Table 1.
6. The newer power plant, Shimal-1, has a single-shaft gas turbine. The coefficient of efficiency of this power plant is 54%. The oldest plant, Shirvan, has coefficient of efficiency of not exceeding 27%. The consumption of conventional fuel is approximately 450 grams per kilowatt-hour (g/kWh).
7. There was a developed National Power System Development Program for the period till 2015 to cover the existing winter electricity shortage as well as provision expanding energy-requirement. The program provides stable growth of power by 2 ways, construction of the new generations and rehabilitation of existing power plants. Reconstruction of Shirvan is a component of the program.

Table 1: Some Features of Azerenerji Thermal Power Plant

No	Power Plant	Installed Capacity (MW)	Available Power (MW)	Year of Commissioning
A. Thermal Power Plant (TPP)				
1.	Shirvan	1,050	890	1960
2.	Az	2,400	2,100	1981–1991
3.	Baki	106	106	2000
4.	Shimal	400	350	2002
5.	Astara	87	87	2006
6.	Sheki	87	87	2006
7.	Khachmaz	87	87	2006
8.	Nahchivan	87	87	2006
9.	Baki	104	104	2006
10.	Babek	60	50	2006
Subtotal (A)		4,468	3,948	
B. Hydro Power Plant (HPP)				
1.	Mingechaur	104	330	
2.	Var-Vari	16.5	13	
3.	Shamkir	380	190	
4.	Enikend	150	135	
5.	Araz	22	20	
6.	Vaixir	4.5	4	
Subtotal (B)		974	692	
Total		5,442	4,640	

MW = megawatt.

Source: Azerenerji

II. STATUS OF SHIRVAN THERMAL POWER PLANT

8. The project site is accessible via an asphalt roadway and there is an existing railway spur within the site. Existing infrastructure and power plant support structures, such as cooling water intake and discharge structures, transmission system, and housing for operating personnel, will be renovated.

9. The proposed facility is not expected to negatively impact municipal infrastructure, since staffing levels are not expected to increase significantly. In addition, according to Azerenerji, implementation of the proposed Project will not create any demographic changes in the adjoining area.

10. The existing Shirvan, with its seven 1960s 150 MW steam turbine generating units, is the second largest power plant in Azerbaijan, and strategically important to the country's power system. In light of this, reconstructing and re-equipping the power plant is one of Azerenerji's most important projects.

11. The Shirvan is located near Shirvan City, on the banks of Kura River, approximately 110 km southwest of Baku (see Map 1).

12. This power plant has an outdoor arrangement—i.e., there is no turbine enclosure. The main source of fuel, natural gas, is supplied by a gas pipeline, while oil is supplied by train.

Materials are delivered to the power plant by railway as well as by a road that links up to one of Azerbaijan's main highways.

13. The power plant has the following facilities: maintenance workshops for repairing thermal and electrical equipment, a chemical laboratory, a water-treatment plant, warehouses, a storage facility for chemical reagents, fuel tanks, and other maintenance infrastructure facilities. In summary:

- (i) Total installed capacity of Shirvan is 1,050 MW, consisting of seven units at 150 MW each.
- (ii) Shirvan is an "open-type" power plant with a steam turbine manufactured in Soviet times by Kharkov Turboatom (based in present-day Ukraine).
- (iii) The power plant was put into operation in 1962.
- (iv) In 2006, the plant generated 5.6 billion kWh, accounting for about 25% of the entire energy output of the Azeri power grid.
- (v) Water from the Kura River is used for cooling.
- (vi) There are six water tanks of 20,000-metric ton (t) capacity and 10 water tanks of 5,000 t capacity.
- (vii) Three 630-millimeter (mm) gas pipelines (operating at a pressure of 9 bars) are available on the site.
- (viii) There are three substations (S/S) on the site of the power plant:
 - (a) A 330-kilovolt (kV) S/S and two autotransformers with 240 mega Volt-Amperes (MVA) each, erected in 1980.
 - (b) A 220 kV S/S and five transformers with 220 MVA each, erected in 1964.
 - (c) A 110 kV S/S and two transformers with 220 MVA each, erected in 1964.
 - (d) Two 220/110kV autotransformers with 220 MVA each.
- (ix) Eight 110 kV transmission lines, three 220 kV transmission lines, and two 330 kV transmission lines derive from these substations.

14. It is important to emphasize that Shirvan, including its infrastructure and network system, is antiquated and needs to be reconstructed.

Figure 1: Combined-Cycle Gas Turbine (CCGT) Generation Facility on the Selected Site

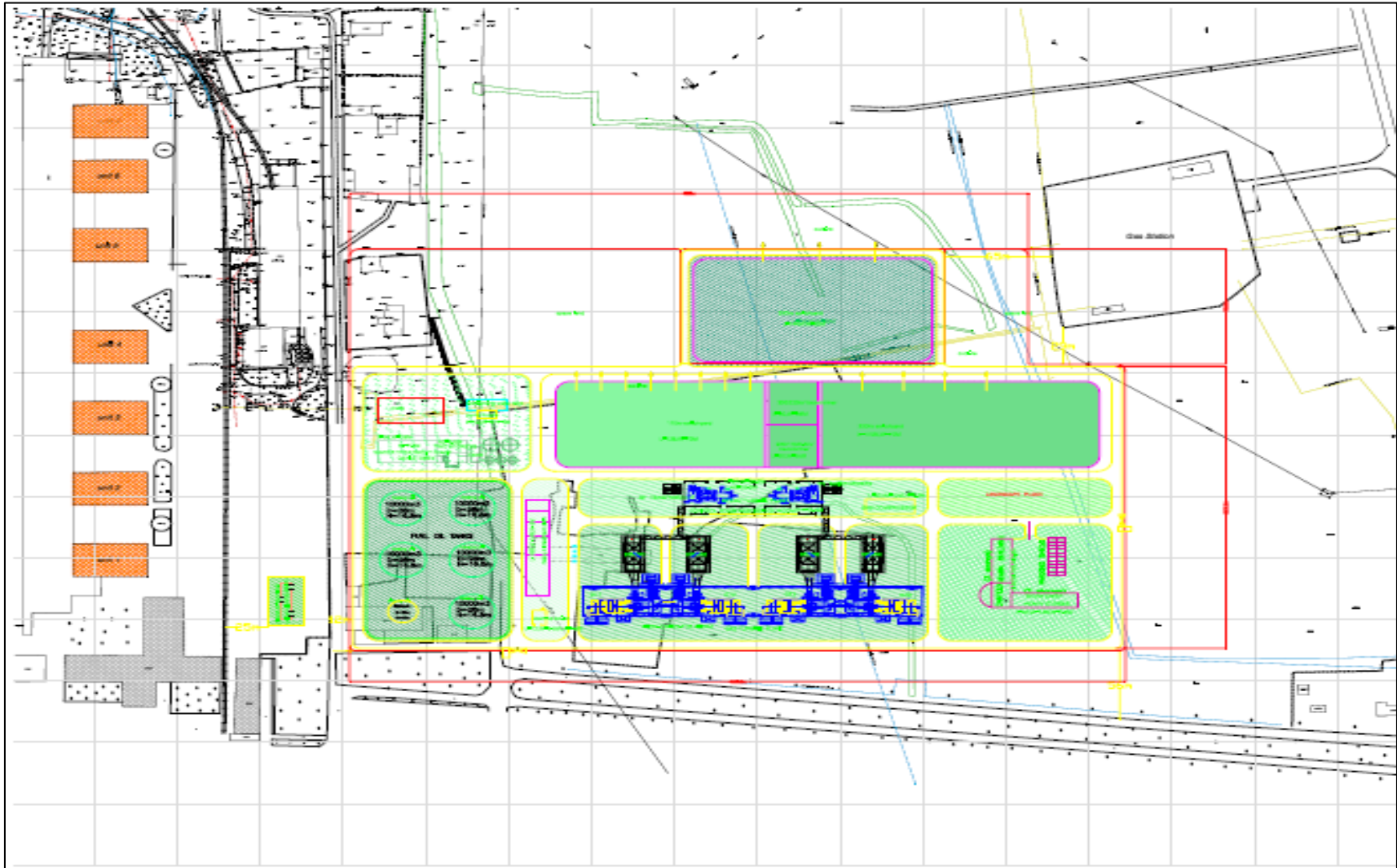
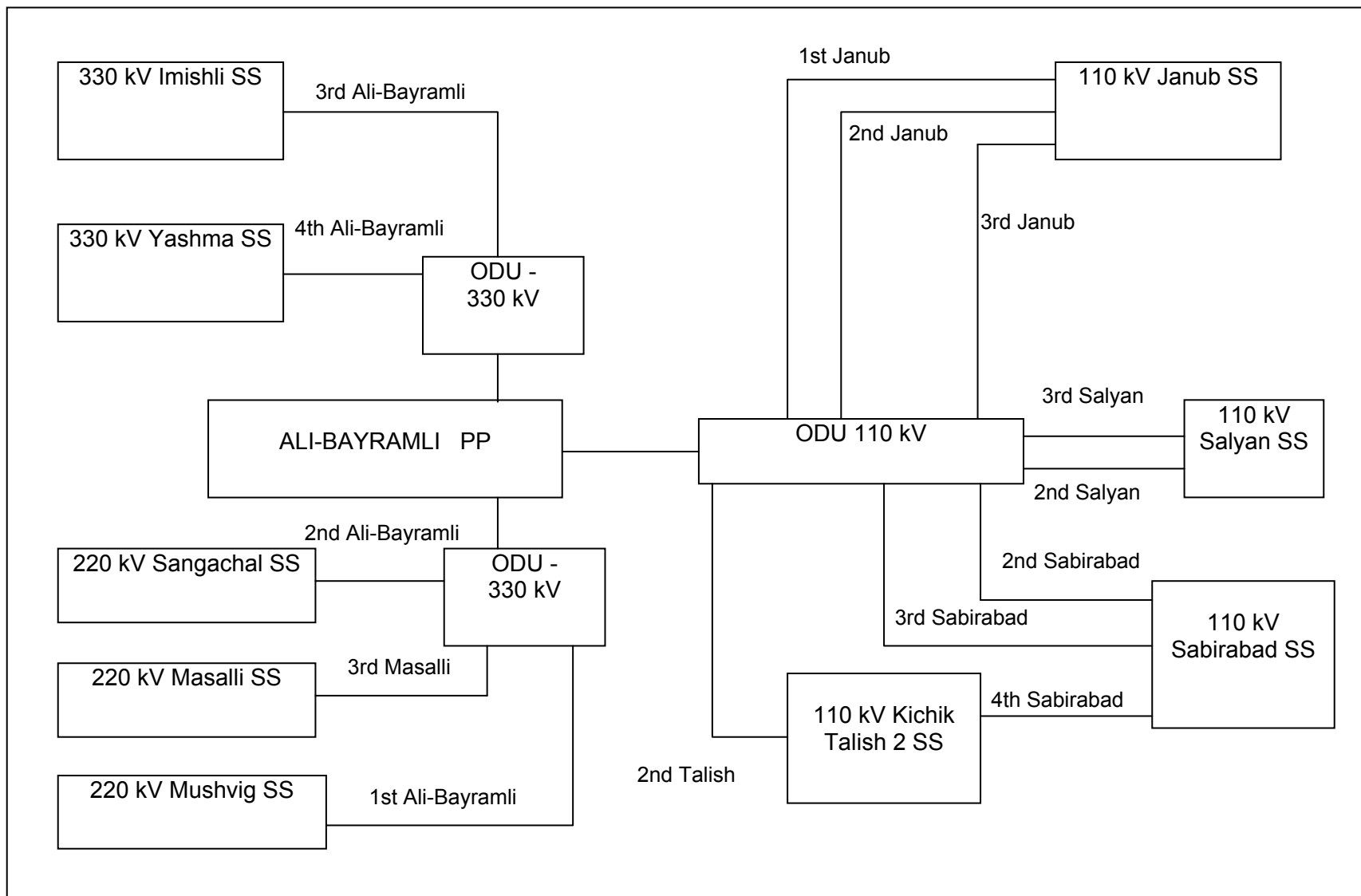


Figure 2: Connections of Shirvan Power Plant with the Azerenerji Power System (Grid)



III. CONDITIONS AND REQUIREMENTS FOR THE PROJECT

A. Site and Infrastructure

15. The existing 66 hectare (ha) site is shown in Map 1. Azerenerji also owns the 30 ha site on which the Project will be built.

16. 4. The following assessment criteria were used: (i) minimum disturbance to surrounding urban populations; (ii) ease of access to the location, road, and railway; (iii) ease of connection to the environment in terms of distance and obstructions; and (iv) minimum disturbance to existing operation.

B. Basic Functional Requirements

17. The Project will be built and designed according to international standards due to norms and standards of technical as well as environmental norms and standards. The basic requirements of the Project include:

- (i) The output power of the Project is to be around 750–800 MW
- (ii) The Project is to run on dual fuel—the main fuel is natural gas, while the reserve fuel is *mazut* (heavy oil).
- (iii) The energy efficiency of the Project should be as high as possible.
- (iv) All infrastructures (substations, transmission lines, branch lines, administration building, etc.), including the main gas feeder pipeline, will be rehabilitated.
- (v) Old units of Shirvan will generate electricity until they are replaced by the Project units.

IV. ANALYSIS AND CHOICE OF TECHNOLOGY ON POWER PLANT RECONSTRUCTION

18. The following technical features of the Project combined-cycle generation facility were analyzed: (A) steam turbines, and (B) combined-cycle plants.

A. Steam Turbines

19. Steam turbines are common in many countries. The existing thermal turbines of Shirvan belong to this class. Steam turbines with installed capacity of 200 MW and 300 MW are widespread and reliable. Steam turbines are manufactured in Germany, Finland (by the company Wartsila), Japan and other countries.

B. Combined-Cycle Plant

20. Azerenerji is experienced in constructing and operating gas turbine and combined-cycle facilities, which can be found in Shimal-1, Baki and Sumgait. The main components (gas turbines) are manufactured by such companies as Siemens, Mitsubishi, Alstom, and General Electric.

21. The advantages of the combined-cycle technology are (i) high fuel efficiency, 52%–56%; (ii) relatively low investment value per kilowatt (kW) of installed capacity (around \$800 per kW);

(iii) low repair costs—around \$2 per 1,000 kWh of electricity; and (iv) short construction time (25 to 27 months).

22. The disadvantages are: (i) necessity of high-pressure gas (26 bar) involving higher construction material cost and (ii) it takes a long-time (more than two hours) to startup units from “cool” condition.

C. Technology and Configuration Selection for Shirvan Power Plant

23. As a result of different technology analysis, it has been decided to use steam and gas combined-cycle technology, utilizing General Electric (GE) “9E” gas turbines based on the following principles as well as considering the main requirements of the Project ; i.e., a high coefficient of efficiency and the possibility to use gas and *mazut* as back up fuel supply:

- (i) Each multiple-roll of the Project includes two units (blocks) of gas turbine generators, two heat-recovery steam generator units and one steam turbine generator unit.
- (ii) The power of each unit is 386.7 MW.
- (iii) The total power of the Project is 760 MW.
- (iv) Natural gas will be used as the main fuel, and mazut will be used as a reserve fuel.
- (v) The bypass pipe of the gas pipeline will be ready to transition from a simple cycle to facilitate a combined cycle plant.
- (vi) The Projects will enable the entering of the double pressure saturated steam into the cycle for production of high and low pressure steam.
- (vii) The basic cooling system for the main condenser of the steam turbine will be with river water by direct cooling.
- (viii) Use of Shirvan's existing equipment is not considered.
- (ix) There will be minimum number of connections to the existing systems.

24. Operating in a basic mode, the Project can produce about 6 Giga Watt hours (GWh) per year using General Electric turbines (Type MS9001E (PG9171E)). These turbines have more than 52% efficiency. About 350 units of these turbines have been built in the world. These units have operated more than 8 million hours in various climatic conditions, including in deserts, tropical zones, and cold-weather areas.

25. These turbines were designed according to their working ability and minimum repair costs. GE class E turbines emit low levels of Nitrogen Oxide exhaust to 15 parts per million with natural gas as fuel.

26. These turbines use a broad spectrum of fuel, including natural gas, light and heavy fractions of diesel oil, naphtha (ligroin), base oil, and fuel oil. Gas turbines designed to use two fuels can be switched under load from one fuel to another.

27. Thereby, due to the high reliability and great experience with different types of fuels, GE technology these turbines were recommended for the Project.

V. DESCRIPTION OF PROJECT

28. Azerenerji concluded to use multi shaft combined cycle technology based on two gas turbine generator units and one steam turbine generator unit, each having a separate power connection to the grid.

A. Gas Turbine Technology

29. The General Electric (GE) MS9001E type of gas turbine was identified as being suitable for the Project. The turbine proposed for use in the Project are considered to be: (i) sound and have a successful track record for use in similar environments (ii) meet the current European Union (EU) standard of 75 milligrams (mg) per m^3n for NO emissions. In addition, the turbine supplier is capable of offering a long-term spare parts and services agreement for their turbines.

Figure 3: General Electric (GE) MS9001E Gas Turbine Combined Cycle Unit



30. An MS9001E turbine basically consists of an input air system, a compressor, a combustion chamber, turbines, an exhaust system, an auxiliary (backup) system, a control system, and others auxiliaries. Air enters the compressor through input air filters and sound attenuators. Then the air mixing with fuel enters the combustion chamber from the compressor. The fuel mixture with compressed air combusts and produces high pressure and temperature, and then the gas expands in the turbine, releasing energy. After expansion, the exhaust can enter the recovery boiler or be released into the atmosphere through the exhaust system. Tables 2 and 3 summarize the main design parameters of gas turbines featured in this report.

Table 2: Gas Turbine Main Design Parameters

Parameter	Detail
Gas turbine type	MS9001E (PG 9171E)
Gas turbine supplier	GE
Ambient air temperature, °C	15
Minimal gas pressure, bar	24.0
Gas turbine nominal capacity of electric power, MW	124.6
Gas turbine gross efficiency %	33.46%
NO _x , (NO ₂)	51.3
CO, mg/m ³ n	18.8

C = Celsius, MW= megawatt, NO_x = nitrogen oxide, NO₂ = Nitrogen dioxide, CO = carbon oxide, mg= milligram per cubic meter.

Source: Consultants.

31. In operating conditions the main parameters are as follows:

Table 3: Gas Turbine Main Design Parameters

Construction of Turbines	Standard	Standard	Standard	By Warming and Airing
Fuel	Gas	Diesel	Black oil	Gas
Output power	126,100 kW	123,300 kW	115,300 kW	125,400 kW
Fuel consumption	10,650 kJ/kWh	10,730 kJ/kWh	10,960 kJ/kWh	10,700 kJ/kWh
Heat	1,343x10 ⁶ kJ	1,328 x10 ⁶ kJ	1,263.7x10 ⁶ kJ	1,341.8x10 ⁶ kJ
Exhaust gas temperature	543°C	543°C	520°C	543°C
Gas leakage	1,505x10 ³ kg/s	1,509x10 ³ kg/s	1,508,6 x10 ³ kg/s	1,504x10 ³ kg/s
Turning speed cycle/minute	3,000	3,000	3,000	3,000

C = Celsius, kg = kilogram, kJ = kilo Joule, kW = kilowatt, kWh = kilowatt-hour, s = second.

Source: Consultants.

B. Heat Recovery Steam Generator

32. The unfired heat recovery steam generator (HRSG) will be of either horizontal or vertical design, with natural circulation, and will be operated at sliding pressure rather than constant pressure.

33. Vibrations caused by the flue gas flow in the structures will be prevented by suitable construction

34. The HRSG will be capable for the operation on continuous partial and base load and the design will assure that the following requirements are met:

- (i) Low thermal inertia to allow a fast start-up,
- (ii) High resistance to thermal shocks,
- (iii) The design provided will meet the specified noise limits,
- (iv) The height of the HRSG flue gas stack will be sufficient to meet all applicable environmental regulations,
- (v) The flue gas stack will be equipped with emission monitoring connections, aviation lights, ladders, and service platforms.

- (vi) The HRSG will be equipped with a flue gas damper¹ located between the HRSG and the flue gas stack to keep the HRSG warm during shutdown.
- (vii) A noise silencer will be provided to reduce noise to the required level.

35. The HRSG construction may be of "outdoor or semi-outdoor" installation type. However, local circumstances will be taken into account when designing dust, noise, and weather protections; in particular, icing conditions when the turbine is not operating will be considered by the contractor. The facade of the HRSG house will fulfill the requirements of local authorities. The key components and equipment, and main gateways and stairs around the HRSG will be protected from any adverse weather conditions, including freezing and rain.

C. Steam Turbine Unit

36. The Project will include steam turbine generator units. The steam turbines will be capable of operating in both fixed and sliding-pressure modes, and in a modified sliding-pressure mode.

37. During normal operation the steam turbine operates without throttling the main steam flow (sliding-pressure mode).

38. Overloading requirements specified in International Electrotechnical Commission standard (IEC) 60045 will be taken into account.

D. Configuration of the Project

39. A combined-cycle facility consists of four main components: control, auxiliary components, gas turbine, and generator. The plant can work both in open and in locked configuration. A gas turbine can function in simple cycle, in combined cycle or in both cycles. In simple cycle, high-temperature exhaust gases are released directly into the atmosphere, while in combined cycle exhaust gases enter the recovery boiler for production of steam. The steam then enters the steam turbine for production of electric energy and/or for co-generation

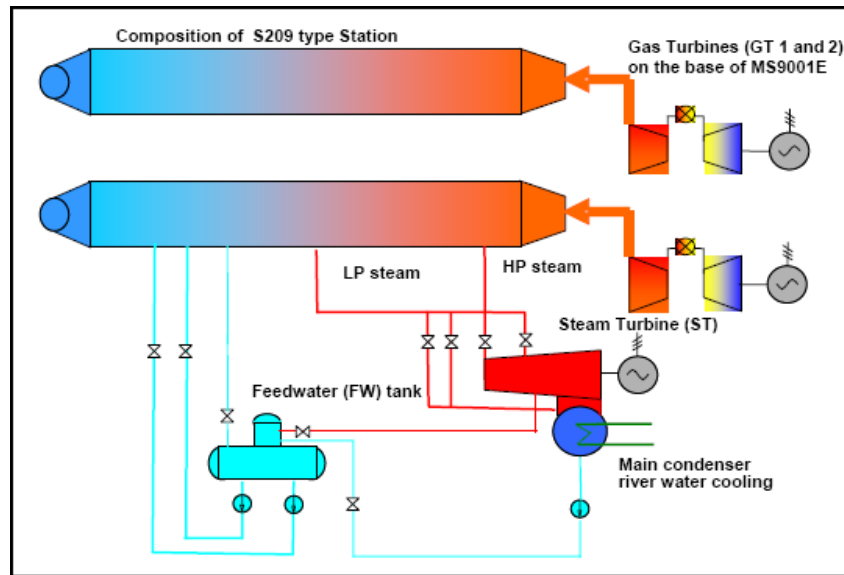
40. Combined steam-gas cycle has some advantages:

- (i) Energy generation is clean—i.e., it's the most acceptable technology from an ecological standpoint.
- (ii) High efficiency factor, more than 50%.
- (iii) Minimal land requirement
- (iv) Minimal water requirements.
- (v) Fast operations. The station starts and shuts down quickly, so it is possible to operate the facility both for base and peak load .
- (vi) Facility construction time is short; accordingly, less time is required to repay the investment.
- (vii) High level of automation and smaller number of staff required.
- (viii) A wide range of fuels can be used, including natural gas, diesel oil, and fuel oil.

41. The basic composition of the Project is shown in Fig.5.2.

¹ Dampers are used to control the flow of air.

Figure 4: Basic Composition of The Project



E. Combined-Cycle Power Plant Cooling Water System

42. The Shirvan extracts its cooling water from the Kura River. Because of the need for more cooling water, and to ensure the Project facility's efficient operation during its expected lifetime, extensive renovation of the existing cooling system will be required. It's possible that an entirely new cooling water system will be necessary.

1. Direct Cooling Water System

43. It is anticipated that a direct cooling water system with the following characteristics will be used for the Project:

- (i) Cooling water is taken from the Kura River.
- (ii) Cooling water total flow at 100% plant capacity is 8,000 kilograms per second (kg/s) for each condenser.
- (iii) Water surface level: 19.42 meters (m) +/- 0.5 m.
- (iv) Condenser top level: 1 m.
- (v) Ground level of the power plant: 17m–18 m.
- (vi) River water temperature: >15⁰ C.
- (vii) Cooling water temperature in the condenser: 10⁰ C.

F. Simple Parameters of the Saturated Steam Cycle

44. Selection of main parameters depends on the main standards of the supplier's equipment available for the Project.

1. High and Low Pressure Steam System

45. The system design using both high and low pressure allows the steam generator and steam turbine to function without any limitations under full load.

2. Feedwater System and Main Condensate System

46. The feed water pumps will be designed according to the boiler code. The Project will be used as base-load to the grid thus it will be possible to use the main condensate pumps and feedwater pumps with constant speed.
47. The capacity of the feed water tank will be sufficient to provide error-free operation.
48. Performance of steam generator installation is provided even if the quantity of returning condensate and make-up water (feed water) changes.
49. The plant will be supplied with a condensate filter.

3. Auxiliary Boiler and Auxiliary Steam Supply System

50. The auxiliary boiler will be of standard type and will be completely automated. The boiler will be controlled from the control room.

4. Feed water Treatment System

51. The facility for treatment of feed water will consist of, but not be limited to, the following systems and equipment: (i) raw-water pumps, (ii) demineralization lines, (iii) raw-water tanks, and (iv) feed water pumps.

5. Tests for Water and Steam Cycle

52. Samples will be taken from different parts of the system and tested to control the water and steam circulating system. Continuous and periodic sampling will be performed and tested in the laboratory.. Samples in the cooling chamber must be kept in a building near the laboratory.

6. Chemical Dosimeters System

53. The main function of the chemical dosimeter system is to maintain the power station's water chemistry mode to standard levels.
54. The Project will use chemicals that are economical, and safe. Fully automatic measuring system will be used to monitor levels. The use of hydrazine will be forbidden.

7. Treatment and Discharge of Wastewater

55. The power station design will minimize the quantity of consumables and wastewater. Waste water from the water treatment facility will be mixed separately and neutralized to pH 6-9. The sewage pond will be protected against overheating. Sewage effluent quality will be monitored against Government standards.

G. Generators and Systems for Power Output

1. Generator Facilities

56. The Project will be based on two gas turbine generators, two steam generators and one steam turbine generator. Each generator's output is about 190 MVA.

57. Each generator will have an air-conditioning system and an air–water cooling system.

H. Control of Gas Turbine Generators, Steam Turbine Generators, and Electrical System

58. The control of gas and steam turbine generators and plant electrical systems are performed by the automation system of the plant via its digital control system (DCS)—i.e., the man–machine interface is through the monitors and keyboards of the DCS in the control room of the plant. The 330 kV, 220 kV, and 110 kV transmission line switchgears each have separate control systems with monitors in the control room. These control systems are linked to the DCS for information exchange.

59. The daily control of the electrical system during normal operation concern mainly generator plants operations, like synchronizing and adjusting the reactive output and voltage.

I. Automation and Control System

1. Level of Automation

60. The plant operations will be automated as follows: (i) the main DCS; (ii) safety related system; (iii) separate control systems (if necessary) for gas turbines, steam turbines, water treatment facilities, etc. using programmable logic controllers; (iv) control room devices for man–machine interfaces; and (v) site instrumentation and data acquisition.

61. The cabinets containing the control systems will be placed in a room in the control building. Electronic cabinets dedicated to signal acquisition (remote input/output cabinets) could be installed at field. For all the equipment not installed in airconditioned environment, provisions will be made for an adequate protection degree (IP 55 minimum).

62. The design of the automation system will generally comply with IEC standards. The measurement units employed will correspond to the *système international d'unités* (international system of units).

2. Main Control Room

63. All of the normal control and monitoring tasks (starting, stopping, normal operation, and load variation) of the Project will be performed from operator terminals in the main control room. In addition, separate local control rooms may be built to control and monitor certain sub processes.

64. The lighting of the control room will be designed to avoid or minimize optical disturbances, in particular on the monitors.

65. Similar care will be paid to minimizing the effects of other potential disturbances (temperature extremes, moisture, noise, etc.).

J. Fuel System

66. The main fuel used by the Project will be natural gas (gas turbine units and auxiliary boiler.) The gas will be supplied via a transmission pipeline.

67. The power of the gas compressor station will not be less than 400,000 m³/hour. The compressor will be compatible with the gas turbine in load rejection without interruption.

68. Supply of reserve black oil (mazut) will be 150,000 t. For this purpose there are six tanks with a capacity of 20,000 t, and ten 5,000 t capacity tanks.

69. Control equipment of black oil system will monitor the condition of the oil tanks, oil supply pipelines and damper valves to ensure that there is no leakage.

70. The gas supply system will include full control and instrumentation equipment for automatic control from the DCS, as well as for the proper supervision, safe and efficient operation during start-up, shutdown and normal running conditions.

71. Safety shutdown systems will be provided to protect the compressors and associated equipment. Particular attention will be paid to protecting against pressure particularly those caused by tripping of the gas turbines.

K. Compressed Air System

72. The compressed air system will supply compressed air for tools, instruments, and combustion process. All compressed air will be filtered and dried.

73. If the main compressor fails or if the system pressure drops to a certain point, alarms on the DCS will go off and the standby compressor will automatically start.

74. Any single failure in compressed air system will not disturb the operation of the system because of back up measures.

L. Safety System (Preservation) of the Project

75. The Project will be designed to preserve all parts and minimize the risk of corrosion. There will be provisions for the preservation of the Plant for a short term standby and for a long-term standby will be arranged.

76. The HRSG, the main condensate line, the feed water tank, and the feed water lines will be filled with water with chemical additives to keep the pH-value high enough. Circulation the water of the will be arranged with auxiliary pipelines and feedwater pumps. Steam lines will be dried or preserved with nitrogen.

77. Facilities for air circulation with dehumidified air will be provided for the steam turbine cylinders and heat exchangers. When ending the preservation phase of the above mentioned parts, the water used will be transferable to the neutralization basin.

M. Civil, Structural, and Building Works

1. General Design Criteria

78. The civil, structural, and building works will include the complete engineering and construction of all foundations, structures, and installation services needed to ensure the

satisfactory operation of the Project. The work will at minimum comply with any standards , Azerbaijan codes, and any other standards or international codes applied by Azerenerji

79. All parts of the Project that needs to be enclosed in a building that meets the requirements of the local planning authority.

80. Special attention will be paid to ensure that the facilities are functional and of pleasant appearance. Buildings housing will be adequately proportioned to facilitate the installations, operation, maintenance, and replacement of the plant.

81. The buildings and structures will be designed to have a minimum working life of 25 years before significant repair or replacement of the main or secondary structural elements is necessary.

82. The design will take into account the climatic and seismic conditions of the site which could normally be considered applicable during the minimum working life of the Project.

2. Scope of Civil Work

83. Planned civil engineering and building works inside the site boundary limits are outlined below. This is not necessarily an exhaustive list.

- (i) **Preliminary works.** (a) stripping and grading of site, (b) building of temporary roads, (c) services and drainage diversion of water, (d) permanent ducts, draw pits, pipe work, and (e) fencing and hard standings of the site.
- (ii) **Site works.** (a) underground utilities, and (b) landscaping.
- (iii) **Civil construction works.** (a) security fencing; (b) roads, parking lots, and paved areas; (c) pipe trenches and channels; (d) cable trenches and ducts; (e) drainage of water; (f) foundations for pipe racks and pipe support; (g) foul water drainage; (h) industrial sewage water; (i) 330 kV, 220 kV, and 110 kV gas-insulated switchgear buildings; (j) HRSG and stack foundations; (k) steam turbine building and steam turbine foundation; (l) gas turbine building and gas turbine foundations; (m) electrical building; (n) control room and office buildings; (o) workshops and store buildings; (p) gas turbine transformer site; (q) steam turbine transformer compound; (r) 220 kV and 110 kV system transformer compounds; (s) water treatment plant building and associated tank foundations; (t) gas compressor station, and (u) mechanical building services.

3. Architectural and Structural Treatments

84. All of the structures below ground level will be made of reinforced concrete. The main buildings will be steel-framed buildings. The main cladding material will be colored profiled metal sheeting in standard factory colors. All supporting structural steel work, non-galvanized handrails and chequered plates will be protected against corrosion by a coating system and decorative paint system. The paint protection will serve a minimum of 15 years before first maintenance.

85. The floors will be structural ground slab, suspended reinforced concrete slab or steel open grid flooring, in accordance with the loading and requirements of usage. Where required

for structural reasons, sound transmission, or fire prevention, internal walls will be of concrete, concrete block, or brickwork. Otherwise, internal walls will be of lightweight panel construction.

86. Staff and escape doors and frames will mainly be made of painted steel. Vehicular access and doors for construction purposes will be plastic coated steel roller shutter doors or folding gates with personnel access doors. Internal office doors and frames in the control/electrical building will be of solid cored timber.

87. Areas with permanent staff occupancy will be provided with metal framed windows with double glazing.

88. The main stairway servicing the main building will be enclosed in a fireproof shaft. External emergency staircases will consist of spiral steel stairs.

89. The internal surfaces of the buildings will depend on the characteristics and function of the building.

90. The gas turbine and steam turbine buildings will be furnished with an overhead traveling crane with sufficient lifting capacity to ensure effective maintenance. The removal of generator rotors will be possible without need to demolish any fixed structure.

91. Special tools and equipment for generator rotor removal will be provided. The following will be considered for maintenance of various components:

- (i) All important components (i.e. pumps, motors, valves, etc.) will be equipped with proper lifting beam or rail for chain hoist above them.
- (ii) Gas turbine/steam turbine building will be provided with adequate lay-down areas needed for major overhauls.
- (iii) Gas turbine/steam turbine building will be sized to accommodate all the steam bypass system without any restriction being imposed on maintenance.

4. Roads and Hardstandings

92. Permanent roads will be provided so that all Project equipment and buildings can be easily accessed. All vehicle roads including concrete curbs will be covered with bitumen macadam on hardcore sub-base.

5. Transformer Foundation

93. Foundation of transformers will be made of reinforced concrete. The foundations will include holding sumps with adequate provision for rainwater and will have a special oil removal system in case of oil spillage. Each transformer will be enclosed by reinforced concrete blast/fire walls on three sides and by a removable fence with personnel access gate on the remaining side.

6. Cable Trenches and Pipe Racks

94. Where direct burial is not suitable, underground cables and pipes will be in trenches.

95. Trenches will be constructed to provide adequate access for maintenance purposes. Trenches will be outfitted with removable reinforced concrete cover slabs. Electrical cables may

be laid in PVC-cable ducts. Routes will be outfitted with manholes.

96. The above ground pipe racks will have minimum headroom of 5.5 m in the trafficable areas.

7. Landscaping

97. The objective of landscaping will to minimize the visual intrusion and reducing the adverse nature of any significant visual impact due to the new construction.

8. Drainage and Domestic and Industrial Wastewater

98. Separate drainage systems will be provided for storm-water runoff, domestic sewage, oily wastes, and chemically contaminated discharges.

9. Water Supply

99. Water for cooling process, drinking, sanitary facilities, and showers will be sourced from the existing water system at the designated terminal point.

10. Mechanical Building Services and Fire Protection

100. The new units will employ a hot water heating system with supply and return pipes. Electrical and automation rooms will be heated by electrical panels. The heating elements will be mainly air heaters with fans and radiators made of corrugated steel sheets.

101. The ventilation system will provide fresh air to occupied areas: (i) to control room temperature and humidity, (ii) to remove excess heat released from the generating process, (iii) to remove noxious fumes and chemical vapors, and (iv) to keep proper pressure differences between certain rooms to prevent the ingress of dust and noxious fumes

102. The heating, ventilation, and air conditioning equipment will have a centralized control system that includes a computer and printer. The control system will be located in the main control room.

103. The entire Project will have adequate fire-protection and fire-detection systems in place, and will conform to National Fire Protection Association and local fire authority regulations.

VI. EVALUATION OF ENVIRONMENTAL AND SOCIAL IMPACT OF THE PROJECT

A. Policy, Legal, and Administrative Framework, and Official Legislative Acts

104. The following laws pertain to environment protection in Azerbaijan and will apply to this Project.

- (i) Flora law, 3 December 1996;
- (ii) Pesticides law, 6 May 1996;
- (iii) Water code, 26 December 1997;
- (iv) Subsoil law, 13 February 1998;
- (v) Meteorological activity law, 17 April 1998;

- (vi) Industrial and domestic waste law, 30 June 1998;
- (vii) Environmental safety law, 8 June 1999;
- (viii) Environmental law, 8 June 1999;
- (ix) Collaboration of population in decides about environmental protection and public sitting of the court law, 9 November 1999;
- (x) Water supply and wastewater law, 30 December 1999;
- (xi) Specially protected territories and objects law, 24 March 2000;
- (xii) Atmospheric air protection law, 27 March 2001;
- (xiii) UN Convention "World cultural and natural heritage protection" ratification law, 6 December 1993;
- (xiv) UN Convention "Climate fluctuation (change)" ratification law, 10 January 1995;
- (xv) Convention "Ozone layer protection" ratification law, 31 May 1996;
- (xvi) Convention "Access to information, public participation in decision-making process and access to justice in questions concerning environmental protection" ratification law, 9 November 1999;
- (xvii) Kyoto Protocol ratification law, 18 July 2000; and
- (xviii) All environmental issues are settled by Ministry of Ecology and Natural Sources.

B. Environmental and Social Impacts

105. The Project will introduce modern combined-cycle technology and will accomplish the following:

- (i) increase the reliability of power plant and power system as a whole;
- (ii) fuel savings of approximately 250,000 t/year;
- (iii) ecologically purer burning of natural gas; and
- (iv) during construction, about 200 new jobs will be created, mainly for the local population.

106. The prevailing direction of wind at the site is north–northwest; the maximum wind speed is 35 m/s. The average number of days for which strong winds prevail is 80 per year. The average annual temperature is 14.5 C, maximum 43 C, minimum -3 C. The average relative humidity is 76%. The annual amount of rainfall ranges from 110 mm to 250 mm. The average atmospheric pressure is 1.01 bar.

107. The use of combined cycle gas-fired turbines in this Project will improve the environmental situation. In addition, Shirvan thermal power units, which do not meet modern environmental standards, will be retired. This will further benefit the environment.

108. NO_x emissions from the gas turbines and the fuel-firing systems of new power units will not exceed 25 parts per million at gas firing and full load in accordance with EU standards.

109. The weighted average noise level at 1 m distance from a soundproof case will not exceed 85 A-rated decibels.

110. The capacity of the new unit steam turbine is smaller than the capacity of the existing steam turbines at the thermal facility, and will therefore require less cooling water for the condenser. This reduces heat pollution of the Kura River.

1. Soil Condition

111. Throughout the construction works, soil monitoring will be carried out. The future plant area will be landscaped. Upon completion of the works, all polluted land will be reclaimed.

112. Detailed geological analysis should be redone since it has been many years since the last analysis. Drainage and foul water drainage works will need to be completed before construction works begin since the site is in a marshy area.

113. The selected area is located on the level (-17 - 18) m above sea level and is in a seismic zone 8 on the Richter scale which is appropriate for building the Project.

2. Temperature and Relative Humidity

114. The following parameters will form the range for plant performance calculations.

Table 6: Mean, Average Minimum, and Average Maximum Ambient Temperatures and Relative Humidity

Ambient Parameter	Temperature	Relative Humidity
Maximum ambient summer condition	+43.0C	70%
Mean ambient condition	+14.5C	76%
Minimum ambient condition	-10.0C	90%
Atmospheric pressure	Average atmospheric pressure is 1.01 bar	
Precipitation	110 to 250 mm per year	
Wind	The prevailing winds are north and north-west Maximum wind speed is 35 m/s.	
Snow	Maximum thickness of ice is 15 mm	

C = Celsius (centigrade), mm = millimeter, m/s = millimeter per second.

Source: Consultants.

3. Ambient Concentrations (in 2006)

- (i) Particular Matter (PM₁₀) 176,640 t
- (ii) Sulphur dioxides (SO₂) 2,771,840 t
- (iii) Nitrogen oxides (NO_x) 111,634,850 t
- (iv) Water availability from Kura River and its quality is shown in Annex 1 (pdf file).

4. Emissions

115. Dry Low-NO_x (DLN) combustion system will be provided in order to meet the current EU requirement of 0.75 mg/m³ for NO_x.

116. The following norm regarding deleterious substances in the air around populated areas will be complied with.

Table 7: Maximum Allowable Concentration of Deleterious Substances in the Air

Pollutant	Maximum Allowable Concentration (mg/m ³)	
	One-time Emission	Daily Average Concentration
NO ₂	0.085	0.04
NO	0.6	0.06
CO	3.0	1.0
SO ₂	0.5	0.05
H ₂ S	0.008	0.008
Soot	0.15	0.05
Dust (non-toxic)	0.5	0.15

CO = carbon oxygen (?), H₂S = hydrogen sulfide (?), mg/m³ = milligrams per cubic meter, NO = nitrogen oxide, NO₂ = nitrogen dioxide (?), SO₂ = sulfur dioxide.

Source: Consultants.

a. Carbon Dioxide (CO₂) Emission

117. Azerbaijan ratified the Kyoto Protocol on 28 September 2000. Consultants recommend Azerenerji to further study of the Joint Implementation or the Clean Development Mechanism opportunities and benefits for the Project outlined in the environmental impact assessment to follow in the next part of report.

118. The level of CO₂ emission in the Azerbaijan power system generated by presently operating thermal power plant and emission from new projected gas-turbine power plants is estimated by the Consultants. Particularly, emission reduction after commissioning of Project evaluated. All calculations were performed in accordance with international standards for Clean Development Mechanism project development and decision making for program realization on the base of Kyoto protocol.

119. To determine base line factors, two cases were considered: (i) emission from all existing thermal plants taking in account type of used fuel, and (ii) emission from Shirvant.

120. In both cases emission factor is the weighted average emissions (in kg CO₂ e/kWh) of all generation units in the system.

121. The emission factor is calculated as the sum of total emission from each generation units divided by the sum of their generation in that year.

122. The total emission from each generation unit is estimated as total fuel consumed by the generating unit multiplied by the carbon intensity of the fuel.

123. 2006 was used as the base year for CO₂ emission calculations and fuel consumptions for different fuels as well as the resulting emission factors are shown in Table 8.. Typical emission factors for a variety of fuels are listed in Appendix 1.

Table 8:. Estimated Emission Factors for Shirvan

Fuel	Net Generation GWh	Consumed fuel (10 ³ t) (A)	Net Calorific Value, (TJ/10 ³ t) (B)	Carbon Emission Factor, (IPCC; tC/TJ) (C)	Emission t CO ₂ (D)=A*B*C*44/12
Gas	4,021	1,796,983			4,372,11
Mazut	1,229	548,632			1,707,41
Total	5,255	2,345,615			6,079,52

Baseline emission factor, (tCO₂/GWh).

CO₂ = carbon dioxide, GWh = gigawatt hour, IPCC = Intergovernmental Panel on Climate Change, t = ton, TJ = TeraJoule.

Source: Consultants.

124. Assuming that the installed capacity is at 760 MW, operating for 8,000 hours per year, the total generation would be 5,868 GWh (2,934 GWh x 2). To produce such amount of energy would consume 1,324 million m³ of gas with specific consumption of 228 g/kWh (kWh (268 dm³/kWh).

125. Taking in account that in 2006 the total generated energy for the country was 5,255.05 GWh and consumed fuel was 2,345,616 t, the new plant for the same amount of fuel could produce 1,0287.8 GWh.

126. This means that the Project would produce 5,032.7 GWh more energy (i.e., 10,287.8 GWh–5,255.05 GWh) than the existing thermal facility.

127. Consequently, the baseline emission would be reduced to the level of 5,032.7 x 1,157 t CO₂ = 5,823,000 t of CO₂.

5. Noise

128. The allowable noise level during construction in residential areas are as follows.

Table 9. Allowable Noise Level in the Area of Residential Construction

Item	Effective Frequency, Hz								Noise Level dB (A)
	63	125	250	500	1,000	2,000	4,000	8,000	
Residential Construction Area	67	57	49	44	40	37	35	33	45

Hz=Hertz, dB(A)= A-rated decibels.

Source: Consultants

6. Water Chemistry

129. The plant will be equipped with sampling, dosing, measurement, and analyzing systems to ensure sufficient quality of water and steam in all operational conditions.

7. Materials

130. In material choices, the main attention will be paid to the compatibility of materials and operating conditions. Also, mechanical, manufacturing and maintenance characteristics (e.g.,

strength and weld ability) of materials will be considered as important criteria of choice. The materials to be chosen will be standardized and represent a long-term operational experience.

C. Potential Environmental Impacts

131. Potential environmental impacts during construction and operation of the proposed facility were evaluated based on current site conditions and previously conducted studies.

132. No significant negative environmental impacts are anticipated during normal construction and operating conditions. In addition, design considerations, administrative controls, and engineering controls will be implemented to reduce the likelihood of negative environmental impacts resulting from adverse conditions, accidents, and acts of nature.

133. Potential environmental impacts include:

1. Positive Impacts

- (i) The concentration of SO₂ and NO_x in the atmosphere due to Project emissions will decrease slightly, but this is not expected to have a significant impact on air quality.
- (ii) Construction of the facility will contribute to general development of the district and will have direct and indirect positive impacts on revenues and living standards of the population.
- (iii) There will be no resettlement of the population.
- (iv) There will be no impact on general topography and land use in the area.

2. Insignificant Impacts

- (i) Impacts on surface and groundwater can be easily mitigated,
- (ii) Impacts on aquatic and terrestrial biota will be insignificant.
- (iii) Noise-related impacts are not anticipated because noise mitigation measures will be taken.

134. The proposed facility will be designed to comply with Azerbaijani and international environmental regulations in respect to air emissions, water pollution, and noise.

D. Worker Health and Safety

135. Air quality inside the plant and in the workplace will meet Azerbaijani and international standards.

E. Cultural and Archaeological Impacts

136. According to available information, the implementation of this project will not impact any unique cultural or archaeological areas or objects.

F. Alternative Analysis

137. The purpose of the alternative analysis is to determine if any options exist that may be more sound or beneficial from environmental, sociocultural, or economic perspectives than the

originally conceived, designed, and proposed Project. The specific alternatives evaluated for the Project and associated conclusions are summarized below:

- (i) **The no action alternative.** Because of the projected high future demand for power in Azerbaijan and the expected retirement of a number of electricity generating assets, the no action alternative was not considered viable.
- (ii) **Alternative power generation technologies.** Alternative technologies include hydropower, wind energy, solar thermal, photovoltaic, and biomass energy. Because of high acreage requirements, climatic considerations, costs, reliability, and/or required lead time, none of the above technologies is considered a viable alternative to the proposed Project.
- (iii) **Alternative plant locations.** Azerenerji has considered a number of possible locations for the proposed power station. Site criteria evaluated included: land ownership, availability, and access; topography; existing and potential environmental impacts; availability of water; equipment transportation; interconnection with regional transmission systems; and local infrastructure. The site was determined to be the most suitable for construction and operation of the Project.
- (iv) **Alternative plant designs.** The Project is, by its very nature and design, one of the cleanest and most efficient fossil fuel plants available. Therefore, no alternative designs were considered to be viable.
- (v) **Alternative fuel utilization.** Alternative fuels include oil, lignite, and coal. Due to increased air emissions, storage considerations, and availability, no primary alternative fuel to natural gas was considered viable.
- (vi) **Alternative water supplies and intakes.** The Project will include a river-water treatment facility. The river-water intake structures will be renewed.
- (vii) **Alternative solid waste disposal.** Solid waste will be disposed of in accordance with applicable municipal and regional practice and law. No viable alternatives to the current solid waste disposal plan were identified.
- (viii) **Alternative pollution control systems and equipment.** The proposed pollution control systems will cause all liquid and gaseous plant effluents to meet or exceed local and international requirements. Therefore, no viable alternatives to the current pollution control systems were identified.

138. No viable alternatives requiring further investigation were identified as part of this analysis.

G. Summary

139. A Project is by its very nature an environmentally friendly means of generating electricity. The proposed Project and the associated gas pipeline are no exception, and will both be designed to meet all local and international environmental requirements. Air emissions are preliminarily estimated to cause neither long-term, significant changes in ambient air quality, nor any environmental or health impacts. Additionally, no indigenous personnel resettlement will be required, and the existing roadways and railway will meet the facility's transportation requirements.

140. Potential impacts commensurate with normal construction activities and normal plant operations are controllable, and can be readily minimized through environmentally sensitive construction practices, and the development and use of appropriate mitigating measures.

141. The baseline emission factor t/ CO₂ was determined for Shirvan as well as for all of Azerenerji's other thermal power plants.

142. The annual baseline emission for the Project after the commissioning and environmental impact reduction were determined by the Consultant.

143. The main advantages of the Project from an ecological standpoint are:

- (i) Low levels of CO₂ emission.
- (ii) The construction of tanks for liquid oil storage prevents leakage of harmful chemicals and soil pollution.
- (iii) Resettlement will not be necessary, and moreover construction of the facility will contribute to the general development of the district, and will have direct and indirect positive impacts on revenues and living standards of the people.