The Islamic Republic of Iran
Thermal Power Plants Holding Company (TPPH)

The Islamic Republic of Iran

Preparatory Survey on the Shahid Rajaee Power Plant Construction Project

Final Report

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Japan International Cooperation Agency (JICA)

Tokyo Electric Power Services Co., Ltd.

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Abbreviations

Abb.	Description
ABFA	Water and Sewage Service
AC	Alternating Current
ADB	Asian Development Bank
AIS	Air Insulated Switchgear
API	American Petroleum Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
AVR	Automatic Voltage Regulator
BAT	Best Available Technology
BOD	Biochemical Oxygen Demand
BOO	Build Own Operate
BOP	Balance of Plant
BOT	Build Operate Transfer
C&I	Control & Instrumentation
CB	Circuit Breaker
CC	Combined Cycle
CCR	Center Control Room
CCTV	Closed Circuit Television
CEMS	Continuous Emission Monitoring System
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
COD	Chemical Oxygen Demand
COP	Conference of the Parties
CPI	Consumer Price Index
DC	Direct Current
DCS	Distributed Control System
DO	Dissolved Oxygen
DOE	Department of Environment
DSO	Distribution system operator
ECA	Energy Conversion Agreement
EDG	Emergency Diesel Generator
EHS	Environment, Health and Safety

Abb.	Description
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EOH	Equivalent Operating Hour
EPA	United States Environmental Protection Agency
EPC	Engineering, Procurement and Construction
EWS	Engineering Work Station
FAC	Final Acceptance Certificate
FIRR	Financial Internal Rate of Return
FIT	Feed In Tariff
FOD	Foreign Object Damage
FS	Feasibility Study
GCB	Gas Circuit Breaker
GDP	Gross Domestic Product
GE	General Electric Company
GEN	Generator
GHG	Greenhouse Gas
GIS	Gas Insulated Switchgear
GT	Gas Turbine
GTCC	Gas Turbine Combined Cycle
GTG	Gas Turbine Generator
GOI	Government of Iran
GPRS	Gas Pressure Reducing Station
HEPA	High Efficiency Particulate Air Filter
HIV/AIDS	Human Immunodeficiency Virus / Acquired Immuno-Deficiency Syndrome
HP	High Pressure
HRSG	Heat Recovery Steam Generator
HSE	Health, Safety and Environmental
I/O	Input/Output
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IEM	Iranian Electricity Market
IERB	Iran Electricity Regulatory Board
IFC	International Finance Cooperation

Abb.	Description
IGMC	Iran Grid Management Company
IMF	International Monetary Fund
IP	Intermediate Pressure
IPB	Isolated Phase Bus
IPDC	Iran Power Development Company
IPO	Iranian Privatization Organization
IPP	Independent Power Producer
IPPMC	Iran Power Plant Maintenance Company
IPT	Intermediate Pressure Turbine
IRR	Internal Rate of Return
IRR	Iranian Rial
ISO	International Organization for Standardization
ITD	Inlet temperature difference
IUCN	International Union for Conservation of Nature
JICA	Japan International Cooperation Agency
KVA	Kilovolt Ampere
LC	Letter of Credit
LCD	Liquid Crystal Display
LP	Low Pressure
LTSA	Long Term Service Agreement
MCC	Motor Control Center
MHPS	Mitsubishi Hitachi Power Systems
MOE	Ministry of Energy
MOP	Ministry of Petroleum
MT	Main Transformer
NIGC	National Iranian Gas Company
NLDC	National Load Dispatch Center
NPV	Net Present Value
NOx	Nitrogen Oxides
O&M	Operation and Maintenance
ODA	Official Development Assistance
OEM	Original Equipment Manufacturer
OFAF	Oil Forced and Air Forced Type
ONAF	Oil Natural and Air Forced Type

Abb.	Description
P/Q	Pre-Qualification
PBO	Planning and Budgetary Organization
PE	Annual Generated Power Energy
PM	Particulate Matters
POPE	Based on Plant Operation Energy
POPH	Based on Plant Operation Hour
PPA	Power Purchase Agreement
PT	Potential Transformer
QBS	Quality Based Selection
QCBS	Quality and Cost Based Selection
RH	Reheater
RTU	Remote Terminal Unit
SABA	Iran Energy Efficiency Organization
SATBA	Renewal Energy and Energy Efficiency Organization
SBD	Standard Bidding Documents
SH	Super-heater
SMS	Siemens
SOx	Sulfur Oxides
SS	Suspended Solid
SSS	Synchro-Self-Shifting (Clutch)
ST	Steam Turbine
SCF	Standard Conversion Factor
SUNA	Renewable Energy Organization of Iran
SWGR	Switch Gear
TAVANIR	Iran Power Generation and Transmission Company
TOR	Terms of Reference
TPPH	Thermal Power Plant Holding Company
TREC	Tehran Regional Electric Company
TSS	Total Suspended Solid
UN	United Nations
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UPS	Uninterrupted Power Supply

Abb.	Description
WACC	Weighted Average Cost of Capital
WB	World Bank
WTP	Willingness To Pay

Chapter 1 Introduction

1.1 Background to Survey

According to Iran Power Generation Transmission & Distribution Management Company (TAVANIR), in 2016, the installed power capacity held by the country was 76,428 MW with the power generation capacity of 66,599 MW and the maximum power demand in the year was 53,198 MW. Power demand has increased significantly from year to year, with an annual average increase from 2000 to 2016 at 6.1% (TAVANIR). The population of Iran increased at the rate of about 1% over the previous year for the past 10 years from 2006 to 2015 (International Futures).

Under the country's Fifth Five-Year National Development Plan (2011-2015), increase of power generation efficiency was selected as one of the objectives in the energy sector and it is taken up the same objective as one of major issues to tackle under the Sixth Five-Year Plan (2017-2021) . Furthermore, in its Intended Nationally Determined Contributions to COP21 (the 21st session of the Conference of the Parties to the United Nations Framework Convention on Climate Change), the Iranian Government expressed its strong political will to target at reducing the country's greenhouse gas emission by 4% by 2030 relative to what would happen in absence of any measures. As one measure to achieve this target, the Iranian Government is considering to introduce combined cycle power generation. Based on such circumstances, with respect to the country's development of new power sources, the Iranian Ministry of Energy (MOE) and other concerned parties expressed their intention to replace conventional steam power plants and promote introduction of gas combined cycle power plants that are highly efficient in power generation and impose less burden on the environment.

Considering this situation, Government of I.R.Iran submitted a request to the Japanese Government for granting Japanese ODA loans for additional development of highly efficient power generation facilities at the Shahid Rajaee Power Plant, which has the third largest power generation capacity in Iran.

This Study will be implemented for the purpose of gathering data necessary to evaluate whether Japan should grant cooperation in the form of a Japanese ODA loan project as requested by Government of I.R.Iran.

1.2 Objectives and Scope of the Study

1.2.1 Objectives of the Study

Based on Government of I.R.Iran's request for an ODA loan for the Shahid Rajaee Power Plant Construction Project (hereinafter referred to as the "Project"), this Study will be implemented for the purpose of gathering data necessary to evaluate whether Japan should grant cooperation in the form of a Japanese ODA loan project. In light of this purpose, the Study Team shall conduct a survey concerning the Project's necessity and objectives, overview, costs, implementation schedule, implementation method (procurement/construction), project implementation system, operation/maintenance system, environmental and social considerations, etc.

According to the preliminary consultation made with the Iranian side, it is expected that the project components listed below should be examined as a scope of targets of this Study.

- Gas combined cycle power plant (GTCC) (ISO base; 680 MW x 2)
- Other related facilities

When at any related facilities, new construction, improvement, etc. become necessary in association with the addition of GTCC to be made, such facilities will be identified in this Study by making consultation with TPPH(Thermal Power Plants Holding Company) and JICA. In addition, examination will be made on an appropriate targeted scope for the Japanese ODA loan project by looking at the entire scope of the Project.

1.2.2 Scope of the Study

This Project concerns the construction of a highly efficient gas turbine combined cycle power plant (GTCC) within the premises of the Shahid Rajaee Power Plant located in Qazvin Province of Iran.

In order to meet Iran's further activating economic activities and increasing power demand in association with the removal and relief of economic sanctions on the country made by the International community (2016) , GTCC will be constructed in a relatively short period of time. In addition, in order to contribute to improvement in power generation efficiency, which is one of the major issues Iran determined to tackle in its energy sector, the application of a new-type, high-efficiency gas turbine will be examined. Also in order to contribute to the achievement of the Iranian Government's policy for COP21 (4% reduction of greenhouse gas emission), examination will be made concerning the introduction of GTCC that gives less burden on the environment.

The major policies of the Study are the following 4 points.

1) Utilization of Japanese companies' technology and review of the requirements for prequalification (P/Q)

In this Study, based on the preliminary consultation made with JICA and the Iranian side, it is projected that GTCC of high efficiency (at a level of 1,600 degrees C) will be installed. During the survey, by introducing stakeholders to technology that is owned by Japanese companies and relevant to related facilities and by inviting stakeholders to facilities and factories located in Japan for inspection, the Japanese companies' technological advantages will be shown objectively to gain understanding of the Iranian side. In addition, the requirements for prequalification to make this Project an infrastructure project of a high quality will be reviewed and organized before holding consultations with TPPH. Particularly, in relation with the introduction of an advanced gas turbine system that has only a limited record of commercial operation, the establishment of fit and proper P/Q requirements is an important issue in order to ensure operational reliability of a gas turbine system by taking the advantages held by Japanese companies into account.

An additional study and review will be conducted regarding the influence of the recent restriction by the U.S.A. on re-export transactions involving Iran. A comparative study will also be conducted on the approval processes of competitive bidding and implementation of negotiated agreements for general construction projects in the electric power sector in Iran.

2) Utilization of existing materials

(1) Utilization of knowledge obtained through previous projects

Prior to this Study, JICA has implemented an ODA loan project entitled, “the Data Collection Survey on Electric Power Sector in the Islamic Republic of Iran,” and in implementing this Preparatory Survey, knowledge, outcome and reports obtained through and made in the previous project will be reviewed and made best use of so that this Study will be able to be implemented efficiently.

3) Policy for examining technical elements

(1) Gas turbine models
(2) Axis composition of GTCC
(3) Steam turbine
(4) Condenser cooling system

4) Environmental and social considerations

(1) Review of an Environmental Impact Assessment (EIA) report and preparation of a draft supplementary EIA report
(2) Support for the drafting of Abbreviated Resettlement Plan
(3) Holding Stakeholder Meetings
(4) Support for the Explanation to Advisory Committee for Environmental and Social Considerations established by JICA

The method of implementing the work is shown in Fig. 1-1 Work Flow. The main terms of reference are as follows.

(1) Domestic preparation work and preparation, explanation, consultation and confirmation of the Inception Report (TOR 1)
(2) Training in Japan (TOR 2)
(3) Background survey of Project (collection of basic information) (TOR 3-1)
(4) Power system survey (TOR 3-2)
(5) Verification of the current status of fuel supply and future perspective (TOR 3-3)
(6) Verification of and study on intake/discharge of service water for the target power plant (TOR 3-4)
(7) Study and survey on natural condition (TOR 3-5)
(8) General design (TOR 3-6)
 1) Selection of candidate sites
 2) Layout conceptual plan within the premises
 3) Specifications, composition and layout plan for the power plant including electrical instrument/machinery systems
(9) Analysis of Issues Related to Past ODA-Loan Projects (TOR3-7)
(10) Survey of US re-export regulation（TOR3-8）
(11) Survey on procurement and construction method (TOR 4-1)
(12) Safety countermeasures of construction work (TOR 4-2)
(13) Preparation of plant construction schedule (TOR 4-3)
(14) Project implementation cost estimation (TOR 4-4)
(15) Cost reduction method survey (TOR 4-5)
(16) Proposal on the scope of yen loan project (TOR 4-6)
(17) Proposals on the implementation system and the operation/maintenance management system (TOR 4-7)

(18) Preparation of risk control sheet (TOR 4-8)
(17) Comparison of competitive bidding and single source selection(TOR4-9)
(19) Preparation of the environmental impact assessment (EIA) report (draft) (TOR 5-1)
(20) Implementation of verification survey on involuntary resettlement and land acquisition (TOR 5-2)
(21) EIA supplement investigation (TOR 5-3)
(22) Confirmation of climate change measures effect (TOR 5-4)
(23) Investigation on project evaluation (TOR 6)

1) Economic and financial analysis will be conducted (calculation of FIRR and EIRR, calculation base of benefits, establishment of conversion factors for economic values and its base will also be presented). (TOR 6-1)
2) Operational effect index will be proposed (indexes will be established and reference values and target values for the target year, which is expected about 2 years later from the project completion, will be established). (TOR 6-2)
3) Confirmation of qualitative effect will be conducted. (TOR 6-3)

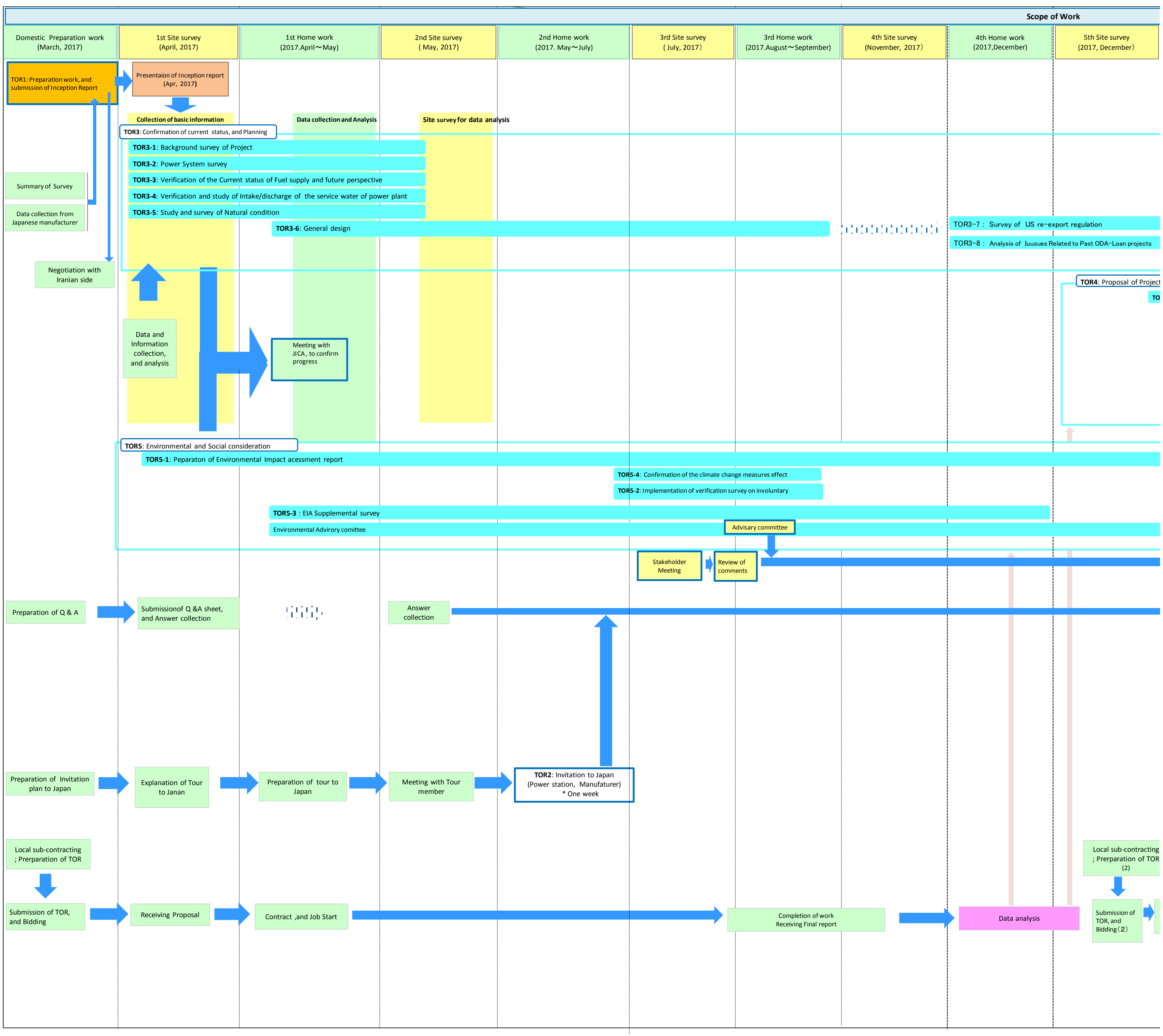


Fig. 1-1 Work Flow(1/2)

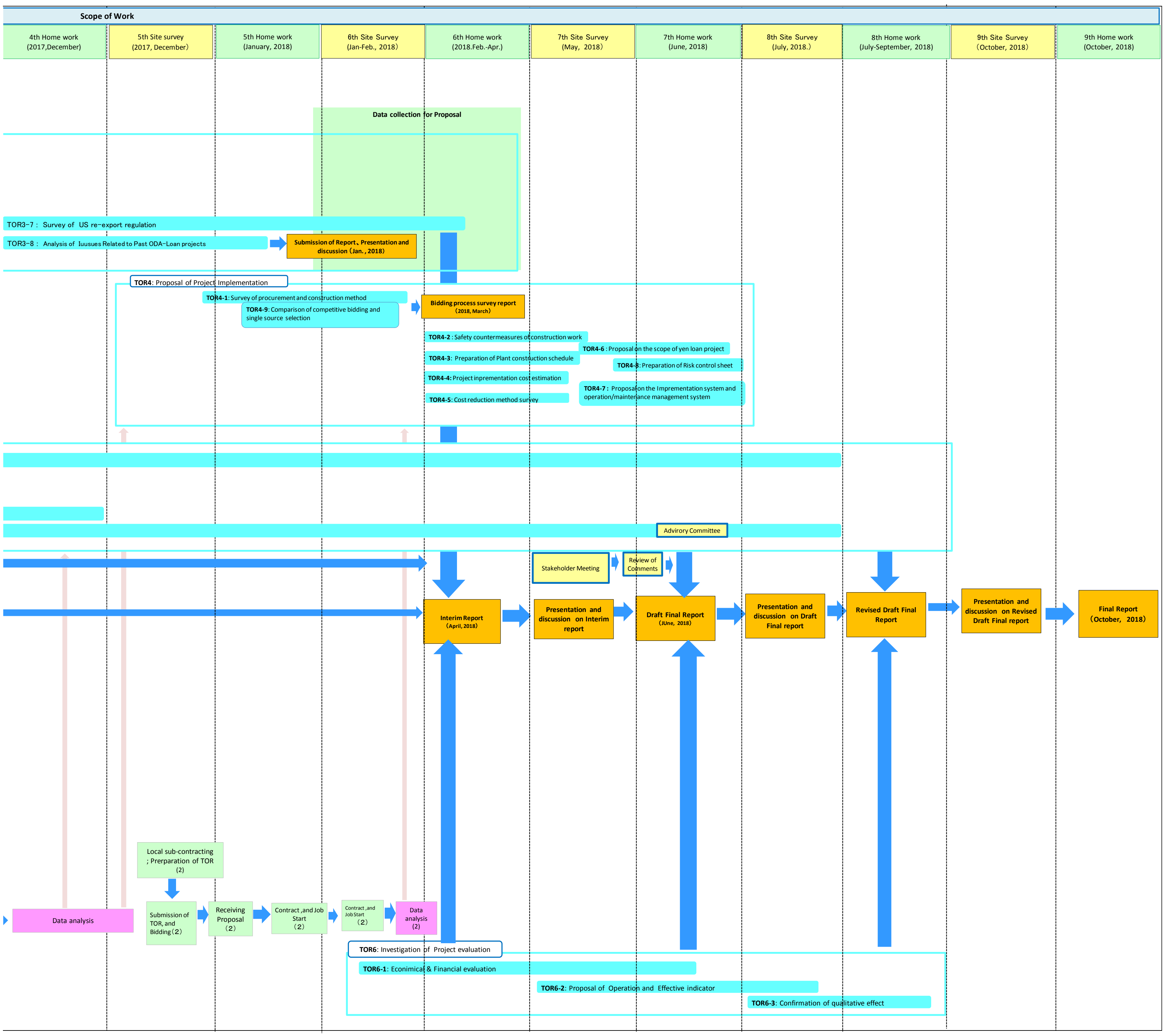
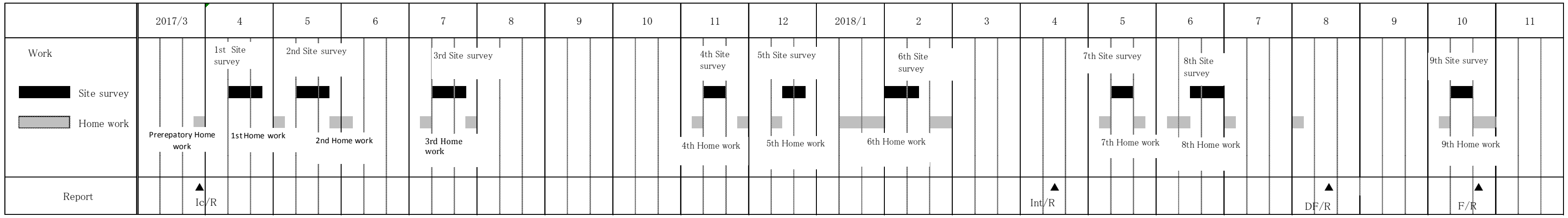


Fig. 1-2 Work Flow(2/2)

1.3 Study Schedule

The following table shows the study schedule.

Table 1-1 Study Schedule



1.4 Study Implementation System

The study implementation system is shown in the following.

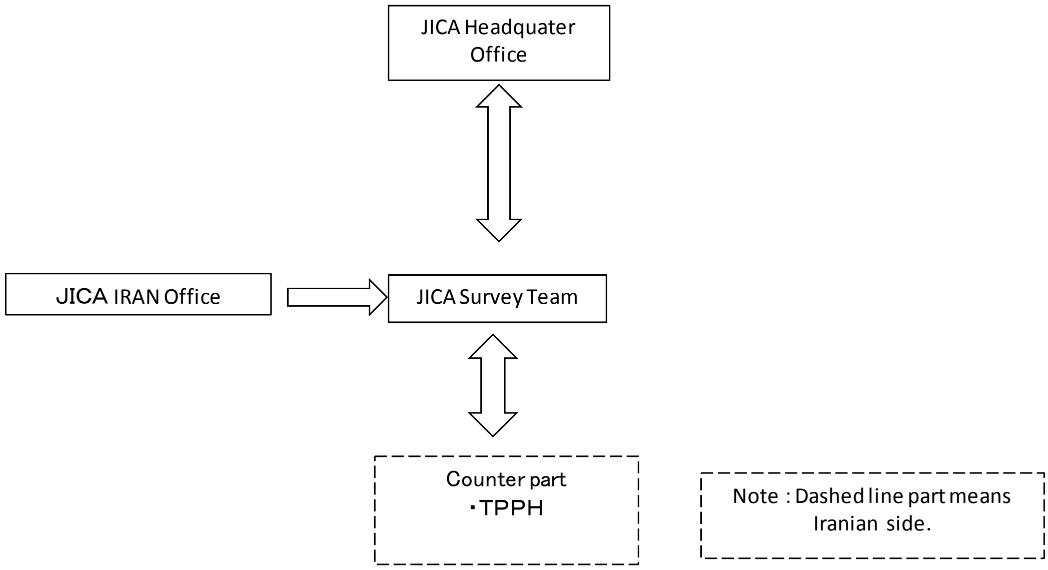
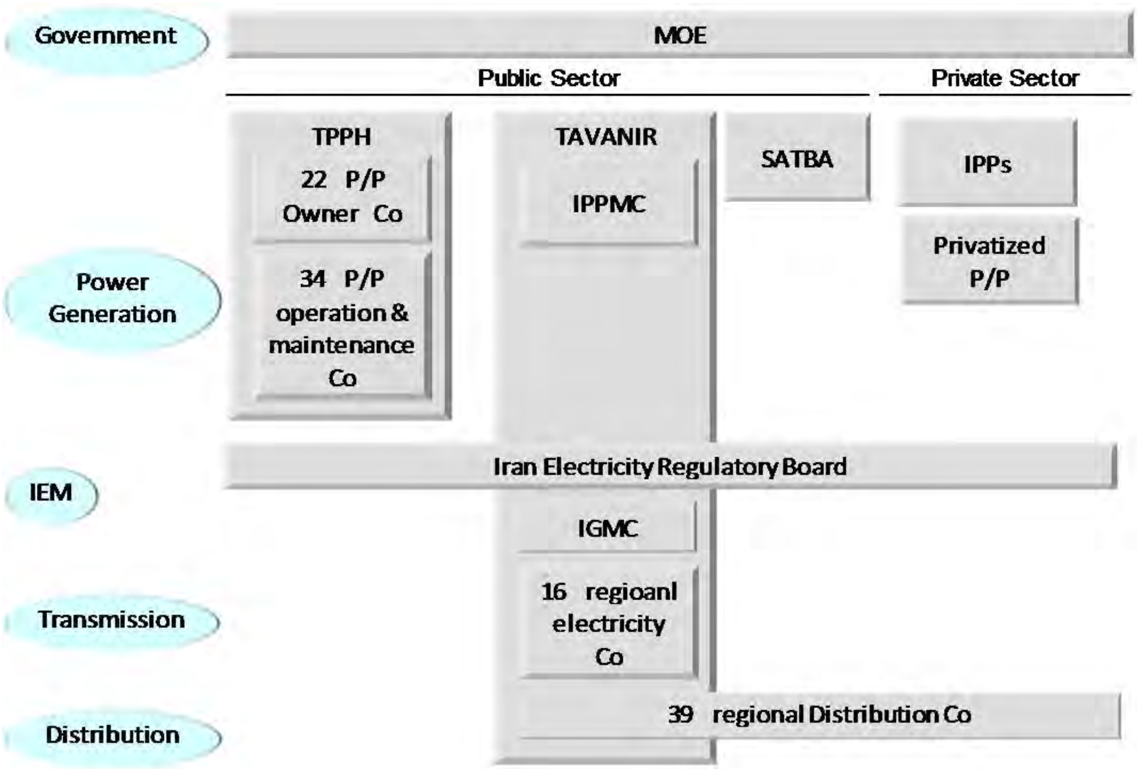


Fig. 1-3 Implementation System Diagram

Chapter 2 Overview of Electric Power Sector

2.1 Electric Power Sector System

The electrical power sector system in Iran viewed from the point of view of electrical power distribution and sales is as follows. The Ministry of Energy (MOE) has responsibility for the electrical power sector as a whole, and the Deputy Minister for Electricity and Energy is responsible for the electrical power sector. In 2015, the system of subsidiaries changed. Until last year, TAVANIR was responsible for the whole system of electrical power generation, transmission, and distribution, but in 2015, TPPH was established, and of the electrical power generation sector, the thermal generation sector was transferred from TAVANIR. Private sector power generation consists of IPP power stations developed by the private sector in BOO and BOT schemes, and publicly owned power stations that have been delegated to the private sector.



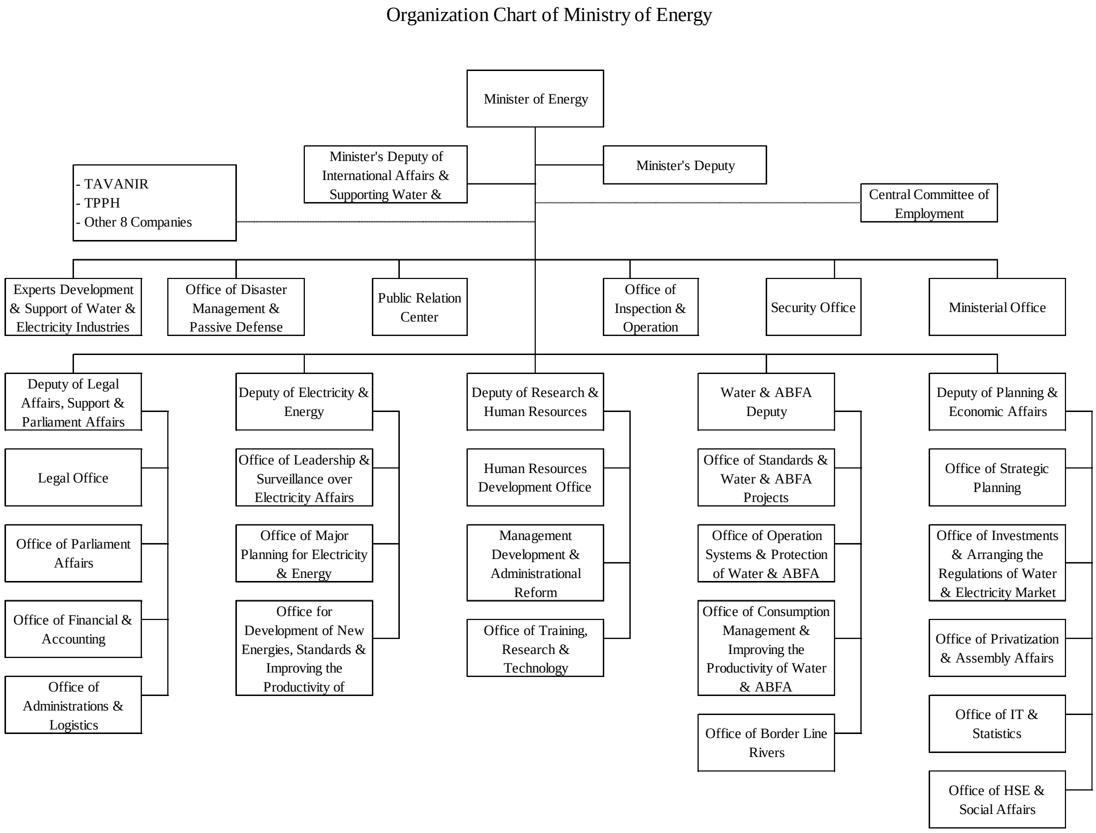
Source: TPPH

Fig. 2-1 Diagram of the Iran Electrical Power Sector System

2.1.1 The Ministry of Energy

The Ministry of Energy (MOE) is the organization responsible for supply of electrical power and other energy, as well as being responsible for water resources management, water and sewage management, human resources development and education, etc. TAVANIR and TPPH are organizations affiliated to the MOE.

Fig. 2-2 shows the organization chart of the Ministry of Energy of Iran. Besides electrical power, they are responsible for water resources. There are 10 organizations that are affiliated to the MOE, including the power transmission and distribution company (TAVANIR) and the electrical power generation company (TPPH). The other 8 affiliated companies are Water Resources Management, Water & Drainage Company, SATKAP Company, Water & Electricity University, Water and Electricity Institute, Niroo Research center, Water Research Institute, and National Water Institute.



Source: TPPH

Fig. 2-2 Organization Chart of Ministry of Energy

2.1.2 TPPH

a. Objectives of TPPH

TPPH has started its official activities on September 10 in 2015, TPPH is introduced as follows on its website.

http://www.tpph.ir/en/SitePages/HomePage.aspx

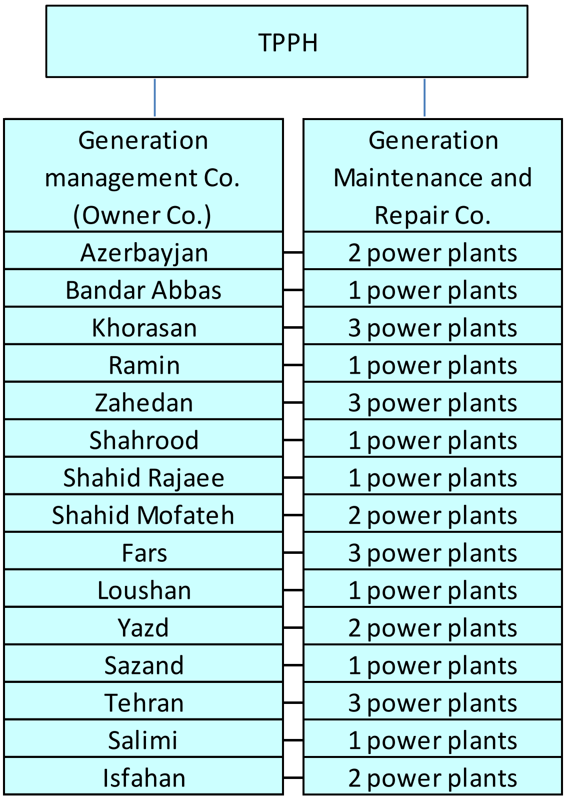
The objectives of the company are defined as follows:

- Planning, management and development of capacities for thermal power generation based on comprehensive programs of the Ministry of Energy and regulations
- Organizing and managing all thermal power producers that belong to the government in whole or in part

The parent organization for establishment of TPPH was the Iran Power Development Company (IPDC), the name IPDC was changed, and the relevant departments were transferred from TAVANIR, etc., in order to strengthen its personnel and its role. IPDC itself was a subsidiary of TAVANIR that was established in 1989, and with its restructuring into TPPH, it came under the jurisdiction of the MOE.

b. TPPH’s subsidiary company

With the independence of the thermal power generation field, the TAVANIR thermal power generation subsidiary was also transferred to TPPH. As described later, privatization of publically operating power plants is in progress, but at present publically operated power plants remain. 15 generation management companies (owner companies) and 27 power generation maintenance and repair companies have been transferred to TPPH. The roles are divided in the thermal power plants: the generation management companies own, operate, and manage the power plants, and the power generation maintenance and repair companies are responsible for maintenance and repair, etc.



Source: TPPH

Fig. 2-3 TPPH Organization Chart

2.1.3 TAVANIR

a. Objectives of TAVANIR

TAVANIR is a company responsible for power transmission, power distribution, and power generation excluding thermal power generation. It is also a holding company, that is mainly responsible for indirect work such as planning and policy, and the practical work seems to be undertaken by each of its subsidiaries. Note that TAVANIR plays a role which is comparable to the role of the Deputy Minister for Electricity and Energy, so it is a subsidiary of MOE, and can be considered to be one department in MOE.

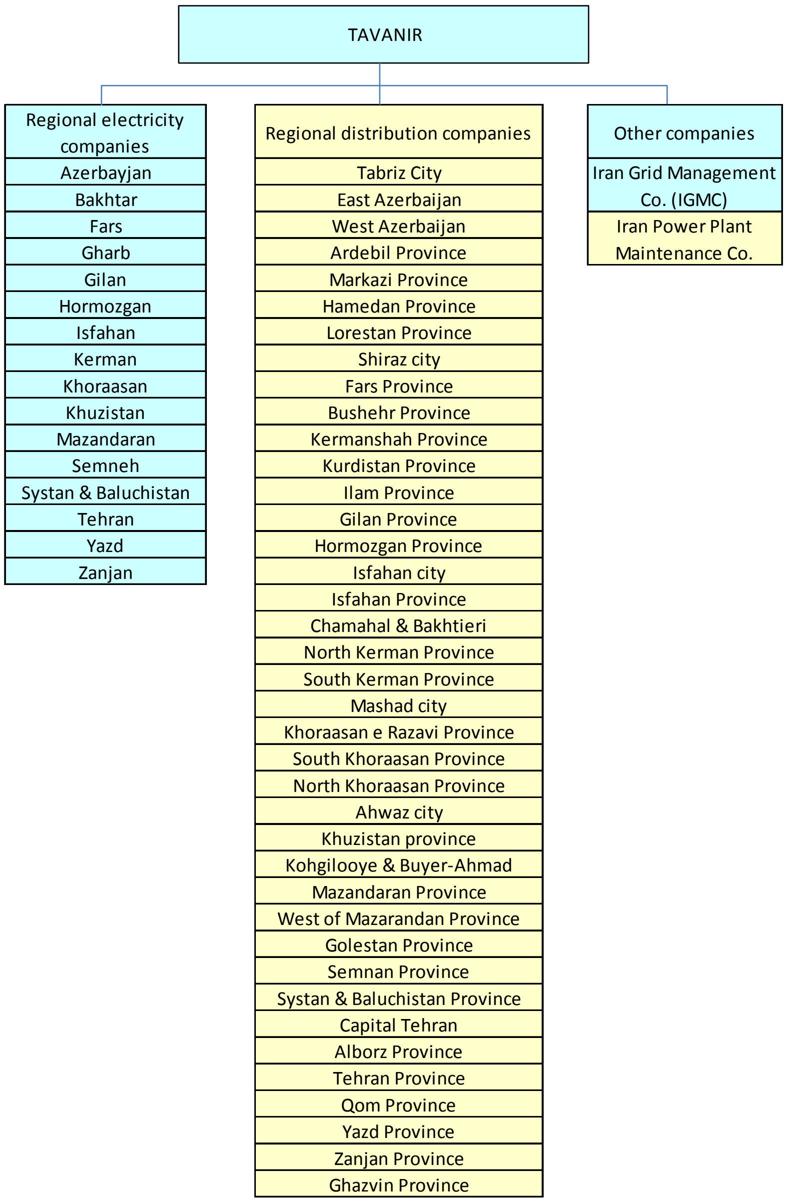
Originally TAVANIR was established in 1970 under the jurisdiction of the Ministry of Water and Electricity (name changed to the Ministry of Energy in 1975). Its initial objective was to enhance the power generation capability and substation capability, and to develop the power transmission and power distribution networks. According to their HP, the current objectives of TAVANIR are "to faster the supervisory activities of the government in the field of operation and development of the Electric Power Industry of the country within the scope of policies issued by the Ministry of Energy, Leading the subsidiary companies of the Electric Power Industries toward increasing their efficiency and productivity, and favorable utilization of the Electric Power Industry's facilities and should it necessitates get involve in certain execution activities, and carrying out the responsibilities of supervision and preparation of programs in behalf of the Ministry of Energy of Iran".

As stated previously, TAVANIR is a state-owned company that manages the transmission and distribution of electrical power within Iran. TAVANIR has 16 regional electric companies and

39 distribution companies under its jurisdiction. In addition it is also responsible for overall management of the Iran Grid Management Company (IGMC) and Iran Power Plant Maintenance Co..

b. TAVANIR's subsidiaries company

Electric companies and distribution companies are divided into each region, and each company has a monopoly on transmission and distribution in that region. What changes the characteristics of the regional distribution companies is the fact that, unlike the electric companies and their subsidiaries which are subsidiaries of TAVANIR, the regional distribution companies are privatized, with TAVANIR having a 40 – 50% ownership share. Therefore they are not subsidiaries, but affiliated companies.



Source: TPPH

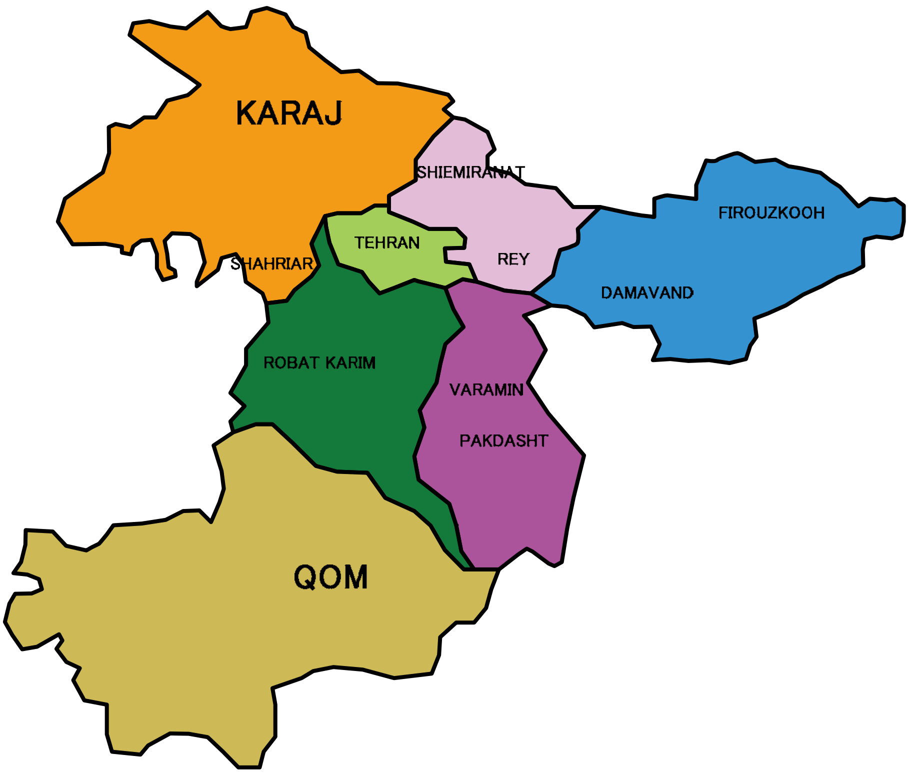
Fig. 2-4 TAVANIR Organization Chart

c. TREC（Tehran Regional Electricity Company）

Operation of the transmission and substation equipment is carried out by 16 regional electric companies, that are subsidiaries of TAVANIR.
The regional electric companies plan their own new and expanded facilities, repairs, etc., but in the case of large-scale repairs or expansion projects, the approval of TAVANIR must be obtained.

Tehran Regional Electric Company (TREC) is the largest of the regional electric companies, and is the regional electric company that supplies the capital, Tehran, and surrounding two states.

Fig. 2-5 shows the supply area of TREC. The area is about 30,000 km², and 23% of the population of Iran is living.



Source: Obtained from TREC, and prepared by the Study team

Fig. 2-5 Tehran Regional Electric Company Territory

TREC supplies the capital Tehran for a long time, and about 1/3 of the 400 kV and 230 kV main system substations are more than 30 years old, which requires replacement of transformer equipment. Therefore, rehabilitation is required, and a renewal plan has been formulated.

Among TREC's substations, in the case of primary system equipment that is more than 30 years old, there are substations for which reliability is a problem during an accident because of omission of breakers in some cases, and there are some substations where because of the omission of a substation bus, during a transmission cable accident an excessive load is placed on the equipment on the intact side (a system that continues transmitting electricity without being disconnected during cable accidents).

TREC understands the problem points and determined plans for modification have been prepared, but due to funding problems, etc., at present they are operated as they are.
The current equipment is well-maintained, and the operators are very knowledgeable, but as stated previously some substations are being operated that have a problem with reliability.

TREC owns, operates, and manages the transmission and distribution equipment. The number of substation staff varies depending on the location, but the standard personnel are six operation and management engineers, plus 14 including the plant manager, security staff, drivers, etc., for a total of 20 persons. The operation and management engineers operate on a two person three shift system (one cycle is a 24-hour period from 8:00 to 8:00).

Also, among the old substations, there are substations with a 63 kV control room separate from the 400 kV and 230 kV control room. One operating and management engineer is stationed in these control rooms (one person, three shifts), to operate and manage the 63 kV equipment.

In these substations, it is desirable that the monitoring rooms be integrated, to achieve reductions in personnel and improve efficiency.

When the operation and management engineers detect a problem with the equipment, they contact the dispatching center, and the equipment repairs are carried out by a repair company affiliated with TAVANIR.

d. Other the subsidiaries and affiliated companies of TAVANIR

・**Regional Distribution Companies**

Some of the 39 regional distribution companies, several are responsible for major cities. There are three distribution companies in Tehran. The others are responsible for wide area (provinces).

The regional distribution companies were privatized in accordance with the 2007 Act on the Independence of Regional Distribution Companies. All 39 regional distribution companies were privatized. However, TAVANIR retained shares in the companies, and own 40 – 50% of the regional distribution companies. They were not completely privatized, and TAVANIR can exercise some influence as they are affiliated companies of TAVANIR. It is considered that this is a measure to ensure that the distribution companies are managed within the framework of the policies of MOE.

・**Iran Grid Management Co. (IGMC)**

IGMC is a state-owned company, and its work is supervised by TAVANIR. The MOE Market Committee carries out supervision of the performance of the e-marketplace, which is a job related to IGMC.

This company was established in order to provide a sound competitive environment between electric power supply companies in accordance with the national electric power industry policy, to attract private sector investment into electric power generation, to reduce government interference in the electric power industry, to allocate subsidies to electric power, to respect the right of customers to choose, and to establish the market to store electricity.

・**Iran Power Plant Maintenance Company（IPPMC）**

IPPMC was established to overhaul and carry out periodic repairs to power plants and high voltage substations, and to manufacture and modify spare parts that are required for domestic power plants. One of their important roles is to enable self-sufficiency in electric power to be realized. At present it is an affiliated company of TAVANIR. The activities of IPPMC include mechanical repairs, power plant repairs, electric repairs, equipment policy matters, joint export matters in association with SANIR, and repair parts policies. TAVANIR[1] owns 49.9% of the shares of the company.

2.1.4 SATBA

The Act for the Establishment of the Renewable Energy and Energy Efficiency Organization (SATBA)[2] was legislated by the Islamic Consultative Assembly on 15th November 2016 and approved by the Guardian Council on 1st January 2017. SATBA was formed by the merger of the Renewable Energy Organization of Iran (SUNA), which was responsible for the development of renewable and new energy resources, and the Iran Energy Efficiency Organization (SABA), which was responsible for the optimization of energy systems. While both SUNA and SABA were under the control of TAVANIR before the merger, SATBA has been under the direct control of MOE since the merger.

Article 1 of this Act recognizes that SATBA is responsible for developing clean and renewable energy resources by establishing infrastructure that is appropriate for increasing efficiency and reducing loss in the transmission, distribution and consumption of power in Iran and improving the efficiency of power generation. Article 2 declares that the top agenda of the organization is to accomplish the aim of developing renewable energy resources by promoting and supporting involvement of the private sector, formulating and implementing incentive policies and developing renewable energy resources at industry level.

2.2 Present Status of Supply & Demand / Forecast Demand

2.2.1 Present Status of Electric Power Demand in Iran

The demand for electric power in Iran in fiscal years 2010 to 2016 is shown in Table 2-1.
Although there was a temporary reduction in electric power demand from fiscal 2011 to 2012 due to economic sanctions, the average annual growth rate between fiscal 2010 and 2016 was 4.8% for peak demand output and 4.3% for electric power demand.
The growth rate in the number of consumers was about 3 to 5%.
As shown in Fig. 2-6, the percentages of demand according to sector in fiscal 2016 were: household use 33%, public use 9.7%, commercial and other 7.4%, industrial use 32.7%, and agricultural use 15.2%. Compared with fiscal 2000 the percentages are almost the same, but the electric power demand has increased by a factor of 2.6.

[1] TAVANIR website; http://amar.tavanir.org.ir/pages/report/stat85/sanatlhtml/Structure.htm
[2] the act of integration of two organizations Renewable Energy Organization of Iran (SUNA) and Energy Efficiency Organization of Iran (SABA) which led to Renewable Energy and Energy Efficiency Organization (SATBA)

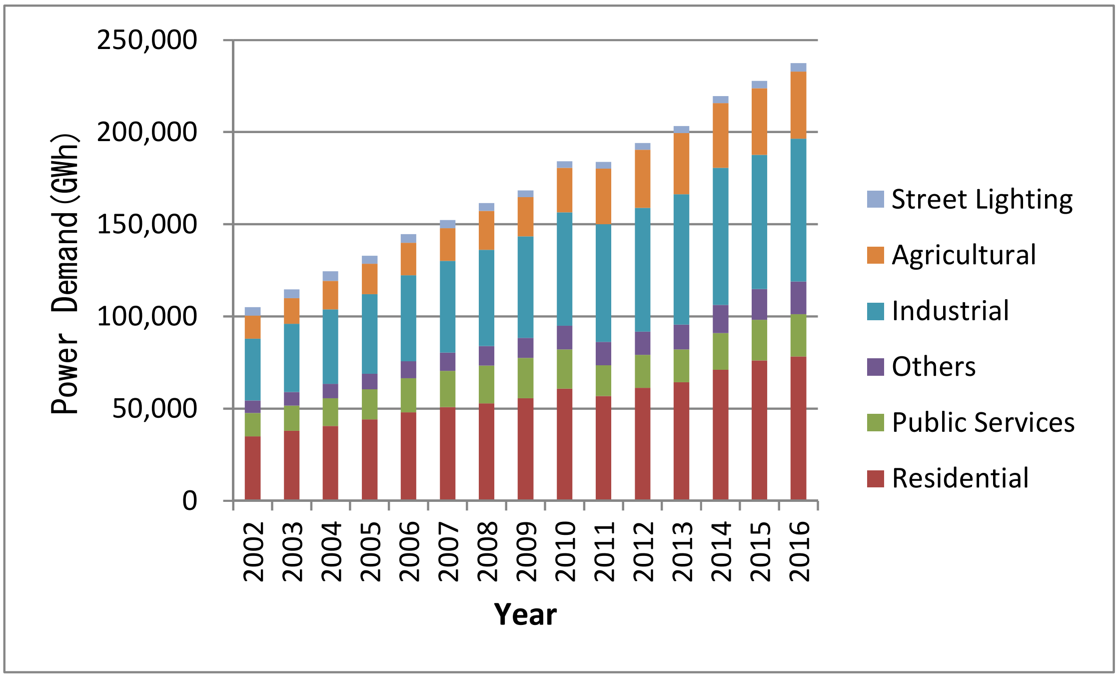
Prior to the economic sanctions the growth rate of electric power demand was between 5 and 9%, the average annual growth rates between fiscal 2000 and 2010 was 6.5% for peak demand and 7.4% for electric power demand.

Over the period 2000 to 2014, the annual average growth rate for the summer maximum demand was 6.1%, and for the peak demand was 6.5%, although there was a temporary reduction in demand under the effect of increases in oil, gas, and electricity prices at the end of 2010 during the economic sanctions.

Table 2-1 Trend of Electric Power Demand in Iran（FY 2010 to 2016）

	2010	2011	2012	2013	2014	2015	2016
Maximun Demand (MW)	40,239	42,367	43,459	46,474	48,937	50,321	53,198
Annual Growth Rate(%)	6.2%	5.3%	2.6%	6.9%	5.3%	2.8%	5.7%
Annual Demand (GWh)	184,183	183,905	194,149	203,192	219,815	227,790	237,436
Annual Growth Rate(%)	9.3%	−0.2%	5.6%	4.7%	8.2%	3.6%	4.2%
Number of Customers (Thousand custormer)	25,693	27,166	28,751	30,288	31,672	32,832	33,823
Annual Growth Rate(%)	6.2%	5.7%	5.8%	5.3%	4.6%	3.7%	3.0%

Source : Statistical Report on 50 years of Activities of Iran Electric Power Industry(1967-2016), Obtained from TAVANIR, and prepared by JICA Study Team



Source: Statistical Report on 50 years of Activities of Iran Electric Power Industry (1967-2016), Obtained from TAVANIR, and prepared by JICA Study Team

Fig. 2-6 Trend in Electric Power Demand According to Sector（2000 to 2016）

2.2.2 Status of Electrical Power Demand in the Regional Electric Companies

As an example of the electrical power demand in the regional electric companies, Table 2-2 shows the demand in Tehran Regional Electric Company (TREC) between 2010 and 2017. TREC supplies the region around the capital Tehran, and is the largest of the 6 regional electric companies.

The annual average growth rate over the period 2001 to 2015 was 5.3% for summer maximum demand, and 4.9% for peak demand.

Because the regional electric company TREC supplies the Tehran that consumes the most electricity due to dynamic economic activity, the annual average growth rate of the electrical power demand over the period 2001 to 2009 was steady with 6.4%.

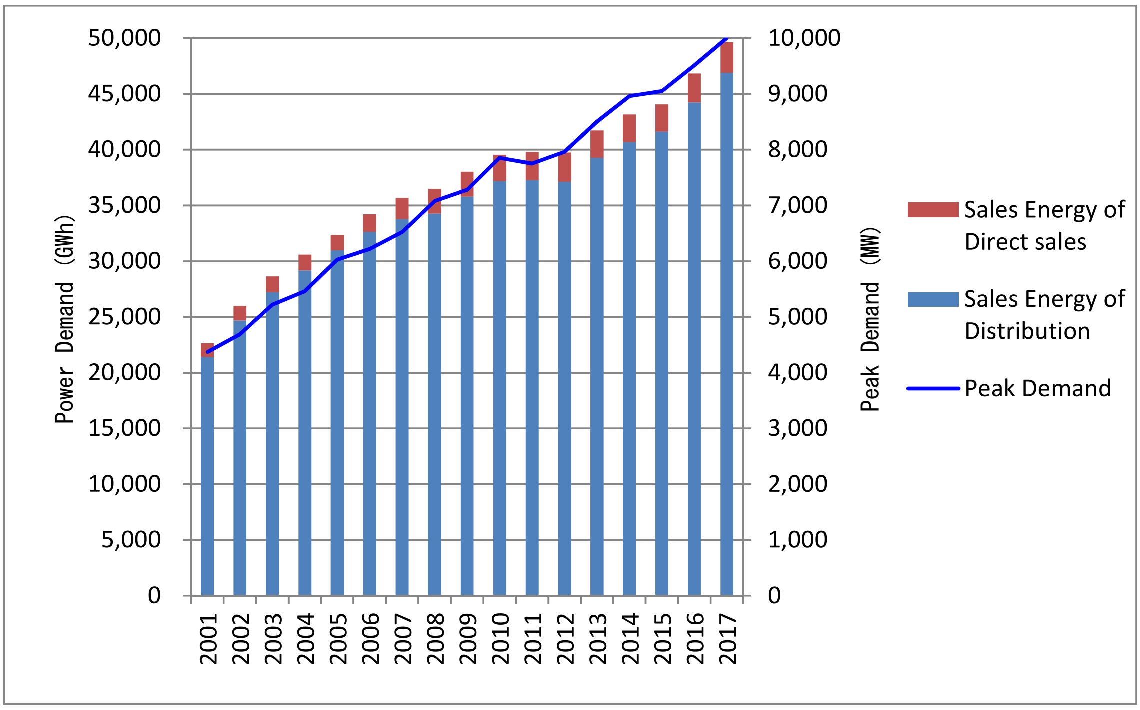
However, the effect of the increase in oil, gas, and electricity prices at the end of 2010 due to the economic sanctions was great, so in 2011 the demand was lower than in the previous year, and in 2012 also the increase in demand was only 2.7%.

Therefore the annual average growth rate over the period 2010 to 2015 was small, being only 2.9% for the maximum summer demand, and 2.2% for the peak demand.

Table 2-2 Trend in Demand within the Area Operated by the Regional Electric Company TREC （FY 2010 to 2017）

Subject	2010	2011	2012	2013	2014	2015	2016	2017
Peak demand of Distribution(MW)	7,615	7,518	7,722	8,250	8,691	8,780	9,230	9,699
Power Demand of Distribution(GWh)	37,174	37,264	37,106	39,274	40,668	41,615	44,246	46,911
Peak demand of Direct sales(MW)	460	501	523	529	553	559	636	762
Power Demand of Direct sales(GWh)	2,376	2,528	2,645	2,448	2,493	2,465	2,588	2,744
Total Peak demand(MW)	7,851	7,750	7,961	8,505	8,960	9,052	9,515	9,999
Annual Growth Rate(%)	7.8%	-1.3%	2.7%	6.8%	5.3%	1.0%	5.1%	5.1%
Total Power Demand (GWh)	39,550	39,792	39,751	41,722	43,161	44,080	46,834	49,655
Annual Growth Rate(%)	4.0%	0.6%	-0.1%	5.0%	3.4%	2.1%	6.2%	6.0%

Source: Obtained from TREC, and prepared by JICA Study Team



Source: Obtained from TREC, and prepared by JICA Study Team

Fig. 2-7 Trend in TREC Electrical Power Demand (2000 to 2017)

2.2.3 Forecast of Electrical Power Demand in Iran

Table 2-3 shows the forecast electrical power demand in Iran between 2016 and 2020.
It is envisaged that the annual average growth rate between 2016 and 2020 will be high at 6.5%.

Due to the stagnation in infrastructure renewal because of the economic sanctions, there is likely to be demand for renewal in the infrastructure field after removal of the sanctions, so it is considered that domestic investment will continue to increase in the future.

Table 2-3 Power Demand Forecast and Required Power Generation Forecast

Subject	2016	2017	2018	2019	2020
Power Demand (GWh)	247,173	263,244	280,586	298,251	318,525
Annual Growth Rate(%)		6.5%	6.6%	6.3%	6.8%
Distribution Losses(%)	10.00%	9.45%	9.20%	8.95%	8.70%
Energy with consideration of distribution losses(GWh)	274,637	290,717	309,015	327,568	348,877
Transmission and Sub-transmission Losses(%)	2.96%	2.93%	2.90%	2.87%	2.84%
Energy with consideration of transmission and sub-transmission losses(GWh)	283,014	299,493	318,248	337,254	359,087
Power plants Consumption(%)	3.50%	3.44%	3.42%	3.27%	3.23%
Amount of energy needed for the consumptions(GWh)	293,278	310,162	329,517	348,641	371,086

Source: The Sixth Five Year Development Plan in TAVANIR

In the case of GDP, which is an index of economic growth and which has a close relationship to electrical power demand, the IMF forecasts that the growth rate in GDP after removal of economic sanctions will be about 4%, as shown in Table 2-4.

Taking into consideration that the annual average growth rate of electrical power demand over the period 2010 to 2017, which included the temporary reduction due to the economic sanctions, was 4.5%, and in 2017 the actual GDP growth rate was 4.3% and the growth rate in the electrical power demand was 4.2%, if it is considered that in the future the growth rates of GDP will be at the 4% level, then it is considered that the growth rate of electrical power demand in the future will be about 6%.

Table 2-4 GDP (Gross Domestic Product) Actual and Forecast of GDP

	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019	2019/ 2020	2020/ 2021	2021/ 2022	2022/ 2023
Nominal GDP (Trillion of IRR)	11,129	12,723	14,772	17,926	20,742	23,811	27,365	31,464
Real GDP	-1.6%	12.5%	4.3%	4.0%	4.0%	4.1%	4.2%	4.4%

Source: IMF Country Report No. 18/93. ISLAMIC REPUBLIC OF IRAN. 2018 ARTICLE IV CONSULTATION—PRESS RELEASE;. STAFF REPORT; AND STATEMENT BY THE EXECUTIVE. DIRECTOR FOR THE ISLAMIC REPUBLIC, Mar. 2018

2.2.4 Forecast of Electrical Power Demand at Regional Electric Company TREC

Table 2-5 shows the forecast electrical power demand in Iran over the period 2016 to 2023 at the regional electric company TREC.

The annual average growth rate of Power demand over the period 2016 to 2020 is 6.2%.
It is envisaged that the electrical power demand of normal electricity consumers will have an annual average growth rate of 6.2% over the period 2016 to 2020, so it is considered that there

will be steady domestic investment after removal of economic sanctions.

Table 2-5 Forecast Demand within the Jurisdiction of the Teheran Regional Electric Company (TREC)

Subject	2018	2019	2020	2021	2022	2023
Peak demand of Distribution(MW)	10,217	10,736	11,261	11,793	12,313	12,138
Power Demand of Distribution(GWh)	50,072	53,150	56,332	59,507	62,685	66,141
Peak demand of Direct sales(MW)	918	1,045	1,148	1,222	1,314	1,401
Power Demand of Direct sales(GWh)	2,881	2,996	3,146	3,397	3,635	3,817
Total Peak demand(MW)	10,533	11,068	11,609	12,158	12,694	13,267
Annual Growth Rate(%)	5.3%	5.1%	4.9%	4.7%	4.4%	4.5%
Total Power Demand (GWh)	52,952	56,146	59,477	62,905	66,320	69,958
Annual Growth Rate(%)	6.6%	6.0%	5.9%	5.8%	5.4%	5.5%

Source: Obtained from TAVANIR, and prepared by JICA Study Team

2.3 Current Status of Power Generation Facilities

2.3.1 Power Generation Facilities

As shown in Table 2-6, the main electric power generation facilities in Iran are thermal power generation facilities such as steam, gas turbine, combined cycle, etc., which accounts for more than 80% of the total. Tables 2-7 to 2-9 show the main thermal power plants.
Also, in recent years the Government of Iran is undertaking initiatives to improve the efficiency of use of electric power, and is planning to introduce efficient energy use and renewable energy. Renewable energy accounts for 4% of total electric power generation.

In addition, privatization of electric power facilities is proceeding as a national policy in Iran. New plant is being developed by BOO or BOT schemes, and at the same time existing facilities are being sold. As of end fiscal 2016, 61% of the total power generation facilities have been privatized. The percentage of privatization in fiscal 2013 was 48.9%, so 12% has been privatized in three years. At the end of 2015, the percentage of privatization was 45.3% due to closure of some private power stations and the development of new power stations by the MOE, but henceforth it is planned that 60 to 70% of the new power stations will be private facilities.

Of these, the rate of privatization of gas turbine and combined cycle power plants exceeds 70%, but in the case of steam power generation facilities the rate of privatization is about 30% at present, since it is important facilities to supply power as base load.

On the other hand, the electric power generation at privatized power plants is 50% of the total power generated, and trend of increase.

Gas turbine power plants can be constructed in a short period of time, and are also scheduled to be constructed in the future, but it is planned that the power plants to be constructed in the future will be mainly combined cycle power plants in order to improve the efficiency. The plans include conversion of existing gas turbine power plants into combined cycle power plants by add on, in order to improve plant efficiency.

Table 2-6 Capacity of Power Generation According to Type (End FY 2016)

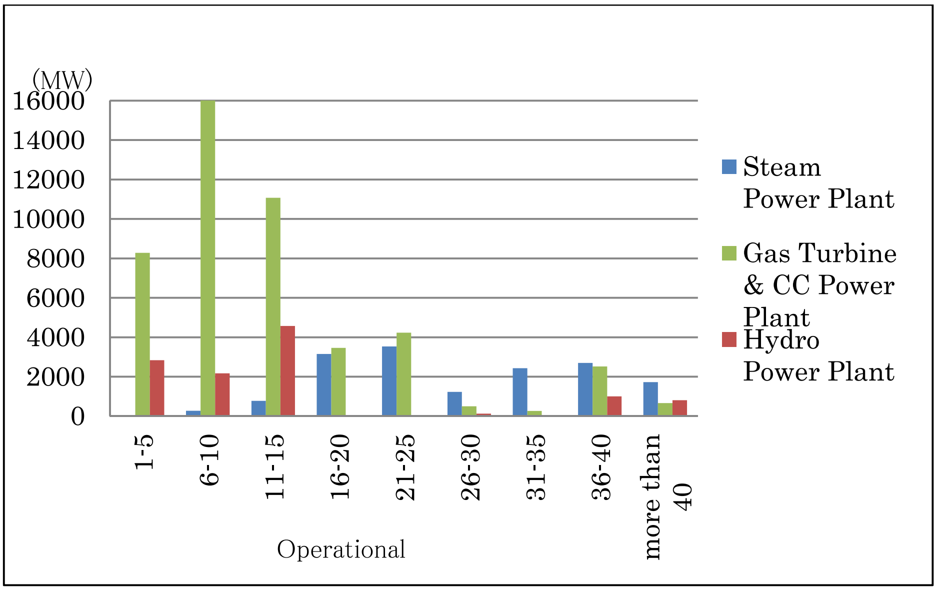
Type of Power Plants	Nominal Capacity(MW)	Ratio of power station		Privatization rate	Operational Capacity(MW)
Steam	15,830	20.7%	83.6% (Thermal Power Plants)	29.0%	15,210
Gas Turbine	27,890	36.5%		74.5%	22,447
Combined Cycle	19,470	25.5%		78.0%	15,857
Diesel	439	0.6%			284
Hydro	11,578	15.1%			11,578
Nuclear & Renewable Energy	1,223	1.6%		4.4%	1,223
Total	76,430	100.0%		45.3%	66,599

Source: Obtained from TAVANIR, and prepared by JICA Study Team

Of the thermal power generation facilities, gas turbine and combined cycle generation account for about 80% of the generation capacity, as they are affected by the external air temperature and pressure. On the other hand, steam power plants producing stable output are important facilities for base load supply etc.

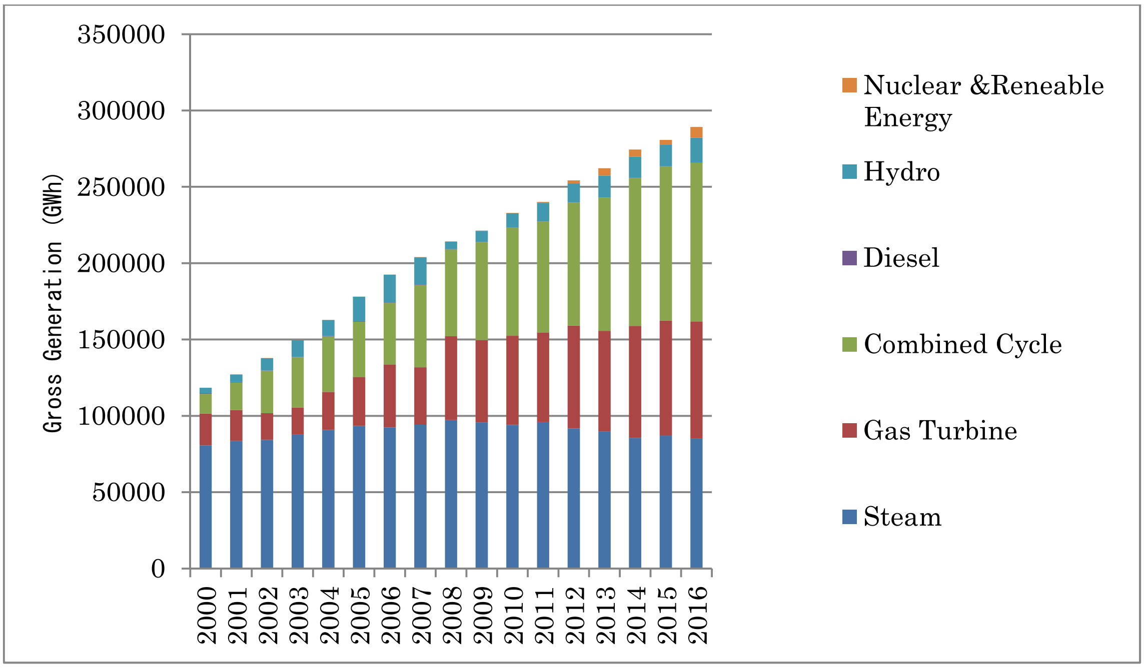
However, as shown in Fig. 2-8, 73% of the capacity of steam power plants is from plants that have been in operation for more than 20 years. Therefore, plant output is decreasing year by year, and there is a necessity for rehabilitation.

Capacity of power generation (End FY 2016) is 76,430MW, if all power plants can operate fully, according to Table 2-6. On the other hand, operational capacity is 66,599MW, considering power down of both Gas turbines and GTCCs during summer time.
As power demand is 53,198MW as shown in Table 2-1, capacity of power generation seems to be sufficient.
However, because of both deterioration of power plant and countermeasure for water shortage, capacity of power generation is evaluated to be becoming insufficient year by year.



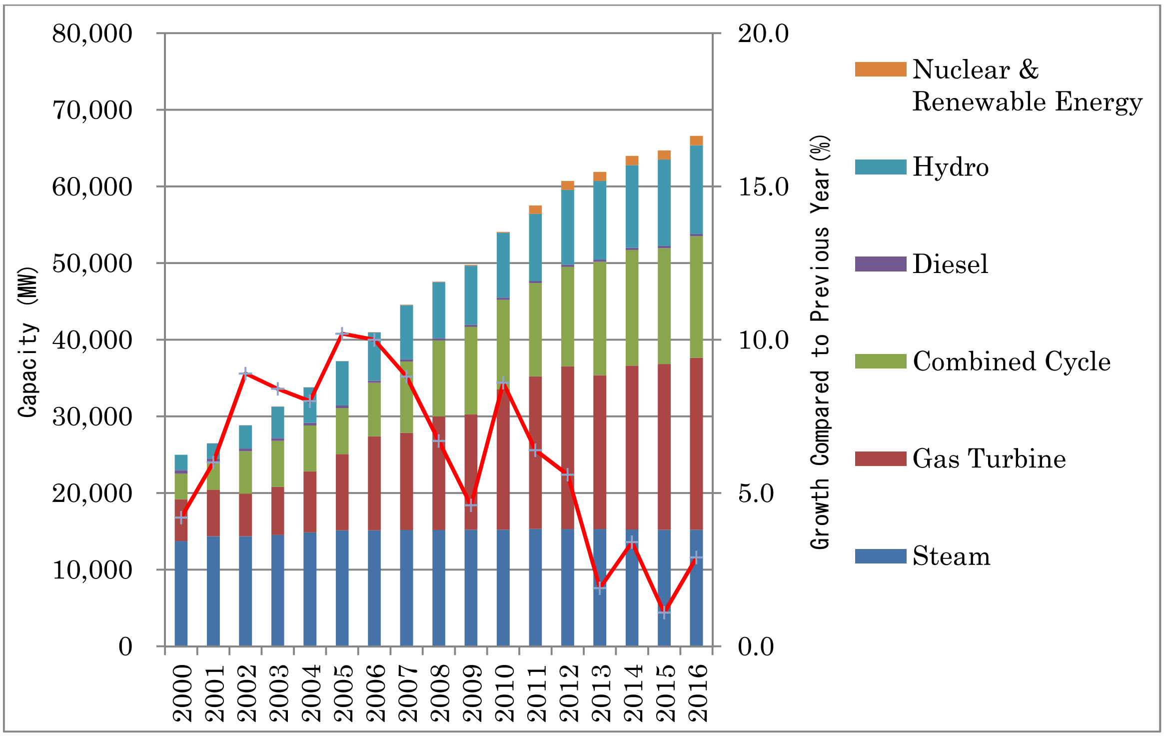
Source: Electric power industry in Iran (2016-2017): Obtained from TAVANIR, and prepared by JICA Study Team

Fig. 2-8 Number of Years of Operation of Power Plant



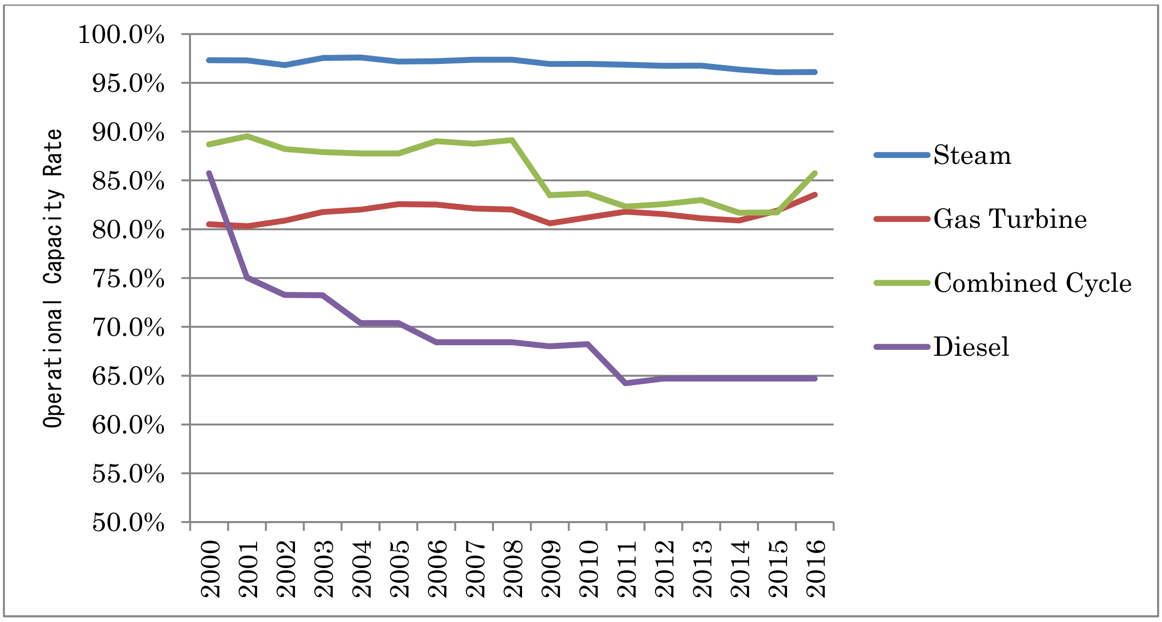
Source: Obtained from TAVANIR, and prepared by JICA Study Team

Fig. 2-9 Trend in Annual Power Generation According to Type



Source: Obtained from TAVANIR, and prepared by JICA Study Team

Fig. 2-10 Trend in Electrical Power Generation Capacity



Source: Obtained from TAVANIR, and prepared by JICA Study Team

Fig. 2-11 Trend in Operational Capacity According to Type

Table 2-7 List of Steam Power Plants (2017)

Name of Power Station	Installed Capacity(MW)			Available Capacity(MW)				Primary/secondary Voltage (kV)	Location	Completion Year	Company
				Summer period		Winter period					
	Number of Units	Unit Capacity	Total Capacity	Output capacity	Outpot Rate	Output capacity	Outpot Rate				
Tarasht (Shahid firoozi)	4	12.5	50.0	40.0	80.0%	40.0	80.0%	11.5/63	Tehran	1959	Teheran
Beasat	3	82.5	247.5	225.0	90.9%	225.0	90.9%	13.2/63	Tehran	1967-1968	Teheran
Islam Abad (Isfahan)	2	37.5	75.0	70.0	93.3%	70.0	93.3%	13.8/63	Isfahan	1969	Isfahan
	1	120.0	120.0	120.0	100.0%	120.0	100.0%	13.8/63		1974	
	2	320.0	640.0	640.0	100.0%	640.0	100.0%	20/230		1980-1988	
	Total		835.0	830.0	99.4%	830.0	99.4%				
Shahid Montazere Ghaem	4	156.3	625.0	560.0	89.6%	560.0	89.6%	15/230	Karaj	1971-1973	Teheran
Loushan (Shahid beheshti)	2	120.0	240.0	240.0	100.0%	240.0	100.0%	10.5/230	Loushan	1973	Gilan
Zarand	2	30.0	60.0	45.0	75.0%	48.0	80.0%	11.5/132	Zarand	1973	Keman
Mashhad	2	60.0	120.0	120.0	100.0%	120.0	100.0%	13.8/63	Mashhad	1973-1974	Khorasan
	1	12.5	12.5	12.5	100.0%	12.5	100.0%			1968-2007	
	Total		132.5	132.5	100.0%	132.5	100.0%				
Zargan	2	145.0	290.0	200.0	69.0%	200.0	69.0%	15/230	Ahwaz	1975-1992	Khozestan
Neka (Shahid salimi)	4	440.0	1760.0	1700.0	96.6%	1720.0	97.7%	20/400	Neka	1979-1981	Mazandaran
	2	9.8	19.6	19.6	100.0%	19.6	100.0%	Turbine extension		2007	
	Total		1779.6	1719.6	96.6%	1739.6	97.8%				
Ahwaz (Ramin)	6	315.0	1890.0	1810.0	95.8%	1810.0	95.8%	20/230	Ahwaz	1979-1999	Khozestan
	2	6.5	13.0	13.0	100.0%	13.0	100.0%	Turbine extension		2007	
	Total		1903.0	1823.0	95.8%	1823.0	95.8%				
Bandar Abbas	4	320.0	1280.0	1280.0	100.0%	1280.0	100.0%	20/230	Bandar Abbas	1980-1986	Hormozgan
Shahid M. Montazeri	8	200.0	1600.0	1568.0	98.0%	1600.0	100.0%	15.75/230/400	Isfahan	1984-1999	Isfahan
	2	8.0	16.0	8.0	50.0%	8.0	50.0%			2011-2012	
	Total		1616.0	1576.0	97.5%	1608.0	99.5%				
Toos	4	150.0	600.0	600.0	100.0%	600.0	100.0%	11.5/132	Mashhad	1985-1987	Khozestan
Tabriz	2	368.0	736.0	650.0	88.3%	650.0	88.3%	20/230	Tabriz	1986-1989	Azarbayjan
Shahid Rajaee	4	250.0	1000.0	1000.0	100.0%	1000.0	100.0%	19/400	Ghazvin	1992	Teheren
Bistoon	2	320.0	640.0	640.0	100.0%	640.0	100.0%	20/230	Kaemanshah	1994	Gharb
Shahid Mofatteh	4	250.0	1000.0	1000.0	100.0%	1000.0	100.0%	19/230	Hamedan	1994	Bakhtar
Iranshahr	4	64.0	256.0	240.0	93.8%	248.0	96.9%	21/230	Iran shahr	1995-97-2002-03	Sistan & Baluchestan
Shazand	4	325.0	1300.0	1260.0	96.9%	1280.0	98.5%	20/230	Arak	2000-2001	Bakhtar
Sahand	2	325.0	650.0	650.0	100.0%	650.0	100.0%	20/230	Tabriz	2004-2005	Azarbayjan
Sarbandar-Mahshahr	4	162.0	648.0	488.0	75.3%	584.0	90.1%	15.75/230	Khozestan	2016	TPPH
Shirvan	3	160.0	480.0	426.0	88.8%	480.0	100.0%	15.75/230	Khorasan	2017-2018	TPPH
Total	79		15240.6	14511.1		14594.1					

Source: TAVANIR documents"IRAN ELECTRIC POWER INDUSTRY (2016-2017)", and prepared by JICA Study Team

Table 2-8 List of Gas Turbine Power Plants (2017)

Name of Power Station	Installed Capacity(MW)			Available Capacity(MW)				Primary/secondary Voltage (kV)	Location	Completion Date	Company
				Summer period		Winter period					
	Number of Units	Unit Capacity	Total Capacity	Output capacity	Outpot Rate	Output capacity	Outpot Rate				
Shiraz	1	11.8	11.8	9.0	76.3%	11.0	93.2%	11/66	Shiraz	1965	Fars
	3	15.0	45.0	30.0	66.7%	36.0	80.0%	11/66		1967	
	1	28.6	28.6	18.0	62.9%	20.0	69.9%	11/66		1973	
	1	25.6	25.6	18.0	70.3%	20.0	78.1%	11/66		1974	
	1	24.2	24.2	17.0	70.2%	18.0	74.4%	11/66		1975	
	1	60.8	60.8	38.0	62.5%	44.0	72.4%	10.5/66		1981	
Mashhad	2	18.8	37.6	36.0	95.7%	38.0	101.1%	5.5/63	Mashhad	1971-1989	Khorasan
	2	79.0	158.0	124.0	78.5%	142.0	89.9%	10.5/63		1977-1978	
Bushehr	3	25.0	75.0	51.0	68.0%	57.0	76.0%	10.5/66	Bushehr	1975-1993	Fars
Loshan (Shahid beheshti)	2	60.0	120.0	100.0	83.3%	110.0	91.7%	10.5/230	Loushan	1977	Gitan
Doroud	2	30.0	60.0	30.0	50.0%	36.0	60.0%	11.5/20	Doroud	1977	Bakhtar
Shahid Zanbagh (Yazd)	4	24.3	97.0	68.0	70.1%	80.0	82.5%	11/63	Yazd	1977-1979	Yazd
Rey	4	32.0	128.0	92.0	71.9%	104.0	81.3%	11/230	Ray	1977-1978	Tehran
	10	23.7	237.0	192.0	81.0%	240.0	101.3%	11.5/230		1977-1987-2007	
	9	32.0	288.0	207.0	71.9%	232.0	80.6%	11/230		1978	
	3	85.0	255.0	183.0	71.8%	217.0	85.1%	11/230		1978	
	1	24.0	24.0	16.0	66.7%	20.0	83.3%	10.5/230		1978	
Zargan	4	32.0	128.0	80.0	62.5%	80.0	62.5%	11/230	Ahvaz	1978-1980	Khozestan(Ahvaz)
Tabriz (New)	2	32.0	64.0	46.0	71.9%	54.0	84.4%	10.5/230	Tabriz	1978	Azarbayjan
Chahbahar (Konarak)	6	23.8	142.5	102.0	71.6%	108.0	75.8%	11/63	Chabahar	1978	Sistan & Baloochestan
Orumia	2	30.0	60.0	38.0	63.3%	44.0	73.3%	11.5/20	Orumia	1981	Azarbayjan
Shariati	6	25.0	150.0	108.0	72.0%	132.0	88.0%	11.5/132	Mashhad	1984-1986	Khorasan
Sufian	4	25.0	100.0	68.0	68.0%	80.0	80.0%	10.5/132	Tabriz	1984-1985	Azarbayjan
Zahedan	3	24.5	73.4	51.0	69.5%	54.0	73.6%	11/63	Zahedan	1986	Sistan & Baluchestan
	1	30.0	30.0	17.0	56.7%	18.0	60.0%	6.6/63		1995	
	1	24.8	24.8	17.0	68.5%	18.0	72.6%	11/63		1997	
	4	24.5	98.0	68.0	69.4%	72.0	73.5%	11/63		2007	
Ghaen	3	25.0	75.0	51.0	68.0%	60.0	80.0%	11.5/132	Ghaen	1987-1994	Khorasan
Hasa	3	29.2	87.6	60.0	68.5%	69.0	78.8%	11.5/63	Shahin Shah	1989	Esfahan
Kangan	6	25.0	150.0	102.0	68.0%	114.0	76.0%	10.5/66, 11.5/66	Kangan	1995-96-97-2002	Fars
	1	14.0	14.0	11.0	78.6%	13.0	92.9%	11/66		1995	
Yazd	2	60.0	120.0	82.0	68.3%	92.0	76.7%	10.5/63	Yazd	1998	Yazd
Farg Darab	3	1.4	4.2	2.7	64.3%	3.0	71.4%	6/66	Darab	2002	Fars
Bandar Abbas	2	25.0	50.0	32.0	64.0%	36.0	72.0%	20/132	Bandar Abba	2002	Hormozgan
Hormozgan (Khalije Gars) C.C	6	165.0	990.0	834.0	84.2%	918.0	92.7%	15.75/230	Bandar Abba	2004-2005	Hormozgan
Shirvan C.C	6	159.0	954.0	756.0	79.2%	864.0	90.6%	15.75/400	Shirvan	2005-2006-2007	Khorasan
Cheisotoon	6	159.0	954.0	648.0	67.9%	792.0	83.0%	15.75/230	Isfahan	2005-2006	Isfahan
Parand	6	159.0	954.0	702.0	73.6%	804.0	84.3%	15.75/230	Tehran	2005	Tehran
Roud Shour	3	263.0	789.0	687.0	87.1%	567.0	71.9%	15.75/230	Tehran	2005-2006	Tehran(Parand)
Orumia C.C	4	159.0	636.0	488.0	76.7%	560.0	88.1%	15.75/230	Orumia	2006-2007	Azarbayjan
	2	162.0	324.0	244.0	75.3%	280.0	86.4%	15.75/230		2009	
Sabaian C.C	4	159.0	636.0	492.0	77.4%	552.0	86.8%	15.75/230	Ardebil	2006-2007	Azarbayjan
	2	162.0	324.0	246.0	75.9%	276.0	85.2%	15.75/230		2009	
Kahnodj	3	25.0	75.0	45.0	60.0%	54.0	72.0%	10.5/230	Kahnodj	2009-2012	Kerman
Asaloye	6	159.0	954.0	810.0	84.9%	906.0	95.0%	15.75/230	Asaloye	2006-2007	Booshehr
Ferdosi C.C	6	159.0	954.0	705.0	73.9%	837.0	87.7%	15.75/230	Khorasan	2006-2007	Khorasan(Mashad)
Jahrom C.C	6	159.0	954.0	654.0	68.6%	780.0	81.8%	15.75/230	Jahrom	2006-2007	Fars
Chabahar	4	24.0	96.0	64.0	66.7%	72.0	75.0%	15.75/230	Chabahar	2007	Sistan & Baluchestan
	2	159.0	318.0	254.0	79.9%	284.0	89.3%	15.75/230		2007-2008	
Shahid Kaveh C.C(Ghaenat)	4	159.0	636.0	444.0	69.8%	516.0	81.1%	15.75/400	Ghaen	2007-2008	Khorasan
Khorramshahr	4	243.0	972.0	768.0	79.0%	900.0	92.6%	15.75/230	Khorramshah	2007-08-09-13	Khozestan
Noshahr	2	23.7	47.4	34.0	71.7%	38.0	80.2%	10.5/230	Noshahr	2008	Mazandaran
Kashan	2	162.0	324.0	234.0	72.2%	272.0	84.0%	15.75/230	Kashan	2008	Isfahan
Golestan	6	162.0	972.0	840.0	86.4%	918.0	94.4%	15.75/230	Golestan	2009	Ali-Abad
Zagros	4	162.0	648.0	472.0	72.8%	536.0	82.7%	15.75/400	Kermanshah	2009-2010	Gharb
Soltanie	4	162.0	648.0	472.0	72.8%	536.0	82.7%	15.27/230	Zanjan	2009-10-11	Zanjan
Semnan C.C	2	162.0	324.0	234.0	72.2%	282.0	87.0%	15.27/230	Semnan	2009	Semnan
Bastami (Shahrood)	2	162.0	324.0	238.0	73.5%	272.0	84.0%	15.27/230	Shahrood	2010	Semnan
Hafez (Fars)	6	162.0	972.0	672.0	69.1%	798.0	82.1%	15.75/230	Fars	2010-11	Fars
Bam Pour	2	162.0	324.0	242.0	74.7%	288.0	88.9%	15.75/230	Iranshahr	2012-14	Sistan & Baloochestan
Esin	4	162.0	648.0	516.0	79.6%	580.0	89.5%	15.75/230	Hormozogan	2013	Hormozogan
Eslamabad Ghard	4	25.0	100.0	96.0	96.0%	116.0	116.0%	10.5/230	Eslamabad	2013	Gharb
Shams Sarakhs	2	25.0	50.0	31.0	62.0%	38.0	76.0%	10.5/132	Sarakhs	2013	Gharb
Taban Sadoogh Yard	2	162.0	324.0	-	-	-	-	-	Yard	2015	(private)
Ofogh	4	166.0	664.0	-	-	-	-	-	Mahshahr	2016	Khouzestan
Piroozan	2	166.0	332.0	-	-	-	-	-	Behbahan	2016	(private)
Goharan	2	166.0	332.0	-	-	-	-	-	Sirjan	2016	(private)
Samangan	2	166.0	332.0	-	-	-	-	-	Kelman	2016	(private)
DG & CHP	126		916.0	-	-	-	-	-	Country	2010-2016	Gharb
Total Gas Power Plants in NG	355		22848.5	15086.7	66.0%	17108.0	74.9%				
Kish (Gas)	3	37.5	112.5	81.0	72.0%	90.0	80.0%	10.5/20	Kish	1922-99-2003	Kish
	1	24.3	24.3	14.0	57.6%	14.0	57.6%			2006-2007	
	2	23.5	47.0	28.0	59.6%	28.0	59.6%			2006-2007	
Khark (Gas)	1	25.0	25.0	16.0	64.0%	20.0	80.0%	10.5/20	Khark	2014	Fars
Total Gas Power Plants out of NG	7		208.8								
Total	362.0		23057.3								

Source: TAVANIR documents "IRAN ELECTRIC POWER INDUSTRY (2016-2017)", and prepared by JICA Study Team

Table 2-9 List of Combined Cycle Power Plants (2017)

Name of Power Station	Installed Capacity (MW)			Available Capacity (MW)				Primary / secondary Voltage (kV)	Location	Completion Date	Company
				Summer period		Winter period					
	Number of Units	Unit Capacity	Total Capacity	Output capacity	Outpot Rate	Output capacity	Outpot Rate				
Gilan Combined-Cycle	6	143.2	859.2	726.0	84.5%	822.0	95.7%	10.5/230		1992	Gilan
	3	148.8	446.4	405.0	90.7%	414.0	92.7%	15.75/230	Rashy	1997	
Montazare Ghaem	6	116.3	697.5	480.0	68.8%	576.0	82.6%	13.8/230	Karaj	1992	Tehran
	3	100.0	300.0	240.0	80.0%	288.0	96.0%	10.5/230		1999-2000	
Qom Combined-Cycle	4	128.5	514.0	368.0	71.6%	432.0	84.0%	13.8/230	Qom	1993	Tehran
	2	100.0	200.0	184.0	92.0%	200.0	100.0%	11.5/230		1997-1998	
Shahid Rajai Combined-Cycle	6	123.8	742.8	504.0	67.9%	600.0	80.8%	13.8/400	Ghazvin	1994	Tehran
	3	100.0	300.0	252.0	84.0%	297.0	99.0%	10.5/400		2001	
Neishabour Combined-Cycle	6	123.4	740.4	546.0	73.7%	606.0	81.8%	13.8/400	Neishabour	1994-1998	Khorasan
	3	100.0	300.0	273.0	91.0%	300.0	100.0%	10.5/400		2002-2003	
Shariati Combined-Cycle	2	123.4	246.8	180.0	72.9%	210.0	85.1%	13.8/132	Mashad	1994	Khorasan
	1	100.0	100.0	95.0	95.0%	100.0	100.0%	10.5/132		2003	
Fars Combined-Cycle	6	123.4	740.4	498.0	67.3%	576.0	77.8%	13.8/230	Shiraz	1995-1998	Fars
	3	98.3	294.9	249.0	84.4%	288.0	97.7%	10.5/230		2002	
Khuy Combined-Cycle	2	123.4	246.8	180.0	72.9%	202.0	81.8%	13.8/230	Khuy	1997	Azarbayjan
	1	102.5	102.5	90.0	87.8%	100.0	97.6%	10.5/132		2002	
Shahid Salimi Combined-Cycle	1	160.0	160.0	154.0	96.3%	160.0	100.0%		Neka	2006	Mazandaran
	2	137.5	275.0	232.0	84.4%	258.0	93.8%	10.5/230		1990	
Yazd Combined-Cycle	2	160.0	320.0	272.0	85.0%	297.0	92.8%	15/230	Yazd	2006-2010	Yazd
	2	123.4	246.8	184.0	74.6%	206.0	83.5%	15/230		2000	
	2	159.0	318.0	228.0	71.7%	262.0	82.4%	15/230		2008-2009	
Kazeroon Combined-Cycle	2	128.0	256.0	190.0	74.2%	220.0	85.9%	13.8/230	Kazeroon	1994	Fars
	4	159.0	636.0	468.0	73.6%	544.0	85.5%	15.75/230		2002-2003	
	3	160.0	480.0	401.0	83.5%	452.0	94.2%	15.75/230		2006-2007	
Kerman Combined-Cycle	8	159.0	1272.0	880.0	69.2%	1000.0	78.6%	15.75/230	Kerman	2001-2002	Kerman
	4	160.0	640.0	528.0	82.5%	588.0	91.9%	15.75/230		2007-2009	
Damavand Combined-Cycle	12	159.0	1908.0	1404.0	73.6%	1608.0	84.3%	15.75/400	Garmsar	2003-2004-2005	Tehran
	6	160.0	960.0	552.0	57.5%	620.0	64.6%	15.75/400		2009-2010-2011	
Sanandaj Combined-Cycle	4	159.0	636.0	456.0	71.7%	528.0	83.0%	15.75/230	Sanandaj	2005-2006	Gharb
	2	160.0	320.0	134.0	41.9%	152.0	47.5%	15.75/230		2011-2012	
Abadan Combined-Cycle	4	123.4	493.6	364.0	73.7%	452.0	91.6%	13.8/230	Abadan	2002-2003	Khozestan
	2	160.0	320.0	272.0	85.0%	262.0	81.9%	10.5/230		2013-2014	
Zavare Combined-Cycle	2	162.0	324.0	220.0	67.9%	262.0	80.9%	15.7/230	Esfahan	2011	Esfahan
	1	160.0	160.0	130.0	81.3%	151.0	94.4%	15.75/230		2012	
Pare Sar Combined-Cycle	4	162.0	648.0	536.0	82.7%	452.0	69.8%	15.75/230	Gilan	2011-2012	Gilan
	2	160.0	320.0	308.0	96.3%	320.0	100.0%	15.75/230		2013	
Shir Kooh Combined-Cycle	2	162.0	324.0	230.0	71.0%	272.0	84.0%	15.75/230	Yazd	2012	Yazd
	1	160.0	160.0	135.0	84.4%	156.0	97.5%	15.75/230		2013	
Genaveh Combined-Cycle	2	162.0	324.0	244.0	75.3%	292.0	90.1%	15.75/230	Boushehr	2011	Genaveh
	1	160.0	160.0	142.0	88.8%	160.0	100.0%	15.75/230		2014	
	Total		484.0	386.0	79.8%	452.0	93.4%				
Shoobad	2	162.0	324.0	-	-	-	-	-	Kahnooj	2014	(private)
	2	80.0	160.0	-	-	-	-	-		2016	
	Total		484.0	-	-	-	-	-			
Chadormaloo	2	166.0	332.0	-	-	-	-	-	Chadormaloo	2014	(private)
	1	160.0	160.0	-	-	-	-	-		2016	
	Total		492.0	-	-	-	-	-			
Total	139		19469.1	11353.0		12906.0					

Source: TAVANIR documents ”IRAN ELECTRIC POWER INDUSTRY (2016-2017)”, and prepared by JICA Study Team

2.3.2 Transmission, Distribution, and Substation Facilities

TAVANIR is responsible for planning and strategy formulation of transmission and distribution facilities in all Iran, and implementation is the responsibility of its subsidiaries, the regional electric companies. In addition, IGMC, a subsidiary of TAVANIR is the entity responsible for monitoring and control of the electrical power system, standardization of protective control relays, determination of specifications, etc., and the regional electric companies take charge of practical affairs in accordance with the guidelines and instructions of IGMC.

The Iranian electric power system consists of a 400 kV and 230 kV primary transmission system, a 132 kV, 66 kV, and 63 kV secondary transmission system, and a 20 kV, and in part 33 kV and 11 kV distribution system.

Also, they have started to investigate a 765 kV ultra-high voltage system as the next generation primary system voltage.

The following dispatching centers have been provided in Iran for monitoring and control of the electric power system. Under the direction of IGMC,

- Central Region and Backup Dispatching Center
- Tehran Dispatching Center
- Northwest Region Dispatching Center
- Northeast Region Dispatching Center
- Southwest Region Dispatching Center
- Southeast Region Dispatching Center
- South Region Dispatching Center
- North Region Dispatching Center
- West Region Dispatching Center

RTU（Remote Terminal Unit）s or optical communication equipment is installed at each substation in order to transmit information to these dispatching centers.

The primary system transmission cables as of the end of fiscal 2016 included 20,477 km of 400 kV transmission cable, and 31,324 km of 230 kV transmission cables, covering the whole country of Iran.

Fig. 2-12 and Fig. 2-13 shows the trend in the total length of the primary system transmission cables and the total capacity of transformers over the period fiscal 2000 to 2016.
The average growth rates of the total length of transmission cable over the period fiscal 2000 to 2016 was 5.1% for 400 kV transmission cables and 3.4% for 230 kV transmission cables.

Table 2-10 shows a list of the 400 kV and 230 kV substations and switch stations of the regional electric company TREC, which supplies the Tehran region. Fig. 2-14 shows the system diagram.

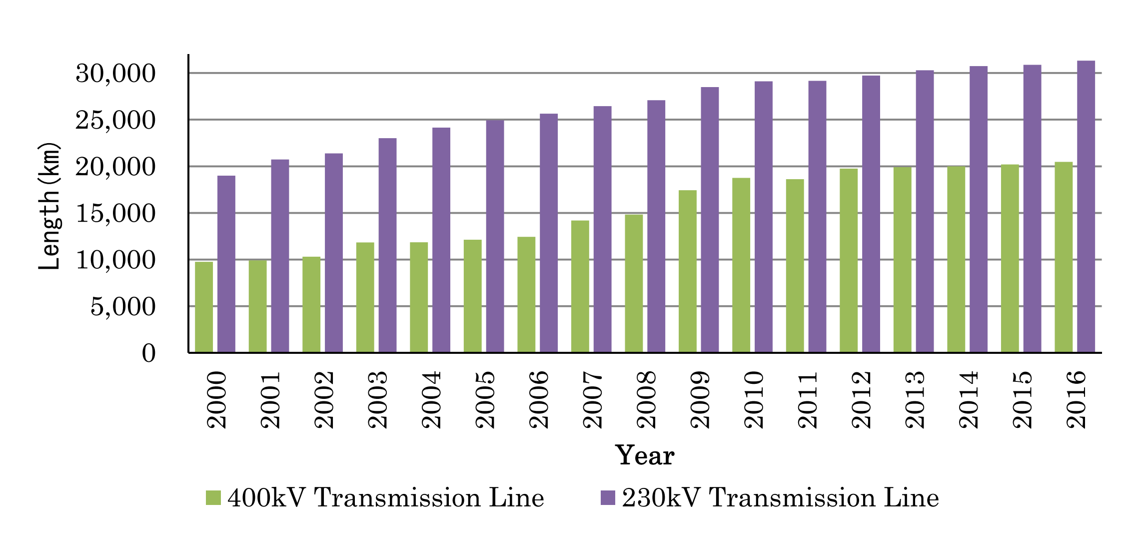
Through surveys within the Tehran Regional Electricity Authority (TREC), summary of the results of consideration on future issues of transmission line and substation equipment will be as follows.

1）Issues of facility configuration / supply reliability：
By omitting the facility from the standard form as a cost reduction measure in equipment construction, substations exist which have problems such as reduction of supply reliability, extension of power outage range, and time-consuming restoration of accidents. Specifically, among the 400 kV substations, there is a substation that omits the bus and directly connects the transmission line and the transformer. At the time of this transmission line accident, the transformer also stops at the same time, causing overloading of the remaining transformer and there is a problem in terms of supply reliability.

2）Issues on voltage maintenance measures：
There are substations where the voltage (230 kV) drops to about 90% of the nominal state at heavy load (peak demand), and stable power quality (voltage maintenance) can’t be secured. It is considered necessary to install shunt capacitor for the purpose of maintaining the voltage for the future.

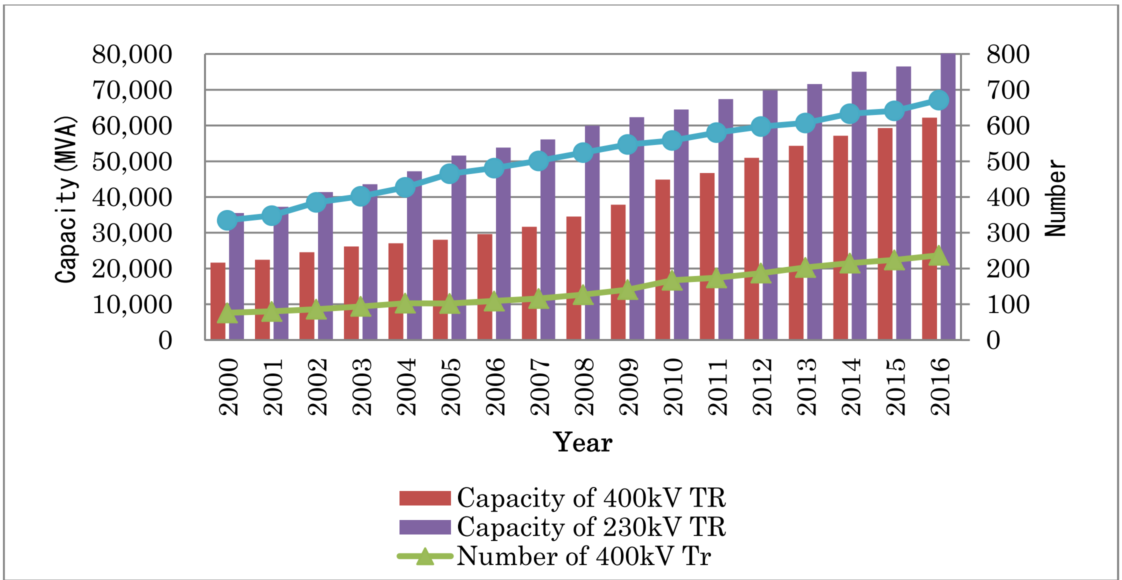
3) Issues on overload measures
The substation facility is designed assuming that the availability of the remaining transformer within 110% when one transformer occurs fault. (Example: when transformers in substation are three： 110 × (3 - 1) / 3 = 73% and in the case of two one： 110 × (2 - 1) / 2 = 55%) The availability at the time when one of the transformers stops failure is called the operation target

value, In Iran there are many substations that are operating beyond this operational target value. When a failure occurs in a transformer of a high availability substation, if the remaining transformer that has become overloaded is shut down for protecting the equipment, then, all the transformers of the substation will be stopped, and a wide range of power failure will occur. For this reason, it is considered necessary to expand facilities such as transformer expansion as a measure to lower the availability of the transformer.



Source: Obtained from TAVANIR, and prepared by JICA Study Team

Fig. 2-12 Trend in Total Length of Primary Transmission Cable



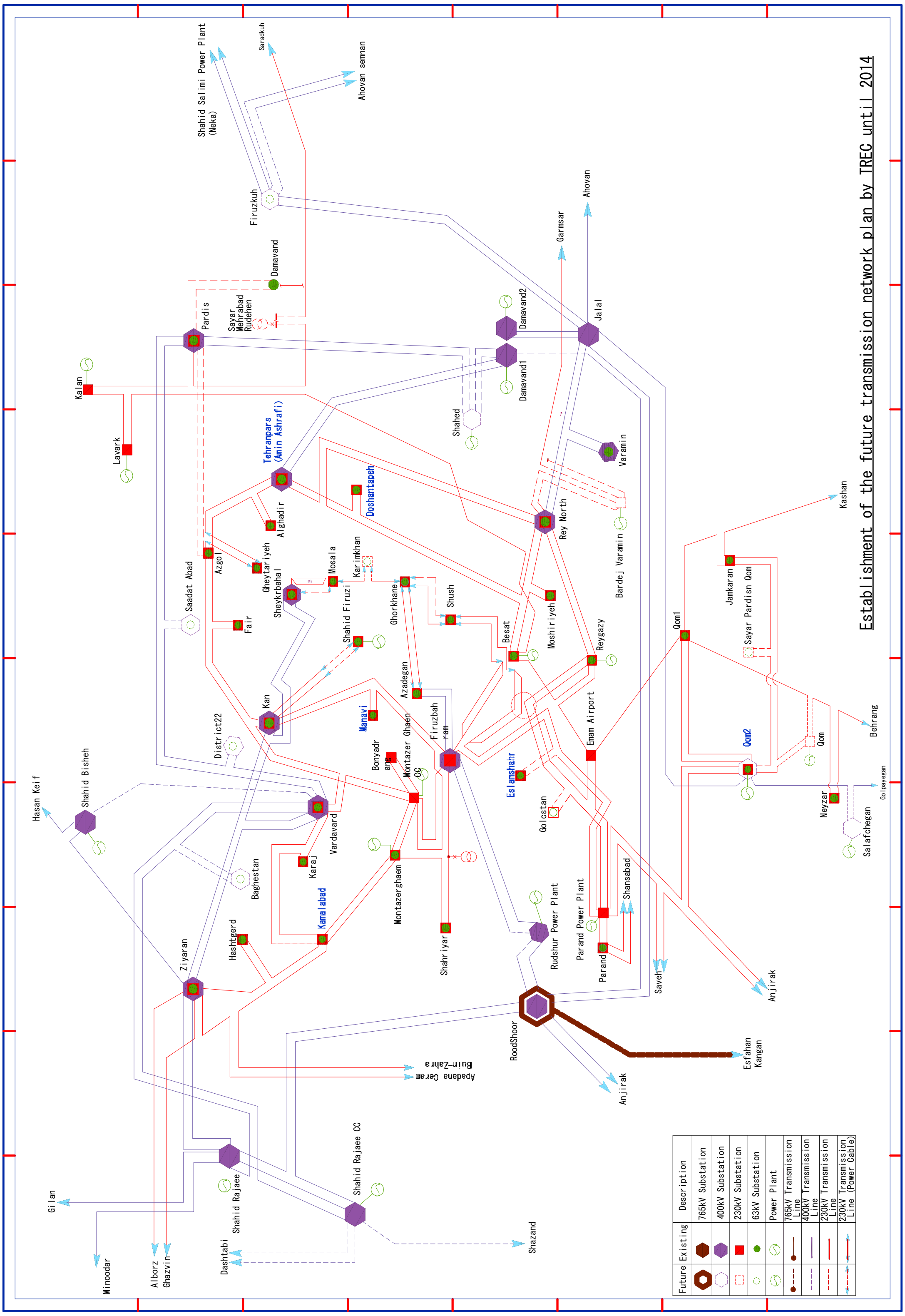
Source: Obtained from TAVANIR, and prepared by JICA Study Team

Fig. 2-13 Trend in the Number of Primary Substations and Total Capacity of Transformers

Table 2-10 List of 400 kV and 230 kV Substations and Switch Stations within the TREC Area

No	Substation Name	Voltage (kV)	Capacity (MVA)	Year of Operation	Operating Year
1	Besat	230/63	360	1967	49
2	Firouzbahram	400/230	2000	1969	47
3	ShahidFirouzi	230/63	340	1970	46
4	MontazerQaem	230/63	540	1971	45
5	MontazerQaem-CHP Switch station	200	–	1971	45
6	Ozgol	230/63	350	1974	42
7	Namayeshgah	230/63	540	1974	42
8	Kan	400/230	1000	1976	40
		230/63	320	1976	40
9	DoshanTappeh	230/63	540	1976	40
10	Manavi	230/63	540	1976	40
11	Qom1	230/63	360	1978	38
12	Ziyaran	400/230	1000	1979	37
		230/63	250	1979	37
13	Tehran Pars	400/230	1000	1981	35
		230/63	360	1981	35
14	Jalal Switch station	400	–	1981	35
15	Rey Gas Turbine	230/63	360	1983	33
16	Rey Shomali	400/230	1500	1987	29
		230/63	680	1987	29
17	Kalan-Switch station	200	–	1989	27
18	Mosalla	230/63	720	1990	26
19	Azadegan	230/63	540	1991	25
		230/20	180	1991	25
20	ShahidRajaeiPower Plant's Switch station (Gas Turbine)	400	–	1993	23
21	ShahidRajaeiPower Plant's Switch station (CHP)	400	–	1995	21
22	Eslamshahr	230/63	480	1995	21
23	Qom Cycle (Qom 2)	230/63	320	1995	21
24	Qourkhaneh	230/63	540	1995	21
		230/20	180	1995	21
25	ZarrinKouh Mobile	230/63	40	1996	20
26	Moshiriyeh	230/63	320	1998	18
27	Alghadir	230/63	500	1999	17
28	BonyadRang	230/25	126	1999	17
29	Shoush	230/63	360	1999	17
30	Firouzkouh Mobile	230/63	40	2000	16
31	Hashtgerd	230/63	320	2002	14
32	Vardavard	400/230	1000	2003	13
		230/63	320	2003	13
33	Parand	230/63	320	2003	13
34	Parand-Power Plant Switch station	200	–	2003	13
35	Qeytariyeh	230/63	320	2003	13
36	Karaj	230/63	320	2003	13
37	Imam Khomeini airport	230/20	80	2004	12
38	Damavand Power Plant's Switch station	400	–	2005	11
39	Pardis	400/230	1000	2008	8
		230/63	320	2005	11
40	Kamalabad	230/63	500	2006	10
41	RoudshourGas Turbine Switch station	400	–	2007	9
42	RoudshourSwitch station	400	–	2007	9
43	Jamkaran	230/63	320	2007	9
44	SaeidabadSemi Mobile	230/20	90	2008	8
45	Neyzar Mobile	230/63	80	2009	7
46	Varamin	400/63	400	2010	6
47	Sheikh Bahaei	400/230	1000	2011	5
		230/63	360	2010	6
48	Shahriyar	230/63	360	2011	5
49	SiahbishePower Plant Switch station	400	–	2014	2
50	Firouzkouh	400/230	200	2015	1

Source: Prepared by JICA Study Team, based on TREC documents (2016.7.12)



Source: Prepared by JICA Study Team, based on TREC documents

Fig. 2-14 TREC Transmission System Diagram

2.4 Electric Power Facility Plans for Future

The development of the power plants shown in Table 2-11 is planned in conjunction with the increase in the electric power system and demand in Iran, by the development of new power plants as sources of electric power, completion of hydroelectric power plants under construction, conversion of existing gas turbine power plants to combined cycle power plants in order to improve efficiency, and development of new power plants by BOO and BOT, etc.
In this way, the reserve capacity will be increased and the electric power supply stabilized.

In addition, the policy of the Iranian Government to privatize power generation facilities of can be seen in this plan in which 60% to 70% of the power plants to be developed are private.

Table 2-11 Time Schedule for Completion of Various New Power Plants

No	Regional electricity power	Name of Power Plant	Kind of Power Plant	Capacity(MW) 2017	2018	2019	2020
1	Ministry of energy	Shirwan	Combined Cycle	160	320	0	160
2		Zarand		0	0	324	160
3		Zahedan		0	0	0	324
4		Bandar abbas		0	307	307	292
5		Tabris		0	0	307	144
6		Khoramabad		0	0	307	0
7		Andimeshk		0	0	0	307
8		Rey C.C.		0	0	0	1,050
9		Ramin Ahvaz		0	0	0	307
10		Tehran 2		0	0	0	446
11		Noshahr	Gas Turbine	25	0	0	0
12		Behshahr		25	0	0	0
13		Sirk	Thermal	0	0	0	350
14		Yazd Solar	Solar	0	0	17	0
15	Private	Pasargad Gheshm	Combined Cycle	0	324	160	0
16		West Mazandaran		307	140	0	0
17		Khorramabad		0	324	160	0
18		Sadough (Yazd 2)		0	0	0	0
29		Dalahoo (Kermanshah)		0	304	160	0
20		Gol Gohar Sirjan		160	160	0	0
21		Samangan		160	0	0	0
22		Heris		0	310	160	0
23		Makoo		74	36	0	0
24		Sabzevar		0	0	0	307
25		Behbahan		0	0	0	0
26		Andimeshk & Dezfoul		0	0	304	150
27		Gachsaran		0	0	0	307
28		Zahedan 2		0	0	0	307
29		Omidieh		0	0	0	307
30		Aras		0	0	0	307
31		Arvand		0	0	307	160
32		Dehdasht		0	0	307	160
33		Parand		160	320	0	0
34		Jahrom		0	480	0	0
35		Oroomieh		0	0	160	320
36		Sabalan		0	160	320	0
37		Rood-e Shoor		0	0	345	0
38		Chabahar		0	0	160	0
39		Kashan		0	160	0	0
40		Semnan		0	0	0	160
41		Sltanih		0	0	0	320
42		Zagros		0	0	0	320
43		Ferdosi		0	480	0	0
44		Aliabad		0	0	0	160
45		Asaloyeh		0	480	0	0
46		Saveh		0	0	0	810
47		Renewable Energies	Renewable	600	960	960	960
48		Dispersed Generation, Heat and Power Production	DG, CHP	250	480	480	480
49	Ministry of Energy	Darian	Hydro	210	0	0	0
50		Roodbar in Lorestan		225	0	0	0
51		Sardasht		50	100	0	0
52		Chamshir		0	55	0	0
53		Plants Hydro power		4	0	20	0
Total of MOE				699	782	1,282	3,540
Total of Private Sector				1,711	5,118	3,983	5,535
Total of the Country				2,410	5,900	5,265	9,075
Privatization rate				71.0%	86.7%	75.7%	61.0%

Source: Prepared by JICA Study Team, based on TAVANIR documents "IRAN ELECTRIC POWER INDUSTRY (2016-2017)"

Also in conjunction with the development of new power plants, it is intended to steadily implement the following construction plans, in order to improve the efficiency of existing power plants.

(1) Rehabilitation of existing facilities
(2) Repowering
(3) Improving the efficiency of combined cycle power generation
(4) Improving the performance of steam power generation

It is planned to increase and strengthen the transmission lines and substations as shown in Tables 2-12 and 2-13, to enable the electric power generated from the new power plants to be stably supplied to the electric power system to satisfy the increase in demand.

Table 2-12 Forecast of Extensions in Sub-Transmission and Transmission Installation

Description	Voltage (kV)	End of 2016	End of 2017	End of 2018	End of 2019	Annual Growth (%)
Transmission Substation Capacity (MVA)	400 & 230	142,653	148,463	156,209	165,892	5.1
Sub-Transmission Substation Capacity (MVA)	66,63& 132	100,321	104,704	110,548	117,853	5.5
Transmission Lines Length (km-Circuit)	400 & 230	51,801	54,252	57,520	61,605	5.9
Sub-Transmission Lines Length (km-Circuit)	66,63& 132	71,476	73,861	78,374	84,015	5.5

Source: Electric power industry in Iran (2016-2017) TAVANIR

Table 2-13 Forecast of Extensions in Distribution Installation

Description	Unit	End of 2016	End of 2017	End of 2018	End of 2019	Annual Growth (%)
Number of Customers	10^3 Customers	33,824	34,840	35,997	37,143	3.1
Energy Sales	10^6 Kwh	237,436	251,436	264,907	278,140	5.4
Distribution Lines Length	km	769,483	78,555	802,366	818,357	2.1
Sub-Transmission Substation Capacity	MVA	114,945	118,078	121,553	124,986	2.8

Source: Electric power industry in Iran (2016-2017) TAVANIR

Tables 2-14 and 2-15 show the total capacity and the component ratio for each power plant type in the Sixth Five-year Development Plan of TAVANIR, as well as their annual generating capacity.

Among the power plant types, there is a trend towards the combined cycle generation whose capacity exceeds 50 % of total generating capacity, and which allows to increase the thermal efficiency including existing gas-fired generation as an add-on. Also, the capacity of renewable energy such as wind power generation, etc., that utilize natural energy without relying on fossil fuel, exceeds 5% of the total generating capacity and its percentage of the total capacity is tending to increase.

On the other hand, in the annual power generation, the generation by renewable power plants that use unstable natural energy is only about 1%, and it is about 6% of all power generation systems including hydroelectric power generation but excluding thermal power generation. Therefore, there is no change to the trend of dependence on thermal power generation for more than 90% of the total. Among thermal power generation, steam generation is capable of generating a stable output throughout the year, so it is planned to rely on it for 20% or more of power generation output.

In order to obtain stable output, an increase in new combined cycle plant and rehabilitation of aging steam generating plants for function-permitting maintenance seem to be necessary.

Table 2-14 Total Generation Capacity and Composition Ratio of Power Plant According to Type (Sixth 5-year Plan)

Type of Power Plants	2016		2017		2018		2019		2020	
	Capacity (MW)	Ratio of Power Station	Capacity (MW)	Ratio of Power Station	Capacity (MW)	Ratio of Power Station	Capacity (MW)	Ratio of Power Station	Capacity (MW)	Ratio of Power Station
Steam	15,830	20.3%	15,830	19.3%	15,830	18.2%	16,155	17.3%	17,455	17.3%
Gas Turbine	26,761	34.4%	23,481	28.7%	19,269	22.1%	15,057	16.1%	10,845	10.8%
Combined Cycle	20,914	26.9%	26,945	32.9%	35,117	40.3%	43,619	46.6%	51,487	51.1%
Diesel	439	0.6%	439	0.5%	439	0.5%	439	0.5%	439	0.4%
Thermal Total	63,944	82.1%	66,694	81.4%	70,654	81.0%	75,269	80.4%	80,225	79.6%
Hydroelectric	11,819	15.2%	12,236	14.9%	12,236	14.0%	12,236	13.1%	12,236	12.1%
Nuclear	1,020	1.3%	1,020	1.2%	1,020	1.2%	1,020	1.1%	1,020	1.0%
Renewable	578	0.7%	1,168	1.4%	2,068	2.4%	3,366	3.6%	4,966	4.9%
Renewable Total	13,417	17.2%	14,424	17.6%	15,324	17.6%	16,622	17.8%	18,222	18.1%
Distributed Generation	500	0.6%	800	1.0%	1,200	1.4%	1,700	1.8%	2,350	2.3%
Total	77,861	100.0%	81,918	100.0%	87,178	100.0%	93,591	100.0%	100,797	100.0%
Annual Growth Rate(%)	5.1%	-	5.2%	-	6.4%	-	7.4%	-	7.7%	-

Source: The Sixth Five Year Development Plan in TAVANIR

Table 2-15 Annual Power Generation of Power Plant According to Type (Sixth 5-year Plan)

Type of Power Plants	2016		2017		2018		2019		2020	
	Power Generation (GWh)	Ratio of Power Station	Power Generation (GWh)	Ratio of Power Station	Power Generation (GWh)	Ratio of Power Station	Power Generation (GWh)	Ratio of Power Station	Power Generation (GWh)	Ratio of Power Station
Steam	86,130	28.6%	86,130	27.0%	86,130	25.3%	87,625	24.2%	91,964	23.7%
Gas Turbine	88,462	29.3%	66,097	20.7%	50,660	14.9%	36,203	10.0%	22,576	5.8%
Combined Cycle	104,912	34.8%	142,998	44.9%	177,433	52.2%	210,878	58.3%	241,430	62.3%
Diesel	71	0.0%	71	0.0%	71	0.0%	71	0.0%	71	0.0%
Thermal Total	279,575	92.7%	295,297	92.7%	314,294	92.5%	334,776	92.5%	356,041	91.8%
Hydroelectric	15,531	5.2%	15,006	4.7%	16,077	4.7%	15,006	4.1%	16,077	4.1%
Nuclear	4,914	1.6%	5,004	1.6%	5,004	1.5%	5,004	1.4%	5,004	1.3%
Renewable	456	0.2%	972	0.3%	1,658	0.5%	2,654	0.7%	3,915	1.0%
Renewable Total	20,901	6.9%	20,981	6.6%	22,739	6.7%	22,663	6.3%	24,996	6.4%
Distributed Generation	986	0.3%	2,334	0.7%	2,839	0.8%	4,424	1.2%	6,764	1.7%
Total	301,462	100.0%	318,612	100.0%	339,872	100.0%	361,863	100.0%	387,802	100.0%

Source: The Sixth Five Year Development Plan in TAVANIR

2.5 Power Generation Policies

2.5.1 Policy on Development of Thermal Power Plants

According to TPPH, construction of power plants with a total capacity of 20,000 MW is planned in the Five-Year Electric Power Development Plan (2017-2021). In the plan, the assumed ratio of the capacity to be developed by the private sector against the capacity to be developed by the public sector is 80:20, which is the same ratio as assumed in the privatization policy, so the private sector and TPPH are expected to develop capacities of 16,000 MW and 4,000 MW, respectively.

As shown in the table below (Table 2-16, which includes power plants to be constructed after the sixth five-year plan), there are power plant development schemes for the national government (TPPH) and the private sector. EPC (engineering, procurement and construction) and PayBack are divided in the former, and PayBack and BOO (build-own-operate) are divided in the latter. Since the national government is unable to provide sufficient funds for the development of power plants due to severe financial hardship, as mentioned later, it has prepared a policy aimed at using private funds effectively for development. This financial hardship was a contributing factor to the adoption of the ratio between private sector and public sector mentioned above. In principle, both Payback and BOO are means of developing power plants without government spending. Therefore, while the national government owns power plants constructed under the Payback scheme, it appears that such plants are considered to be privately-owned plants in the calculation of the private-to-public ratio mentioned above because in practice they are developed by the private sector.

EPC is a form of contract that the government concludes with construction companies in ordinary power source development by the national government. It is also referred to as full-turnkey.

(1) Payback

PayBack is a unique power source development method in Iran aimed at reducing fuel consumption by optimizing power generation efficiency by 15%. It will be used in order to install a total of 7.5 GW of steam turbine generators in the existing eight state-owned and 13 privately-owned gas turbine power plants to convert them into CC (combined cycle) power plants.

The schemes for converting state-owned and privately-owned power plants differ in content.

(a) Scheme for privately-owned plants

As an incentive for owners of privately-owned gas turbine power plants to invest in the conversion of their plants into Combined Cycle (CC) plants, an amount equal to the saving in fuel expenses derived from the conversion will be paid back to them. The incentive will be provided for five years after the completion of the conversion. In principle, no other incentives will be provided to the owners.

A PayBack contract will be concluded between an owner of a power plant and TPPH. As the conditions of each PayBack contract will be decided in negotiations between the two parties, the conditions may differ from one contract to another.

(b) Scheme for state-owned plants

The national government concludes an EPCF (engineering, procurement, construction and finance) contract with a contractor for the conversion of existing state-owned power plants into CC plants to supplement a shortage of funds. This type of contract prescribes that the government will pay back the construction expenses and the interest on them to the contractor in five years after the completion of the construction. The payback period varies depending on the international market price of fuel. While the payback period is currently five years, it used to be shorter when the price was higher. The repayments amounts for EPC costs and non-EPC costs (including interest and commitment fees) are calculated separately. The total amount of repayment is supposed to be equal to the saving in the fuel expenses derived from the conversion.

Table 2-16 Development plan of Various New Thermal Power Plants

Owner	PP name	Scheme	Type	Capacity	Comletion year (Iranian calender)
TPPH	Shirvan	EPC	CC	480.0	1396-1397
TPPH	Mahshahr	EPC	Gas Turbine	324.0	1395
TPPH	Zarand Kerman	EPC	Gas Turbine	324.0	1398
TPPH	Tosee Ramin Ahvaz	EPC	Steam	650.0	1399-1400
TPPH	Tosee Shazand	EPC	Steam	650.0	1399-1400
TPPH	East Bandar Abbas	EPC	Steam	1,400.0	1400-1401
TPPH	Tabas	EPC	Coal	650.0	1400
TPPH	Rajaee	EPC	CC	1,368.0	1399
	EPC Total			5,846.0	
TPPH	Iranshahr	Payback	CC	160.0	1400
TPPH	Shahroud	Payback	CC	160.0	1400
TPPH	shahid Kaveh	Payback	CC	320.0	1400-1401
TPPH	Persian Gulf	Payback	CC	480.0	1400-1401
TPPH	South Isfahan	Payback	CC	480.0	1400-1401
TPPH	Hafez	Payback	CC	480.0	1400-1401
TPPH	Mahshahr	Payback	CC	320.0	1400-1401
TPPH	Homozgan	Payback	CC	320.0	1400-1401
Private	Roudshour	Payback	CC	316.5	1398
Private	Chabahar	Payback	CC	160.0	1398
Private	Kashan	Payback	CC	160.0	1397
Private	Uremia	Payback	CC	480.0	1399
Private	Semnan	Payback	CC	159.0	1398
Private	Soltanieh	Payback	CC	320.0	1399
Private	Zagros	Payback	CC	320.0	1399
Private	Sabalan	Payback	CC	480.0	1397-1398
Private	Aliabad	Payback	CC	480.0	1397
Private	Parand	Payback	CC	477.0	1396
Private	Ferdowsi	Payback	CC	477.0	1397
Private	Asalouyeh	Payback	CC	477.0	1397
Private	Jahrom	Payback	CC	480.0	1396
	Payback Total			7,506.5	
Private	Qeshm	BOO	CC	484.0	1397(324) 1398(160)
Private	Mazandaran - Nowshahr	BOO	CC	447.0	1396(307) 1397(140)
Private	KhoramAbad	BOO	CC	484.0	1397(324) 1398(160)
Private	Sadoogh - Taban	BOO	CC	160.0	1396
Private	Dalahoo	BOO	CC	484.0	1396(304) 1397(180)
Private	Sirjaan	BOO	CC	160.0	1396
Private	Samangan	BOO	CC	160.0	1396
Private	Heris	BOO	CC	454.0	1396(304) 1397(150)
Private	Makoo	BOO	CC	110.0	1396(74) 1397(36)
Private	Sabzevar	BOO	CC	467.0	1399(307) 1400(160)
Private	Behbahan	BOO	CC	160.0	1396
Private	Dezfool	BOO	CC	454.0	1398(304) 1399(150)
Private	Zahedan 2	BOO	CC	467.0	1399(307) 1400(160)
Private	Aryan (zanjan 2)	BOO	CC	467.0	1400(307) 1401(160)
Private	Zanjan 1	BOO	CC	467.0	1401(307) 1402(160)
Private	Omidiyeh	BOO	CC	467.0	1402(307) 1403(160)
Private	Aras	BOO	CC	467.0	1399(307) 1400(160)
Private	Andimeshk 2	BOO	CC	467.0	1403(307) 1404(160)
Private	Bandzark	BOO	CC	467.0	1401(307) 1402(160)
Private	Andimeshk 3	BOO	CC	467.0	1400(307) 1401(160)
Private	Loshan	BOO	CC	467.0	1402
Private	Dehdasht	BOO	CC	467.0	1398(307) 1399(160)
Private	Abadan	BOO	CC	910.0	1401(620) 1402(290)
Private	Saveh (Unit)	BOO	CC	1,200.0	1399(810) 1401(390)
Private	Zahedan (Unit)	BOO	CC	880.0	1400(308) 1401(572)
	BOO Total			11,684.0	
	Total			25,036.5	

Sources: Reference materials provided by TPPH, Data compiled in a table by the JICA Study Team

(2) BOO

(a) BOO Scheme

BOO is a scheme to use private funds to develop infrastructure. In this scheme, the government

(TPPH) designs projects and private companies construct, own and operate power plants. As the power demand in Iran is expected to continue increasing alongside population growth and improved living standards, many power sources will be required. However, it is difficult for the national government to develop all necessary power sources due to financial difficulties. Since 2000, the Iranian Government accepts private investment for the construction of power plants under BOT (build, operate and transfer) or BOO (build, own and operate) scheme.[3]

The government implements a policy of inviting domestic and foreign private investment in the construction of power plants by providing the following incentives to private investors for the construction and operation of CC power plants.[4]

・BOO contract
・ECA (energy conversion agreement) for five years
・Guaranteed fuel supply
・Offtake tariff standard set at US Cent 2.6/kWh
・Revision of the tariff in accordance with price escalation rates and changes in foreign exchange rates
・Assistance in acquisition of environmental and other licenses
・Approval for export after a five-year ECA period
・Guarantee of payment by the government

Although both BOT and BOO are mentioned above, only BOO is used at present. According to TPPH, although BOT was used for the development of gas turbine power plants in the past, in principle, only BOO will be used in the future. The CC power plant will be the only type of thermal power plant to be developed in the future. The reason for this is that the BOO contract period is 20 years. The lifespan of CC power plants is shorter than that of gas turbine and steam turbine power plants and is approximately the same as the BOO contract period. Therefore, BOT will bring no benefit to the government, which is why only BOO will be used.

In a case where a private power producer constructs and operates a power plant under BOO, SATBA concludes a PPA (power purchase agreement) based on FITs (feed-in tariffs) with the producer. Meanwhile, SATBA concludes a contract with a DSO (distribution system operator) for a small-scale power generation scheme. Under this contract, a DSO is an agent of SATBA that reads meters, prepares invoices, and makes payments, etc. on behalf of SATBA in a small-scale power generation scheme. SATBA pays DSOs for the payment that they have made on its behalf. Although electric power generated by SATBA plants and purchased by SATBA from private producers is delivered to consumers through its power distribution and transmission networks, SATBA does not sell electricity but transmits it free of charge. Budgetary allocation from the government is practically the only revenue source of SATBA.

The benefits mentioned below are expected from the development of social capital by the private sector under BOO contracts.[5]

・Transfer of ownership and management of projects from the public to private sector will increase national product in society.
・Privatization will have a positive effect on the government budget by creating budgetary flexibility with reduction in government spending
・Improved economic efficiency is another positive effect of privatization, which is considered

3 Considering of BOO Contract in project management & its role in developing of rivatization, Nouredin Gandomi & Shiva Rezai, The 4th International Conference on Innovative Research in Management, Economics and Accounting, July 2016

4 Investment opportunities and incentives in power industry, 2nd business forum Iran Europe, Ministry of Energy Iran, March 2016

to be a tool for the improvement of government operation.

(b) ECA

ECA of Iran is based on two major principles, namely, (1) free feedstock gas supply, and (2) offtake of electricity from suppliers at competitive tariffs. Both of these components of ECA are offered for five years. MOE has reached an agreement with the Ministry of Petroleum on the supply of gas, which is converted into electric power for the domestic market. Therefore, this ECA is considered to be an energy conversion agreement as opposed to a conventional power purchase agreement (PPA) provided elsewhere. According to TPPH, a unit tariff schedule that is used to set offtake tariffs is revised every year in consideration of the price escalation rate and changes in foreign exchange rates, while the power generation efficiency of a power plant decides which offtake tariff in the schedule is applicable to the plant. The number of companies eligible for the application of the tariffs is estimated to be between seven and nine at present.[5]

The major conditions of the ECA are as follows:

- A five-year agreement based on free supply of feedstock gas
- An agreement on offtake at a preset tariff (which is to be revised every year to protect investors from losses derived from price inflation and changes in foreign exchange rates)
- Discretionary grid connection for 20 years
- A fixed financial model of TPPH offering 20% of IRR (internal rate of return)
- The Ministry of Economic Affairs and Finance of Iran guarantees ECAs with equity capital registered under FIPPA (the Foreign Investment Promotion and Protection Act) and the incurred interest to build trust in the agreements among investors. Investors can obtain low-interest loans from international banks with this guarantee.[6]

(c) Development under BOO

Table 2-17 shows the thermal power plants constructed under the BOT and BOO schemes. Except for the two gas turbine power plants constructed under BOT, all the rest have been constructed under BOO.

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[5] Information obtained in the interview at IGMC

[6] New Contracts Offer Synergies Between Players in Iran's Power Industry、Hamid Soorghali Business Analyst with Energy Pioneers Ltd., 2016/8/8/ http://www.bourseandbazaar.com/articles/2016/8/8/synergies-between-local-and-international-players-in-irans-power-industry

Table 2-17 Constructed Thermal Power Plants by BOO (MW)

Power Plant Name	Type	Unit	Capacity	Scheme
Chehdsotoun (South Isfahan)	Gas Turbine	6*159	954	BOT
Roudshour	Gas Turbine	3*264	792	BOO
Ferdowsi	Gas Turbine	6*159	954	BOO
Asalouyeh	Gas Turbine	6*159	954	BOO
Khoramshahr	Gas Turbine	6*162	972	BOO
Golstan(Aliabad)	Gas Turbine	6*162	972	BOO
Zavareh	CC	1*160+2*162	484	BOO
Fars (Hafez)	Gas Turbine	6*162	972	BOT
Pareh-sar	CC	2*160+4*162	968	BOO
Kahnouj Small Scale Steam	Gas Turbine	3*25	75	BOO
Nowshahr Small Scale Steam	Gas Turbine	2*25	50	BOO
Kashan	Gas Turbine	2*162	324	BOO
Gonaveh	CC	1*160+2*162	484	BOO
Shirkouh	CC	1*160+2*162	484	BOO
Andakan	CC	1*160+2*166	492	BOO
Showbad (Kahnou)	CC	1*160+2*162	484	BOO
Shams Sarakhs	CC	2*25	50	BOO
Taban	CC	2*162	324	BOO
Behbahan	CC	2*166	332	BOO
Golgohar (Sirjan 2)	CC	2*162	324	BOO
Samangan (Sirjan 1)	CC	2*162	324	BOO
			11769	

Source : TPPH

Table 2-18 shows the schedule for the construction of thermal power plants, according to which power plants will be constructed in nine years with a total capacity that is comparable to the plants constructed in the past 17 years.

Table 2-18 Schedule of BOO Power plants (MW) (Iranian Year)

		Cap	1396	1397	1398	1399	1400	1401	1402	1403	1404
1	Qeshm	484		324	160						
2	Mazandaran - Nowshahr	447	307	140							
3	KhoramAbad	484		324	160						
4	Sadoogh - Taban	160	160								
5	Dalahoo	484	304	180							
6	Sirjaan	160	160								
7	Samangan	160	160								
8	Heris	454	304	150							
9	Makoo	110	74	36							
10	Sabzevar	467				307	160				
11	Behbahan	160	160								
12	Dezfool	454			304	150					
13	Zahedan 2	467				307	160				
14	Aryan (zanjan 2)	467					307	160			
15	Zanjan 1	467						307	160		
16	Omidiyeh	467							307	160	
17	Aras	467				307	160				
18	Andimeshk 2	467								307	160
19	Bandzark	467						307	160		
20	Andimeshk 3	467					307	160			
21	Loshan	467							467		
22	Dehdasht	467			307	160					
23	Abadan	910						620	290		
24	Saveh (Unit)	1200				810		390			
25	Zahedan (Unit)	880					308	572			
	Total	11684	1629	1154	931	2041	1402	2516	1384	467	160

Source: Information obtained from TPPH

2.5.2 Privatization

Full-scale privatization of the electric power sector in Iran began in the 2000's. The Iranian Privatization Organization (IPO) was established under the Ministry of Economic Affairs and Finance in 2001 for the implementation of privatization. In 2004, Article 44 of the Constitution was amended. This amendment allowed free interpretation of privatization and efficient privatization of state-owned companies in key sectors. The Supreme Leader of Iran, Ayatollah Khamenei, gave instructions for the privatization of 80% of state-owned companies in accordance with the Constitution.[46] In the electric power sector, a new law enacted in 2004 has given TAVANIR authority to reorganize itself, to make each of its power plants an independent company and to sell 65% of the shares of these companies on the Tehran Stock Exchange.[7] Privatization is implemented in the power generation and distribution areas, while power transmission is out of the scope of the privatization in accordance with the stipulation of Article 44 of the Constitution. IPO implements the privatization of power generation and distribution. According to MOE, it selects state-owned companies to be privatized and IPO selects the best methods to privatize them.

[7] Iran announces new plans for privatisation and structural reform in the power sector, Written by Adrian Creed and Dr Amir Kordvani., May 2014

According to TPPH, the sale of shares for the privatization of power plants is conducted on the Tehran Stock Exchange. For the purpose of privatization, shares in power plant power generation management companies are sold at auction as a set with shares in the power generation maintenance and repair company responsible for the same plant, and all shares are sold to the company that offers the highest price. Therefore, each privatized company has only one shareholder. Shares in a privatized company are sold on the Tehran Stock Exchange, regardless of whether it is listed or not. A shareholder may list a company that it owns on the stock exchange. However, no privatized company has been listed so far.

Table 2-19 shows the power plants that have been privatized so far. Since the amendment of the Constitution and establishment of IPO in 2004, 35 power plants have been privatized. According to TPPH, as privately-owned power plants already account for 80% of the plants in the country, the government has no plan to privatize remaining state-owned power plants.

As many companies were nationalized after the revolution, it is thought that the public sector has played a major role in economic activities in Iran. Further economic development requires the growth and development of the private sector, and privatization is thought to be consistent with this requirement. A great concern in the electric power sector and especially in the power generation area in Iran is that many power plants in the country are decrepit and many of them require large-scale repair. However, the current state of public finances in Iranian government only allows limited repairs of such plants. This fact also seems to have influenced the privatization of the power generation area.

Table 2-19 Privatized Power Plants

No	Name	Capa (MW)	Type
1	Tabriz	736	Steam
2	Shahid Mohammad Montazeri	1616	Steam
3	Montazerghaem	625	Steam
4	Birch	600	Steam
5	Mashhad	133	Steam
6	Zergan (Shahid Modhej)	290	Steam
7	Tabriz	64	Gas Turbine
8	Orumia	960	Gas Turbine
9	Sabalan	960	Gas Turbine
10	Kashan	324	Gas Turbine
11	Parand	954	Gas Turbine
12	Shariati	150	Gas Turbine
13	Mashhad	196	Gas Turbine
14	Shams fern	50	Gas Turbine
15	Zergan (Shahid Modhej)	128	Gas Turbine
16	Soltanieh	648	Gas Turbine
17	Jerusalem (Semnan)	324	Gas Turbine
18	Chabahar	414	Gas Turbine
19	Zagros	648	Gas Turbine
20	Jahrom	954	Gas Turbine
21	Kahnooj	75	Gas Turbine
22	Noshahr	47	Gas Turbine
23	Yazd Shahid lily	97	Gas Turbine
24	Sarv (Chadermalu)	332	Gas Turbine
25	Khoy	349	Combined cycle
26	Montazerghadem	998	Combined cycle
27	Damavand	2868	Combined cycle
28	Qom	714	Combined cycle
29	Shariati	347	Combined cycle
30	Neyshabur	1040	Combined cycle
31	Abadan	814	Combined cycle
32	Sanandaj	956	Combined cycle
33	Fars	1035	Combined cycle
34	Kazeroon	1372	Combined cycle
35	Gilan	1306	Combined cycle

Source: Information obtained from TAVANIR

All the regional DSOs have been privatized. The privatization of the DSOs differs from that of power plants in that TAVANIR still owns 40% to 50% of their shares. In addition, none of the regional DSOs is listed on the Tehran Stock Exchange.

The Mapna Group has been involved in privatization in the electric power sector. Construction of power plants used to be the main business of the group. However, the group has expanded its business to various fields including oil and gas, railway transportation and manufacturing. The group is listed on the Tehran Stock Exchange. It was the fourth largest company among the listed companies in 2010. When the Mapna Group was an affiliate of TAVANIR, SABA Investment Company, TAVANIR Holding and Sazman Gostaresh va No Sazi Sanaie Iran owned 51 %, 39 % and 10 % of its shares, respectively. At present, SABA, Edalat Brokerage, MAPNA Employees Investment Co. and Ayandeh Negar own 90 % of the shares.

2.5.3 Renewable Energy

While TPPH is responsible for the development of thermal power plants, SATBA is responsible for the development of renewable/clean energy.

The Sixth Five-Year Plan (March 2016 – March 2021) of the government includes a plan to construct new photovoltaic (PV) and wind power plants to increase the capacity of renewable energy power generation to 5 GW, or 10 % of the total power generation capacity.

This increase to 5 GW is to be achieved with the construction of power plants by the public and private sectors. According to SATBA, however, no specific target has been set for the increase in capacity by the public or private sector or for the use of each type of renewable energy. Power plant development by the government will be limited due to the budgetary constraints of the government, as mentioned above. Therefore, the private sector is expected to take the lead in plant construction.

(1) Scheme for Renewable Energy Development

BOO and FIT is the scheme used for the development of renewable energy by the private sector. BOO is used for the construction and operation of power plants and FITs are used as tariffs for the sale of electric power. The procedures for development under BOO and FIT are as follows:

Phase1 - Registration and construction permit: An applicant prepares an application form for a construction permit and submits the form to SATBA. SATBA issues the permit to the applicant after verifying such facts as whether or not the project area in the application overlaps with that of a registered project.

Phase2 - Acquisition of necessary permits: The applicant needs to acquire an environmental permit, grid connection permit and land ownership transfer permit from competent authorities. After having acquired all the necessary permits and prepared all the necessary documents, the applicant concludes an agreement for a plant development and operation project with SATBA.

Phase3 - Project implementation: The applicant takes responsibility for the financing and implementation of the project. The applicant manages the construction work in the project under the supervision of SATBA. SATBA negotiates with a grid management company for grid connection after the completion of construction.

Phase4 Project operation: The applicant operates the plant and submits monthly invoices for operation. SATBA pays the bills after applying an adjustment factor and considering the available time of the plant.[8]

8 IRAN RENEWABLES SECTOR UPDATE Herbert Smith Freehills 2017 LEILA HUBEAUT PARTNER, PARIS JOANNA ADDISON PARTNER, DOHA ERGEN EGE AVOCAT, PARIS

(2) State of Development of Renewable Energy

Tables 2-20 and Table 2-21 show the renewable energy power plants installed in Iran

Table 2-20 Installed renewable energy power plants situation up to end of Jan, 2018

Item	Power plant	Governmental capacity (MW)	Non-Governmental capacity (MW)	Total (MW)
1	Wind	98.86	115.86	214.72
2	Solar (PV)	7.40	114.60	122.00
3	Biomass	0.00	10.56	10.56
4	Small Hydropower	62.40	19.85	82.25
5	Waste heat recovery	0.00	0.60	0.60
	Total	**168.66**	**270.47**	439.13

Source: Information obtained from SATBA

Table 2-21 Installed Power Plant with Non-Governmental Sector (Feb, 2018)

No	Project Name	Capacity	Construction Site	Date of Operation
Wind Power Plant				
1	Mapna-Kahak 1	5	Takestan ,Qazvin	July 2014
2	Mapna-Kahak 2	20	Takestan ,Qazvin	January 2015
3	Mapna-Kahak 3	30	Takestan ,Qazvin	February 2017
4	Behin Ertebet Mehr	2.5	East Azerbaijan	
5	Agh Kand	23.8	Siahpoosh, Qazvin	
6	Binalood	28.4	Neishabour, Khorasan Razavi	September 2010
7	Dizbad	4	Neishabour, Khorasan Razavi	January 2017
8	Tavan Bad	0.66	Khaf, Khorasan Razavi	January 2017
9	Fanavaran Energy Pak	1.5	Khaf, Khorasan Razavi	September 2016
Total		**115.86**	MW	
Solar Power Plant				
10	Atrian Parsian	0.514	Malard, Tehran	May 2018
11	Pak Bana	0.228	Qom	September 2018
12	Aftab Mad Rah Abrisham	35	Hamadan	December 2018
13	Tara Moshaver	0.215	Shams Abad, Alborz	January 2018
14	Ghadir Energy	10	Jarghouyeh, Esfahan	April 2018
15	Mehran Energy Arvand Co.	1.2	Rafsanjan, Kerman	July 2018
16	Tose-e Faragir Jask Co.	10	Mahan, Kerman	July 2018
17	Solar Energy Arka Co.	10	Mahan, Kerman	July 2018
18	Abouyand Co.	1.313	Damghan	December 2018
19	Sanaye Siman Shahrekord	1.5	Shahrekord	December 2018
20	Energy_e_Nou Atieh	10	Yazd	January 2018
		10	Sistan&Balouchestan, Zahedan	
21	Iran Tablou Co.	0.63	Nazar Abad, Albourz	January 2018
22	Behnad Energy Pars Lian Co.	4	Sarvestan, Fars	January 2018
23	Pars Ray Energy Bahar Co.	10	Ray, Tehran	
24	Aftab Kavir Part	10	Khosef, South Khorasan	
Total		**114.6**	MW	
Biomass Power Plant				
25	Municipality of Mashhad	0.6	Mashhad, Khorasan Razavi	September 2009
26	Niroo Sabin Aria	1.06	Shiraz, Fars	September 2009
27	Kian Group	1.9	Abali, Tehran	-

28	Water and Waste Water Management Company of Tehran	4	Rey, Tehran	October 2010
29	Tadbir Tosee Salamat	3	Kahrizak, Tehran	January 2016
Total		**10.56**	MW	
Small Hydro Power plant				
30	Modiriat Tosee Energy Mashhad	0.44	Mashhad, Khorasan Razavi	March 2014
31	Parsina Nano Danesh	0.24	Arak, Markazi	2015
32	Pardisan Sazeh Tarahan	0.17	Brojerd, Lorestan	March 2016
33	Farab	10	Kordestan	March 2016
34	Roushd Sanaat	2.7	Qom, Delijan	July 2018
35	Sabz Mah Ab Co.	6.3	Bijar, Gilan	
Total		**19.85**	MW	
Waste heat recovery				
36	**Kesht Sanat Dehkhoda**	**9.6**	Ahwaz	2017
Total		**9.6**	MW	
Total		**270.47**	MW	

Source: Information obtained from SATBA

(3) Renewable Energy Development Plan

As shown in Tables 2-20 and -21, the total power generation capacity of the installed plants has not reached the target of 5 GW.

・Development plan for private sector

Total capacity of the plants which construction permits have been issued is approximately 3,000 MW. Valid period of the permit is six months. An applicant must obtain the environmental, grid-connection and land use permits within this valid period. Many issued construction permits have been canceled. Many permits have been canceled because of problems in financing, non-availability of land and unsatisfactory grid connection conditions. Table 2-22 shows the number of companies that have concluded PPAs.

Table 2-22 Companies with PPA (Jan. 2018)

Item	Power plant	Number of company	Capacity (MW)
1	Biomass	3	6.00
2	Small Hydropower	8	22.00
3	Wind	26	1,339.40
4	Solar (PV)	130	1,529.03
5	Waste heat recovery	5	64.00
	Total	**172**	**2,960.43**

Source: Information obtained from SATBA

It is highly likely that the planned power plant will be developed as a PPA has been concluded, so it is expected that the generation capacity mentioned in Table 2-22 will be realized. Even if the capacity to be developed by the government mentioned below is added, the total capacity will not reach 5 GW. However, as there is still time until the completion of the current sixth five-year plan, the government is inviting applications for PPA with FITs left unchanged for 2017. Using the capacity generated by plants to be constructed by new applicants, the government intends to achieve the target of 5 GW.

・Development plan for the government (SATBA)

SATBA planned to develop following renewal energy power plants; A total of 2 GW of wind power generation capacity (capacities to be developed by the public and private sectors combined) is planned to be developed within the implementation period of the current five-year plan. Among them, SATBA is constructing wind power plants with a total capacity of 22 MW (36 units of 660 KW generators). The contractor for construction is an Iranian company, Sabanirou Co. Eighteen (18) generator units are to be installed at Milnader (Zabol) and Sarab, respectively. In addition, SATBA is preparing two additional projects. One project is the construction of a wind power plant with a total capacity of 250 MW (with 2.5 MW units) in Maqba. A German company will construct a power generation facility with 50-MW capacity, while SATBA is holding consultation with Siemens for the development of the remaining 200-MW capacity. The other project is the development of a wind power plant with a capacity of 106 MW. SATBA is holding consultations with a PBO on this plan.

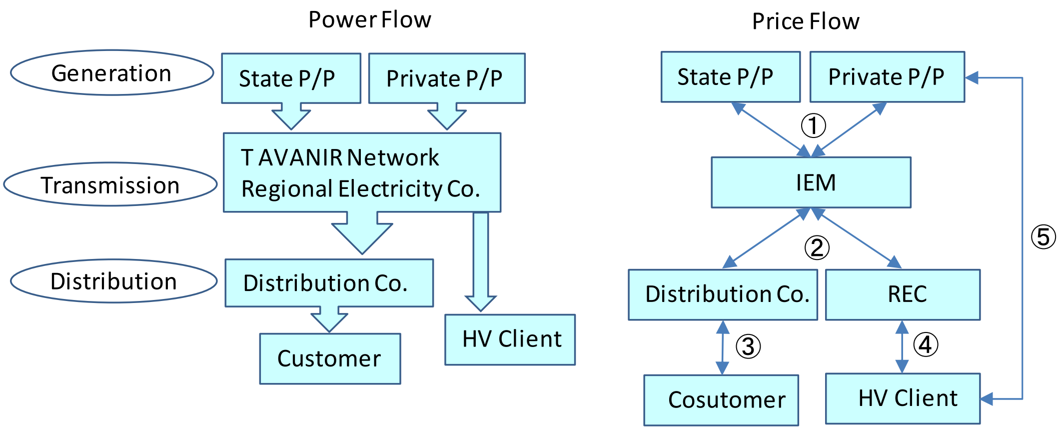
・Privatization

The privatization of state-owned Renewal Energy (RE) power plants is in progress. Wind power plants in the northern region have been privatized (sold). While HP of SATBA puts its wind power generation capacity at 168 MW, its current capacity is 91.59 MW. Although the government has a policy of privatization, it has no plans to privatize the remaining state-owned power plants, because it focuses and concentrate their availabilities more on the construction of new power plants for infrastructure development.

2.6 Electrical Power Distribution (Power Charging System)

2.6.1 Electrical Power Distribution Routes

Iran has its own electrical power transaction form and its own electrical power pricing system. The following is an overview explanation.



Source: Prepared by the Study Team from data obtained

Fig. 2-15 Power Flow and Price Flow

In the past TAVANIR had a de facto monopoly position in the Iran electrical power sector, but this has changed greatly as a result of corporate spin-off and liberalization. In the generation sector many power stations have been privatized, and the thermal power generation sector has been spun off from TAVANIR into a separate company and TPPH has been established. The regional distribution companies have also been privatized (companies affiliated to TAVANIR). The regional electric companies have remained under the jurisdiction of TAVANIR, while transforming from a company that was formerly responsible for regional power generation, transmission, and distribution, into a company with jurisdiction over transmission.

The format of electrical power distribution is the same as in most of the country, with power being transmitted from the generating companies to the transmission network of TAVANIR, and from the distribution network of the regional distribution companies the power is sold to the ordinary customers. For some high-voltage and ultra-high voltage customers, the power is directly sold from the transmission network.

On the other hand, the flow of price differs slightly from the actual flow of electrical power. Iran has an electronic electrical power wholesale market known as IEM, operated and managed by IGMC, and regulated by the Iran Electricity Regulatory Board. The electrical power generated is sold through the Iranian Electricity Market (IEM), and viewed from the IEM there is the sellers' price (1) and the buyers' price (2). The electrical power purchased at the IEM is sold to VHV (Very High Voltage) and HV (High Voltage) customers by the transmission companies (4), and the distribution companies sell to the other customers (3). Also, private power generators can conclude bilateral sales contracts with VHV and HV customers (5). Also, ECA contracts and renewable energy are exceptions to the above table. The outline of electricity prices of the IEM and others is provided below.

2.6.2 Liberalization of the Electrical Power Wholesale Market

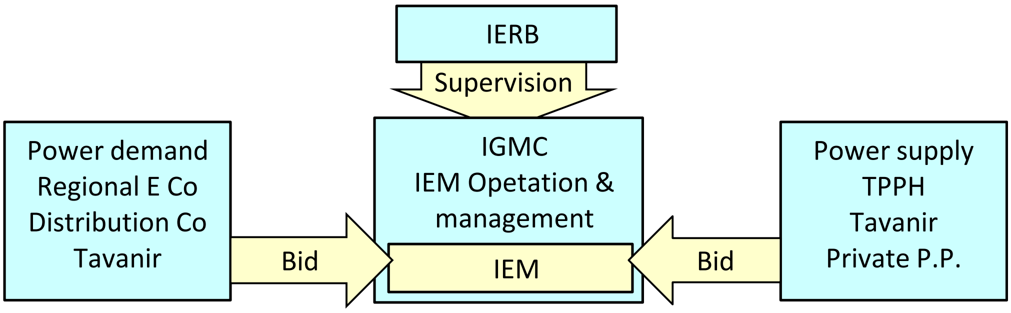
(1) Overview of the IEM

IEM is the electrical power wholesale market operated and managed by IGMC via an electronic network. IGMC and the market are controlled by the Iran Electricity Regulatory Board (IERB).

The participants in the market on the electrical power supply side are almost all domestic electrical power generation companies, and include the thermal power plants of TPPH, the other power stations of TAVANIR, and the private power companies. Although it is said that there are others, according to IGMC the amount of their sales is negligible. The electrical power demand side includes the distribution companies (that sell to normal customers), the regional electric companies (that sell to customers that purchase directly from the transmission lines), and TAVANIR (for export).

IERB conducted a study on electric power markets in other countries and proposed a model for the IEM (Iranian Electricity Market). Based on this model, the "buying and selling electricity regulations" was legislated by the council of ministers in September 2003. The IEM officially commenced operation on 23 November 2003[9].

[9] IGMC HP
http://www.igmc.ir/en/Company-units/Deputies/Electricity-Market/Market-in-depth#1740154-introduction-to-iem



Source: Prepared by the Study Team based on data obtained

Fig. 2-16 Overview of the IEM

1) Iran Grid Management Co. (IGMC)[10]

IGMC was established in 2004 based on Article G of Explanatory Note 12 of the Budget Act, for the purpose of reorganizing the electrical power industry in Iran, and they commenced activities in the latter half of 2005.

Their objectives and scope of activities are as follows.

- To develop the national network and carry out transmission and monitoring, in order to ensure electrical power supply in the country and to maintain the safety and continuity of the network.
- To provide open access to the network for government and non-government participants, for transmission and distribution.
- To provide the conditions for competitive transactions, and to establish, operate, and develop the electrical power market.
- To adopt effective policies for the introduction of competition in electrical power generation and distribution, and to implement the necessary policies in order to ensure supply of electrical power and to revitalize the activities of non-government organizations, within the scope of authority of the Ministry of Energy.

2) Iran Electricity Regulatory Board (IERB)[11]

The IERB was established in 2003 by the Ministerial Decree of the Minister of Energy, from a necessity to reorganize and reregulate the electrical power system.

IERB is a government bureau that supervises the electrical power market, and guarantees the fairness and justice of the electrical power market environment through its actions. Its specific actions include supervising the compliance of the procedures adopted by the market operators with the market methods defined by law. In addition, they monitor the function and relationships of the market participants including IGMC that function as the system and market operators. Finally, IERB has the authority to process demands on the market players.

[10] IGMC HP http://www.igmc.ir/en/
[11] IGMC HP http://www.igmc.ir/en/Company-units/Deputies/Electricity-Market/Market-in-depth#1740153-regulatory-board

(2) Transactions on IEM

Apart from in-house power generation, electrical power generated within the country is bought and sold via the IEM, the transactions on IEM are managed and operated by IGMC, and supervised by IERB. Exceptions include Energy Conversion Agreements (ECA), Power Purchase Agreements (PPA), and renewable energy. Of these, the system has been established for PPAs, but at present it has not been adopted by any power station. There are 3 types of electricity market carrying out transactions on IEM: the day-ahead market, the power exchange, and bilateral contracts.

1) Day Ahead Market

This is the main market of the IEM, and accounts for about 90% of the electrical power transacted on the IEM. It is an auction for the electrical power for the following day. All stations submit tenders on the day prior to supply of electrical power. The sellers submit prices and quantities in their tenders. Customers submit demand quantities only. In reality, this mechanism is a one-sided auction for the sellers.

Sales Bidding

Bidder	Quantity	Unit Price
A	20	120
	10	140
B	30	110
	20	170
C	10	100
	20	150
D	40	130
	10	160

Sales Bid Price

Unit Price	Successful Bidder	Quantity	Cumulative Value
100	C	10	10
110	B	30	40
120	A	20	60
130	D	30	90
140	A	10	100
150	C	20	120
160	D	10	130
170	B	20	150

Source: Prepared by the Study Team based on data obtained

Fig. 2-17 Mechanism for Determining the Day Ahead Market Price

A uniform price is not determined by the auction in the Day Ahead Market, but tenders are fulfilled up to the total demand quantity of the buyers. Explaining the example in the figure above, assume the tenders of the sellers is as shown in Fig. 2-17, and the cumulative demands of the buyers is 110. In this case, the tenders for sale in the cumulative column are successful until 110. The total quantity of the tenders with prices from 100 to 140 are successful, and a quantity of 10 is successful for the tender of price 150. The upper limit of the price is determined by the sellers' maximum tender price limit set by the Regulatory Board. The following table shows the trend in the volume of transactions, value of transactions, and unit selling prices on IEM.

Table 2-23 Trend in Tenders on the Day Ahead Market

Year	Auction (MWh)	Bilateral + Exchange	Sold amounts IRR Mil	Unit price IRR/kWh
2011-12	221,480,240	0	88,881,067	401
2012-13	237,840,481	0	95,182,381	400
2013-14	250,892,134	2,926,134	122,582,186	494
2014-15	263,852,290	20,130,990	151,532,510	622
2015-16	270,217,289	48,710,541	157,433,606	711

2016-17	279,179,375	23,453,499	155,143,081	607
2017-18	298,157,624	31,662,431	155,723,909	584

Source: IGMC

The volume of transactions have increased year-by-year as the domestic electrical power demand has increased. The transaction unit price had increased since fiscal year 2015-16, but after that unit price decreased. It is considered that this is related to energy production costs which will be referred later (Note that energy production costs consist of whole costs, not only production costs but also transmission and distribution costs). Production costs were the highest in 2014 - 15 and then declined. Because unit production cost is calculated after the fiscal year end, it seems to be the reason that there is a one year difference in the peak with the transaction unit price.
The breakdown of the average unit purchase price on IGMC is as shown below. The sales price includes a Capacity Payment and an Ancillary Service Payment, in addition to the electricity price. The capacity payment is paid in accordance with the capacity released on the IEM, with the objective of development of additional generating capacity.

The Ancillary Service Payment is made in accordance with the quality of electric power that a plant provides. A power plant applies for the payment by stating the type of service it provides and the market operators calculate the payment amount in accordance with the quality of the service. Self-start (black start) power plants, frequency adjustment and reactive power are considered to be ancillary services.

Table 2-24 Breakdown of the IGMC Electrical Power Purchase Price (IRR/kWh)

Year	Energy Rate	Capacity rate	Ancillary service	Total
2013-14	341	152	2	496
2014-15	427	193	4	624
2015-16	421	291	4	717
2016-17	364	242	3	609
2017-18	339	232	14	585

Source: IGMC

2) Power exchange

Power exchange is a futures transaction for electrical power. Basically, a transaction is established between the buyer and the seller for the price, quantity, period, etc. In the case of sellers, this system can only be used by the private generation companies. Also, an upper limit on the quantity of electrical power that can be transacted in the Power exchange is determined for each power generating unit. The transactions on the Power exchange are excluded from transactions on the Day Ahead Market, for both sellers and buyers.

3) Bilateral contracts

This is a method whereby sellers and buyers carry out direct negotiations to determine the price. Buyers and sellers can freely negotiate regarding the price and quantity. However, it is necessary to apply to the system operator and obtain approval for transactions. Almost all bilateral contracts are long-term contracts.

4) Buyers price

As stated above, the IEM is a one-sided auction, in which the sellers submit tenders based on the principle of competition, but the buyers only apply for the quantity that they require. IGMC purchases the electrical power applied for by the buyers, and sells it to the buyers. The selling price to the buyers is the average purchase price by IGMC. The transmission cost is allocated to the transmission system users based on the usage. The following is a breakdown of the average sales price to buyers.

Table 2-25 IGMC Breakdown of Sales Price（IRR/kWh）[12]

Year	Energy rate	Transmission fee	Total
2013-14	435	66	502
2014-15	631	80	717
2015-16	721	142	895
2016-17	630	147	777
2017-18	612	135	747

Source: IGMC

(3) Transactions other than the electrical power wholesale market - ECA & Renewable energy

As stated previously, basically, the electrical power generated and sold using the TAVANIR network is transacted on the IEM, but there are exceptions. These exceptions are the ECA contracts and renewable energy.

1) Energy Conversion Agreement (ECA)

The tariff stipulated in an ECA should be used as the tariff of power offtake by TPPH from a contracted power plant during the ECA period. As an individual BOO agreement has been concluded for each BOO project, there is no unified tariff and the tariffs vary among agreements. A tariff of US Cent 2.6/kWh is considered to be the standard.

2) Renewable energy

A PPA is concluded on FIT basis. MOE is obliged to purchase electric power from a private renewable energy (RE) power plant to promote its use. A law enacted in 2011 obliges MOE to purchase electric power at a price guaranteed for 20 years under a long-term agreement. Guaranteed prices will be adjusted every year in accordance with changes in the local CPI (consumer price index) and the foreign exchange rate against the U.S. dollar.[13] Table 2-27 shows the offtake tariffs for electric power generated by RE power plants from 2015 on. Although the law stipulates that FITs shall be revised every year, the current FITs will be valid at least until the end of this project year (2017 – 2018).

In principle, a private power plant is connected to a power transmission network. However, a power plant with an output capacity of less than 7 MW may be connected to a power distribution network. Whether or not connect such a station to a transmission or distribution

[12] The electricity unit prices in Table 2-16, Table 2-17, and Table 2-18 differ from each other, and this is because the values in the respective denominators are the quantity of generation at the power station, the quantity actually purchased by IGMC, and the quantity sold by IGMC. As the measurement location becomes further from the power station, transmission losses increase, and the value in the denominator becomes gradually smaller.

[13] Iran power sector Enough to double GDP, Sector overview Equity Research 20 January 2016, Renaissance Capital

network is primarily decided by the geographic conditions of the plant site and the availability of networks around the site. The basic rule is to connect small-scale power generation facilities (1 MW or less and 100 kW or less for wind and PV power generation, respectively) including roof-top PV facilities to distribution networks.

SATBA and a power producer conclude a PPA. Meanwhile, SATBA concludes a contract with a DSO (distribution service operator) for a small-scale power generation scheme. Under this contract, a DSO is an agent of SATBA that reads meters, prepares invoices and makes payments on behalf of SATBA in small-scale power generation schemes. SATBA pays DSOs for the payment that they have made on its behalf. Although electric power generated by SATBA own plants and purchased by SATBA from private producers is delivered to consumers through its power distribution and transmission networks, SATBA does not sell electricity but transmits it free of charge. Budgetary allocation from the government is practically the only revenue source of SATBA.

Table 2-26 Offtake Tariffs for Electric Power Generated by RE Power Plants

(IRRs per kWh)

<table>
<tr><th>No</th><th colspan="2">Technology type</th><th>2015</th><th>2016-18</th></tr>
<tr><td rowspan="3">1</td><td rowspan="3">Biomass</td><td>Landfill</td><td>2,900</td><td>2,700</td></tr>
<tr><td>The anaerobic digestion of manure, sewage and agriculture</td><td>3,150</td><td>3,500</td></tr>
<tr><td>Incineration and waste gas storage</td><td>5,870</td><td>3,700</td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">Wind farm</td><td>above 50 megawatt capacity*</td><td>4,060</td><td>3,400</td></tr>
<tr><td>with the capacity of 50 MW and less</td><td>4,970</td><td>4,200</td></tr>
<tr><td rowspan="3">3</td><td rowspan="3">Solar farm</td><td>above 30 megawatt capacity*</td><td rowspan="2">5,600</td><td>3,200</td></tr>
<tr><td>with the capacity of 30 MW and less</td><td>4,000</td></tr>
<tr><td>with the capacity of 10 MW and less</td><td>6,750</td><td>4,900</td></tr>
<tr><td>4</td><td colspan="2">Geothermal (including excavation and equipment)</td><td>5,770</td><td>4,900</td></tr>
<tr><td>5</td><td colspan="2">Waste Recycling in industrial processes</td><td>3,050</td><td>2,900</td></tr>
<tr><td rowspan="2">6</td><td rowspan="2">Small hydropower with the capacity of 10 MW and less</td><td>Installation on the rivers and side facility of dams</td><td rowspan="2">3,700</td><td>2,100</td></tr>
<tr><td>Installation on the pipelines</td><td>1,500</td></tr>
<tr><td>7</td><td colspan="2">Fuel cell systems</td><td>-</td><td>4,948</td></tr>
<tr><td>8</td><td colspan="2">Turbo expanders</td><td>1,800</td><td>1,600</td></tr>
<tr><td>9</td><td colspan="2">Other renewable sources excluding hydropower plants</td><td>4,873</td><td>-</td></tr>
</table>

(IRRs per kWh)

<table>
<tr><th>No</th><th colspan="2">Technology type</th><th>2015</th><th>2016</th></tr>
<tr><td>1</td><td>Wind</td><td>with the capacity of 1 MW and less</td><td>5,930</td><td>5,700</td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">Solar</td><td>with the capacity of 100 kW and less</td><td>8,730</td><td>7,000</td></tr>
<tr><td>with the capacity of 20 kW and less</td><td>9,770</td><td>8,000</td></tr>
</table>

* Allocated to the consumers and limited to the connection capacity

Source: Information obtained from SATBA

2.6.3 Electrical Power Consumer Prices

(1) Trend in electrical power consumer prices

The electricity prices for consumers are determined by law. In 2016, the cabinet approved a 10% price increase in the August price adjustment. According to the MOE, the average price after the 2015 adjustment was about 600 IRR/kWh, but it is envisaged that the average price after the price adjustment will be 670 IRR/kWh.

The consumer electricity price is affected by political decisions, and does not necessarily reflect the wishes of TAVANIR. Therefore, price changes have not been made every year, and recently in 2012 and 2013 the price change was deferred. It is considered that this was related to the fact that price changes had been made consecutively in December 2010 and March 2011. At present, the purchase price exceeds the sales price, so it is envisaged that TAVANIR will increase the price until the purchase price and the sales price are equal. However, electrical power prices are determined politically, so it is not known when this will be realized.

Tariff schedules have been prepared for different types of power consumers. Tables 2-27 to -31 show examples of the numerous schedules in use.

Table 2-27 Tariff1 Residential Uses

Base Price kWh/IRR

per month(kWh)	2010	2011	2014	2015	2016	2017	2018
Up to 100	270	300	372	409	450	458	490
Over 100-200	320	350	434	477	525	534	571
Over 200-300	720	750	930	1,023	1,125	1,144	1,224
Over 300-400	1,300	1,350	1,674	1,841	2,025	2,059	2,303
Over 400-500	1,500	1,550	1,922	2,114	2,325	2,365	2,531
Over 500-600	1,900	1,950	2,418	2,660	2,926	2,976	3,184
Over 600	2,100	2,150	2,666	2,933	3,226	3,281	3,511

Source: TAVANIR

Table 2-28 Tariff2 Public Uses

Year	Tariff code		with power above 30 kW				with 30 kW power or less			
			Power price (kW/IRR)	Energy price (kWh/IRR)			Power price (kW/IRR)	Energy price (kWh/IRR)		
				Middle load hours	peak load hours	Low load hours		Middle load hours	peak load hours	Low load hours
2010	A-2	1	30,000	1,000	2,000	500	-	1,200	2,400	600
		2	25,000	300	600	150	-	400	800	200
	B-2		12,000	150	300	75	-	200	400	100
2011	A-2	1	30,000	1,100	2,200	550	-	1,300	2,600	650
		2	25,000	340	680	170	-	440	880	220
	B-2		12,000	190	380	95	-	240	480	120
2014	A-2	1	37,200	1,364	2,728	682	-	1,612	3,224	806
		2	31,000	422	844	211	-	546	1,092	273
	B-2		14,880	236	472	118	-	298	596	149
2015	A-2	1	44,640	1,637	3,274	819	-	1,934	3,868	967
		2	37,200	506	1,012	253	-	655	1,310	328
	B-2		17,856	283	566	142	-	358	716	179
2016	A-2	1	49,104	1,801	3,602	901	-	2,127	4,254	1,064
		2	40,920	557	1,114	279	-	721	1,442	361
	B-2		19,642	311	622	156	-	394	788	197
2017	A-2	1	49,939	1,832	3,664	916	-	2,163	4,326	1,082
		2	41,616	566	1,132	283	-	733	1,466	367
	B-2		19,976	316	632	158	-	401	802	201
2018	A-2	1	53,435	1,960	3,920	980	-	2,314	4,658	1,107
		2	44,529	707	1,212	303	-	784	1,068	392
	B-2		21,374	338	679	169	-	429	808	215

Source: TAVANIR

Table 2-29 Tariff3 Production Uses (Water and Energy)

Year	Tariff code		with power above 30 kW				with 30 kW power or less			
			Power price (kW/IRR)	Energy price (kWh/IRR)			Power price (kW/IRR)	Energy price (kWh/IRR)		
				Middle load hours	peak load hours	Low load hours		Middle load hours	peak load hours	Low load hours
2010	A-3		-	135	270	68	-	135	270	68
	B-3		12,000	175	350	88	-	215	430	108
	C-3	Option 1	20,000	225	450	113	-	325	650	163
		Option 2	-	325	650	163				
2011	A-3		-	80	160	40	-	80	160	40
	B-3		12,000	155	310	78	-	195	390	98
	C-3	Option 1	20,000	205	410	103	-	305	610	153
		Option 2	-	305	610	153				
2014	A-3		-	100	200	50	-	100	200	50
	B-3		14,880	194	388	97	-	242	484	121
	C-3	Option 1	24,800	254	508	127	-	378	756	189
		Option 2	-	378	756	189				
2015	A-3		-	110	220	55	-	110	220	55
	B-3		16,368	213	426	107	-	266	532	133
	C-3	Option 1	27,280	279	558	140	-	416	832	208

		Option 2	-	416	832	208				
2016	A-3		-	121	242	61	-	121	242	61
	B-3		18,005	234	468	117	-	293	586	147
	C-3	Option 1	30,008	307	614	154	-	458	916	229
		Option 2	-	458	916	229				
2017	A-3		-	123	246	62	-	123	246	62
	B-3		18,311	238	476	119	-	298	596	149
	C-3	Option 1	30,518	312	624	156	-	466	932	233
		Option 2	-	466	932	233				
2018	A-3		-	122	264	66	-	132	264	66
	B-3		19,593	255	510	128	-	319	638	160
	C-3	Option 1	32,654	334	668	167	-	499	998	250
		Option 2	-	499	998	250				

Source: TAVANIR

Table 2-30 Tariff4 Production Uses (Industry and Mine)

Year	Tariff code		with power above 30 kW				with 30 kW power or less			
			Power price (kW/IRR)	Energy price (kWh/IRR)			Power price (kW/IRR)	Energy price (kWh/IRR)		
				Middle Load Hours	Peak Load Hours	Low Load Hours		Middle Load Hours	Peak Load Hours	Low Load Hours
2010	A-4	Option 1	32,000	340	680	170	-	440	880	220
		Option 2	12,000	390	780	195				
	B-4	Option 1	18,000	200	400	100	-	270	540	135
		Option 2	9,000	240	480	120				
2011	A-4	Option 1	32,000	340	680	170	-	440	880	220
		Option 2	12,000	390	780	195				
		Option 3	-	430	860	215				
	B-4	Option 1	18,000	200	400	100	-	270	540	135
		Option 2	9,000	240	480	120				
		Option 3	-	270	540	135				
2014	A-4	Option 1	39,680	422	844	211	-	546	1,092	273
		Option 2	14,880	484	968	242				
		Option 3	-	534	1,068	267				
	B-4	Option 1	22,320	248	496	124	-	336	672	168
		Option 2	11,160	298	596	149				
		Option 3	-	336	672	168				
2015	A-4	Option 1	47,616	506	1,012	253	-	655	1,310	328
		Option 2	17,856	581	1,162	291				
		Option 3	-	641	1,282	321				
	B-4	Option 1	26,784	298	596	149	-	403	806	202
		Option 2	13,392	358	716	179				
		Option 3	-	403	806	202				
2016	A-4	Option 1	52,378	557	1,114	279	-	721	1,442	361
		Option 2	19,642	639	1,278	320				
		Option 3	-	705	1,410	353				
	B-4	Option 1	29,462	328	656	164	-	443	886	222
		Option 2	14,731	394	788	197				
		Option 3	-	443	886	222				

2017	A-4	Option 1	53,267	566	1,132	283	-	733	1,466	367
		Option 2	19,956	650	1,300	325				
		Option 3	-	717	1,434	359				
	B-4	Option 1	29,963	334	668	167	-	451	902	226
		Option 2	14,981	401	802	201				
		Option 3	-	451	902	226				
2017	A-4	Option 1	56,997	606	1,212	303	-	784	1,568	392
		Option 2	21,374	696	1,392	348				
		Option 3	-	767	1,534	384				
	B-4	Option 1	22,060	356	714	179	-	483	966	242
		Option 2	16,030	429	858	215				
		Option 3	-	483	966	242				

Source: TAVANIR

Table 2-31 Tariff5 Other Uses

Price Category		2010	2011	2014	2015	2016	2017	2018
with power above 30 kW								
Power price (kW/IRR)		30,000	20,000	24,800	29,760	32,736	33,293	35,624
Energy price (kWh/IRR)	Middle load hours	1,000	1,100	1,364	1,637	1,801	1,832	1,960
	peak load hours	2,000	2,200	2,728	3,274	3,602	3,664	3,920
	Low load hours	500	550	682	819	901	916	980
with 30 kW power or less								
consumption/ month (kWh/month)	Up to 100	1,000	1,100	1,364	1,637	1,801	1,832	1,960
	Over 100-200	1,000	1,150	1,426	1,711	1,882	1,914	2,048
	Over 200-300	1,400	1,200	1,488	1,786	1,965	1,998	2,138
	Over 300-400	1,400	1,250	1,550	1,860	2,046	2,081	2,227
	Over 400-500	1,400	1,400	1,736	2,083	2,291	2,330	2,493
	Over 500-600	1,400	1,600	1,984	2,381	2,619	2,664	2,850
	Over 600	2,000	1,800	2,232	2,678	2,946	2,994	3,206

Source: TAVANIR

The month for revision of the prices in the above tables varies from year to year; in fiscal 2010, it was December, in fiscal 2011, it was April, in fiscal 2014, it was April, and in fiscal 2015, it was March 2016[14]. Although it was not possible to obtain the information during the survey, as stated previously, there was a price revision actually in September 2016, in which the price increase is likely to about 10% over the previous year's price. In the Persian calendar, a year begins in March and ends in March in the following year.

The average sales prices as a result of applying the above sales tariff table were as follows.

Table 2-32 Average Electrical Power Sales Price (IRR/kWh)

Year	Residential	Public	Agriculture	Industry	Others	Average	Inflation
2005-06	102.74	176.81	21.56	201.57	539.74	152.08	
2006-07	102.92	181.70	21.25	200.41	541.16	152.78	0.5%
2007-08	124.67	159.61	20.97	205.86	507.95	164.98	8.0%
2008-09	119.34	228.92	21.98	204.61	552.36	174.25	5.6%
2009-10	129.00	152.00	21.00	206.00	501.00	165.00	-5.3%
2010-11	142.26	226.53	46.80	263.58	599.10	208.70	26.5%

14 The start date of the New Year in the Persian calendar corresponds to 21nd, March in A.D.

2011-12	334.84	501.56	125.65	441.91	1275.25	409.48	96.2%
2012-13	337.46	491.01	131.10	427.52	1339.45	407.01	-0.6%
2013-14	364.80	516.30	133.40	442.60	1342.20	418.50	2.8%
2014-15	439.40	617.60	177.90	542.60	1664.00	525.60	25.6%
2015-16	515.56	729.80	192.94	640.26	1965.38	616.90	17.4%
2016-17	538.37	765.44	208.53	675.41	2183.23	662.03	7.3%

Source: Electric power industry in Iran 2014-2015

The price increases in fiscal 2010 and 2011 overlapped, so the sales price increased greatly, and the increase was about double. Thereafter in fiscal 2012 and 2013 there was no price revision, but a price revision was carried out in 2014.

In addition, it is considered that the future direction of the price is upwards, but as the price itself is a political matter, when and how much the price increase is impossible to predict.

(2) Sales prices to VHV and HV customers

Different prices are applicable to VHV and HV customers that directly purchase their electrical power from the transmission lines, and not via the distribution network. Basically, the price is determined by contract negotiated individually between the parties in long-term contracts.

(3) Electrical power subsidies

There are 2 types of so cold subsidy. Those are fuel subsidy and Government budget. The Government decides domestic fuel price and fuel price for generation are set cheaper than fuel price for other category in Iran. The amounts which are corresponding to difference between purchase price from National petroleum Co. or National gas Co. and international price are recognized as fuel subsidy. Fuel subsidy is not actual payments from the Government and it is recognized only through calculation.

In law, TPPH and TAVANIR are a company, but from the financial viewpoint, it also has the aspect of a government organization. As a government organization, they prepare a budget, and differences between forecast expenditure and income are paid from the national budget, so that income and expenditure in the budget are balanced.

The income is broadly divided into electrical power income and disbursements from the government. When TPPH and TAVANIR are considered as a self-supporting organization, the budget dispersed from the government is effectively considered to be a subsidy.

The following table shows the comparison between the cost of sales and the sales tariffs. It was not possible to obtain data for the fuel subsidies up to 2010 and the cost of goods in 2012, etc., so the table is incomplete. As shown in the table below, the cost of sales greatly exceeds the sales tariff. The amount of the difference is compensated for by the fuel subsidies and budget. The sales tariff increases yearly, but the difference with the cost of sales is great, so even in 2014 the sales tariff was less than half the cost of sales. From 2013 the fuel subsidy has been abolished, so the compensation from the budget has increased.

Table 2-33 Cost of sales, Subsidies, Sales Tariffs

(Rial/kWh)

Year	Costs *1	Fuel subsidy	Net Costs	Sales tariff	Net budget *2
2004-05	301.0	-	301.0	151.1	149.9
2005-06	316.6	-	316.6	152.1	164.5
2006-07	326.1	-	326.1	152.3	173.8
2007-08	310.0	-	310.0	165.0	145.0
2008-09	397.7	-	397.7	174.3	223.4
2009-10	430.0	-	430.0	165.0	265.0
2010-11	537.4	-	537.4	208.7	328.7
2011-12	1,240.1	649.0	591.1	409.5	181.6
2012-13	-	-	-	407.0	-
2013-14	1,107.0	-	1,107.0	418.7	688.4
2014-15	1,131.0	-	1,131.0	525.6	605.4
2015-16	904.0	-	904.0	616.9	287.1
2016-17	958.0	-	958.0	662.0	296.0

*1 Year 2004-05 to 2010-11 Costs without fuel subsidy year 2011-12 and after costs with fuel subsidy
*2 year 2004-05 to 2011-12 Budget, 2013-14 and after bidgt + fuel subsidy

Source: Electric power industry in Iran 2011-2012、2014-2015

Fuel subsidy (as reference)

Daily essentials like wheat and energy are subsidized in Iran like in other middle east countries. Energy such as gasoline diesel and electricity and basic foods such as bread, egg and food oil are subsidized in Iran.

2000 era and after increase in energy subsidy became a factor of strict national finance in line with increase of domestic energy demand At the beginning, gasoline price was raised in incremental steps from 2007 to 2014, and On a nominal price basis, the gasoline price increased by a factor of 7 in seven years, through a major reduction in subsidies[15].

Transitions in energy subsidy from 2014 to 2016 were as follows. The Government reduce energy subsidy after 2014 also but flagging oil market is considered as main reason for energy subsidy reduction. Domestic fuel price for generation was not increased as described above, on the contrary it was decreased in fiscal year 2016-17. Therefore, it should be understood that fuel subsidy was reduced rather according to the result of external factor; prolonged slump in international oil market not due from the Governmental policy.

[15] FY2014 Ministry of Foreign Affairs Foreign and Security Affairs Research Project (General Project) “The Middle East as a Global Strategy Issue – Outlook to 2030 and Response –” Chapter 6 Subsidies and Structural Reform, Yoshikazu Kobayashi, The Japan Institute of International Affairs

Table 2-34 Fossil-fuel subsidies in IRAN (as reference)

USD mil

Product	2014	2015	2016
Oil	33,754	17,151	16,075
Electricity	13,091	12,254	4,888
Gas	18,766	17,554	13,841
Coal	0	0	0
Total	65,611	46,959	34,804

Source：IEA fossil-fuel subsidies database

Table 2-35 Indicators for year 2016（as reference）

	Average subsidisation rate (%)	Subsidy per capita ($/person)	Total subsidy as share of GDP (%)
Iran	65.5%	434.8	9.2%

Source: IEA fossil-fuel subsidies database

Chapter 3 Natural Conditions

3.1 Overview

The site is located just under 2 hours by car from Tehran.

According to the field investigations conducted at the time of the second site survey, the ground surface of the site was covered with plants, and the surface layer was a silty fine sand covering a mixture of sand and gravel. There are trees near the boundary line on the north side within the site of the Shahid Rajaee Power Plant, which will have to be removed together with the tree stumps and roots prior to commencement of construction. Also, there is one (1) cable laid in a cable trench in the center of the site. In addition, there are structures in several locations, and there are also concrete pipes on the site, so it will be necessary to remove these prior to construction.

An on-site borehole survey and a laboratory soil test were conducted for the basic design of the foundation and the details of soil properties were elucidated by the results of the survey and test.


Source: prepared by JICA Study team

Fig. 3-1 Photo of Candidate Site

3.2 Site Geological Conditions

Site investigations such as soil investigation, topographical survey, infrastructure survey, etc., has been carried out to confirm that there are no problems in the natural conditions, etc., in the site for construction of the new high-efficiency low environmental load gas combined cycle generating plant within the site of the Shahid Rajaee Power Plant in Iran. The detailed contents to be carried out are described in Section 3.2.1onwards.

3.2.1 Status of the Ground

A borehole survey has been carried out in July 2017 by local consultants engaged by the JICA consultant team. The results will be summarized and the site ground conditions will be described.

The quantities to be surveyed are as shown below. The quantities of the survey were decided in accordance with ground conditions at the plant site.

(1) Quantity and Location of the Study

1) Field Work

The items and quantities of the field work are as follows:

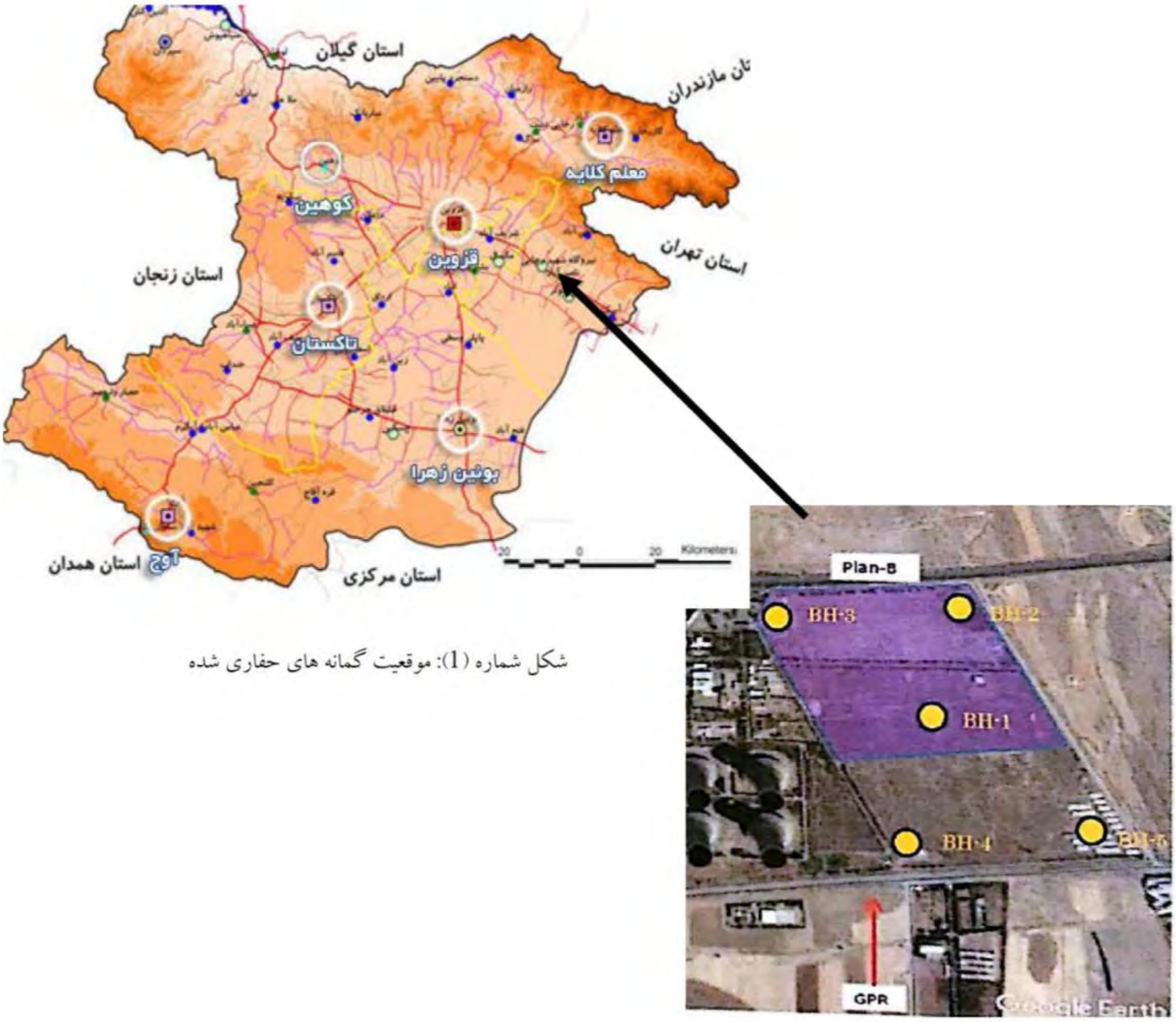
a) Boring : 5 points (BP1-BP5)
: 100 m in length at 1 boring point and 30 m in length at 4 boring points, 220m in total length
b) Standard Penetration Test : Every 1 meter intervals (Total 170 sets at most)

2) Laboratory Test

The items and quantities of the laboratory test are as follows:

a)	Particle-size Analysis	: 63 pieces	of all samples
b)	Atterberg Limits	: 63 pieces	of all samples
c)	Specific Gravity Test	: 5 pieces	of all samples
d)	Direct Shear Test	: 5 pieces	of all samples
e)	Chemical Test	: 5 pieces	of all samples

The locations of the boreholes are as shown below.



Source: created by JICA study team utilizing Google Earth

Fig. 3-2 Location of the bore holes

Table 3-1 Coordinates of the bore holes

Row	BH No.	X	Y	Z	Depth (m)
1	BH-1	437591	4001253	1286	100
2	BH-2	437984	4001564	1303	30
3	BH-3	437545	4001779	1300	30
4	BH-4	437209	4000977	1283	30
5	BH-5	437674	4000631	1282	30

Source: prepared by JICA Study team

3.2.2 Results of Geological Survey

The maximum and the minimum soil density at each depth as obtained in the above surveys are shown in Table 3-2.

Table 3-2 Maximum and Minimum Density

Sample No.	Depth (Cm)	Maximum Density (gr/cm3)	Minimum Density (gr/cm3)
BH-1	2.00-6.00	1.98	1.80
BH-2	3.00-7.00	1.93	1.75
BH-3	3.00-4.00 &6.00-9.00	1.95	1.77
BH-4	3.00-6.00 &9.00-10.00	1.91	1.75
BH-5	3.00-6.00 &9.00-10.00	1.96	1.79

Source: prepared by JICA Study team

Table 3-3 shows the soil cohesion and friction angle at each boring depth.

Table 3-3 Results of Mechanical Tests

BH NO	DEPTH (m)	C (Kg/ Cm2)	Φ (Deg.)
BH-1	2.00-6.00	0.04	35.4
BH-2	3.00-7.00	0.06	34.6
BH-3	3.00-4.00 &6.00-9.00	0.05	34.8
BH-4	3.00-6.00 &9.00-10.00	0.08	33.8
BH-5	3.00-6.00 &9.00-10.00	0.04	36.1

Source: prepared by JICA Study team

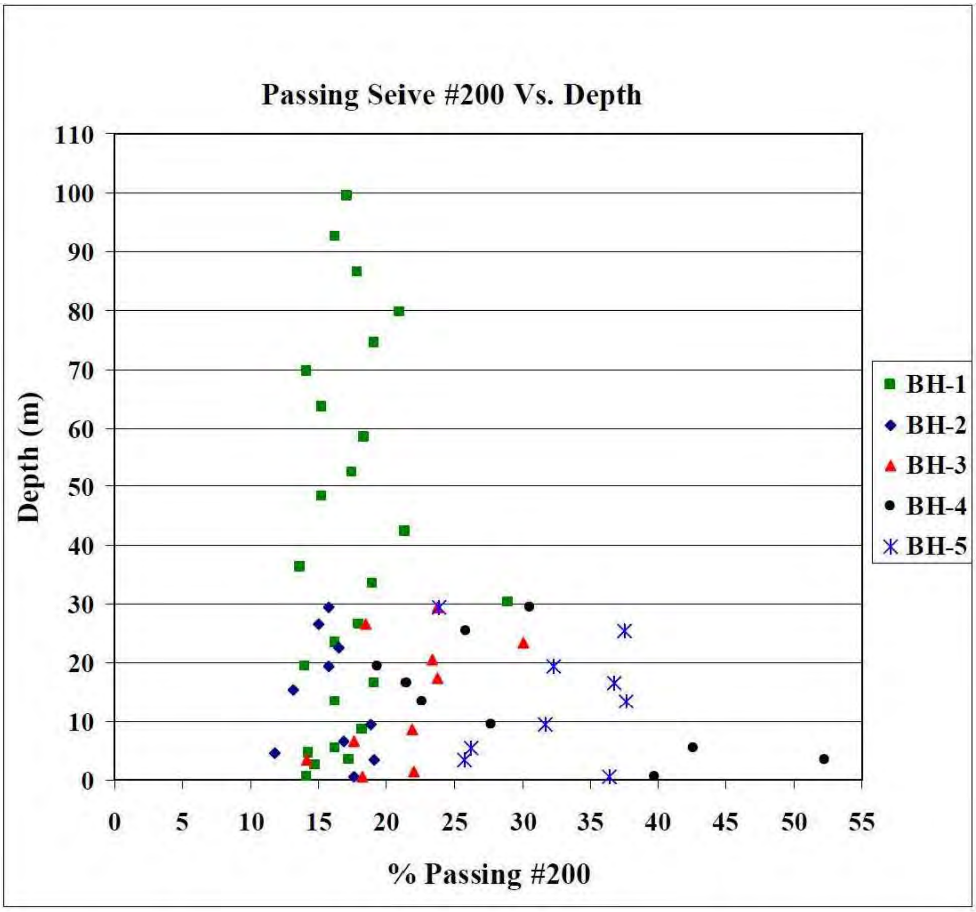
In addition, Table 3-4 shows the results of chemical component analysis at each depth.

Table 3-4 Results of Chemical Component Analysis

Sample No:	DEPTH (cm)	PH (at 25 °C)	Cl^- WT %	$So4^{2-}$ WT %	T.D.S WT %
BH-1	2.00-3.00	7.6	0.01	0.25	2.55
BH-2	3.00-4.00	7.8	0.02	0.28	2.86
BH-3	1.00-2.00	7.5	0.02	0.16	2.33
BH-4	3.00-4.00	7.6	0.01	0.35	2.54
BH-5	3.00-4.00	7.7	0.02	0.21	2.48

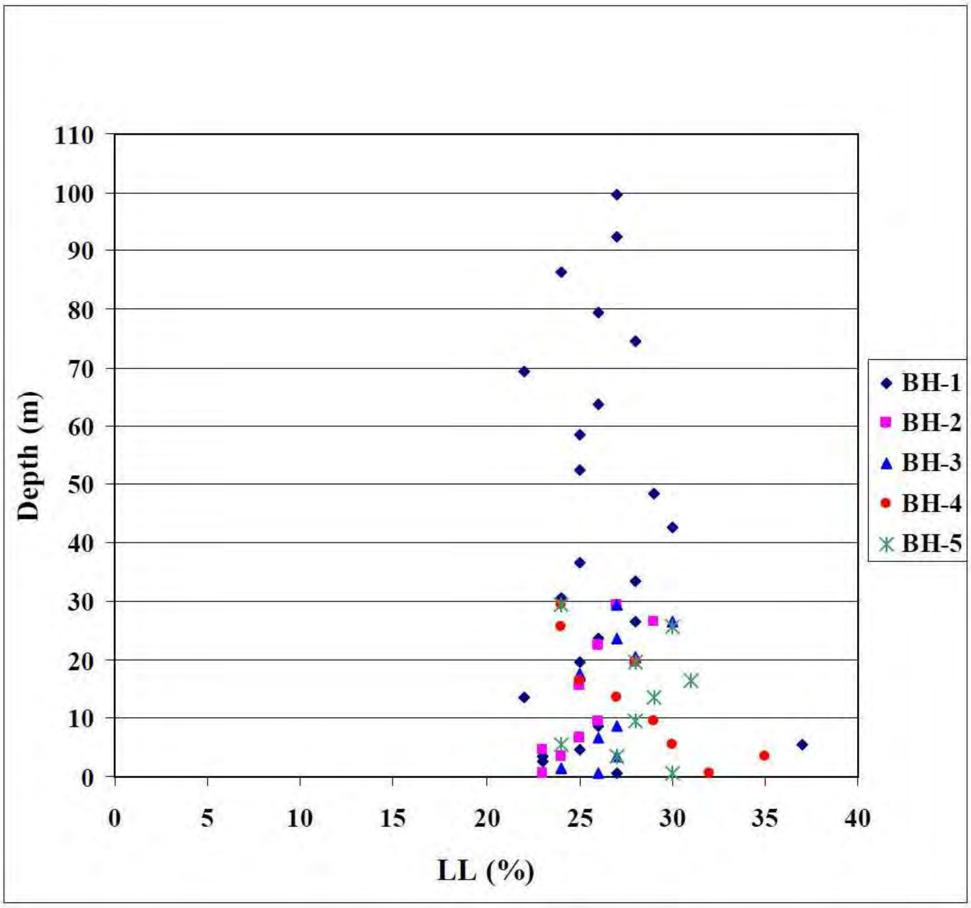
Source: prepared by JICA Study team

Fig. 3-3 shows the passing rate of a grain size of 0.074 mm or less, Fig. 3-4 the liquid limit and Fig. 3-5 the plasticity index respectively.



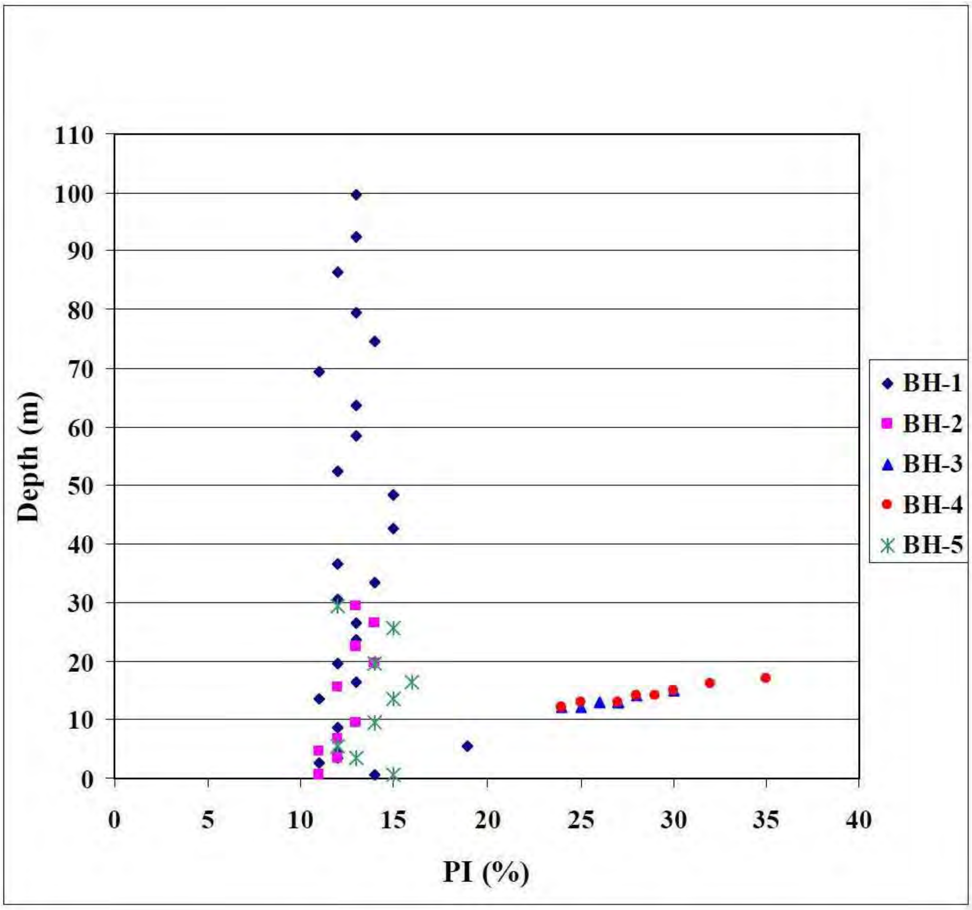
Source: prepared by JICA Study team

Fig. 3-3 Passing Rate



Source: prepared by JICA Study team

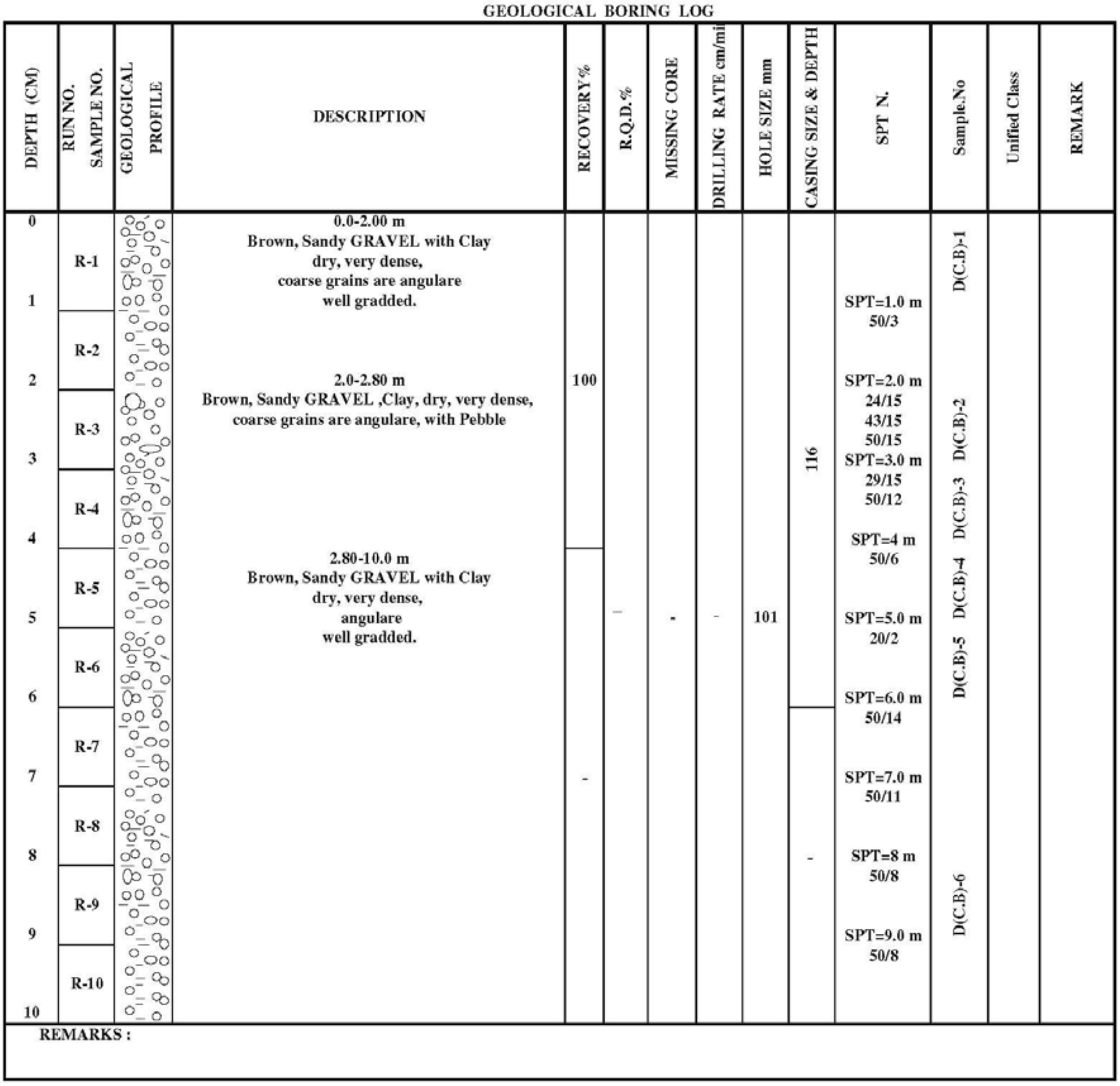
Fig. 3-4 Liquid Limit



Source: prepared by JICA Study team

Fig. 3-5 Plasticity Index

The typical geological boring log at the site is shown in Fig.3-6. No large differences are seen at 5 survey points.



GEOLOGICAL BORING LOG

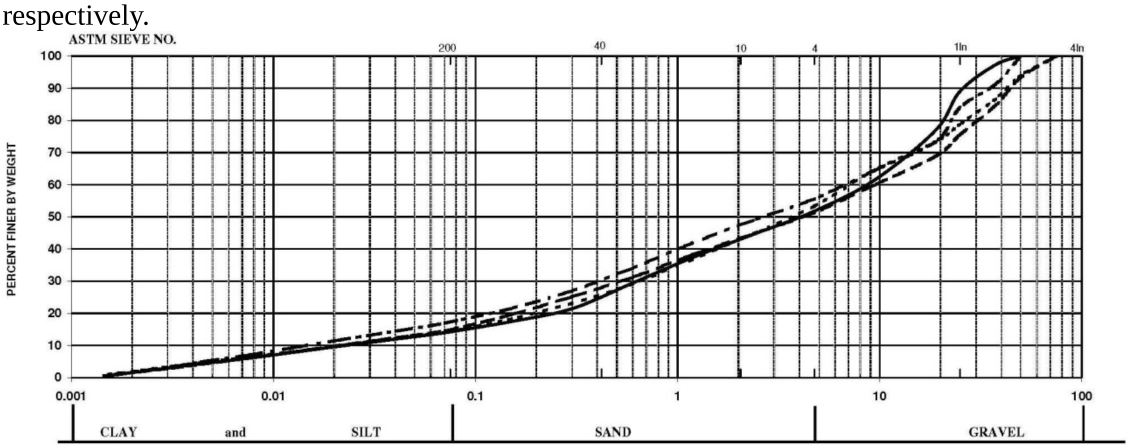
DEPTH (CM)	RUN NO. SAMPLE NO.	GEOLOGICAL PROFILE	DESCRIPTION	RECOVERY%	R.Q.D.%	MISSING CORE	DRILLING RATE cm/mi	HOLE SIZE mm	CASING SIZE & DEPTH	SPT N.	Sample.No	Unified Class	REMARK
0	R-1		0.0-2.00 m Brown, Sandy GRAVEL with Clay dry, very dense, coarse grains are angulare well gradded.								D(C.B)-1		
1	R-2									SPT=1.0 m 50/3			
2	R-3		2.0-2.80 m Brown, Sandy GRAVEL ,Clay, dry, very dense, coarse grains are angulare, with Pebble	100						SPT=2.0 m 24/15 43/15 50/15	D(C.B)-2		
3	R-4								116	SPT=3.0 m 29/15 50/12	D(C.B)-3		
4	R-5		2.80-10.0 m Brown, Sandy GRAVEL with Clay dry, very dense, angulare well gradded.							SPT=4 m 50/6	D(C.B)-4		
5	R-6				–	-	-	101		SPT=5.0 m 20/2	D(C.B)-5		
6	R-7									SPT=6.0 m 50/14			
7	R-8			-						SPT=7.0 m 50/11			
8	R-9								-	SPT=8 m 50/8			
9	R-10									SPT=9.0 m 50/8	D(C.B)-6		
10													

REMARKS :

Source: prepared by JICA Study team

Fig. 3-6 Typical Geological Boring Log at Site

The typical grain size distribution diagram and table are shown in Fig.3-7 and in Table 3-5 respectively.



Source: prepared by JICA Study team

Fig. 3-7 Typical Grain Size Distribution Diagram

Table 3-5 Typical Grain Size Distribution

DEPTH	SYMBOL	M.C.	L.L.	P.I.	UNIFIED CLASS	Passing 50 mm	Passing 37.5 mm	Passing 25 mm	Passing 19 mm	Passing 9.5 mm	Passing 4.75 mm	Passing 2.36 mm	Passing 1.18 mm	Passing 0.6 mm	Passing 0.3 mm	Passing 0.15 mm	Passing 0.075 mm
m .		%	%	%		(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
0.00-1.00	———	–	27.0	14.0	GC	100.00	97.31	89.07	77.03	61.55	51.74	44.45	37.25	29.39	21.39	17.38	14.18
2.00-3.00	— — ·	–	23.0	11.0	GC	93.33	84.72	75.56	68.89	60.00	51.30	44.63	38.13	31.19	25.08	19.52	14.80
3.00-4.00	- · - ·	–	23.0	12.0	GC	100.00	91.29	84.00	73.46	64.49	55.59	48.89	41.78	34.04	26.95	21.46	17.27
4.00-5.00	······	–	25.0	12.0	GC	93.94	86.67	78.79	73.33	64.61	53.32	44.58	36.70	29.13	23.07	18.22	14.28

Source: prepared by JICA Study team

The typical geological parameters as deemed as the design guidelines are shown in Table 3-6.

Table 3-6 Typical Geological Parameters

Parameter	Unit	Materials of the second layer
Classification	-	GC and SC
Cohesion (C)	kg/cm^2	0.0 – 0.05
Internal friction angle (φ)	Degree	34 – 37
Natural specific weight (γ)	t/m^3	1.85 – 1.95
Modulus of elasticity (E)	kg/cm^2	700 – 1200
Poisson's ratio (γ)	-	0.29 – 0.31
Over-consolidation ratio (OCR)	-	> 5

Source: prepared by JICA Study team

3.2.3 Discussion on Geological Properties

(1) Geological Conditions at Site

- The grain size distribution analysis has revealed the existence of gravelly soil at all survey points. While the ground consists mostly of gravel and sand, clay is also found in the fine-grain fraction. (Fig.3-6)
- The strength test of the ground has revealed that the soil fraction of the ground excluding gravel has an N value of approximately 20, indicating that it is compact sand. (Fig.3-6)
- The ground mostly consists of gravelly sand and the ratio of particles with a grain size of 0.0075 μm or less (fine-grain fraction) is 20 % or less. Therefore, there will be no negative effects from the absorption of water into the ground (*e.g.*, at the time of rain), such as the clayey component becoming muddy or loosening of the ground. (Fig.3-6)
- Although clay content in the fine-grain fraction is large, the ground consists of gravelly sand with a ratio of particles with a grain size of 0.0075 μm or less at 20 % or less. Therefore, it has been concluded that the soil taken from this ground can be used for backfilling. (Fig. 3-3)
- As seen in the geological boring log, the geological strata are composed of tight sandy gravels (N-value>50). (Fig.3-6)
- The plasticity index and the liquid limit are shown in Fig. 3-4 and Fig. 3-5. The plasticity indexes are concentrated on 10 to 15%. The liquid limits are concentrated on 20 to 30%.

(2) Chemical Components at Site

- The chemical component analysis has revealed that the soil in the entire site has neutral to slightly alkaline pH values and, thus, will have no adverse effect on concrete. (Table 3-4)
- As the existence of sulfate ions in the soil in the planned power plant construction

sites is suspected, sulfate resisting concrete must be used for the construction of underground structures. Application of asphalt on concrete surfaces that come into direct contact with soil is recommended as a safety measure. (Table 3-4)

3.2.4 Groundwater Conditions

The levels of the groundwater have been checked during the borehole survey to be carried out by the local consultants engaged by the JICA consultant team. According to the hearing survey with the power plant staff in the second site survey, the groundwater existed at the depth of 40 m or more from the ground surface as based on the water level of the borehole used at the existing power plant.

In groundwater level monitoring in the borehole survey, the existence of groundwater was not observed in BH-2 to -5 bored to GL-30m, but it was observed in BH-1 at GL-64.5 m.

3.3 Topographical Conditions of the Site

3.3.1 Topographical Conditions

A topographical survey has been carried out by local consultants engaged by the JICA consultant team. The results are summarized and a description is provided regarding the local topography.

(1) Survey Range

The area to be surveyed was not only the Plan-B new power station construction area, but included about 75 hectares, also covering the areas for the new Administration Building and Switch Yard. The area to be surveyed is shown in the following figure.

Source: created by JICA study team utilizing Google Earth

Fig. 3-8 Survey Area

1) Benchmarks

Temporary benchmarks were installed at ten locations in the Plan-B area. The UTM coordinates and elevation of each benchmark were determined using a GPS device and a national control point near the plant (grade 2 national benchmark, NCC/040-007) as a reference point. Table 3.2 shows the UTM coordinates and elevation of each benchmark.

Table 3-7 Coordinates of the bench marks

Row	TBM No.	X	Y	H
1	TBM-1	437885.202	4001601.521	1298.176
2	TBM-2	437612.405	4001787.059	1297.641
3	TBM-3	437469.541	4001578.388	1292.106
4	TBM-4	437510.635	4001356.638	1289.01
5	TBM-5	437393.445	4001239.449	1285.345
6	TBM-6	437310.451	4001044.013	1280.831
7	TBM-7	437505.392	4001022.285	1282.967
8	TBM-8	437570.173	4001144.052	1285.867
9	TBM-9	437676.506	4001295.949	1289.996
10	TBM-10	437811.005	4001493.103	1294.998

Source: prepared by JICA Study team

2) Topographic Map

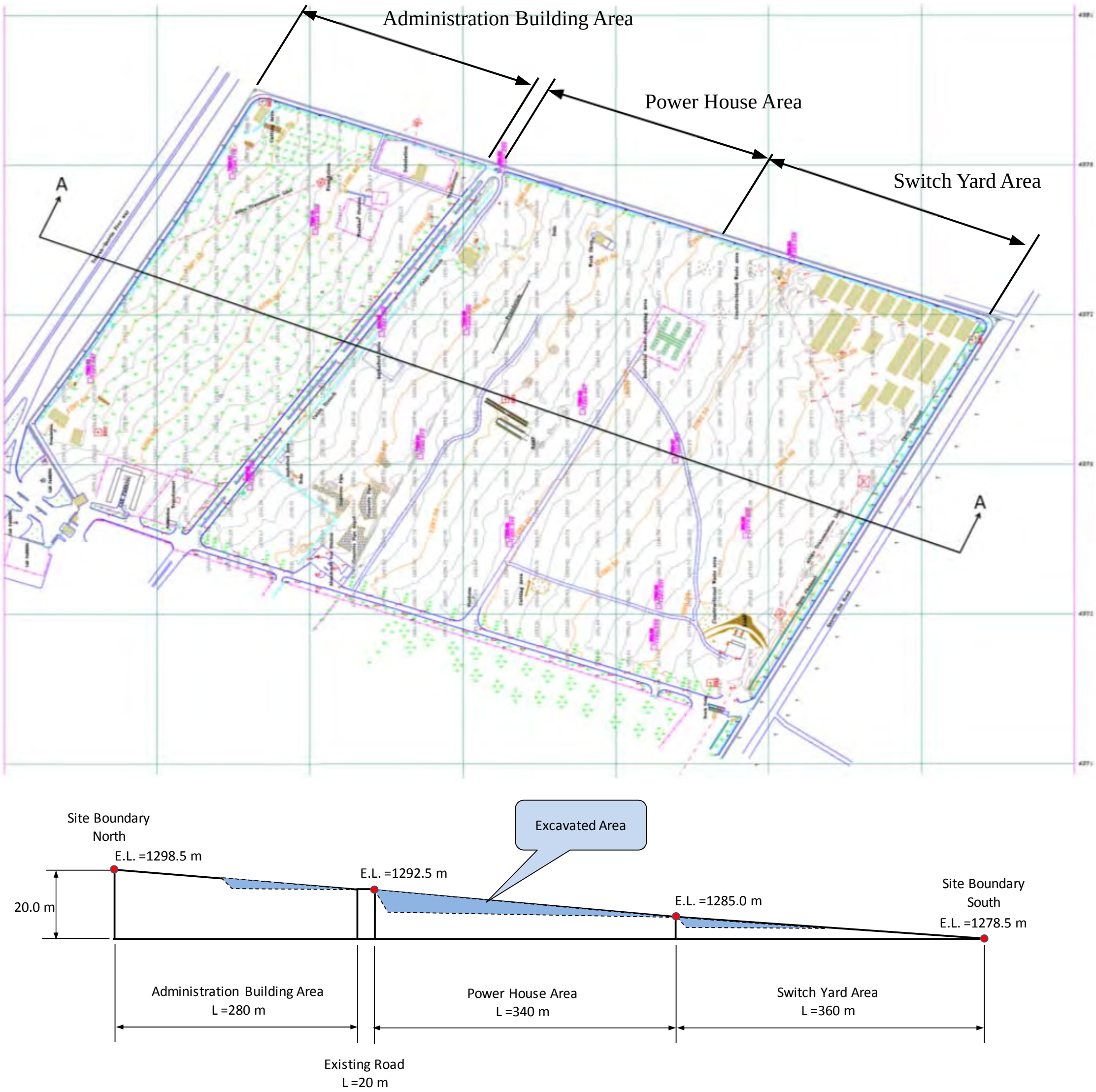
The results of a topographic survey of an approx. 75 ha in the Plan-B area were used for the creation of a 1:1000-scale topographic map with contours at 0.5 m intervals of the area. The existing structures at the site were also surveyed and represented on the map.

3.3.2 Land Formation Plan

A geological survey of the site revealed that the ground in the site consists of compact sandy and gravelly soil and that the groundwater level in the site is sufficiently deep (deeper than GL-60m). This allows to conclude that there are no geological problems for land formation at the site.

The topographic survey conducted by local consultants revealed a slope in the north-south direction in the site. There is an elevation difference of 20 m in the site, with an elevation of 1,298.5 m at the northern edge of the site and 1,278.5 m at the southern edge. In the power plant construction plan, the Administration Building, Power House and Switch Yard are to be constructed in the northern, central and southern areas of the site, respectively, as shown in the figure below.

As a spread foundation will presumably be used in the construction of these structures, the ground will be excavated in the required areas to the required depths, and excavated earth will be disposed of within the plant site.



A-A Section (No-Scale Diagram)

Source: prepared by JICA Study team

Fig. 3-9 Topological Map Made by Site Investigation

3.4 Climatic Conditions

A survey has been carried out on the various types of climatic data (winds directions, wind speeds, rainfall, air temperature and humidity, air composition, etc.). The results are summarized and a description will be provided regarding the climatic conditions.

The meteorological conditions and specifications to be used in the project were set mainly using data recorded at the Qazvin Synoptic Meteorological Station located approximately 24 km west of the Shahid Rajaee Thermal Power Plant.

(Temperature and humidity)

The temperature and humidity data recorded at the Qazvin Station, the meteorological station closest to the plant, and other stations near the plant were analyzed. The average annual temperature, average annual maximum temperature and average annual minimum temperature are 14.1 ºC, 21.2 ºC and 6.8 ºC, respectively. The daily maximum temperate is 44.0 ºC recorded between June and August and the daily minimum temperature is -28.0 ºC recorded in January. The average annual relative humidity is 65.0 %.

(Precipitation)
Thirty-two (32) existing meteorological stations near the plant were selected as the sources of precipitation data for statistical analysis conducted on the basis of the accuracy, reliability and period of measurement of the data. Precipitation has been measured for the past 46 years at these stations. The statistical analysis of the precipitation data has revealed that, of the average annual precipitation of 320.5 mm, 34.3 % is observed in the winter, 28.7 % in the fall, 33.5 % in the spring and only 3.5 % in the summer.

(Wind direction and velocity)
Wind direction and velocity has been measured for 55 years at the Qazvin Station, the station closest to the plant. The prevailing wind direction is southeast throughout the year and in each season. The average velocity of the prevailing wind is between 1 m/s and 4 m/s and the average annual wind velocity is 1.97 m/s. The maximum instantaneous wind velocity observed at the station is 38.9 m/s.

3.5 Well Water

A survey will be carried out of the present status of well water intake and drainage methods, quantities of water, and routes. The results have been summarized and a description will be provided regarding the water.

(Rivers)
The river system in which the new power plant site is located consists of the Shoor River, the river system in the Qazvin Plains, the Bahjat Abad (Zaghe) River and the Unes Abad River.
The Behjat Abad River is an important source of water intake into the plant. It is a 3.5 km-long tributary and has a catchment area of 120 km^2. The gauging station closest to the plant is in Behjat Abad. The station was established in 1979 and water flow has been measured for 36 years at this station. The average annual flow rate is 0.22 m^3/s and the maximum flow rate is observed in April and May.

(Groundwater)
A groundwater survey was conducted with consideration for the possibility of the use of groundwater from boreholes in and near the plant site for plant operation. There are seven boreholes in and around the site. Their depths are between 150 m and 200 m and their pumping rates are between 1.5 L/s and 19.3 L/s.
The groundwater level in the plant area dropped by 36 m between 1965 and 2016, which is a rate of 0.68m/year. In association with this drop in the groundwater level, the salinity of groundwater has noticeably increased.

Groundwater will be supplied to the new power plant as in the case with the existing plant. The quality requirements for groundwater and the required amount are described in “5.3.4 (4) Design and Performance Requirements.”

3.6 Conclusion

Based on the results of the above surveys of natural conditions, a study has been carried out into the ancillary facilities associated with the power station, preliminary design of buildings, etc., routes for transportation of equipment, and temporary storage locations. The results have been summarized and a description is provided below regarding the civil engineering design.

(1) As a deep layer of sandy and gravelly soil is found below the ground surface of the site, the bearing capacity of the ground is expected to be high even near ground level. Based on the absence of silt and cohesive soil that may cause ground settlement, it has been concluded that consolidation settlement will not occur in the site. However, as a few centimeters of immediate settlement is expected to occur immediately after a load is applied on the ground, the absence of adverse effect from the immediate settlement on the foundation structures will be confirmed in the stage of the detailed design.

(2) Based on the results of the surveys of natural conditions in and near the project site, it has been concluded that there is no need to use a pile foundation for the construction of structures that apply a large load on the ground such as the Power House and fuel tanks. As the site is on a gentle slope, the construction sites will be prepared with cutting and spread foundations will be constructed on the prepared ground.

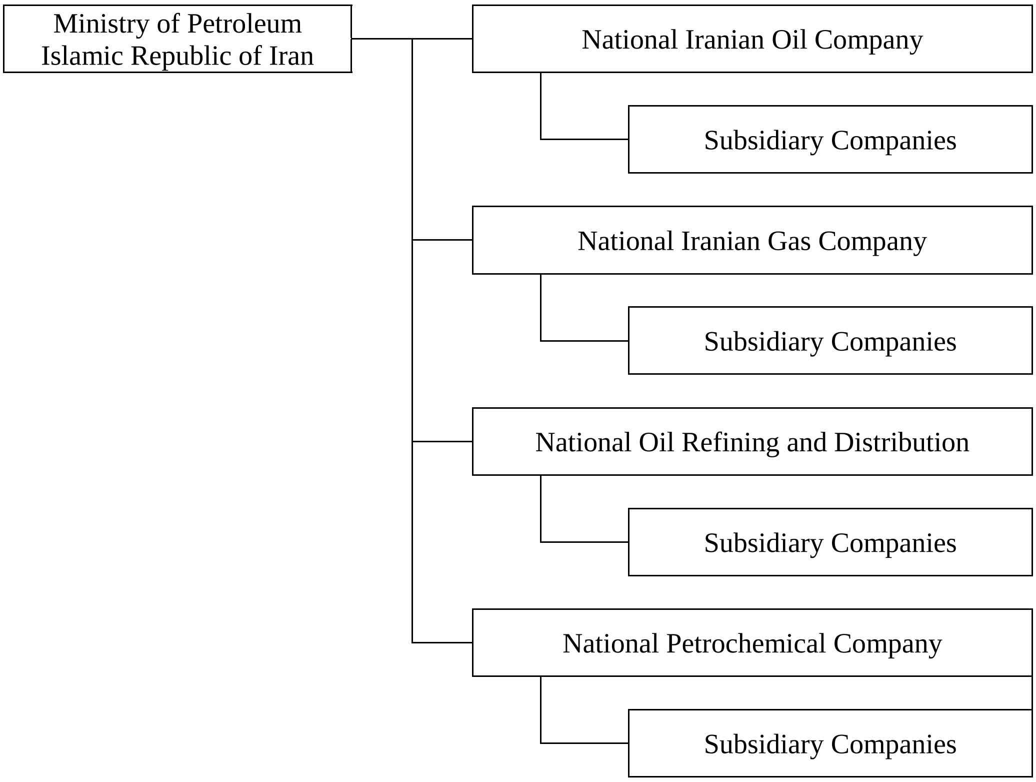
Chapter 4 Fuel Supply Plan

4.1 Fuel Sector in Iran

4.1.1 Outline of Fuel Sector in Iran

The fossil fuel industry is one of the major industries in Iran. Therefore, exports of oil and gas account for the majority of trade value. Because it is a major industry, the fossil fuel industry is managed by the Ministry of Petroleum (MoP) under the government. The organization of the fossil fuel industry is shown in

Fig. 4-1. The fossil fuel industry is divided into four parts by major public companies as the subordinate organization of MoP. Also each company has subsidiary companies.



Source: MoP WEB Site

Fig. 4-1 Organization of the Fossil Fuel Industry

The new facilities which are forecasted in this study are the combined cycle power plant which will use natural gas as the main fuel. So, the National Iranian Gas Company (NIGC) is the most relevant in this study. The organization of NIGC is shown in Fig. 4-2.

- National Iranian Gas Company
  - Provincial Gas Companies
    - Chaharmahal
    - Bushehr
    - East Azarbaijan
    - Golestan
    - Isfahan
    - Gilan
    - Fars
    - Kerman
    - Hamedan
    - Ilam
    - Kermanshah
    - Khoozestan
    - Khorasan razavi
    - Kordestan
    - Lorestan
    - North Khorasan
    - Qazvin
    - Qom
    - Markazi
    - Mazandaran
    - Semnan
    - South Khorasan
    - Sistan& Balochestan
    - Tehran
    - West Azarbaijan
    - Zanjan
    - Yazd
    - Hormozgan
    - Ardebil

    Total 29 Companies
  - Gas Treating Companies
    - Fajr
    - Bid Boland
    - Hashemi
    - Parsian
    - South Pars
    - Sarkhoon & Qeshm
    - Ilam

    Total 7 Companies
  - Iranian Gas Transmission Company
    - Iranian Gas Transmission Company
    - District No.1 ~10

    Total 11 Companies
  - Iranian Gas Engineering & Development Company
  - Iranian Gas Commercial Company
  - Underground Gas Storage Company

Source: NIGC WEB Site

Fig. 4-2 Organization of NIGC

According to NIGC's website, NIGC has subsidiary companies having various roles. The gas facilities are managed and operated by each provincial company. Shahid Rajaee Power Station which is the subject of this study is located in Qazvin, so Qazvin Province Gas Company is in charge of the gas supply management for the power station. And Iranian Gas Transmission Company which is in charge of the gas transmission separates the company for each area to manage. The areas are shown in the following figure. Tehran and Qazvin province is located in Area III.

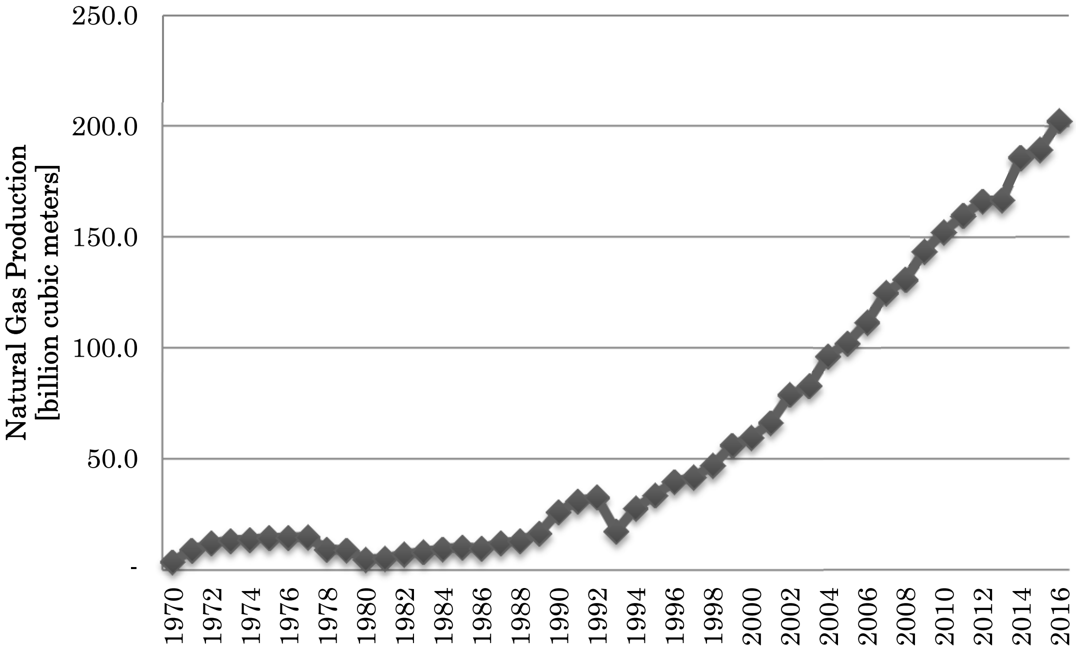
Source: Google Earth, Naft&EMA website[1]

Fig. 4-3 Area of Natural Gas Supply

[1] http://naftema.com/news/44769/

4.1.2 Current Status of Natural Gas Development in Iran

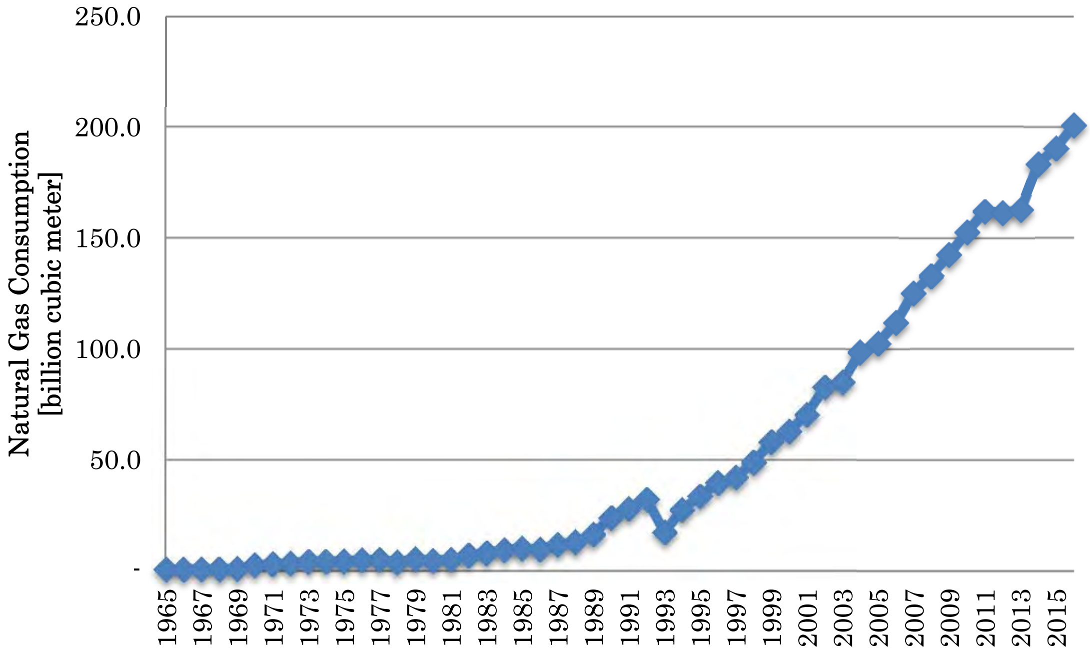
The natural gas production by 2016 in Iran is shown in Fig. 4-4.



Source: BP Statistical Review of World Energy 2017

Fig. 4-4 Trend of Natural Gas Production in Iran

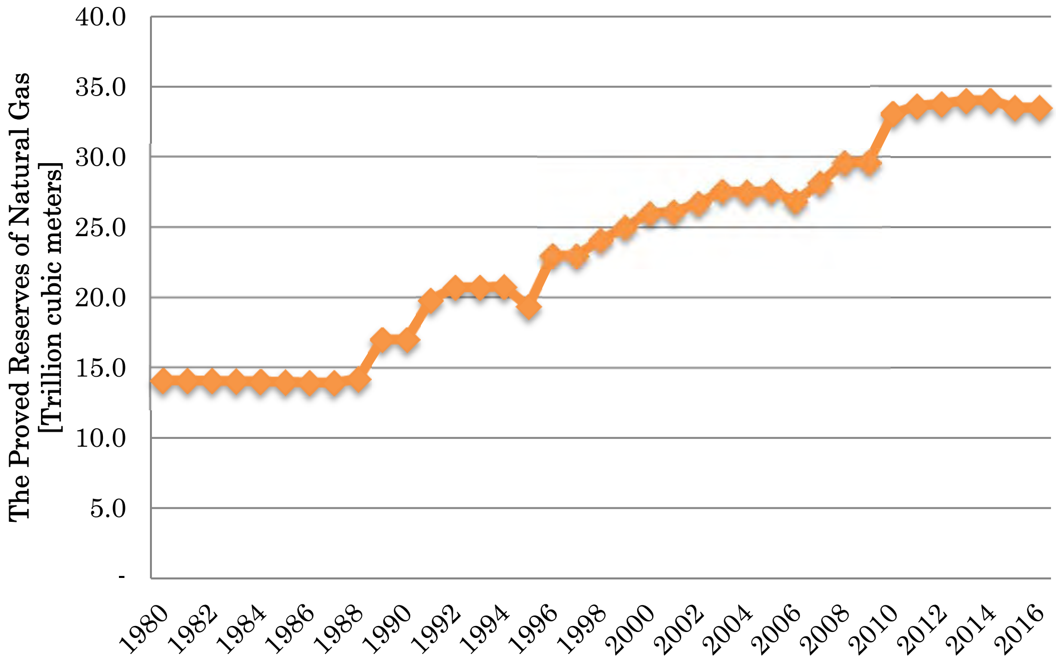
The natural gas production in 2016 was more than 200 billion cubic meters which is 5.7 % of the world gas production (No.3 in the world). But the natural gas consumption in Iran reached 5.7 % of the world gas consumption (No.4 in the world), so Iran is importing gas from Azerbaijan and Turkmenistan during the winter season which is the highest gas demand season. The natural gas is mainly using for power generation, industry (petrochemical and so on), consumers, and gas injection for oil fields. The natural gas consumption by 2016 in Iran is shown in Fig. 4-5.



Source: BP Statistical Review of World Energy 2017

Fig. 4-5 Trend of Natural Gas Consumption

After around 1990, production and consumption expanded rapidly in Iran. Also the proven reserves expanded with production and consumption by the development of natural gas mining technology, etc. According to BP Statistical Review of World Energy 2017, the proven reserves of Iran in 2016 reached 18 % of the world share (No.1 in the world). The proven reserves of natural gas are shown in Fig. 4-6.



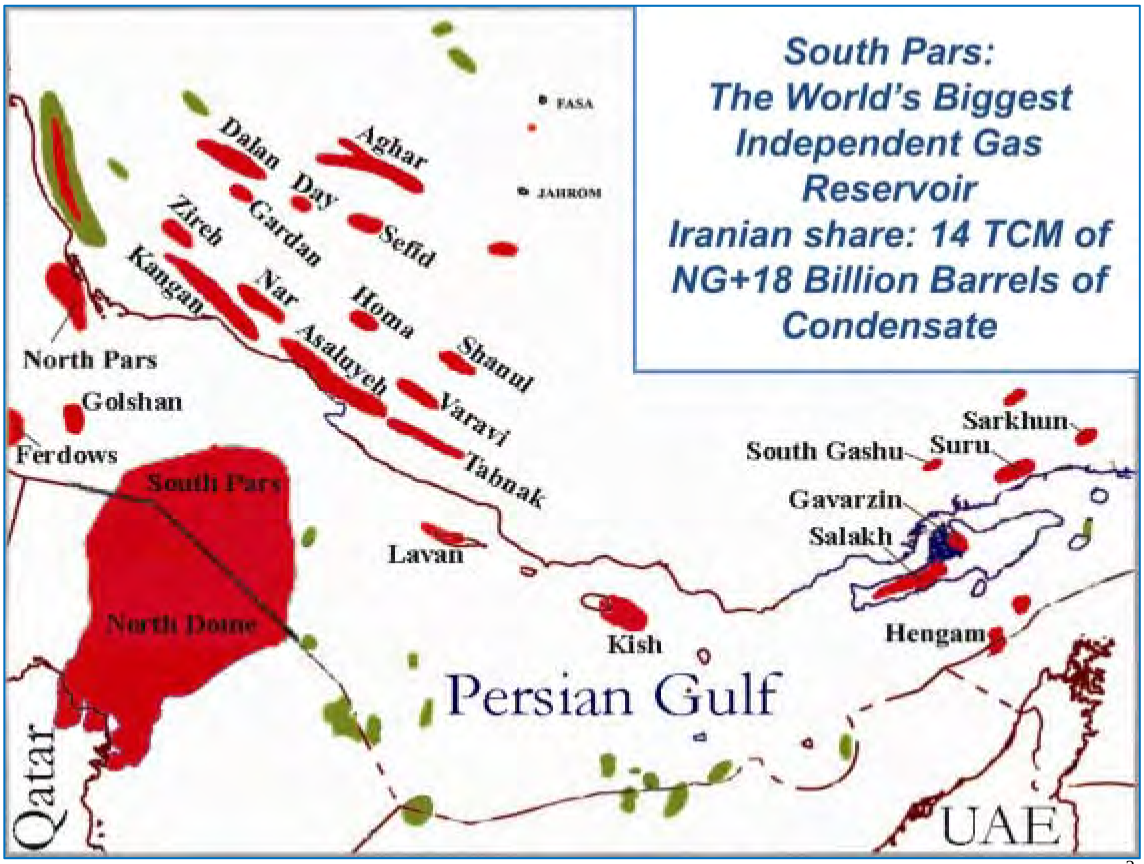
Source: BP Statistical Review of World Energy 2017

Fig. 4-6 Trend of Proven Reserves of Natural Gas in Iran

Although Iran is one of the world's leading countries in gas development, it does not export much natural gas. In 2016, annual natural gas exports by pipeline remained at 8.4 billion cubic meters. Even so, Iran is grabbing the whole world's attention as a new natural gas development country due to the high potential for natural gas development.

4.2 Gas Pipelines

In Iran, natural gas is supplied directly from refineries and gas storage facilities to places of consumption throughout the country through gas pipelines. Gas fields in and around the Persian Gulf are the major production area of natural gas, which is supplied throughout Iran through gas pipelines. Fig.4-7 shows major gas fields in and around the Persian Gulf. Among these gas fields, the South Pars Gas Field is the largest. Reference materials distributed in a workshop organized by the International Gas Union (IGU) state that the South Pars Gas Field is the world's largest gas field.



Source: Reference materials distributed in the IGU Executive Committee Workshop[2]

Fig. 4-7 Major Gas Fields (in red) and Oil Field (in green) in and around the Persian Gulf

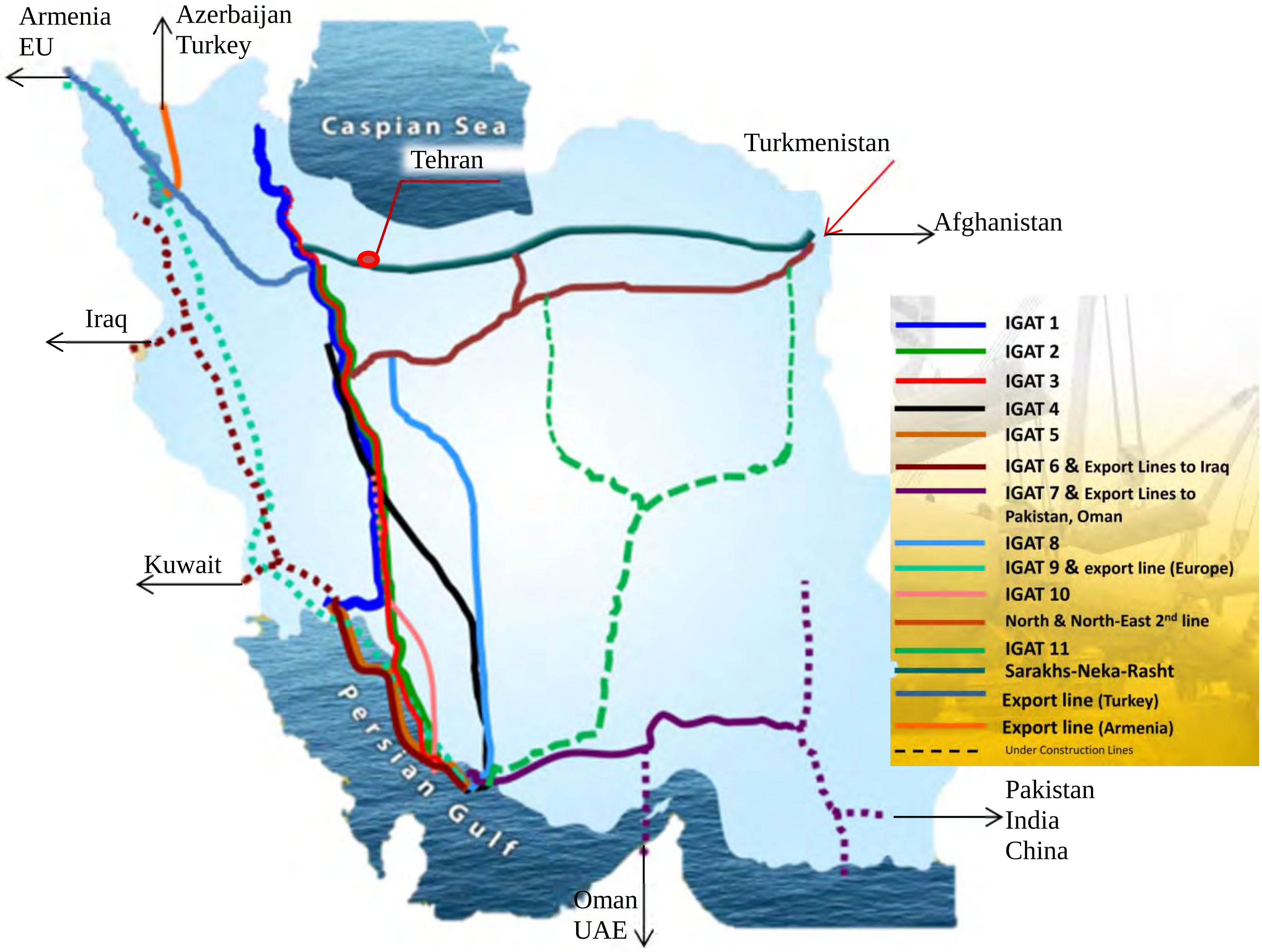
Gas pipelines in Iran are classified by supply area into ten large groups. Subsidiaries of the Iranian Gas Transmission Company manage gas distribution in their respective service areas. The major gas pipelines called Iran Gas Trunklines (IGATs) are literally the trunks of the gas pipeline network and gas is distributed from the trunk lines to the entire country. Some IGATs are used for exporting natural gas.

[2] A workshop held on 30th March 2017 organized by IGU
Session 2 ; Regional gas industry issues and opportunities – The Future of Gas in the Middle East
Natural Gas Industry in I.R.IRAN – Past, Present, Future ; H.E. Amir Hossein Zamaninia, Deputy Petroleum Minister in International Affairs & Trading (Iran)
http://www.igu.org/news/igu-executive-committee-workshop

Table 4-1 IGATs: Outline of Iran Gas Trunklines

IGAT Number	Total length (km)	Pipe diameter (inch)	Description
I	1103	42	From Bid-Boland Refinery in Khūzestān Province to Astara County
II	1039	56	From Kangan Refinery in Fars Province to Qazvin Province
III	1267	56	From Asalouyeh County to central and northwestern Iran
IV	1145	56	From Asalouyeh County to Fars and Isfahan Provinces
V	504	56	Used for gas injection in oil fields in Khūzestān Province
VI	610	56	Used for gas distribution from Asalouyeh County to Khūzestān Province and export to countries west of Iran
VII	902	56	From Asalouyeh County to Hormuzgān, Sistan-Baluchestan and Kermān Provinces
VIII	1050	56	From Asalouyeh County to Fars, Isfahan and Qom Provinces
IX	1863	56	From Asalouyeh County through Khūzestān and Ilam Province and Kurdistan and Iranian Azerbaijan Regions to the border with Turkey
X	632	56	A trunk line to reinforce gas distribution to central Iran
XI	1200	56	From Asalouyeh County to Bushehr, Fars, Yazd, Isfahan and Semnan Provinces and the Tehran-Mashhad Pipeline

Source : 2017 IGU Executive Committee Workshop (2017)



Source: Reference materials distributed in the IGU Executive Committee Workshop in 2017, Figure prepared by the Study Team

Fig. 4-8 Outline of Existing and Planned IGATs in Iran

4.3 The Existing Fuel Facilities of Shahid Rajaee Power Station

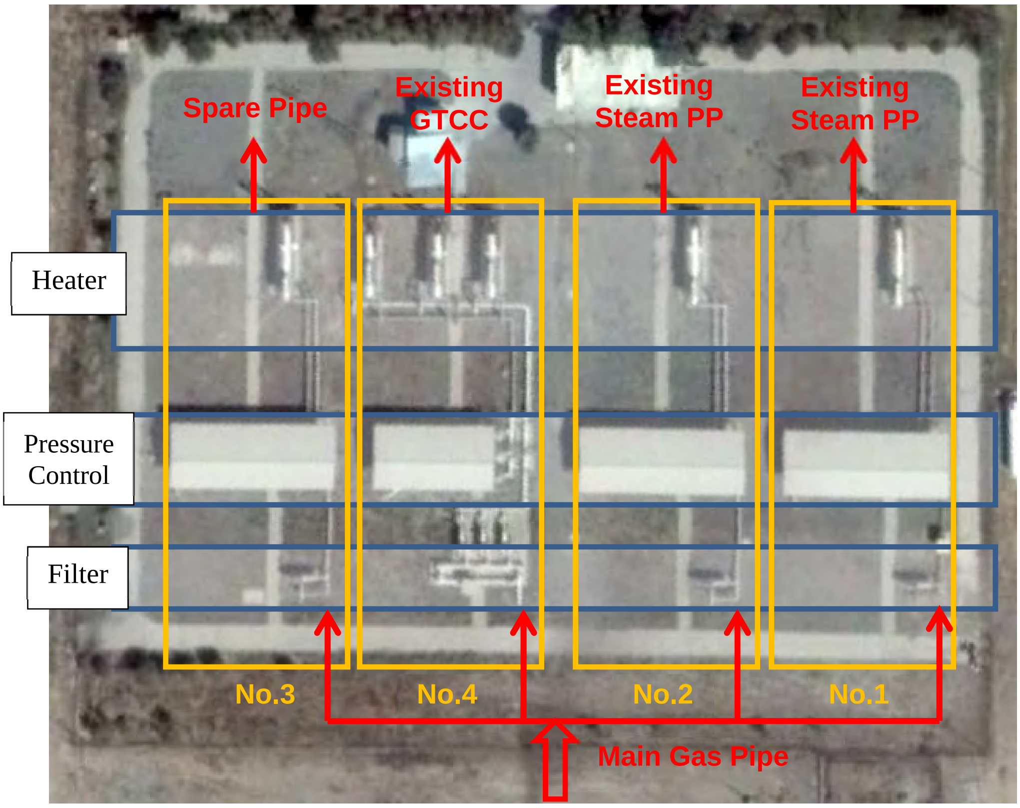
4.3.1 Gas Facilities

The existing gas facilities are located to the south-east from the existing GTCC. The location of gas facilities in the site is shown in Fig.4-9. The gas facilities are managed by Qazvin province Gas Company which is a subsidiary company of NIGC under the control of MoP. Although TPPH and Shahid Rajaee Power Station do not manage the facilities, they are dedicated gas supply facilities for Shahid Rajaee Power Station.

Source: created by JICA study team utilizing Google Earth

Fig. 4-9 The Location of Gas Facilities

In the gas facilities, there are treatment facilities as indicated in Fig.4-10, that carry out heating, pressure reducing, and filtering. There are four lines, No.1 and No.2 belong to the existing steam PP, and No.4 belongs to the existing GTCC. Line No.3 of four lines is a spare line, and it is not used currently. The condition of each gas is shown in Table 4-2. The spare line is installed in parallel to No.1 and No.2 lines, and it is closed by a blind flange in the existing steam PP.



Source: created by JICA study team utilizing Google Earth

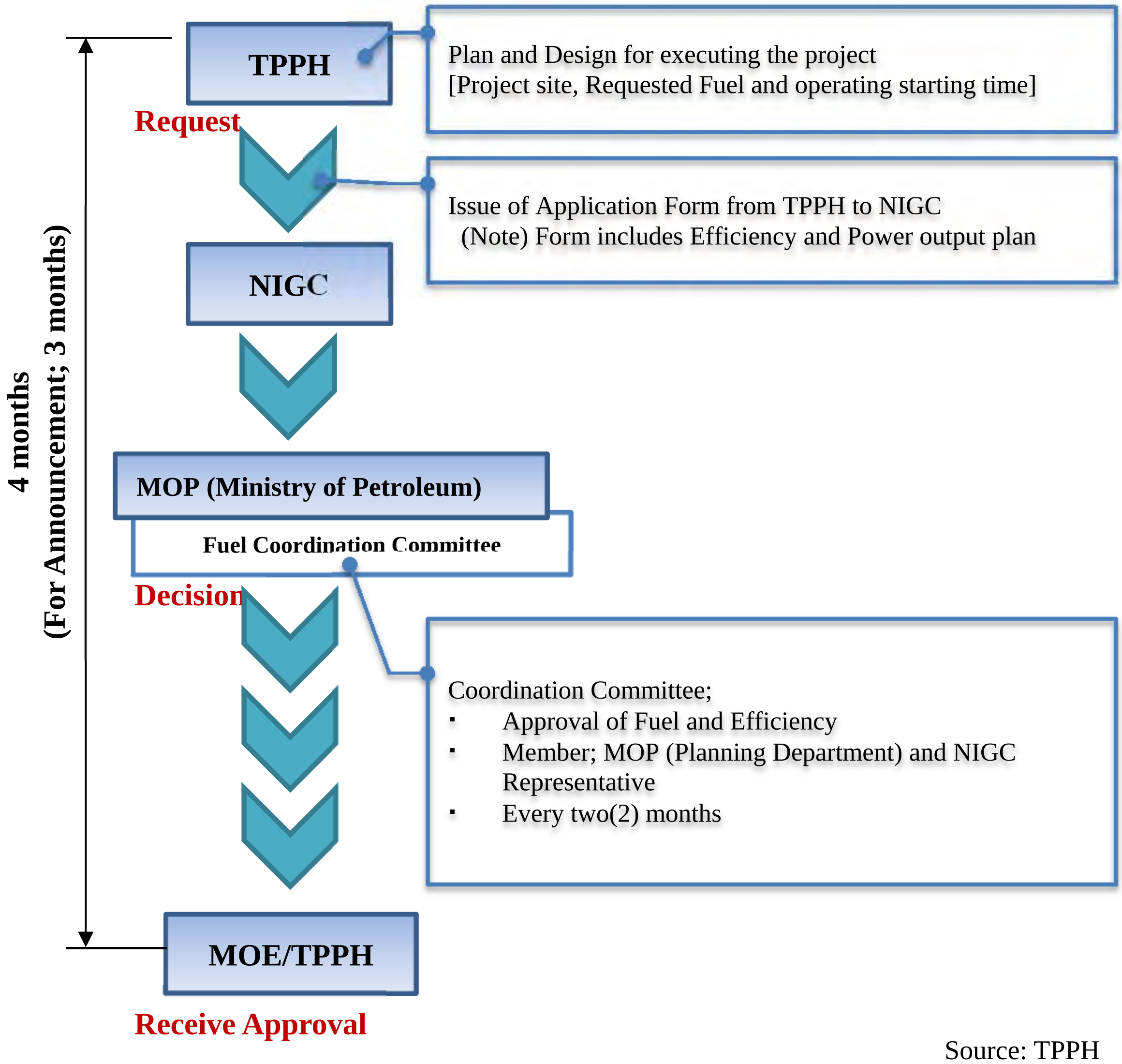
Fig. 4-10 Layout of the Existing Gas Facilities

Table 4-2 Gas Condition in the Existing Gas Facilities

	Before NIGC Metering Station		After NIGC Metering Station	
	Pressure (psi)	**Temperature (C)**	**Pressure (psi)**	**Temperature (C)**
Minimum	400	Ambient Temperature	250±5%	15±5
Maximum	700	Ambient Temperature	250±5%	15±5
Average	550	Ambient Temperature	250	15

Source：TPPH

These gas supplies are decided by the application which indicates gas supply conditions and is requested from TPPH to the province gas company. According to TPPH, the generating company applies to the gas company to supply the quantity of gas necessary for generation, and the gas company supplies the gas in accordance with the application. Even if the gas supply capacity or ability is not enough with the existing facilities, the province gas company extends the gas facility at the gas company's responsibility. According to TPPH, the flow of fuel supply application is shown in below.



Source: TPPH

Fig. 4-11 Flow of Application for Fuel Supply

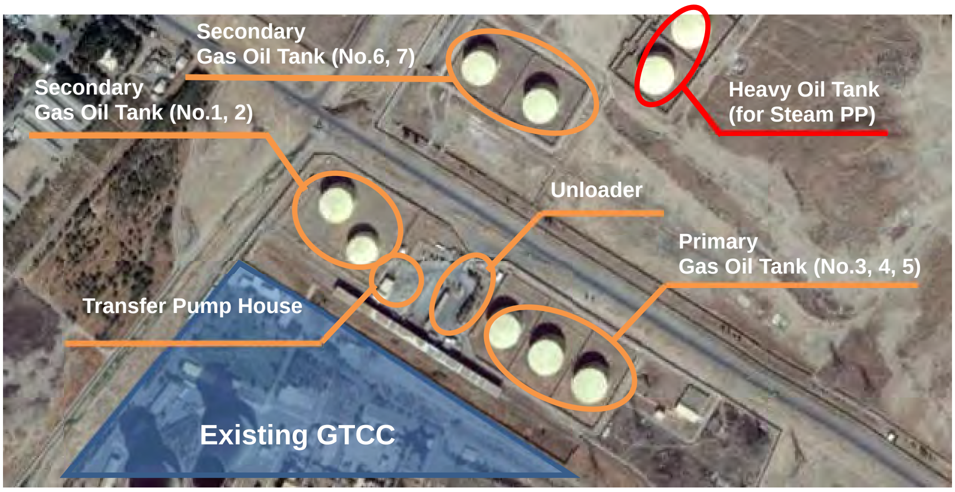
First, TPPH will plan and design for executing project. On the planning, the project site, the amount of requested fuel, and commercial operating date are usually focused. Then, TPPH will issue the application document to NIGC as formal application. In the application, the efficiency, the power output, the technology which is H or J class gas turbine combined cycle power plant in case of this project will be written as addition on above executing plan.

MOP is holding the fuel coordination committee once in 2 months. The committee judges whether it is an efficient project deserving fuel supply and decides whether to supply fuel. The planning department of MOP and the representative of NIGC will attend the committee. The results of the committee will be announced to MOE and TPPH within 3 months from the application. As a result of the committee, if fuel supply is available, it will be approved in about 1 month after the announcement.

4.3.2 Gas Oil Facilities

The existing gas oil facilities are located to north-east of the existing GTCC. The gas oil is supplied by truck and pipeline. First, the gas oil is stored in the primary gas oil tank. Then the gas oil is transferred to the secondary gas oil tank by an oil pump.

The storage capacity of teach primary tank in the existing gas oil facilities is 20,000 m^3. In the case of secondary gas oil tanks, there is one 20,000 m^3 capacity tank and three 30,000 m^3 capacity tanks in the gas oil facility area. According to TPPH, the power station should have a back-up fuel storage facility that can store back-up fuel for 5 days (depending on the facility).



Source: created by JICA study team utilizing Google Earth

Fig. 4-12 Layout of the Existing Gas Oil Facilities

4.3.3 Status of Fuel Use in Shahid Rajaee Power Station

According to BP Statistical Review of World Energy 2017, the amount of natural gas imported by pipeline is 7.4 billion cubic meters (from Azerbaijan and Turkmenistan) due to the gas shortage because of the demand for heating in the winter season. Therefore, in Shahid Rajaee Power Station, gas oil is used instead of natural gas in the winter season. The annual usage of gas oil in 2016 was approximately 200,000 tons/year for the existing GTCC at Shahid Rajaee Power Station.

Table 4-3 The Annual Usage of Gas Oil from 2012 to 2016 (the Existing GTCC)

Unit No.			2012	2013	2014	2015	2016
1	GT1	Gas	167	124	137	172	180
		Oil	53,210	73,253	50,275	50,902	29,123
	GT2	Gas	164	140	133	190	189
		Oil	78,742	79,200	35,039	36,298	38,293
2	GT1	Gas	154	137	136	159	189
		Oil	37,295	71,845	76,353	27,375	31,972
	GT2	Gas	148	89	182	212	167
		Oil	64,486	26,325	41,513	28,375	32,569
3	GT1	Gas	145	125	130	180	175
		Oil	53,115	87,875	26,080	32,613	27,224
	GT2	Gas	153	139	148	171	193
		Oil	55,815	75,234	76,789	23,468	40,530

Gas: Million cubic meters, Oil: tons

Source: created by JICA study team

Chapter 5 Power System Analysis and Grid Connection Plan

5.1 Basic concept and calculation conditions of power system analysis

5.1.1 Objectives

To define the technical requirements for connecting the Shahid Rajaee thermal power plant (640 MW×2) to the existing 400 kV power system, and to carry out a power system analysis calculation of the situations of the network system based on these requirements. In addition to confirm that operation of facilities and power system can continue in stable operation. (Refer to MONENCO's Final (3rd) report) (Note)

(Note) This power system analysis was performed by MONENCO with JICA Study Team. Title of MONENCO's Final (3rd) report is "Power System Analysis for Preparatory Survey on Shahid Rajaee Power Plant Construction PROJECT, COMPLEMENTARY Studies, by MONENCO (May 2018)".

Specifically to carry out power flow calculation, fault current calculation, and transient stability simulation for interconnection of the Shahid Rajaee thermal power plant to the existing power system.

5.1.2 Power Flow Analysis

To confirm the power flow of the transmission line and the transformer, voltage of each bus at peak and Light demand power system.

(1) Power flow

【N-0 Criterion】 (Normal Condition)	To confirm that the network current is within the rated capacity in each of the facilities when the operation of all the facilities is normal. ・Transmission line：Within the rated capacity 100% ・Transformer：Within the rated capacity 100%
【N-1 Criterion】 (A single fault condition)	When a fault occurs in a single facility, to confirm that the current in the rest of the facilities which are in normal operation is within the rated capacity. ・Transmission line：Within the rated capacity 100% ・Transformer：Within the rated capacity 110%

(2) Voltage

【N-0 Criterion】 (Normal Condition)	To confirm that each bus voltage is kept within the allowable voltage range ・Bus voltage：Within 0.95～1.05[P.U.]
【N-1 Criterion】 (A single fault condition)	To confirm that each bus voltage is kept within the allowable voltage range ・Bus voltage：Within 0.90～1.05[P.U.]

5.1.3 Fault Current Analysis

To confirm that each fault current is within short circuit breaking capacity of the circuit breaker.
・Short circuit breaking capacity of the 400kV circuit breaker:50kA

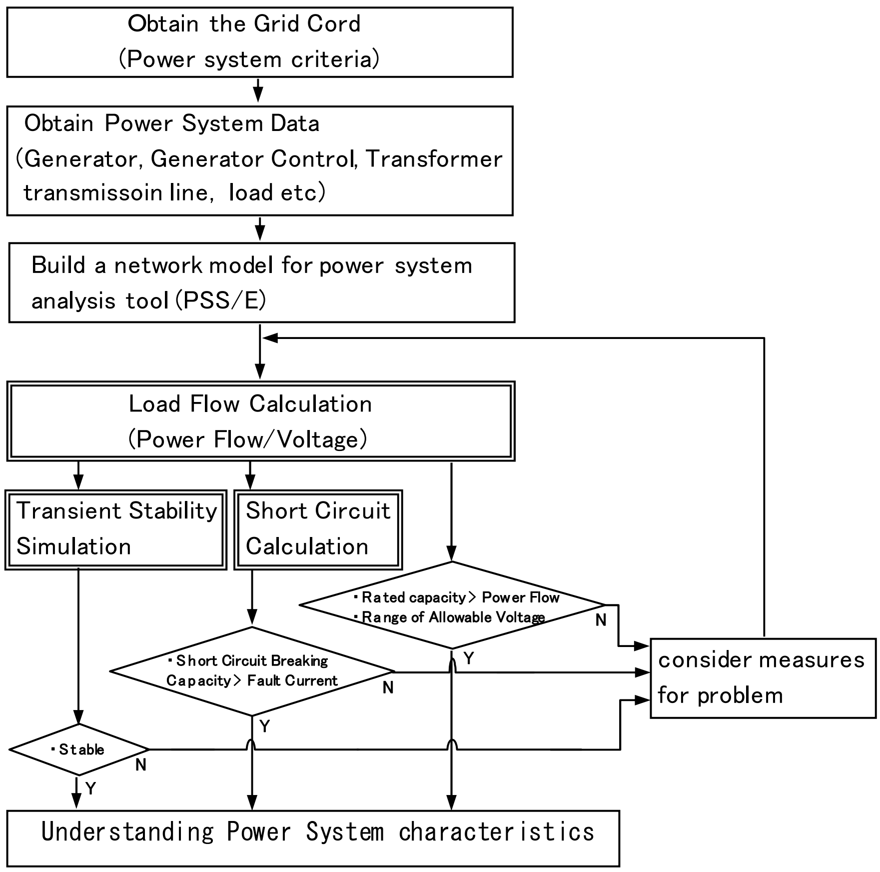
5.1.4 Steady state stability/Transient stability Analysis

To confirm that the Steady state stability/Transient stability of the Iranian power system is stable when a fault occurs in a single facility around the Shahid Rajaee area.

5.1.5 System Frequency Analysis

To confirm that the system frequency must not fall below 49.5Hz when it is occur the outage of one generator.

5.1.6 Work Flow of Power System Analysis

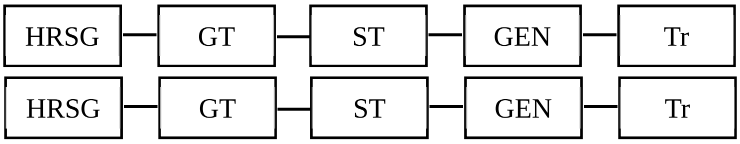


Source: prepared by JICA Study Team

Fig 5-1 Work Flow of Power System Analysis

5.1.7 New Generator Specification

(1)New Generator Configuration：640MW×2unit（1 on 1）

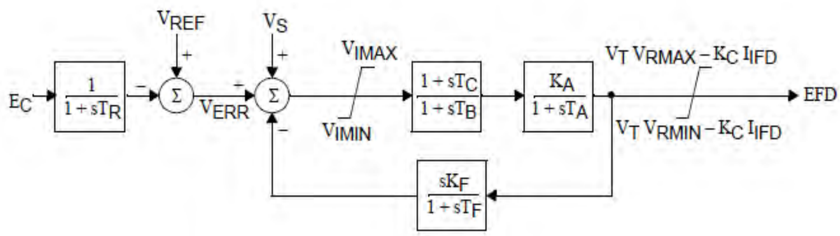


HRSG：Heat Recovery Steam Generator
GT：Gas Turbine
ST：Steam Turbine
GEN：Generator
Tr：Transformer

Source: prepared by JICA Study Team

Fig 5-2 New Generator Configuration

(2)AVR Model

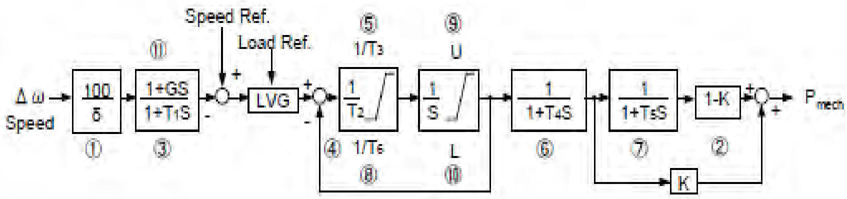


Ec：Generator Terminal Voltage
Vref：Voltage reference
Kn：Gain
Tn：Time constant
IIFD：Field current
EFD：Field Voltsge

Source: prepared by JICA Study Team

Fig 5-3 New Generator AVR Model

(3)Governor Model



△ω：Rotation Speed
δ：Speed Droop
K：Gas turbine power fraction
Tn：Time constant
Pmech：Machine output command

Source: prepared by JICA Study Team

Fig 5-4 New Generator Governor Model

5.1.8 Power System Modeling

Power system modeling is as follows.

(1) System configuration in：2024

(2) Demand level

・Peak(Peak Load)：78068MW

・Light(Light Load)：37622MW

(3) Output of new generator

・Peak (summer): 530MW

・Light (winter): 640MW

(4) Power station site location

・A point: North side of existing switchgear

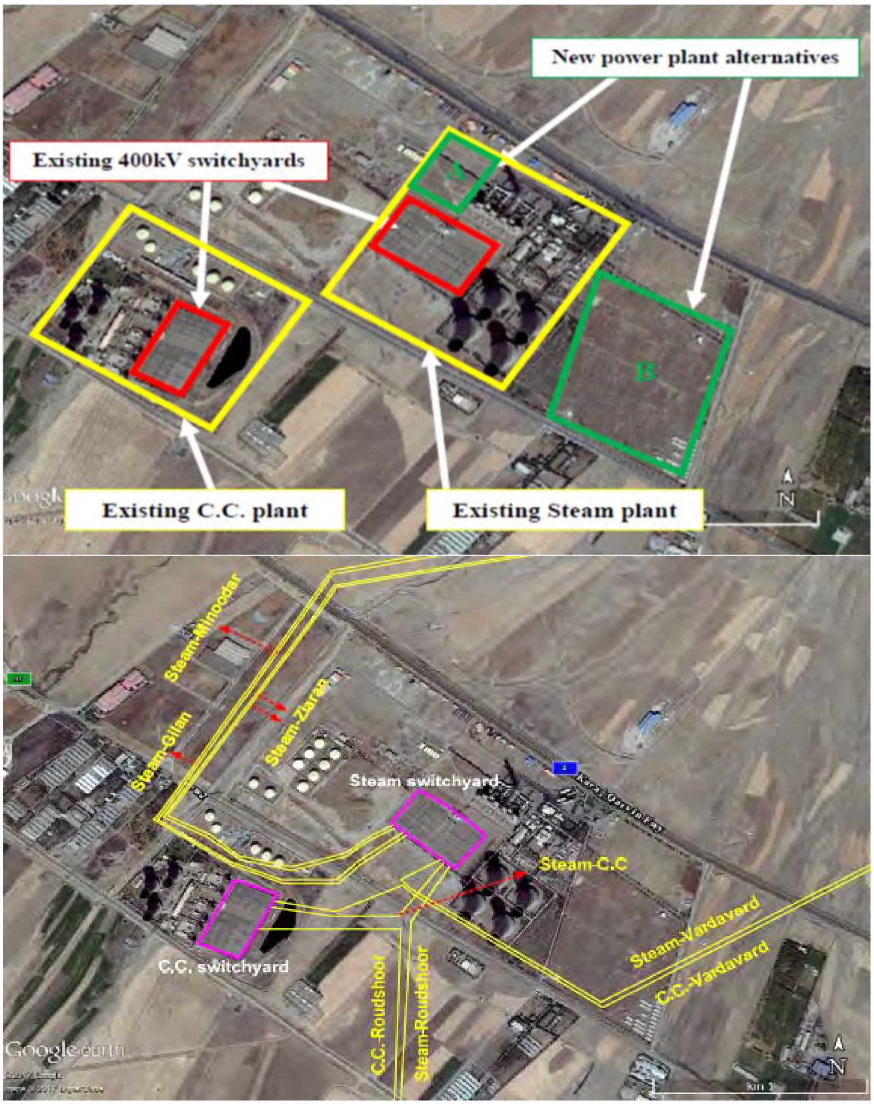
・B point: East side of existing power station

5.2 Result of Power system analysis on 2cct and π connection

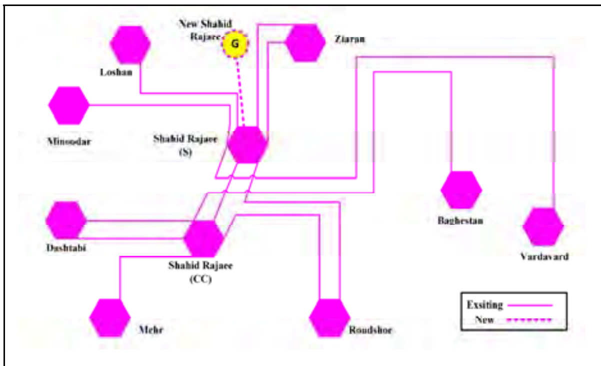
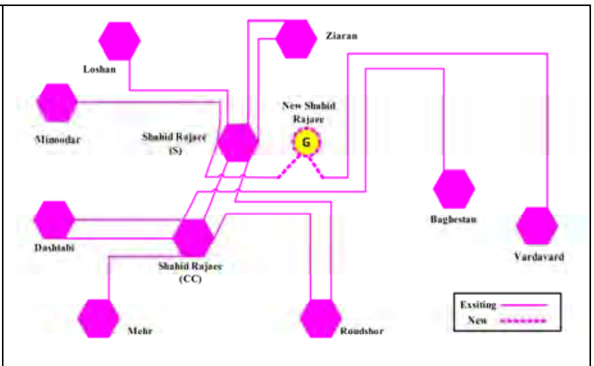
(1) System connection method of new generator

・It draws it in to the existing Rajaee power station 400kV switch gear twice in the line.

・The switch gear is newly established, and the ation 400kV switch gear twice in the line 400kV one line



Source: Obtained from Google Earth, and prepared by JICA Study Team

	
New power plant connection to 400kV existing steam substation through two-circuit 400kV transmission line	New power plant connection to 400kV Rajaee steam-Vardavard transmission line

Source: prepared by JICA Study Team

Fig 5-5 Shahid Rajaee new plant connection scenario and location

5.2.1 Case Scenario（2cct and π connection）

To confirm the power flow of the transmission line and the transformer, voltage of each bus at peak and Light demand power system. Case Scenario of Calculation is as follows.

Table 5-1 Case Scenario of Calculation

Location	Case	Shahid Rajaee new power plant connection scenario and location
A	A-1	New power plant connection to 400kV existing steam substation through two-circuit 400kV transmission line
	A-2	New power plant connection to 400kV Rajaee steam-Vardavard transmission line
	A-3	New power plant connection to 400kV Rajaee combined cycle - Baghestan transmission line
	A-4	New power plant connection to 400kV Rajaee steam-Ziaran transmission line
	A-5	New power plant connection to 400kV Rajaee steam-Roudshoor transmission line
B	B-1	New power plant connection to 400kV existing steam substation through two-circuit 400kV transmission line
	B-2	New power plant connection to 400kV Rajaee steam-Vardavard transmission line
	B-3	New power plant connection to 400kV Rajaee combined cycle - Baghestan transmission line
	B-4	New power plant connection to 400kV Rajaee combined cycle - Roudshoor transmission line

Source: prepared by JICA Study Team

5.2.2 Result of pre calculation（2cct and π connection）

(1)Result of Power Flow Calculation
In case scenario A-1-B-4, it was confirmed that the case with both【 N-0 criteria 】and【 N-1 criteria 】 the current and the voltage pre and post new generator system interconnection was the tolerances or less.

(2)Result of Three-phase short circuit current
The Fault current of the three-phase short circuit exceeds 50 kA pre and post new generator interconnection.

Table 5-2 Three-phase short circuit current(Pre and post new generator interconnection)
【New power plant connection to 400kV existing steam substation through two-circuit 400kV transmission line】

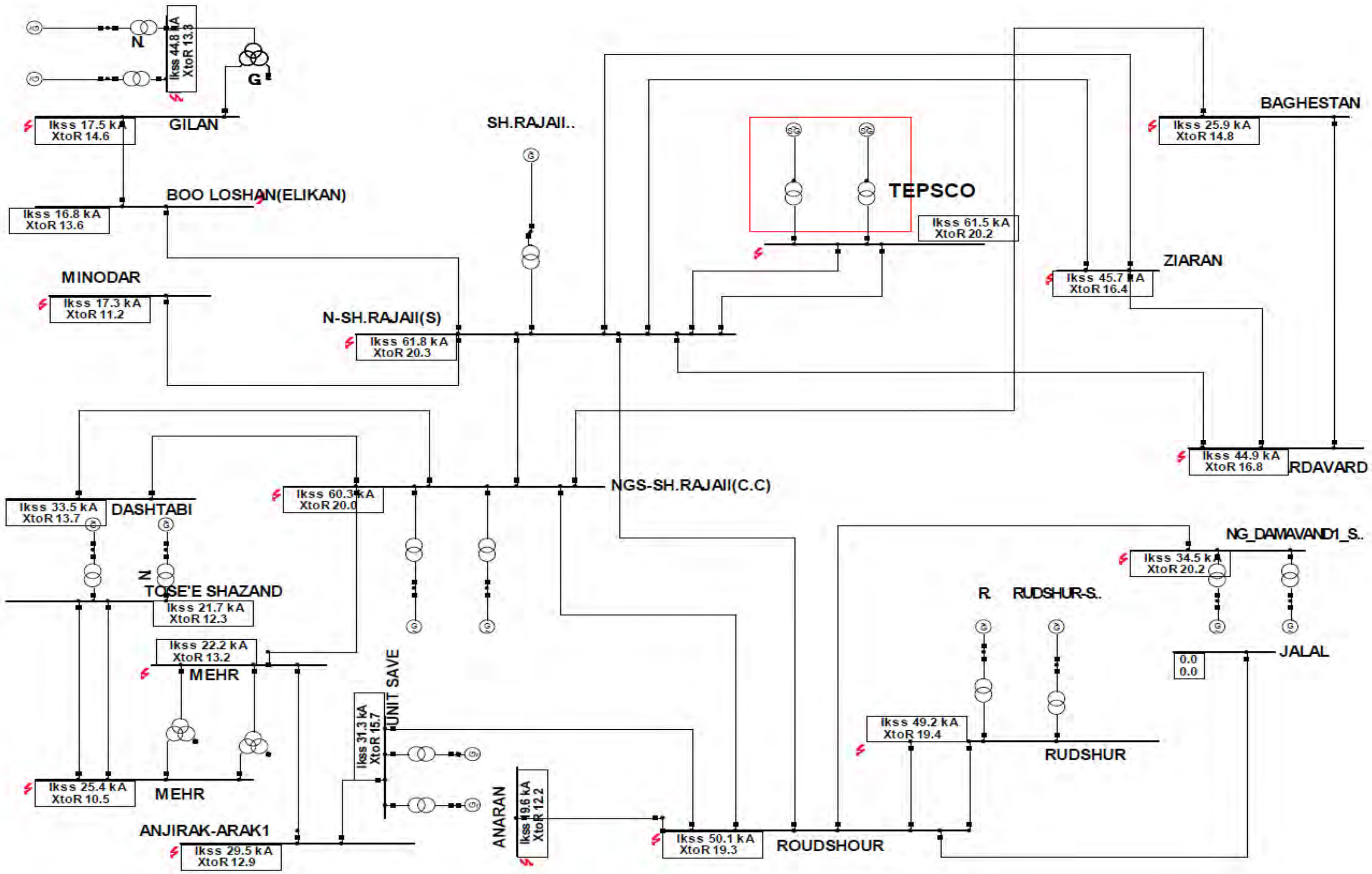
Substation Name	Voltage (kV)	Pre-connection		Post-connection	
		Ikss (kA)	X/R	Ikss (kA)	X/R
ANARAN	400	19.5	12.2	19.6	12.2
ANJIRAK-ARAK	400	29.5	12.9	29.5	12.9
BAGHESTAN	400	25.4	14.7	25.9	14.8
BOO	400	16.7	13.7	16.8	13.6
DASHTABI	400	31.9	13.5	33.5	13.7
GILAN	400	17.4	14.6	17.5	14.6
JALAL	400	38.1	19.1	38.2	19
MEHR	400	22.2	13.2	25.4	10.5
MEHR	230	25.4	10.5	22.2	13.2
MINODAR	400	17.0	11.2	17.3	11.2
N-SH.RAJAII(S)	400	55.9	18.7	61.8	20.3
NGS-SH.RAJAII(C.C)	400	55.0	18.7	60.3	20
NGS_GILAN	230	44.7	13.4	44.8	13.3
NG_DAMAVAND	400	34.3	20.3	34.5	20.2
ROUDSHOUR	400	49.5	19.3	50.1	19.3
RUDSHUR	400	48.6	19.4	49.2	19.4
NEW P/S	400	-	-	61.5	20.2
TOSE'E SHAZAND	230	21.7	12.3	21.7	12.3
UNIT SAVE	400	31.2	15.7	31.3	15.7
VARDAVARD	400	43.7	16.8	44.9	16.8
ZIARAN	400	43.2	16.0	45.7	16.4

Source: calculated by JICA Study Team

Table 5-3 Three-phase short circuit current (Pre and post new generator interconnection)
【New power plant connection to 400kV Rajaee steam-Vardavard transmission line】

Substation Name	Voltage (kV)	Pre-connection		Post-connection	
		Ikss (kA)	X/R	Ikss (kA)	X/R
ANARAN	400	19.5	12.2	19.6	12.2
ANJIRAK-ARAK	400	29.5	12.9	29.5	12.9
BAGHESTAN	400	25.4	14.7	25.9	14.8
BOO	400	16.7	13.7	16.8	13.6
DASHTABI	400	31.9	13.5	33.4	13.7
GILAN	400	17.4	14.6	17.5	14.6
JALAL	400	38.1	19.1	38.2	19.0
MEHR	400	22.2	13.2	22.2	13.2
MEHR	230	25.4	10.5	25.4	10.5
MINODAR	400	17.0	11.2	17.3	11.2
N-SH.RAJAII(S)	400	55.9	18.7	61.7	20.2
NGS-SH.RAJAII(C.C)	400	55.0	18.7	60.2	20.0
NGS_GILAN	230	44.7	13.4	44.8	13.3
NG_DAMAVAND	400	34.3	20.3	34.5	20.2
ROUDSHOUR	400	49.5	19.3	50.1	19.3
RUDSHUR	400	48.6	19.4	49.2	19.4
NEW P/S	400	-	-	56.6	19.6
TOSE'E SHAZAND	230	21.7	12.3	21.7	12.3
UNIT SAVE	400	31.2	15.7	31.3	15.7
VARDAVARD	400	43.7	16.8	44.9	16.8
ZIARAN	400	43.2	16.0	45.6	16.3

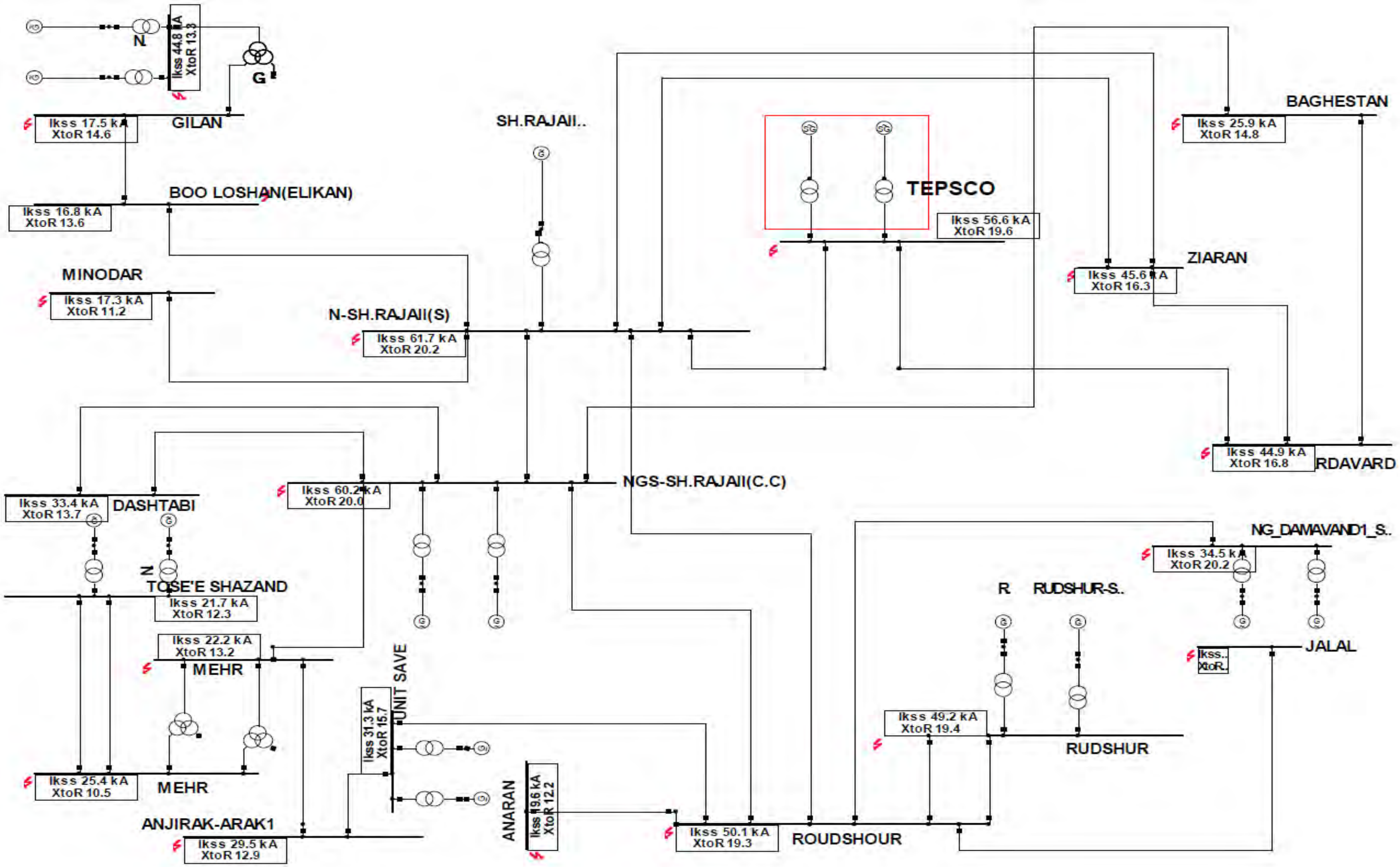
Source: calculated by JICA Study Team



Source: calculated by JICA Study Team

Fig 5-6 Three-phase short circuit current(Post new generator interconnection)

【New power plant connection to 400kV existing steam substation through two-circuit 400kV transmission line】



Source: calculated by JICA Study Team

Fig 5-7 Three-phase short circuit current(Post new generator interconnection)

【New power plant connection to 400kV Rajaee steam-Vardavard transmission line】

(3)Result of Single-phase short-circuit current

The Fault current of the Single-phase short-circuit exceeds 50 kA pre and post new generator interconnection.

Table 5-4 Single-phase short-circuit current (pre and post new generator interconnection)

【New power plant connection to 400kV existing steam substation through two-circuit 400kV transmission line】

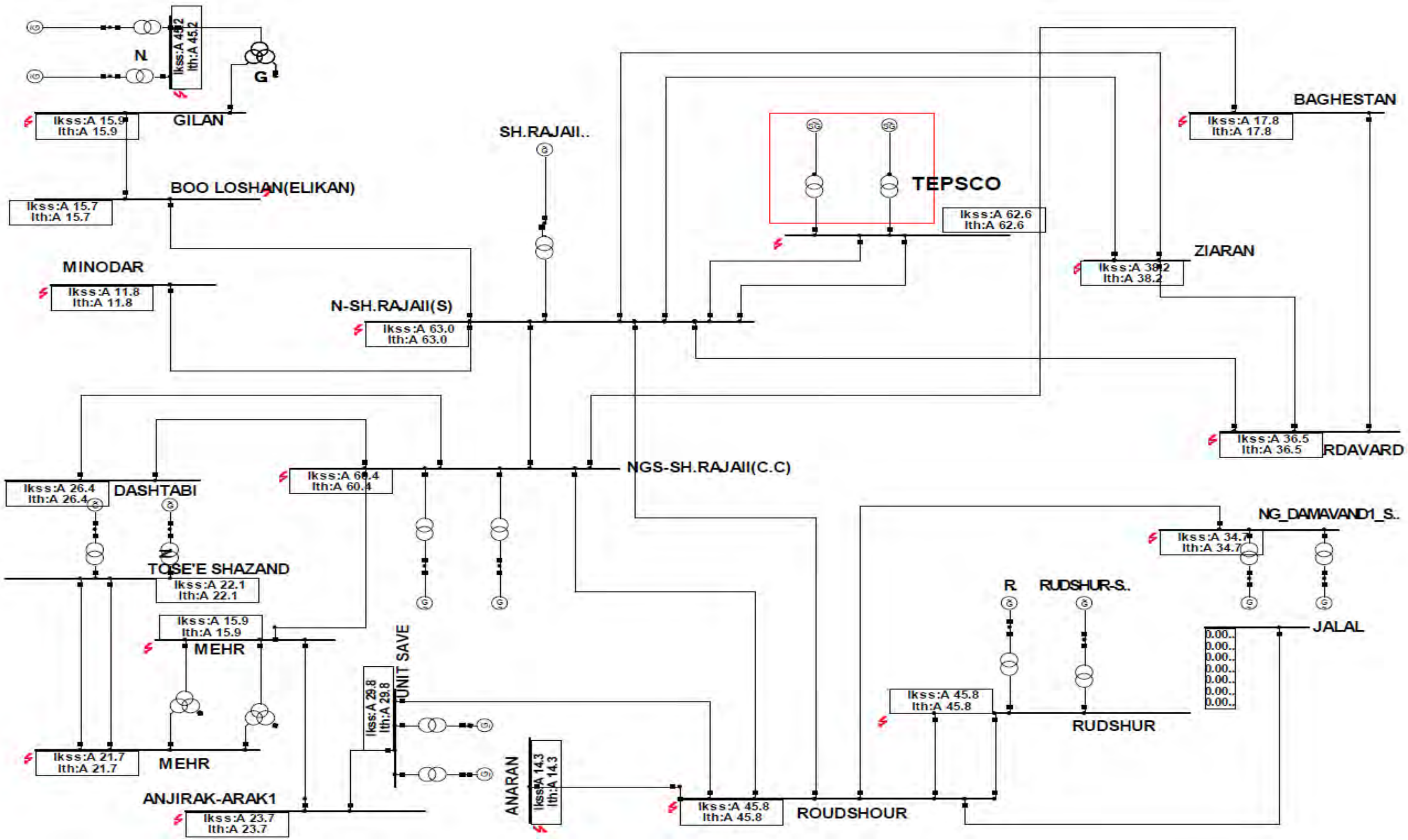
Substation Name	Voltage (kV)	Pre-connection		Post-connection	
		Ikss (kA)	X/R	Ikss (kA)	X/R
ANARAN	400	14.3	14.3	14.3	14.3
ANJIRAK-ARAK	400	23.7	23.7	23.7	23.7
BAGHESTAN	400	17.5	17.5	17.8	17.8
BOO	400	15.6	15.6	15.7	15.7
DASHTABI	400	25.1	25.1	26.4	26.4
GILAN	400	15.9	15.9	15.9	15.9
JALAL	400	37.7	37.7	37.7	*37.7*
MEHR	400	15.9	15.9	21.7	21.7
MEHR	230	21.7	21.7	15.9	15.9
MINODAR	400	11.6	11.6	11.8	11.8
N-SH.RAJAII(S)	400	54.2	54.2	63.0	63.0
NGS-SH.RAJAII(C.C)	400	53.1	53.1	60.4	60.4
NGS_GILAN	230	45.2	45.2	45.2	45.2
NG_DAMAVAND	400	34.5	34.5	34.7	34.7
ROUDSHOUR	400	45.4	45.4	45.8	45.8
RUDSHUR	400	45.4	45.4	45.8	45.8
NEW P/S	400	-	-	62.6	62.6
TOSE'E SHAZAND	230	22.1	22.1	22.1	22.1
UNIT SAVE	400	29.7	29.7	29.8	29.8
VARDAVARD	400	35.7	35.7	36.5	36.5
ZIARAN	400	36.1	36.1	38.2	38.2

Source: calculated by JICA Study Team

Table 5-5 Single-phase short-circuit current (pre and post new generator interconnection)
【New power plant connection to 400kV Rajaee steam-Vardavard transmission line】

Substation Name	Voltage (kV)	Pre-connection		Post-connection	
		Ikss (kA)	X/R	Ikss (kA)	X/R
ANARAN	400	14.3	14.3	14.3	14.3
ANJIRAK-ARAK	400	23.7	23.7	23.7	23.7
BAGHESTAN	400	17.5	17.5	17.8	17.8
BOO	400	15.6	15.6	15.7	15.7
DASHTABI	400	25.1	25.1	26.4	26.4
GILAN	400	15.9	15.9	15.9	15.9
JALAL	400	37.7	37.7	37.7	37.7
MEHR	400	15.9	15.9	15.9	15.9
MEHR	230	21.7	21.7	21.7	21.7
MINODAR	400	11.6	11.6	11.8	11.8
N-SH.RAJAII(S)	400	54.2	54.2	62.4	62.4
NGS-SH.RAJAII(C.C)	400	53.1	53.1	60.0	60.0
NGS_GILAN	230	45.2	45.2	45.2	45.2
NG_DAMAVAND	400	34.5	34.5	34.7	34.7
ROUDSHOUR	400	45.4	45.4	45.8	45.8
RUDSHUR	400	45.4	45.4	45.8	45.8
NEW P/S	400	-	-	55.8	55.8
TOSE'E SHAZAND	230	22.1	22.1	22.1	22.1
UNIT SAVE	400	29.7	29.7	29.8	29.8
VARDAVARD	400	35.7	35.7	36.5	36.5
ZIARAN	400	36.1	36.1	38.1	38.1

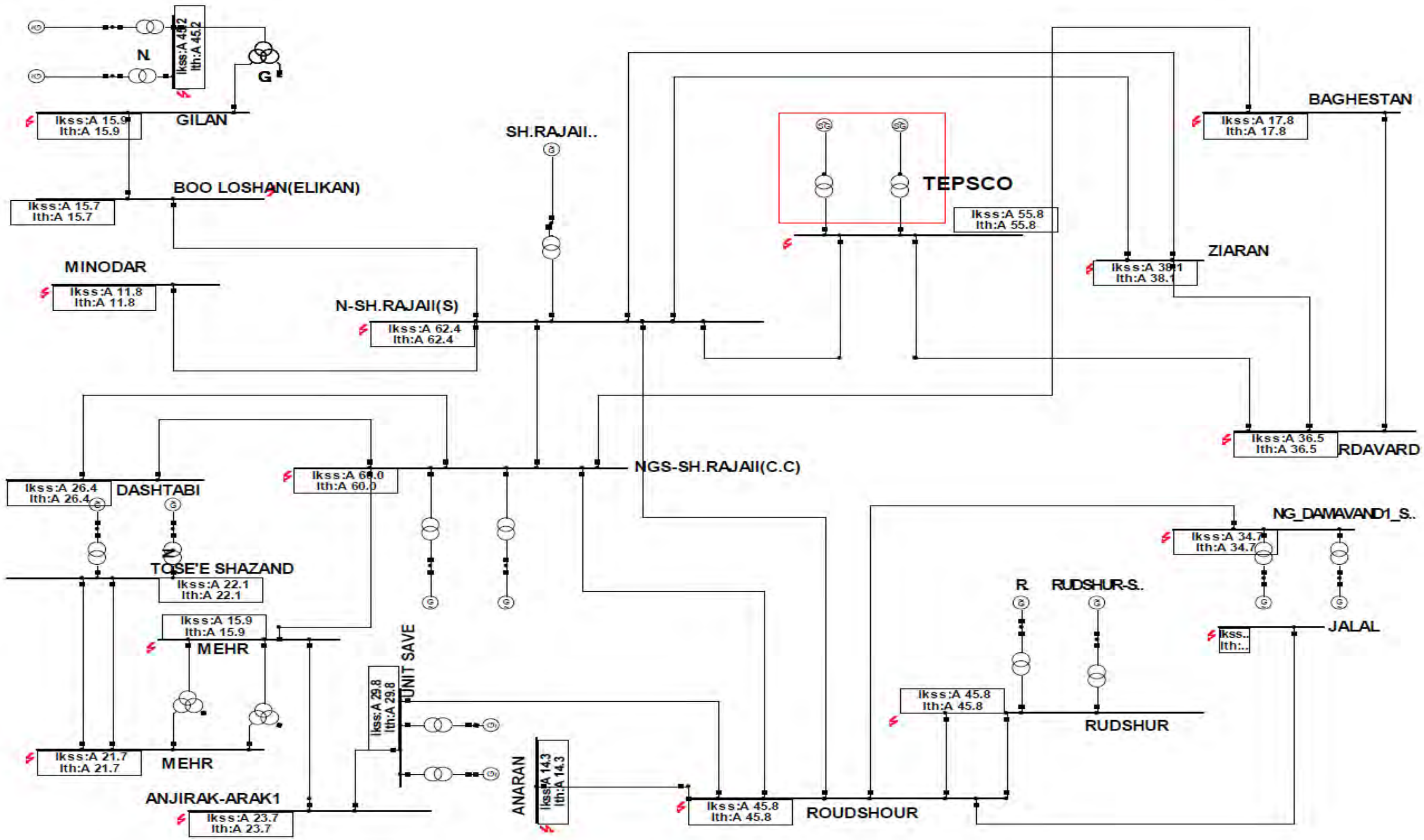
Source: calculated by JICA Study Team



Source: calculated by JICA Study Team

Fig 5-8 Single-phase short-circuit current(post new generator interconnection)

【New power plant connection to 400kV existing steam substation through two-circuit 400kV transmission line】



Source: calculated by JICA Study Team

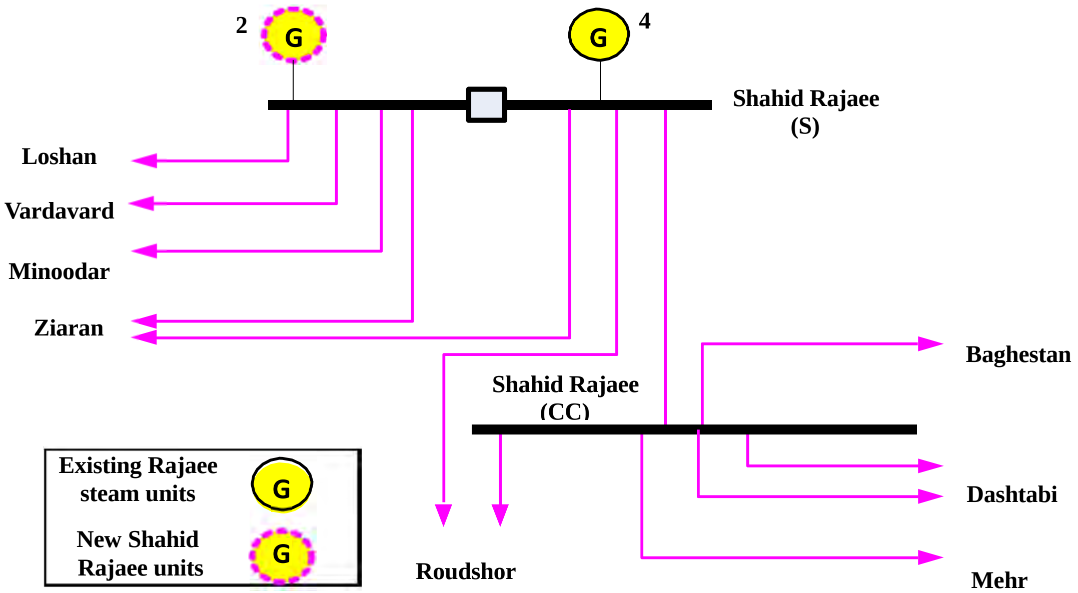
Fig 5-9 Single-phase short-circuit current(post new generator interconnection)

【New power plant connection to 400kV Rajaee steam-Vardavard transmission line】

5.2.3 Method of fault current reduction【Bus-splitting】（2cct and π connection）

In order to reduce the short circuit level, the bus splitting should be done in Shahid Rajaee Steam 400kV switchyard in such way that the amount of short circuit levels after bus-splitting are lower than the circuit breakers rated capacity.

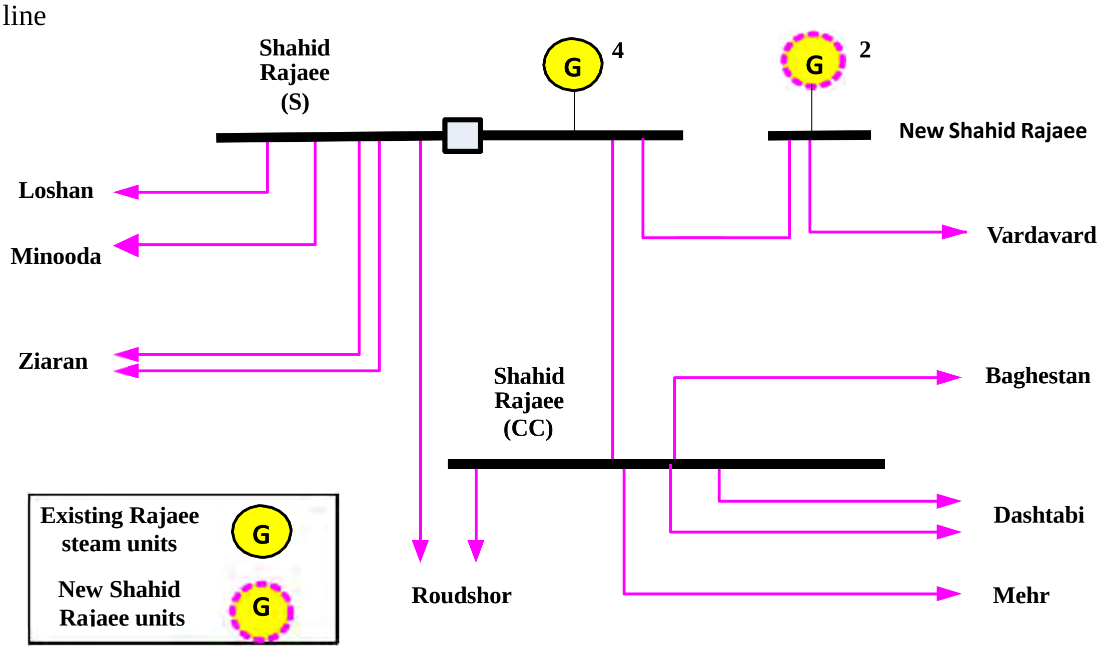
(1) Bus-splitting at new power plant connection to 400kV existing steam substation through two-circuit 400kV transmission line



Source: prepared by JICA Study Team

Fig 5-10 Bus-splitting in Rajaee steam substation for fault current reduction

(2) Bus-splitting at new power plant connection to 400kV Rajaee steam-Vardavard transmission line



Source: prepared by JICA Study Team

Fig 5-11 Bus-splitting in Rajaee steam substation for fault current reduction

(3) Three-phase short circuit current after bus-splitting

The three-phase short-circuit current is below 50 kA, after the bus splitting operation measures execution and system interconnection of new generators.

Table 5-6 Three-phase short circuit current (after the bus splitting operation measures execution)

【New power plant connection to 400kV existing steam substation through two-circuit 400kV transmission line】

Substation Name	Voltage (kV)	Pre-splitting		Post- splitting	
		Ikss (kA)	X/R	Ikss (kA)	X/R
ANARAN	400	19.6	12.2	19.5	12.2
ANJIRAK-ARAK	400	29.5	12.9	29.5	12.9
BAGHESTAN	400	25.9	14.8	25.9	14.8
BOO	400	16.8	13.6	15.9	14.1
DASHTABI	400	33.5	13.7	30.1	14.0
GILAN	400	17.5	14.6	17.2	14.9
JALAL	400	38.2	19	38.1	19.1
MEHR	400	25.4	10.5	22.2	13.2
MEHR	230	22.2	13.2	25.4	10.5
MINODAR	400	17.3	11.2	15.4	11.5
N-SH.RAJAII(S)-1	400	61.8	20.3	**49.5**	19.5
N-SH.RAJAII(S)-2	400	61.8	20.3	**35.8**	16.5
NGS-SH.RAJAII(C.C)	400	60.3	20	**49.3**	19.5
NGS_GILAN	230	44.8	13.3	44.6	13.4
NG_DAMAVAND	400	34.5	20.2	34.5	20.2
ROUDSHOUR	400	50.1	19.3	**49.5**	19.5
RUDSHUR	400	49.2	19.4	48.6	19.6
NEW P/S	400	61.5	20.2	**35.7**	16.5
TOSE'E SHAZAND	230	21.7	12.3	21.7	12.3
UNIT SAVE	400	31.3	15.7	31.2	15.7
VARDAVARD	400	44.9	16.8	44.7	16.8
ZIARAN	400	45.7	16.4	45.0	16.2

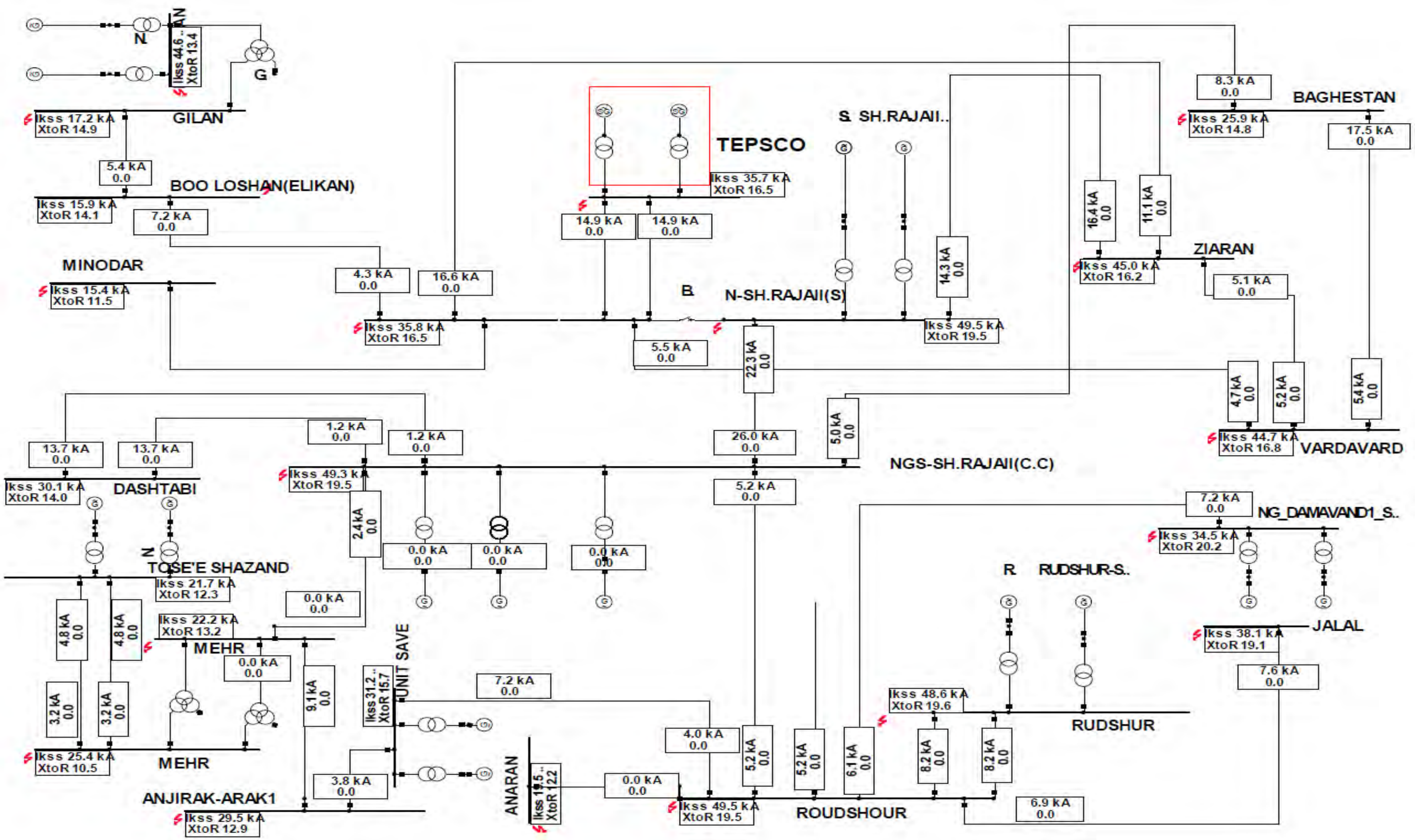
Source: calculated by JICA Study Team

Table 5-7 Three-phase short circuit current (after the bus splitting operation measures execution)

【New power plant connection to 400kV Rajaee steam-Vardavard transmission line】

Substation Name	Voltage (kV)	Pre-splitting		Post- splitting	
		Ikss (kA)	X/R	Ikss (kA)	X/R
ANARAN	400	19.6	12.2	19.6	12.1
ANJIRAK-ARAK	400	29.5	12.9	29.5	12.9
BAGHESTAN	400	25.9	14.8	25.8	14.9
BOO	400	16.8	13.6	15.5	14.0
DASHTABI	400	33.4	13.7	28.0	15.3
GILAN	400	17.5	14.6	17.1	14.9
JALAL	400	38.2	19.0	38.1	19.0
MEHR	400	22.2	13.2	22.2	13.2
MEHR	230	25.4	10.5	25.4	10.5
MINODAR	400	17.3	11.2	14.6	11.2
N-SH.RAJAII(S)-1	400	61.7	20.2	**43.0**	23.1
N-SH.RAJAII(S)-2	400	61.7	20.2	**29.8**	13.5
NGS-SH.RAJAII(C.C)	400	60.2	20.0	**43.3**	22.9
NGS_GILAN	230	44.8	13.3	44.4	13.4
NG_DAMAVAND	400	34.5	20.2	34.5	20.2
ROUDSHOUR	400	50.1	19.3	**49.9**	19.1
RUDSHUR	400	49.2	19.4	49.0	19.2
NEW P/S	400	56.6	19.6	**41.2**	22.5
TOSE'E SHAZAND	230	21.7	12.3	21.7	12.3
UNIT SAVE	400	31.3	15.7	31.3	15.6
VARDAVARD	400	44.9	16.8	44.7	16.6
ZIARAN	400	45.6	16.3	31.8	13.6

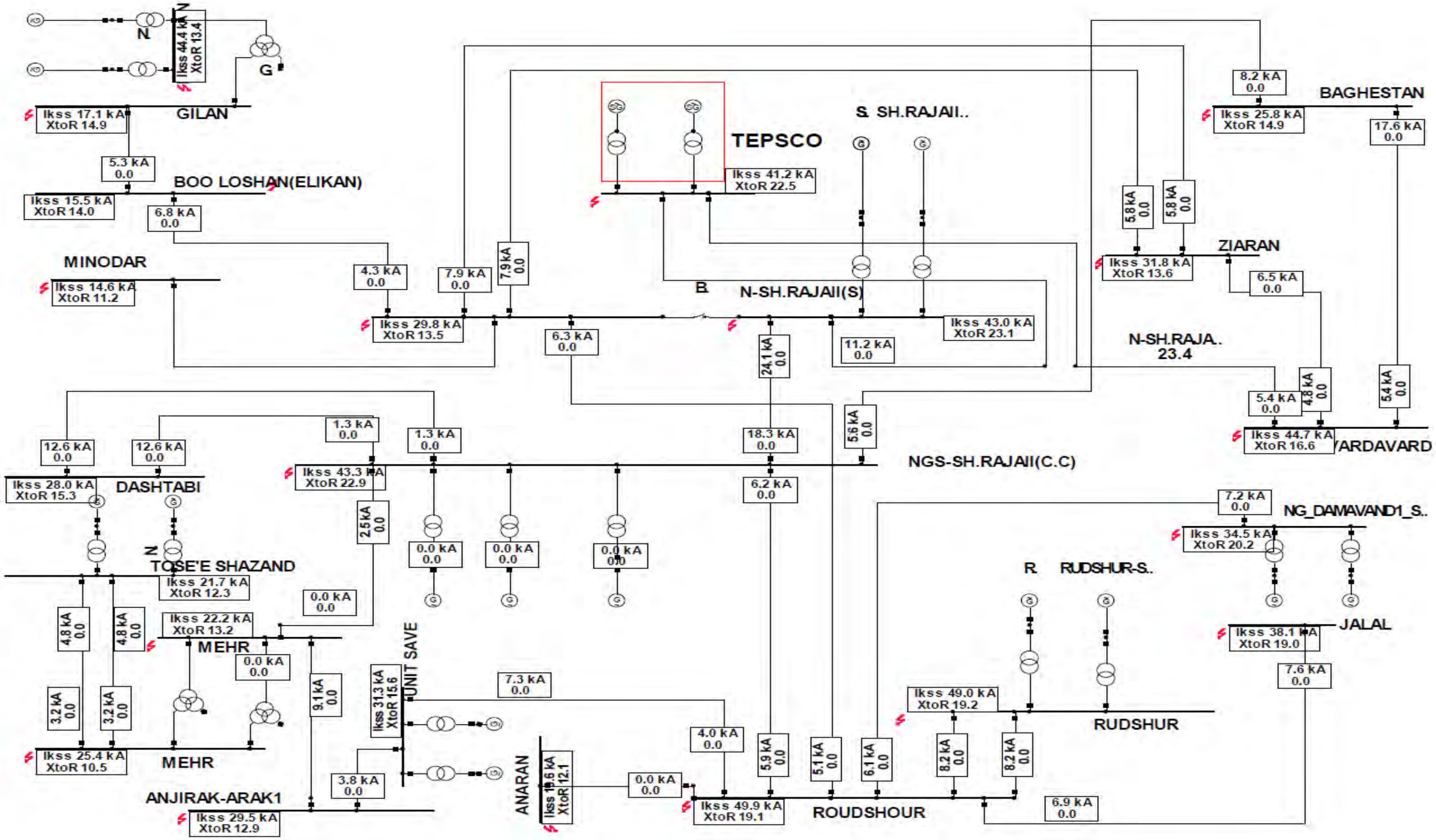
Source: calculated by JICA Study Team



Source: calculated by JICA Study Team

Fig 5-12 Three-phase short circuit current (after the bus splitting operation measures execution)

【New power plant connection to 400kV existing steam substation through two-circuit 400kV transmission line】



Source: calculated by JICA Study Team

Fig 5-13 Three-phase short circuit current (after the bus splitting operation measures execution)

【New power plant connection to 400kV Rajaee steam-Vardavard transmission line】

(4) Single-phase short-circuit current after bus-splitting

The Single-phase short-circuit current is below 50 kA, after the bus splitting operation measures execution and system interconnection of new generators.

Table 5-8 Single-phase short-circuit current(after the bus splitting operation measures execution)

【New power plant connection to 400kV existing steam substation through two-circuit 400kV transmission line】

Substation Name	Voltage (kV)	Pre-splitting		Post- splitting	
		Ikss (kA)	X/R	Ikss (kA)	X/R
ANARAN	400	14.3	14.3	14.3	14.3
ANJIRAK-ARAK	400	23.7	23.7	23.7	23.7
BAGHESTAN	400	17.8	17.8	17.8	17.8
BOO	400	15.7	15.7	15.1	15.1
DASHTABI	400	26.4	26.4	24.1	24.1
GILAN	400	15.9	15.9	15.8	15.8
JALAL	400	37.7	37.7	37.7	37.7
MEHR	400	21.7	21.7	15.8	15.8
MEHR	230	15.9	15.9	21.7	21.7
MINODAR	400	11.8	11.8	10.7	10.7
N-SH.RAJAII(S)-1	400	63.0	63.0	**48.2**	48.2
N-SH.RAJAII(S)-2	400	63.0	63.0	**33.5**	33.5
NGS-SH.RAJAII(C.C)	400	60.4	60.4	**48.0**	48.0
NGS_GILAN	230	45.2	45.2	45.1	45.1
NG_DAMAVAND	400	34.7	34.7	34.7	34.7
ROUDSHOUR	400	45.8	45.8	45.3	45.3
RUDSHUR	400	45.8	45.8	45.4	45.4
NEW P/S	400	62.6	62.6	**33.5**	33.5
TOSE'E SHAZAND	230	22.1	22.1	22.1	22.1
UNIT SAVE	400	29.8	29.8	29.7	29.7
VARDAVARD	400	36.5	36.5	36.3	36.3
ZIARAN	400	38.2	38.2	37.7	37.7

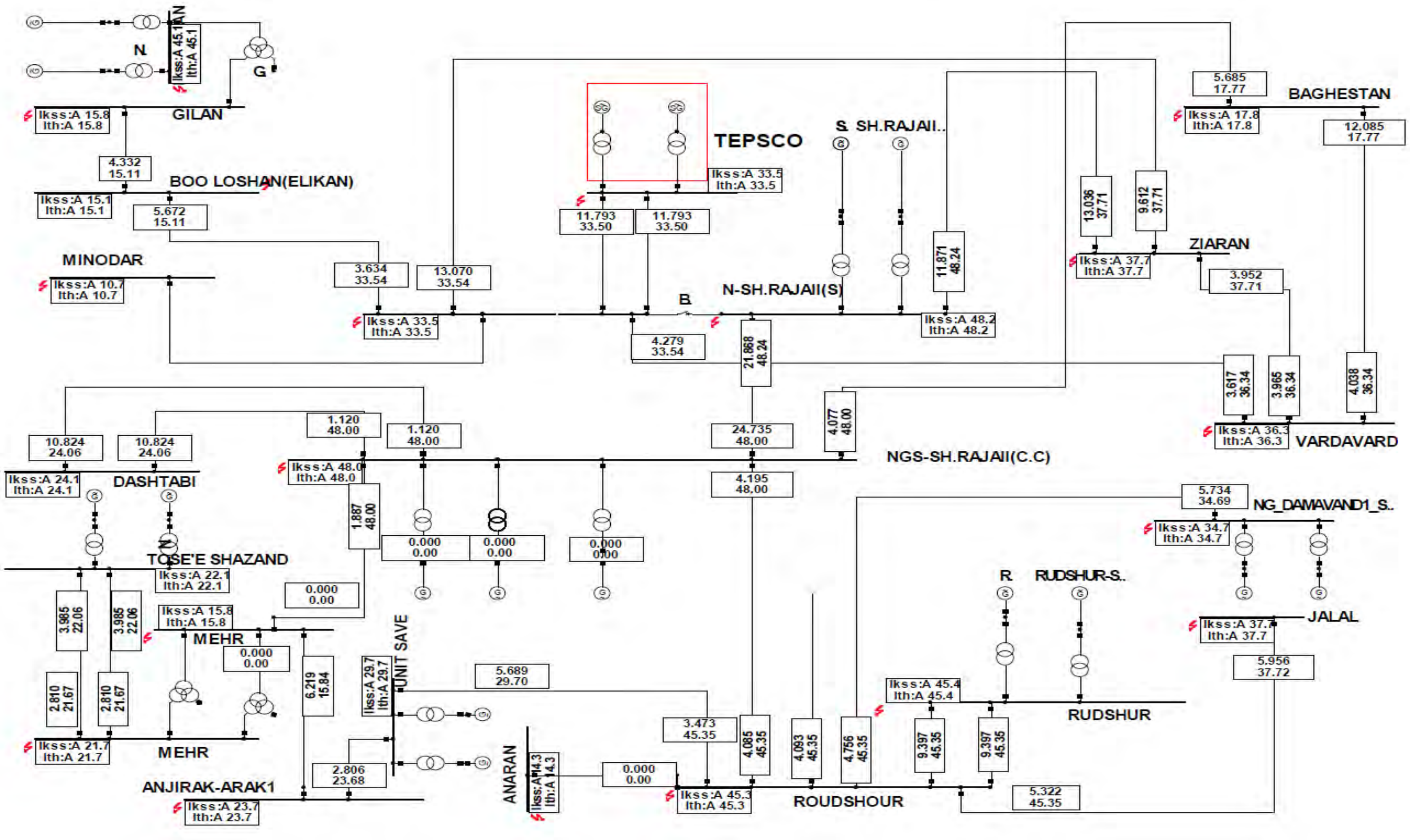
Source: calculated by JICA Study Team

Table 5-9 Single-phase short-circuit current(after the bus splitting operation measures execution)

【New power plant connection to 400kV Rajaee steam-Vardavard transmission line】

Substation Name	Voltage (kV)	Pre- splitting		Post- splitting	
		Ikss (kA)	X/R	Ikss (kA)	X/R
ANARAN	400	14.3	14.3	14.3	14.3
ANJIRAK-ARAK	400	23.7	23.7	23.7	23.7
BAGHESTAN	400	17.8	17.8	17.8	17.8
BOO	400	15.7	15.7	14.7	14.7
DASHTABI	400	26.4	26.4	23.4	23.4
GILAN	400	15.9	15.9	15.7	15.7
JALAL	400	37.7	37.7	37.7	37.7
MEHR	400	15.9	15.9	15.8	15.8
MEHR	230	21.7	21.7	21.7	21.7
MINODAR	400	11.8	11.8	9.8	9.8
N-SH.RAJAII(S)-1	400	62.4	62.4	**45.3**	45.3
N-SH.RAJAII(S)-2	400	62.4	62.4	**22.0**	22.0
NGS-SH.RAJAII(C.C)	400	60.0	60.0	**45.2**	45.2
NGS_GILAN	230	45.2	45.2	45.0	45.0
NG_DAMAVAND	400	34.7	34.7	34.7	34.7
ROUDSHOUR	400	45.8	45.8	45.6	45.6
RUDSHUR	400	45.8	45.8	45.6	45.6
NEW P/S	400	55.8	55.8	**42.7**	42.7
TOSE'E SHAZAND	230	22.1	22.1	22.1	22.1
UNIT SAVE	400	29.8	29.8	29.8	29.8
VARDAVARD	400	36.5	36.5	36.3	36.3
ZIARAN	400	38.1	38.1	24.9	24.9

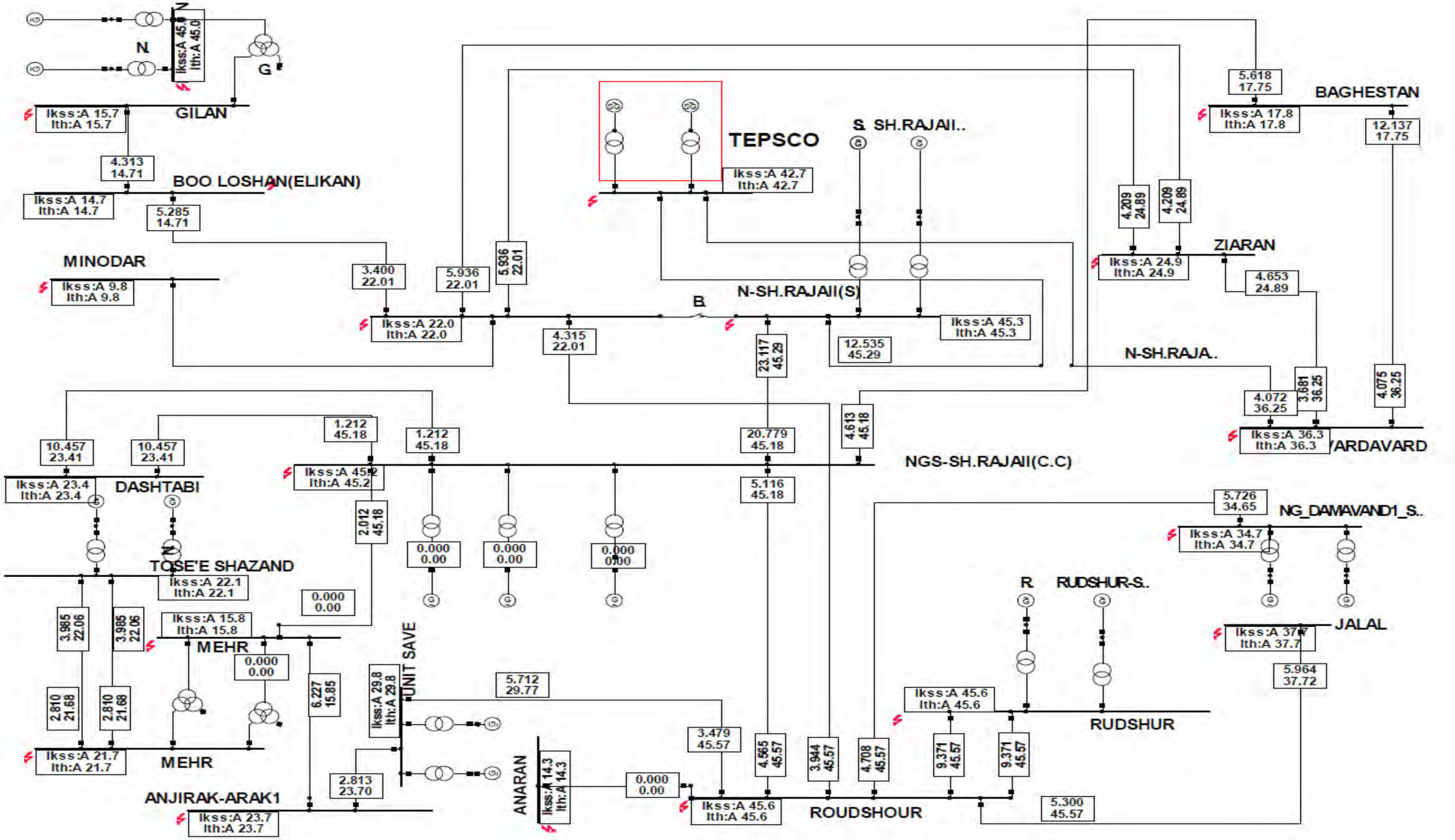
Source: calculated by JICA Study Team



Source: calculated by JICA Study Team

Fig 5-14 Single-phase short-circuit current(after the bus splitting operation measures execution)

【New power plant connection to 400kV existing steam substation through two-circuit 400kV transmission line】



Source: calculated by JICA Study Team

Fig 5-15 Single-phase short-circuit current(after the bus splitting operation measures execution)

【New power plant connection to 400kV Rajaee steam-Vardavard transmission line】

5.2.4 Result of Power Flow and Voltage after the Bus Splitting operation measures （2cct and π connection）

In the following case scenario for Peak and Light demand, it was confirmed that the power flow and the voltage is in the tolerance or less after bus splitting operation measures.

(1)New power plant connection to 400kV existing steam substation through two-circuit 400kV transmission line(Peak Load)
(2)New power plant connection to 400kV existing steam substation through two-circuit 400kV transmission line(Light Load)
(3)New power plant connection to 400kV Rajaee steam-Vardavard transmission line(Peak Load)
(4)New power plant connection to 400kV Rajaee steam-Vardavard transmission line(Light Load)

(1)New power plant connection to 400kV existing steam substation through two-circuit 400kV transmission line(Peak Load)

・Voltage：0.99～1.03P.U.
・Power Flow：within rated capacity of all facilities

Table 5-10 Voltage of new power plant connection to 400kV existing steam substation through two-circuit 400kV transmission line(Peak Load)

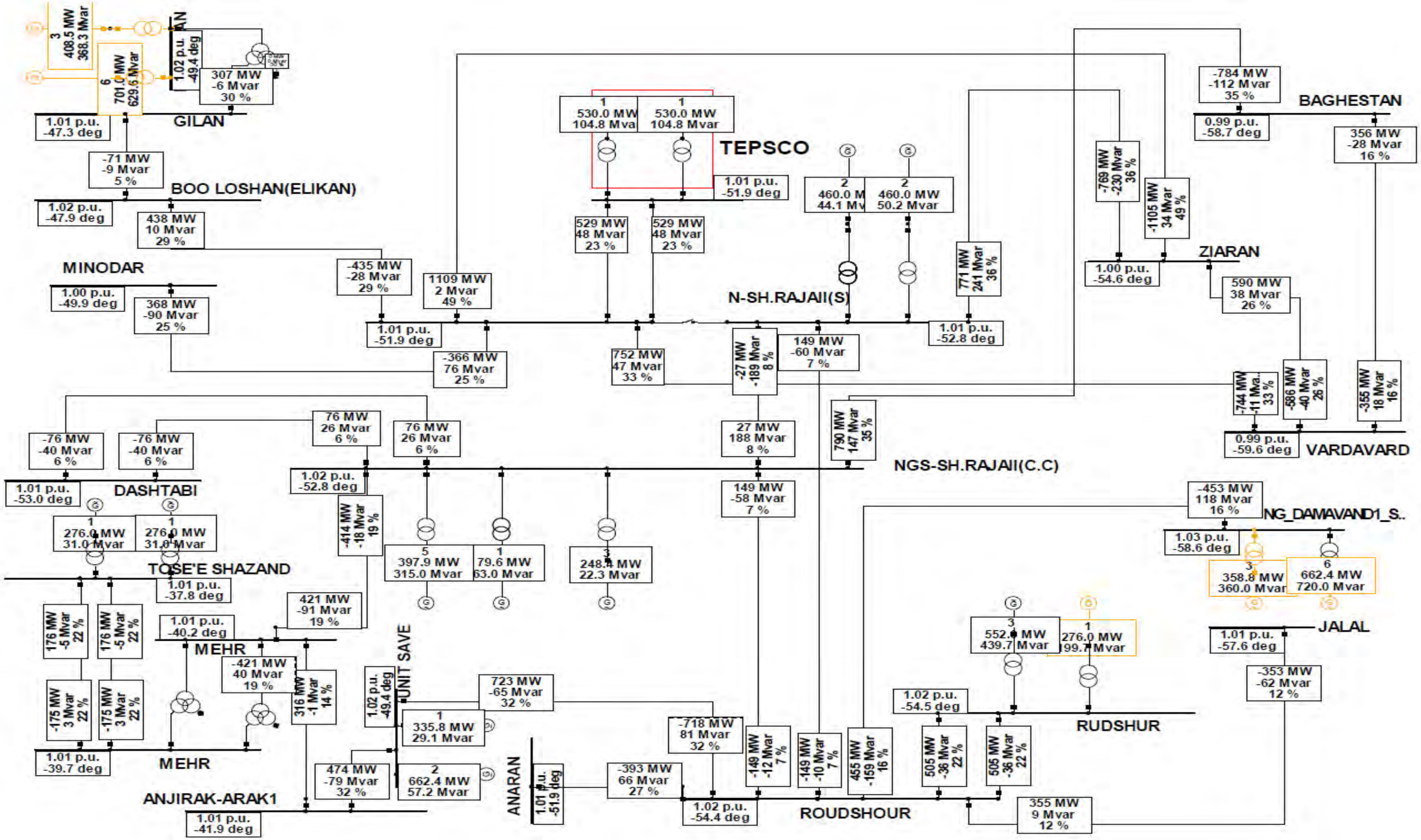
Name	Nominal Voltage (kV)	Pre-connection		Post-connection	
		Magnitude(pu.)	Angle(deg)	Magnitude(pu.)	Angle(deg)
ANARAN	400	1.00	-66.6	1.01	-51.9
ANJIRAK-ARAK	400	0.99	-52.9	1.01	-41.9
BAGHESTAN	400	0.98	-75.5	0.99	-58.7
BOO LOSHAN(ELIKAN)	400	1.01	-65.2	1.02	-47.9
DASHTABI	400	1.00	-70.1	1.01	-53.0
GILAN	400	1.01	-63.9	1.01	-47.3
JALAL	400	1.00	-72.5	1.01	-57.6
MEHR	400	1.00	-51.3	1.01	-40.2
MEHR	230	1.00	-50.8	1.01	-39.7
MINODAR	400	1.00	-67.4	1.00	-49.9
N-SH.RAJAII(S)-1	400	1.00	-69.9	1.01	-52.8
N-SH.RAJAII(S)-2	400	1.00	-69.9	1.01	-51.9
NGS-SH.RAJAII(C.C)	400	1.00	-69.9	1.02	-52.8
NGS_GILAN	230	1.01	-65.8	1.02	-49.4
NG_DAMAVAND	400	1.03	-74.7	1.03	-58.6
ROUDSHOUR	400	1.01	-69.9	1.02	-54.4
RUDSHUR	400	1.01	-70.0	1.02	-54.5
TEPSCO	400	-	-	1.01	-51.9
TOSE'E SHAZAND	230	1.01	-48.8	1.01	-37.8
UNIT SAVE	400	1.01	-63.7	1.02	-49.4
VARDAVARD	400	0.99	-76.4	0.99	-59.6
ZIARAN	400	1.00	-71.9	1.00	-54.6

Source: calculated by JICA Study Team

Table 5-11 Power Flow of new power plant connection to 400kV existing steam substation through two-circuit 400kV transmission line(Peak Load)

Name	Nominal Voltage (kV)	Pre-connection			Post-connection		
		Loading%	P (MW)	Q (Mvar)	Loading%	P (MW)	Q (Mvar)
BAGHESTAN_ NGS-SH.RAJAII(comb-sycle)	400	34	-741	-81	35	-784	-112
BAGHESTAN_ VARDAVARD	400	14	313	-60	16	356	-28
BOO LOSHAN(ELIKAN)_ N-SH.RAJAII(steam)	400	34	510	6	29	438	10
DASHTABI_ NGS-SH.RAJAII	400	5	-65	-34	6	-76	-40
DASHTABI_ NGS-SH.RAJAII(comb-sycle)	400	5	-65	-34	6	-76	-40
GILAN_ BOO LOSHAN(ELIKAN)	400	10	142	-46	5	71	-37
JALAL_ ROUDSHOUR	400	9	-282	-49	12	-353	-62
MEHR_ ANJIRAK-ARAK	400	13	284	13	14	316	-1
N-SH.RAJAII(steam)_ NGS-SH.RAJAII(C.C.)	400	20	-416	-197	8	-27	-189
N-SH.RAJAII(steam)_ VARDAVARD	400	28	630	57	33	752	47
N-SH.RAJAII(steam)_ ZIARAN	400	37	822	97	36	771	241
NGS-SH.RAJAII(comb-sycle)_ R_MEHR	400	27	-586	55	19	-414	-18
NG_DAMAVAND_SHOHDAYE PAKDASHT	400	18	-514	144	16	-453	118
ROUDSHOUR_ NGS-SH.RAJAII(comb-sycle)	400	3	3	-13	7	-149	-12
RUDSHUR_ NG-ROUDSHOUR	400	24	-532	72	22	-505	35
R_MEHR_ MEHR	400	27	-601	8	19	-421	40
ROUDSHOUR_ ANARAN	400	33	-487	97	27	-393	66
TEPSCO-Rajaee steam	400	-	-	-	23	529	48
TEPSCO-Rajaee steam	400	-	-	-	23	529	48
TOSE'E SHAZAND_ MEH R	230	22	179	7	22	176	-5
TOSE'E SHAZAND_ MEHR	230	22	179	7	22	176	-5
UNIT SAVE_ ANJIRAK ARAK	400	45	-650	128	32	-468	59
UNIT SAVE_ROUDSHOUR	400	39	-867	126	32	-718	81
ZIARAN_ VARDAVARD	400	23	523	32	26	590	38

Source: calculated by JICA Study Team



Source: calculated by JICA Study Team

Fig 5-16 Power Flow diagram of new power plant connection to 400kV existing steam substation through two-circuit 400kV transmission line(Peak Load)

(2)New power plant connection to 400kV existing steam substation through two-circuit 400kV transmission line(Light Load)

・Voltage：1.00～1.05P.U.
・Power Flow：within rated capacity of all facilities

Table 5-12 Voltage of new power plant connection to 400kV existing steam substation through two-circuit 400kV transmission line(Light Load)

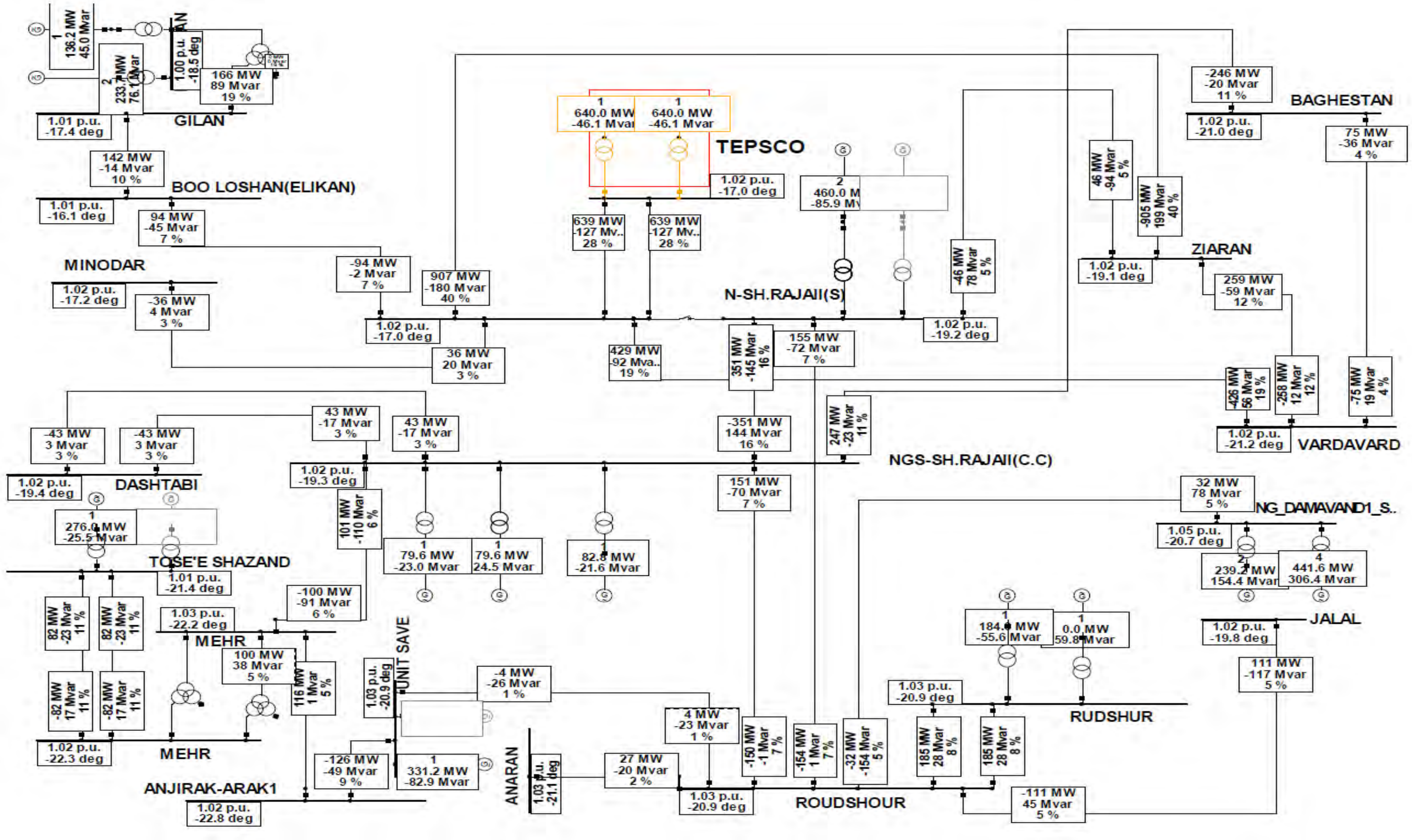
Name	Nominal Voltage (kV)	Pre-connection		Post-connection	
		Magnitude(pu.)	Angle(deg)	Magnitude(pu.)	Angle(deg)
ANARAN	400	1.03	-36.6	1.03	-21.1
ANJIRAK-ARAK	400	1.02	-34.6	1.02	-22.8
BAGHESTAN	400	1.03	-39.0	1.02	-21.0
BOO LOSHAN(ELIKAN)	400	1.02	-35.4	1.01	-16.1
DASHTABI	400	1.03	-37.3	1.02	-19.4
GILAN	400	1.01	-35.7	1.01	-17.4
JALAL	400	1.02	-35.5	1.02	-19.8
MEHR	400	1.03	-34.2	1.03	-22.2
MEHR	230	1.02	-34.3	1.02	-22.3
MINODAR	400	1.03	-36.7	1.02	-17.2
N-SH.RAJAII(S)-1	400	1.03	-37.2	1.02	-19.2
N-SH.RAJAII(S)-2	400	1.03	-37.2	1.02	-17.0
NGS-SH.RAJAII(C.C)	400	1.03	-37.2	1.02	-19.3
NGS_GILAN	230	1.00	-36.5	1.00	-18.5
NG_DAMAVAND	400	1.05	-37.8	1.05	-20.7
ROUDSHOUR	400	1.03	-37.2	1.03	-20.9
RUDSHUR	400	1.03	-37.2	1.03	-20.9
TEPSCO	400	-	-	1.02	-17.0
TOSE'E SHAZAND	230	1.01	-33.3	1.01	-21.4
UNIT SAVE	400	1.03	-36.0	1.03	-20.9
VARDAVARD	400	1.03	-39.2	1.02	-21.2
ZIARAN	400	1.03	-37.9	1.02	-19.1

Source: calculated by JICA Study Team

Table 5-13 Power Flow of new power plant connection to 400kV existing steam substation through two-circuit 400kV transmission line(Light Load)

Name	Nominal Voltage (kV)	Pre-connection			Post-connection		
		Loading%	P (MW)	Q (Mvar)	Loading%	P (MW)	Q (Mvar)
BAGHESTAN_ NGS-SH.RAJAII(comb-sycle)	400	4	78	-47	11	-246	-20
BAGHESTAN_ VARDAVARD	400	14	198	-90	4	75	-36
BOO LOSHAN(ELIKAN)_ N-SH.RAJAII(steam)	400	3	-40	1	7	94	-45
DASHTABI_ NGS-SH.RAJAII	400	3	-40	1	3	-43	3
DASHTABI_ NGS-SH.RAJAII(comb-sycle)	400	5	-39	-57	3	-43	3
GILAN_ BOO LOSHAN(ELIKAN)	400	7	185	-128	10	-142	-30
JALAL_ ROUDSHOUR	400	4	77	-1	5	111	-117
MEHR_ ANJIRAK-ARAK	400	12	274	-33	5	116	1
N-SH.RAJAII(steam)_ NGS-SH.RAJAII(C.C.)	400	2	-4	-49	16	351	-145
N-SH.RAJAII(steam)_ VARDAVARD	400	9	204	-51	19	429	-92
N-SH.RAJAII(steam)_ ZIARAN	400	12	274	-33	5	-46	78
NGS-SH.RAJAII(comb-sycle)_ R_MEHR	400	7	-104	-89	6	101	-110
NG_DAMAVAND_SHOHDAYE PAKDASHT	400	6	-57	91	5	32	78
ROUDSHOUR_ NGS-SH.RAJAII(comb-sycle)	400	2	4	-27	7	-150	-1
RUDSHUR_ NG-ROUDSHOUR	400	10	-234	-29	8	-185	-29
R_MEHR_ MEHR	400	5	-104	60	5	100	38
ROUDSHOUR_ ANARAN	400	6	-87	-6	2	27	-20
TEPSCO-Rajaee steam	400	-	-	-	28	639	-127
TEPSCO-Rajaee steam	400	-	-	-	28	639	-127
TOSE'E SHAZAND_ MEH R	230	11	85	-24	11	82	-23
TOSE'E SHAZAND_ MEHR	230	11	85	-24	11	82	-23
UNIT SAVE_ ANJIRAK ARAK	400	7	-90	-11	9	127	-32
UNIT SAVE_ROUDSHOUR	400	8	-176	-3	1	4	-23
ZIARAN_ VARDAVARD	400	7	167	-44	12	259	-59

Source: calculated by JICA Study Team



Source: calculated by JICA Study Team

Fig 5-17 Power flow diagram of new power plant connection to 400kV existing steam substation through two-circuit 400kV transmission line(Light Load)

(3)New power plant connection to 400kV Rajaee steam-Vardavard transmission line(Peak Load)

・Voltage：0.98～1.03P.U.
・Power Flow：within rated capacity of all facilities

Table 5-14 Voltage of new power plant connection to 400kV Rajaee steam-Vardavard transmission line(Peak Load)

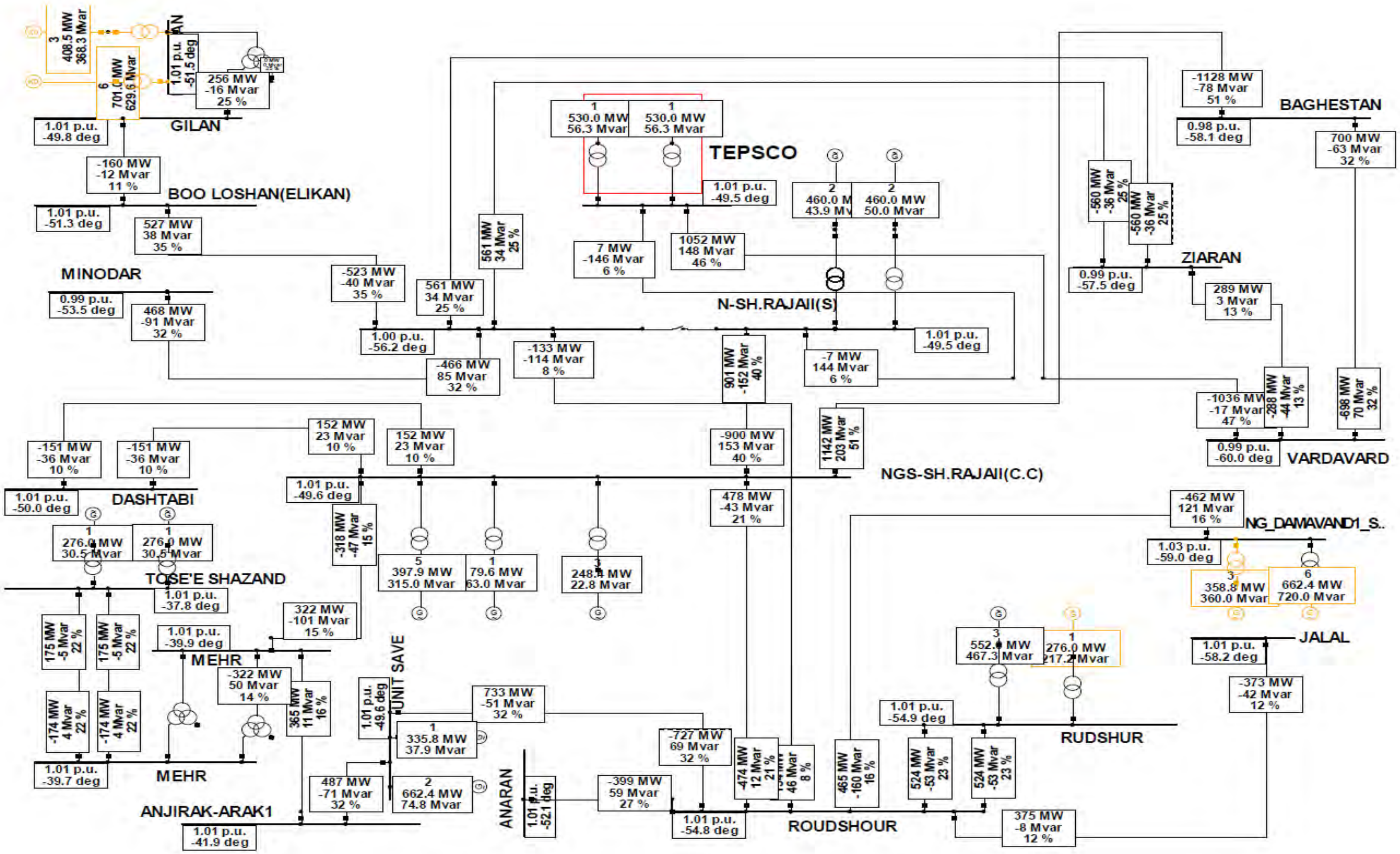
Name	Nominal Voltage (kV)	Pre-connection		Post-connection	
		Magnitude(pu.)	Angle(deg)	Magnitude(pu.)	Angle(deg)
ANARAN	400	1.00	-66.6	1.01	-52.1
ANJIRAK-ARAK	400	0.99	-52.9	1.01	-41.9
BAGHESTAN	400	0.98	-75.5	0.98	-58.1
BOO LOSHAN(ELIKAN)	400	1.01	-65.2	1.01	-51.3
DASHTABI	400	1.00	-70.1	1.01	-50.0
GILAN	400	1.01	-63.9	1.01	-49.8
JALAL	400	1.00	-72.5	1.01	-58.2
MEHR	400	1.00	-51.3	1.01	-39.9
MEHR	230	1.00	-50.8	1.01	-39.7
MINODAR	400	1.00	-67.4	0.99	-53.5
N-SH.RAJAII(S)-1	400	1.00	-69.9	1.01	-49.5
N-SH.RAJAII(S)-2	400	1.00	-69.9	1.00	-56.2
NGS-SH.RAJAII(C.C)	400	1.00	-69.9	1.01	-49.6
NGS_GILAN	230	1.01	-65.8	1.01	-51.5
NG_DAMAVAND	400	1.03	-74.7	1.03	-59.0
ROUDSHOUR	400	1.01	-69.9	1.01	-54.8
RUDSHUR	400	1.01	-70.0	1.01	-54.9
TEPSCO	400	-	-	1.01	-49.5
TOSE'E SHAZAND	230	1.01	-48.8	1.01	-37.8
UNIT SAVE	400	1.01	-63.7	1.01	-49.6
VARDAVARD	400	0.99	-76.4	0.99	-60.0
ZIARAN	400	1.00	-71.9	0.99	-57.5

Source: calculated by JICA Study Team

Table 5-15 Power Flow of new power plant connection to 400kV Rajaee steam-Vardavard transmission line(Peak Load)

Name	Nominal Voltage (kV)	Pre-connection			Post-connection		
		Loading%	P (MW)	Q (Mvar)	Loading%	P (MW)	Q (Mvar)
BAGHESTAN_ NGS-SH.RAJAII(comb-sycle)	400	34	-741	-81	51	-1128	-78
BAGHESTAN_ VARDAVARD	400	14	313	-60	32	700	-63
BOO LOSHAN(ELIKAN)_ N-SH.RAJAII(steam)	400	34	510	6	35	527	38
DASHTABI_ NGS-SH.RAJAII	400	5	-65	-34	10	-151	-36
DASHTABI_ NGS-SH.RAJAII(comb-sycle)	400	5	-65	-34	10	-151	-36
GILAN_ BOO LOSHAN(ELIKAN)	400	10	142	-46	11	160	-32
JALAL_ ROUDSHOUR	400	9	-282	-49	12	-373	-42
MEHR_ ANJIRAK-ARAK	400	13	284	13	16	365	11
N-SH.RAJAII(steam)_ NGS-SH.RAJAII(C.C.)	400	20	-416	-197	40	901	-152
N-SH.RAJAII(steam)_ VARDAVARD	400	28	630	57	6	-7	144
N-SH.RAJAII(steam)_ ZIARAN	400	37	822	97	25	561	34
NGS-SH.RAJAII(comb-sycle)_ R_MEHR	400	27	-586	55	15	-318	-47
NG_DAMAVAND_SHOHDAYE PAKDASHT	400	18	-514	144	16	-462	121
ROUDSHOUR_ NGS-SH.RAJAII(comb-sycle)	400	3	3	-13	21	-474	12
RUDSHUR_ NG-ROUDSHOUR	400	24	-532	72	23	-523	52
R_MEHR_ MEHR	400	27	-601	8	14	-322	50
ROUDSHOUR_ ANARAN	400	33	-487	97	27	-399	59
TEPSCO-Rajaee steam	400	-	-	-	6	7	-146
TEPSCO-Vardavard	400	-	-	-	46	1052	148
TOSE'E SHAZAND_ MEH R	230	22	179	7	22	175	-5
TOSE'E SHAZAND_ MEHR	230	22	179	7	22	175	-5
UNIT SAVE_ ANJIRAK ARAK	400	45	-650	128	32	-480	55
UNIT SAVE_ROUDSHOUR	400	39	-867	126	32	-727	69
ZIARAN_ VARDAVARD	400	23	523	32	13	289	3

Source: calculated by JICA Study Team



Source: calculated by JICA Study Team

Fig 5-18 Power Flow diagram of new power plant connection to 400kV Rajaee steam-Vardavard transmission line(Peak Load)

(4) New power plant connection to 400kV Rajaee steam-Vardavard transmission line(Light Load)

・Voltage：1.00～1.05P.U.
・Power Flow：within rated capacity of all facilities

Table 5-16 Voltage of new power plant connection to 400kV Rajaee steam-Vardavard transmission line(Light Load)

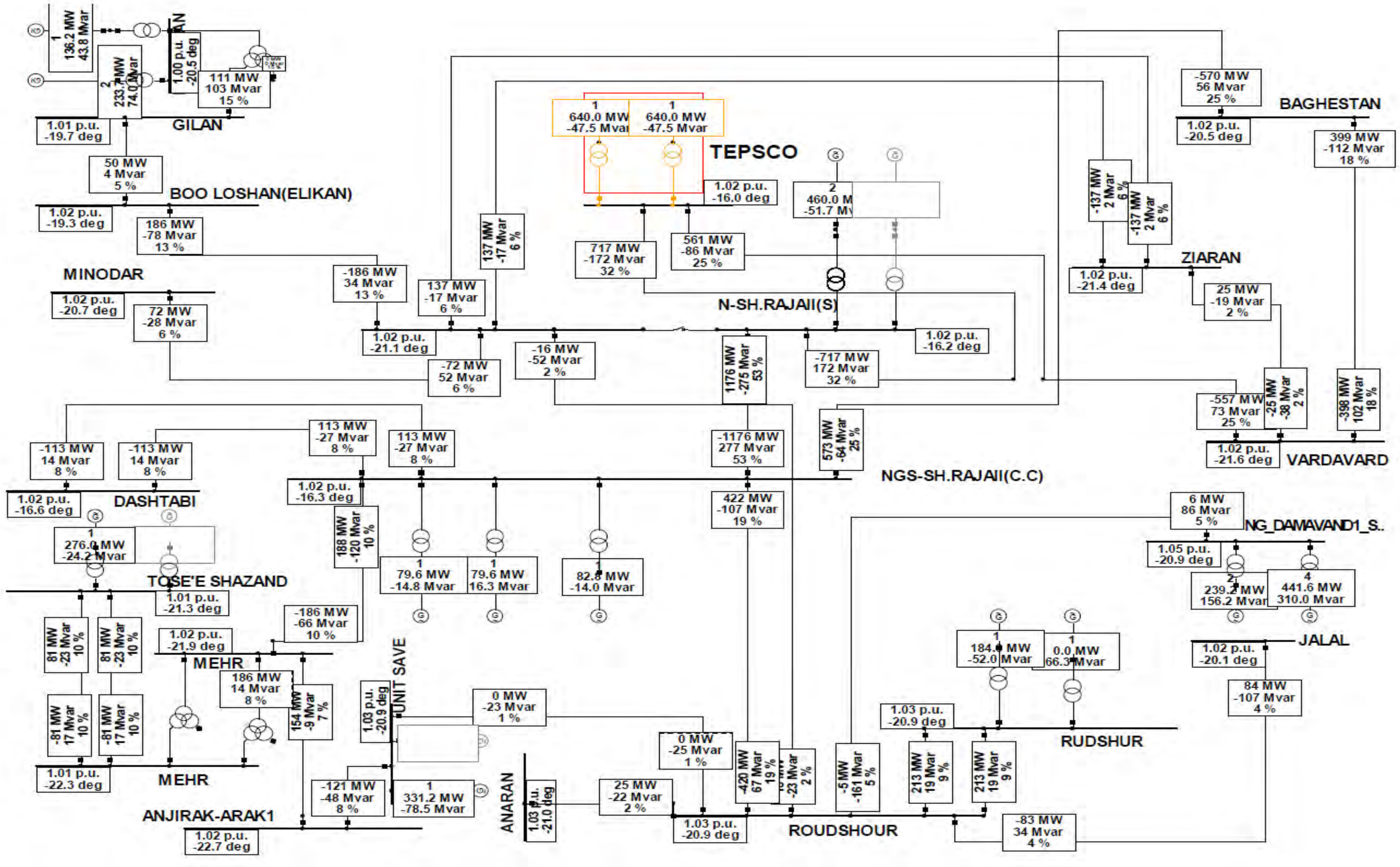
Name	Nominal Voltage (kV)	Pre-connection		Post-connection	
		Magnitude(pu.)	Angle(deg)	Magnitude(pu.)	Angle(deg)
ANARAN	400	1.03	-36.6	1.03	-21.0
ANJIRAK-ARAK	400	1.02	-34.6	1.02	-22.7
BAGHESTAN	400	1.03	-39.0	1.02	-20.5
BOO LOSHAN(ELIKAN)	400	1.02	-35.4	1.02	-19.3
DASHTABI	400	1.03	-37.3	1.02	-16.6
GILAN	400	1.01	-35.7	1.01	-19.7
JALAL	400	1.02	-35.5	1.02	-20.1
MEHR	400	1.03	-34.2	1.02	-21.9
MEHR	230	1.02	-34.3	1.01	-22.3
MINODAR	400	1.03	-36.7	1.02	-20.7
N-SH.RAJAII(S)-1	400	1.03	-37.2	1.02	-16.2
N-SH.RAJAII(S)-2	400	1.03	-37.2	1.02	-21.1
NGS-SH.RAJAII(C.C)	400	1.03	-37.2	1.02	-16.3
NGS_GILAN	230	1.00	-36.5	1.00	-20.5
NG_DAMAVAND	400	1.05	-37.8	1.05	-20.9
ROUDSHOUR	400	1.03	-37.2	1.03	-20.9
RUDSHUR	400	1.03	-37.2	1.03	-20.9
TEPSCO	400	-	-	1.02	-16.0
TOSE'E SHAZAND	230	1.01	-33.3	1.01	-21.3
UNIT SAVE	400	1.03	-36.0	1.03	-20.9
VARDAVARD	400	1.03	-39.2	1.02	-21.6
ZIARAN	400	1.03	-37.9	1.02	-21.4

Source: calculated by JICA Study Team

Table 5-17 Power Flow of new power plant connection to 400kV Rajaee steam-Vardavard transmission line(Light Load)

Name	Nominal Voltage (kV)	Pre-connection			Post-connection		
		Loading%	P (MW)	Q (Mvar)	Loading%	P (MW)	Q (Mvar)
BAGHESTAN_ NGS-SH.RAJAII(comb-sycle)	400	4	78	-47	25	-570	56
BAGHESTAN_ VARDAVARD	400	14	198	-90	18	399	-112
BOO LOSHAN(ELIKAN)_ N-SH.RAJAII(steam)	400	3	-40	1	13	186	-78
DASHTABI_ NGS-SH.RAJAII	400	3	-40	1	8	-113	14
DASHTABI_ NGS-SH.RAJAII(comb-sycle)	400	5	-39	-57	8	-113	14
GILAN_ BOO LOSHAN(ELIKAN)	400	7	185	-128	5	-50	-51
JALAL_ ROUDSHOUR	400	4	77	-1	4	84	-107
MEHR_ ANJIRAK-ARAK	400	12	274	-33	7	154	-9
N-SH.RAJAII(steam)_ NGS-SH.RAJAII(C.C.)	400	2	-4	-49	53	1176	-275
N-SH.RAJAII(steam)_ VARDAVARD	400	9	204	-51	32	-717	172
N-SH.RAJAII(steam)_ ZIARAN	400	12	274	-33	6	137	-17
NGS-SH.RAJAII(comb-sycle)_ R_MEHR	400	7	-104	-89	10	188	-120
NG_DAMAVAND_SHOHDAYE PAKDASHT	400	6	-57	91	5	6	86
ROUDSHOUR_ NGS-SH.RAJAII(comb-sycle)	400	2	4	-27	19	-420	67
RUDSHUR_ NG-ROUDSHOUR	400	10	-234	-29	9	-213	-20
R_MEHR_ MEHR	400	5	-104	60	8	186	14
ROUDSHOUR_ ANARAN	400	6	-87	-6	2	25	-22
TEPSCO-Rajaee steam	400	-	-	-	32	717	-172
TEPSCO-Vardavard	400	-	-	-	25	561	-86
TOSE'E SHAZAND_ MEH R	230	11	85	-24	10	81	-23
TOSE'E SHAZAND_ MEHR	230	11	85	-24	10	81	-23
UNIT SAVE_ ANJIRAK ARAK	400	7	-90	-11	8	121	-32
UNIT SAVE_ROUDSHOUR	400	8	-176	-3	1	0	-23
ZIARAN_ VARDAVARD	400	7	167	-44	2	25	-19

Source: calculated by JICA Study Team



Source: calculated by JICA Study Team

Fig 5-19 Power Flow diagram of new power plant connection to 400kV Rajaee steam-Vardavard transmission line(Light Load)

5.2.5 Result of Steady state/Transient stability calculation after the bus splitting operation measures execution（2cct and π connection）

In the case scenario of 1-1～1-9 and 2-1～2-9, it was confirmed that the generator around Shahid Rajaee area is able to be continued stable, and it is acceptable from Steady state/Transient Stability study perspective.

- 1：New power plant connection to 400kV existing steam substation through two-circuit 400kV transmission line(Peak Load and Light Load)
- 2：New power plant connection to 400kV Rajaee steam-Vardavard transmission line(Peak Load and Light Load)

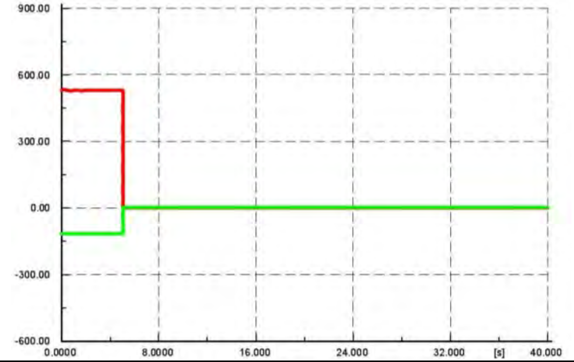
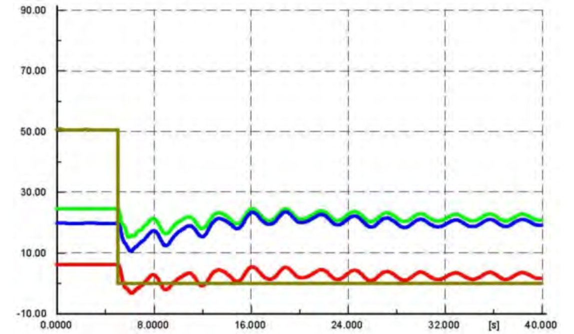
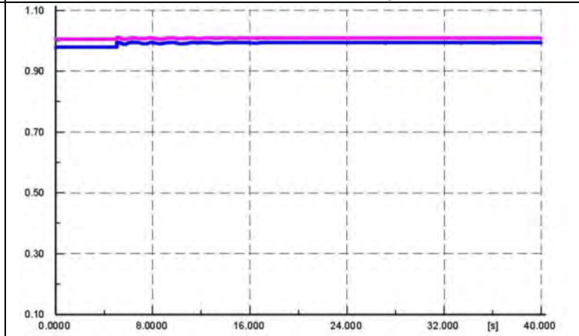
Table 5-18 Accident Case

Configuration	No	Contingency Characteristic
1：New power plant connection to 400kV existing steam substation through two-circuit 400kV transmission line	1	The outage of Shahid Rajaee new generator unit
	2	The outage of Shahid Rajaee existing steam generator unit
	3	The outage of Shahid Rajaee existing combined generator unit
	4	Three-phase short circuit fault in 400kV Shahid Rajaee new power plant-Rajaee Steam transmission line and the outage of transmission line after 100miliseconds
	5	Three-phase short circuit fault in 400kV Rajaee Steam-Vardavard transmission line and the outage of transmission line after 100miliseconds
	6	Three-phase short circuit fault in 400kV Rajaee Steam-Minoodar transmission line and the outage of transmission line after 100miliseconds
	7	Three-phase short circuit fault in 400kV Rajaee Steam-Ziaran transmission line and the outage of transmission line after 100miliseconds
	8	Three-phase short circuit fault in 400kV Rajaee Steam-Loshan transmission line and the outage of transmission line after 100miliseconds
	9	Three-phase short circuit fault in 400kV Rajaee Steam-Roudshour transmission line and the outage of transmission line after 100miliseconds
2：New power plant connection to 400kV Rajaee steam-Vardavard transmission line	1	The outage of Shahid Rajaee new generator unit
	2	The outage of Shahid Rajaee existing steam generator unit
	3	The outage of Shahid Rajaee existing combined generator unit
	4	Three-phase short circuit fault in 400kV Shahid Rajaee new power plant-Rajaee Steam transmission line and the outage of transmission line after 100miliseconds
	5	Three-phase short circuit fault in 400kV Shahid Rajaee new power plant-Vardavard transmission line and the outage of transmission line after 100miliseconds
	6	Three-phase short circuit fault in 400kV Rajaee Steam-Minoodar transmission line and the outage of transmission line after 100miliseconds
	7	Three-phase short circuit fault in 400kV Rajaee Steam-Ziaran transmission line and the outage of transmission line after 100miliseconds
	8	Three-phase short circuit fault in 400kV Rajaee Steam-Loshan transmission line and the outage of transmission line after 100miliseconds
	9	Three-phase short circuit fault in 400kV Rajaee Steam-Roudshour transmission line and the outage of transmission line after 100miliseconds

Source: prepared by JICA Study Team

【Result of Steady state /Transient stability calculation】

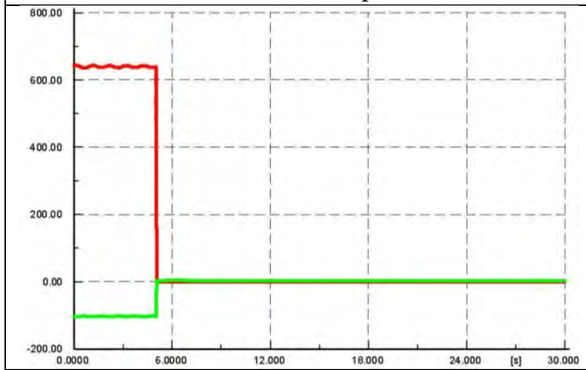
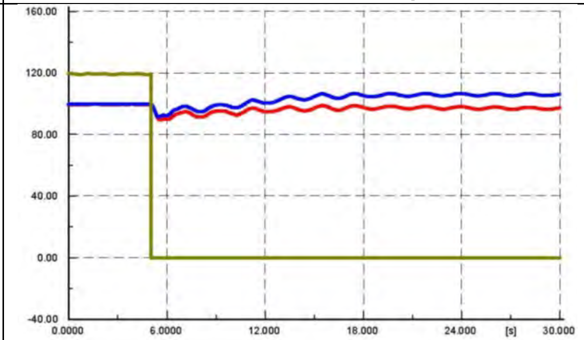
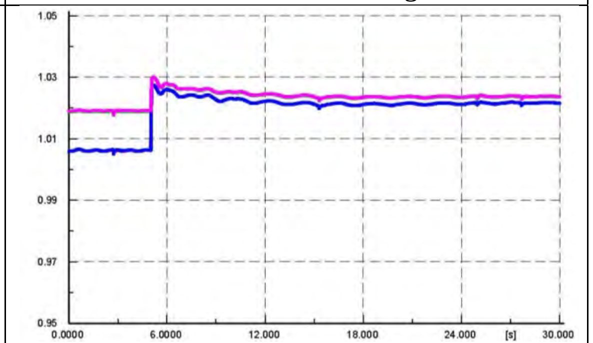
(1)1-1 The outage of Shahid Rajaee new generator unit (Peak Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-20 1-1 The outage of Shahid Rajaee new generator unit (Peak Load)

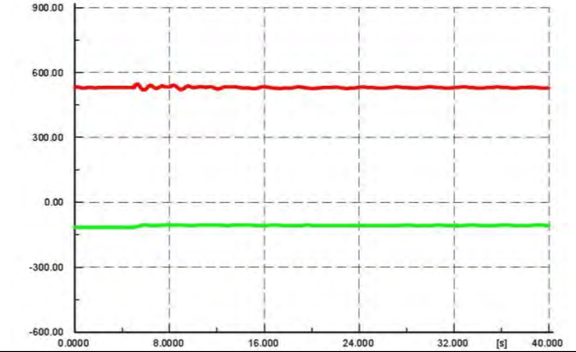
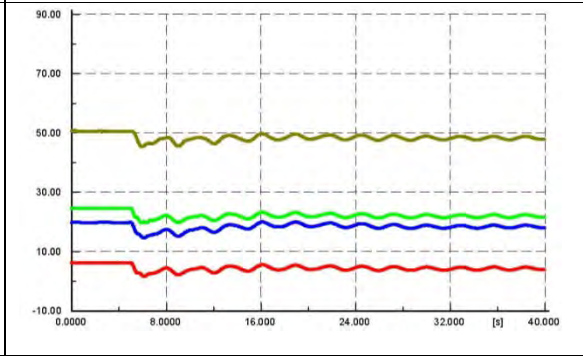
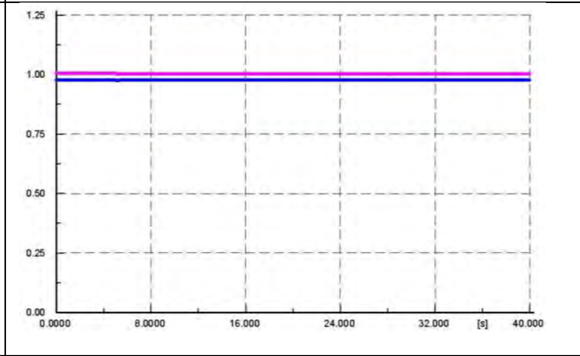
(2)1-1 The outage of Shahid Rajaee new generator unit(Light Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-21 1-1 The outage of Shahid Rajaee new generator unit(Light Load)

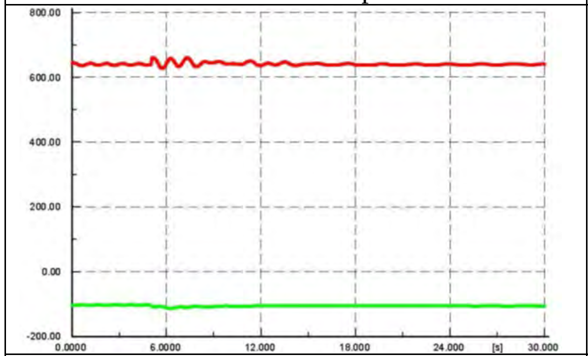
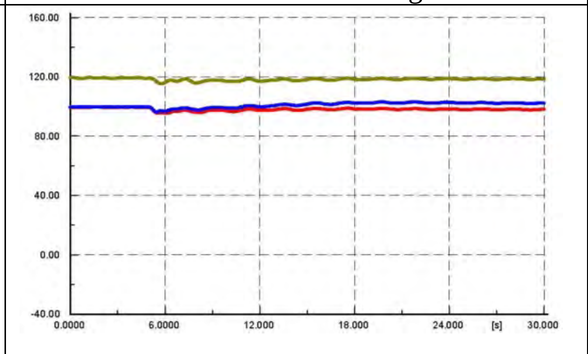
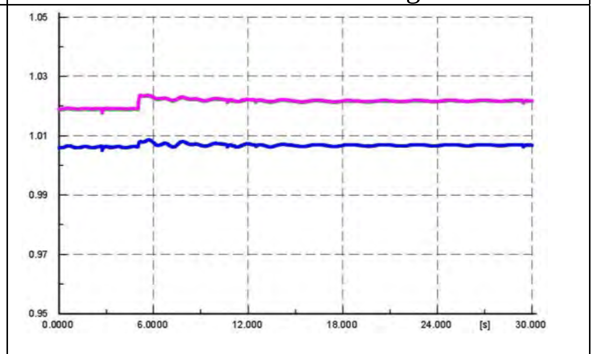
(3)1-2 The outage of Shahid Rajaee existing steam generator unit(Peak Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-22 1-2 The outage of Shahid Rajaee existing steam generator unit(Peak Load)

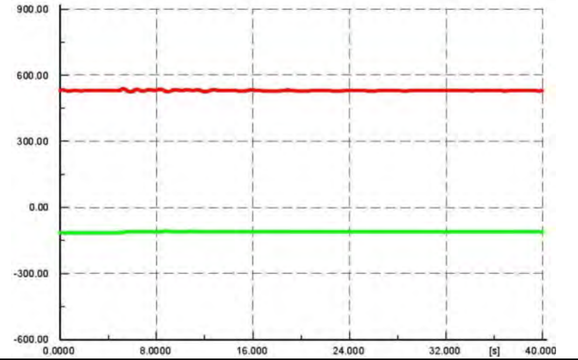
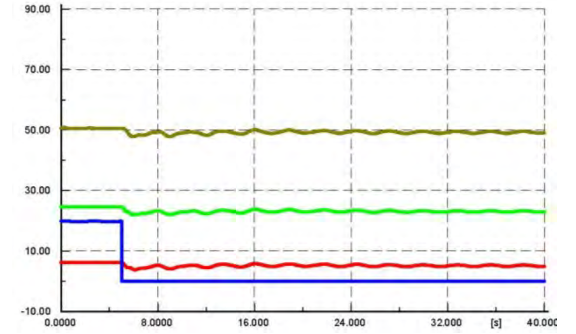
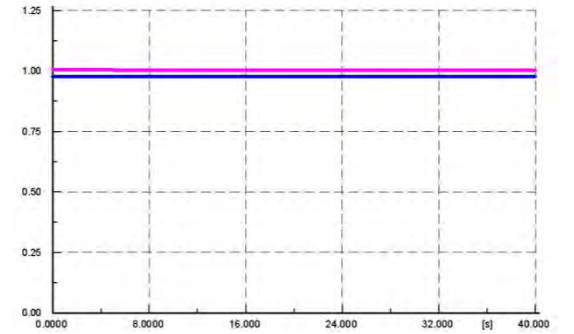
(4)1-2 The outage of Shahid Rajaee existing steam generator unit(Light Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-23 1-2 The outage of Shahid Rajaee existing steam generator unit(Light Load)

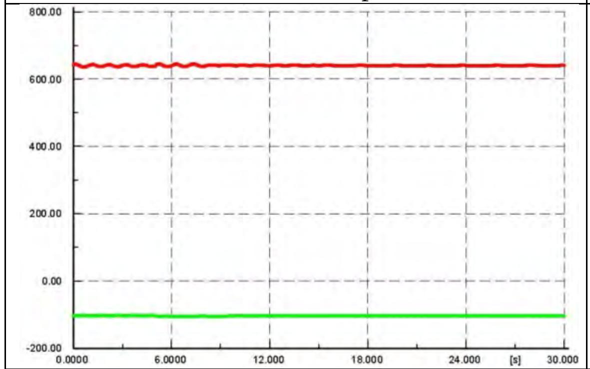
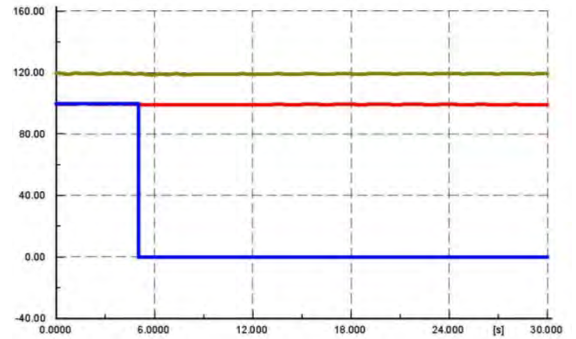
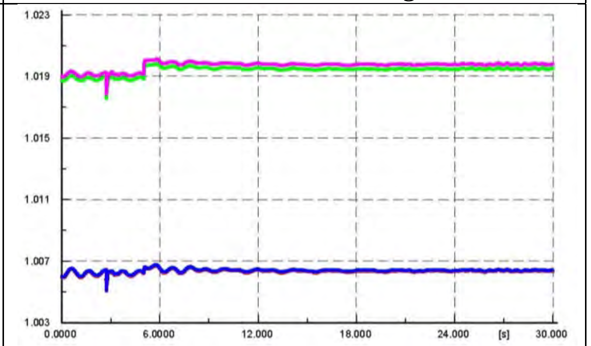
(5)1-3 The outage of Shahid Rajaee existing combined generator unit(Peak Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-24 1-3 The outage of Shahid Rajaee existing combined generator unit(Peak Load)

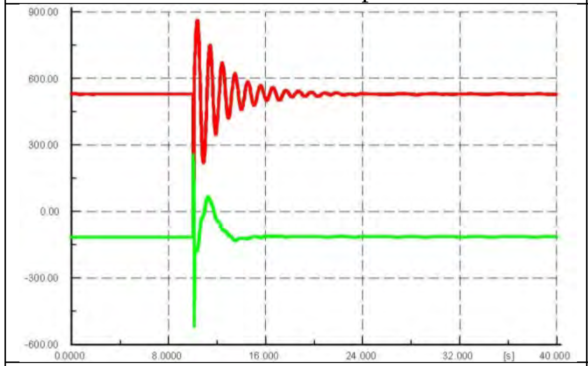
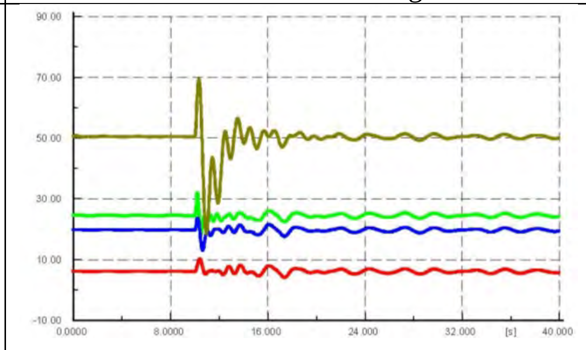
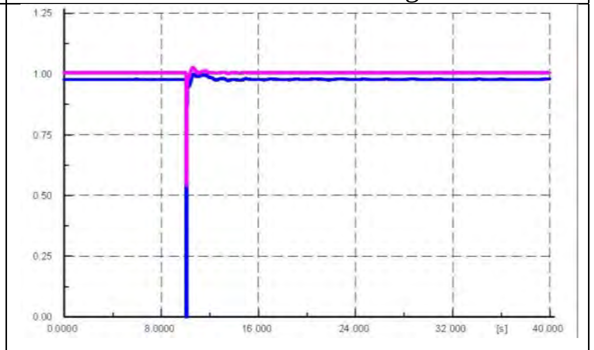
(6) 1-3 The outage of Shahid Rajaee existing combined generator unit(Light Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-25 1-3 The outage of Shahid Rajaee existing combined generator unit(Light Load)

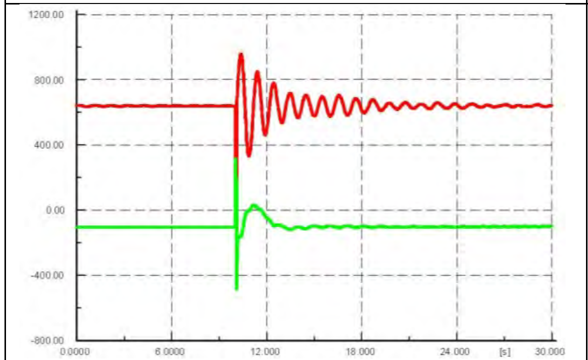
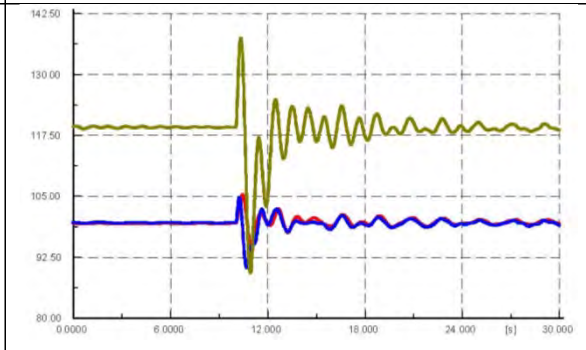
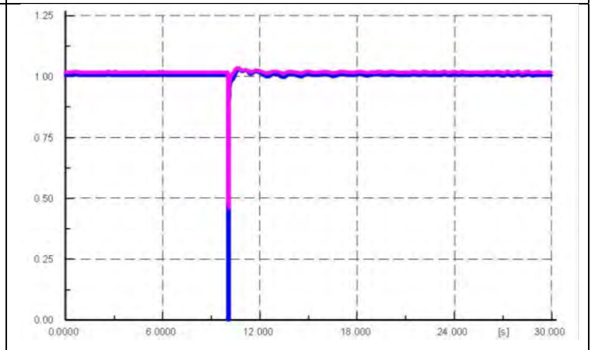
(7)1-4 Three-phase short circuit fault in 400kV Shahid Rajaee new power plant-Rajaee Steam transmission line (Peak Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-26 1-4 Three-phase short circuit fault in 400kV Shahid Rajaee new power plant-Rajaee Steam transmission line and the outage of transmission line after 100miliseconds(Peak Load)

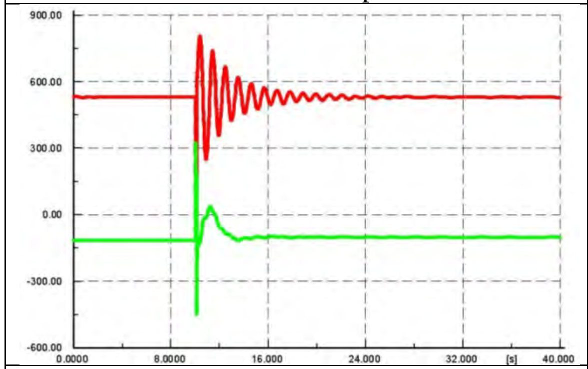
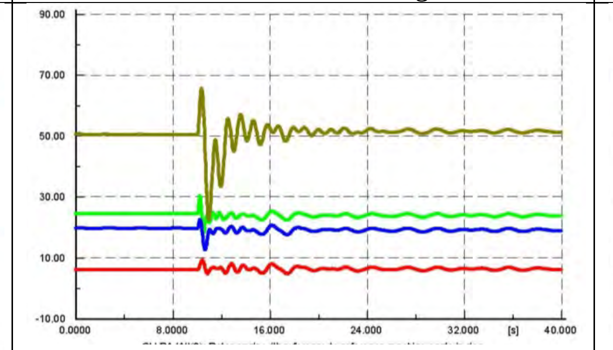
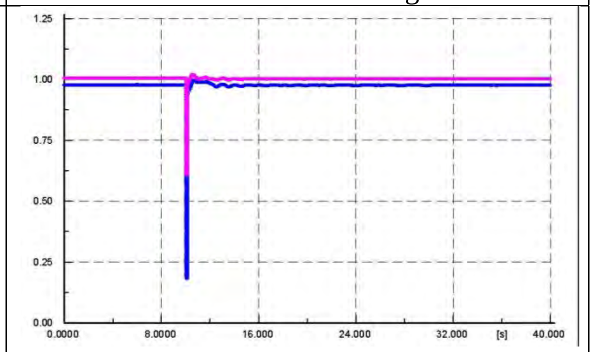
(8)1-4 Three-phase short circuit fault in 400kV Shahid Rajaee new power plant-Rajaee Steam transmission line (Light Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-27 1-4 Three-phase short circuit fault in 400kV Shahid Rajaee new power plant-Rajaee Steam transmission line and the outage of transmission line after 100miliseconds(Light Load)

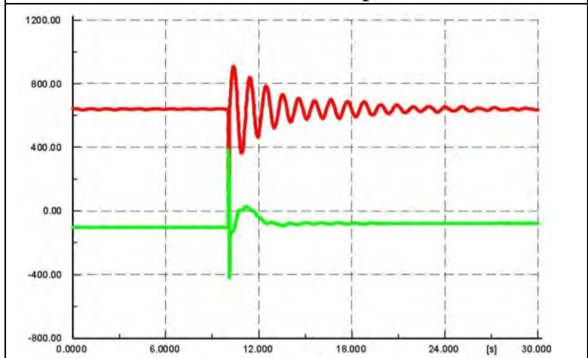
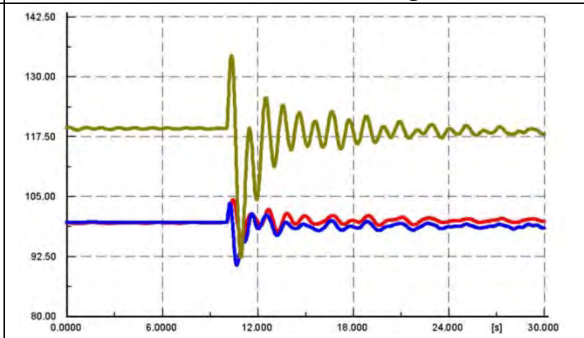
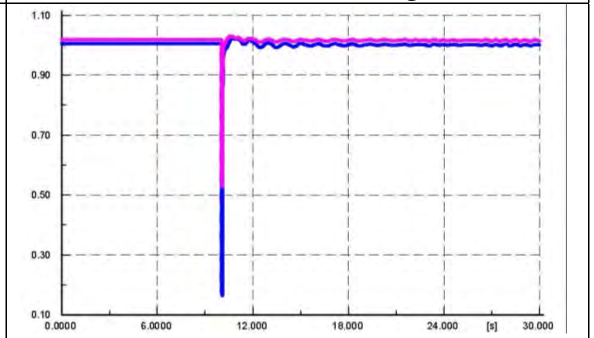
(9)1-5Three-phase short circuit fault in 400kVRajaee Steam-Vardavard transmission line (peak Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
EPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-28 1-5 Three-phase short circuit fault in 400kV Rajaee Steam-Vardavard transmission line and the outage of transmission line after 100miliseconds（Peak Load）

(10)1-5Three-phase short circuit fault in 400kVRajaee Steam-Vardavard transmission line (Light Load)

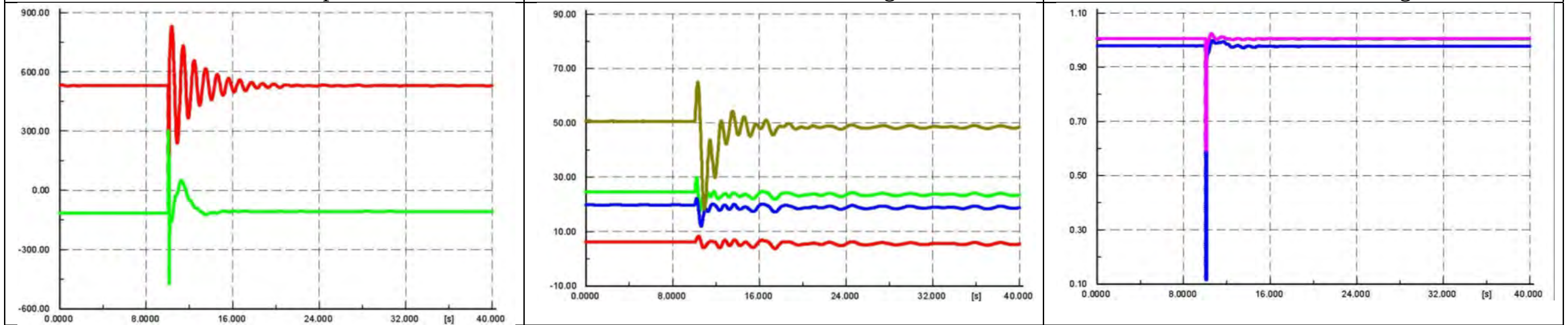
Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-29 1-5 Three-phase short circuit fault in 400kV Rajaee Steam-Vardavard transmission line and the outage of transmission line after 100miliseconds(Light Load)

(11)1-6 Three-phase short circuit fault in 400kV Rajaee Steam-Minoodar transmission line (Peak Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage



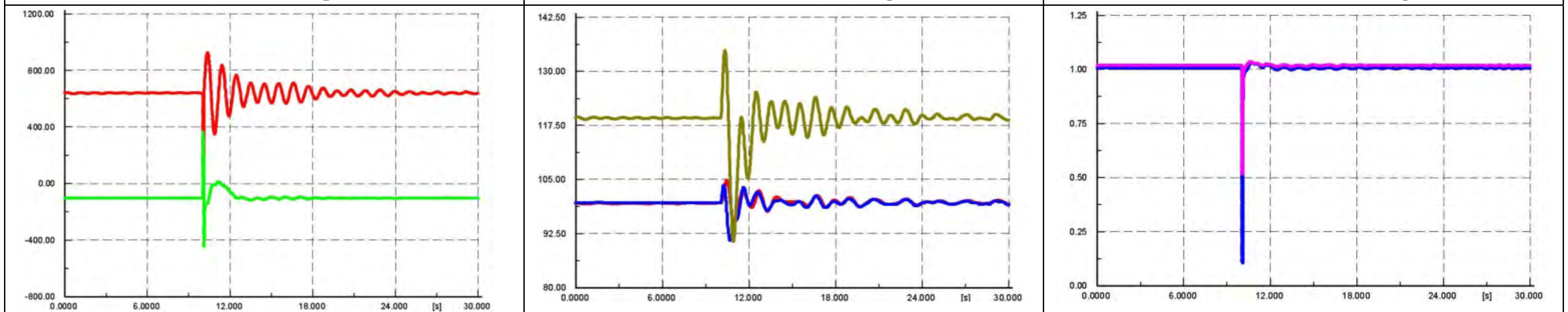
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-30 1-6 Three-phase short circuit fault in 400kV Rajaee Steam-Minoodar transmission line and the outage of transmission line after 100miliseconds（Peak Load）

(12)1-6 Three-phase short circuit fault in 400kV Rajaee Steam-Minoodar transmission line (Light Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage



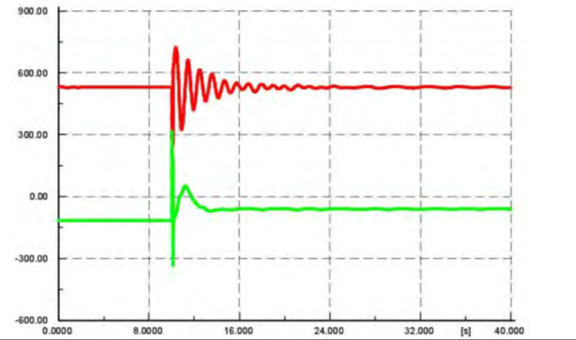
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-31 1-6 Three-phase short circuit fault in 400kV Rajaee Steam-Minoodar transmission line and the outage of transmission line after 100miliseconds (LightLoad)

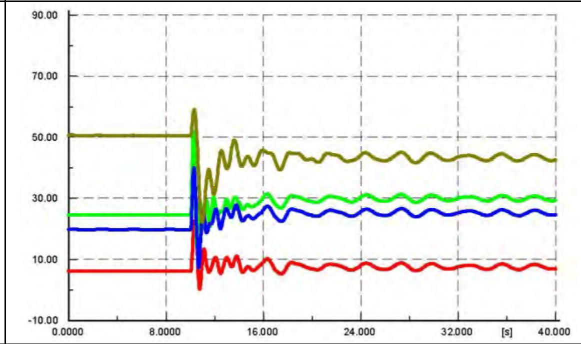
(13)1-7 Three-phase short circuit fault in 400kV Rajaee Steam-Ziaran transmission line（Peak Load）

Generator Output



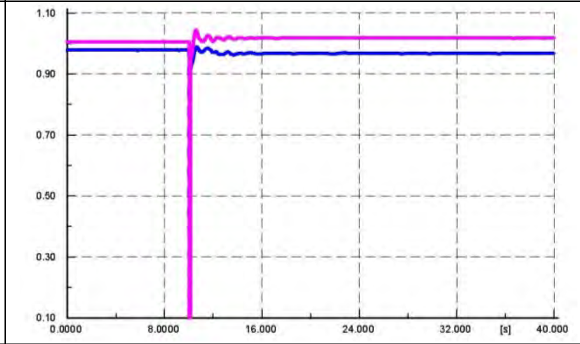
TEPSCO-G1, Active Power, MW
TEPSCO-G1, Reactive Power, MVar

Generator Internal Angle



SH-RAJAII(2), Rotor Angle, deg
SH-RAJAII(3), Rotor Angle, deg
SH-RAJAII(4), Rotor Angle, deg
TEPSCO-G1, Rotor Angle, deg

Generator Bus Voltage



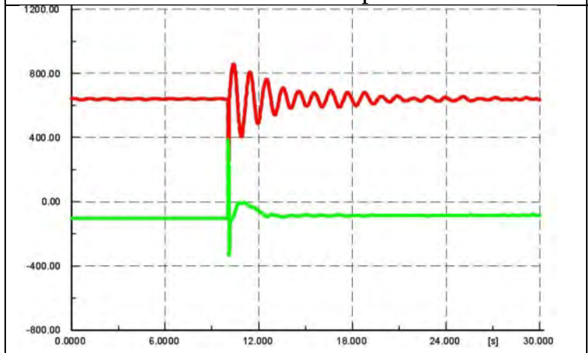
TEPSCO, Voltage, P.U.
SH-RAJAII(1), Voltage, P.U.
SH-RAJAII(S), Voltage, P.U.
SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-32 1-7 Three-phase short circuit fault in 400kV Rajaee Steam-Ziaran transmission line and the outage of transmission line after 100miliseconds（Peak Load）

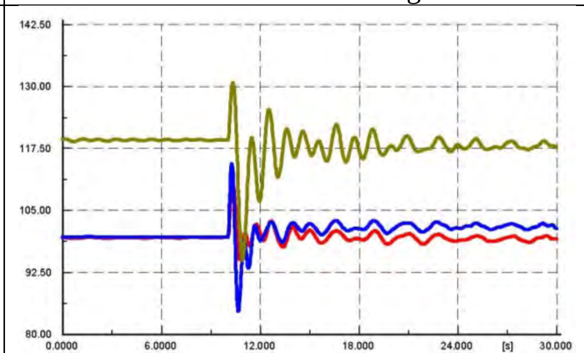
(14)1-7 Three-phase short circuit fault in 400kV Rajaee Steam-Ziaran transmission line（Light Load）

Generator Output



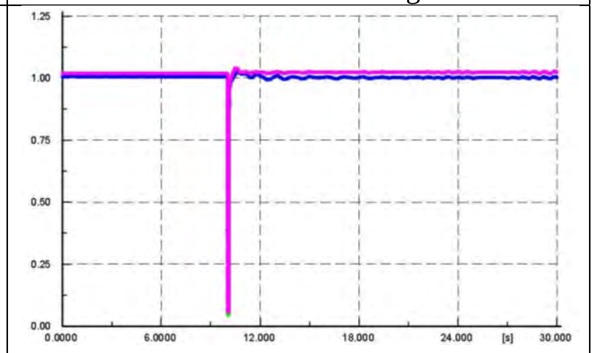
TEPSCO-G1, Active Power, MW
TEPSCO-G1, Reactive Power, MVar

Generator Internal Angle



SH-RAJAII(2), Rotor Angle, deg
SH-RAJAII(3), Rotor Angle, deg
SH-RAJAII(4), Rotor Angle, deg
TEPSCO-G1, Rotor Angle, deg

Generator Bus Voltage

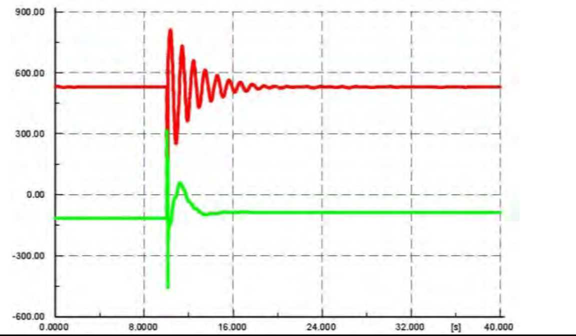
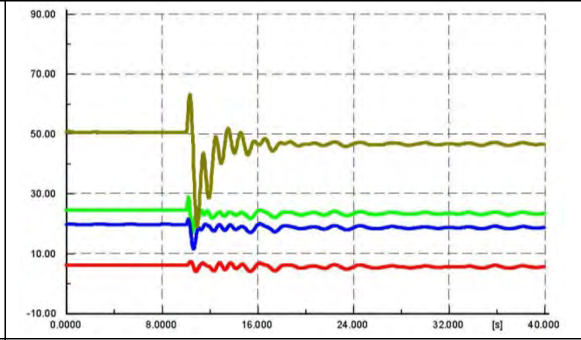
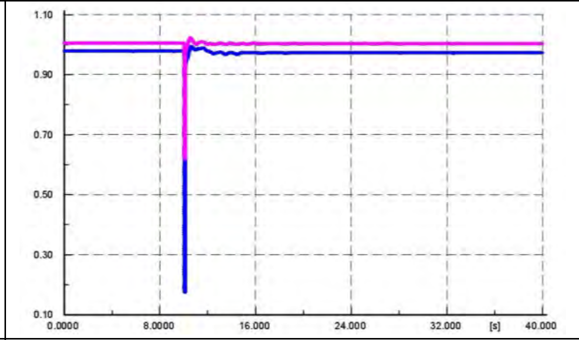


TEPSCO, Voltage, P.U.
SH-RAJAII(1), Voltage, P.U.
SH-RAJAII(S), Voltage, P.U.
SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-33 1-7 Three-phase short circuit fault in 400kV Rajaee Steam-Ziaran transmission line and the outage of transmission line after 100miliseconds（Light Load）

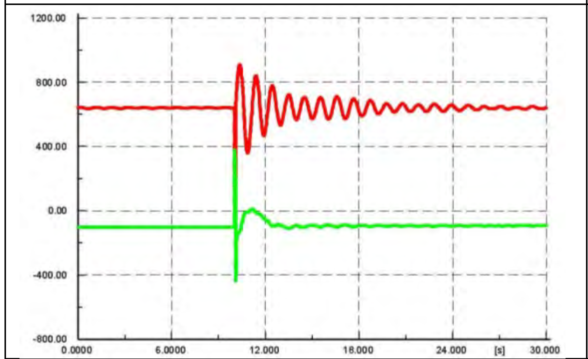
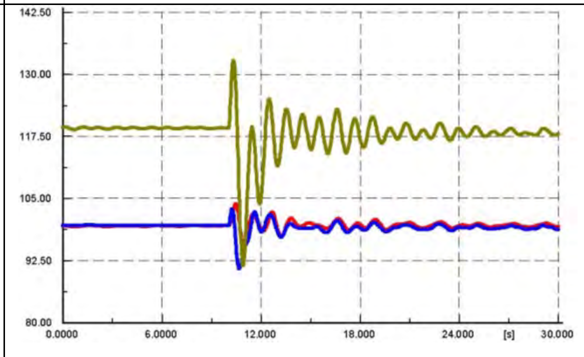
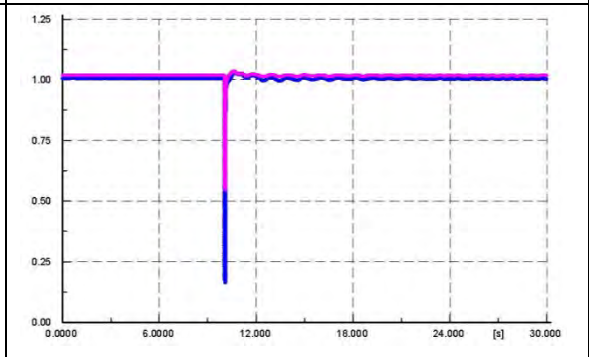
(15)1-8 Three-phase short circuit fault in 400kV Rajaee Steam-Loshan transmission line（Peak Load）

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-34 1-8 Three-phase short circuit fault in 400kV Rajaee Steam-Loshan transmission line and the outage of transmission line after 100miliseconds（Peak Load）

(16)1-8 Three-phase short circuit fault in 400kV Rajaee Steam-Loshan transmission line（Light Load）

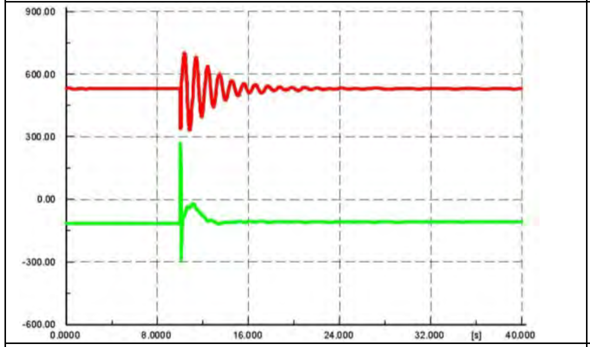
Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-35 1-8 Three-phase short circuit fault in 400kV Rajaee Steam-Loshan transmission line and the outage of transmission line after 100miliseconds（Light Load）

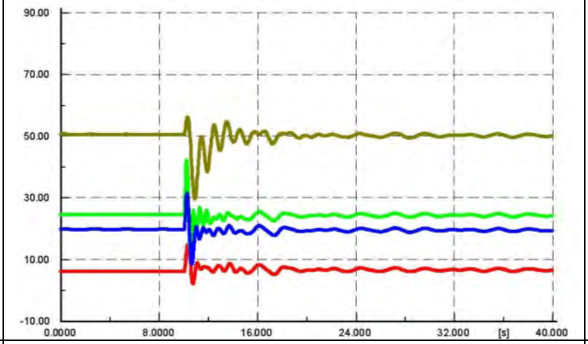
(17)1-9 Three-phase short circuit fault in 400kV Rajaee Steam-Roudshour transmission line（Peak Load）

Generator Output



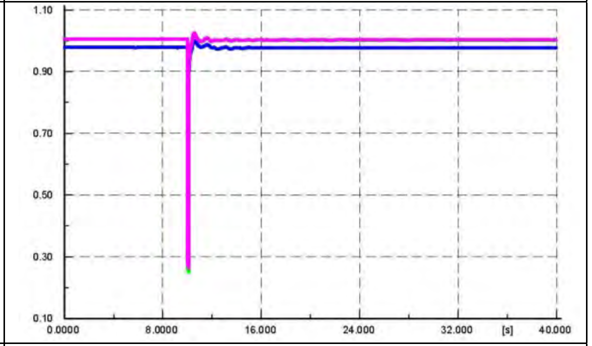
TEPSCO-G1, Active Power, MW
TEPSCO-G1, Reactive Power, MVar

Generator Internal Angle



SH-RAJAII(2), Rotor Angle, deg
SH-RAJAII(3), Rotor Angle, deg
SH-RAJAII(4), Rotor Angle, deg
TEPSCO-G1, Rotor Angle, deg

Generator Bus Voltage



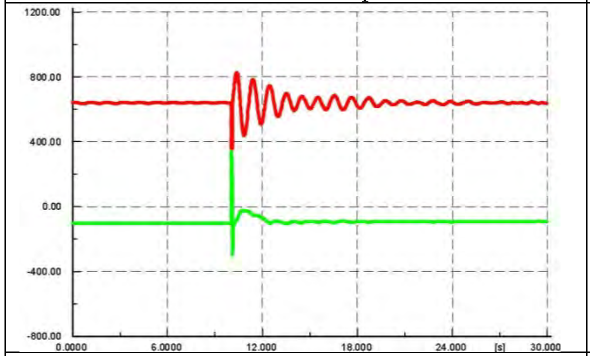
TEPSCO, Voltage, P.U.
SH-RAJAII(1), Voltage, P.U.
SH-RAJAII(S), Voltage, P.U.
SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-36 1-9 Three-phase short circuit fault in 400kV Rajaee Steam-Roudshour transmission line and the outage of transmission line after 100miliseconds（Peak Load）

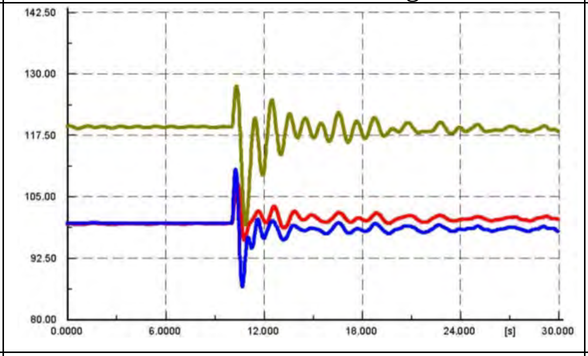
(18)1-9 Three-phase short circuit fault in 400kV Rajaee Steam-Roudshour transmission line（Light Load）

Generator Output



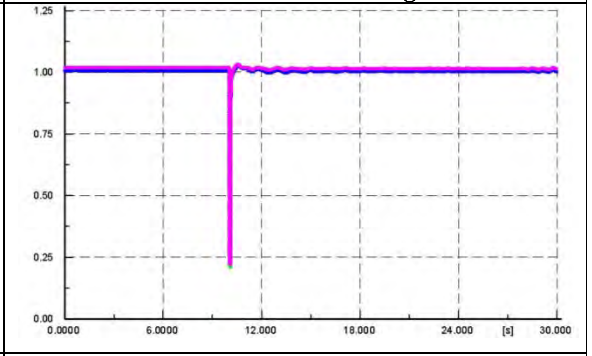
TEPSCO-G1, Active Power, MW
TEPSCO-G1, Reactive Power, MVar

Generator Internal Angle



SH-RAJAII(2), Rotor Angle, deg
SH-RAJAII(3), Rotor Angle, deg
SH-RAJAII(4), Rotor Angle, deg
TEPSCO-G1, Rotor Angle, deg

Generator Bus Voltage



TEPSCO, Voltage, P.U.
SH-RAJAII(1), Voltage, P.U.
SH-RAJAII(S), Voltage, P.U.
SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-37 1-9 Three-phase short circuit fault in 400kV Rajaee Steam-Roudshour transmission line and the outage of transmission line after 100miliseco(Light Load)

(19)2-1 The outage of Shahid Rajaee new generator unit (Peak Load)

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<tr><th>Generator Output</th><th>Generator Internal Angle</th><th>Generator Bus Voltage</th></tr>
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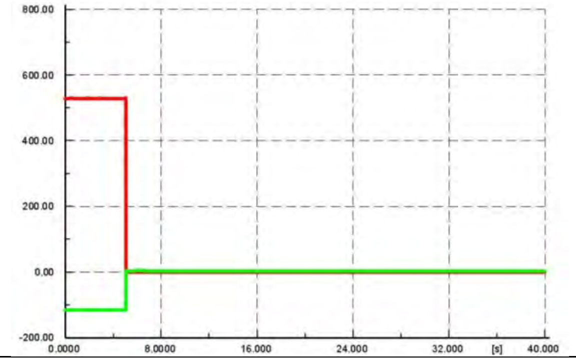

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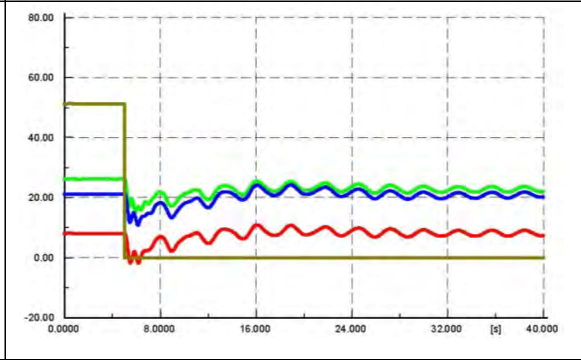

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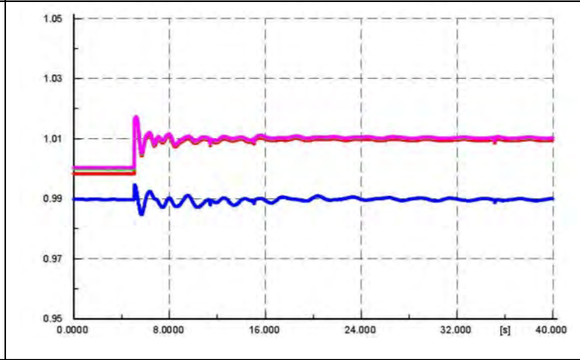

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<td>TEPSCO-G1, Active Power, MW
TEPSCO-G1, Reactive Power, MVar</td>
<td>SH-RAJAII(2), Rotor Angle, deg
SH-RAJAII(3), Rotor Angle, deg
SH-RAJAII(4), Rotor Angle, deg
TEPSCO-G1, Rotor Angle, deg</td>
<td>TEPSCO, Voltage, P.U.
SH-RAJAII(1), Voltage, P.U.
SH-RAJAII(S), Voltage, P.U.
SH-RAJAII(C.C), Voltage, P.U.</td>
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Source: calculated by JICA Study Team

Fig 5-38 2-1 The outage of Shahid Rajaee new generator unit (Peak Load)

(20)2-1 The outage of Shahid Rajaee new generator unit (Light Load)

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<tr><th>Generator Output</th><th>Generator Internal Angle</th><th>Generator Bus Voltage</th></tr>
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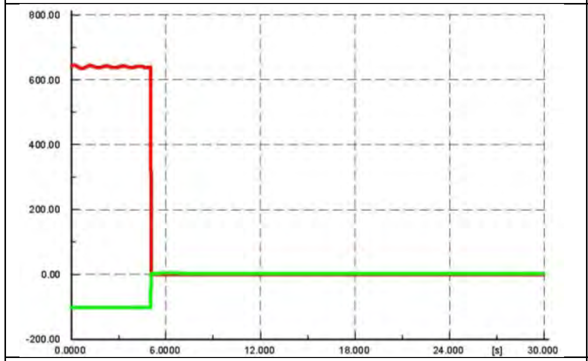

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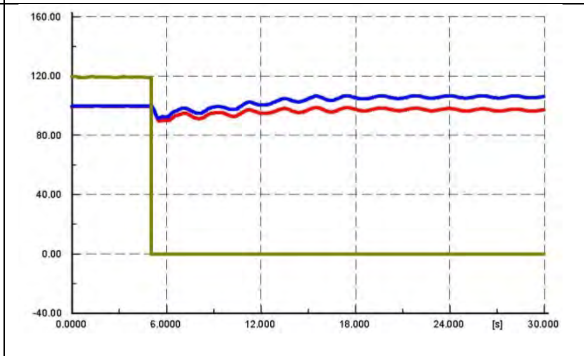

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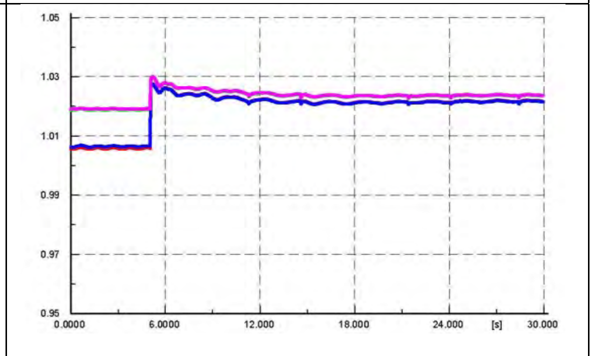
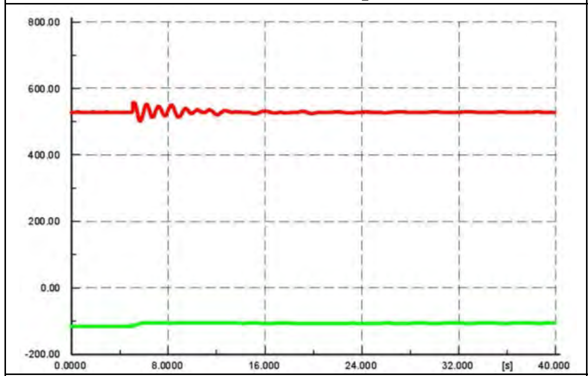
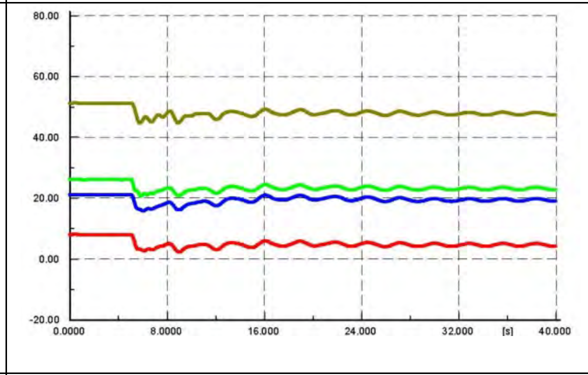
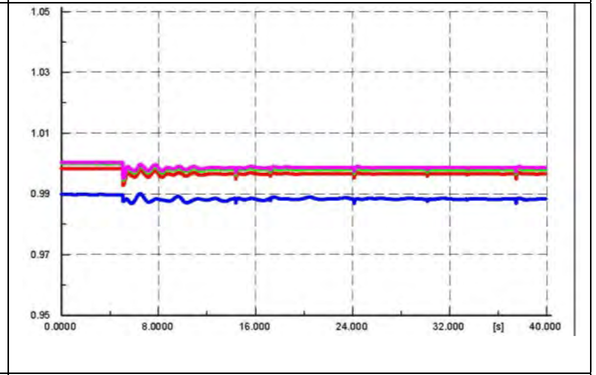


</td>
</tr>
<tr>
<td>TEPSCO-G1, Active Power, MW
TEPSCO-G1, Reactive Power, MVar</td>
<td>SH-RAJAII(2), Rotor Angle, deg
SH-RAJAII(3), Rotor Angle, deg
SH-RAJAII(4), Rotor Angle, deg
TEPSCO-G1, Rotor Angle, deg</td>
<td>TEPSCO, Voltage, P.U.
SH-RAJAII(1), Voltage, P.U.
SH-RAJAII(S), Voltage, P.U.
SH-RAJAII(C.C), Voltage, P.U.</td>
</tr>
</table>

Source: calculated by JICA Study Team

Fig 5-39 2-1 The outage of Shahid Rajaee new generator unit(Light Load)

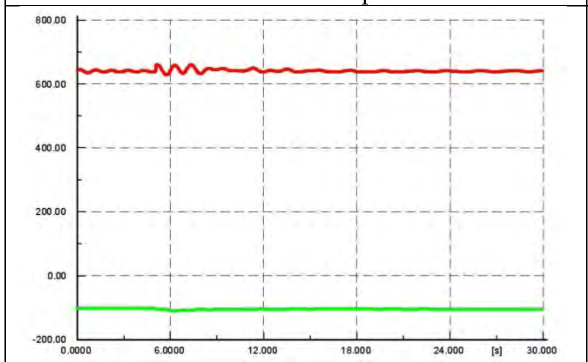
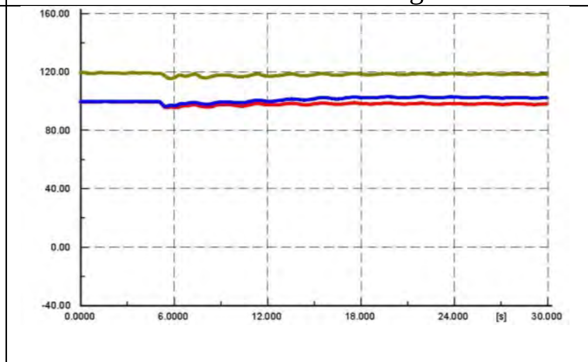
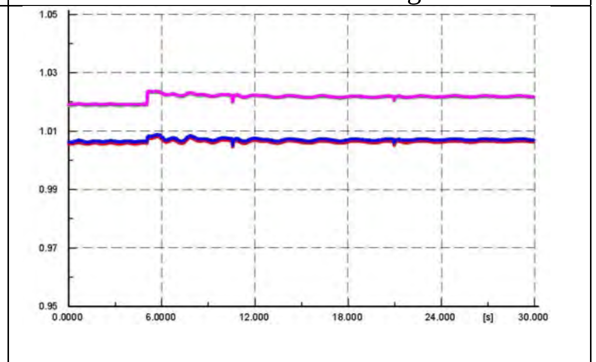
(21)2-2 The outage of Shahid Rajaee existing steam generator unit (Peak Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-40 2-2 The outage of Shahid Rajaee existing steam generator unit (Peak Load)

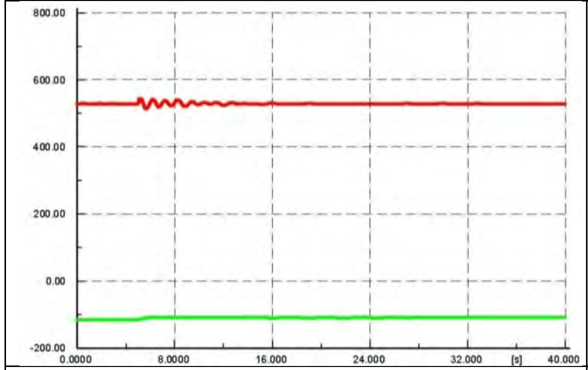
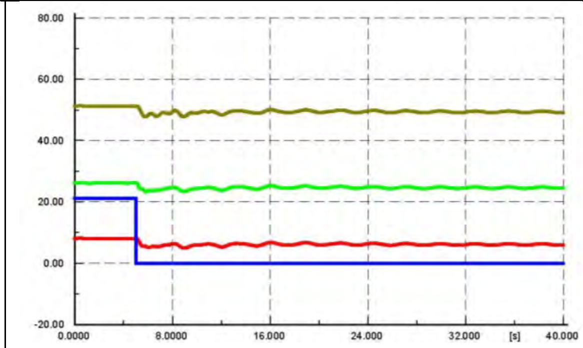
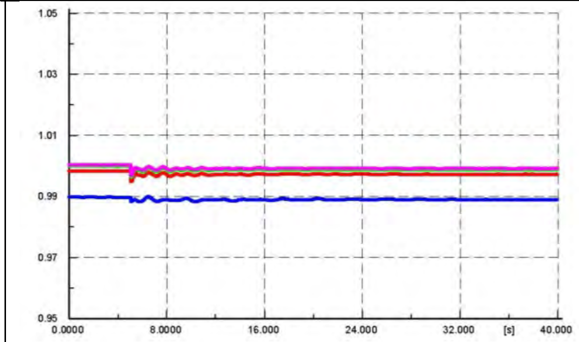
(22)2-2 The outage of Shahid Rajaee existing steam generator unit (Light Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-41 2-2 The outage of Shahid Rajaee existing steam generator unit (Light Load)

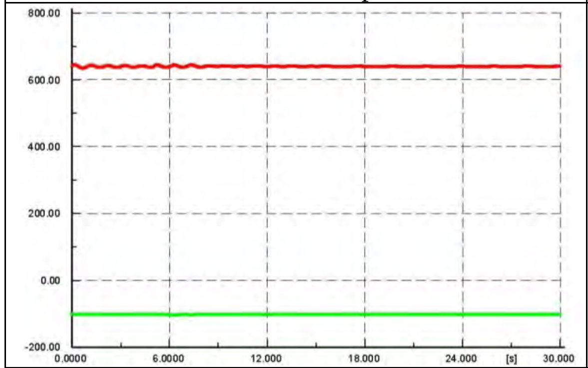
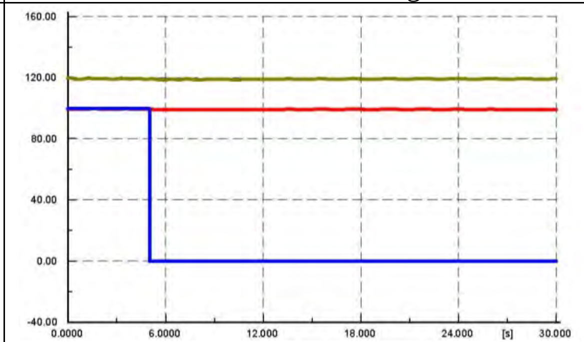
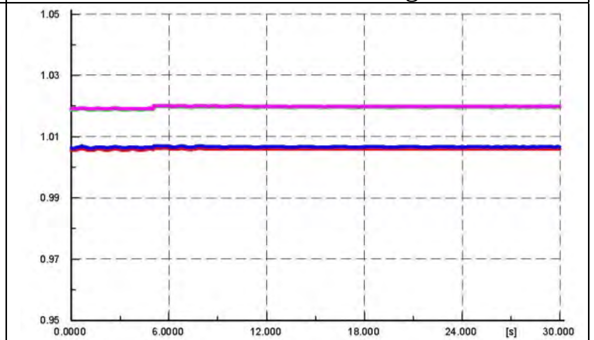
(23)2-3 The outage of Shahid Rajaee existing combined generator unit (Peak Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-42 2-3 The outage of Shahid Rajaee existing combined generator unit (Peak Load)

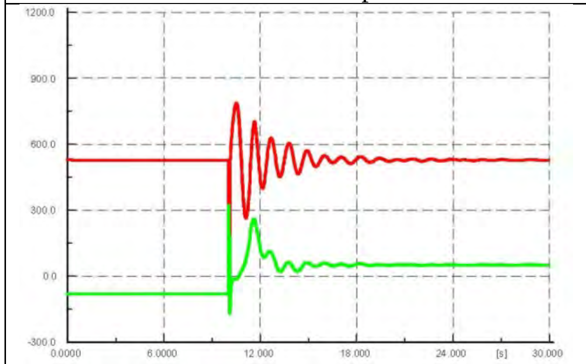
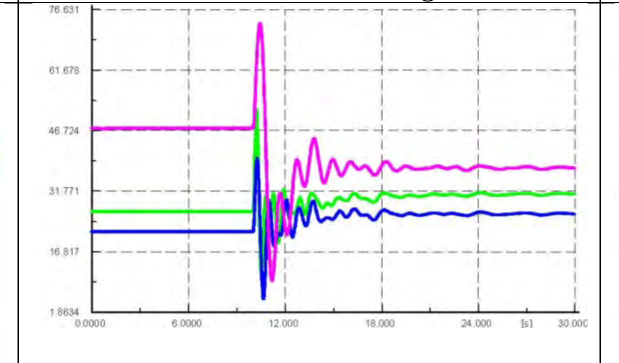
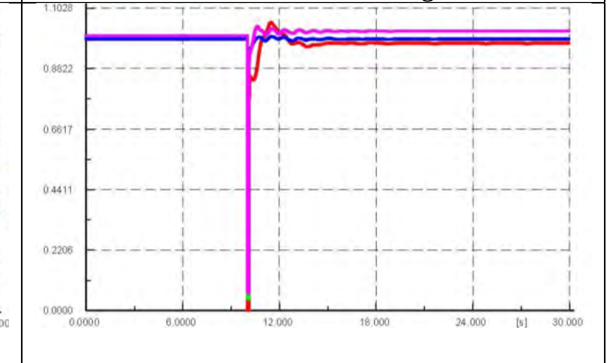
(24)2-3 The outage of Shahid Rajaee existing combined generator unit (Light Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-43 2-3 The outage of Shahid Rajaee existing combined generator unit (Light Load)

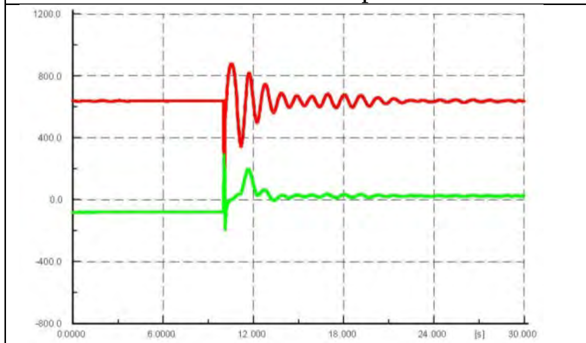
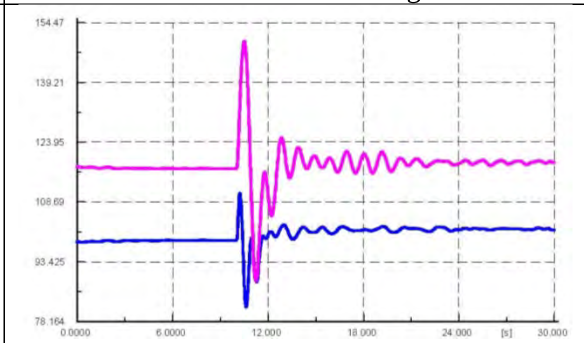
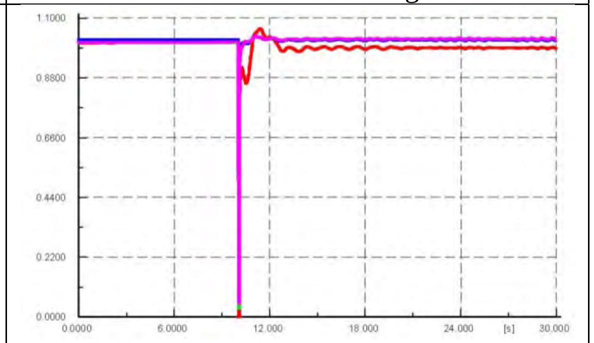
(25)2-4Three-phase short circuit fault in 400kV Shahid Rajaee new power plant-Rajaee Steam transmission line(Peak Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-44 2-4 Three-phase short circuit fault in 400kV Shahid Rajaee new power plant-Rajaee Steam transmission line and the outage of transmission line after 100miliseconds (Peak Load)

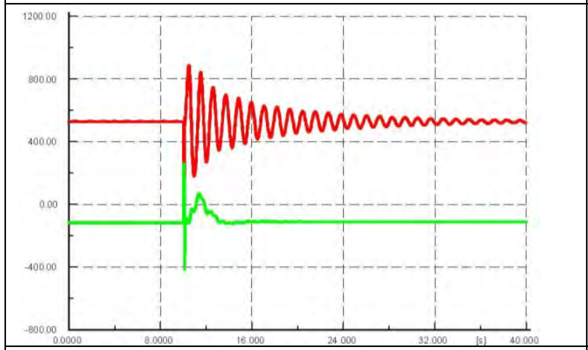
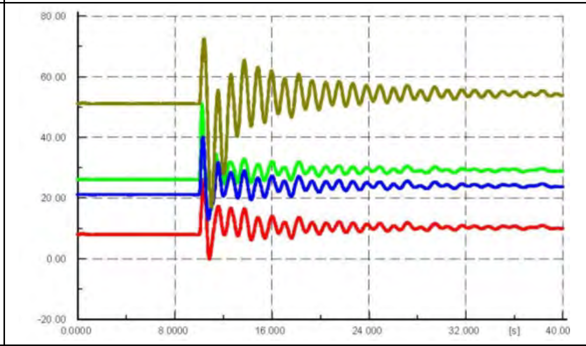
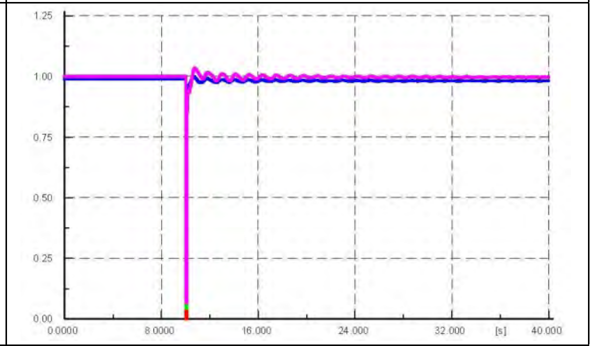
(26)2-4Three-phase short circuit fault in 400kV Shahid Rajaee new power plant-Rajaee Steam transmission line(Light Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-45 2-4 Three-phase short circuit fault in 400kV Shahid Rajaee new power plant-Rajaee Steam transmission line and the outage of transmission line after 100miliseconds (Light Load)

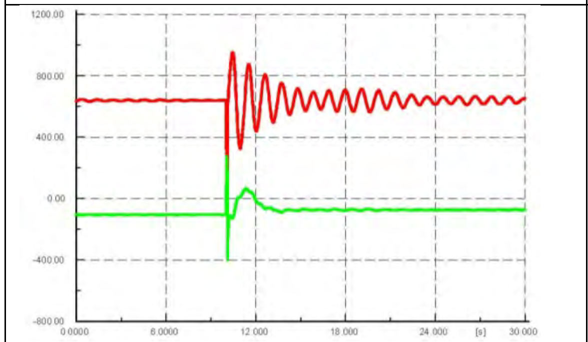
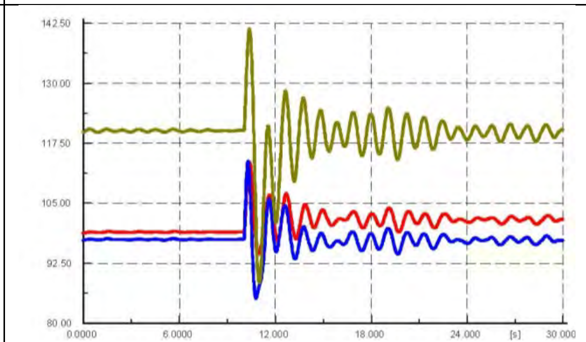
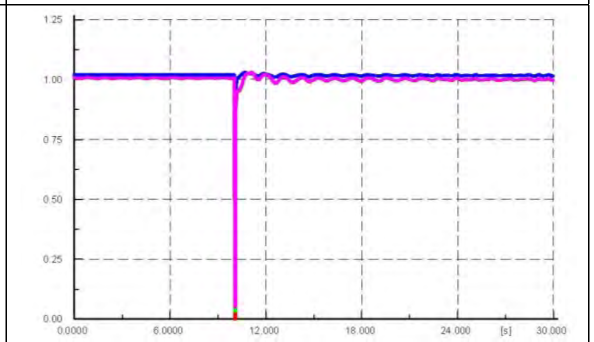
(27)2-5 Three-phase short circuit fault in 400kV Shahid Rajaee new power plant- Vardavard transmission line（Peak Load）

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-46 2-5 Three-phase short circuit fault in 400kV Shahid Rajaee new power plant- Vardavard transmission line and the outage of transmission line after 100miliseconds (Peak Load)

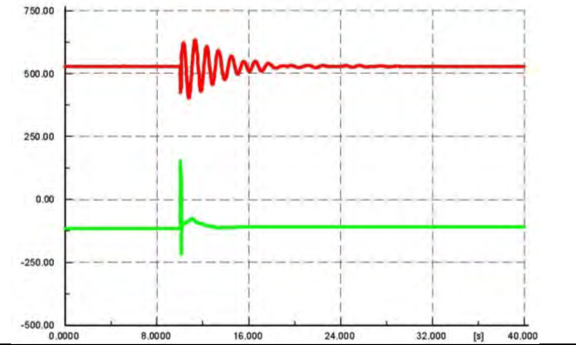
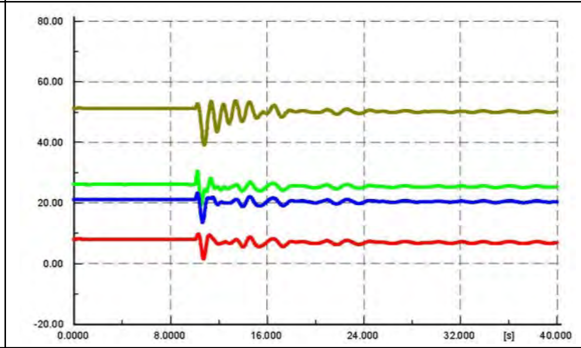
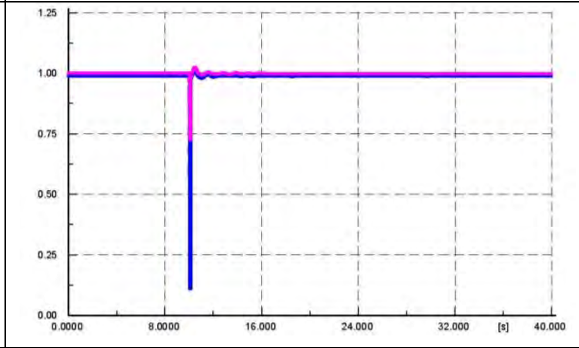
(28)2-5 Three-phase short circuit fault in 400kV Shahid Rajaee new power plant- Vardavard transmission line（Light Load）

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-47 2-5 Three-phase short circuit fault in 400kV Shahid Rajaee new power plant- Vardavard transmission line and the outage of transmission line after 100miliseconds(Light Load)

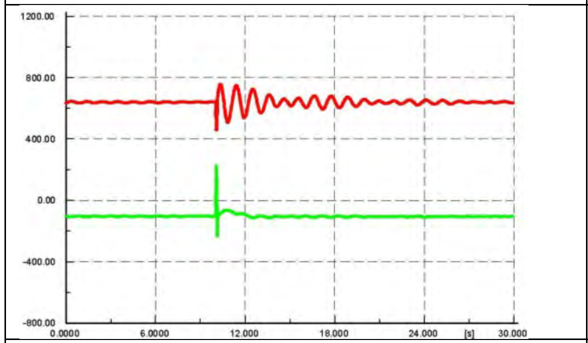
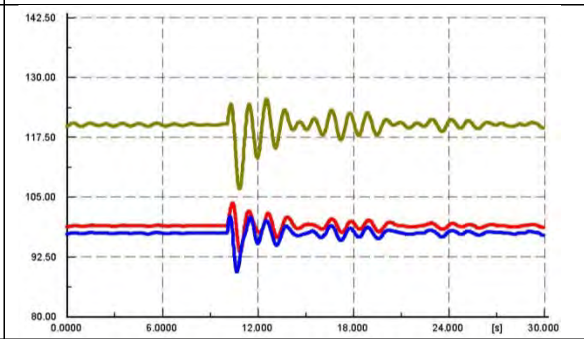
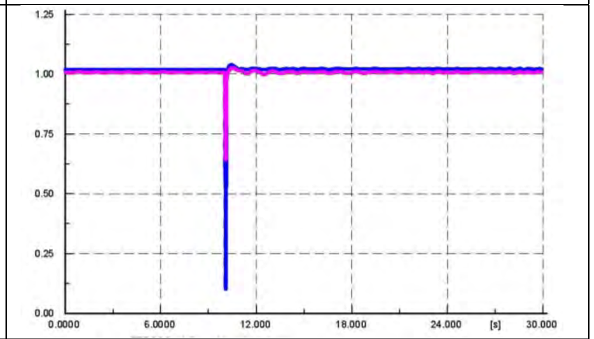
(29)2-6 Three-phase short circuit fault in 400kV Rajaee Steam-Minoodar transmission line（Peak Load）

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-48 2-6 Three-phase short circuit fault in 400kV Rajaee Steam-Minoodar transmission line and the outage of transmission line after 100miliseconds（Peak Load）

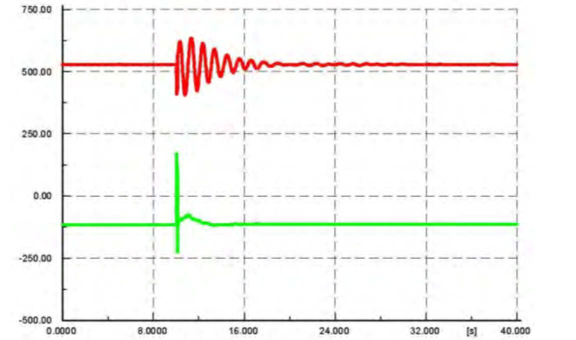
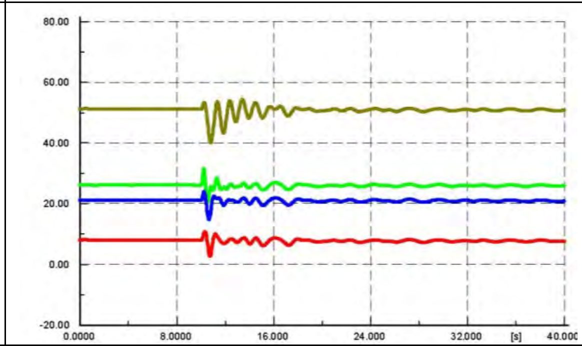
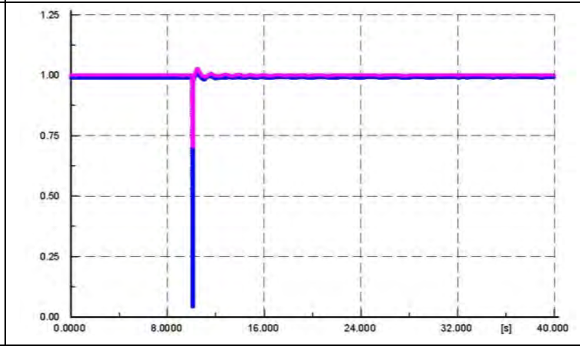
(30)2-6 Three-phase short circuit fault in 400kV Rajaee Steam-Minoodar transmission line（Light Load）

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-49 2-6 Three-phase short circuit fault in 400kV Rajaee Steam-Minoodar transmission line and the outage of transmission line after 100miliseconds(Light Load)

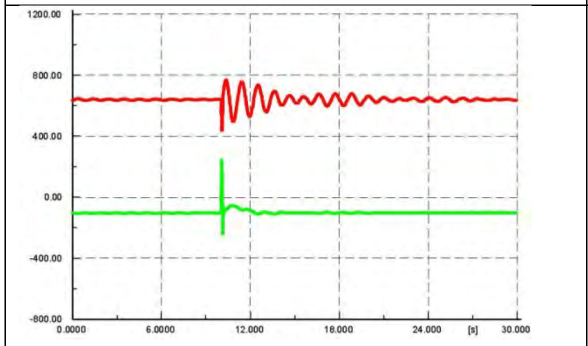
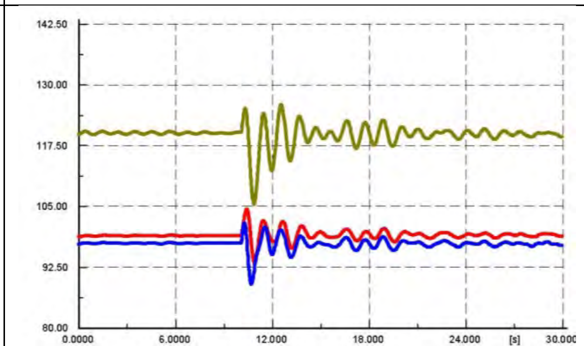
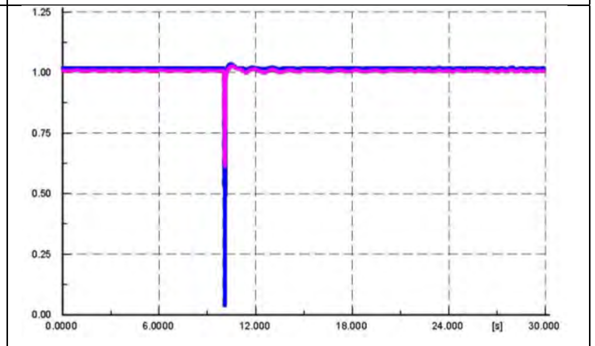
(31)2-7 Three-phase short circuit fault in 400kV Rajaee Steam-Ziaran transmission line（Peak Load）

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-50 2-7 Three-phase short circuit fault in 400kV Rajaee Steam-Ziaran transmission line and the outage of transmission line after 100miliseconds（Peak Load）

(32)2-7 Three-phase short circuit fault in 400kV Rajaee Steam-Ziaran transmission line（Light Load）

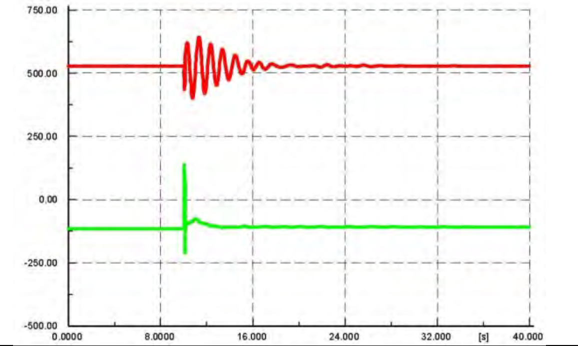
Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-51 2-7 Three-phase short circuit fault in 400kV Rajaee Steam-Ziaran transmission line and the outage of transmission line after 100miliseconds（Light Load）

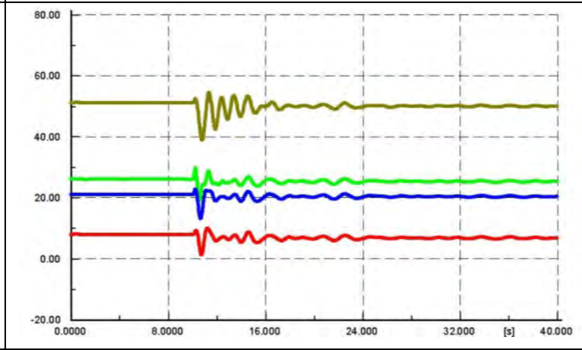
(33)2-8 Three-phase short circuit fault in 400kV Rajaee Steam-Loshan transmission line（Peak Load）

Generator Output



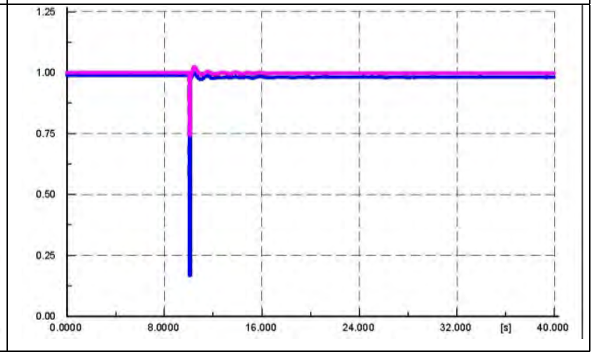
TEPSCO-G1, Active Power, MW
TEPSCO-G1, Reactive Power, MVar

Generator Internal Angle



SH-RAJAII(2), Rotor Angle, deg
SH-RAJAII(3), Rotor Angle, deg
SH-RAJAII(4), Rotor Angle, deg
TEPSCO-G1, Rotor Angle, deg

Generator Bus Voltage



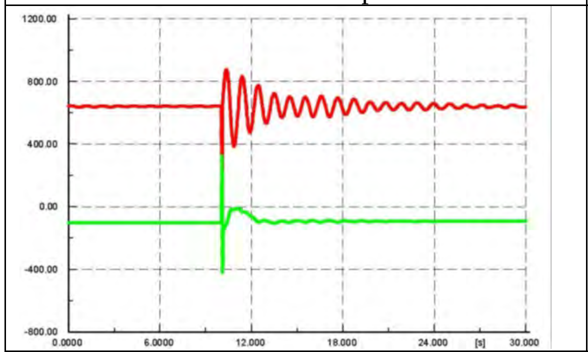
TEPSCO, Voltage, P.U.
SH-RAJAII(1), Voltage, P.U.
SH-RAJAII(S), Voltage, P.U.
SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-52 2-8 Three-phase short circuit fault in 400kV Rajaee Steam-Loshan transmission line and the outage of transmission line after 100miliseconds（Peak Load）

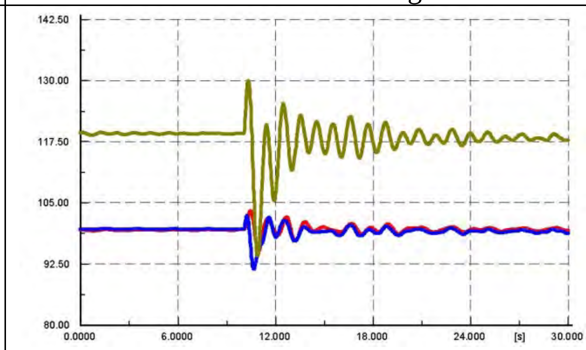
(34)2-8 Three-phase short circuit fault in 400kV Rajaee Steam-Loshan transmission line（Light Load）

Generator Output



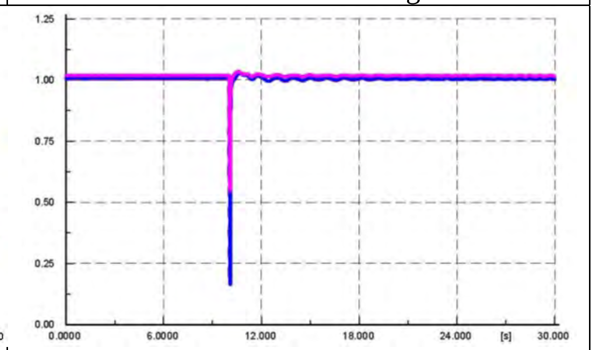
TEPSCO-G1, Active Power, MW
TEPSCO-G1, Reactive Power, MVar

Generator Internal Angle



SH-RAJAII(2), Rotor Angle, deg
SH-RAJAII(3), Rotor Angle, deg
SH-RAJAII(4), Rotor Angle, deg
TEPSCO-G1, Rotor Angle, deg

Generator Bus Voltage

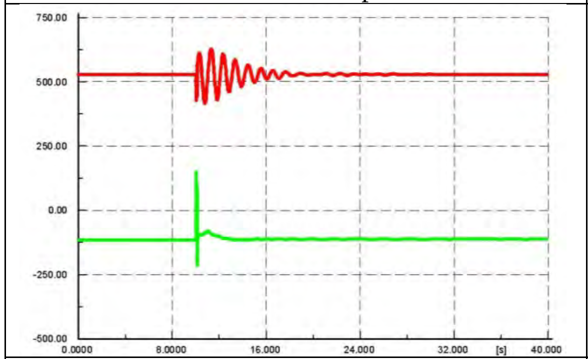
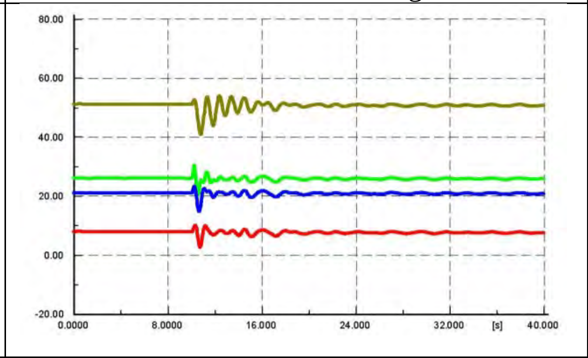
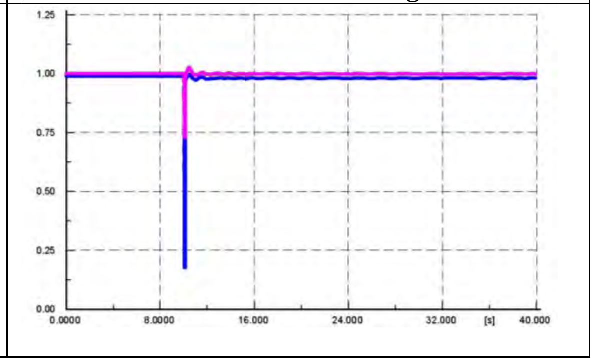


TEPSCO, Voltage, P.U.
SH-RAJAII(1), Voltage, P.U.
SH-RAJAII(S), Voltage, P.U.
SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-53 2-8 Three-phase short circuit fault in 400kV Rajaee Steam-Loshan transmission line and the outage of transmission line after 100miliseconds（Light Load）

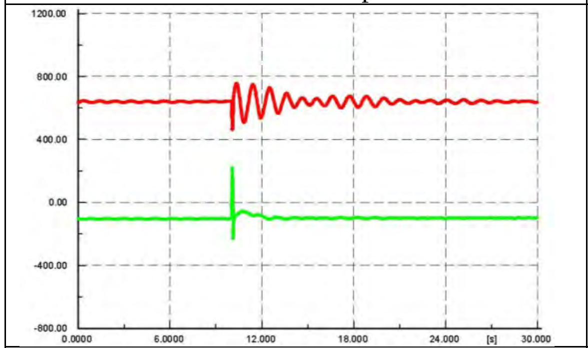
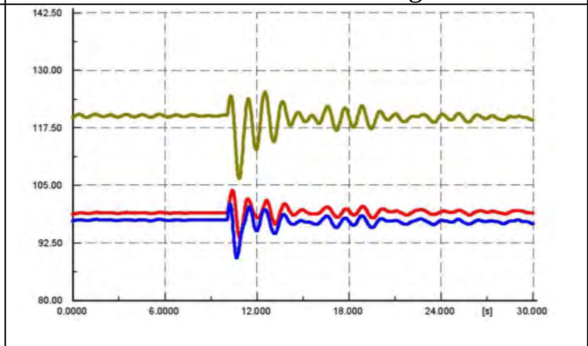
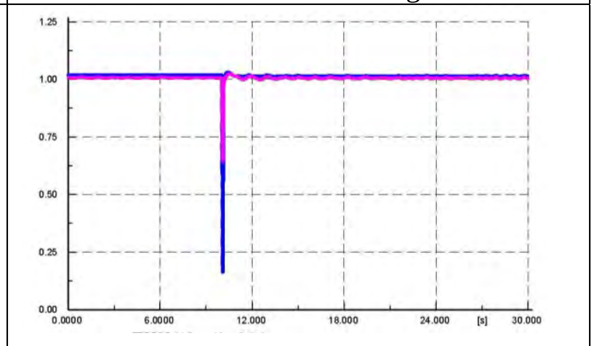
(35)2-9 Three-phase short circuit fault in 400kV Rajaee Steam-Roudshour transmission line（Peak Load）

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-54 2-9 Three-phase short circuit fault in 400kV Rajaee Steam-Roudshour transmission line and the outage of transmission line after 100miliseconds（Peak Load）

(36)2-9 Three-phase short circuit fault in 400kV Rajaee Steam-Roudshour transmission line（Light Load）

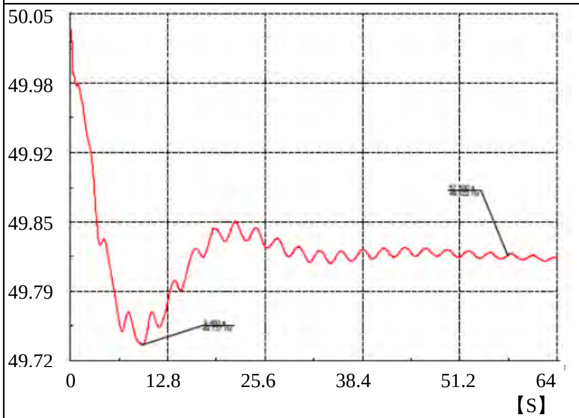
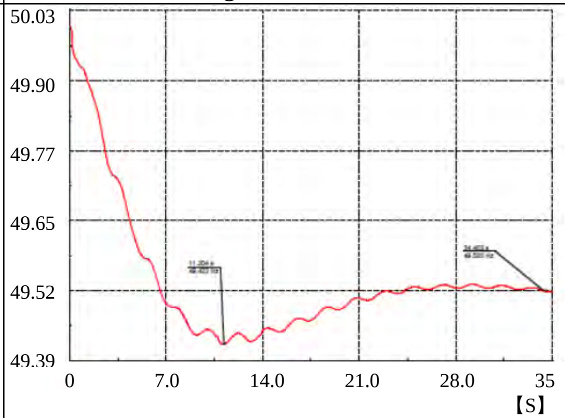
Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-55 2-9 Three-phase short circuit fault in 400kV Rajaee Steam-Roudshour transmission line and the outage of transmission line after 100miliseconds (Light Load)

5.2.6 Result of power system frequency calculation after generator unit outage

In the case scenario of the outage of Shahid Rajaee new generator unit, it is confirmed that the system frequency is 49.52Hz.

Peak Load【Hz】	Light Load【Hz】
	
・Minimum frequency：49.737Hz—9.5s ・Final frequency：49.822Hz—57.5s	・Minimum frequency：49.422Hz—11.2s ・Final frequency：49.520Hz--34.4s

Source: calculated by JICA Study Team

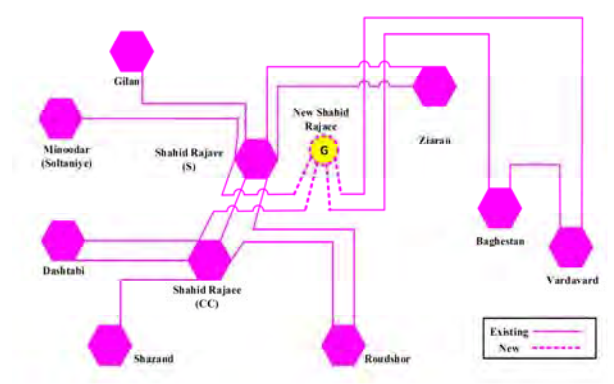
Fig 5-56 System Frequency of the outage of Shahid Rajaee new generator unit

5.3 Result of Power system analysis on 2π connection

For the power system connection of the new generator, we carried out power system analysis of two line attraction and π pulling from the Vardavard transmission line.
Subsequently, based on the request from TAVANIR who is managing the entire power system, considering power system reliability aspect, we carried out additional power system analysis of 2π pulling from the Vardavard transmission line and the Baghestan transmission line.

(1) System connection method of new generator

The switch gear is newly established, and the 2π connection
（Shahid Rajaee(S)～Vardavard, Shahid Rajaee(CC)～Baghestan）



Source: Obtained from Google Earth, and prepared by JICA Study Team

Fig 5-57 System connection method of new generator

5.3.1 Result of pre calculation（2π connection）

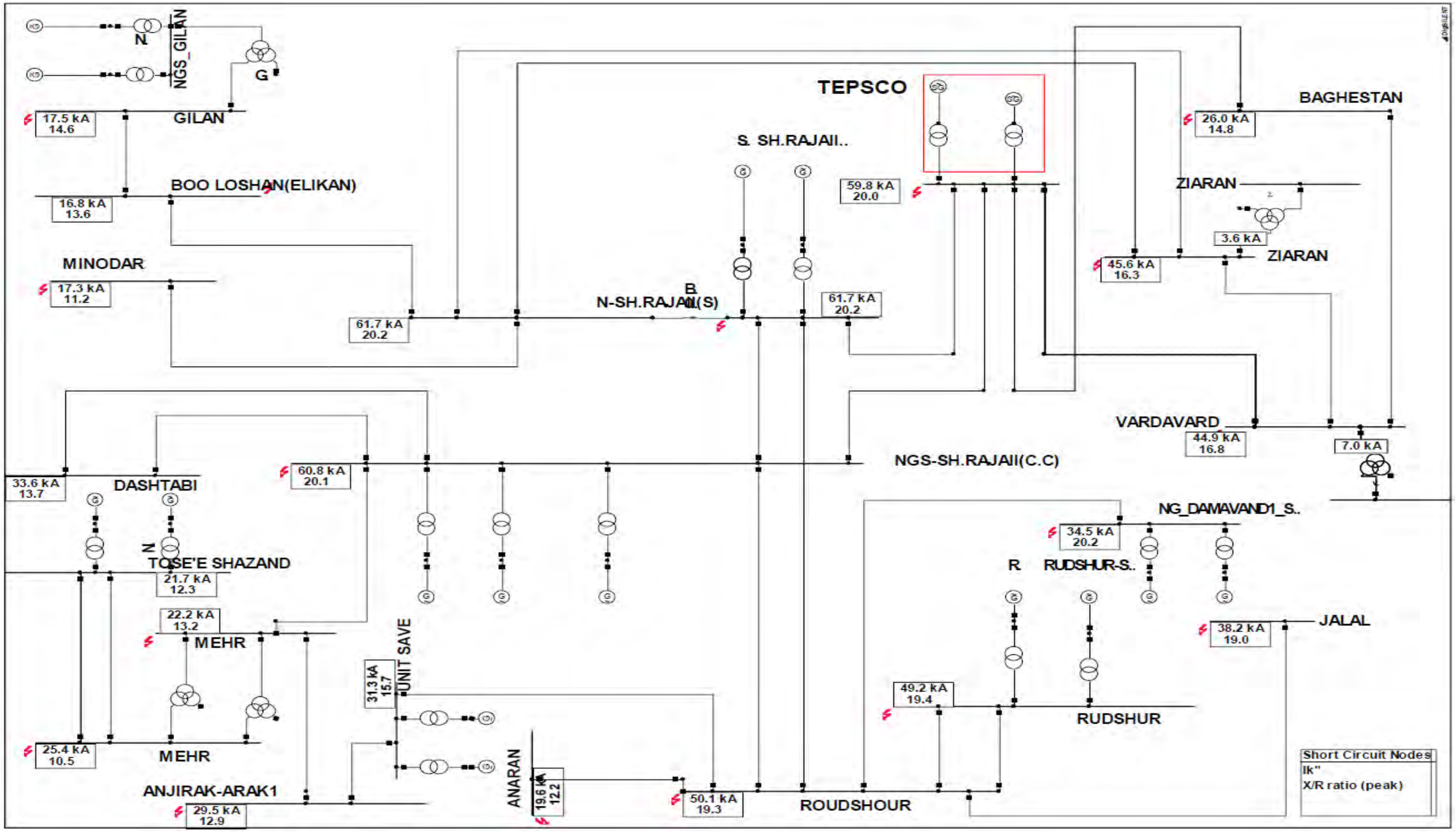
(1)Result of Three-phase short circuit current

As shown in Table 5-19 and Fig. 5-58, when a new generator is connected with 2π connection（Shahid Rajaee (S) ~ Vardavard, Shahid Rajaee (CC) ~ Baghestan）, the three-phase short circuit current exceeds 50 kA pre and post new generator interconnection.

Table 5-19 Three-phase short circuit current(pre and post new generator interconnection)
【2π connection（Shahid Rajaee(S)～Vardavard, Shahid Rajaee(CC)～Baghestan）】

Substation Name	Voltage (kV)	Pre-connection		Post-connection	
		Ikss (kA)	X/R	Ikss (kA)	X/R
ANARAN	400	19.5	12.2	19.6	12.2
ANJIRAK-ARAK	400	29.5	12.9	29.5	12.9
BAGHESTAN	400	25.4	14.7	26	14.8
BOO	400	16.7	13.7	16.8	13.6
DASHTABI	400	31.9	13.5	33.6	13.7
GILAN	400	17.4	14.6	17.5	14.6
JALAL	400	38.1	19.1	38.2	19
MEHR	400	22.2	13.2	22.2	13.2
MEHR	230	25.4	10.5	25.4	10.5
MINODAR	400	17.0	11.2	17.3	11.2
N-SH.RAJAII(S)	400	55.9	18.7	61.7	20.2
NGS-SH.RAJAII(C.C)	400	55.0	18.7	60.8	20.1
NGS_GILAN	230	44.7	13.4	44.8	13.3
NG_DAMAVAND	400	34.3	20.3	34.5	20.2
ROUDSHOUR	400	49.5	19.3	50.1	19.3
RUDSHUR	400	48.6	19.4	49.2	19.4
NEW P/S	400	-	-	59.8	20
TOSE'E SHAZAND	230	21.7	12.3	21.7	12.3
UNIT SAVE	400	31.2	15.7	31.3	15.7
VARDAVARD	400	43.7	16.8	44.9	16.8
ZIARAN	400	43.2	16.0	45.6	16.3

Source: calculated by JICA Study Team



Source: calculated by JICA Study Team

Fig 5-58 Three-phase short circuit current (post new generator interconnection)【2π connection（Shahid Rajaee(S)～Vardavard, Shahid Rajaee(CC)～Baghestan）】

(2)Result of Single-phase short-circuit current

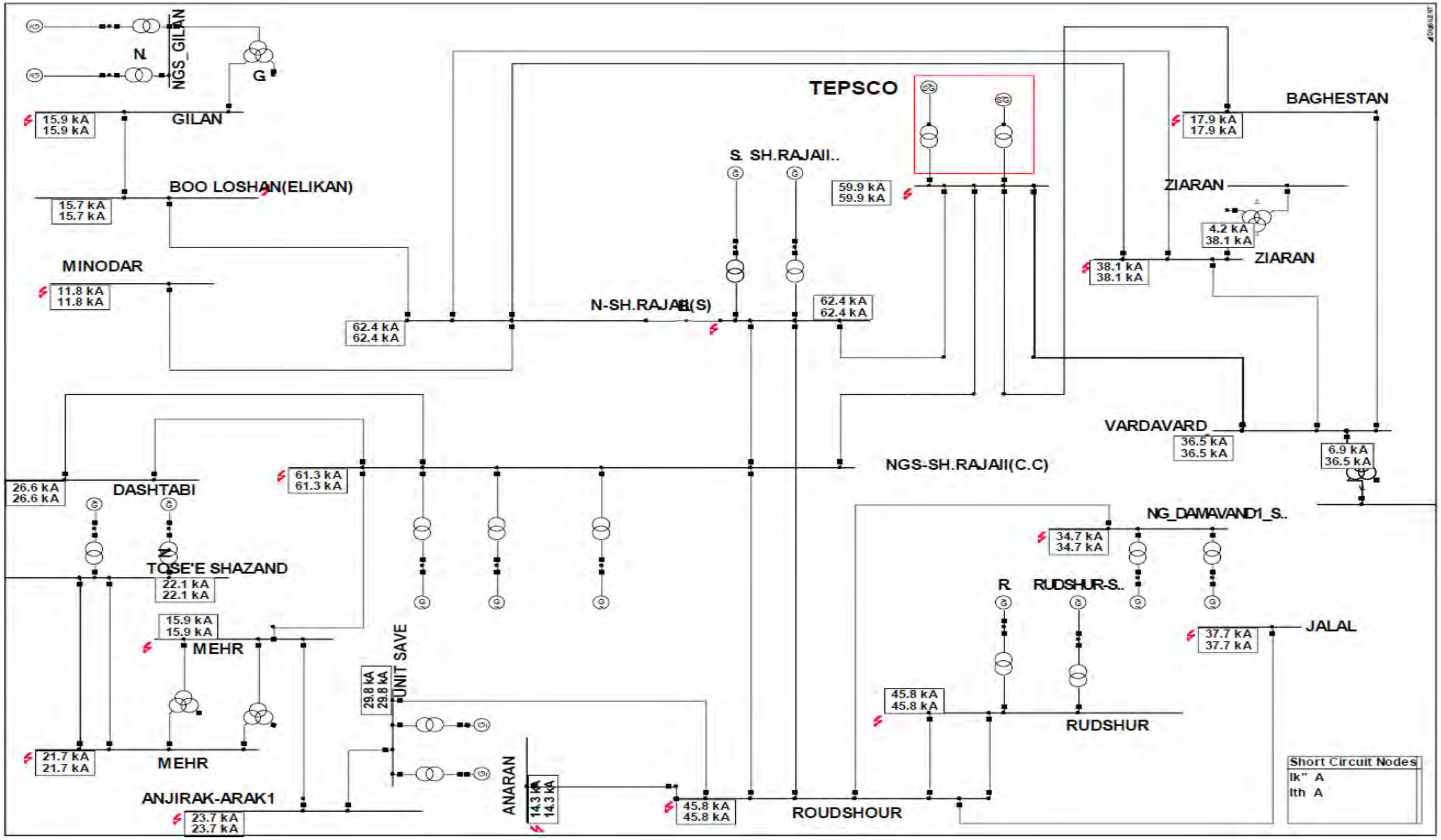
As shown in Table 5-20 and Fig. 5-59, when a new generator is connected with 2π connection （Shahid Rajaee (S) ~ Vardavard, Shahid Rajaee (CC) ~ Baghestan）, the Single-phase short-circuit current exceeds 50 kA pre and post new generator interconnection.

Table 5-20 Single-phase short-circuit current (pre and post new generator interconnection)

【2 π connection（Shahid Rajaee(S)～Vardavard, Shahid Rajaee(CC)～Baghestan）】

Substation Name	Voltage (kV)	Pre-connection		Post-connection	
		Ikss (kA)	X/R	Ikss (kA)	X/R
ANARAN	400	14.3	14.3	14.3	14.3
ANJIRAK-ARAK	400	23.7	23.7	23.7	23.7
BAGHESTAN	400	17.5	17.5	17.9	17.9
BOO	400	15.6	15.6	15.7	15.7
DASHTABI	400	25.1	25.1	26.6	26.6
GILAN	400	15.9	15.9	15.9	15.9
JALAL	400	37.7	37.7	37.7	37.7
MEHR	400	15.9	15.9	15.9	15.9
MEHR	230	21.7	21.7	21.7	21.7
MINODAR	400	11.6	11.6	11.8	11.8
N-SH.RAJAII(S)	400	54.2	54.2	62.4	62.4
NGS-SH.RAJAII(C.C)	400	53.1	53.1	61.3	61.3
NGS_GILAN	230	45.2	45.2	45.2	45.2
NG_DAMAVAND	400	34.5	34.5	34.7	34.7
ROUDSHOUR	400	45.4	45.4	45.8	45.8
RUDSHUR	400	45.4	45.4	45.8	45.8
NEW P/S	400	-	-	59.9	59.9
TOSE'E SHAZAND	230	22.1	22.1	22.1	22.1
UNIT SAVE	400	29.7	29.7	29.8	29.8
VARDAVARD	400	35.7	35.7	36.5	36.5
ZIARAN	400	36.1	36.1	38.1	38.1

Source: calculated by JICA Study Team



Source: calculated by JICA Study Team

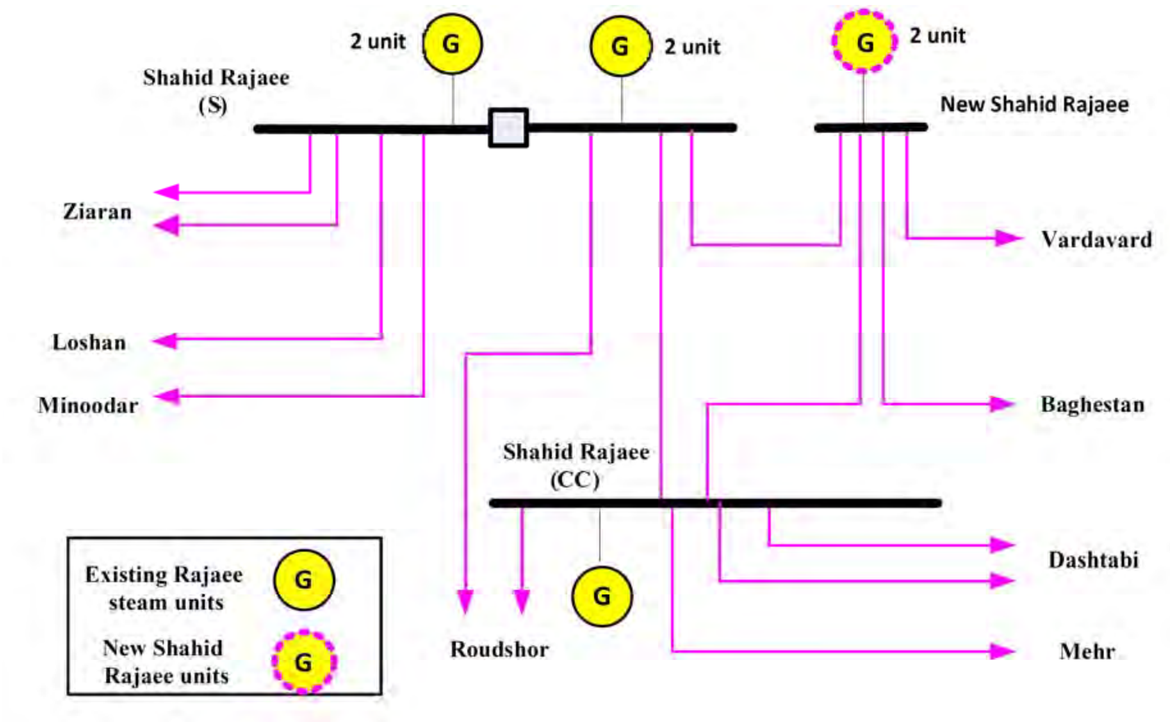
Fig 5-59 Single-phase short-circuit current (post new generator interconnection)

【2 π connection（Shahid Rajaee(S)～Vardavard,Shahid Rajaee(CC)～Baghestan)】

5.3.2 Method of fault current reduction【Bus-splitting】(2π connection, Bus-splitting)

In order to reduce the short circuit level, the bus splitting should be done in Shahid Rajaee Steam 400kV switchyard in such way that the amount of short circuit levels after bus-splitting are lower than the circuit breakers rated capacity.

(1) Bus-splitting at new power plant connection to 400kV 2Bus-splitting at Shahid Rajaee(S)～Vardavard,Shahid Rajaee(CC)～Baghestan)



Source: prepared by JICA Study Team

Fig 5-60 Bus-splitting in Rajaee steam substation for fault current reduction
【2π connection（Shahid Rajaee(S)～Vardavard, Shahid Rajaee(CC)～Baghestan）】

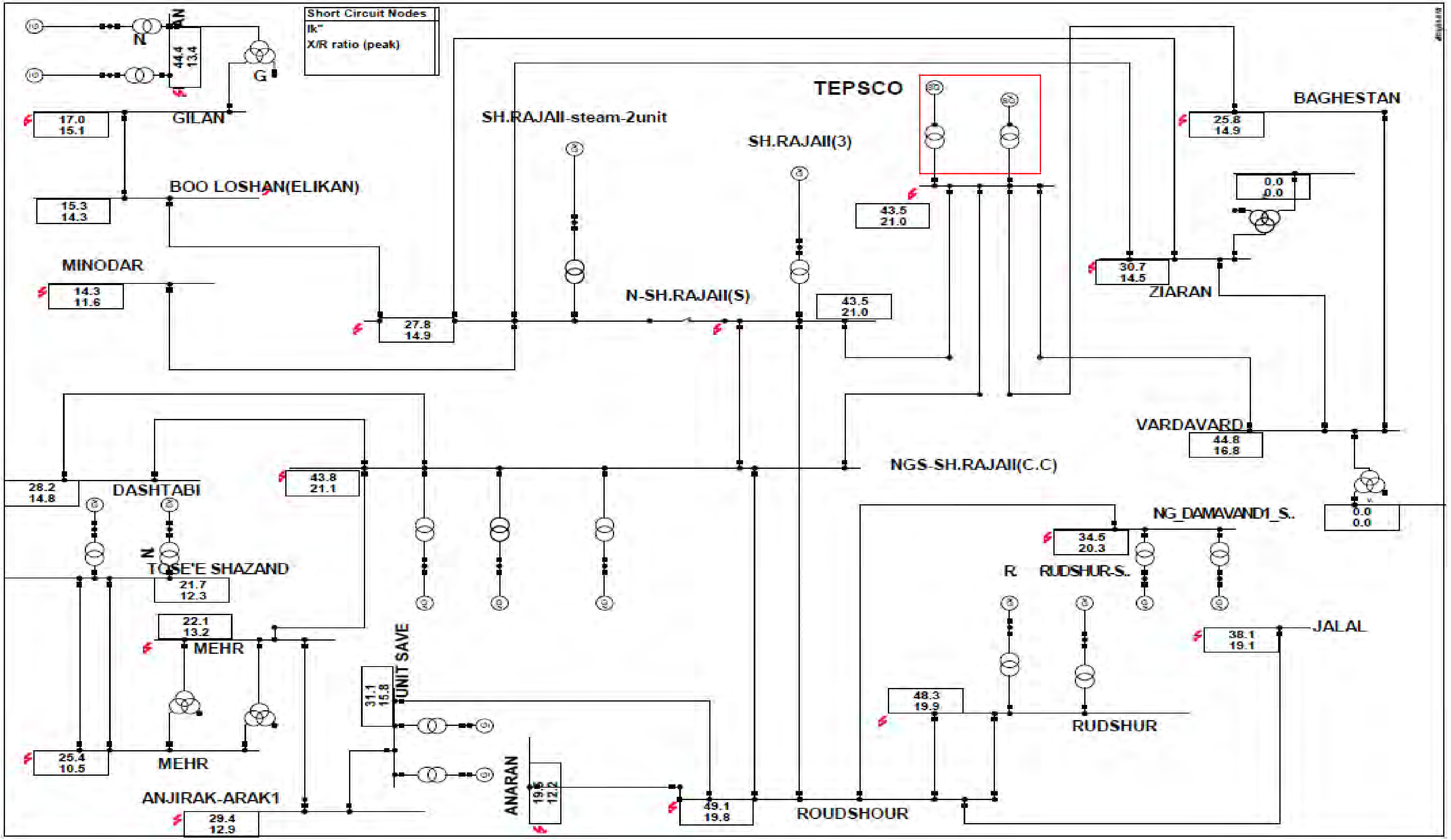
(2) Three-phase short circuit current after bus-splitting

As shown in Table 5-21 and Fig. 5-61, the three-phase short-circuit current is below 50 kA, when a new generator is connected with 2π connection（Shahid Rajaee (S) ~ Vardavard, Shahid Rajaee (CC) ~ Baghestan）, after the bus splitting operation measures execution and system interconnection of new generators.

Table 5-21 The three-phase short-circuit current after the bus splitting operation measures execution 【2π connection（Shahid Rajaee(S)～Vardavard, Shahid Rajaee(CC)～Baghestan）】

Substation Name	Voltage (kV)	Pre-splitting		Post- splitting	
		Ikss (kA)	X/R	Ikss (kA)	X/R
ANARAN	400	19.6	12.2	19.5	12.2
ANJIRAK-ARAK	400	29.5	12.9	29.4	12.9
BAGHESTAN	400	26	14.8	25.8	14.9
BOO	400	16.8	13.6	15.3	14.3
DASHTABI	400	33.6	13.7	28.2	14.8
GILAN	400	17.5	14.6	17.0	15.1
JALAL	400	38.2	19	38.1	19.1
MEHR	400	22.2	13.2	22.1	13.2
MEHR	230	25.4	10.5	25.4	10.5
MINODAR	400	17.3	11.2	14.3	11.6
N-SH.RAJAII(S)-1	400	61.7	20.2	43.5	21.0
N-SH.RAJAII(S)-2	400	61.7	20.2	27.8	14.9
NGS-SH.RAJAII(C.C)	400	60.8	20.1	43.8	21.1
NGS_GILAN	230	44.8	13.3	44.4	13.4
NG_DAMAVAND	400	34.5	20.2	34.5	20.3
ROUDSHOUR	400	50.1	19.3	49.1	19.8
RUDSHUR	400	49.2	19.4	48.3	19.9
NEW P/S	400	59.8	20	43.5	21.0
TOSE'E SHAZAND	230	21.7	12.3	21.7	12.3
UNIT SAVE	400	31.3	15.7	31.1	15.8
VARDAVARD	400	44.9	16.8	44.8	16.8
ZIARAN	400	45.6	16.3	30.7	14.5

Source: calculated by JICA Study Team



Source: calculated by JICA Study Team

Fig 5-61 The three-phase short-circuit current after the bus splitting operation measures execution

【2π connection（Shahid Rajaee(S)～Vardavard, Shahid Rajaee(CC)～Baghestan）】

(3) Single-phase short-circuit current after bus-splitting

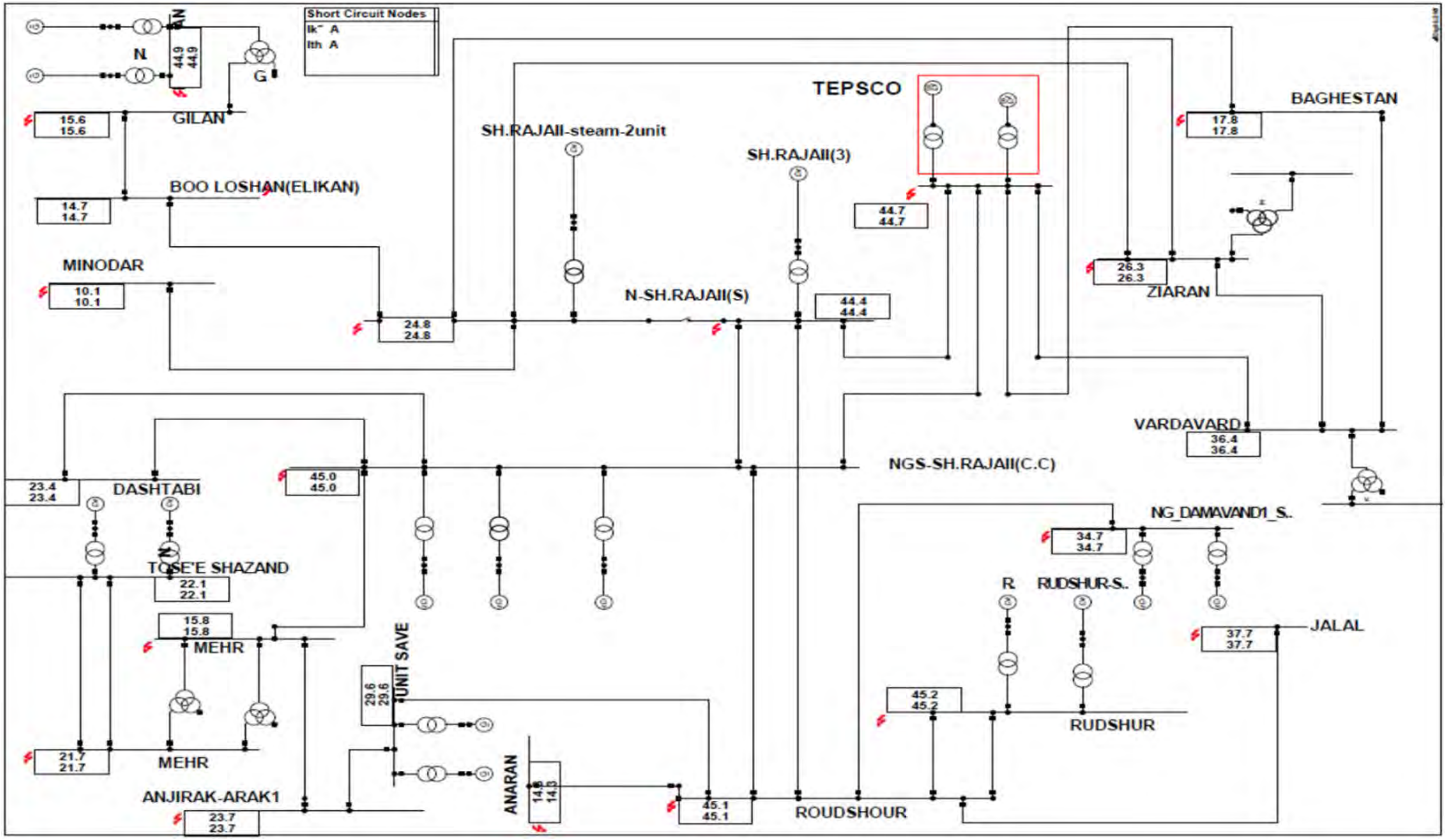
As shown in Table 5-22 and Fig. 5-62, the Single-phase short-circuit current is below 50 kA, when a new generator is connected with 2π connection（Shahid Rajaee (S) ~ Vardavard, Shahid Rajaee (CC) ~ Baghestan）, after the bus splitting operation measures execution and system interconnection of new generators.

Table 5-22 Single-phase short-circuit current after the bus splitting operation measures execution

【2π connection（Shahid Rajaee(S)～Vardavard, Shahid Rajaee(CC)～Baghestan）】

Substation Name	Voltage (kV)	Pre-splitting		Post- splitting	
		Ikss (kA)	X/R	Ikss (kA)	X/R
ANARAN	400	14.3	14	14.3	14.3
ANJIRAK-ARAK	400	23.7	23	23.7	23.7
BAGHESTAN	400	17.9	17	17.8	17.8
BOO	400	15.7	15	14.7	14.7
DASHTABI	400	26.6	26	23.4	23.4
GILAN	400	15.9	15	15.6	15.6
JALAL	400	37.7	37	37.7	37.7
MEHR	400	15.9	15	15.8	15.8
MEHR	230	21.7	21	21.7	21.7
MINODAR	400	11.8	11	10.1	10.1
N-SH.RAJAII(S)-1	400	62.4	62	44.4	44.4
N-SH.RAJAII(S)-2	400	62.4	62	24.8	24.8
NGS-SH.RAJAII(C.C)	400	61.3	61	45.0	45.0
NGS_GILAN	230	45.2	45	44.9	44.9
NG_DAMAVAND	400	34.7	34	34.7	34.7
ROUDSHOUR	400	45.8	45	45.1	45.1
RUDSHUR	400	45.8	45	45.2	45.2
NEW P/S	400	59.9	59	44.7	44.7
TOSE'E SHAZAND	230	22.1	22	22.1	22.1
UNIT SAVE	400	29.8	29	29.6	29.6
VARDAVARD	400	36.5	36	36.4	36.4
ZIARAN	400	38.1	38	26.3	26.3

Source: calculated by JICA Study Team



Source: calculated by JICA Study Team

Fig 5-62 Single-phase short-circuit current after the bus splitting operation measures execution

【2π connection（Shahid Rajaee(S)～Vardavard, Shahid Rajaee(CC)～Baghestan）】

5.3.3 Result of Power Flow and Voltage after Bus Splitting operation measures（2π connection）

In the following case scenario for Peak and Light demand, it was confirmed that the power flow and the voltage is in the tolerance or less after bus splitting operation measures.

(1)New power plant connection to 400kV 2π connection（Shahid Rajaee(S)～Vardavard, Shahid Rajaee(CC)～Baghestan) (Peak Load)
(2)New power plant connection to 400kV 2π connection（Shahid Rajaee(S)～Vardavard, Shahid Rajaee(CC)～Baghestan) (Light Load)

(1) New power plant connection to 400kV 2π connection（Shahid Rajaee(S)～Vardavard, Shahid Rajaee(CC)～Baghestan) (Peak Load)

・Voltage：0.98～1.03P.U.
・Power Flow：within rated capacity of all facilities

Table 5-23 Voltage of new power plant connection to 400kV 2π connection（Shahid Rajaee(S)～Vardavard, Shahid Rajaee(CC)～Baghestan) after bus Splitting operation (Peak Load)

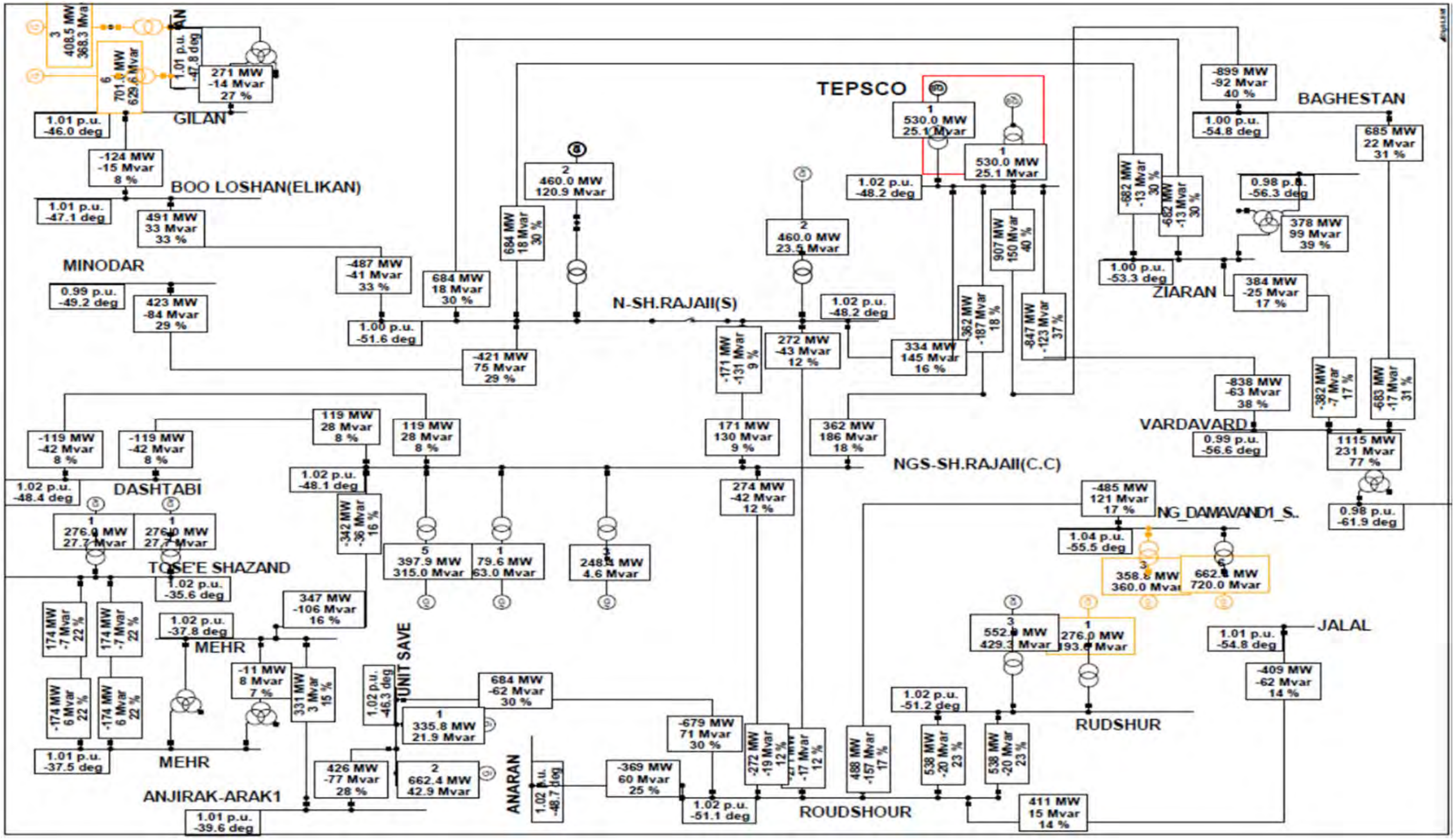
Name	Nominal Voltage (kV)	Pre-connection		Post-connection	
		Magnitude(pu.)	Angle(deg)	Magnitude(pu.)	Angle(deg)
ANARAN	400	1.00	-66.6	1.02	-48.7
ANJIRAK-ARAK	400	0.99	-52.9	1.01	-39.6
BAGHESTAN	400	0.98	-75.5	1.00	-54.8
BOO LOSHAN(ELIKAN)	400	1.01	-65.2	1.01	-47.1
DASHTABI	400	1.00	-70.1	1.02	-48.4
GILAN	400	1.01	-63.9	1.01	-46.0
JALAL	400	1.00	-72.5	1.01	-54.8
MEHR	400	1.00	-51.3	1.02	-37.8
MEHR	230	1.00	-50.8	1.01	-37.5
MINOODAR	400	1.00	-67.4	0.99	-49.2
N-SH.RAJAII(S)-1	400	1.00	-69.9	1.02	-48.2
N-SH.RAJAII(S)-2	400	1.00	-69.9	1.00	-51.6
NGS-SH.RAJAII(C.C)	400	1.00	-69.9	1.02	-48.1
NGS_GILAN	230	1.01	-65.8	1.01	-47.8
NG_DAMAVAND	400	1.03	-74.7	1.04	-55.5
ROUDSHOUR	400	1.01	-69.9	1.02	-51.1
RUDSHUR	400	1.01	-70.0	1.02	-51.2
TEPSCO	400	-	-	1.02	-48.2
TOSE'E SHAZAND	230	1.01	-48.8	1.02	-35.6
UNIT SAVEH	400	1.01	-63.7	1.02	-46.3
VARDAVARD	400	0.99	-76.4	0.99	-56.6
ZIARAN	400	1.00	-71.9	1.00	-53.3

Source: calculated by JICA Study Team

Table 5-24 Power flow of new power plant connection to 400kV 2π connection（Shahid Rajaee(S)～Vardavard, Shahid Rajaee(CC)～Baghestan）after bus splitting operation(Peak Load)

Name	Nominal Voltage (kV)	Pre-connection			Post-connection		
		Loading%	P (MW)	Q (Mvar)	Loading%	P (MW)	Q (Mvar)
BAGHESTAN_ NGS-SH.RAJAII(comb-sycle)	400	34	-741	-81	40	-899	-92
BAGHESTAN_ VARDAVARD	400	14	313	-60	31	685	22
BOO LOSHAN(ELIKAN)_ N-SH.RAJAII(steam)	400	34	510	6	33	491	33
DASHTABI_ NGS-SH.RAJAII	400	5	-65	-34	8	-119	-42
DASHTABI_ NGS-SH.RAJAII(comb-sycle)	400	5	-65	-34	8	-119	-42
GILAN_ BOO LOSHAN(ELIKAN)	400	10	142	-46	8	124	-30
JALAL_ ROUDSHOUR	400	9	-282	-49	14	-409	-62
MEHR_ ANJIRAK-ARAK	400	13	284	13	15	331	3
N-SH.RAJAII(steam)_ NGS-SH.RAJAII(C.C.)	400	20	-416	-197	9	-171	-131
N-SH.RAJAII(steam)_ ROUDSHOUR	400	3	-7	-61	12	272	-43
N-SH.RAJAII(steam)_ VARDAVARD	400	28	630	57	16	334	145
N-SH.RAJAII(steam)_ ZIARAN	400	37	822	97	30	684	18
NGS-SH.RAJAII(comb-sycle)_ R_MEHR	400	27	-586	55	16	-342	-36
NG_DAMAVAND_SHOHDAYE PAKDASHT	400	18	-514	144	17	-485	121
ROUDSHOUR_ NGS-SH.RAJAII(comb-sycle)	400	3	3	-13	12	-272	-19
RUDSHUR_ NG-ROUDSHOUR	400	24	-532	72	23	-538	20
R_MEHR_ MEHR	400	27	-601	8	15	-347	54
ROUDSHOUR_ ANARAN	400	33	-487	97	25	-369	60
TEPSCO-Baghestan	400	-	-	-	40	907	150
TEPSCO-CC	400	-	-	-	18	-362	-187
TEPSCO-Steam	400	-	-	-	16	-334	-146
TEPSCO-Vardavard	400	-	-	-	37	847	123
TOSE'E SHAZAND_ MEHR	230	22	179	7	22	174	-7
TOSE'E SHAZAND_ MEHR	230	22	179	7	22	174	-7
UNIT SAVEH_ ANJIRAK ARAK	400	45	-650	128	28	-421	44
UNIT SAVEH_ROUDSHOUR	400	39	-867	126	30	-679	71
ZIARAN_ VARDAVARD	400	23	523	32	17	384	-25

Source: calculated by JICA Study Team



Source: calculated by JICA Study Team

Fig 5-63 Power flow diagram of new power plant connection to 400kV 2π connection（Shahid Rajaee(S)～Vardavard, Shahid Rajaee(CC)～Baghestan) after bus Splitting operation (Peak Load)

(2)New power plant connection to 400kV 2 π connection（Shahid Rajaee(S)～Vardavard, Shahid Rajaee(CC)～Baghestan) (Light Load)

・Voltage：1.00～1.05P.U.

・Power Flow：within rated capacity of all facilities

Table 5-25 Voltage of new power plant connection to 400kV 2 π connection（Shahid Rajaee(S)～Vardavard, Shahid Rajaee(CC)～Baghestan) after bus Splitting operation (Light Load)

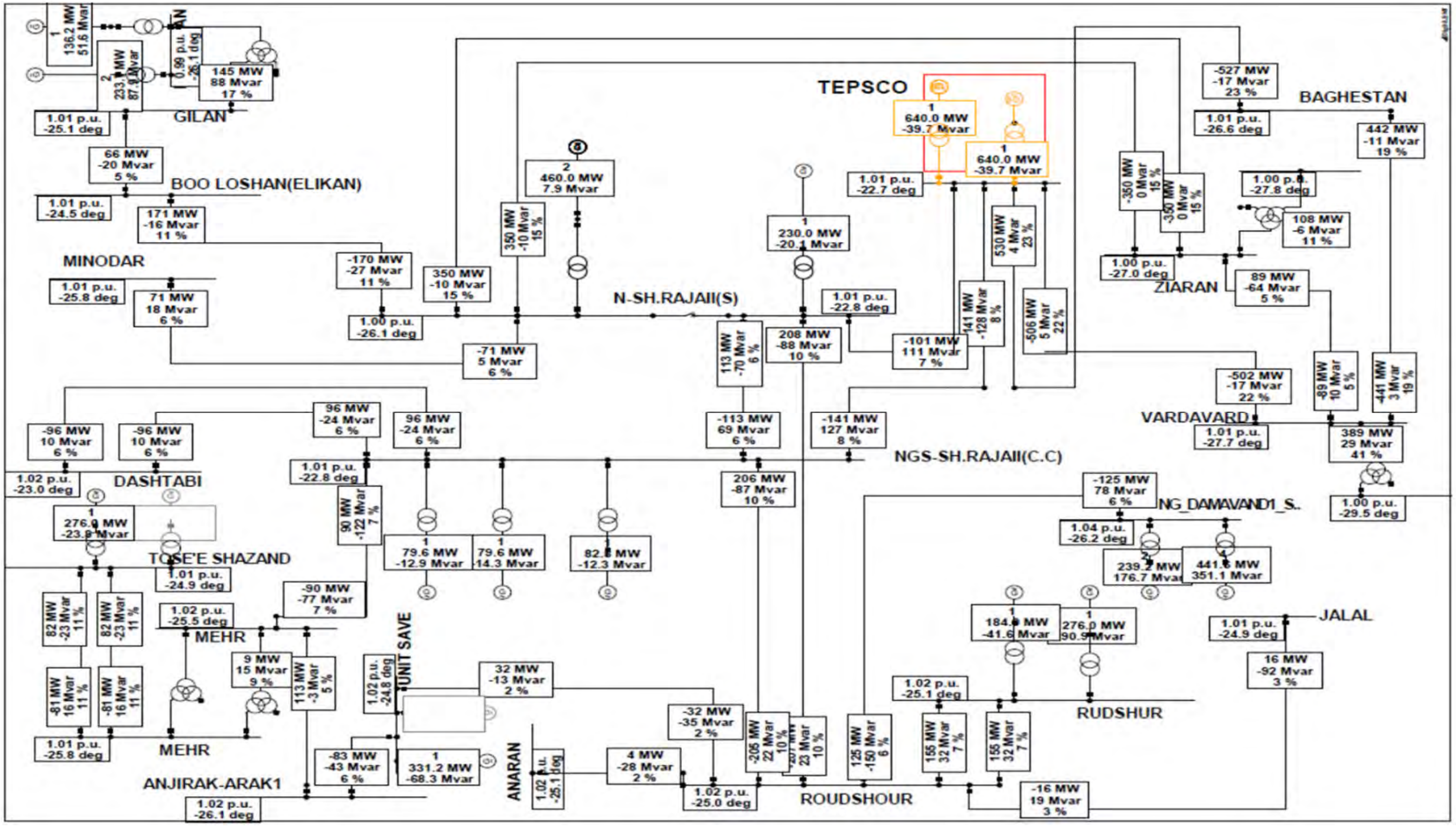
Name	Nominal Voltage (kV)	Pre-connection		Post-connection	
		Magnitude(pu.)	Angle(deg)	Magnitude(pu.)	Angle(deg)
ANARAN	400	1.02	-45	1.02	-27.8
ANJIRAK-ARAK	400	1.02	-41	1.02	-28.1
BAGHESTAN	400	1.01	-49.4	1.01	-29.6
BOO LOSHAN(ELIKAN)	400	1.01	-45.2	1.01	-27.4
DASHTABI	400	1.01	-47.2	1.02	-26.3
GILAN	400	1.01	-45.5	1.01	-27.9
JALAL	400	1.01	-44.4	1.01	-27.5
MEHR	400	1.02	-40.7	1.02	-27.6
MEHR	230	1.01	-40.8	1.01	-27.8
MINOODAR	400	1.01	-46.5	1.01	-28.6
N-SH.RAJAII(S)-1	400	1.01	-47.2	1.02	-26.1
N-SH.RAJAII(S)-2	400	1.01	-47.2	1.00	-29.0
NGS-SH.RAJAII(C.C)	400	1.01	-47.1	1.02	-26.1
NGS_GILAN	230	1	-46.5	0.99	-28.9
NG_DAMAVAND	400	1.04	-47.4	1.04	-29.1
ROUDSHOUR	400	1.02	-45.9	1.02	-27.9
RUDSHUR	400	1.02	-45.9	1.02	-27.9
TEPSCO	400	-	-	1.02	-26.1
TOSE'E SHAZAND	230	1.01	-39.8	1.01	-26.9
UNIT SAVEH	400	1.02	-44.1	1.02	-27.4
VARDAVARD	400	1.01	-49.7	1.01	-30.7
ZIARAN	400	1.01	-48.2	1.00	-29.9

Source: calculated by JICA Study Team

Table 5-26 Power flow of new power plant connection to 400kV 2π connection（Shahid Rajaee(S)～Vardavard, Shahid Rajaee(CC)～Baghestan) after bus Splitting operation (Light Load)

Name	Nominal Voltage (kV)	Pre-connection			Post-connection		
		Loading%	P (MW)	Q (Mvar)	Loading%	P (MW)	Q (Mvar)
BAGHESTAN_ NGS-SH.RAJAII(comb-sycle)	400	13	-300	-34	23	-527	-17
BAGHESTAN_ VARDAVARD	400	6	129	-22	19	442	-11
BOO LOSHAN(ELIKAN)_ N-SH.RAJAII(steam)	400	14	206	-51	11	171	-16
DASHTABI_ NGS-SH.RAJAII(comb-sycle)	400	3	-35	9	6	-96	10
GILAN_ BOO LOSHAN(ELIKAN)	400	4	-31	-45	5	-66	-26
JALAL_ ROUDSHOUR	400	6	164	-100	3	16	-92
MEHR_ ANJIRAK-ARAK	400	3	52	1	5	113	-3
N-SH.RAJAII(steam)_ NGS-SH.RAJAII(C.C.)	400	11	-197	-139	6	113	-70
N-SH.RAJAII(steam)_ ROUDSHOUR	400	6	-121	-65	10	208	-88
N-SH.RAJAII(steam)_ VARDAVARD	400	11	253	-22	7	-101	111
N-SH.RAJAII(steam)_ ZIARAN	400	19	425	45	15	350	-10
NGS-SH.RAJAII(comb-sycle)_ R_MEHR	400	10	-216	-83	7	90	-122
NG_DAMAVAND_SHOHDAYE PAKDASHT	400	8	-164	92	6	-125	78
ROUDSHOUR_ NGS-SH.RAJAII(comb-sycle)	400	6	119	-8	10	-205	22
RUDSHUR_ NG-ROUDSHOUR	400	10	-143	48	7	-155	-33
R_MEHR_ MEHR	400	10	-218	43	4	90	25
ROUDSHOUR_ ANARAN	400	10	-143	-4	2	4	-28
TEPSCO-Baghestan	400	-	-	-	23	530	4
TEPSCO-CC	400	-	-	-	8	141	-128
TEPSCO-Steam	400	-	-	-	7	101	-112
TEPSCO-Vardavard	400	-	-	-	22	506	-5
TOSE'E SHAZAND_ MEH R	230	11	87	-21	11	82	-23
TOSE'E SHAZAND_ MEHR	230	11	87	-21	11	82	-23
UNIT SAVEH_ ANJIRAK ARAK	400	14	-196	-2	6	83	-39
UNIT SAVEH_ROUDSHOUR	400	12	-264	-3	2	-32	-35
ZIARAN_ VARDAVARD	400	8	183	-32	5	89	-64

Source: calculated by JICA Study Team



Source: calculated by JICA Study Team

Fig 5-64 Power flow diagram of new power plant connection to 400kV 2π connection（Shahid Rajaee(S)～Vardavard, Shahid Rajaee(CC)～Baghestan) after bus Splitting operation (Light Load)

5.3.4 Result of Steady state/Transient stability calculation after the bus splitting operation measures execution（2π connection）

In the case scenario of 1～15, it was confirmed that the generator around Shahid Rajaee area is able to be continued stable, and it is acceptable from Steady state/Transient Stability study perspective.

・New power plant connection to 400kV 2π connection（Shahid Rajaee(S)～Vardavard, Shahid Rajaee(CC)～Baghestan) after bus Splitting operation (Peak Load and Light Load)

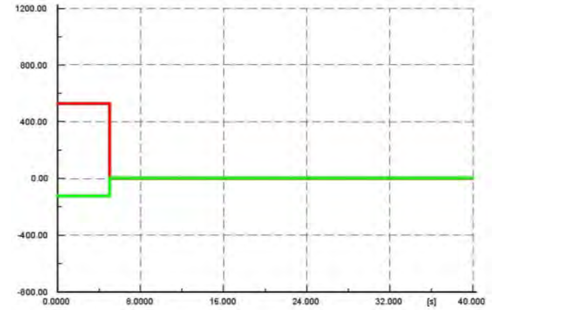
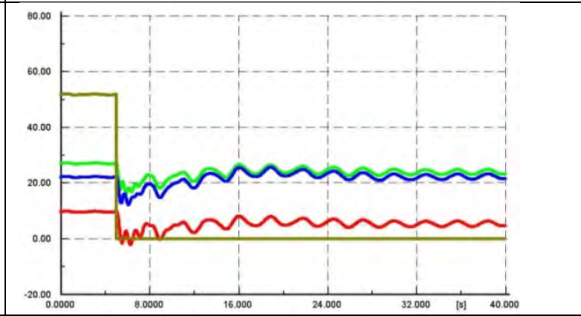
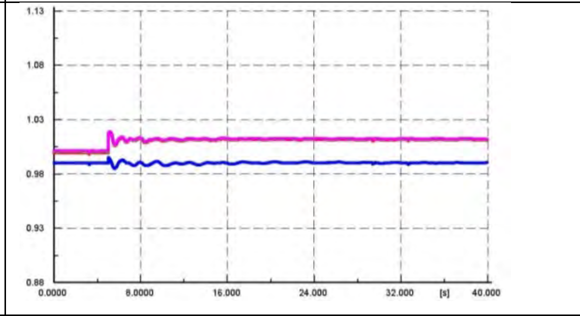
Table 5-27 Accident Case

No.	Contingency Characteristic
1	The outage of Shahid Rajaee new unit
2	The outage of Shahid Rajaee exsiting steam unit
3	The outage of Shahid Rajaee exsiting C.C. unit
4	Three-phase short circuit fault in 400 kV Shahid Rajaee new power plant-Rajaee Steam transmission line and the outage of transmission line after 100 miliseconds
5	Three-phase short circuit fault in 400 kV Shahid Rajaee new power plant-Rajaee C.C transmission line and the outage of transmission line after 100 miliseconds
6	Three-phase short circuit fault in 400 kV Shahid Rajaee new power plant- Vardavard transmission line and the outage of transmission line after 100 miliseconds
7	Three-phase short circuit fault in 400 kV Shahid Rajaee new power plant-Baghestan transmission line and the outage of transmission line after 100 miliseconds
8	Three-phase short circuit fault in 400 kV Rajaee Steam-Minoodar transmission line and the outage of transmission line after 100 miliseconds
9	Three-phase short circuit fault in 400 kV Rajaee Steam-Ziaran transmission line and the outage of transmission line after 100 miliseconds
10	Three-phase short circuit fault in 400 kV Rajaee Steam-Loshan transmission line and the outage of transmission line after 100 miliseconds
11	Three-phase short circuit fault in 400 kV Rajaee Steam-Roudshour transmission line and the outage of transmission line after 100 miliseconds
12	Three-phase short circuit fault in 400 kV Rajaee C.C-Roudshour transmission line and the outage of transmission line after 100 miliseconds
13	Three-phase short circuit fault in 400 kV Rajaee C.C-Mehr transmission line and the outage of transmission line after 100 miliseconds
14	Three-phase short circuit fault in 400 kV Rajaee C.C-Dashtabi transmission line and the outage of transmission line after 100 miliseconds
15	Three-phase short circuit fault in 400 kV Rajaee C.C- Rajaee Steam transmission line and the outage of transmission line after 100 miliseconds

Source: prepared by JICA Study Team

【Result of Steady state/Transient stability calculation】

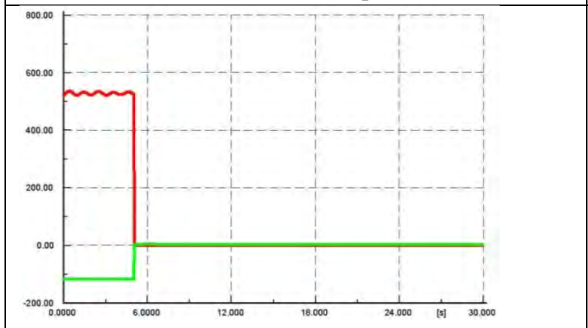
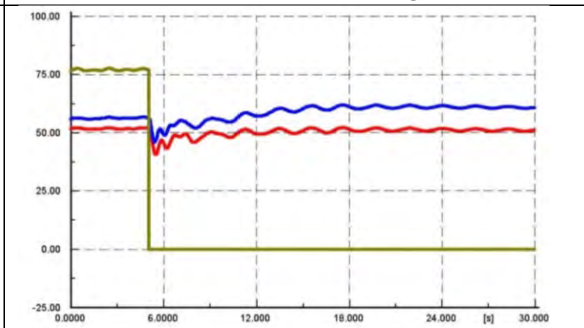
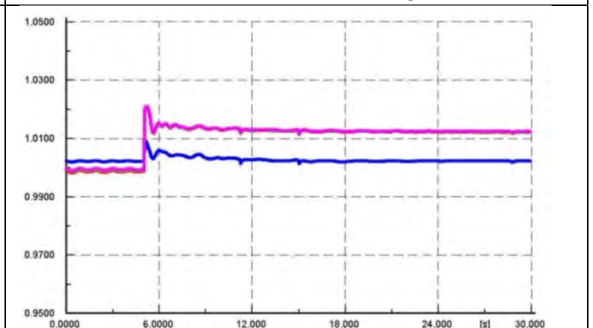
(1)1 The outage of Shahid Rajaee new unit (Peak Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-65 1 The outage of Shahid Rajaee new unit (Peak Load)

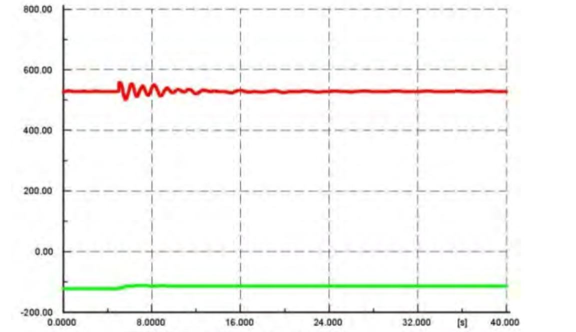
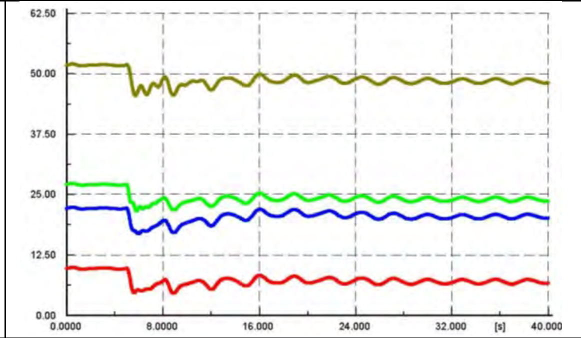
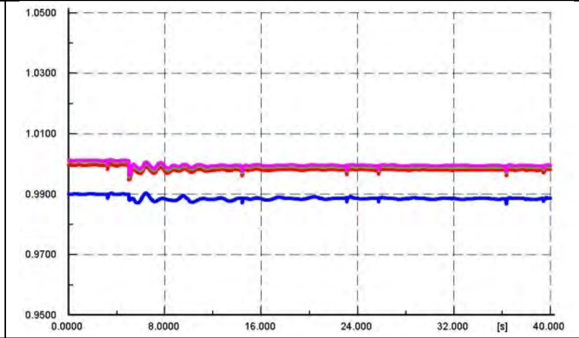
(2)1 The outage of Shahid Rajaee new unit (Light Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-66 1 The outage of Shahid Rajaee new unit (Light Load)

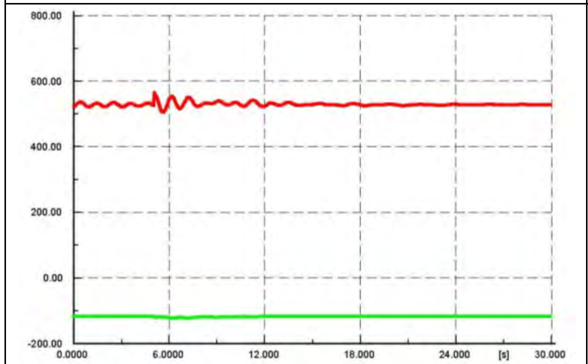
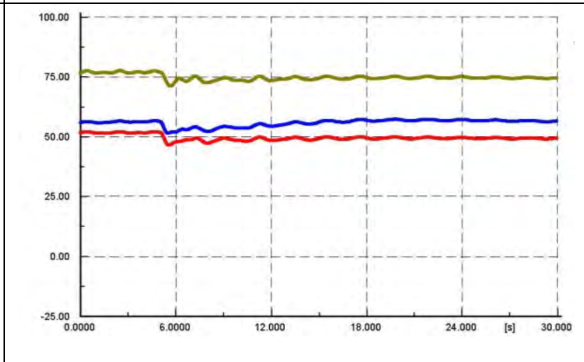
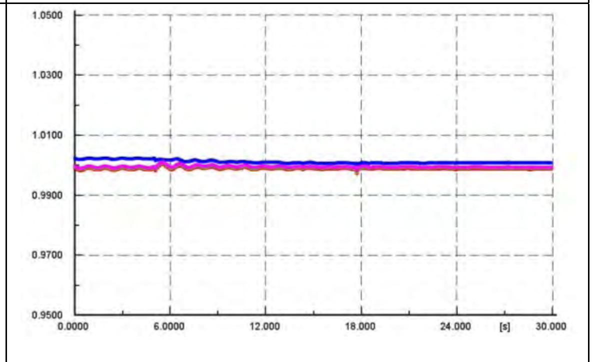
(3)2 The outage of Shahid Rajaee exsiting steam unit (Peak Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-67 2 The outage of Shahid Rajaee exsiting steam unit (Peak Load)

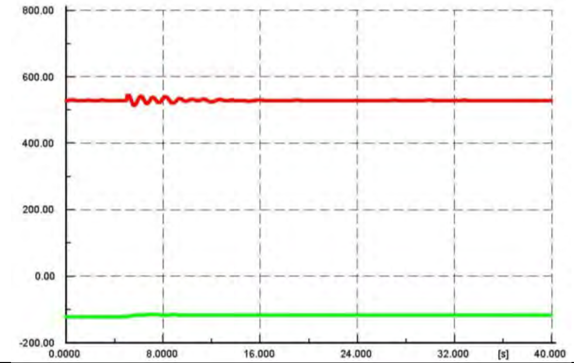
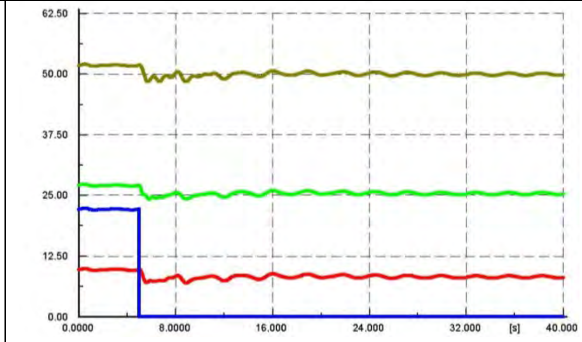
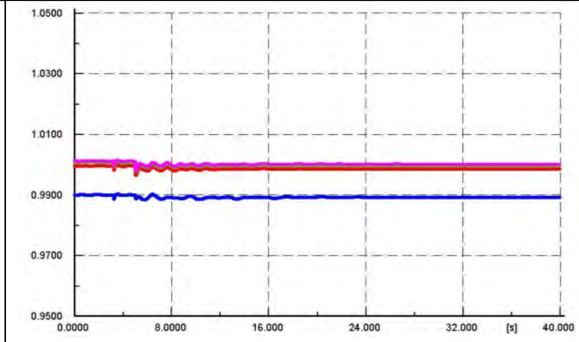
(4)2 The outage of Shahid Rajaee exsiting steam unit (Light Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-68 2 The outage of Shahid Rajaee exsiting steam unit (Light Load)

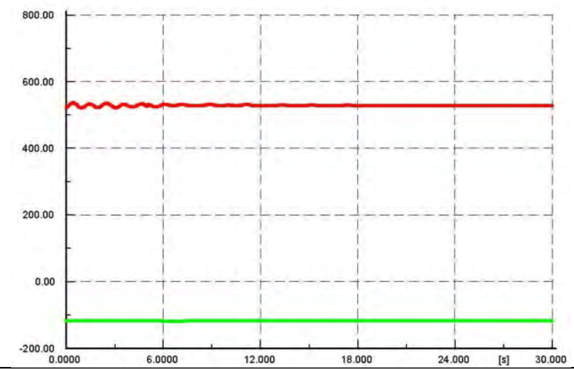
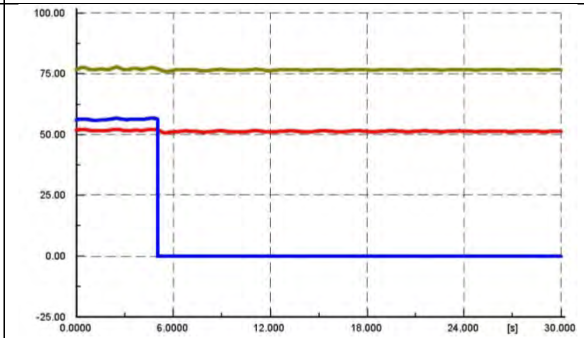
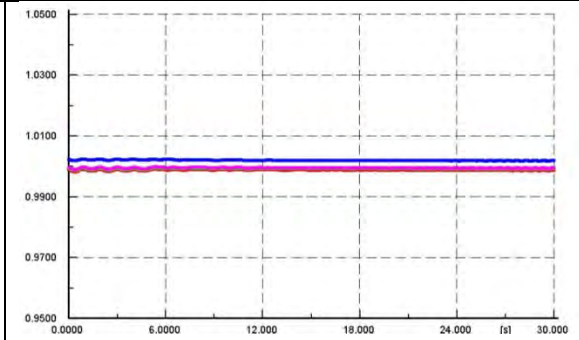
(5)3 The outage of Shahid Rajaee exsiting C.C. unit (Peak Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-69 3 The outage of Shahid Rajaee exsiting C.C. unit (Peak Load)

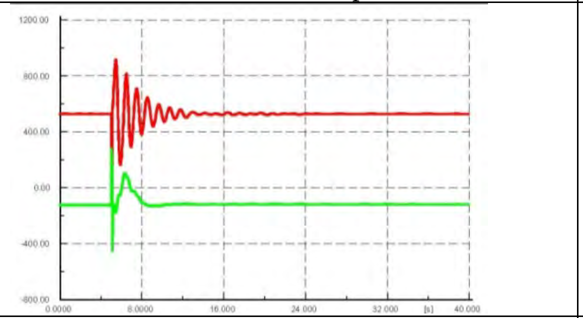
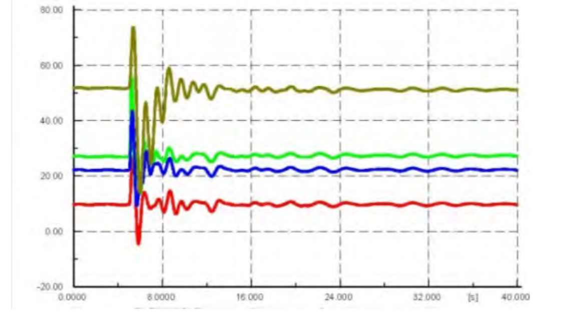
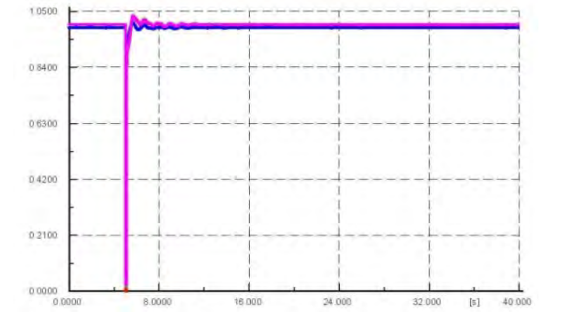
(6)3 The outage of Shahid Rajaee exsiting C.C. unit (Light Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-70 3 The outage of Shahid Rajaee exsiting C.C. unit (Light Load)

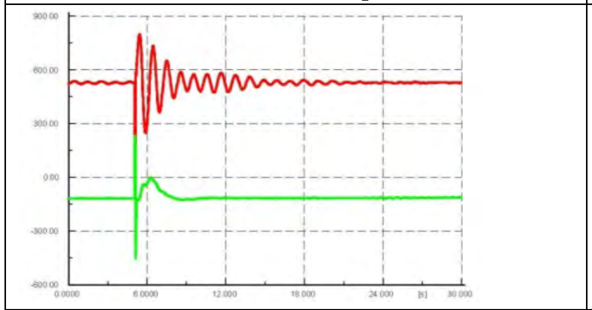
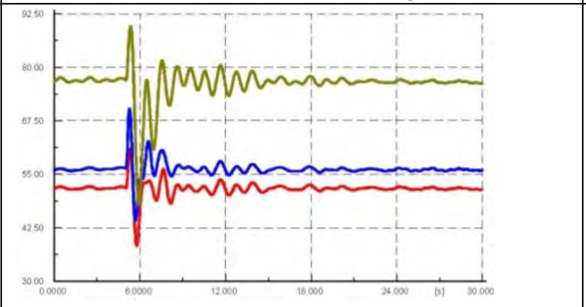
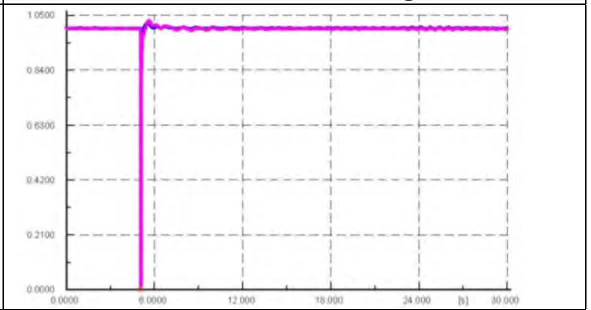
(7)4 Three-phase short circuit fault in 400 kV Shahid Rajaee new power plant-Rajaee Steam transmission line and the outage of transmission line after 100 miliseconds(Peak Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-71 4 Three-phase short circuit fault in 400 kV Shahid Rajaee new power plant-Rajaee Steam transmission line and the outage of transmission line after 100 miliseconds(Peak Load)

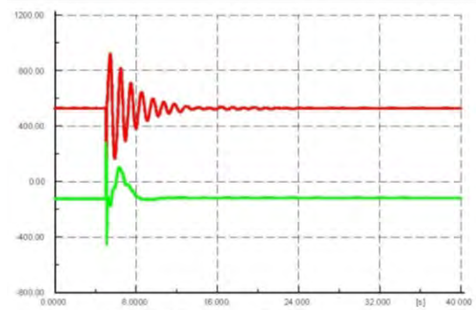
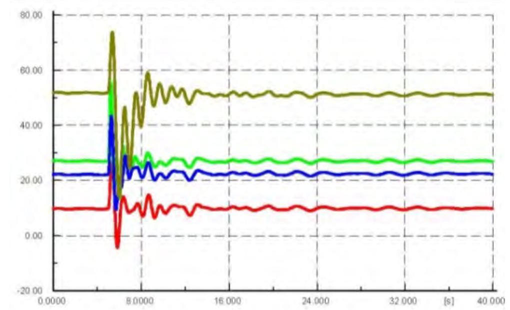
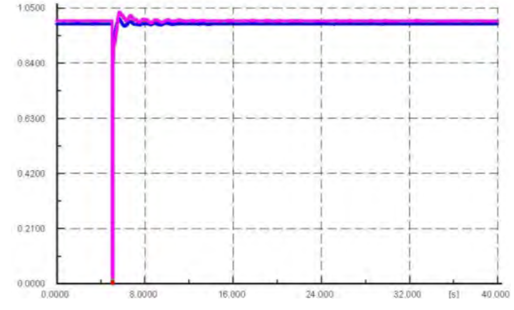
(8)4 Three-phase short circuit fault in 400 kV Shahid Rajaee new power plant-Rajaee Steam transmission line and the outage of transmission line after 100 miliseconds(Light Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-72 4 Three-phase short circuit fault in 400 kV Shahid Rajaee new power plant-Rajaee Steam transmission line and the outage of transmission line after 100 miliseconds(Light Load)

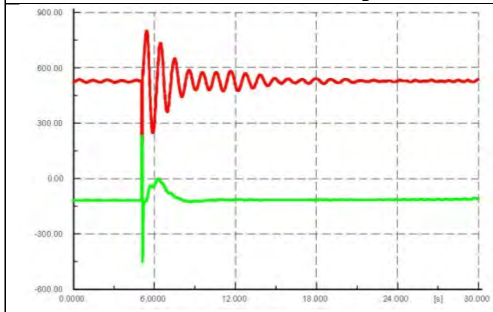
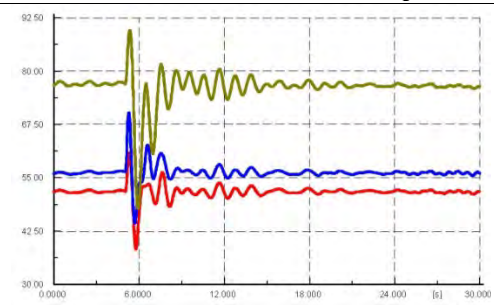
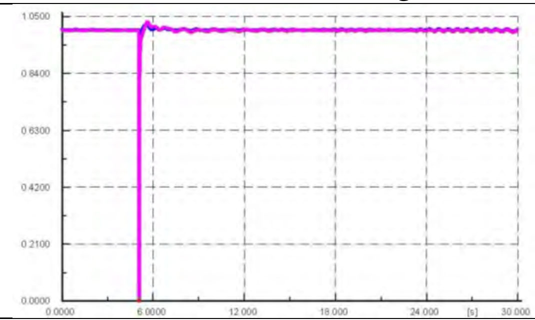
(9)5 Three-phase short circuit fault in 400 kV Shahid Rajaee new power plant-Rajaee C.C transmission line and the outage of transmission line after 100 miliseconds(Peak Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-73 5 Three-phase short circuit fault in 400 kV Shahid Rajaee new power plant-Rajaee C.C transmission line and the outage of transmission line after 100 miliseconds(Peak Load)

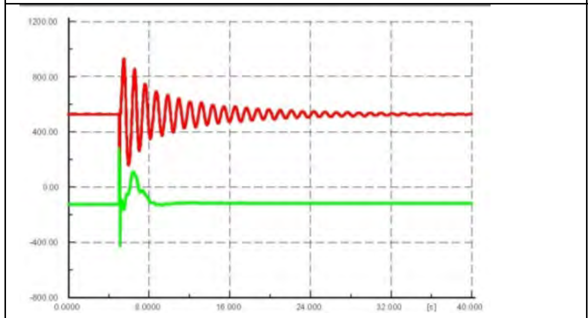
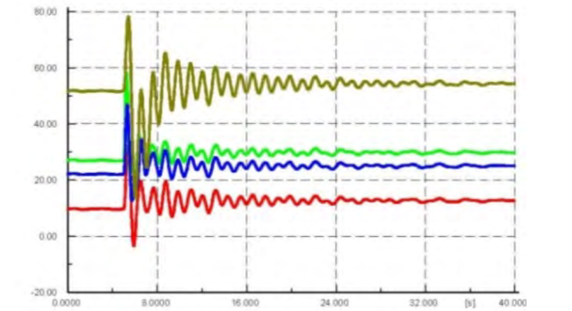
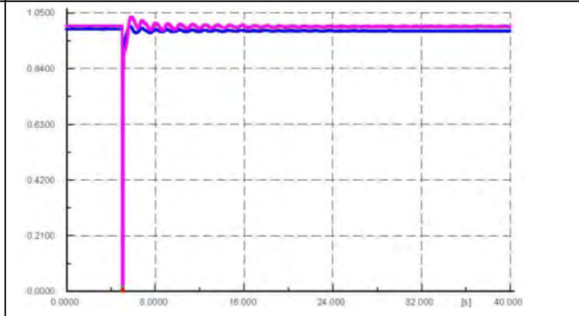
(10) 5 Three-phase short circuit fault in 400 kV Shahid Rajaee new power plant-Rajaee C.C transmission line and the outage of transmission line after 100 miliseconds(Light Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-74 5 Three-phase short circuit fault in 400 kV Shahid Rajaee new power plant-Rajaee C.C transmission line and the outage of transmission line after 100 miliseconds(Light Load)

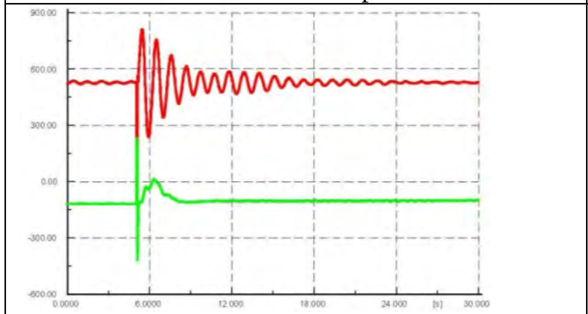
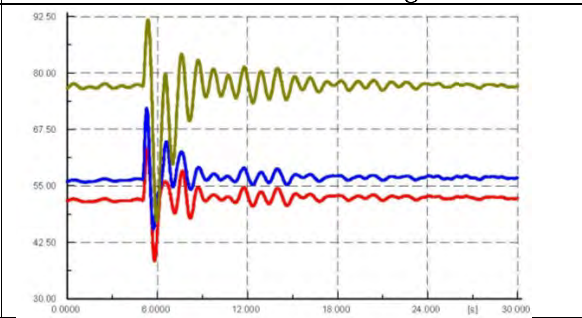
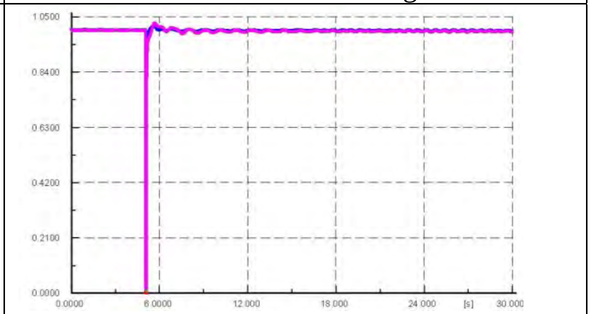
(11)6 Three-phase short circuit fault in 400 kV Shahid Rajaee new power plant- Vardavard transmission line and the outage of transmission line after 100 miliseconds(Peak Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-75 6 Three-phase short circuit fault in 400 kV Shahid Rajaee new power plant- Vardavard transmission line and the outage of transmission line after 100 miliseconds(Peak Load)

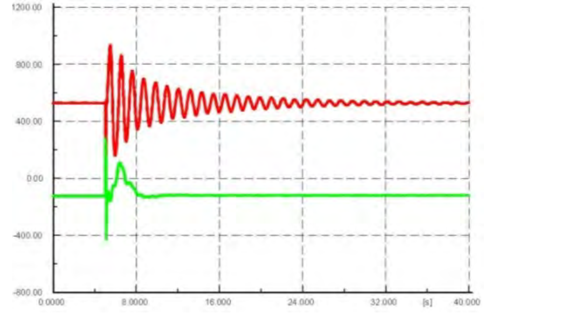
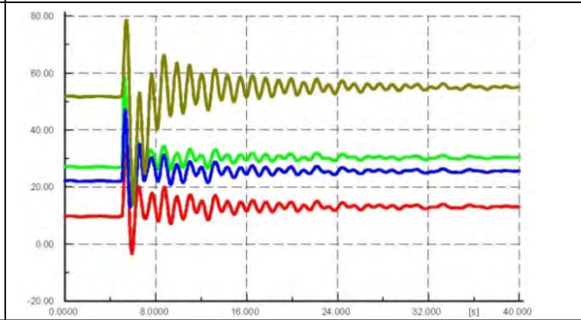
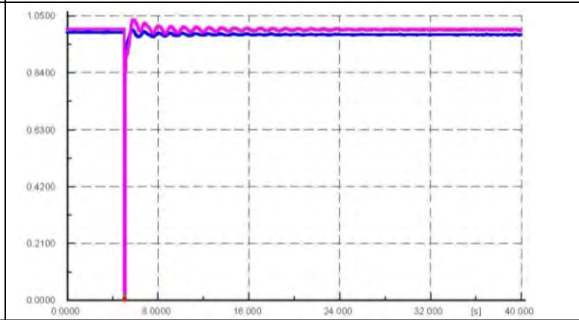
(12) 6 Three-phase short circuit fault in 400 kV Shahid Rajaee new power plant- Vardavard transmission line and the outage of transmission line after 100 miliseconds(Light Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-76 6 Three-phase short circuit fault in 400 kV Shahid Rajaee new power plant- Vardavard transmission line and the outage of transmission line after 100 miliseconds(Light Load)

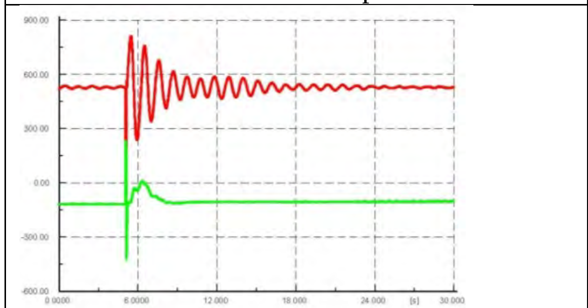
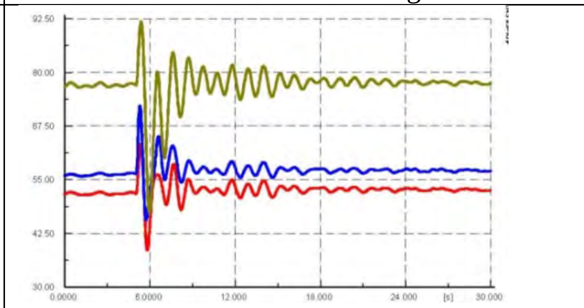
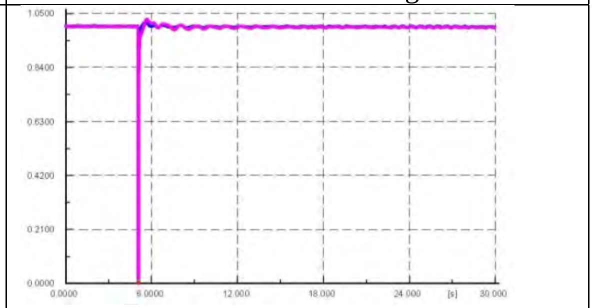
(13)7 Three-phase short circuit fault in 400 kV Shahid Rajaee new power plant-Baghestan transmission line and the outage of transmission line after 100 miliseconds(Peak Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-77 7 Three-phase short circuit fault in 400 kV Shahid Rajaee new power plant-Baghestan transmission line and the outage of transmission line after 100 miliseconds(Peak Load)

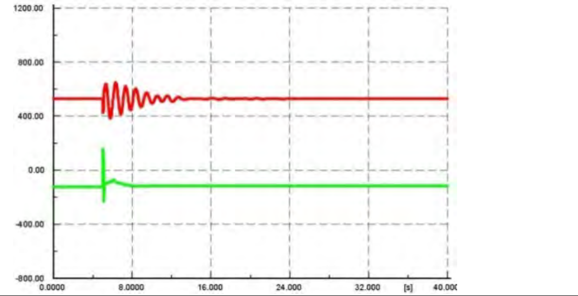
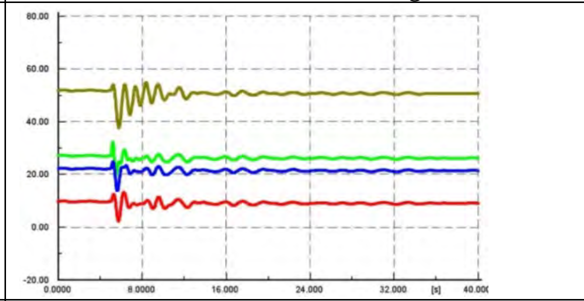
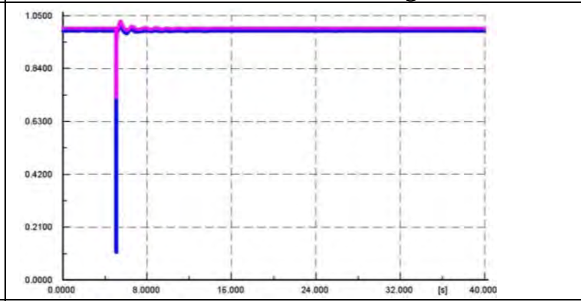
(14) 7 Three-phase short circuit fault in 400 kV Shahid Rajaee new power plant-Baghestan transmission line and the outage of transmission line after 100 miliseconds(Light Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-78 7 Three-phase short circuit fault in 400 kV Shahid Rajaee new power plant-Baghestan transmission line and the outage of transmission line after 100 miliseconds(Light Load)

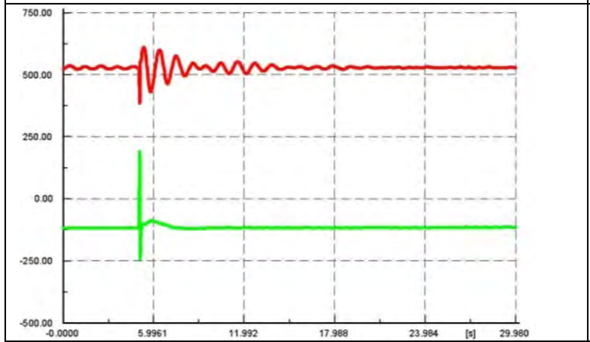
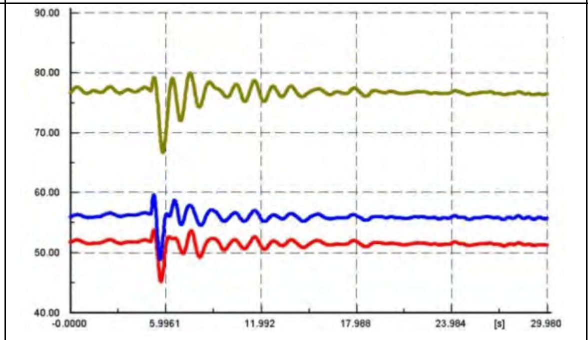
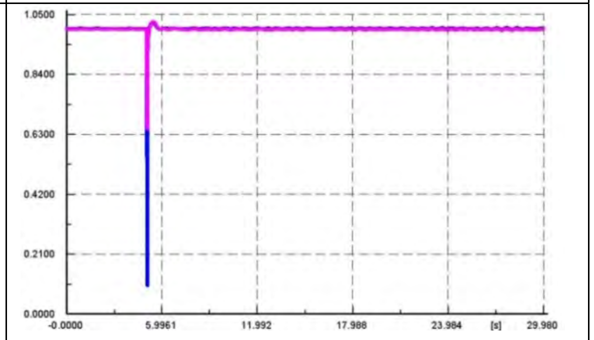
(15)8 Three-phase short circuit fault in 400 kV Rajaee Steam-Minoodar transmission line and the outage of transmission line after 100 miliseconds(Peak Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-79 8 Three-phase short circuit fault in 400 kV Rajaee Steam-Minoodar transmission line and the outage of transmission line after 100 miliseconds(Peak Load)

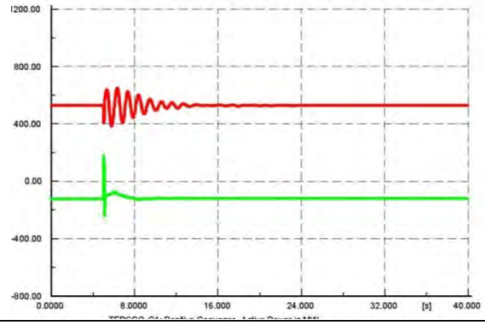
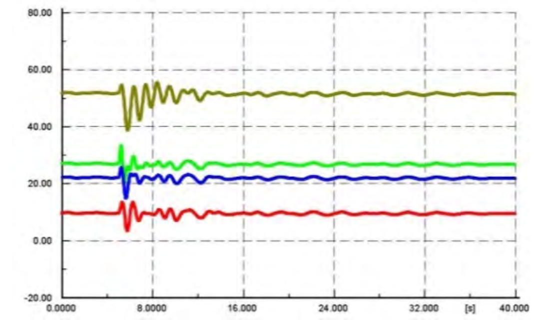
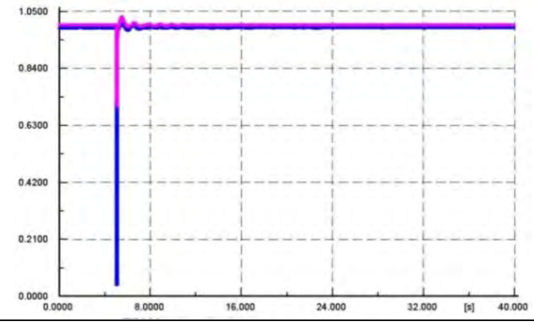
(16) 8 Three-phase short circuit fault in 400 kV Rajaee Steam-Minoodar transmission line and the outage of transmission line after 100 miliseconds(Light Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-80 8 Three-phase short circuit fault in 400 kV Rajaee Steam-Minoodar transmission line and the outage of transmission line after 100 miliseconds(Light Load)

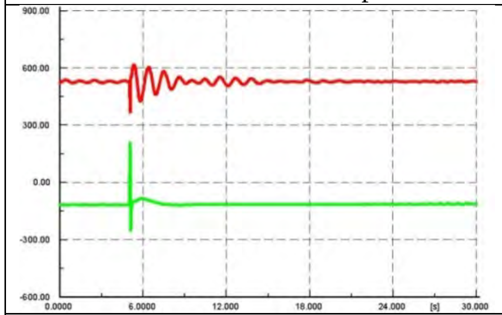
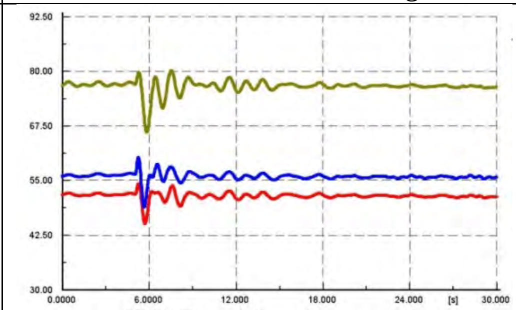
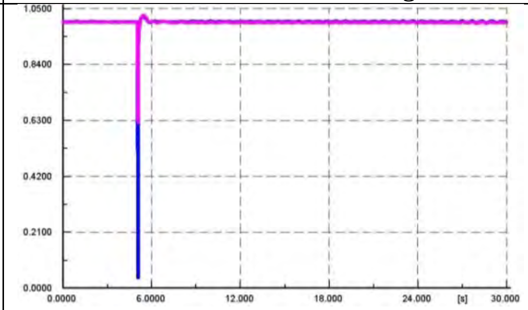
(17) 9 Three-phase short circuit fault in 400 kV Rajaee Steam-Ziaran transmission line and the outage of transmission line after 100 miliseconds(Peak Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-81 9 Three-phase short circuit fault in 400 kV Rajaee Steam-Ziaran transmission line and the outage of transmission line after 100 miliseconds(Peak Load)

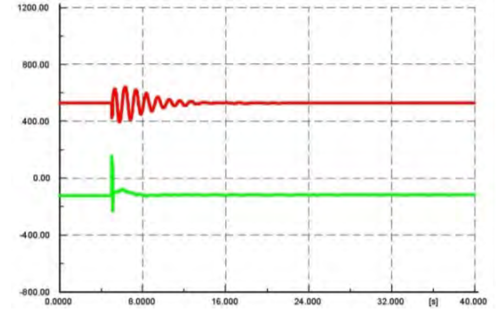
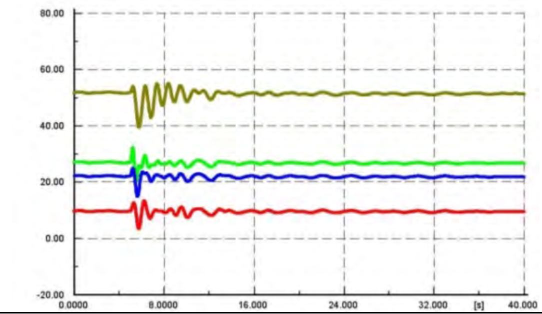
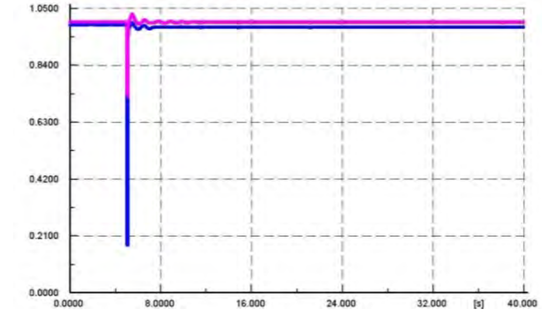
(18) 9 Three-phase short circuit fault in 400 kV Rajaee Steam-Ziaran transmission line and the outage of transmission line after 100 miliseconds(Light Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-82 9 Three-phase short circuit fault in 400 kV Rajaee Steam-Ziaran transmission line and the outage of transmission line after 100 miliseconds(Light Load)

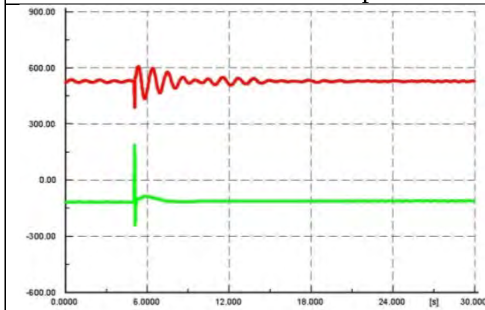
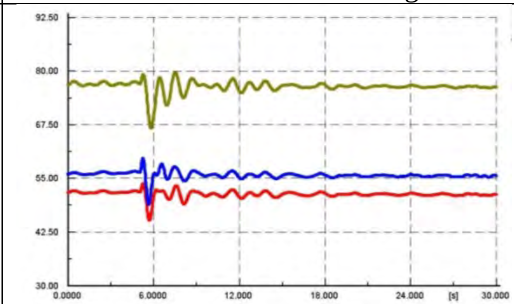
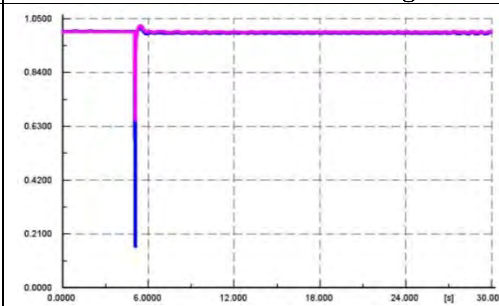
(19)10 Three-phase short circuit fault in 400 kV Rajaee Steam-Loshan transmission line and the outage of transmission line after 100 miliseconds(Peak Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-83 10 Three-phase short circuit fault in 400 kV Rajaee Steam-Loshan transmission line and the outage of transmission line after 100 miliseconds(Peak Load)

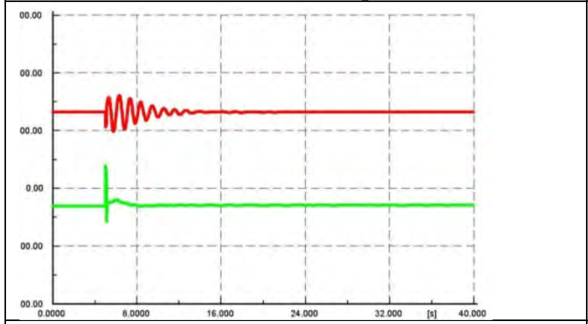
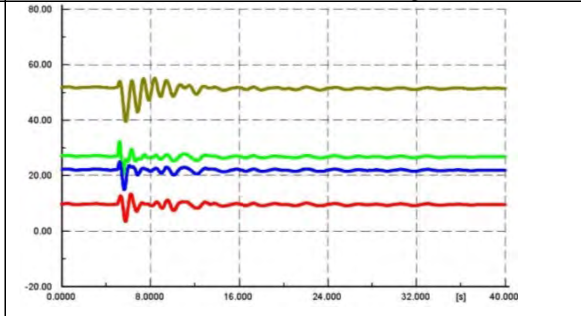
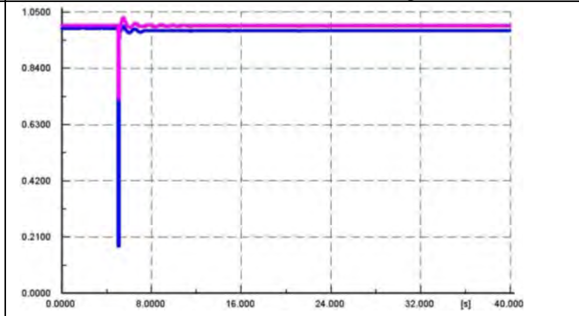
(20) 10 Three-phase short circuit fault in 400 kV Rajaee Steam-Loshan transmission line and the outage of transmission line after 100 miliseconds(Light Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-84 10 Three-phase short circuit fault in 400 kV Rajaee Steam-Loshan transmission line and the outage of transmission line after 100 miliseconds(Light Load)

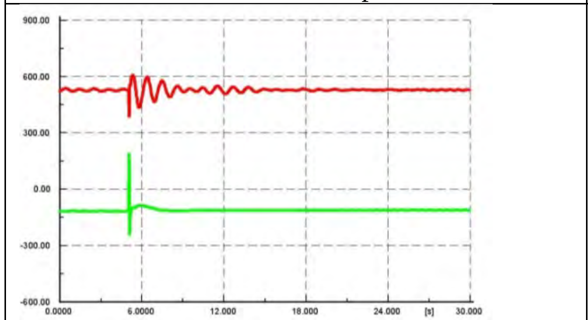
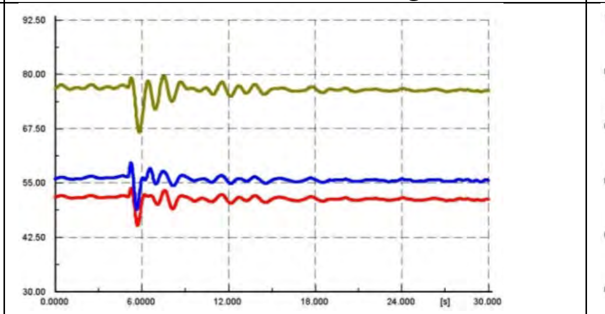
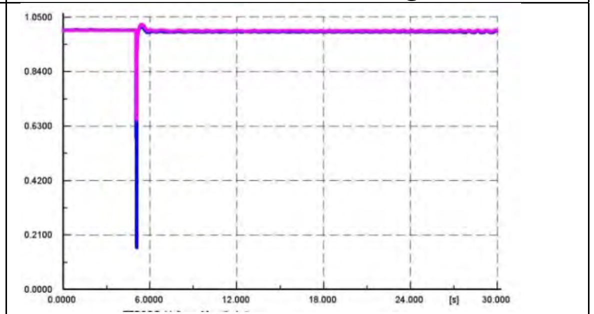
(21)11 Three-phase short circuit fault in 400 kV Rajaee Steam-Roudshour transmission line and the outage of transmission line after 100 miliseconds(Peak Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-85 11 Three-phase short circuit fault in 400 kV Rajaee Steam-Roudshour transmission line and the outage of transmission line after 100 miliseconds(Peak Load)

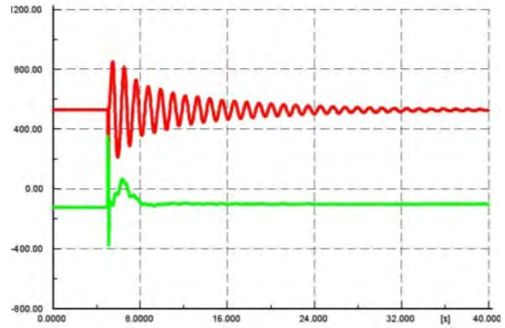
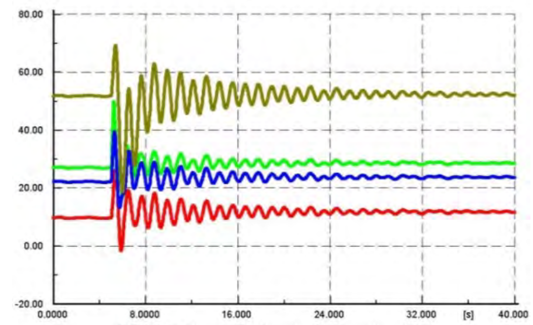
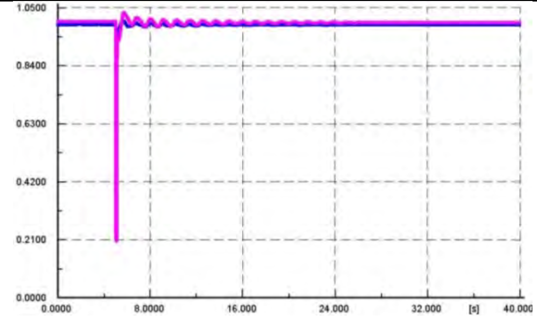
(22) 11 Three-phase short circuit fault in 400 kV Rajaee Steam-Roudshour transmission line and the outage of transmission line after 100 miliseconds(Light Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-86 11 Three-phase short circuit fault in 400 kV Rajaee Steam-Roudshour transmission line and the outage of transmission line after 100 miliseconds(Light Load)

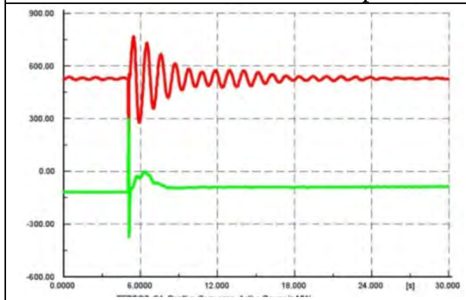
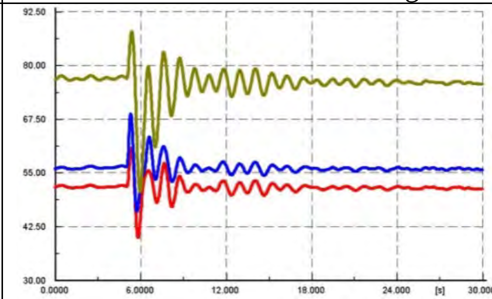
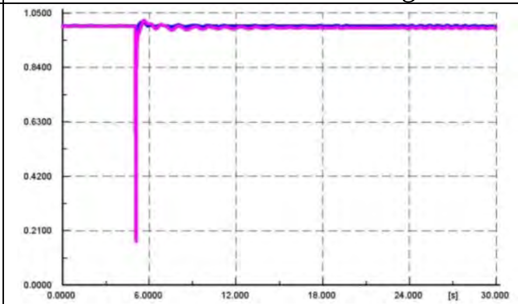
(23)12 Three-phase short circuit fault in 400 kV Rajaee C.C-Roudshour transmission line and the outage of transmission line after 100 miliseconds(Peak Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-87 12 Three-phase short circuit fault in 400 kV Rajaee C.C-Roudshour transmission line and the outage of transmission line after 100 miliseconds(Peak Load)

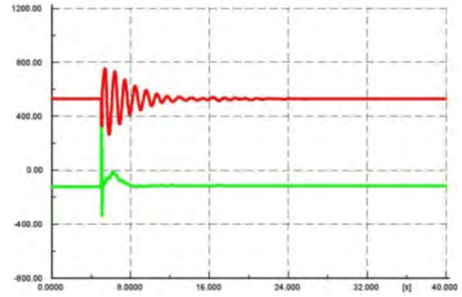
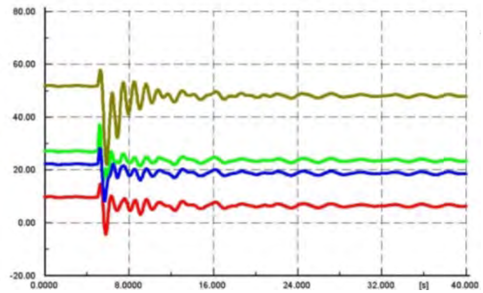
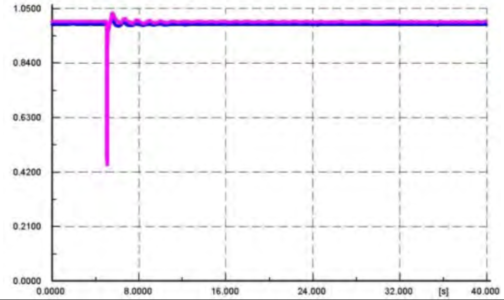
(24) 12 Three-phase short circuit fault in 400 kV Rajaee C.C-Roudshour transmission line and the outage of transmission line after 100 miliseconds(Light Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-88 12 Three-phase short circuit fault in 400 kV Rajaee C.C-Roudshour transmission line and the outage of transmission line after 100 miliseconds(Light Load)

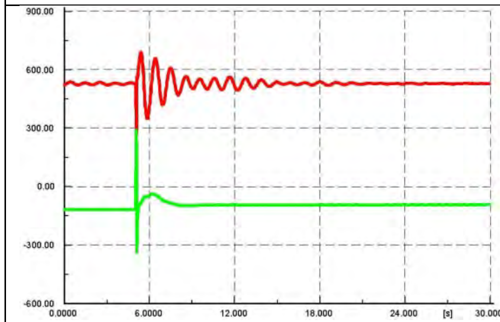
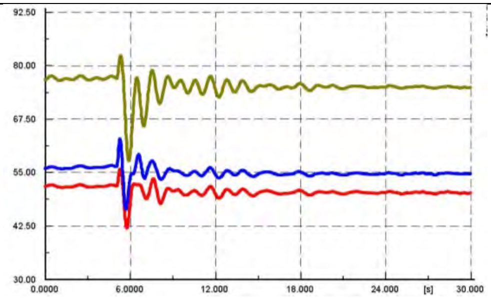
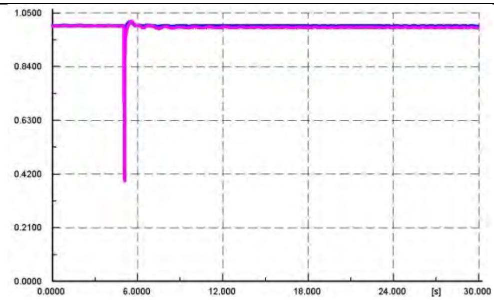
(25)13 Three-phase short circuit fault in 400 kV Rajaee C.C-Mehr transmission line and the outage of transmission line after 100 miliseconds(Peak Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-89 13 Three-phase short circuit fault in 400 kV Rajaee C.C-Mehr transmission line and the outage of transmission line after 100 miliseconds(Peak Load)

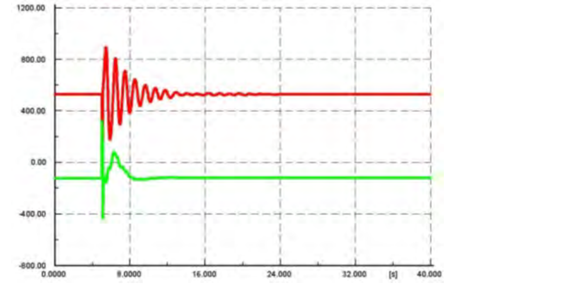
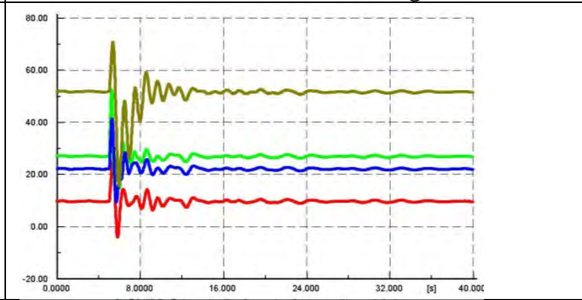
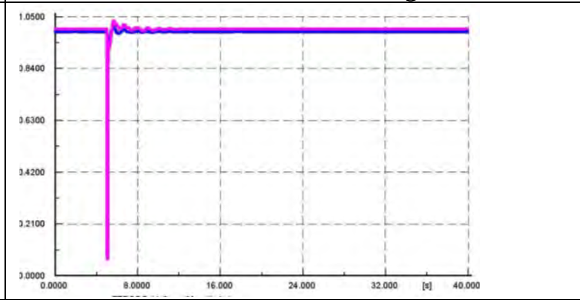
(26) 13 Three-phase short circuit fault in 400 kV Rajaee C.C-Mehr transmission line and the outage of transmission line after 100 miliseconds(Light Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-90 13 Three-phase short circuit fault in 400 kV Rajaee C.C-Mehr transmission line and the outage of transmission line after 100 miliseconds(Light Load)

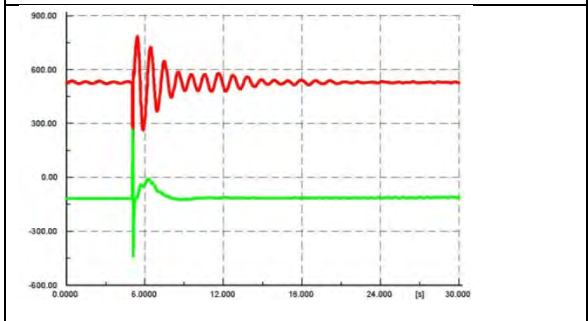
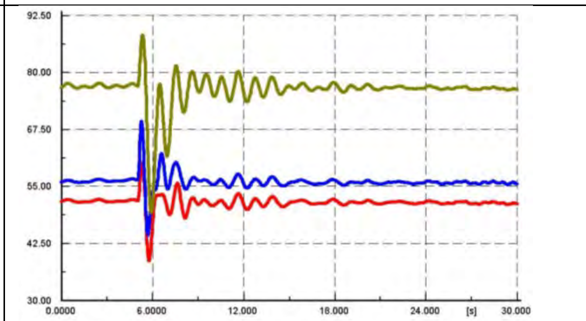
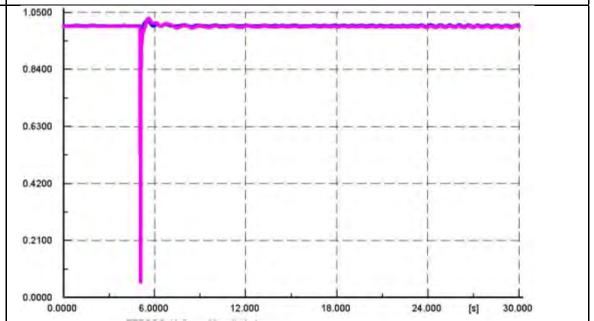
(27)14 Three-phase short circuit fault in 400 kV Rajaee C.C-Dashtabi transmission line and the outage of transmission line after 100 miliseconds(Peak Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-91 14 Three-phase short circuit fault in 400 kV Rajaee C.C-Dashtabi transmission line and the outage of transmission line after 100 miliseconds(Peak Load)

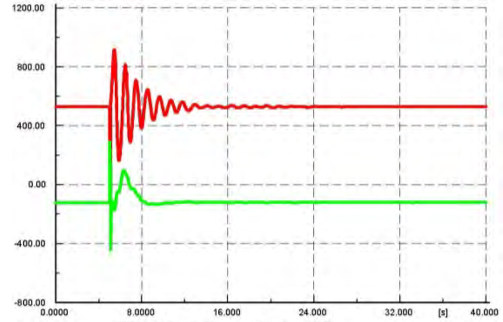
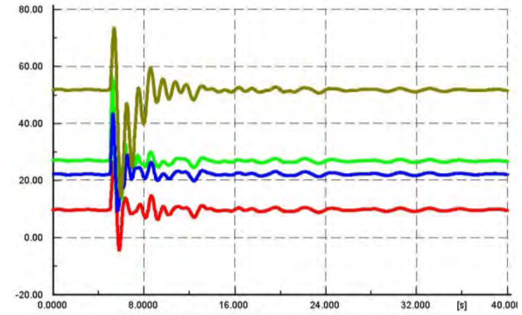
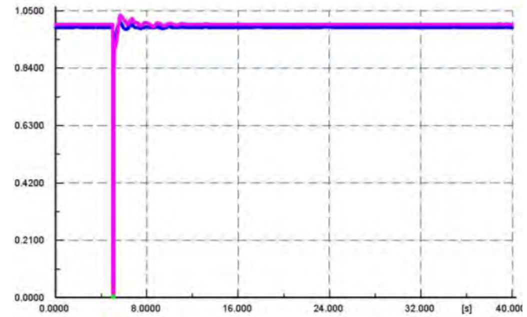
(28) 14 Three-phase short circuit fault in 400 kV Rajaee C.C-Dashtabi transmission line and the outage of transmission line after 100 miliseconds(Light Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-92 14 Three-phase short circuit fault in 400 kV Rajaee C.C-Dashtabi transmission line and the outage of transmission line after 100 miliseconds(Light Load)

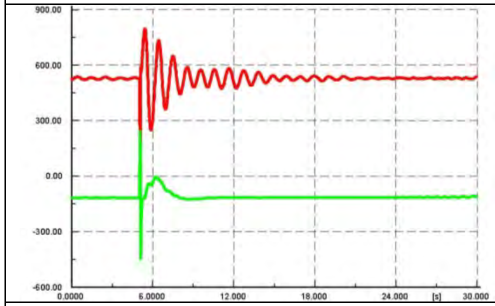
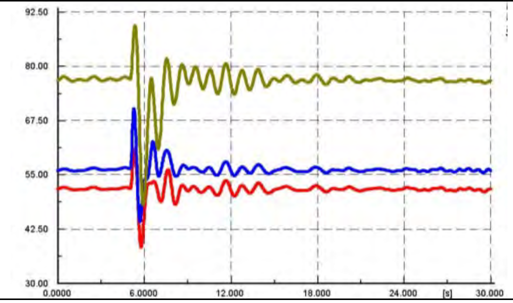
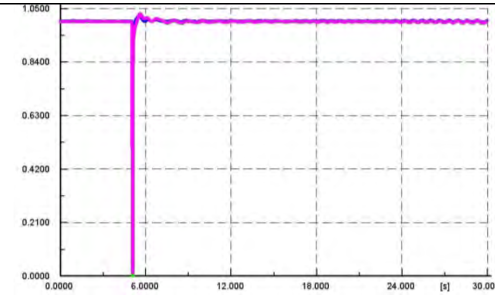
(29)15 Three-phase short circuit fault in 400 kV Rajaee C.C- Rajaee Steam transmission line and the outage of transmission line after 100 miliseconds(Peak Load)

Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-93 15 Three-phase short circuit fault in 400 kV Rajaee C.C- Rajaee Steam transmission line and the outage of transmission line after 100 miliseconds(Peak Load)

(30) 15 Three-phase short circuit fault in 400 kV Rajaee C.C- Rajaee Steam transmission line and the outage of transmission line after 100 miliseconds(Light Load)

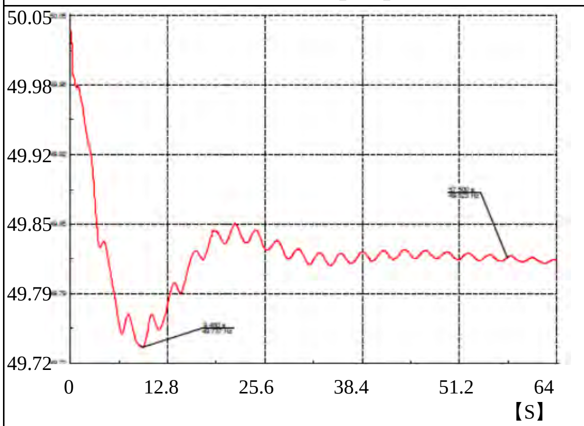
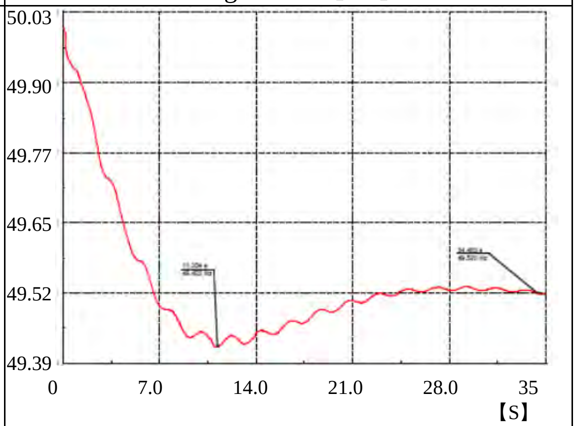
Generator Output	Generator Internal Angle	Generator Bus Voltage
		
TEPSCO-G1, Active Power, MW TEPSCO-G1, Reactive Power, MVar	SH-RAJAII(2), Rotor Angle, deg SH-RAJAII(3), Rotor Angle, deg SH-RAJAII(4), Rotor Angle, deg TEPSCO-G1, Rotor Angle, deg	TEPSCO, Voltage, P.U. SH-RAJAII(1), Voltage, P.U. SH-RAJAII(S), Voltage, P.U. SH-RAJAII(C.C), Voltage, P.U.

Source: calculated by JICA Study Team

Fig 5-94 15 Three-phase short circuit fault in 400 kV Rajaee C.C- Rajaee Steam transmission line and the outage of transmission line after 100 miliseconds(Light Load)

5.3.5 Result of power system frequency calculation after generator unit outage（2π connection）

In the case scenario of the outage of Shahid Rajaee new generator unit, it is confirmed that the system frequency is 49.52Hz.

Peak Load【Hz】	Light Load【Hz】
	
・Minimum frequency：49.737Hz—9.5s ・Final frequency：49.822Hz—57.5s	・Minimum frequency：49.422Hz—11.2s ・Final frequency：49.520Hz--34.4s

Source: calculated by JICA Study Team

Fig 5-95 System Frequency of the outage of Shahid Rajaee new generator unit

5.4 Summary of Power System Analysis

(1)Result of Fault Current Calculation
The short-circuit current of the Shahid Rajaee power station 400kV bus exceeds 50kA pre and post new generator interconnection to power system. If the bus of this power station is to done the bus splitting operation, it becomes less than 50 kA.

Table 5-28 Three short circuit current and Single-phase short-circuit current 【kA】

Configuration	Power station and substation name	Before bus splitting				After bus splitting	
		Pre interconnection of new generator		Post interconnection of new generator			
		3LG	1LG	3LG	1LG	3LG	1LG
existing substation through two-circuit	Shahid Rajaee exiting steam power station (S-1)	55.9	54.2	61.8	63.0	**49.5**	**48.2**
	Shahid Rajaee exiting steam power station (S-2)	—	—	—	—	**35.8**	**33.5**
	Shahid Rajaee exiting combined power station (CC)	55.0	53.1	60.3	60.4	**49.3**	**48.0**
Vardavard transmission line πconnection	Shahid Rajaee exiting steam power station (S-1)	55.9	54.2	61.7	62.4	**43.0**	**45.3**
	Shahid Rajaee exiting steam power station (S-2)	—	—	—	—	**29.8**	**22.0**
	Shahid Rajaee exiting combined power station (CC)	55.0	53.1	60.2	60.0	**43.3**	**45.2**
25connection ・Shahid Rajaee(S)～Vardavard ・Shahid Rajaee(CC)～Baghestan	Shahid Rajaee exiting steam power station (S-1)	55.9	54.2	61.7	62.4	**43.5**	**44.4**
	Shahid Rajaee exiting steam power station (S-2)	—	—	—	—	**27.8**	**24.8**
	Shahid Rajaee exiting combined power station (CC)	55.0	53.1	60.8	61.3	**43.8**	**45.0**

Source: calculated by JICA Study Team

(2)Result of Power Flow/Transient Stability/System Frequency calculation
It was confirmed that Power Flow/System Frequency/Transient Stability at new generator interconnection after the bus splitting were unquestionable. The system study condition and the calculation result are as follows.

〇Generator interconnection condition

- New power plant connection to 400kV Shahid Rajaee(S) through two-circuit 400kV transmission line
- New power plant connection to 400kV π connection（Shahid Rajaee(S)～Vardavard）
- New power plant connection to 400kV 2π connection（Shahid Rajaee(S)～Vardavard, Shahid Rajaee(CC)～Baghestan）

〇System configuration

- Bus splitting operation of Shahid Rajaee 400kV substation

〇Criteria

【 N-0 Criteria 】----(Normal Condition)
【 N-1 Criteria 】----(A single fault condition)

○Result of Calculation

- Power Flow：Within 100%【within 100% of rated capacity】
- Voltage：0.98～1.05P.U.【0.95～1.05P.U.】
- Steady state stability/Transient stability：Stable【Not step-out of generator】
- System Frequency：49.52Hz【49.5Hz or higher】

(3)Conclusion

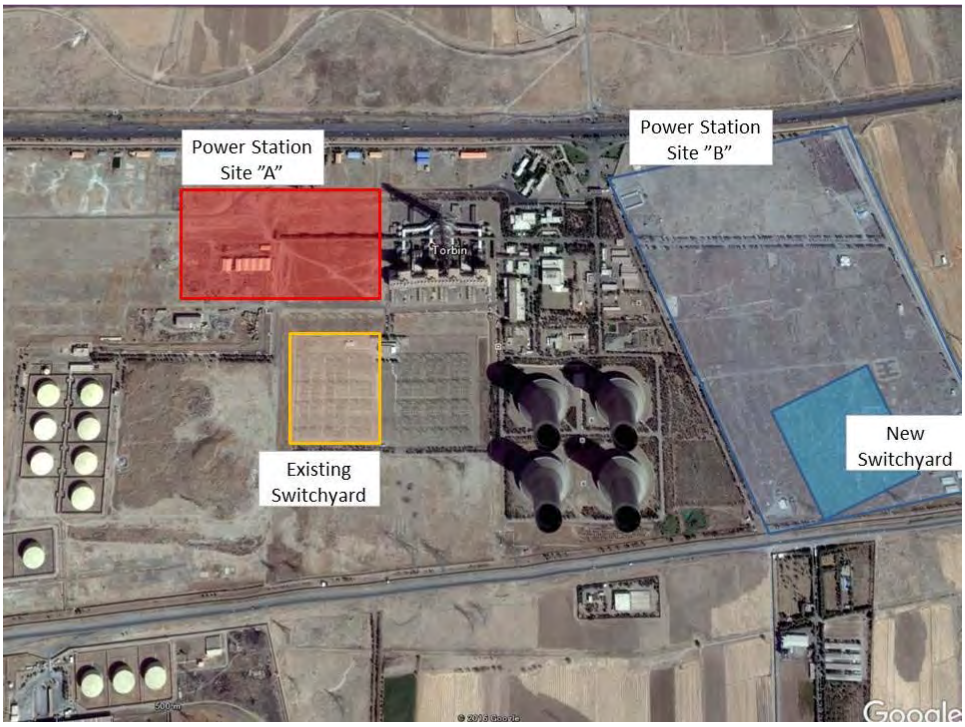
We carry out the power system analysis calculation for interconnecting the Shahid Rajaee new power plant (640 MW×2) to the existing 400kV power system. As a result, the fault current of the three-phase short circuit and the Single-phase short-circuit current exceeds 50 kA pre and post new generator interconnection. Therefore the bus splitting should be done in Shahid Rajaee Steam 400kV switchyard, in order to reduce the short circuit level.

It was confirmed that Power Flow/Steady state stability/Transient stability/System Frequency/ at new generator interconnection after the bus splitting were unquestionable, and operation of facilities and power system can continue in stable operation.

5.5 Grid Connection Plan

5.5.1 Location of a new power plant and a 400kV switching station

TPPH has planned to construct a new power plant at Shahid Rajaee and to transmit a generating power to the national grid through a 400kV switching station. There are two candidate sites, “A” and “B”, for the power station, further as for the 400kV switching station, two plans have been considered, one is to construct a new switching station and another is to re-use the existing switching station.



Source: created by JICA study team utilizing Google Earth

Fig 5-96 Planning location of a power plant and a 400kV switching station

Three plans out of these combination plans have been studied. Plan 1 is combination of a power plant “B” and a new switching station. Plan 2 is combination of a power plant “B” and the existing switching station. Plan 3 is combination of a power plant “A” and the existing switching station.

Table 5-29 Combination plans of a power plant and a switching station

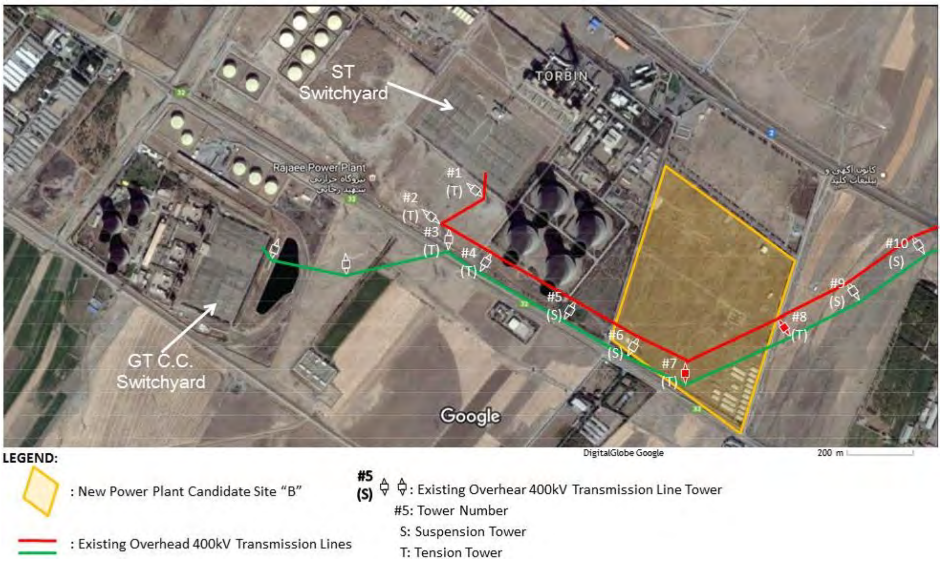
	Location of New Power Plant	
	Candidate Site "A"	Candidate Site "B"
New Switchyard	~~Plan 4~~	Plan 1
Existing Switchyard	Plan 3	Plan 2

Source: created by JICA study team

5.5.2 Existing National Grid

The existing 400kV transmission line runs near the planned Shahid Rajaee power plant “B”. In case of connecting the new switching station to the national grid in Plan 1, this connection would be joined to the existing 400kV overhead transmission line between tower number 7 and tower number 8.

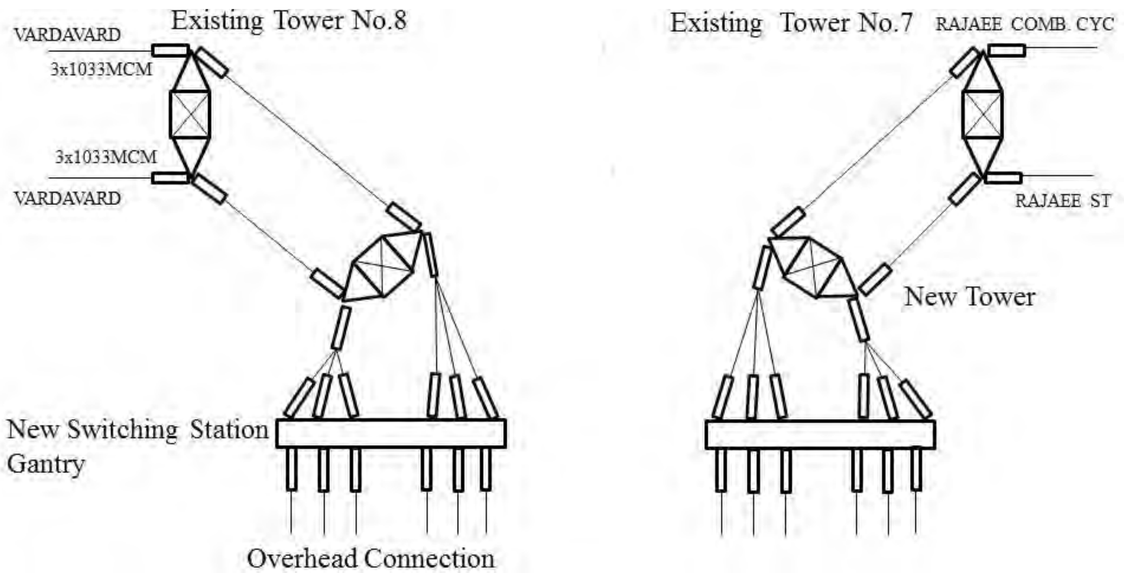
As other towers are suspension tower, existing transmission lines could not be divided between towers to connect outgoing lines to the grid. Therefore, lines to the grid shall be connected to the dividable transmission line between tower number 7 and tower number 8, which are tensile towers.



Source: created by JICA study team utilizing Google Earth

Fig 5-97 Existing 400kV overhead transmission line

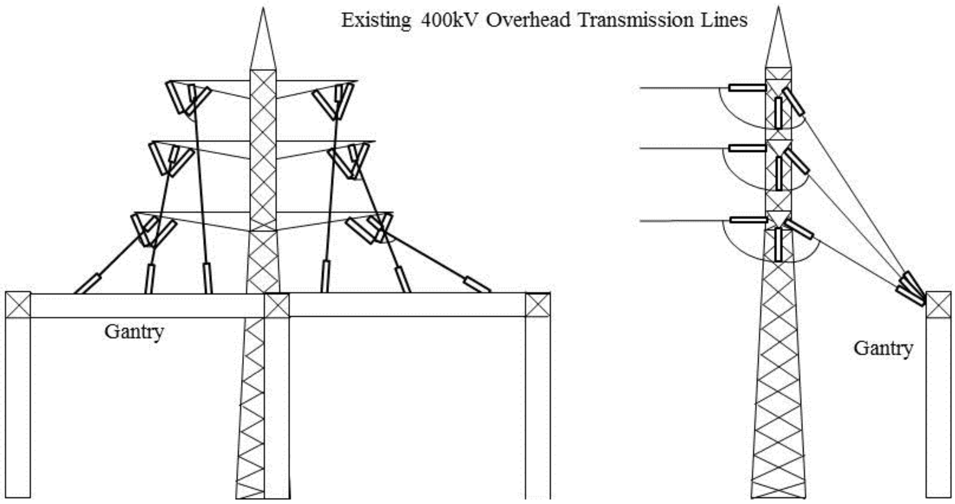
The outgoing line will be connected to each circuit of the existing 400kV transmission lines after dividing the lines. Power system analysis has proved that no troubles occur on transmitting capacity, power flow and accidental short-circuit current after connection to the grid.



Source: created by JICA study team

Fig 5-98 Connection by overhead line: plane drawing

Connection by overhead line in elevation drawing is as follows;



Source: created by JICA study team

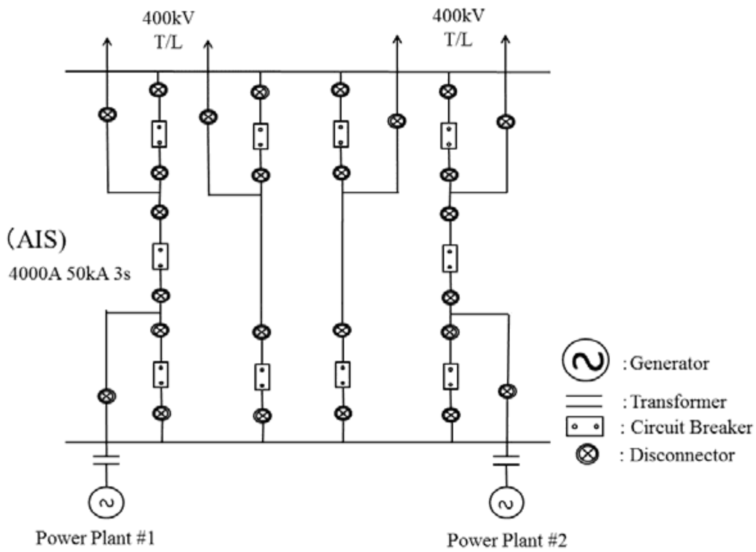
Fig 5-99 Connection by overhead line: elevation drawing

In plan 2 and Plan 3, as the power plant is connected to the existing 400kV switching station, connection to the grid is not necessary. In these cases also, it is proved that no troubles occur on transmitting capacity and others.

5.5.3 Busbar configuration of a 400kV switching station

Busbar configuration of a new switching station in Plan 1 is one and a half circuit breaker, which is a standard of a 400kV busbar configuration in Iran.

As for number of feeder at the switching station, the outgoing feeder is four circuits with considering grid reliability at failure and the generator feeder is two circuits same as number of generators.



Source: created by JICA study team

Fig 5-100 Busbar configuration of a 400kV switching station

5.5.4 400kV equipment

400kV equipment at the new switching station is Air Insulated Switchgear (AIS) in order to reduce initial cost and in accordance with the discussions with TPPH. AIS has been selected because of lower cost, adequate existing area in Shahid Rajaee Power plant and environmental conditions. TPPH recommends to use Iranian qualified AIS equipment (DS, CB, CT, CVT, …).

The Iranian unit price indicated by TPPH is applied to the estimation for all products and construction prices including labor charge except the 400kV XLPE cable.

A lifetime of substation equipment is assumed fifty (50) years and the overhaul inspection will be carried out every twenty-five (25) years. As the existing 400kV switching station already passed twenty-five (25) years without being operated even once since construction, the remaining lifetime would be twenty-five (25) years.

5.5.5 Method of connection

The method of connecting the power plant to the switching station and connecting the switching station to the grid is two ways, one is an overhead connection and another is an underground connection. As the result of combining these methods of connection and Plan 1 to 4, the following 5 plans are studied.

1. Plan 1-1, power plant “B”, new switching station, overhead connection from power plant to switching station, overhead connection from switching station to the grid

2. Plan 1-2, power plant “B”, new switching station, underground connection from power plant to switching station, overhead connection from switching station to the grid

3. Plan 2-1, power plant “B”, existing switching station, overhead connection from power plant to switching station

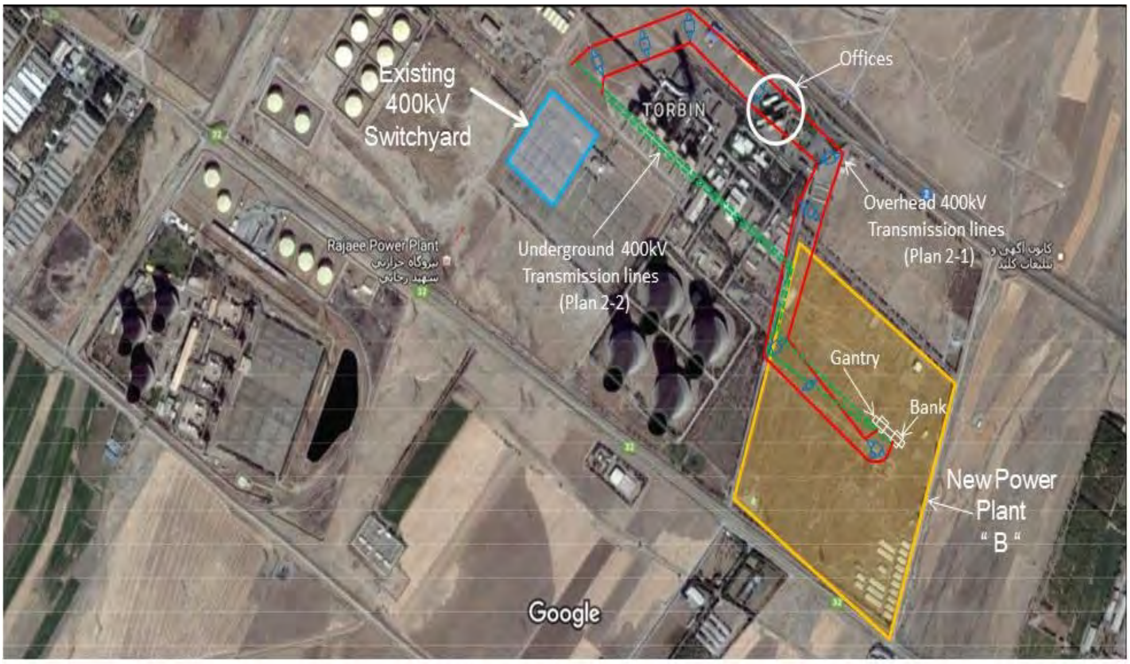
4. Plan 2-2, power plant “B”, existing switching station, underground connection from power plant to switching station

5. Plan 3-1, power plant “A”, existing switching station, overhead connection from power plant to switching station

Plan 1-1 & Plan 1-2

Source: created by JICA study team utilizing Google Earth

Fig 5-101 Power plant "B"－new switching station



Plan 2-1 & Plan 2-2

Source: created by JICA study team utilizing Google Earth

Fig 5-102 power plant "B"－existing switching station

Plan 3-1

Source: created by JICA study team utilizing Google Earth

Fig 5-103 power plant "A"－existing switching station

Above 5 plans have been indicated in the following table.

Table 5-30 Plans for comparison

Plan No.	1		2		3
	1-1	**1-2**	**2-1**	**2-2**	**3-1**
Location of New Power Plant	Candidate Site "B"	Candidate Site "B"	Candidate Site "B"	Candidate Site "B"	Candidate Site "A"
Location of Switchyard	New Switchyard	New Switchyard	Existing Switchyard	Existing Switchyard	Existing Switchyard
Switchyard Configuration	1 1/2 CB	1 1/2 CB	1 1/2 CB	1 1/2 CB	1 1/2 CB
Switchgear Type	AIS	AIS	AIS	AIS	AIS
Country of Origin for Switchgear	IRAN	IRAN	IRAN	IRAN	IRAN
No. of Bay	4 strings	4 strings	2 strings	2 strings	2 strings
Connection Method	Overhead Connection	Underground Connection	Overhead Connection	Underground Connection	Overhead Connection
Distance from power plant to Switchyard (m)	50	100	1,950	1,600	200
No. of Transmission Tower	0	-	9	-	2
Distance from Switchyard to Grid (m)	400+200	400+200	-	-	-
No. of Transmission Tower	2	2	-	-	-

Source: created by JICA study team

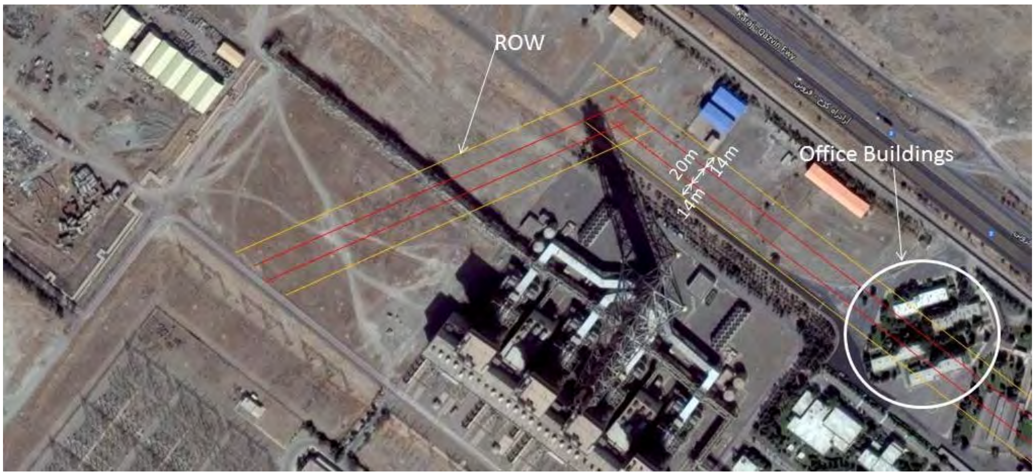
5.5.6 Relocation of office buildings

In Plan 2-1, four office buildings which belong to Shahid Rajaee power plant have been located underneath the 400kV transmission lines which are planned to connect the new power plant to the existing switching station. Four buildings are same scale and each building has floor of 600m^2 and two layers.

Under current Iranian regulations, any structure is not permitted to build within fourteen (14) meter from 400kV transmission line due to Right of Way (ROW). The distance between 400kV lines is twenty (20) meter as for a standard of 400kV overhead transmission line design in Iran.

It is forbidden to construct a structure within a width of forty-eight (48) meter near a 400kV transmission line. Therefore, the buildings which are scheduled to be underneath the 400kV transmission line shall be relocated.

We could obtain the Iranian cost for dismantling, transferring and re-constructing the office buildings through TPPH's cooperation.



Source: created by JICA study team utilizing Google Earth

Fig 5-104 ROW of the 400kV overhead transmission line

5.5.7 Techno-economical comparison

The fifty (50) years' Life Cycle cost is compared among five plans due to the reason why the lifetime of substation equipment is assumed fifty (50) years. All equipment is Iranian products except the 400kV XLPE cable as mentioned previously and all cost are Iranian prices.

As to cost comparison, several assumptions have been set up.

Assumption-1: The operating cost of the new 400kV switching station is seventy percent of ordinary cost. The rest thirty percent is expected an assistance from the existing 400kV switching station. (Plan 1-1, Plan 1-2)

Assumption-2: The operating cost of the existing 400kV switching station increases twenty percent due to the facilities of a double scale. (Plan 2-1, Plan 2-2, Plan 3-1)

Assumption-3: The load loss should occur due to a long distance between the new power station "B" and the existing 400kV switching station. (Plan 2-1, Plan 2-2)

Assumption-4: The independent control building should be constructed at the new 400kV switching station. (Plan 1-1, Plan 1-2)

Assumption-5: The existing control building should be extended for an additional control and protection system for the additional 400kV equipment. (Plan 2-1, Plan 2-2, Plan 3-1)

Assumption-6: Interest and inflation are as the same rate and these will cancel each other in the calculation. (All Plans)

Furthermore, other conditions to estimate cost are as follows;

1. As to the new 400kv switching station, initial cost at first and overhaul cost after twenty-five years occur.
2. As to the existing 400kV switching station, overhaul cost at first and dismantling and construction cost after twenty-five years occur.
3. The cost for gas pipe and oil pipe depends on the location of power plant.

Under these conditions, Life Cycle cost shall be estimated for each plan.

Table 5-31 Techno-economical comparison

Plan No.			**1**		**2**		3
			1-1	**1-2**	**2-1**	**2-2**	**3-1**
Location of New Power Plant			Candidate Site "B"	Candidate Site "B"	Candidate Site "B"	Candidate Site "B"	Candidate Site "A"
Location of Switchyard			New Switchyard	New Switchyard	Existing Switchyard	Existing Switchyard	Existing Switchyard
Switchyard Configuration			1 1/2 CB	1 1/2 CB	1 1/2 CB	1 1/2 CB	1 1/2 CB
Switchgear Type			AIS	AIS	AIS	AIS	AIS
Country of Origin for Switchgear			IRAN	IRAN	IRAN	IRAN	IRAN
No. of Bay			4 strings	4 strings	2 strings	2 strings	2 strings
Connection Method			Overhead Connection	Underground Connection	Overhead Connection	Underground Connection	Overhead Connection
Distance from power plant to Switchyard (m)			50	100	1,950	1,600	200
No. of Transmission Tower			0	-	9	-	2
Distance from Switchyard to Grid (m)			400+200	400+200	-	-	-
No. of Transmission Tower			2	2	-	-	-
Cost	Initial Cost	Erection Cost (MUSD)	20.00	20.00	-	-	-
Cost	Initial Cost	Connection Cost (MUSD)	0.30	1.06	0.84	8.80	0.09
Cost	Initial Cost	Relocation Cost for Offices (MUSD)	-	-	1.91 1)	-	-
Cost	Initial Cost	Overhaul Cost on Resume (MUSD)	-	-	0.08	0.08	0.08
Cost	Running Cost	Maintenance Cost for 50yrs (MUSD)	2.07	2.07	1.24	1.24	1.24
Cost	Running Cost	Overhaul Cost at every 25yrs (MUSD)	0.14	0.14	-	-	-
Cost	Running Cost	Replacement Cost (MUSD)	-	-	12.41 2)	12.41 2)	12.41 2)
Cost	Running Cost	Operation: Cost for 50yrs (MUSD)	4.59 3)	4.59 3)	1.31 4)	1.31 4)	1.31 4)
Cost	Running Cost	Operation: Concurrence Ratio	0.70 5)	0.70 5)	0.20 6)	0.20 6)	0.20 6)
Cost	Pipe Cost	Gas Pipe Cost Deviation (MUSD)	0.00	0.00	0.00	0.00	1.75
Cost	Pipe Cost	Oil Pipe Cost Deviation (MUSD)	0.29	0.29	0.29	0.29	0.00
Loss	Loss (MW)		0.00	0.00	0.33	0.33	0.00
Loss	Unit Price (1000USD/MW)		2,631.58	2,631.58	2,631.58	2,631.58	2,631.58
Loss	Loss Cost (MUSD)		0.00	0.00	0.87	0.87	0.00
Life Cycle Cost (MUSD)			**27.40**	**28.16**	**18.96**	**25.02**	**16.89**

Remarks: "1)" means relocation cost for 4 offices.
"2)" means dismantling cost for the existing switchgear is included.
"3)" means cost for additional operators because of the independent operating building.
"4)" means cost for additional operators because of the combined operating building.
"5)" means 70% of manpower is required for operating a new substation and 30% of manpower will be expected assistance from the existing substation.
"6)" means extra 20% of manpower is required for operating new switchgears in the existing substation.

Source: created by JICA study team

5.5.8 Conclusion

1. As the candidate site “A” in plan 3-1 is not the sufficiently available land to construct a power plant, it is difficult to layout efficiently the power plant. Therefore, this plan will not be recommended for the reason.
2. As for Plan 2-1 and 2-2, difficulty would occur against emergency response due to the long distance between a power plant and a 400kV switching station. These plans will not be recommended for the reason.
3. From a cost and operating point of view, **Plan 1-1** would be recommended as the most suitable plan.

Plan 1-1 is repeated herein.

Plan 1-1: the power plant ”B”, the new 400kV switching station, overhead connection from the power plant ”B” to the new 400kV switching station, overhead connection from the new 400kV switching station to the grid

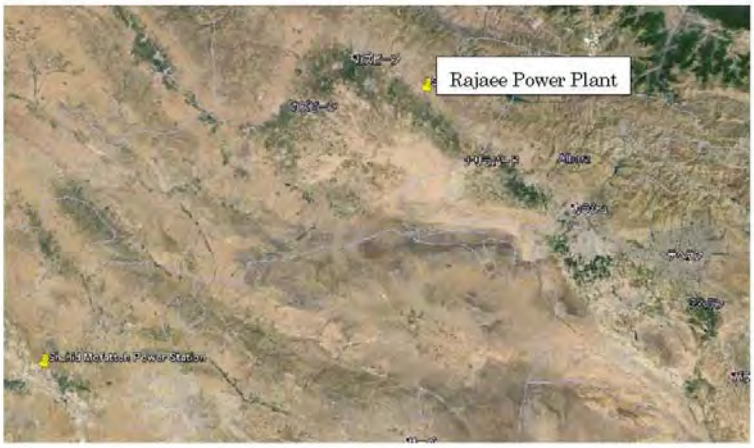
Chapter 6 Environmental and Social Considerations

6.1 Overview of the Project

6.1.1 Location of the Planned Project Site

This Project has a target site within the site of the existing Shahid Rajaee Power Plant, which is located in Iran's northern province of Qazvin, about 100 km northwest of the capital of Iran.

The power-generating capacity of the Shahid Rajaee Power Plant is 1,000 MW (250 MW x 4 units) at its steam power plants and 1,042 MW(347MW×3 units[1]) at its combined cycle power plant.



★Shahid Rajaee Power Plant
Location: 25km south of Qazvin, Qazvin-Tehran Highway, Iran
URL: http://www.rajaeepowerplant.ir

Source: Obtained from Google Earth, and prepared by JICA Study Team

Fig. 6-1 Location of Project Site

Overview of the Project

The government of Iran, in "Intended Nationally Determined Contributions" which is their policy objective toward COP21 (the 21st Conference of the Parties to the UNFCCC), expressed their commitment to the reduction of greenhouse gas by 4% (12% at the maximum) by 2030 as compared with the case where no measures are taken, and cited the combined cycle as a means for achieving the objective.

[1] One unit of 347MW is composed of 123.4MW×2 units of gas turbine and 100.6MW×1 unit of steam turbine.

The energy sector accounts for 90% of the total greenhouse gas emissions, of which the power generation fields such as thermal power plants are emitting 20% of the total.
In establishing the INDC target, the increasing demand for electric power associated with economic growth is considered as BAU scenario, and then the following measures are provided in the field of power generation in order to achieve the target. The introduction of a combined cycle power plant is cited as one of the measures[2].

- By 2030 a wind power plant of 6,000 MW and a hydroelectric power plant of 18,700 MW will be installed.
- Increase the share of the high-efficiency combined cycle power plant with a thermal efficiency of about 45% from 27.5% in 2015 to 54.3% in 2025. (Improvement of open cycle gas turbine or new construction of combined cycle power plant)
- Installation of a 2,000 MW nuclear power plant.

The estimated greenhouse gas emission reduction in Iran is approximately 210 million t-CO_2 per year in 2030, of which the contribution of the power generation field including thermal power plant will be more than 30% of the total reduction, approximately 60 million t-CO_2 per year. Implementation of reduction measures through thermal power generation is therefore important for achieving the goal.

In this regard, the Iranian Department of Energy etc. indicated their intention to promote the introduction of low-environmental-impact gas combined cycle power generation facilities instead of conventional steam power generation facilities in the future development of new power sources.

Based on the situation above, this Project relates to the construction of two units of new combined cycle power generation units with the maximum output of 640 MW within the site of the existing Shahid Rajaee Power Plant.

The power plant has approximately 60% of power efficiency (generating end output, LHV base), and meets the criteria for the 500MW-class combined cycle listed in BAT (Best Available Technology, February 2017) released by Ministry of Economy, Trade and Industry and Ministry of the Environment in Japan.

It will adopt the technology enabling minimum fuel consumption per output and lower emission of nitrogen oxide (NOx) and carbon dioxide (CO_2).

It is also planned to newly construct gas pressure reducing facilities, gas switch stations, etc., within the same site.
The combined-cycle power plant generates electricity using both gas turbine and steam turbine, to thereby use less water compared to the conventional power generation using steam turbine only.

For intake of raw water, it is planned to use ground water taken from water wells, two within the project site and five outside of the site.

For the power plant facilities under planning, a dry-type forced-draft direct cooling system will be introduced, which does not use water resulting in reduction of total water intake and large scale groundwater intake will not be undertaken.

[2] 「Islamic Republic of Iran Intended Nationally Determined Contribution」（2015）,「Iran's Third National Communication to UNFCCC, Chapter 3: National GHGs Mitigation Policies Energy」（2015）

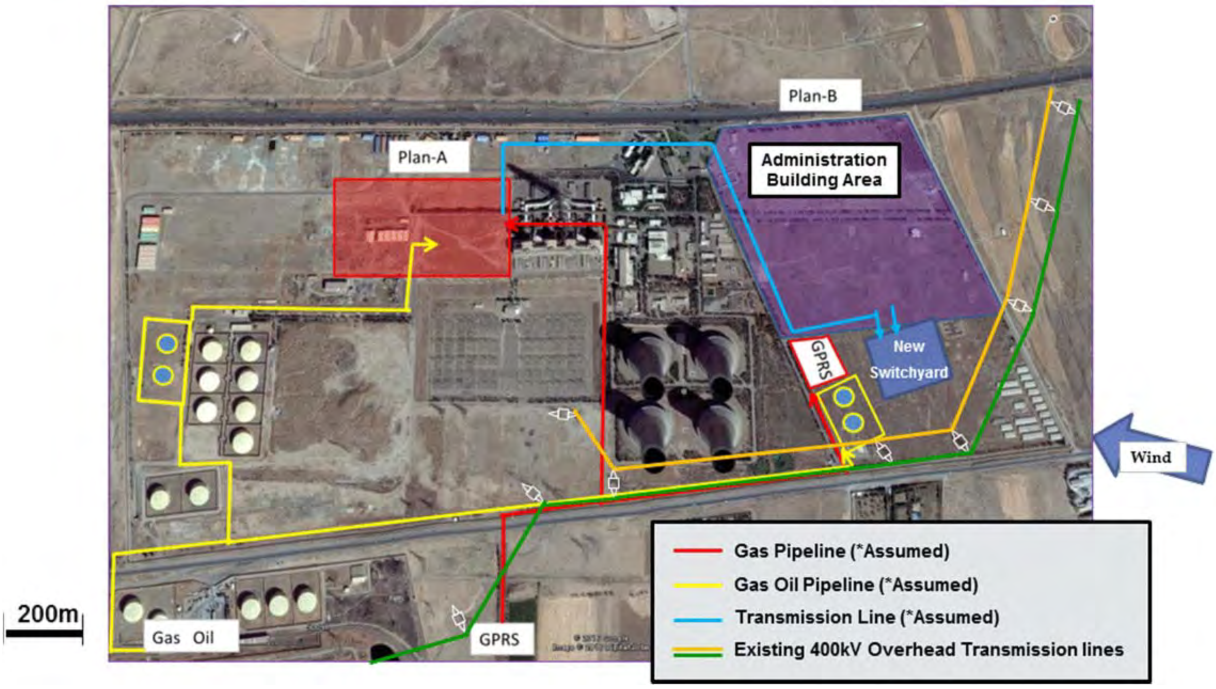
The planned amount of water intake is about 300m^3 / day at the maximum, which is only 1.6% of the permitted water intake amount at existing power plants, 19,000 m^3/day, and can sufficiently cope with the pumps used at the existing wells. A new water intake permission will not be necessary.

The amount of wastewater discharged from the power plant is about 360m^3 / day at the maximum, and it will be entirely stored in the reservoir installed within the power plant site after treatment to reuse for watering such as greening.

No river is located near the power plant site, and in case of temporary increase of waste water, during periodic inspection for example, and at the same time in the winter when water-reuse is smaller and the capacity of the reservoir is exceeded, wastewater from the power plant may be discharged into the adjacent irrigation canals, as is the case of the existing facility

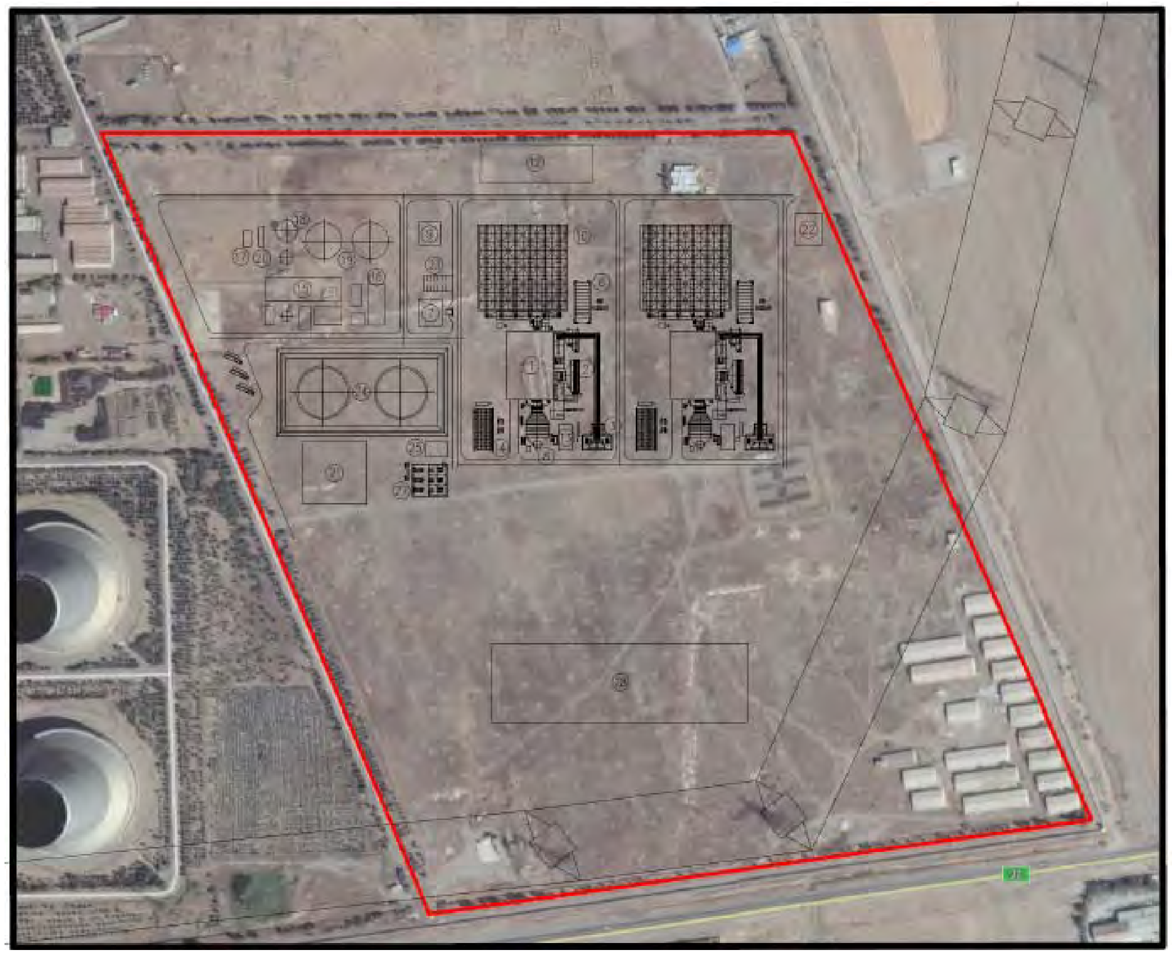
.

The layout of the existing Shahid Rajaee Power Plant and the planned new power generation units is shown below. The new power generation units will be established in the location of Plan-B, using the open area in the east of the existing power plant.



Source: Obtained from Google Earth, and prepared by JICA Study Team

Fig. 6-2 Layout of Shahid Rajaee Power Plant and Planned New Power Generation Units



NO.	EQUIPMENT LIST
1	TURBINE BUILDING
2	INLET AIR FILTER
3	TRANSFORMER
4	NOT USED
5	NOT USED
6	ELECTRICAL & CONTROL PACKAGE
7	CENTRAL CONTROL BUILDING
8	HEAT RECOVERY STEAM GENERATOR
9	AUX.BOILER
10	AIR COOLED CONDENSER
11	NOT USED
12	ADMINISTRATION BUILDING
13	FEED WATER PUMP
14	CLOSED CYCLE COOLING WATER COOLER
15	WATER TREATMENT PLANT
16	WASTE WATER TREATMENT PLANT
17	F/F PUMP
18	RAW WATER / FIRE WATER TANK
19	DEMI WATER TANK
20	BOTTLE STORAGE
21	GAS METERING STATION
22	WORKSHOP/WAREHOUSE
23	PARKING
24	FUEL OIL STORAGE TANK
25	FUEL OIL TRANSFER PUMP
26	NOT USED
27	FUEL GAS COMPRESSOR
28	AIS

Source: obtained from Google Earth and prepared by JICA Study Team

Fig. 6-3 Layout of the New Power Plant Units

6.1.2 Overview of Related Facilities

Electric power to be generated by the new power plants planned to be constructed in this project will be transmitted via existing 400 kV transmission lines, and no plan is being made to construct new transmission lines.

In addition, gas fuel to be used for power generation will be supplied from the gas pressure reducing facilities currently in use for the existing power plant through a new pipeline (approximately 200m) to be installed in the existing pipeline installation area outside the site.

Also, light oil will be supplied from the light oil tank installed for the existing power plant via a pipeline planned to be newly constructed within the site.

6.2 State of the Environment

In the following sections, the overall state of the environment will be discussed based on the results of the first to fourth site surveys. Detail of the results obtained concerning the state of the environment through document studies and field investigations will be described in Section of 6.6.

6.2.1 Overview of the Natural Environment

The flora and fauna observed within the project area includes several herbaceous species and rodents species, which are commonly seen in the wide area around the site, and no precious species are observed. There are no major sources of air pollution and noise emission in the local area except for the existing power plant, which means the project site can be considered to be relatively clean and quiet.

No river is found in the area around the existing power plant, and excess wastewater which cannot be reused is discharged to nearby irrigation water canals for agriculture in the surrounding area.

The nearest natural conservation area is the Bashgol Protected Area (25,334ha) located in an area at about 68 km distance from south-east of the existing power plant.

6.2.2 Overview of the Social Environment

The project site is located in the site of the existing power plant and in an area where land preparation has already been completed and there is no house within the site.

The nearest residential area is a small Asghabad village located about 1.5 km to its north and there is no residential area nearer to the power plant.

Qazvin City (population 400 - 500 thousand people) is located about 20 km away from the site. As for the surrounding land use, the south side is mainly agricultural land, and corn, melon, watermelon, vegetables, etc. are cultivated.

The waste water from the existing power plant which cannot be reused, for sprinkling in winter for example, is stored in the adjacent agricultural canal, and will be used in the surrounding farmland in the coming spring.

An agreement was made on the regional contribution between the existing Shahid Rajaee Power

Station and the local community, noting that waste water is provided to the surrounding farmers as agricultural water in compensation for using groundwater for power plants,.
Since there is no river nearby, fishery is not implemented around the power plant.

6.2.3 Status of monitoring in the existing power plant

The current status of exhaust gas, waste water, air quality and noise, and the waste treatment method is described below, in order to present basic information for determining the cumulative impact of the project within the project facility including the existing power plant and the surrounding area.

(1) Exhaust gas
The pollution concentration measurement is conducted within the existing steam power plant using a continuous monitoring system, and also in the existing combined cycle power plant every three months by the consultant registered and authorized by DOE.

Gas fuel is normally used in the existing power plant. In winter, in case natural gas supply is not sufficient, heavy oil fuel is used in the steam power plant and light oil is used in the combined cycle power plant, mixed with natural gas in certain cases. In consequence, pollution concentration varies depending on the fuel used.

The monitoring result of the pollution concentration of exhaust gas from the existing power plant is shown in Table 6-1 and Table **6**-2.

In the steam power plant, NOx concentration often exceeds the emission standard, and SOx also exceeds the standard value several times in the case of burning heavy oil.

Also in the combined cycle power plant, NOx concentration does not meet the emission standard in several cases and SOx also exceeds the standard value several times in the case of burning light oil.

Table 6-1 Monitoring Result of the Exhaust Gas from the Existing Steam Power Plant

Date	Parameter	Unit	Steam power plant				Emission gas standard of Iran （Grade-2） (mg/Nm^3)		
			No1	No2	No3	No4			
2016.03.12	Fuel	-	Mix (Gas/Heavy oil)	Mix (Gas/Heavy oil)	Mix (Gas/Heavy oil)	Mix (Gas/Heavy oil)	Gas	Heavy oil	Diesel oil
	SOx	mg/Nm^3	1057	-	1040	1549	200	800	150
	NOx	mg/Nm^3	613	-	613	676	300	400	250
2016.06.09	Fuel	-	Gas	Gas	Gas	Gas	Gas	Heavy oil	Diesel oil
	SOx	mg/Nm^3	0	0	0	0	200	800	150
	NOx	mg/Nm^3	475	503	438	623	300	400	250
2016.08.28	Fuel	-	Gas	Gas	Gas	Gas	Gas	Heavy oil	Diesel oil
	SOx	mg/Nm^3	0	0	0	0	200	800	150
	NOx	mg/Nm^3	493	707	805	585	300	400	250
2016.11.24	Fuel	-	-	Heavy oil	Heavy oil	Heavy oil	Gas	Heavy oil	Diesel oil
	SOx	mg/Nm^3	-	741	644	468	200	800	150
	NOx	mg/Nm^3	-	170	161	185	300	400	250
2017.02.21	Fuel	-	Mix (Gas/Heavy oil)	Mix (Gas/Heavy oil)	-	Mix (Gas/Heavy oil)	Gas	Heavy oil	Diesel oil
	SOx	mg/Nm^3	359	144	-	194	200	800	150
	NOx	mg/Nm^3	201	171	-	202	300	400	250
2017.05.30	Fuel	-	Gas	Gas	Gas	Gas	Gas	Heavy oil	Diesel oil
	SOx	mg/Nm^3	0	0	0	0	200	800	150
	NOx	mg/Nm^3	249	128	170	585	300	400	250

Date	Parameter	Unit	Steam power plant				Emission gas standard of Iran （Grade-2）(mg/Nm^3)		
			No1	No2	No3	No4			
2017.08.22	Fuel	-	Heavy oil	Heavy oil	Heavy oil	Heavy oil	Gas	Heavy oil	Diesel oil
	SOx	mg/Nm^3	316	281	300	558	200	800	150
	NOx	mg/Nm^3	80	160	189	175	300	400	250
2017.11.20	Fuel	-	-	-	Gas	Gas	Gas	Heavy oil	Diesel oil
	SOx	mg/Nm^3	-	-	0	0	200	800	150
	NOx	mg/Nm^3	-	-	297	299	300	400	250
2018.03.05	Fuel	-	Gas	Mix (Gas/Heavy oil)	Gas	-	Gas	Heavy oil	Diesel oil
	SOx	mg/Nm^3	0	59	0	-	200	800	150
	NOx	mg/Nm^3	280	296	249	-	300	400	250

Source: prepared by JICA Study Team

Table 6-2 Monitoring Result of the Exhaust Gas from the Existing Combined Cycle Power Plant

Date	Parameter	Unit	Combined Cycle PP 1		Combined Cycle PP 2		Combined Cycle PP 3		Emission gas standard of Iran （Grade-2） (mg/Nm^3)		
			GT No1	GT No2	GT No3	GT No4	GT No5	GT No6			
2016.03.12	Fuel	-	Mix (Gas /Diesel oil)	Mix (Gas /Diesel oil)	Mix (Gas /Diesel oil)	Mix (Gas /Diesel oil)	Mix (Gas /Diesel oil)	Mix (Gas /Diesel oil)	Gas	Heavy oil	Diesel oil
	SOx	mg/Nm^3	174	-	146	169	-	-	200	800	150
	NOx	mg/Nm^3	295	-	271	326	-	-	300	400	250
2016.06.09	Fuel	-	Gas	Gas	Gas	Gas	Gas	Gas	Gas	Heavy oil	Diesel oil
	SOx	mg/Nm^3	0	0	0	0	3	0	200	800	150
	NOx	mg/Nm^3	244	224	242	275	348	424	300	400	250
2016.08.28	Fuel	-	Gas	Gas	Gas	Gas	Gas	Gas	Gas	Heavy oil	Diesel oil
	SOx	mg/Nm^3	0	0	0	0	0	0	200	800	150
	NOx	mg/Nm^3	253	193	238	232	299	444	300	400	250
2016.11.24	Fuel	-	-	-	Diesel oil	Diesel oil	Diesel oil	Diesel oil	Gas	Heavy oil	Diesel oil
	SOx	mg/Nm^3	-	-	7	35	18	23	200	800	150
	NOx	mg/Nm^3	-	-	176	126	171	125	300	400	250
2017.02.21	Fuel	-	Diesel oil	Diesel oil	-	-	Diesel oil	Diesel oil	Gas	Heavy oil	Diesel oil
	SOx	mg/Nm^3	3	31	-	-	12	11	200	800	150
	NOx	mg/Nm^3	147	150	-	-	115	140	300	400	250
2017.05.30	Fuel	-	Gas	Gas	Gas	Gas	Gas	Gas	Gas	Heavy oil	Diesel oil
	SOx	mg/Nm^3	0	0	0	0	3	0	200	800	150
	NOx	mg/Nm^3	123	134	188	124	163	123	300	400	250

Date	Parameter	Unit	Combined Cycle PP 1		Combined Cycle PP 2		Combined Cycle PP 3		Emission gas standard of Iran (Grade-2) (mg/Nm^3)		
			GT No1	GT No2	GT No3	GT No4	GT No5	GT No6			
2017.08.22	Fuel	-	Gas	Diesel oil	Gas	Diesel oil	Diesel oil	Gas	Gas	Heavy oil	Diesel oil
	SOx	mg/Nm^3	0	31	0	27	16	0	200	800	150
	NOx	mg/Nm^3	140	130	121	103	207	80	300	400	250
2017.11.20	Fuel	-	Gas	Gas	-	Gas	-	Gas	Gas	Heavy oil	Diesel oil
	SOx	mg/Nm^3	0	0	-	0	-	0	200	800	150
	NOx	mg/Nm^3	168	137	-	159	-	174	300	400	250
2018.03.05	Fuel	-	Gas	Gas	Gas	Gas	Gas	-	Gas	Heavy oil	Diesel oil
	SOx	mg/Nm^3	0	0	0	0	3	-	200	800	150
	NOx	mg/Nm^3	123	134	188	124	163	-	300	400	250

Source: prepared by JICA Study Team

(2) Waste water

The result of the monitoring of the pollutant concentration of the water emission is reported to DOE as necessary. Table 6-3 indicates the monitoring result of concentration of pollutants in the waste water from the existing power plant.

Table 6-3 Monitoring Result of Waste Water from the Existing Power Plant

Item Day/month/year	Monitoring results （mg/l）				Waste water standards of Iran (Discharged to surface water for using agriculture and irrigation) （mg/l）
	30/5/2017	22/8/2017	20/12/2017	5/3/2018	
Chlorine	0.1	0.2	0.2	0.1	0.2
Oil and grease	0	0	0	2.6	10
BOD	0	0	0	0	100
COD	7	4	3.6	4.6	200
DO	3.8	5.2	4.1	4.1	2
Total Suspended Solids	4	38	10	2	100
pH	8.2	8.1	7.8	7.4	6-8.5
Turbidity	4.61	15.7	4.65		50
Total coliform / 100mL	23	120	120	120	1000(MPN)

Source: prepared by JICA Study Team

JICA Study Team also conducted the water quality measurement of the treated waste water using reused water at the sprinkler and water at the discharge channel within the project site.
The result as shown Table 6-4 indicates that the effluent standard of Iran is well satisfied.

Table 6-4 Result of Water Quality of Effluent

Item	Sprinkle water （mg/l）	Water of discharge channel （mg/l）	Waste water standards of Iran (Discharged to surface water for using agriculture and irrigation) （mg/l）
Cadmium	ND	ND	0.05
Chloride	36	86	600
Mercury	ND	ND	Negligible
Lead	ND	ND	1
Sulfite	0.01	1.341	1
Oil and grease	ND	ND	10
BOD	ND	ND	100
COD	ND	3	200
Total Suspended Solids	ND	ND	100
pH	7.5	7.6	6-8.5

Note: ND indicates “under limit of detection”.

Source: prepared by the Study Team

(3) Air quality

Air quality (PM_{10} and $PM_{2.5}$) measurement has been conducted every three months at eight locations around the boundary of the power plant site shown in Figure 6-4, by the consultant registered and authorized by DOE. Table 6-5 shows the result of the air quality monitoring within the existing power plant site.

Both PM_{10} and $PM_{2.5}$ are well below the environmental quality standard in Iran. The measurement of NO_2 and SO_2 has not been conducted.

Source: obtained from Google Earth and prepared by Study Team

Fig. 6-4 Measurement Points of Air Quality and Noise

Table 6-5 Result of the Air Quality Monitoring （μg/m³）

Day/month/year	Point No	$PM_{2.5}$	PM_{10}	Day/month/year	Point No.	$PM_{2.5}$	PM_{10}
22/2/2017	1	3.9	41.2	20/11/2017	1	8.9	54.8
	2	4.1	48.4		2	8.8	45.9
	3	5.8	38.3		3	10.1	115.1
	4	7.4	51.8		4	8.9	44.0
	5	5.6	55.2		5	7.3	41.0
	6	6.5	65.2		6	7.4	39.7
	7	4.1	37.1		7	7.9	38.5
	8	5.5	63.3		8	8.0	57.0
30/5/2017	1	4.3	38.8	05/03/2018	1	7.0	35.9
	2	5.2	42.2		2	6.5	29.3
	3	4.6	35.6		3	6.9	28.4
	4	5.7	47.4		4	7.7	38.8
	5	5.8	52.1		5	6.8	42.3
	6	4.8	59.3		6	6.3	39.6
	7	5.9	41.7		7	6.2	56.6
	8	4.6	48.6		8	6.3	44.4
22/8/2017	1	2.7	46.6	Iran standard		35（24hr）	150(24hr)
	2	2.5	37.5				
	3	2.6	41.2				
	4	2.8	45.4				
	5	1.9	21.7				
	6	3.8	45.3				
	7	3.7	52.6				
	8	2.1	25.4				
Iran standard		35（24hr）	150(24hr)				

Source: prepared by JICA Study Team

(4) Noise

Noise level measurement has also been conducted every three months at eight locations around the boundary of the power plant site shown in Figure 6-4, similar to the air quality measurement, by the consultant registered and authorized by DOE.

Table 6-6 shows the result of the noise monitoring within the existing power plant site. The noise level is below the environmental quality standard in Iran.

Table 6-6 Result of the Noise Monitoring (dBA)

Day/month/year	Point No.	Noise level Leq	Iran standard (Industrial Area)	Day/month/year	Point No.	Noise level Leq	Iran standard (Industrial Area)
22/2/2017	1	63	Day:75 Night:65	20/11/2017	1	62	Day:75 Night:65
	2	65			2	57	
	3	62			3	71	
	4	61			4	62	
	5	62			5	44	
	6	58			6	43	
	7	59			7	62	
	8	61			8	64	
30/5/2017	1	62		05/03/2018	1	66	
	2	65			2	61	
	3	65			3	64	
	4	62			4	64	
	5	64			5	64	
	6	59			6	52	
	7	61			7	62	
	8	64			8	56	
22/8/2017	1	61					
	2	60					
	3	66					
	4	66					
	5	63					
	6	62					
	7	63					
	8	66					

Source: prepared by JICA Study Team

(5) Waste

The overview of the waste treatment system in the existing power plant is shown in Table 6-7. Concerning hazardous waste, sludge and waste oil generated from waste water treatment is sold for recycle, and other hazardous waste including sludge from waste water treatment, incineration ash from the boiler and oily mud are landfilled within an anti-seepage pit authorized by the Department of Environment (DOE) and built in the site.

Hazardous waste was disposed of in the past at the disposal site in Booin Zahra City 90km away from the project site, but today they are disposed of in the pit within the project site.
As for general waste, paper and iron scrap is sold to the specialized recycle operator, and residual food of the power plant staffs
is composted and reused for fertilizer.

Table 6-7 Overview of the waste treatment system in the existing power plant

Classification of waste (Hazardous or Non hazardous)	Description of waste	Content	Disposal method (Recycle by 3rd party, land fill to authorized place etc)
Non hazardous	Ferrous scrap	metal	Recycle by Selling
Non hazardous	Nonferrous scrap	Copper, aluminum	Recycle by Selling
Hazardous	Waste electrodes (stubs)	Stub	Land fill in the power plant site
Hazardous	Ash from boiler	Ash	Land fill in the power plant site
Hazardous	Waste oil	Oil	Recycle by Selling
Hazardous	Oily sludge	Sludge contaminated by oil products	Land fill in the power plant site
Hazardous	Sludge from wastewater treatment unit	Sludge	Land fill in the power plant site
Hazardous	Sludge from pretreated raw water	Sludge	Recycle by Selling
Non hazardous	Waste paper, can, bin	Paper, can, bin	Recycle by Selling
Non hazardous	Solid domestic waste	Solid domestic waste	Recycle
Non hazardous	Food waste	Remains of food	Compost

Source: prepared by JICA Study Team

6.3 Laws and Regulations Related to Environmental Impact Assessment

6.3.1 Environment-Related Legal System

In Iran, environmental protection is under the jurisdiction of the Department of Environment. In 1971, the Department of Environment was established for the purposes of protection and improvement of the environment, prevention and management of environmental pollution and worsening pollution, and conservation of wild life and marine life in its territorial seas. The Department of Environment has provincial offices to perform environmental monitoring at the provincial level.

The basic law for environmental protection in Iran is the "Environmental Protection and Enhancement Act (1982)" which was issued in 1974 and revised in 1982.

The Department of Environment is the government body responsible for application and enforcement of the above Act and other environmental protection laws and regulations.
Laws Iran has in relation with environmental protection are as follows:

- Environmental Protection and Enhancement Act (1982)
- Environmental Impact Assessment Decree 138 (1994)
- Air Pollution Control Act (1996)
- Air Pollution Prevention Executive Regulation (2016)
- Standards of Air Pollution arising from Industries and Workshops (1999)
- Water Distribution Act (1982)
- Water Pollution Control Rule (1984)
- Solid Waste Management Act (2004)
- Municipality Act (1955)
- Noise Protection Act (2008)

6.3.2 International Treaties

International treaties signed or ratified by Iran are as follows:

- UN Conference on the Man & Environment (Stockholm Declaration-1972)
- UN Conference on Environment & Development (Rio Declaration-1992)
- AGENDA 21-Character for Future (Rio-1992)
- Principal on the Conservation of the Forests (Rio-1992)
- United Nations Environment Program (UNEP-1972)
- International Union Conservation Nature & Natural Resources (1948)
- Convention on Wetlands (Ramsar-1971)
- Convention Concerning to the Protection of the World Cultural and Natural Heritage (UNESCO-1972)
- Convention for the Protection of the Ozone Layer (Vienna – 1987)
- Protocol on Substances that Deplete the Ozone Layer (Montreal – 1987)
- Convention on the Control of Trans-boundary Movement of Hazardous Wastes & Their Disposal (Basel – 1989)
- UN Framework Convention on Climate Change (New York – 1992)
- Kyoto Protocol to the UN Framework Convention on Climate Change (Kyoto–1998)
- UN Convention to Combat Desertification (Paris – 1994)
- Convention on the Prevention of Marine Pollution by Dumping of Waste and other Matter (London – 1972)

- Convention on Oil Pollution Preparedness, Response and Co-operation (London – 1990)
- Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties (Brussels – 1969)
- Protocol Relating to Intervention on the High Seas in Cases of Pollution by Substances Other Than Oil (London – 1973)
- Berne Treaty on the Protection of Endangered Species in Their Habitats
- CITES Convention (Control of International Trade in Endangered Species)

6.3.3 Legal System and Procedures for Environmental Impact Assessment

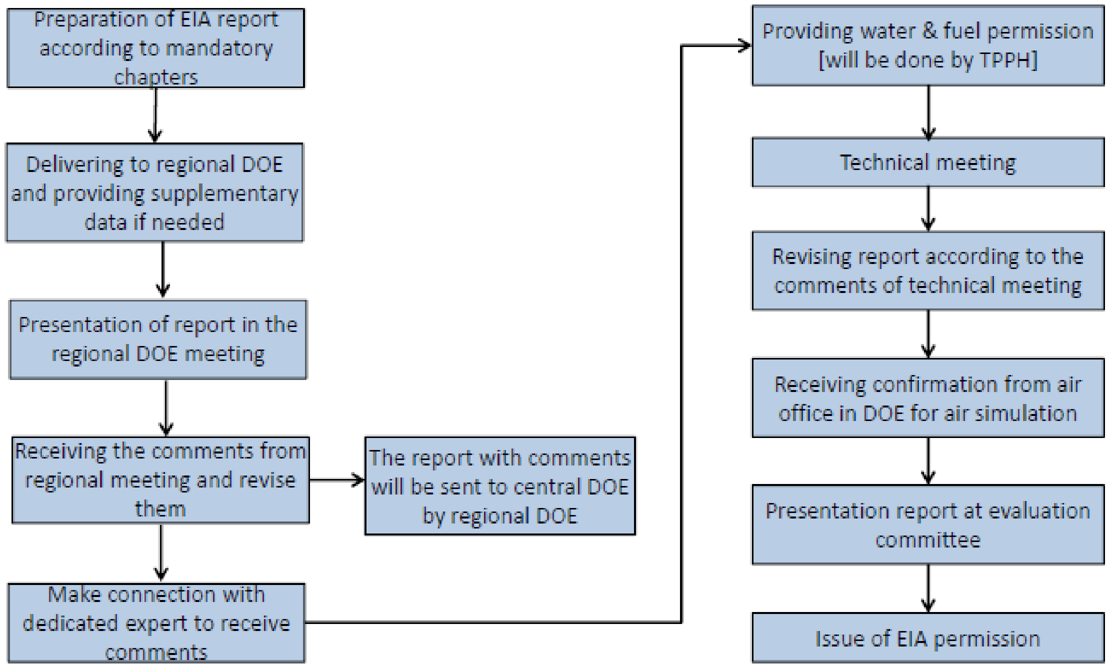
In Iran, Environmental Impact Assessment (EIA) is carried out pursuant to the Environmental Impact Assessment Decree 138 (1994). When constructing a thermal power plant of 100 MW or larger in Iran, EIA is required.

A flow of EIA procedures in Iran is shown in Figure below. The number of date for the review is not specified in the Decree cited above. According to TPPH, based on what they experienced in the past, it takes at least about three months from when an EIA report is submitted until the Department of Environment issues EIA approval, since the review by the technical committee and the committee for the final review take long time.

Risk assessment is considered an important item, and a detailed safety analysis method, which is normally not required in the EIA in other countries, is required for the gas supply facility and the combustion facility, which are not a subject in the F/S report by the Study Team. In this regard, an additional period for implementing risk assessment will be necessary based on F/S report by employing a consultant. In consequence, TPPH considers that it will take approximately one year for obtaining the approval from DOE after receiving F/S report from the Study Team.

The monitoring reports during construction and operation phase (including working safety report) will be submitted every month to DOE, and will be examined by the monitoring committee consisting of DOE and TPPH.
The local government having the jurisdiction for this project is the Qazvin Provincial Government.

In Iran, although disclosure of information to the general public, explanatory meetings for residents, etc., in relation to EIA reports are not defined in the EIA procedures, the EIA report will be disclosed in Persian language at the state and provincial DOE.



Source: prepared by JICA Study Team

Fig. 6-5 Flow of EIA Procedures in Iran

The general composition of the EIA report based on the regulation is shown below.

1. Non –technical abstract	1.1 Overview of the project 1.2 location of project (Alternatives) 1.3 General spec. of alternatives 1.4 Technical aspects of different alternatives 1.5 Environmental impacts 1.6 Social impacts, 1.7 Mitigation assessment of Environmental of project 1.8Risk analysis of project on Environment
2. Project description	2.1Title of project 2.2 Objectives and, requirement of project 2.3 Iran global future planning and project 2.4 Laws and regulations related to the Environmental issues. 2.5 Purposed location for the project 2.6 Alternatives for project from technical and location viewpoints 2.7 Different phases of project 2.8 Detailed description of project activities in construction and operation phase 2.9 Auxiliary facilities 2.10 Specialty of each and every alternative
3.Environmental issues during construction period	3.1 Site mobilization 3.2 Site preparation 3.3 Earth work, excavation, and soil consolidation 3.4 Accommodation of staff 3.5 Development of green area
4. Pollutant, important waste, and related hazardous to the project	4.1Soil pollution in construction and operation phase 4.2 Water pollution in construction and operation phase 4.3 Noise pollution in construction and operation phase 4.4 Air pollution in construction and operation phase

5.Project HSE	5.1During construction ・Explosion, fire 5.2 During operation
6.Existing condition of environment of region	6.1 Area to be studied 6.2 The natural environment(Geology, Erosion ,soil contamination , topography, seismicity , fault zones of region , water resource, surface water ,quality of surface water , undergrounded water , water pollution, climate , air/ noise pollution) 6.3 Natural Environment 6.4 Social Environment
7.Assessment of Environmental impact (positive /negative) of the project	
8.Analysis of project impact on environment and results methodology	
9. Management and Environmental pollution monitoring	9.1 Mitigation measure for reduction and control of negative impact of project on Environment (chemical, physical, air quality noise, vibration, soil, topography ,ground water , surface water, waste) 9.2 Natural Environment (fauna, flora,landscaping) 9.3 Safety, health of working groups、 monitoring planning , training, waste management system, ways to use waste,
10. Environmental risks Assessment and management	10.1 Prediction of most probable Environmental issues related to the project 10.2 Formulating the problem(identification of hazards around site , evaluation of effectiveness of it and consequences) 10.3 Human Environment and related risk 10.4 Explosion 10.5 Assess and forecast Environmental hazards 10.6 Analysis of crisis management due to Environmental issues 10.7 Environmental risks management 10.8 Conclusion

Source: prepared by JICA Study Team

6.3.4 Gap between JICA Guidelines for Environmental and Social Considerations and Iran's Environment-related Legal System

When implementing surveys on environmental and social considerations for this project, it is required that the "JICA Guidelines for Environmental and Social Considerations" (April 2010) (hereinafter referred to as the "JICA Guidelines") and environment-related laws of Iran be followed.

A comparison was made between the JICA Guidelines and the EIA system in Iran as shown in Table below. As the result of the comparison, it was found that Iran does not define disclosure of information, explanatory meetings for residents, etc., in relation to EIA reports, and therefore it is planned in this project to disclose information and then to hold stakeholder meetings at the phases of scoping and Draft EIA in the course of this Study.

Table 6-8 Comparison of Key Environmental and Social Consideration Items provided respectively in the JICA Guidelines and Iran's EIA-related Legal System

Items	JICA Guidelines	EIA system in Iran	Existence of gap and how to cope with it
Basic issues	➢ In the implementation of the project, the survey and the examination of the environmental and social impact of the project shall be conducted in the planning stage of the project in order to consider the alternative or the mitigation measure to prevent or minimize the impact and to reflect the findings in the project plan.	➢ In a major development project, the implementation of the EIA survey in the stage of feasibility study (F/S) is required. ➢ Concerning the negative impact of the project, the development of mitigation measure, alleviation measure, and controlling measures is stipulated.	➢ There is no significant gap.
Information Disclosure	➢ EIA reports shall be disclosed to all local stakeholders, residents, etc. Also, the reports shall be disclosed on the JICA web site.	➢ No related provision is in place.	➢ Since there is a gap, the result of scoping and EIA summary reports will be disclosed to stakeholders who are considered relevant, prior to explanatory meetings for residents, during this preparatory survey. In addition, the same will be disclosed to participants of explanatory meetings.
Participation of residents	➢ Information on the Project shall be disclosed to project proponents and discussions with local residents and stakeholders (particularly with local residents who can be affected directly) shall be encouraged. ➢ In the case of category A projects, project proponents shall make an explanation to local residents and stakeholders at an early stage about the necessity of development, predicted negative environmental and social impacts, and analytical results of alternative plans. ➢ In the case of category A projects, explanatory meetings for local residents shall in principle be held twice in total,	➢ No related provision is in place.	➢ Since there is a gap, stakeholder meetings will be held at the phases of scoping and Draft EIA during this preparatory survey, to offer explanation concerning the necessity of development, predicted negative environmental and social impacts, analytical results of alternative plans, etc.

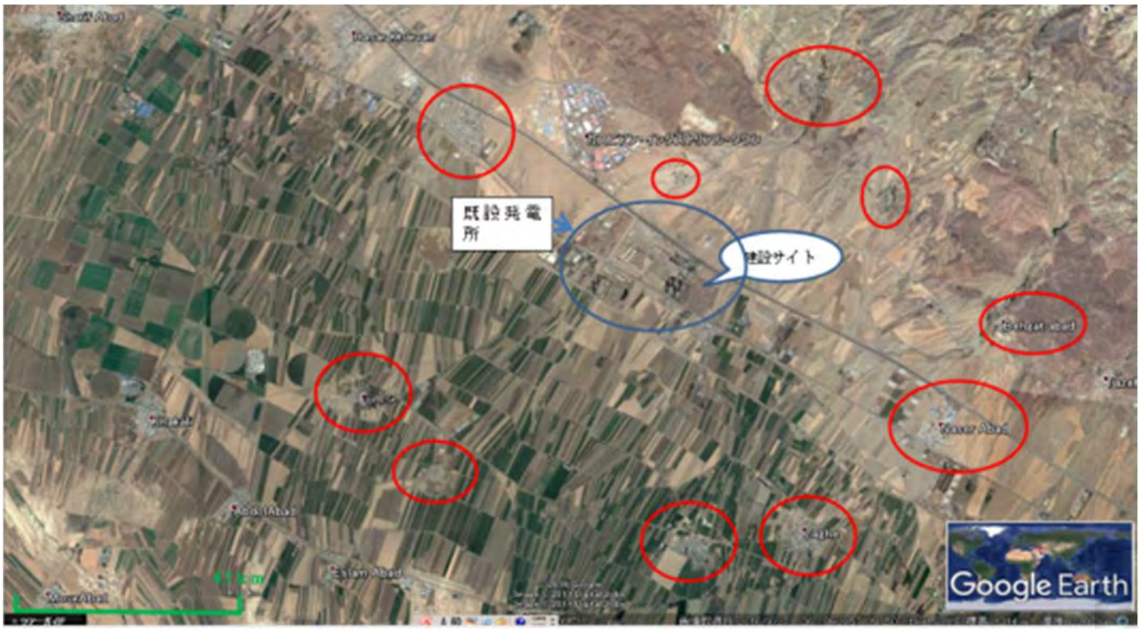
Items	JICA Guidelines	EIA system in Iran	Existence of gap and how to cope with it
	one when the scoping is made and another when EIA reports are being prepared. In the case of category B projects, it is provided that explanatory meetings shall be held as required.		
Examination of mitigation measures	➢ Multiple alternatives shall be examined in order to avoid or minimize adverse impacts. ➢ In the examination of measures, priority is to be given to avoidance of adverse impacts on the environment; when this is not possible, minimization and reduction of impacts must be considered next. ➢ Compensation measures shall be examined only when impacts cannot be avoided with any of the aforementioned measures. ➢ Appropriate follow-up plans and systems, such as monitoring plans and environmental management plans, shall be prepared; the costs of implementing such plans and systems, and the financial methods to fund such costs shall be determined. Plans for projects with particularly large potential adverse impacts shall be accompanied by detailed environmental management plans.	➢ Alternatives shall be compared and examined. ➢ Mitigation measures, reduction measures, and control measures against the negative impact of the project shall be developed. ➢ EIA reports shall clearly describe environmental management plans, environmental monitoring plans, accident prevention measures, risk assessment, etc. ➢ Confirmation shall be made whether environmental management plans and environmental monitoring plans are being implemented appropriately.	➢ The priority of mitigation measures, reduction measures and compensation is specified in JICA Environmental and Social Considerations Guidelines, but not in the EIA system in Iran. The EIA concerning this project shall take into account the priority of the mitigation measures in accordance with JICA Environmental and Social Considerations Guidelines.
Assessment items of the environmental and social consideration	➢ The scope of the impact to be investigated and examined with regard to environmental and social considerations include the impact on human health and safety and the natural environment (including transboundary or global environmental impact) through the atmosphere, water, soil, waste, accident, water use, climate change, ecosystem and biota, and social considerations for the matters listed below. ➢ Population migration including involuntary resettlement,	➢ Physical environment(geography and geology, soil, water quality, meteorology, temperature, air quality, noise) ➢ Natural and biological environment(flora and fauna, aquatic and terrestrial organisms) ➢ Social hygienic environment (consideration of the opinion of the medical science university near	➢ No gap is observed in a large category, but the items in small categories especially in the environmental and social area (poor people, indigenous people, gender, children's rights, infectious disease, working environment, etc.)are not precisely described in the EIA system in Iran as are described in JICA environmental and

Items	JICA Guidelines	EIA system in Iran	Existence of gap and how to cope with it
	Local economy including employment and means of livelihood, land use and local resource use, social organization including social infrastructure and regional decision-making organizations, the existing social infrastructure and social services, socially vulnerable group including poor people and indigenous people, fairness in distribution of damage and benefits and development process, gender, right of children, cultural heritage, conflict of interests within the local area, infectious diseases such as HIV / AIDS, and labor environment (including working safety).	the project site) ➢Social, economic, cultural environment (Population and Demography, employment, social infrastructure, education, cultural heritage, cultural and religious custom) ➢Impact on land use and on the other development project ➢Risk assessment (accident prevention measures, etc.)	social consideration guidelines. ➢As a countermeasure, the assessment of environmental and social consideration will be conducted according to JICA environmental and social consideration guidelines.
Monitoring, grievance redress system	➢Appropriate follow-up plan or system such as environmental management plan and monitoring plan, including the necessary expense and fund-rising method, shall be developed. Detailed environmental management plan should be prepared especially for the project with larger impact expected. ➢In case an adequate monitoring is presumed to be essential for an appropriate environmental and social consideration, such as a project where the mitigation measures should be implemented while examining the effect of the mitigation measures at the same time, it should be ensured that the monitoring plan is included in the project plan and that the feasibility of the plan is confirmed. ➢The grievance redress system to address grievance from the affected people and community.	➢The monitoring plan shall be developed and conducted for the items predicted be subject to the environmental and social impact.	➢No gap exists regarding monitoring. ➢The consideration items regarding the development of grievance redress mechanism specified in JICA environmental and social considerations guidelines are not described in the EIA system in Iran. The system for handling grievance in the existing Shahid Rajaee power plant shall be determined in this survey, and if it was found that an appropriate grievance redress mechanism is not in place ,the consent for the preparation of the grievance mechanism shall be obtained through explanation of the requirements of JICA environmental and social consideration guidelines.
Ecosystem	➢The project should not cause	➢The assessment of the	➢There is no significant

Items	JICA Guidelines	EIA system in Iran	Existence of gap and how to cope with it
and biota	significant alteration or significant deterioration of the precious natural habitat or precious forest.	natural and ecological environment (flora and fauna, aquatic and terrestrial ecosystem) is conducted.	gap.
Indigenous people	➢The impact of the project on the indigenous people should be avoided with all possible measures considered. In case the impact cannot be avoided through such consideration, a viable countermeasure for such people should be developed in order to minimize and compensate for the possible impact	➢No regulation exists.	➢The land use of the indigenous people is determined in the survey and the response will be considered as necessary.

Source: Prepared by JICA Study Team

It is planned to disclose information and offer explanation concerning the outline of the Project to leaders of local communities located near the power plant (those who have an executive position called “Shora” in the society of Iran) prior to explanatory meetings for residents as well as to invite them to such explanatory meetings. Residential areas near the power plant by information disclosure are shown in Figure below.



Source: obtained from Google Earth and prepared d by JICA Study Team

Fig. 6-6 Residential Areas Closely Located to Power Plant for which Information will be Disclosed prior to Explanatory Meetings for Residents

6.3.5 Standards Relevant to the Project

In this section, environment-related standards applicable to the thermal power plant projects in

Iran and IFC/WB EHS guideline values which the JICA Guidelines refer to are discussed. In this project, it is necessary to satisfy both the environmental standards of Iran and IFC/WB EHS guideline values, and therefore it is planned to ensure compliance with the stricter guidelines or standards of these two.

(1) Ambient air quality
Ambient air quality standards and gas emission standards of both Iran and IFC/WB EHS guidelines are shown in the Table below.

In the IFC/WB EHS guidelines, it is specified that "in the basic, pollutant concentration in ambient air does not exceed the environmental standard value of the host country. In addition, as a general rule, this Guideline stipulates that the contribution concentration of the project emission shall not exceed 25 ％of the air quality standards of the host country in consideration of the impact from the existing facilities and the surrounding facilities."

In this project, the height of stacks, etc., will be determined so that contribution concentration shall be below 25% of the air quality standards in Iran.

Table 6-9 Ambient Air Quality Standards of Iran and International Organization

Pollutant	Averaging time	Standards of Iran(μg/m^3)	IFC/WB EHS guideline values (μg/m^3)
CO	1 hour	40,000	-
	8 hours	10,000	-
SO_2	1 hour	196	500 (guideline):10 min. value
	24 hours	395	125 (interim target 1) 50 (interim target 2) 20 (guideline)
NO_2	1 hour	200	200 (guideline)
	Annual average	100	40 (guideline)
PM_{10}	24 hours	150	150 (interim target) 100 (interim target 2) 75 (interim target 3) 50 (guideline)
	Annual average	-	70 (interim target 1) 50 (interim target 2) 30 (interim target 3) 20 (guideline)
$PM_{2.5}$	24 hours	35	75 (interim target 1) 50 (interim target 2) 37.5 (interim target 3) 25 (guideline)
	Annual average	-	35 (interim target 1) 25 (interim target 2) 15 (interim target 3) 10 (guideline)
O_3	8 hours	148	160 (interim target 1) 100 (guideline)
	Annual average	12	

Source:･Air Pollution Prevention Executive Regulation (2016)、IFC/WB Environmental, Health, and Safety (EHS) Guidelines、General （2007）

Table 6-10 Gas Emission Standards of Iran and of International Organization

<table>
<tr><th colspan="5">Emission Standards concerning thermal power plant in Iran</th><th colspan="4">Emission Gas Guideline Value in IFC/WB EHS Guidelines value *1</th></tr>
<tr><th>Pollutant</th><th>Fuel type</th><th>Unit</th><th>Grade-1
(newly setup)
(boiler using gas and liquid fuel: O_2 3% equivalent,
Gas turbine: O_2 15% equivalent)</th><th>Grade-2
(former value)
(boiler using gas and liquid fuel: O_2 3% , equivalent
Gas turbine: O_2 15% equivalent)</th><th>Fuel type</th><th>Unit</th><th>Gas turbine
（O_2 15% equivalent）</th><th>Boiler
（O_2 3% equivalent）</th></tr>
<tr><td rowspan="3">SO_x</td><td>Gas</td><td>mg/Nm^3</td><td>100</td><td>200</td><td>Gas</td><td rowspan="3">mg/Nm^3</td><td>-</td><td></td></tr>
<tr><td>Heavy Oil</td><td>mg/Nm^3</td><td>700</td><td>800</td><td rowspan="2">Oil</td><td rowspan="2">Sulfur content: 1% or less 0.5% or less</td><td rowspan="2">200-1,500</td></tr>
<tr><td>Light oil</td><td>mg/Nm^3</td><td>100</td><td>150</td></tr>
<tr><td rowspan="3">NO_x</td><td>Gas</td><td>mg/Nm^3</td><td>150</td><td>300</td><td>Gas</td><td rowspan="3">mg/Nm^3
(ppm)</td><td>51 (25)</td><td>240</td></tr>
<tr><td>Heavy Oil</td><td>mg/Nm^3</td><td>200</td><td>400</td><td rowspan="2">Oil</td><td rowspan="2">152 (74)</td><td rowspan="2">400</td></tr>
<tr><td>Light oil</td><td>mg/Nm^3</td><td>200</td><td>250</td></tr>
<tr><td rowspan="2">PM</td><td rowspan="2">-</td><td rowspan="2">mg/Nm^3</td><td rowspan="2">100
(Gas turbine is excluded.)</td><td rowspan="2">150</td><td>Gas</td><td rowspan="2">mg/Nm^3</td><td>-</td><td>-</td></tr>
<tr><td>Oil</td><td>50</td><td>50</td></tr>
<tr><td>CO</td><td>-</td><td>mg/Nm^3</td><td>150</td><td>200</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>H_2S</td><td>-</td><td>mg/Nm^3</td><td>6</td><td>8</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
</table>

Notes:
*1: Non-degraded air shed
Source: Standards of Air Pollution arising from Industries and Workshops (1999), IFC/WB Environmental, Health, and Safety (EHS) Guidelines Thermal Power Plant（2008）

(2) Water quality

Wastewater quality standards of Iran and IFC/WB EHS guidelines are shown in the Table below.

At the existing Shahid Rajaee Power Plant, wastewater is treated and reused for sprinkling in the site of the power plant.

In wintertime when a large amount of water for sprinkling is not needed, treated wastewater will be discharged into the irrigation canal for use in agriculture in the local area.

Table 6-11 Wastewater Quality Standards of Iran and of International Organization

Item		Wastewater quality standards of Iran			IFC/WB EHS guideline values(thermal power station) (mg/L)
		Wastewater discharged to surface water (mg/L)	Wastewater discharged to water well (mg/L)	Use in agriculture and irrigation (mg/L)	
Silver	Ag	1	0.1	0.1	-
Aluminum	Al	5	5	5	-
Arsenic	As	0.1	0.1	0.1	0.5
Boron	B	2	1	1	-
Barium	Ba	5	1	1	-
Beryllium	Be	0.1	1	0. 5	-
Calcium	Ca	75	-	-	-
Cadmium	Cd	0.1	0.1	0.05	0.1
Chlorine	Cl	1	1	0.2	0.2
Chloride	Cl^-	600	600	600	-
Formaldehyde	CH_2O	1	1	1	-
Phenol	C_6H_5OH	1	Negligible	1	-
Cyanide	CN	0.5	0.1	0.1	-
Cobalt	CO	1	1	0.05	-
Chrome	Cr^{+6}	0.5	1	1	0.5（Total Cr）
Chrome	Cr^{+3}	2	2	2	
Copper	Cu	1	1	0.2	0.5
Fluoride	F	2.5	2	2	-
Iron	Fe	3	3	3	1
Mercury	Hg	Negligible	Negligible	Negligible	0.005
Lithium	Li	2.5	2.5	2.5	-
Magnesium	Mg	100	100	100	-
Manganese	Mn	1	1	1	-
Molybdenum	Mo	0.01	0.01	0.01	-
Nickel	Ni	2	2	2	-
Ammonium	NH_4	2.5	1	-	-
Nitrite	NO_2	10	10	-	-
Nitrate	NO_3	50	10	-	-
Phosphate	P	6	6	-	-
Lead	Pb	1	1	1	0.5
Selenium	Sc	1	0.1	0.1	-
Hydrogen Sulfide	H_2S	3	3	3	-
Sulfite	SO_3^-	1	1	1	-
Sulfate	SO_4^-	400*1	400*1	500	-
Vanadium	V	0.1	0.1	0.1	-
Zinc	Zn	2	2	2	1
Oil and grease		10	10	10	10
Detergent	ABS	1.5	1.5	1.5	-
BOD_5*3	BOD_5	30 (instant 50)	30 (instant 50)	100	-
COD*3	COD	60 (instant 100)	60 (instant 100)	200	-
DO	DO	2	-	2	-
Total Dissolved Solids	TDS	*1	*2	-	-
Total Suspended Solids	TSS	40 (instant 60)	-	100	50
Suspended Solids	SS	0	-	-	-
pH	pH	6.5-8.5	5-9	6-8.5	6 –9
Radioactive Substances		0	0	0	-
Turbidity		50	-	50	-
Color		75	75	75	-
Temperature		Up to 3 degrees C. (within a radius of 200m)	-	-	-
Coliform Bacteria (in 100mL)		400	400	400	-
Total coliform (MPN in		1000	1000	1000	-

Item		Wastewater quality standards of Iran: Wastewater discharged to surface water (mg/L)	Wastewater quality standards of Iran: Wastewater discharged to water well (mg/L)	Wastewater quality standards of Iran: Use in agriculture and irrigation (mg/L)	IFC/WB EHS guideline values(thermal power station) (mg/L)
100mL)					
Parasite Eggs		-	-	*4	-

[*1]：Chloride, sulfate and total dissolved solid can exceed their standard values if they do not exceed by more than 10% of the values at 200m from the discharge outlet

[*2]：Chloride ,sulfate and total dissolved solids can exceed their standard values if they do not exceed 10% of the values.

[*3]：BOD_5 or COD can be reduced to 90% in the existing industries.

[*4]：If treated wastewater is used in agriculture, the value cannot exceed 1 per 1 liter.

Source: Water Pollution Control Rule (1984)、IFC/WB Environmental, Health, and Safety (EHS) Guidelines Thermal Power Plant（2008）

(3) Noise and vibration

Noise emission standards of Iran and IFC/WB EHS guidelines are shown in the Table below. Since the project site is located within the site of the Shahid Rajaee Power Plant, noise emission standards for the category of "industrial area" are applicable to the area along the boundary of the plant site.

Table 6-12 Noise Emission Standards of Iran and of International Organization

Category	Standards of Iran (dB(A))		IFC/WB EHS guideline values (dB(A))	
	Daytime (07:00-22:00)	Nighttime (22:00-07:00)	Daytime (07:00-22:00)	Nighttime (22:00-07:00)
Residential area	55	45	55	45
Residential area + commercial area	60	50	-	-
Commercial area	65	55	70	70
Residential area + industrial area	70	60	-	-
Industrial area	75	65	70	70

Source：Noise Protection Act (2008)、IFC/WB Environmental, Health, and Safety (EHS) Guidelines、General（2007）

The vibration standard value is not established either in Iran or in IFC/WB EHS Guideline which is adopted in EU and other major industrialized countries.

The vibration standard in Japan is shown in Table 6-13 for information in impact estimation.

Table 6-13 Vibration Standard Value of Japan

Category	Daytime (05:00-19:00 or 08:00-22:00)	Nighttime (19:00-05:00 or 22:00-8:00)
Residential area	60～65	55～60
Residential area + commercial area + industrial area	65～70	60～65

Source: Vibration Regulation Law, 1976(4) Odors

In Iran, the regulation standard for odor related to chemicals, which is the cause of odor produced in the process in the power plant, factories, etc.

In this project, since a desulfurization system using malodorous ammonia is not installed, other chemicals generating malodor as well, generation of malodor is not predicted, and consequently the international environmental standard for malodor of Japan and other western countries is not described.

Malodor resulting from domestic waste (garbage) may be generated, but the standard value and other regulation in this regard is not established in Japan and other industrialized countries.

(5) Waste

In Iran, waste management is regulated under the Waste Management Act enacted in 2004. In the 1955 Municipality Act, the roles of local governments in management of waste and prevention of industrial pollution are regulated

(6) Working safety

In Iran, the safety and health management of workers is considered based on the Labour Law established in 1990.

Under the Labour Law, regulation of safety standards related to work, arrangement of required equipment, confirmation of training and compliance status, periodic health checks, monitoring of accident and diseases, etc. are stipulated in Chapter4 Working Safety and Sanitation, Article 85 to 106.

Various technical safety standards are established for each business type by the Safety High Council composed of related organizations including Ministry of Health, Labor and Welfare, Ministry of Industry, Environment Bureau, etc. and approved by Ministry of Social Welfare.
The major technical safety standards regarding the power plant includes:

- Standard related to environmental protection promotion law
- Standard related to air purification law
- Regulation regarding the allocation of safety inspection personnel
- Fire-fighting regulations
- Regulations regarding personal gears
- Regulations regarding safety sign

6.4 Examination of Alternatives

6.4.1 In case of the Project is implemented and not implemented

A comparison was made between a case in which the project is implemented and another case in which it is not implemented as shown in the Table below. In the case of non-implementation of the project, sufficient electricity supply will not be available against demand. Therefore, this project should be implemented.

Table 6-14 Comparison of Case in which Implemented and Not implemented

Item	In case the project is implemented	Non-implementation
Technology	- A highly efficient combined cycle power plants will be constructed on the site of the Shahid Rajaee Power Plant.	- No change will be made from the present state.
Economy	- Although construction cost will arise, the project can contribute to economic development of Iran as well as create jobs through procurement of materials and equipment and human resources domestically in Iran and specifically, locally in the area where the project site is located.	- There will be no construction cost. It, however, will not lead to economic development of Iran and even the economy can be affected negatively due to a shortage of electricity. In addition, it cannot lead to creation of jobs and contribution to the local economy.
Environmental and social considerations	- The installation of the high-efficiency gas combined cycle power generation facility will contribute to the implementation of the policy objective of Iran government ,“the reduction of greenhouse gas by 4% by 2030” toward COP21. - Although it is expected that the newly constructed power stations can emit gases, wastewater, noise, etc., the planned new power plants will be a highly efficient combined cycle power plant that will be in compliance with the environmental standards of Iran.	- The operation of the existing low-efficiency power generation facility is inevitable and CO_2 reduction compared to the current emission is not possible. - There will be no change from the present state of the environment and the society.
Comprehensive evaluation	- As the environmental standards of Iran will be complied, no serious impact on environmental society is assumed and the project implementation case is assumed to be comparatively advantageous from the economic point of view.	- The case of non-implementation is assumed to be less advantageous in view of economy.

Source: Prepared by JICA Study Team

6.4.2 Examination of Candidate Sites

The existing Shahid Rajaee Power Plant was selected as the site to construct the planned new power plant for the following reasons:

- The existing Shahid Rajaee Power Plant has been aging and it cannot meet the present gas emission standards,
- Land preparation in the vacant lot of the site has been completed and it is not a woodland, farm land, or residential area,
- It is not necessary to install new transmission lines, and
- The total length of gas pipeline to be newly installed is short.

Detailed examination has not been made of other sites to construct the planned new power plant, because, as described below, when compared with the candidate site in the existing power plant, it will not be possible to construct the new plant in any other area in a short period of time.

- A new piece of land will need to be obtained and prepared for construction work,
- It will take longer time, and
- It will be necessary to newly install transmission lines and a gas pipeline.

The two locations within the site of the Shahid Rajaee Power Plant (Plan A and Plan B) were comparatively examined and the result is shown in the table below. Both of the plans are conducted within the existing power plant site with only a poor ecosystem, and no land acquisition is necessary.

The two plans have no significant difference in view of environmental and social considerations. The Plan B has advantage in view of construction work and heat efficiency, and the selection will conducted through consultation with the project proponent and the stakeholders.

Table 6-15 Characteristics of Plan A and Plan B

items	Plan A	Plan B
Land area	Sufficient area (15ha)	Larger area (30ha)
Construction work	Displacement of some existing facilities is necessary.	Displacement of the facilities is not needed.
Land acquisition	Not necessary	Not necessary
Vegetation	Poor ecosystem	Poor ecosystem
Surrounding conditions	Heat from the existing facility is carried from south-east (main wind direction) and heat efficiency is lowered.	Impact of heat from the existing facility is not assumed.
Total evaluation	Need for displacement of the existing facility at the construction activity and the lower heat efficiency due to the surrounding condition: Plan A is comparatively less advantageous.	No need for displacement of the existing facilities and less impact on heat efficiency resulting from the surrounding conditions: Plan B is comparatively advantageous.

Source: prepared by JICA Study Team

Source: Obtained from Google Earth, and prepared by JICA Study Team

Fig. 6-7 Candidate Project Sites

6.4.3 Examination of fuel types

The results of the comparison of fuel types between natural gas, petroleum and coal are shown in Table 6 -16.

Natural gas has advantage in easy fuel supply, no need for development of the related infrastructure, and less emission of SOx, dust, and CO_2 into ambient air, and thus is selected as fuel in the project.

Table 6-16 Examination of Fuels

Items	Natural gas	Oil	Coal
Technical aspects	・Pipelines used in the existing power plant may be used. ・Neither large scale LNG tank or ash treatment facility is necessary to be constructed. ・Combined cycle generation may be adopted.	・Construction of large scale oil tank is necessary. ・Construction of oil pipeline for oil supply is necessary. ・Heavy oil may not be used for fuel of combined cycle generation.	・A railway for transporting coal needs to be constructed. ・Construction of a large-scaled coal storage and ash treatment facility is necessary. ・Combined cycle generation by coal gasification is not in a commercial phase.
Economic aspects	・Natural gas is abundantly buried and produced in Iran, and pipelines are ready for use.	・Construction cost for pipeline is high. ・Land for construction of a large oil tank is necessary.	・Price per unit is low. ・Railway construction cost is high. ・Land acquisition for coal storage and ash disposal is needed.
Environmental and social considerations	・ Ash is not contained in fuel, sulfur content is also less than in petroleum and coal in general, producing less soot and SOx.CO_2 generated per unit output is the smallest, and the influence on global warming is the smallest.	・Oil contains ash and sulfur, producing soot and SOx. Depending on the sulfur content, desulfurization equipment is also required. CO_2 generated per unit output is larger than in natural gas, and the influence on global warming is also larger than natural gas.	Coal contains a lot of ash, and dust collecting system may be necessary. Depending on the sulfur content, desulfurization equipment is also required. CO_2 generated per unit output is the largest, and the influence on global warming is also larger.
General evaluation	Natural gas is comparatively advantageous in that the existing gas pipeline may be used, there is a large deposit in Iran, and that generation of soot, SO_2 and CO_2 is smaller.	Oil is comparatively less advantageous in that construction of oil tank and pipeline is necessary, and that larger amount of SOx and CO_2 generation is anticipated.	Coal is comparatively less advantageous in that construction of coal transportation railway, coal storage and ash disposal site is necessary, and that larger amount of soot, CO_2 and SOx is generated.

Source: prepared by JICA Study Team

6.4.4 Examination of Cooling Systems

Since there is no river in the area around the project site, groundwater has been taken and used at the existing power plant. In order to control intake of groundwater, either a natural-draft indirect cooling system or a forced-draft direct cooling system will be selected, both of which basically does not use water, as condenser cooling system.

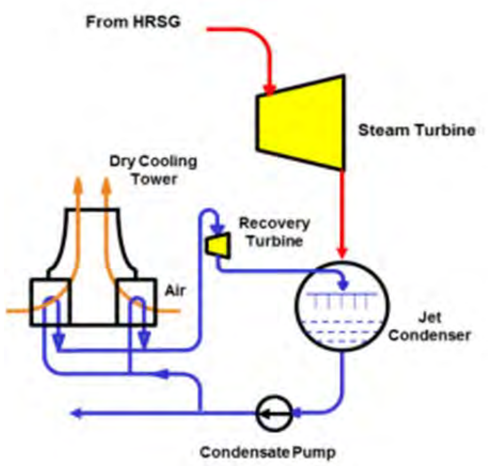
At the first stakeholder meeting, many of the participants showed concern about the impact of the project on water consumption for daily life and agriculture, and in that view, the consideration of the dry-type cooling system for condenser cooling system was presented for its minimum water consumption.

As a result of the consideration, it was found that a natural-draft indirect cooling system needs certain amount of water in summer, and TPPH expressed their intension to select the forced-draft direct cooling system in this view. In consequence, the forced-draft cooling system is adopted in this project.
The explanation of the result was provided at the second stakeholder meeting and the participants showed no particular concern on this result. The final decision will be made based on the result of the stakeholder meeting.

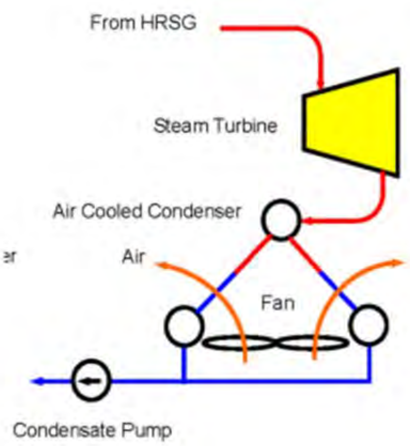
Table 6-17 Features of Different Cooling Systems

Item	Natural-draft indirect cooling system	Forced-draft direct cooling system
Construction cost	[Base]	Almost the same
Operating cost	[Base]	Slightly more expensive
Cooling water(condenser)	Water supply is needed in summer.	Unnecessary
Installation floor area	[Base]	Slightly smaller
Water quality management	Unnecessary	Unnecessary
Power generation efficiency	[Base]	Almost the same
Noise emission	[Base]	Large impact
Past experience in Iran	Employed in many cases	Employed in some cases
Total evaluation	More advantageous in that running cost is lower, noise impact is smaller, and that it has been adopted in many cases in Iran. Less advantageous in that water supply is necessary.	Comparatively less advantageous in that running cost is rather higher, noise impact is larger, and that the number of adoption in Iran is smaller. Advantageous in that water is not necessary.

Source: Prepared by JICA Study Team



Natural-draft indirect cooling system



Forced-draft direct cooling system

Source: prepared by JICA Study Team

Fig. 6-8 Schematic Diagram of Cooling Systems

6.5 Results of Scoping and Survey Plan

6.5.1 Results of Scoping

The draft scoping was developed concerning the environmental and social items to be considered in accordance with JICA Guidelines, based on the result of the on-site survey and the predicted level of the environmental impact of the construction of the thermal power plant.

The electricity generated by this project is planned to be transmitted using the existing 400 kV transmission line and new transmission line will not be constructed.

The pipeline for fuel supply is installed within the existing pipeline site only for 300m, and land acquisition and resident resettlement do not occur. The impact during construction phase is also insignificant; and there is no item to be added to this draft scoping.

Table 6-18 Scoping Result

No	Item	Assessment: Construction period: Positive	Assessment: Construction period: Negative	Assessment: Operation period: Positive	Assessment: Operation period: Negative	Reasons of assessment
【Pollution control measure】						
1	Air quality	D	B	D	A	**During construction:** Civil engineering work, such as land formation may cause dust, while heavy equipment and trucks will discharge air pollutants (SOx, NOx etc). The emission may cause temporary impact in the vicinity of the construction area. **During operation:** Operation of the power station will discharge NOx in case gas fuel is used and NOx, SOx and PM in case light oil is used, causing impact to ambient air quality in a wide area.
2	Water quality	D	B	D	B	**During construction:** Domestic waste water from workers, waste water from concrete and oil-containing waste water will be generated, and temporary impact on water quality of discharge channel is anticipated. **During operation:** Waste water from the plant, oil-containing waste water and domestic waste water will be generated from the operation of the power plant, and impact on water quality of discharge channel is anticipated.
3	Waste	D	B	D	B	**During construction:** The construction work will generate general waste including waste packing materials and domestic waste and hazardous waste including waste oil from construction machines. **During operation:** Along with the operation of the power plant, general waste including domestic waste, and hazardous waste such as sludge from wastewater treatment facility and waste oil from equipment will be generated.
4	Soil contamination	D	B	D	B	**During construction:** Lubrication oil and fuel may be spilled from construction vehicles and construction machinery, if not appropriately handled. **During operation:** There is a possibility that lubrication oil and fuel are spilled in case of accident.
5	Noise and vibration	D	B	D	B	**During construction:** Operation of construction machines and vehicles will generate noise and vibrations causing temporary impact. Activities with high noise level including piling may cause impact on a wider area. **During operation:** The operation of the plant will cause noise and vibration.
6	Land subsidence	D	C	D	C	**During construction:** There is a possibility that land subsidence occurs temporarily, because the project will take ground water. Impact on land

No	Item	Assessment: Construction period Positive	Assessment: Construction period Negative	Assessment: Operation period Positive	Assessment: Operation period Negative	Reasons of assessment
						subsidence will be studied during the survey. **Operation phase:** There is a possibility that land subsidence occurs temporarily, because the project will take ground water. Impact on land subsidence will be studied during the survey.
7	Odor	D	B	D	B	**During construction:** The construction work will generate general waste and hazardous waste like waste oil. **During operation:** General waste and hazardous waste like sludge and waste oil will also be generated during operation.
8	Substratum contamination	D	D	D	D	**During construction and operation:** The project will not discharge waste water to the river; therefore, no particular impact on substratum contamination is expected.
【Natural environment】						
1	Wild life preservation area	D	D	D	D	**During construction and operation:** The project site is not located in designated protected area. There is no such protected area nearby.
2	Terrestrial ecosystems and rare species	D	B	D	B	**During construction and operation:** The project site is already developed. The flora and fauna observed within the project area includes several herbaceous species and rodents species, which are commonly seen in the wide area around the site, and no precious species are observed. Therefore, the direct impact of land alteration will be insignificant. Air pollution, noise and vibration impact during construction and operation may affect growth of flora and behavior of fauna; however, the impact will be only temporary and limited, since the area around the project site is bare land and agricultural land with dry ecosystem, not rich in biodiversity.
3	River ecosystems and rare species	D	D	D	D	**During construction and operation:** The project will not take river water. The project will not also discharge wastewater to the river.
4	River hydrology	D	D	D	D	**During construction and operation:** The project will not take river water.
5	Underground hydrology	D	C	D	C	**During construction and operation:** There is a possibility that ground water level decreases, because the project will intake ground water. Current ground water level will be studied during the survey.
6	Topography and geology	D	D	D	D	**During construction and operation:** The project site is within the existing power plant boundary; therefore, no impact is expected.
【Social environment】						
1	Resettlement and Land acquisition	D	D	D	D	**Before construction:** The project site is located within the existing power plant boundary; therefore, local people will not be resettled.
2	Poor people	D	D	D	D	**Before construction:** The project site is located within the existing power plant boundary; therefore, the impact on poor people is not predicted. **During construction and operation:** No particular impact on poor people is expected.
3	Ethnic minorities	D	C	D	C	**Before construction:** The project site is located within the existing power plant boundary; therefore, the impact on ethnic minorities is not predicted. **During construction and operation:** A further survey on ethnic minorities will be conducted, since land use of the surrounding areas of the project site by minorities is not well known at this moment.
4	Local economy including employment and means of livelihood	B	D	B	D	**Before construction:** The project site is located within the existing power plant boundary; therefore, the impact on employment and means of livelihood is not predicted. . **During construction and operation:** There is a possibility that local people may be employed as workers by the power station or that procurement of materials and equipment may be done in the local area resulting in the improvement of the local economy.
5	Land use and	D	D	D	D	**Before construction:** The project site is located within the existing power

No	Item	Assessment: Construction period Positive	Assessment: Construction period Negative	Assessment: Operation period Positive	Assessment: Operation period Negative	Reasons of assessment
	utilization of local resources					plant boundary; therefore, the impact on land use and utilization of local resources is not predicted. . **During construction and operation:** The factors of giving impact on land use and utilization of local resources will not be anticipated.
6	Water use	N D	C	D	C	**During construction:** The temporary impact on the surrounding ground water use may be expected due to intake of ground water by the project. A further survey will be conducted to find out the current situation of ground water use. Domestic waste water from workers, waste water from concrete and oil-containing waste water will be generated and temporary impact on water quality of discharge channel and water use is anticipated. A further survey will be conducted to find out the current situation of irrigation water use. **During operation phase:** The impact on the surrounding ground water use may be expected due to intake of ground water by the project. A further survey will be conducted to find out the current situation of ground water use. Domestic waste water, waste water from plant and oil-containing waste water will be generated, and temporary impact on water quality of discharge channel and water use is anticipated, if not appropriately treated before discharge. A further survey will be conducted to find out the current situation of irrigation water use.
7	Existing social infrastructure and social service	D	D	D	D	**During construction and operation:** There are Qazvin with population of 400 thousand near the project site, which have accommodation facilities and social infrastructure including medical facility, school, sewage and road; therefore, no impact of inflow of workers is expected.
8	Social bodies including society-related capitals and social organizations that make local decisions	D	D	D	D	**Before construction:** The project site is located within the existing power plant boundary; therefore, the impact on l society-related capitals and social organizations that make local decisions is not predicted. . **During construction and operation:** No particular impact on social bodies including society-related capitals and social organizations that make local decisions is expected.
9	Unfair distribution of damage and benefit	D	B	D	B	**Before construction:** The project site is located within the existing power plant boundary; therefore, the unfair distribution of damage and benefit is not predicted.. **During construction and operation:** If employing local people and/or outsourcing contracts are not fair, benefit may be unfairly distributed.
10	Conflict of interests within the local area	D	B	D	D	**Before construction:** The project site is located within the existing power plant boundary; therefore, conflict of interests within the local area will not occur. **During construction:** Conflict between local residents and construction workers coming from outside may occur, if workers from outside do not understand local custom. **During operation:** Conflict between local residents and construction workers will not occur, because not many workers from outside is expected to be hired.
11	Cultural heritage	D	D	D	D	**During construction and operation:** The project site is a land developed for the existing power plant, and there are no historical, cultural and/or religious heritages in the project site.
12	Scenery	D	C	D	C	**During construction and operation:** The project site is located within the existing power plant, so that impact by structures like construction cranes, stacks and cooling towers will be limited. The survey of the scenic points of the surrounding sites will be conducted.
13	Gender	D	C	D	C	**Before construction:** The project site is located within the existing power plant boundary; therefore, disadvantage for women will not occur.

No	Item	Assessment: Construction period Positive	Assessment: Construction period Negative	Assessment: Operation period Positive	Assessment: Operation period Negative	Reasons of assessment
						During construction and operation: No particular impact on gender is expected. The occupational situation etc. in the nearest residential area will be confirmed by the questionnaire / interview survey currently being conducted and the influence / evaluation on gender will be specified.
14	Rights of children	D	B	D	D	**Before construction:** The project site is located within the existing power plant boundary; therefore, impact on children's right will not occur. **During construction:** Since construction work requires many workers, there is the possibility that many children are hired and drop out of school. Under the Labor Law of the country, employment of minors under the age of 15 is prohibited, and TPPH strictly prohibits child labor, including EPC contractors. **During operation:** Children will not be hired for simple labor by power plant during operation phase.
15	HIV/AIDS and other infectious diseases	D	B	D	D	**During construction:** Inflows of foreign workers may spread this sort of infectious diseases. **During operation:** Large number of inflows of foreign workers is not expected; therefore, spreading infectious diseases is not expected to occur.
16	Work environment (including labor safety)	D	B	D	B	**During construction:** There is a temporary and relatively high possibility of accident caused by construction activities. **During operation:** There is a possibility of labor accident.
【Other】						
1	Accident	D	B	D	B	**During construction:** Accidents may occur during construction work and/or operation of vehicles. **During operation:** Accidents may occur during operation of facilities and/or vehicles.
2	Impact across the borders and on climatic change	D	D	D	B	**During construction:** Construction activity will generate CO_2, but emission volume is low and only during construction period; therefore, no impact across the borders and on climate change is expected. **During operation:** Operation of the power station will generate CO_2. However, impact across the borders and on climate change will be smaller than the conventional thermal power plant of the similar capacity.

Note) Categories are classified as follows:
A: There will be a serious impact.
B: There will be a certain impact.
C: The extent of impact will be uncertain. (A further survey will be needed to make the expected impact clear.)
D: Impact will hardly be expected.

Source: prepared by JICA Study Team

6.5.2 Survey Plan

Based on the above-mentioned results of scoping, the assessment policy including the necessary survey items, survey methods, the assessment criteria for environmental items assumed to be affected by the Project concerning the environmental items which may be affected by the project are summarized in Table below.
(1) Collection and efficiency improvement of appropriate baseline information

In order to predict environmental impacts and minimize such impacts, it is necessary to collect and organize information on the present state. The information collection on the natural environment, data on climate, ambient air quality, water quality, terrestrial biota, etc., will be conducted basically from existing documents and through interview surveys targeting at concerned parties and, if necessary, site surveys will also be carried out.

In addition, for air quality and noise, the monitoring results of existing power plants will be referred, and for animals and plants, the survey conducted at the development of the site will be referred to improve efficiency

To obtain information on the social environment, data on the social environment (such as land use, land transport, hygiene and sanitation, demographics, education, social infrastructure, income and occupation), scenic areas, cultural heritage, ethnic minorities, etc., will be collected from existing documents and through interview surveys targeting at concerned parties.

In addition, stakeholder meetings will be held to provide information on the project and to collect opinions.

Table 6-19 Survey Items, Methods, Predicted Impact and Assessment Policy

Item	Survey item	Survey range	Survey method	Predicted assessment policy
Air quality	- Related environmental standards - Meteorological information - Current situation of air pollution	Within 30km radius. The existing power plant site	- Obtaining air quality standards and exhaust fume standards - Obtaining meteorological data from neighboring meteorological station (temperature, humidity, wind direction, wind speed. etc.) - Collecting existing measured data of air pollutants in the atmosphere (SO_2, NO_2, PM_{10}, etc.) within the existing power plant and the surrounding area and measuring baseline data in the surrounding area.	- During construction, the implementation of appropriate air pollution control measures will be checked. - During operation, the compliance with the emission gas concentration standards will be ensured according to the provision of the emission standard of Iran and IFC/WB EHS Guidelines. - The project will simulate atmospheric diffusion of pollutant in exhaust gas during operation using internationally adopted model. In addition to the new facility, the cumulative impact of the existing facility and the new facility is also simulated, based on the monitoring result of the existing facility. The result is examined, with view of the current status of pollution, to ensure compliance with the emission standard according to the provision of the emission standard of Iran and IFC/WB EHS Guidelines..
Water turbidity	- Related environmental standards - Current conditions of water quality	Within 15km radius. The existing power plant site	- Obtaining water quality standards and waste water standards. - Collecting existing measured data on surface water and ground water (temperature, BOD, nutrient salt, etc.) and	- During construction, the implementation of appropriate measures to control water pollution will be checked. - The project will comply with the discharge standards of Iran and IFC/WB EHS Guidelines for domestic waste water and waste water from the power

Item	Survey item	Survey range	Survey method	Predicted assessment policy
			measuring baseline data.	plant, by installing waste water treatment facilities.
Waste and Odor	- Related standards	The existing power plant site	- Obtaining standards related to waste handling.	- The plan for disposal of hazardous waste will be checked, including contract with a licensed company to collect and treat it, with view of the current implementation status in the existing facility. - Domestic waste will be appropriately treated and disposed of.
Soil contamination	- Nothing in particular	The existing power plant site	- Nothing in particular	- During construction and operation, the project will check appropriate measures to control oil leakage for respective phase.
Noise and vibration	- Related environmental standards - Current situations of noise and vibration	Within 3km radius. The existing power plant site	- Obtaining noise standards - Checking the result of the monitoring of the existing power plant and measurement of the baseline data of the surrounding area.	- During construction and operation, the implementation of appropriate measures to control noise and vibration will be checked. - Conducting noise simulation to ensure compliance with the noise standards stipulated by Iran and IFC/WB EHS Guidelines, with view to the monitoring result of the existing facility.
Terrestrial ecosystem and rare species	- Habitat status of vegetation, reptiles, amphibians, birds and mammals	Within 15km radius. The existing power plant site	-Examination of the existing documents and hearing from DOE. - Observation of the survey data collected at the development of the existing power plant.	- During construction and operation: The implementation of appropriate prevention measures against air pollution and noise/vibration will be checked.
Ethnic minorities	-Presence / absence of ethnic minority, ethnic name, number of people, their characteristics	Within 15km radius.	- Collecting information on ethnic minorities through hearing with the relevant organizations and experts.	- In the cases where impacts on ethnic minorities are assumed, appropriate explanation on the project and environmental social impact / mitigation measures will be provided.
Land subsidence, hydrology (ground water), Water use	- Current situations of land subsidence. - underground water level	Within 15km radius. The existing power plant site	- Collecting existing measured data	- Examining impacts on groundwater level, land subsidence and irrigation water by groundwater intake and water discharge. The appropriate mitigation measures, if needed, will be checked.
Local economy including employment and means of livelihood, Unfair distribution of loss and benefit, Conflict of interests within the local area ,Gender, Rights of children	- Current situations of jobs and livelihood - Local economic development programs	Within 15km radius. The existing power plant site	- Collecting material on situations of employment and income in the area	- The appropriateness of the employment policy of local people will be checked. - The fairness of the employment criteria will be checked.
Scenery	- Current situations of scenic spots	Within 15km radius. The existing power plant	- Collecting information on scenic spots	- If the project is likely to cause impact to a scenic spot, the implementation of an appropriate mitigation measures will be checked.

Item	Survey item	Survey range	Survey method	Predicted assessment policy
		site		
HIV/AIDS and other infectious diseases	- Nothing in particular	The existing power plant site	- Nothing in particular	- During construction, the development of appropriate labor health program will be checked.
Work environment (including labor safety)	- Nothing in particular	The existing power plant site	- Nothing in particular	- During construction and operation, the project will prepare labor safety programs.
Accident	- Nothing in particular	-	- Nothing in particular	- During construction and operation, the development of appropriate accident prevention and accident response plans will be checked.
Impact across the borders and on climatic change	- Estimating CO_2 generation volumes of the project	-	- Estimating CO_2 generation volumes based on fuel consumption volumes and power generation efficiency.	- During construction, the implementation of appropriate measures to reduce CO_2 generation volumes as necessary will be checked. - During operation, the implementation of appropriate monitoring of fuel type and fuel consumption volume will be checked.

Source: prepared by JICA Study Team

(2) Prediction and assessment of environmental impacts

By reviewing collected information for each of the environmental items identified in the scoping process, prediction and evaluation will be made on adverse impacts on the natural and social environment that will possibly be generated during the construction and operation start periods.
It is fundamental to develop mitigation measures to reduce such impacts as much as possible.

6.6 The result of Baseline survey

6.6.1 Natural environment

(1) Meteorology

The meteorological data at Qazvin meteorological station, the nearest weather station from the Shahid Rajaee Power Station, from 2014 to 2017 is shown below. The measurement of wind direction and wind speed at the meteorological station is only 3 times a day (morning, daytime, nighttime) and the result is summarized into 8 directions.

a) Temperature

According to the data from Qazvin meteorological station, the annual average temperature of Qazvin is 14.1 degrees centigrade, with the average annual high temperature of 21.2 degrees centigrade and the average annual low temperature of 6.8 degrees centigrade.

Qazvin is one of the coldest regions in Iran with an average monthly high temperature of 28 degrees centigrade and average monthly low temperature of 5 degrees centigrade (Fig. 6-9). The highest daily temperature reaches 44.0 degrees centigrade from June to August, whereas the lowest daily temperature is as low as -28.0 degrees centigrade in January.

b) Precipitation

The average monthly precipitation in site indicates that summer tends to be dry with little rain, while 70 % of precipitations are concentrated in autumn and winter (Fig. 6-11).

c) Humidity

Monthly average humidity is high in autumn and winter, approximately 55% to 75%, and is lower in summer around 35 % (Fig. 6-10).

d) Solar radiation

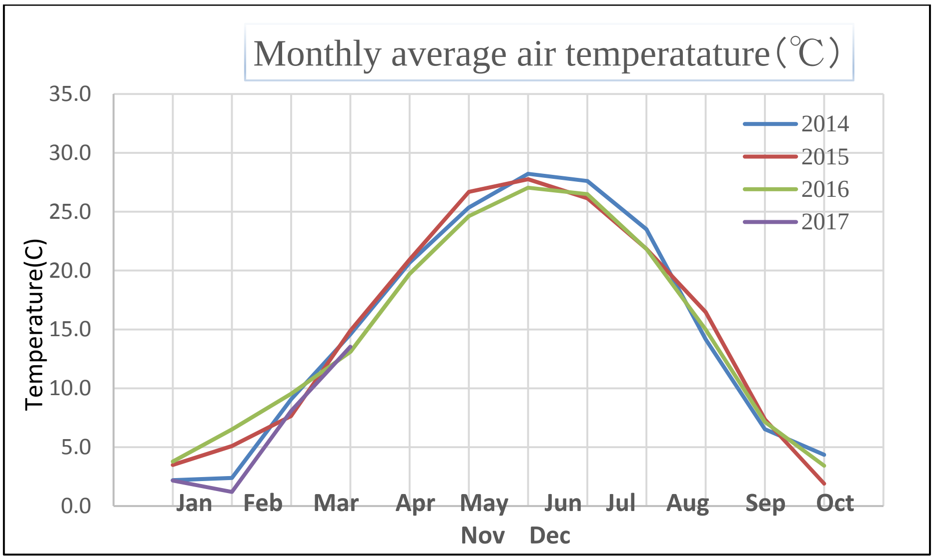
Monthly average solar radiation is concentrated in summer (June-August), 80,000cal/cm^{2}, and is less in winter, about one-third of summer season (Fig. 6-12).

e) Wind direction and wind speed

South-east wind is dominant throughout the year, and in respect of time zone, north wind is dominant in the morning, south-east wind is dominant in the daytime, and west and east wind is dominant in nighttime. West wind is dominant in May to June.

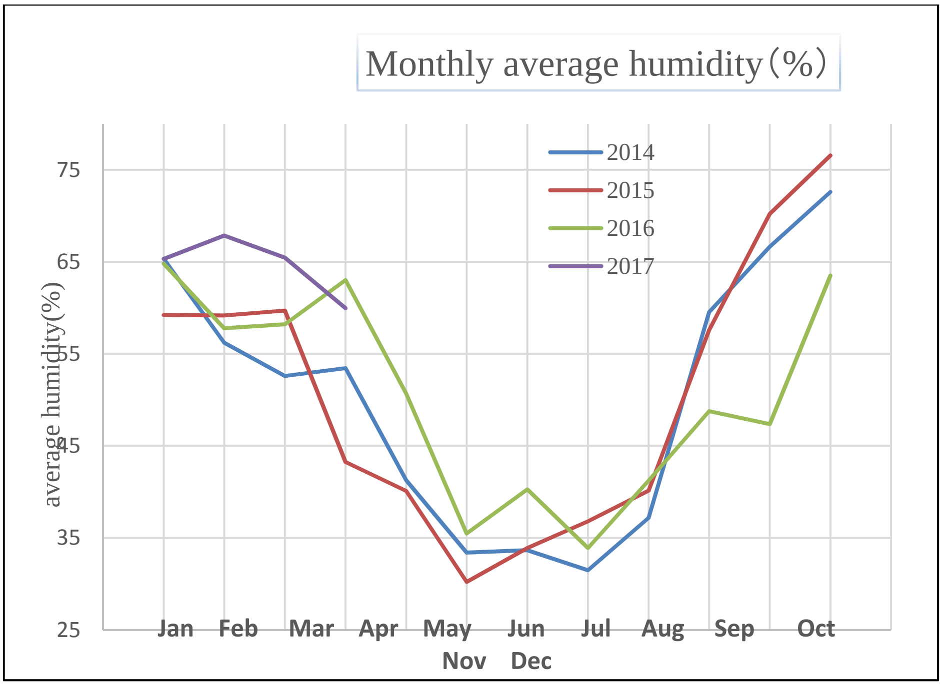
The occurrence of “calm” referring to wind speed below 0.5m/s（1kt）is 44%. For wind speed over 0.5m/s, 2-3ｍ/s （4-6 kt) occurs most frequently. High wind exceeding 6m/s（11kt） appears less than 1% throughout the year, mainly in winter (January to March).

As described in Chapter 3.2.5, the Instantaneous maximum wind speed sometimes reaches 38.9m/s.



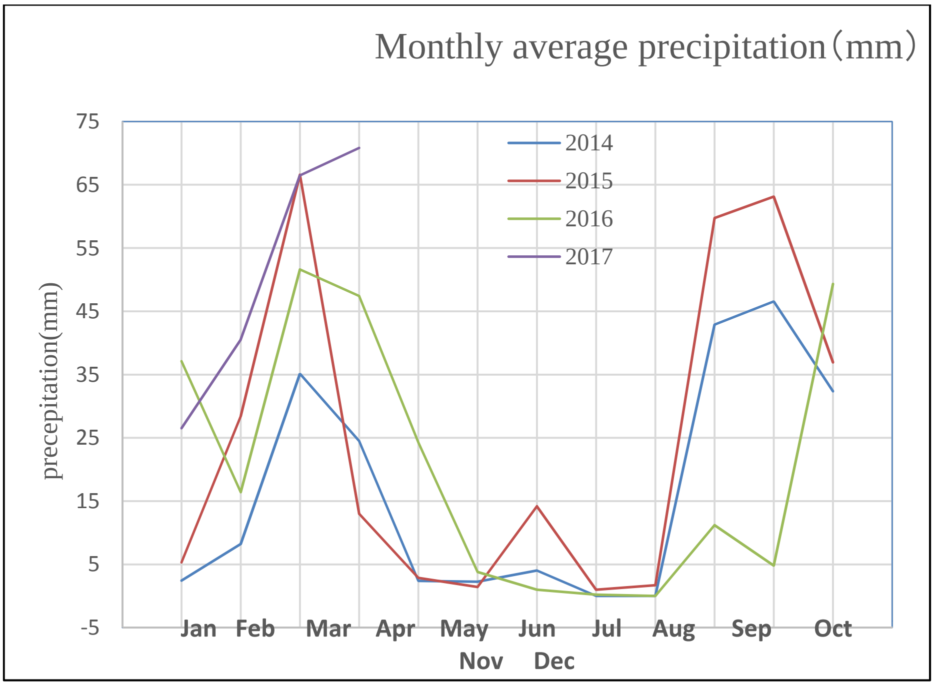
Source: prepared by JICA Study Team

Fig. 6-9 Monthly Average Air Temperature at Qazvin Meteorological Station in 2014~2017



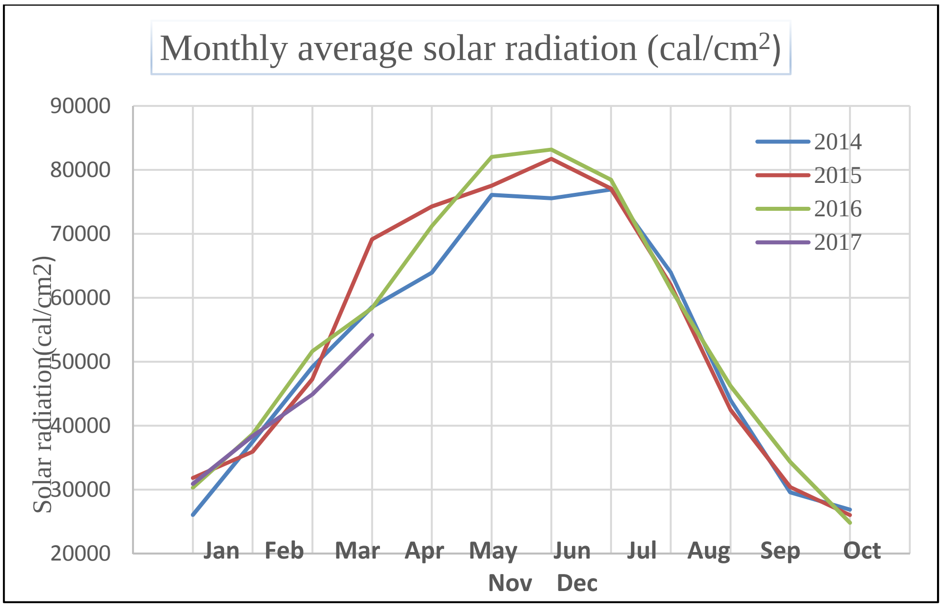
Source: prepared by JICA Study Team

Fig. 6-10 Monthly Average Humidity at Qazvin Meteorological Station



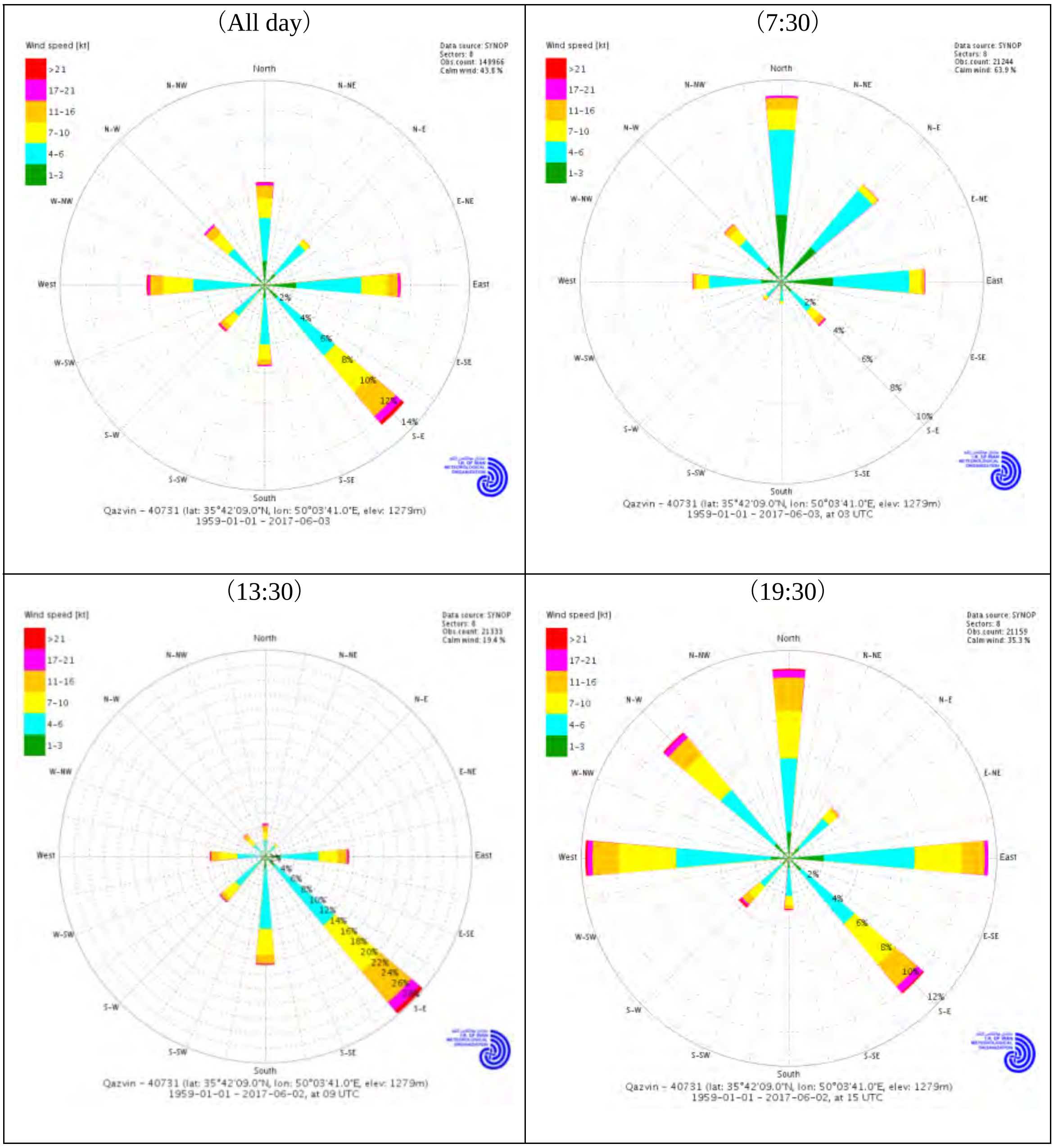
Source: prepared by JICA Study Team

Fig. 6-11 Monthly Average Precipitation at Qazvin Meteorological Station



Source: prepared by JICA Study Team

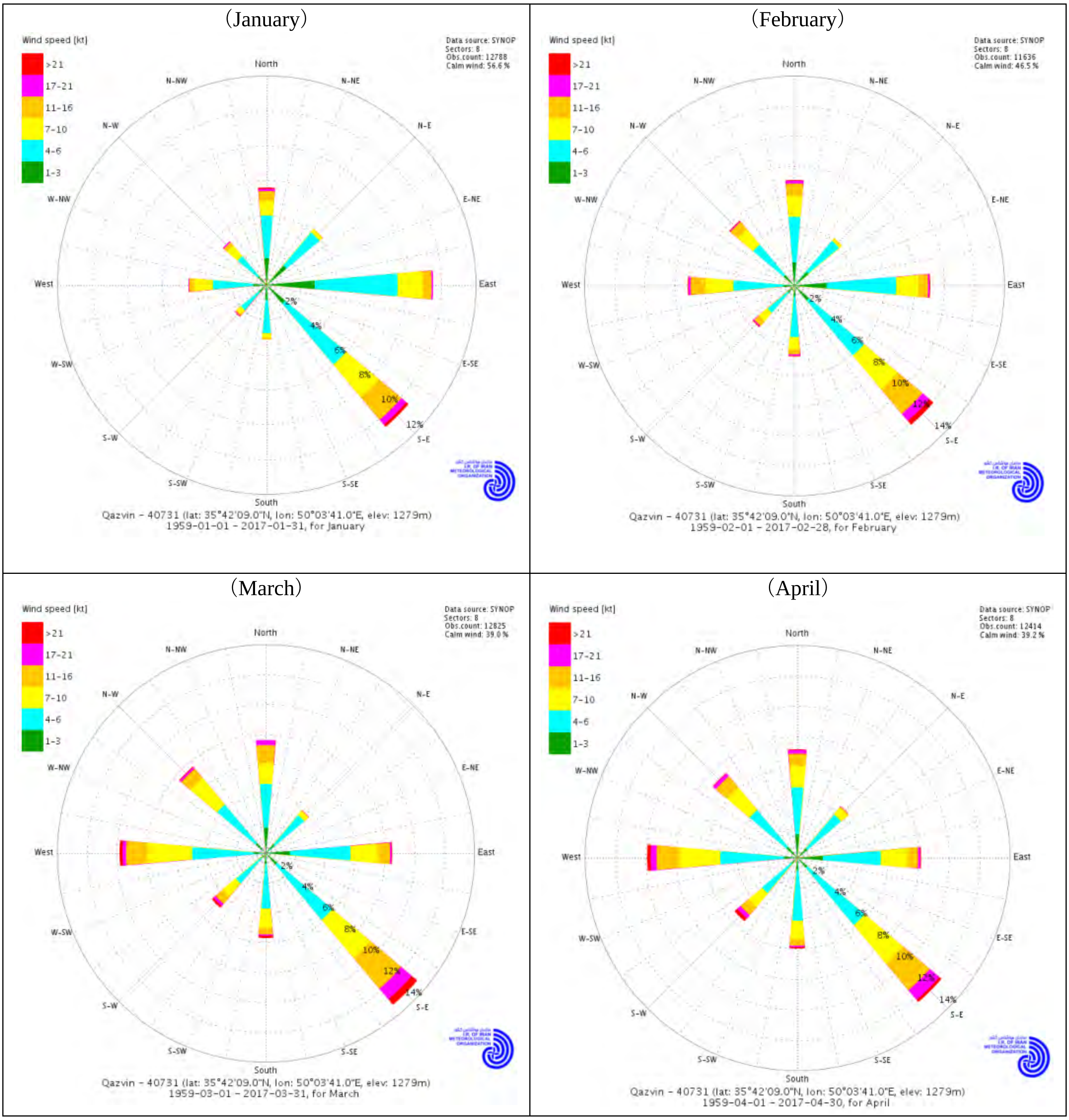
Fig. 6-12 Monthly Average Solar Radiation at Qazvin Meteorological Station



Note: wind speed unit : knot (1 kt≒0.51m/s).

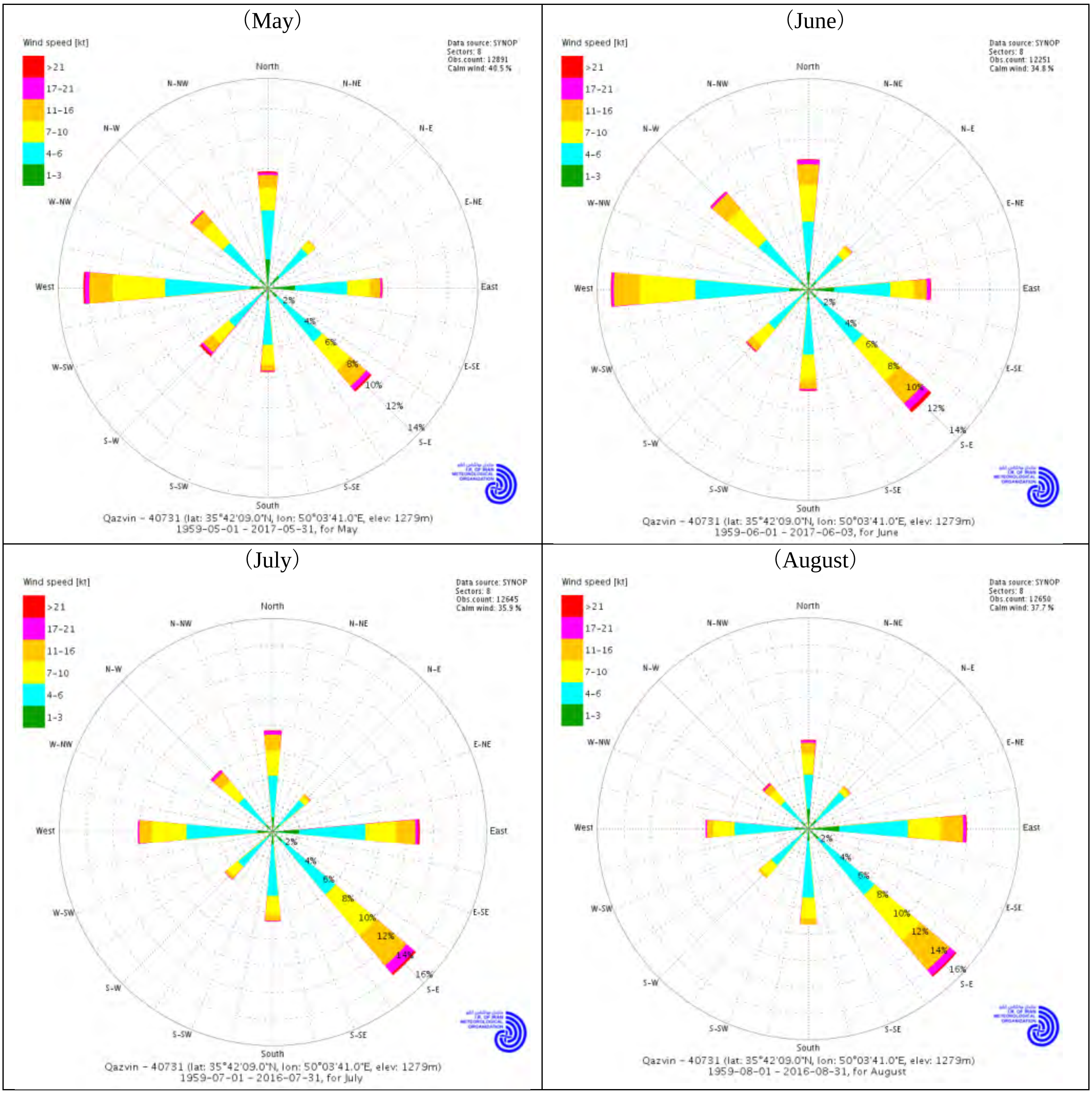
Source: prepared by JICA Study Team

Fig. 6-13 Average Wind Direction/speed at Qazvin Meteorological Station in 1959-2017 (annual)



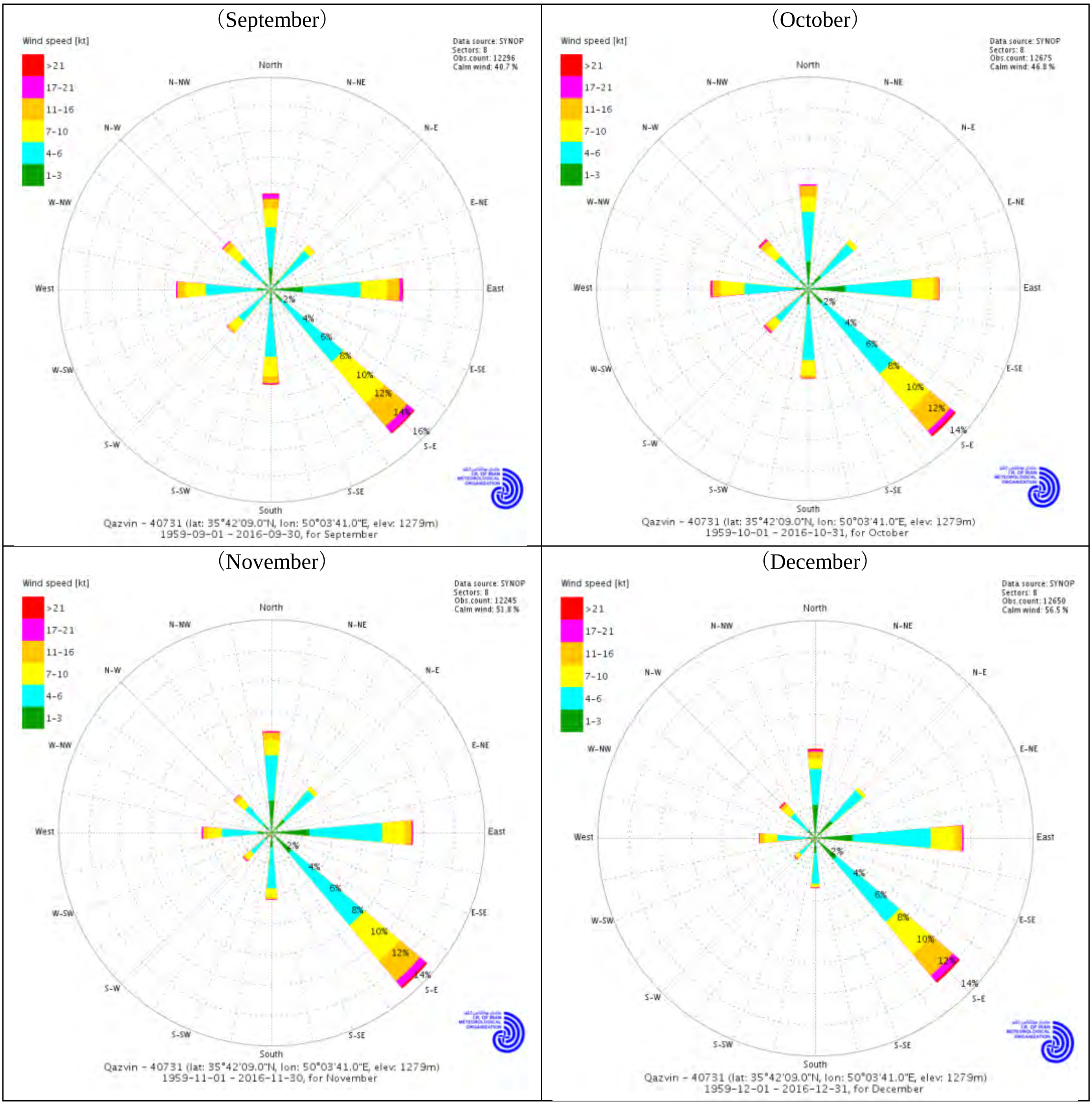
Source: prepared by JICA Study Team

Fig. 6-14 Average Wind Direction and Speed at Qazvin Meteorological Station from 1959 to 2017 (January~April)



Source: prepared by JICA Study Team

Fig. 6-15 Average Wind Direction and Speed at Qazvin Meteorological Station from 1959 to 2017 (May~August)



Source: prepared by JICA Study Team

Fig. 6-16 Average Wind Direction and Speed at Qazvin Meteorological Station from 1959 to 2017 (September~December)

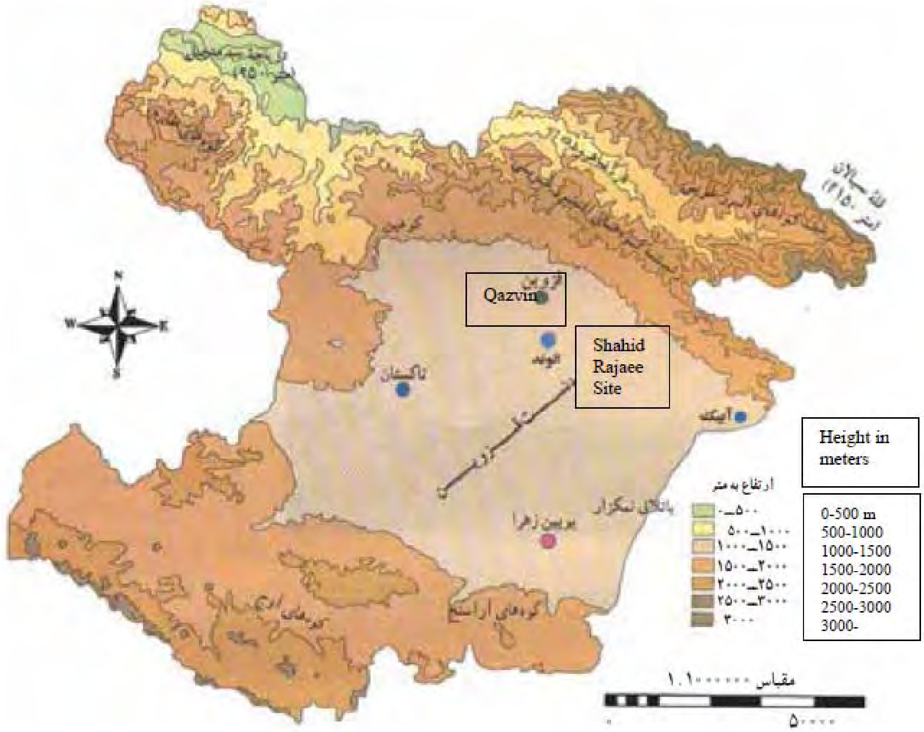
(2) Topography and Geology

a) Topography

The topography and elevation of the area around the project site (within 15km radius) are given in the figure below. The elevation of the area around the project site is in the range of 1,000 to 1,500 meters.

The terrain is mainly flat with the gradient less than 7%, in some places hilly or with small forms of topography. The area consists of flat plains (80%) and hills (20%)(Fig. 6-17 ~Fig. 6-18).

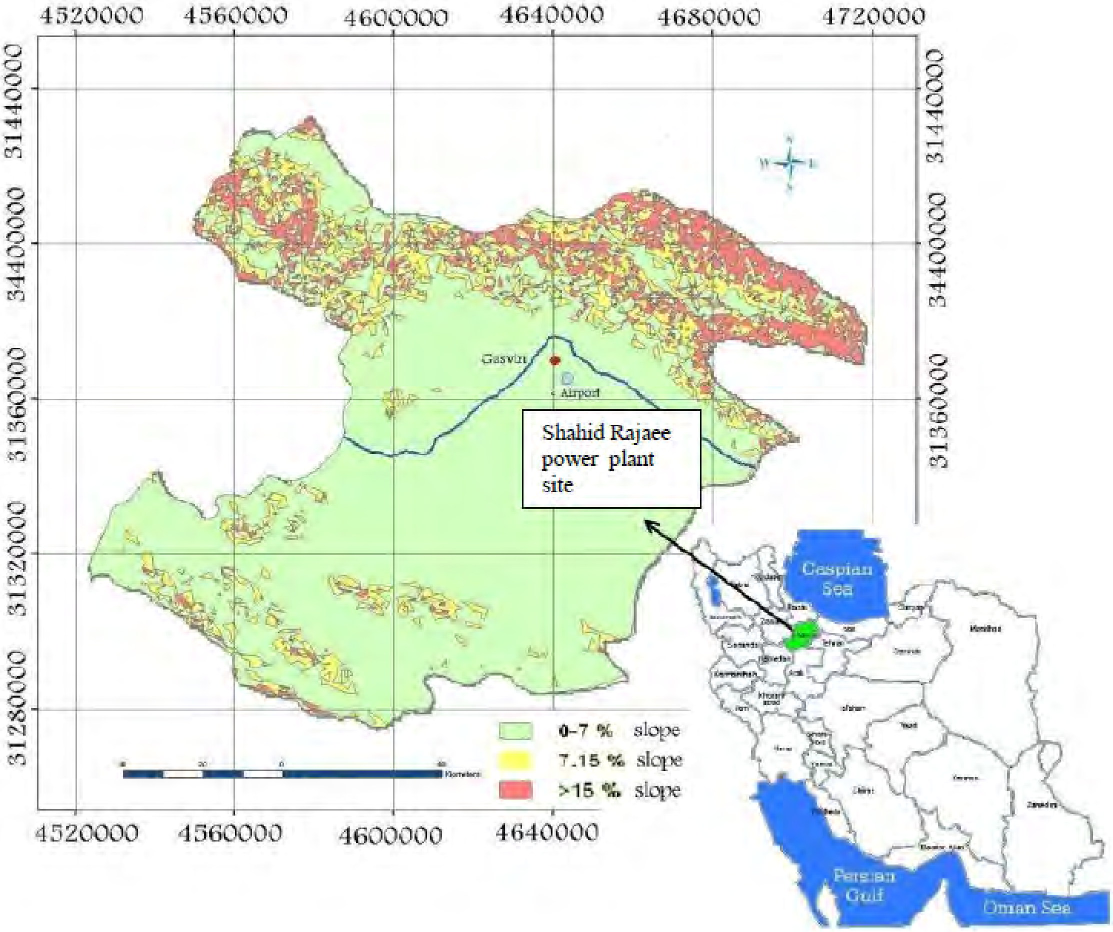
The project site is located in Central Alborz subzone which is a portion of Alp - Himalaya mountain range that is surrounded by Caspian depression and Central Iran plain. The eastern extreme of Alborz range connects to Pamir mountain range, and the altitude reaches 2,000m and higher at the point 3km north of the project site.



No.	Layer Height-m	Area(km2)	Area(ha)	%
1	0-500	270	27000	1.73
2	500-1000	540	54000	3.46
3	1000-1500*	4500	450000	28.9
4	1500-2000	6000	600000	38.54
5	2000-2500	3960	395000	25.43
6	2500-3000	168	16800	1.07
7	3000	130	13000	0.835
Total		15568	1556800	

Source: data from National Cartographic Center Iran

Fig. 6-17 Topography of Qazvin Province



Source: ENVIRONMENTAL SCIENCES Vol.8, No.3, Spring 2011

Fig. 6-18 Slope of Qazvin Province

b) Geology

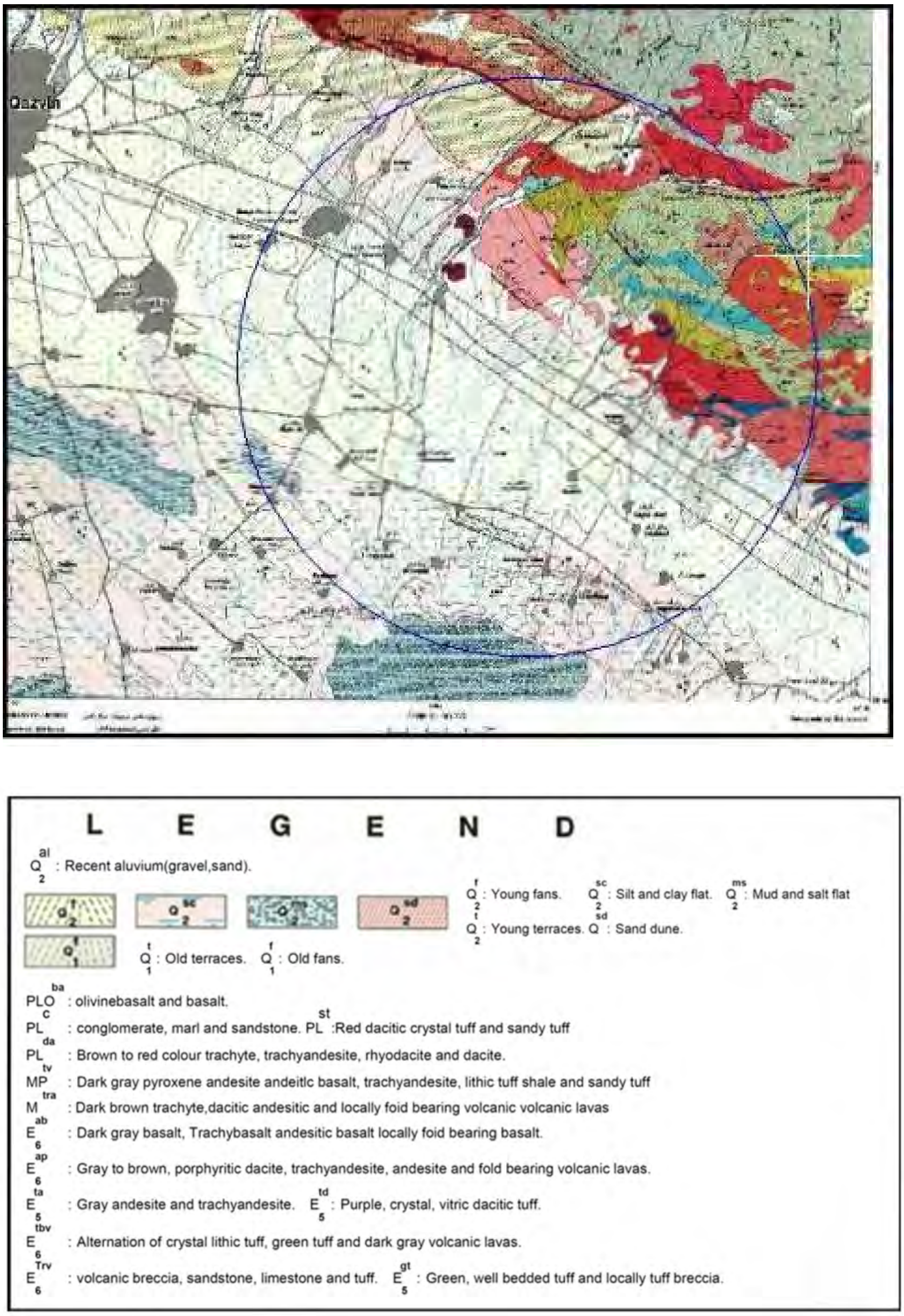
The geological subzones from stratigraphy and tectonic points of view as follows:

The most parts of the area around the power plant site is a cultivated area that consist of Quaternary young terraces. South to south west of this area consists of silt and clay flat with mud and salt flat in south extreme (Fig. 6-19).

North to north east of the area is a faulting zone that is covered by Paleogen to Neogen volcanic rocks such as trachyte, porphyry, andesite, basalt, green tuff and dark gray volcanic lavas.

According to the result of the boring survey of the site, the geological structure of the site consists of sand and gravel to the deep layer, and silt and clay layer which tend to cause subsidence does not emerge.

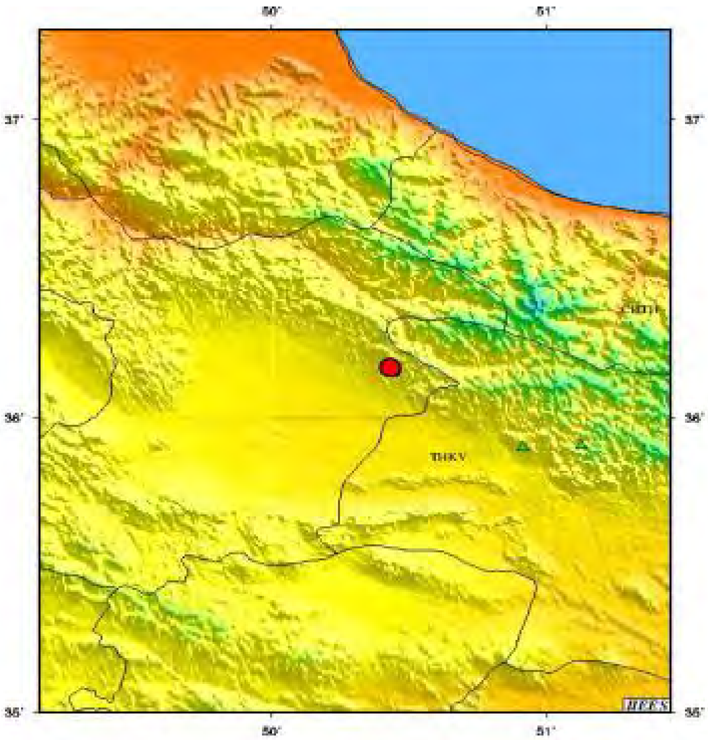
The result of the geological boring survey of the power plant site is described in Chapter 3.2.



Source: data from National Cartographic Center Iran

Fig. 6-19 Geological map around the power plant

(3) Seismicity
According to the data of International Institute of Earthquake Engineering and Seismology (IIEES), there were only 2 minor earthquakes recorded within a radius of 15 km of power plant site in the last 20 years (Fig. 6-20).



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Prel. Rep.	Date	Time(UTC)	Lat.	Lon.	Depth	Mag.	Reference
✓	2009/07/29	09:27:42.7	36.17	50.43	15	ML:4	IIEES
✓	2015/11/13	03:50:18.0	36.16	50.442	14	ML:2.5	IIEES

Source: data from International Institute of Earthquake Engineering and Seismology (IIEES)

Fig. 6-20 Recorded instrumental earthquake (1996-2017) within 15 km radius of Rajaii Power Plant Site

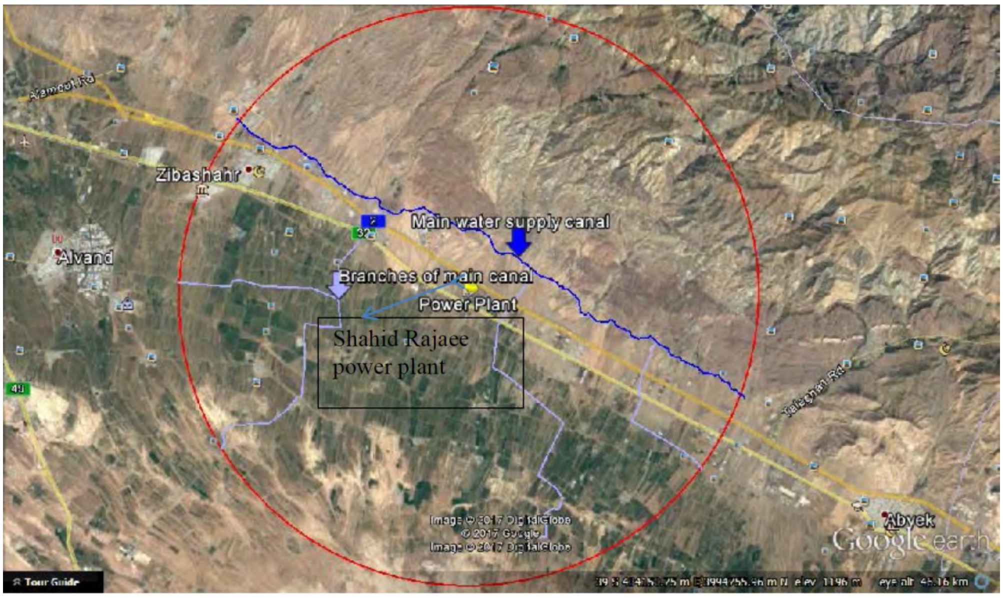
(4) Hydrology

a. Rivers

The rivers in the area around the power plant site (15 km radius) are mostly seasonal river and there is not any major permanent river. There is only one permanent river, known as River Behjatabad, used for public water in Abyek and for irrigation. Its source is in the northern mountains and flows toward south to cultivated area.

As described in Chapter 3.2.6, Behjat Abad River is 3.5km length with a basin of 120km^2. The water gauging station nearest from the power plant is located in Behjat Abad and has conducted measurement since 1979, for 36 years. The annual average flow rate is 0.22 m^3/s, and the maximum flow rate is observed in April and May.

For irrigation of cultivated lands a canal with 8.0 width and 2.5m height parallel to Tehran high -way has been constructed (Fig. 6-21).



Source: Obtained from Google Earth, and prepared by JICA Study Team

Fig. 6-21 Water canal within the radius of 15km of Shahid Rajaee power plant

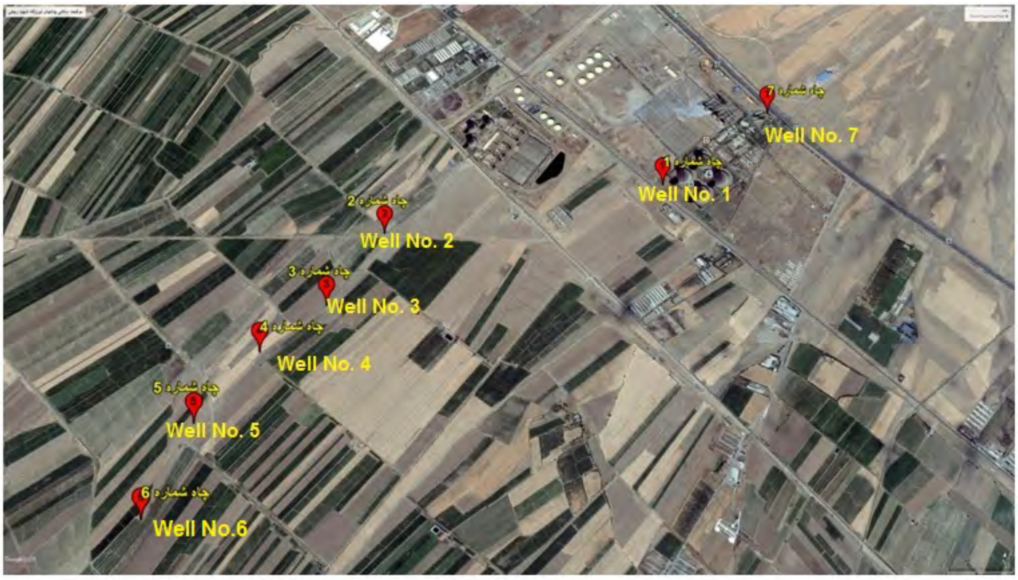
b. Ground water

As described in Chapter 3.2.6, the water intake wells for taking groundwater used for the power plant are located in the power plant site (one well) and around the site (6 wells). Well No.4 is not used at present (Fig. 6-22).

The average exploitation, depth of the well, and maximum allowable exploitation according to the license are described in Table 6-20.

The well depth is approximately 150 meters to 200 meters, the actual surface level of round water is 55 to 77meters, with sufficient groundwater quantity. The average exploitation ranges from 1.5 L/s to19.3 L/s, and the actual exploitation is much below the allowable exploitation (106～234L/s) (Table 6-20).

The lowering of water level is observed in the wells used by the power plant.
However, the ground water level of Qazvin aquifer close to the power plant has lowered of 36m between 1965 to 2016, with the estimated annual average decrease of -0.68m.
The monitoring of the ground water level in the wells used by the power plant shall be continued.



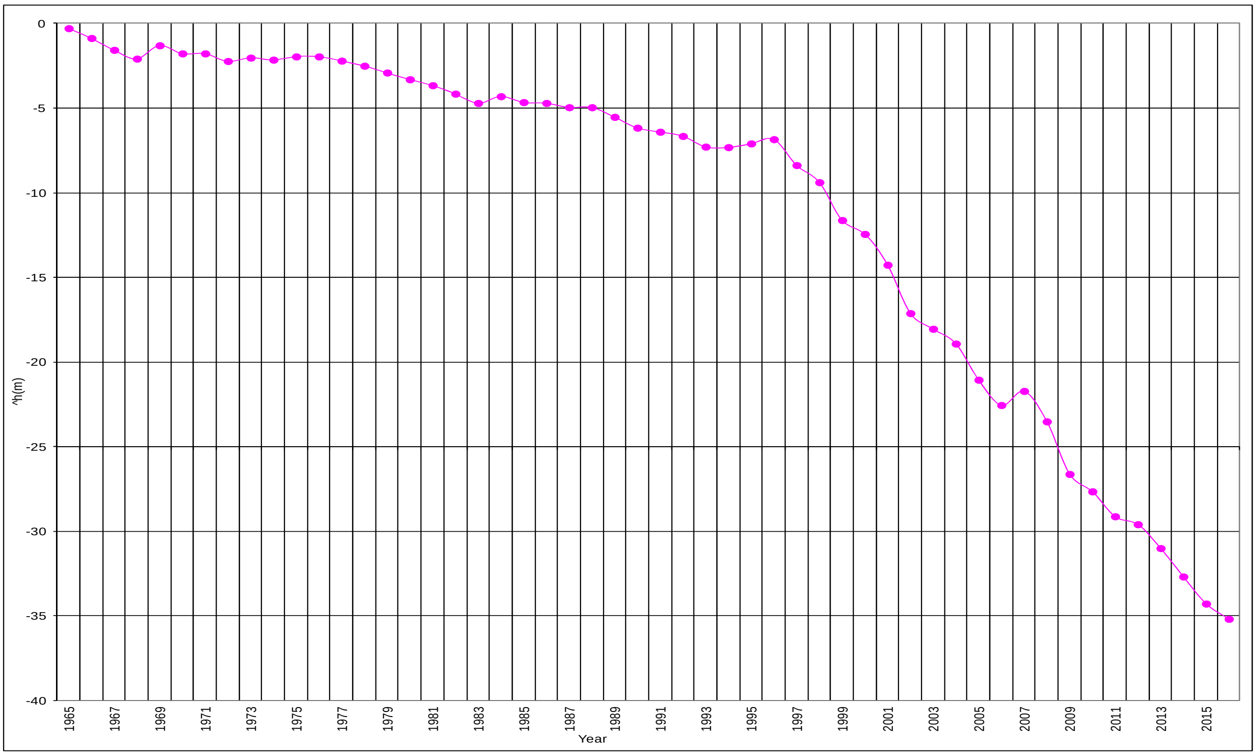
Source: Obtained from Google Earth, and prepared by JICA Study Team

Fig. 6-22 Exploitation Wells for taking Ground Water used in the Power Plant

Table 6-20 Outline of the Wells for Ground Water Exploitation for the Existing Power Plant

No	Aquifer Thickness (m)	Average of exploitation within the past two years (L/s)	Depth to water table (m)	Depth to pump facilities	Well Depth (m)	Maximum allowable exploitation according to the license (L/s)	Well location
1	144	13.9	55	132	199	126	Inside of the power plant site
2	101	1.5	55	108	156	234	outside of the power plant site
3	95	3.5	55	108	150	234	outside of the power plant site
4	95	-	55	108	150	234	outside of the power plant site
5	97	13.9	55	108	152	234	outside of the power plant site
6	98	9.0	52	102	150	234	outside of the power plant site
7	128	15.3	72	150	200	108	Inside of the power plant site

Source: prepared by JICA Study Team



Source：prepared from the data of Qazvin Water Resource Department

Fig. 6-23 Interannual Variability of Water Level of Qazvin Aquifer

(5) Ground Subsidence
Qazvin Province is currently home to 440,000 hectares of farmlands. There were 3,500 hectares of gardens where almonds and pistachios were grown, but now it shrank to barely 2,000 hectares.
Decline in rainfall combined with aggressive development has forced the residents of the province to excessively withdraw groundwater, accelerating land subsidence as a result.

Taking advantage of Shahrud River, sealing illegal water wells and reducing legal ones were the measures implemented to alleviate the water problem. In 2017 more than 1600 illegal water wells were sealed.

The declination of ground water levels is observed in southern parts of Qazvin province, but not in the area of the Shahid Rajaee power plant.

(6) Air quality
There are no major sources of air pollution and noise emission in the local area except for the existing power plant, which means the project site can be considered to be relatively clean and quiet.

As continuous air quality monitoring by DOE or any other environmental authority is not conducted around the power plant site, on-site survey was conducted in the surrounding villages on five points shown in Fig. 6-24 on March 11, 2018. At the time of measurement, 4 units of steam power plant and 3 units of gas-combined cycle power plant were in operation in the existing power plant.

Measurement results of air quality around the project site are shown in Table 6-21, and the outline of the results is described as below.

- Sulfur dioxide（SO_2）

Regarding SO_2 concentrations, one-hour values lie between 30.0～114.9μg/ m^3, 24-hour values between 50.1～91.2μg/ m^3, which satisfy the environmental standard of Iran (one-hour average value of 196μg/ m^3 and 24-hour average value of 395μg/ m^3) at all measurement points.

Additionally, the measured values are also well below more strict guideline values such as EHS guideline value (24-hour average value:125μg/ m^3), EU and Japan standard (1-hour average value: 286-350μg/ m^3, 24-hour average value:114-125μg/ m^3) .

Consequently, the measurement results indicate that the air quality around the project site, as regards to SO_2, overall may be said to be in a clean status.

- Nitrogen dioxide（NO_2）

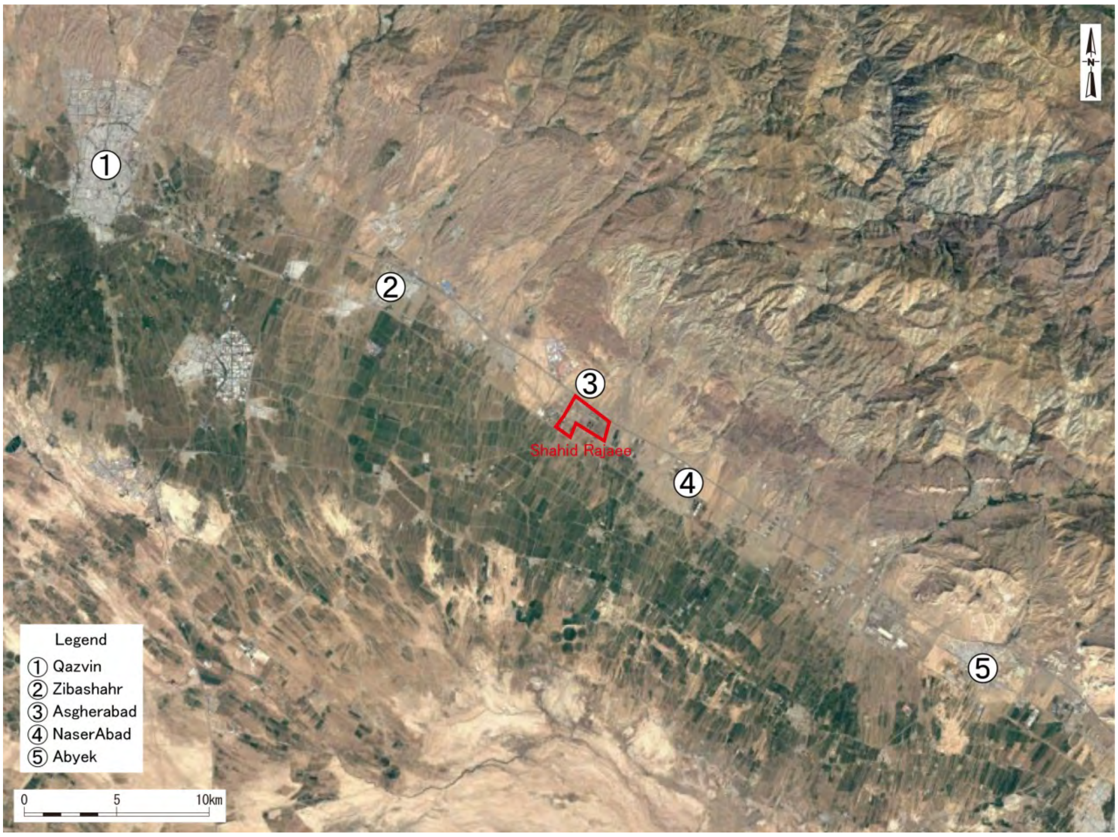
Regarding nitrogen dioxide（NO_2）concentrations, one-hour average values lie between 3.7～33.1μg/m^3, 24-hour average values lie between 17.4～27.7μg/m^3, satisfying the environmental standard of Iran (1-hour average value: 395μg/m^3) at all measurement points.

Additionally, the measurement values also satisfy EHS guideline value of IFC (1-hour average value:125μg/m^3) and Japan standard (24-hour average value:113μg/m^3) .
Consequently, the measurement results indicate that the air quality around the project site, as regards to NO_2, overall may be said to be in a clean status.

- Particulate matter（PM_{10}）

Regarding the concentration of particulate matter (PM_{10}) with radius smaller than 10 μ, one-hour average values lie between 49.0～74.0μg/m^3, 24-hour average values lie between 57.8～63.1μg/m^3, satisfying the environmental standard of Iran (24-hour average value: 150μg/m^3) at all measurement points.

Additionally, the measured values are also well below more strict guideline values such as EHS guideline value (24-hour average value:150μg/m^3) and Japan standard (1-hour average value: 200 μg/m^3, 24-hour average value:100μg/m^3) Consequently, the measurement results indicate that the air quality around the project site is not polluted by PM_{10} and overall in a clean status.



Source: Obtained from Google Earth, and prepared by JICA Study Team

Fig. 6-24 Air Quality Measurement Point around the Project site

Table 6-21 Measurement Result of Air Quality around the Project Site (unit: μg /m^3)

Item	Measurement point	1-hour average value		24-hour average value	Iran standard	IFC EHS guidelines※ Interim target 1	EU Standard (Japan standard (μg/m^3)
		Min.	Max.	Average measurement value at the point			
Sulfur dioxide (SO_2)	Abyek	34.3	62.9	50.4	196 (1hour) 395 (24hr)	- (1 hour) 125※ (24hour)	350 (286)(1hr) 125 (114)(24hr)
	Naserabad	40.0	68.9	54.1			
	Asghrabad	48.6	114.9	91.2			
	Zybashahar	38.6	97.1	67.3			
	Qazvin	30.0	82.9	50.1			
Nitrogen dioxide (NO_2)	Abyek	16.4	19.5	17.4	200 (1hr) 100 (Annual)	200 (1hour) - (24hr) 40(Annual)	200 (-) (1hr) - (113) (24hr) 40(Annual)
	Naserabad	16.4	25.5	19.1			
	Asghrabad	3.7	33.1	27.7			
	Zybashahar	16.4	30.8	22.5			
	Qazvin	16.4	30.8	21.0			
Particulate matter (PM_{10})	Abyek	56.5	69	63.1	- (1hr) 150 (24hr)	- (1hr) 150※ (24hr)	(200) (1hr) 50 (100) (24hr)
	Naserabad	54.4	69	61.5			

Item	Measurement point	1-hour average value		24-hour average value	Iran standard	IFC EHS guidelines※ Interim target 1	EU Standard (Japan standard ($\mu g/m^3$)
		Min.	Max.	Average measurement value at the point			
	Asghrabad	54.0	68.1	58.6	- (Annual)	70※(Annual)	40(Annual)
	Zybashahar	50.5	70.2	57.8			
	Qazvin	49.0	74	60.8			

Source: environmental air quality standards of the international organizations and related countries are cited from:
WHO: Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen dioxide and Sulfur Dioxide, Global update,2005
EU: Directive 1999/30/EC
Japan: Notification No.25/1973 of the Environment Agency, Notification No.38/1978 of the Environment Agency

(7) Water quality
No river is found in the area around the existing power plant, and wastewater discharged from the power plant is in principle reused for sprinkling within the site or discharged to nearby irrigation water canals in wintertime.

The result of measurement of water quality of six wells shown in (4) b. during the last 3 years (2014-2016) is shown in Table 6-22.

Table 6-22 Sampling reports for 6 wells of the Existing Power Plant (2014-2016)

Items	Unit	Min.	Max.	Average
Hydrogen-ion concentration（pH）	-	7.4	8	7.7
water temperature	^oC	17	27	22
Chemical oxygen demand（COD）	mg/l	Nil	Nil	Nil
Bicarbonate(HCO_3)	mg/l	190	220	205
Nitrate(NO_3)	mg/l		0.77	0.24
Sulfur(SO_4)	mg/l	145	210	177.5
Total silica(SiO_2)	mg/l	18	30	24
Total Dissolved Solid(TDS)	mg/l	558	918	738
Turbidity	NTU	≤1.0	≤1.0	≤1.0
Calcium(Ca)	mg/l	90	120	105
Chlorine(CL)	mg/l	50	-	-
Conductivity	µS./cm	765	1258	1011.5
Total Iron (T-Fe）	mg/l	0.0	0.018	0.0
Potassium(K)	mg/l	1	2	1.5
Sodium (Na)	mg/l	115	200	157.5
Total hardness	mg- $caco_3$/l	169	185	177

Source: Prepared by JICA Study Team

JICA Study Team has also conducted water quality measurement at five wells used by the power plant for water intake, and the result of the measurement is indicated in Table 6-23.

Table 6-23 Result of Water Quality Measurement

Item	N0.1	N0.2	N0.5	N0.6	N0.7
pH	7.6	7.9	7.8	7.7	7.5
TSS	ND	ND	ND	ND	ND
BOD(mg/l)	ND	ND	ND	ND	ND
COD(mg/l)	ND	ND	ND	ND	ND
PO_4-P(mg/l)	0.06	0.13	0.03	0.23	0.21
NO_3-N (mg/l)	15	36	19	15	12
NO_2-N (mg/l)	ND	ND	ND	ND	ND
Oil and Greases (mg/l)	ND	ND	ND	ND	ND

Source: Prepared by JICA Study Team

(8) Noise

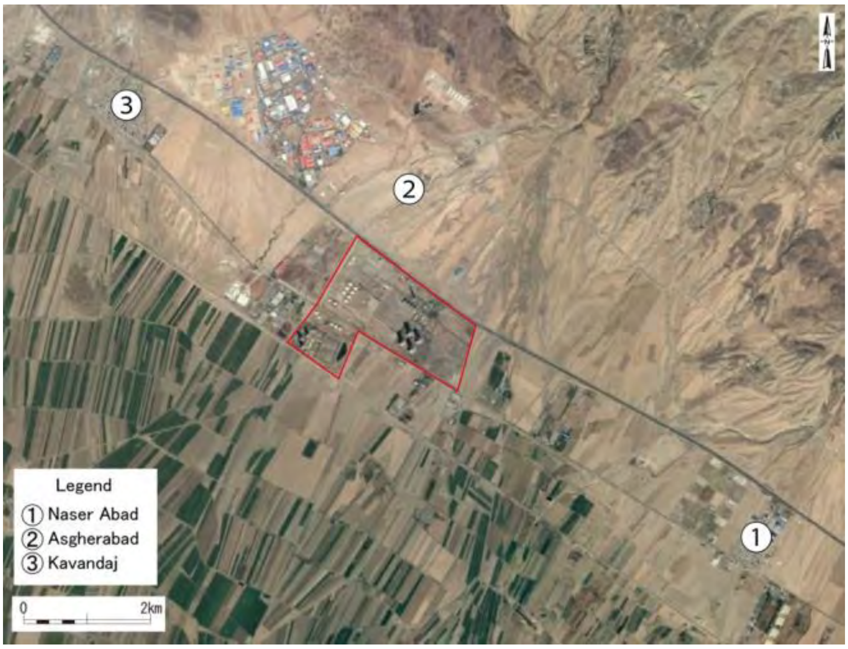
A continuous survey of noise level is not conducted around the power plant by DOE or other environmental organizations. For this reason, a field survey on the noise level was conducted around the power station 24 hours at 1 hour intervals on March 11, 2018 at three locations shown in Fig.6-25. At the time of measurement, the power plant is in operation.

The result is shown in Table 6-24 and the overview is described below.

・Noise level (Leq)in Naserabad is 49～61dBA in daytime and 36～56dBA in nighttime.
・Noise level (Leq)in Asghrabad is 31～46dBA in daytime and 31～46dBA in nighttime.
・Noise level (Leq)in Kawandaj is 37~49dBA in daytime and 31～39dBA in nighttime.

The noise level at the survey points, except Naserabad, satisfy the environmental noise standard in Iran and EHS guideline value of IFC for daytime.

The noise level at the survey points, except Kawandaj, does not satisfy the environmental noise standard in Iran and EHS guideline value of IFC for nighttime.
The reason for exceeding these standards is due to traffic of heavy vehicles.



Source: obtained from Google Earth and prepared by JICA Study Team

Fig. 6-25 Noise Monitoring points around the Project Site

Table 6-24 Result of the Measurement of Noise (Leq) around the Project Site

Point	time	Noise level(dBA)			Standards of Iran (dBA) ・Residential area:	IFC/WB EHS guidelines(dBA) ・Residential area:
		Min	Max	Ave		
Naserabad	Day	49	61	55	55(Day) 45(Night)	55(Day) 45(Night)
	Night	36	56	46		
Asghrabad	Day	31	46	41		
	Night	31	46	36		
KawandaJ	Day	37	49	44		
	Night	31	39	36		

Source: prepared by JICA Study Team

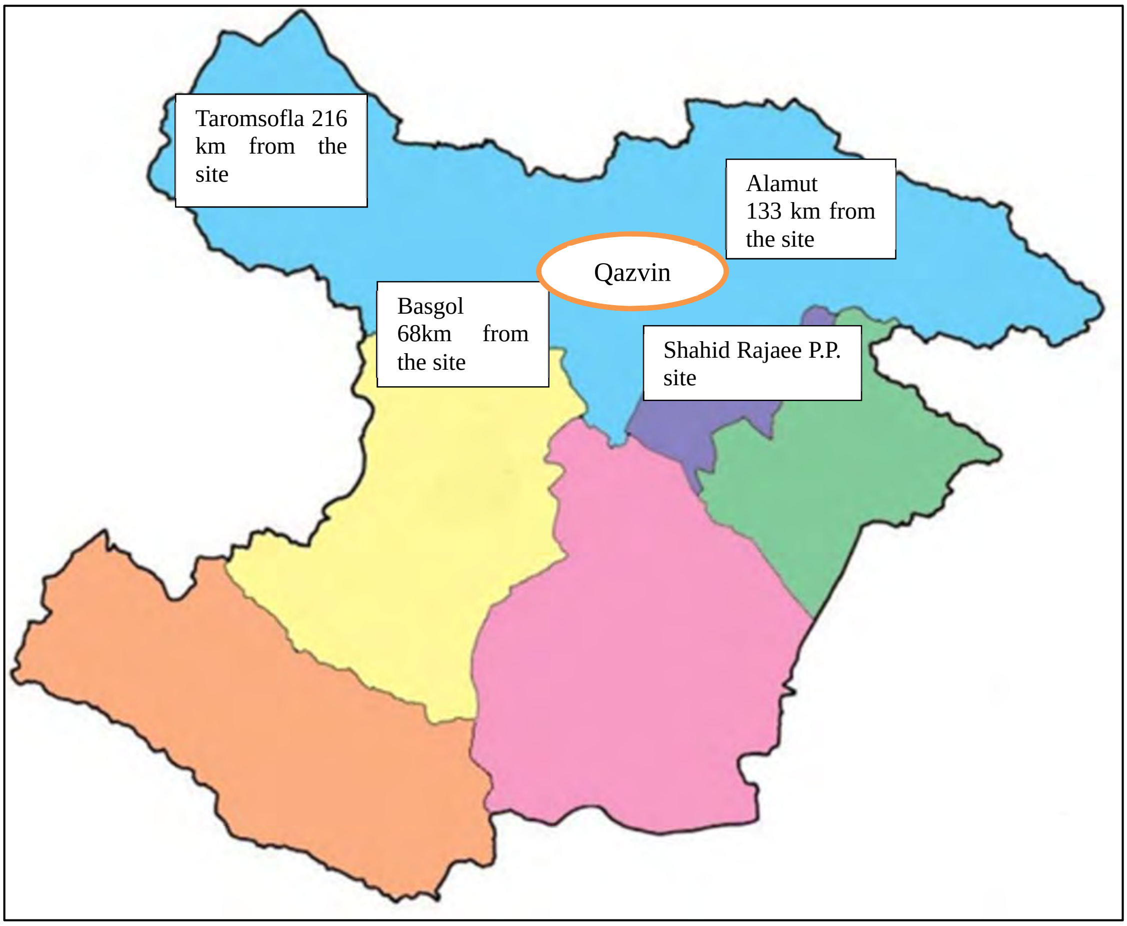
(9) Natural Parks and Protected Areas

Qazvin province does not have any National park, but there are three protected areas which are called Bashgol, Alamut and Taromsofla as shown in the figure below. The nearest one from the Shahid Rajaee power plant is Bashgol protected area.

The area of Bashgol is about 25,334 ha and its distance to Shahid Rajaee site is about 68 km. Bashgolis a land of water springs, with wetland and forest, rich with flora species. Mammals including large herbivorous mammals such as gazelle and muffron, various kinds of birds in addition to eagles and vultures are inhabited. The area is designated as protected areas under the Act on Promotion of Environmental Protection (1982) for protection of animals and plants including wetlands, forests and endangered species, and has been protected since 1997 by DOE.

Alamut has about 118,000 ha in the western edge of the Elburz range, between the dry and barren plain of Qazvin, and its distance from Shahid Rajaee site is about 133km.

Taromsofla has about 47,000 ha, located at the north-western of Qazvin, and its distance to Shahid Rajaee site is about 216 km. Alamut and Taromsofla have been protected since 2017 by DOE for precious flora and fauna species.



Source: Prepared by JICA Study Team

Fig. 6-26 Protected Areas of Qazvin province and distances from Shahid Rajaee site

(10) Terrestrial ecosystem and precious species

a. Terrestrial Flora

The area around the Shahid Rajaee power plant site, including transmission line and gas pipeline consists of farmland and meadow land, and no woodland is observed.

According to the existing documents and interviews with experts from DOE, 32 species of plants have been confirmed in Qazvin State as shown in Table 6-25.

These species are not endangered species of the International Conservation Union for Nature Conservation (IUCN). In addition, Iran has not created its own red list.

Although there are no past record of survey, plants that grow in the power plant site are mostly herbaceous plants except greening trees, which are normally found in the surrounding agricultural lands, and are not considered endangered species..

Table 6-25 Species of Flora in Qazvin Province

No	English name	Latin name	Division	IUCN
1	Greea juniper	*JUNIPERUS excelsa*	Arbor	-
2	Almond	*Amygdalus lycioides*	Arbor	-
3	Barberry	*Berberis*	Shrub	-
4	Honey suckle	*Lonicera spp.*	Shrub	-

5	Pistacia tree	*Pistacia vera*	Arbor	-
6	Walnut	*Juglans regia*	Arbor	-
7	Oak tree	*Quercus spp*	Shrub	-
8	Hawthom	*Crataegus*	Shrub	-
9	Christs thom	*Patiurus spina christi*	Arbor	-
10	Wild almond	*Irvingia malayana*	Arbor	-
11	Hawthom	*Crataegus aronia*	Shrub	-
12	Pistacia atlantica	*Pistacia atlantica*	Arbor	-
13	Cannabis	*disambiguation*	Herbaceous	-
14	Mongolian milkvetch	*Astragalus spp.*	Herbaceous	-
15	Centaurea	*Centaurea spp.*	Herbaceous	-
16	Esfand	*Peganum harmala*	Herbaceous	-
17	Rosa persica	*rosa persica*	Herbaceous	-
18	Sophora	*stphnolobium japonicum*	Arbor	-
19	Liquorice	*glycyrrhiza glabra*	Herbaceous	-
20	Camelthom	*Alhagi camelarum*	Shrub	-
21	Spear Thistle	*cirsium vulgare*	Herbaceous	-
22	Chicory	*cichorium intybus*	Herbaceous	-
23	Fumaria officinlis	*fumaria officinalis*	Herbaceous	-
24	Plmtae	*artemisia abrotanum*	Herbaceous	-
25	Aster	*aster*	Herbaceous	-
26	Thymus kotschyanus	*thymus kotschyanus*	Shrub	-
27	Borage	*borage offieinalis*	Herbaceous	-
28	Tamarisk	*tamarix*	Arbor	-
29	Sweep Qazvini	*Qazvini nihilum deduces*		-
30	Lawn	*lawn*	Herbaceous	-
31	Alfalfa	*medicago sativa*	Herbaceous	-
32	Prosopis farcta	*prosopis farcta*	Arbor	-

Source: prepared by JICA Study Team

b. Terrestrial Fauna

< Mammals>

According to interviews with existing documents and DOE experts, 13 species of mammals have been confirmed in Qazvin province, as shown in Table 6-26.

The list of fauna species living in Qazvin province is shown in the tables below. There are four endangered species of mammals and birds observed, Ursus arctos, Panthera pardus, Ovis orientalis, and Rhinolophus euryale,but these species are inhabited in the mountain, wetland and forest from the view of their habitat characteristics, and the power plant site area consisting of flat farmland and dry land are not suitable for their habitat. Also, according to the hearing from the expert from DOE, most of them live in the forests or protected areas, and they are not assumed to live in the dry area around the project site.

Although there are no past survey records, large mammals and bats are not observed in the area, except only small rodents. In consequence, it is considered that endangered mammal species do not inhabit in the area in and around the project site.

Table 6-26 Species of Mammal in Qazvin Province

No	English name	Latin name	Habitat characteristics	IUCN
1	Brown Bear	Ursus arctos	Rocky mountain area with shrub	EN
2	Leopard	Panthera pardus	Mountain area in Iran.	VU
3	Eurasian Lynx	Lynx lynx	Wide area such as forests and grassland	-
4	Wild Cat	Felis silvestris	Wide area such as dry land, grassland, and forests.	-
5	Jungle Cat	Felis chaus	Prefer the environment with water such as wetlands and marsh, and dense vegetation	-
6	Wolf	Canis lupus	Wide area such as tundra, forests, mountains.	-
7	Caracal,	Caracal caracal	Wide area such as forests, grassland, rocky area.	-
8	Otter Eueopean Otter	Lutra lutra	Wide aquatic environment such as rivers, marsh, coastal area.	-
9	Goitered Gazelle	Gazella subgutturosa	Wide area in semi-dry and dry land	-
10	Mouflon	Ovis orientalis	Moutains and cliffs	EN
11	Goat	Capra aegagrus hircus	In almost any habitat environment.	-
12	Mediterranean Horseshoe Bat	Rhinolophus euryale	Bush and forests.	VU
13	Geoffroys Bat	Myotis emarginatus	Wide area in Iran.	-

Notes：CR:Critically Endangered
EN:Endangered
VU:Vulnerable
NT:Near Threatened

Source: prepared by JICA Study Team

〈Birds〉

According to the existing documents and interviews with DOE experts, 24 species of birds have been confirmed in Qazvin province, as shown in Table 6-27.

Among them, five species of endangered species of valuable species IUCN are confirmed: Egyptian vulture, Houbara, Imperial Eagle, Saker Facon, and Greater Spotted Eagle. In view of their habitat characteristics, these species live in places with vegetation such as mountainous areas, rocky areas, forests, etc.

Flat farmlands and dry areas around the project site are not suitable for their habitation. Even through interviews with DOE experts, these endangered species inhabit forests or protected areas and are not considered to live in farmlands and dry areas around the project site.

Although the past survey record around the site does not exist, the hearing from the power plant staffs indicated that large bird species such as eagles and vultures are not observed in the area.
In consequence, it is considered that endangered bird species do not inhabit in the area in and around the project site.

Table 6-27 Species of Birds in Qazvin Province

No	English name	Latin name	Habitat characteristics	IUCN
1	Egyptian vulture	Neophron percnopterus	Nests in cliffs, rocky areas, big trees, etc.	EN
2	Houbara Bustard	Chlamydotis undulata	Habitat in dry and semi-dry area in Iran.Resting in shrub zone.	VU
3	Lesser kestrel	Falco naumanni	Feeding in grassland and grass field.	VU
4	Imperial Eagle	Aquila heliaca	-Inhabited in grass field and riverine forests.	VU
5	Barbary Falco	Falco pelegrinoides	Observed mainly in dry area.	-
6	Peregrine	Falco peregrinus	Inhabited in a wide area such as wetland, dry land, tropical zone and cold zone.	-
7	Bustard	Otididae	Living mainly in grass land of Asia and Africa.	-
8	Caspian Snowcock	Tetraogallus caspius	Inhabited in steep slopes, valleys, mountains, grasslands, etc.	-
9	Saker Facon	Falco cherrug	Nesting in mountains and flat ledge shelves.	EN-
10	Merlin	Falco columbarius	Habitat on plain area farmland and riverbed	-
11	Hobby	Falco subbuteo	Inhabited in forest area.	-
12		Circus	Inhabited on wetlands, reclaimed land, lakes shore, shore of river	-
13	Buzzard	Buteo buteo	Inhabited in a wide environment, but need forest area for nesting.	-
14	Goshawk	Accipiter gentilis	Inhabited in forest area	-
15	Kestrel	Falco tinnunculus	Widely inhabited including forests	-
16	Lanner Falcon	Falco biarmicus	Widely inhabited including forests and dry area	-
17	Sparrow Hawk	Accipiter nisus	Mainly inhabited in forests-	-
18	Levant Sparrow Hawk	Accipiter brevipes	Mainly in forests near aquatic environment	-
19	Greater Spotted Eagle	Clanga clanga	Inhabited in forests near wetland.	VU
20	Bearded vultre	Gypaetus barbatus	Normally inhabited in mountains over 1000m.	-
21	Griffon Vulture	Gyps fulvus	Mountains and dry area	-
22	cinereous vulture	Gegypius monachus	Inhabited in dry grassland and	-
23	Eurasian crane	Grus grus	Habitat in wetland, rivers, grassland, estuaries, tidelands	-

No	English name	Latin name	Habitat characteristics	IUCN
24	Spoonbill	Platalea leucorodia	Habitat in rivers, lakes, mangrove swamps, etc.	-

Notes：CR:Critically Endangered
EN:Endangered
VU:Vulnerable
NT:Near Threatened

Source: prepared by JICA Study Team

＜Reptiles and amphibians＞

According to the existing documents and interviews with DOE experts, reptiles and amphibians are not confirmed in Qazvin province. In Iran, 16 species of reptiles and 4 species of amphibians which are IUCN endangered species have been confirmed, as shown in Table 6-28 and Table 6-29 .

Regarding reptiles, Spur-thighed Tortoise, Central Asian Tortoise and a lizard Eremias pleskei are the only species that may live in flat dry area , in view of their habitat characteristics. The surroundings are being used as bare land and agricultural land, and it is not suitable for habitat of these species.

Although the past survey record around the site does not exist, the hearing from the power plant staffs indicated that the turtles and lizards cited above are not observed in the area.

Regarding amphibians, river, which is their habitat, does not exist around the project site.

In consequence, it is considered that endangered reptile and amphibian species do not inhabit in the area in and around the project site.

Table 6-28 Species of Reptiles in Iran

No	English name	Latin name	Habitat characteristics	IUCN
1	loggerhead sea turtle	Cretta cretta	Habitat in oceans. Egg-laying in coastal area	VU
2	Green turtle	Chelonia mydas	Shallow coastal area	EN
3	Hawksbill Turtle	Eretmochelys imbricata	Habitat mainly in marine coastal area	CR
4	Olive Ridley Turtle	Lepidochelys olivacea	Habitat in oceans. Egg-laying in coastal area	VU
5	Leatherback Turtle	Dermochelys coriacea schlegelii	Habitat in oceans. Egg-laying in coastal area	VU
6	Mesopotamian Softshell Turtle	Rafetus euphraticus	Habitat mainly in river area.	EN
7	Spur-thighed Tortoise	Testudo graeca Linnaeus	Habitat in dry area and grass field.	VU
8	Central Asian Tortoise	Testudo horsfieldii	Habitat mainly in grass field and dry area.	VU
9	Marsh Crocodile	Crocodylus palustris	Inhabit in fresh water areas such as rivers,	VU

No	English name	Latin name	Habitat characteristics	IUCN
			lakes, ponds	
10	Latifi s Viper	Montivipera latifi	Inhabit in vegetated mountain area	EN
11	Meadow viper	Vipera ursinii eriwanensis	Habitat in mountains and grassland.	VU
12	Mountain Viper	Montivipera albicornuta	Habitated in rocky area, not in grassland and farmland.	VU
13	Wagner's Viper	Montivipera wagneri	Rocky area in mountain, especially near rivers.	CR
14	Pleskes Racerunner	Eremias pleskei	In Iran, seen from semi-dry area to grassland.	CR
15	Egyptian Mastigure	Uromastyx aegyptia	Habitat in rocky area.	VU
16	Persian Toad Agame	Phrynocephalus persicus	Semi-dry area higher than 1,150m altitude.	VU

Notes：CR:Critically Endangered
EN:Endangered
VU:Vulnerable
NT:Near Threatened

Source: prepared by JICA Study Team

Table 6-29 Species of Amphibians in Iran

NO	English name	Latin name	Habitat characteristics	IUCN
1	Luristan newt	Neurergus kaiseri	Aquatic area such as - small rivers.	CR
2	Kurdistan spotted newt	Neurergus microspilotus	Small rivers-	CR
3	Gorgan salamander	Paradactylodon gorganensis	Aquatic environment in - caves, etc.	CR
4	Lake Urmia Newt	Neurergus crocatus	Egg-laying in - mountainous rivers	VU

Notes：CR:Critically Endangered
EN:Endangered
VU:Vulnerable
NT:Near Threatened

Source: prepared by JICA Study Team

6.6.2 Social environment

(1) Land Use

The project site is located in the site of the existing power plant and in an area where land preparation has already been completed and there is no house within the site.

The nearest residential area is a small village of Asghabad located about 1.5 km to its north and there is no residential area nearer to the power plant.

Fishery is not implemented around the power plant since there is no river nearby. The figures below show the land use of the area around the project site.

Source: Photographed and prepared by JICA Study Team

Fig. 6-27 The Nearest Residential Area

Source: Photographed and prepared by JICA Study Team

Fig. 6-28 Land Use on the South Side of Shahid Rajaee Power Plant

(2) Water Use

Water shortage in Qazvin area has been an issue for a long time. In 1969, government decided to construct a dam in Taleghan area after some years of delay, and since 2006, Taleghan dam became operational for irrigation of Qazvin areas through the 9km canal to Zyaran, which is nearby the Shahid Rajaee power plant.

Nowadays, the canal supplies the required water for the Yonosabad, Asghabad, Naserabad Kavandaj and Hesarkhravan residential areas. A new dam, called Nahab dam , which will improve water capacity of the area, was to start operation by March 2018 but not yet in operation at the current moment. As for ground water availability, only 700 wells are now in operation in province of Qazvin to supply water for irrigation use as well as households use.

(3) Sanitation

Table 6-30 shows the location of medical centers in each District near the Shahid Rajaee power plant. About half of the districts have their own medical centers, and even the districts which do not have one can easily access to any medical centers nearby.

Qazvin province has 14 hospitals total with 2,153 beds, consisted of 7 governmental hospitals with 1,267 beds, 4 private hospitals with 441 beds and 3 other hospitals with 445 beds.

Table 6-30 Medical centers near the Shahid Rajaee power plant

No.	Name of District	Medical Centers
1	Anjilagh	-
2	Asghabad	-
3	Hajitapeh	○
4	Sharknab	○
5	Zagheh	○
6	Zarchebostan	-
7	Yonesabad	○
8	Behtajatabad	-
9	Kavandaj	-
10	Caspian Industrial City	-
11	Hesarkharvan	○
12	Falizan	-
13	Naserabad	○

Source: prepared by JICA Study Team

(4) Population and Demography

The population of the 15 settlements around the Shahid Rajaee Power plant and the distance from the power plant is shown in Table 6-31.

Most of the settlements are more than 5 kilometers away from the power plant site and the population is less than 1,000. The nearest settlement from the project site is Asghabad Settlement, located about 1,500m to the north from the site boundary with 150 inhabitants.

Qazvin City (population 400 - 500 thousand people), the capital of Qazvin province, is located about 20 km away from the site. The total population of Qazvin has risen to more than 1.273 million people in 2016. The population growth rate was 1.17% in 2016. The population is significantly concentrated in Qazvin city center, which is about 400,000 people.

Table 6-31 Population of the Settlements and the Distance from the Power Plant

No.	Name of Village	Population (Parsons)	Distance from Shahid Rajaee Power plant (m)
1	Anjilaq.	450	6,000
2	Asgha Abad	150	1,500
3	Ebrahimabad	50	5,000
4	Hesar Kharav	4,036	8,000

5	Hezar Jolfa	118	5,500
6	Haji Tape	1,300	8,000
7	kahavank	99	12,000
8	Kavandaj	1,600	3,000
9	Khatayan.	802	6,000
10	Mahmoudian.	459	10,000
11	Yonesabad	400	2,000
12	Behtajatabad	700	6,000
13	Naserabad	2,100	4,000
14	Hajiabad	67	20,000
15	Zagheh	1,200	6,000

Source: prepared by JICA Study Team

(5) Education

Formal education in Iran is divided into general and higher education: General education includes primary, lower secondary, upper secondary and technical and vocational training.

All children spend six years of their lives at primary level from age 6 to 12 and attend high school from ages 12 to 18. About 88.4% of population is educated and the rest are not educated in Qazvin province. Table 6-32 shows the presence of school in the Districts near Shahid Rajaee power plant.

The average literacy rate in Qazvin province is 87.7% for male and 80.4% for female, and the literacy rate for rural area of Qazvin province is 82.2% for male and 71.6% for female.

Table 6-32 Schools near Shahid Rajaee power plant

No.	Name of District	Elementary School	Lower Secondary School	Upper Secondary School
1	Anjilagh	x	-	-
2	Asghabad	x	-	-
3	Hajitapeh	x	x	-
4	Sharknab	x	-	-
5	Zagheh	x	x	-
6	Zarchebostan	x	-	-
7	Yonesabad	x	-	-
8	Behtajatabad	x	-	-
9	Kavandaj	x	x	-
10	Caspian Industrial City	-	-	-
11	Hesarkharvan	x	x	x
12	Falizan	x	-	-
13	Naserabad	x	x	x

Source: prepared by JICA Study Team

(6) Public Infrastructure

There are highways, roads, railway, gas pipelines, schools, clinics and other public infrastructures near the proposed project site. In terms of public utility, all flats of residential buildings in the districts nearby are supplied with electric energy and natural gas meter. Overall, the public infrastructures are in good condition, except for the waste water system of some districts that needs development.

(7) Land Traffic
According to the statistics by Information and Technical Documentation Bureau of the Ministry of Roads and Transportation, 488,000 persons are transported by minibus, and 461,000 persons are transported by passengers' cars, and these two ways of transportation are the most common in Qazvin province.

(8) Employment
Iran is one of the largest economies in the Middle East and North Africa (MENA) region, with an estimated Gross Domestic Product (GDP) in 2017 of US$438 billion. It also has the population of very close to 80 million people in 2016.

Iran's economy is characterized by the hydrocarbon sector, agriculture and services sectors, manufacturing and financial sectors. Unemployment rate in Qazvin province is 10% for women and 7.4% for men in 2016. The labor force engaged in industry, agriculture, and service respectively has been 19.4%, 31.5%, and 49.1% in the country. At present, agriculture sector, due to drought and modernization of irrigation systems, has less labor forces.

(9) Income and Expenditure
In the year 2014, the average annual income of an urban household was about 204.5 million Rials. The average annual income for a rural household was 121.1 million Rials.

In the year 2014, the average annual net expenditure of an urban household amounted to 206 million Rials including 151 million Rials for non-food expenditures (73.3 percent) and 55 million Rials (26.7 percent) for food, which increased by 25.4 percent in comparison to the previous year.

Average rural household net expenditure in the year 2014 amounted to 129.6 million Rials, including 73.5 million Rials for non-food expenditures (56.7 percent) and 56.1 million Rials (43.3 percent) for food which increased by 19.8 percent in comparison to the previous year.

(10) Tourist Site and Cultural Heritage
According to the field survey, there are a total of 10 historic cultural and religious facilities such as mosques and palaces in the city of Qazvin about 20 km away from the project site, which is a tourist site, but there are no historical facilities around the project site and it is not a tourist destination.

For this reason, the impact assessment of the landscape will not be conducted during and after construction of the power station thereafter.

Source: prepared by JICA Study Team

Fig. 6-29 Historical Cultural Heritage Sites within 15km radius of Shahid Rajaee power plant

(11) Minorities

The minorities such as Christian, Jews, Zoroastrian and others were less than 0.25% (About 3,000 people) of the population of Qazvin province at the time of the year 2011, living in harmony with Iranian people.

According to the hearing survey, minorities do not live around the proposed project site, nor do they use the project site, and for this reason, the impact of the power plant during construction and operation phase on the minorities is not assumed, and will be excluded from the impact assessment.

6.7 Environmental Impact Evaluation

6.7.1 Construction Phase

(1) Air quality
Generation of dust is expected by land preparation, and flying dust is expected to impact the air quality of the surrounding area.

According to the Beaufort scale, when wind speed exceeds about 6 m/s, dust on the ground may be lifted up. The occurrence ratio of wind speed exceeding about 6 m/s around the project site is below 1% throughout the year, whereas it is occurs slightly more often in winter.

Dust caused by the strong winds in the dry season will be reduced with periodic watering in the site and road.

Emission of air pollutants (SOx, NOx, PM) from construction machinery and vehicles may affect air quality of the surrounding site.
Periodic maintenance and management of all the construction machinery and vehicles will be conducted to reduce pollutant emission. Adjustment of the construction schedule shall be considered in advance in order to avoid the concentration of machinery and vehicles in one specific period.

The impact of the project on the atmospheric air quality will be minimized by the mitigation measures cited above, although air quality monitoring in the busiest construction period will still be necessary.

(2) Water quality
Domestic wastewater and excretion from workers, concrete effluent and oil-containing effluents are generated and may affect the water quality of the irrigation canal in the surrounding sea.
A wastewater treatment facility for workers, such as a septic tank and temporary toilet, will be installed in the worker’s camp and construction area.

Concrete-generated waste water and oil-containing effluent are treated at a neutralization and oil-separation system installed within the construction area. Waste water will be checked for compliance with the water quality standard of Iran and IFC/WB EHS Guidelines.

Treated waste water is finally sent to the existing waste water reservoir and is reused within the site as much as possible. Waste water that could not be reused will be discharged into the irrigation canal.
These measures will minimize the impact of contamination of irrigation canal water. Water quality monitoring of waste water and the irrigation canal will still be necessary.

(3) Waste
Waste generated from the construction work will include general waste such as packing material and domestic waste, and hazardous waste such as waste oil and waste battery.
Waste will be collected separately and stored in an appropriate place and method. Paper wastes and iron scraps will be recycled, and other general wastes will be appropriately disposed of, as with the case in the existing facility. Small amount of sludge and waste oil will be generated from waste water treatment and is recycled, and other hazardous waste including sludge from waste water treatment, is landfilled within an anti-seepage pit authorized by DOE and built in the site.

As water pollution, soil pollution, odor or sanitary problems resulting from waste will be mitigated with the above-described mitigation measures, the environmental impact will be minimized and insignificant. The monitoring of waste will be conducted regarding the type, generation amount and disposal method of waste.

(4) Soil contamination
Soil pollution may possibly be caused by leakages of lubricate collected from construction machinery, fuel oil and chemicals. Oil and chemicals will be stored at an appropriate storage place equipped with anti-permeation system in the project site. With these measures the impact of soil contamination will be negligible.

(5) Noise and Vibration
Operation of heavy equipment and vehicles for transporting materials will cause noise and vibration impacts. There are no households in the direct neighborhood of the site, but some households are located in 1.5 km on the north of the project site, and sufficient consideration must be given to minimizing any noise impact.

<Noise>
The level of noise resulting from the operation of the construction machinery was simulated using the following estimation model.
Noise level estimation model
Noise predictions were carried out in accordance to International Standard ISO 9613, Acoustics-Attenuation of Sound during Propagation Outdoors.

$$LPA = LWA - 20 \cdot \log R - 8 - A\gamma - AE$$

In which
LPA : Sound pressure level by A-weighted (dBA)
LWA : Sound power level by A-weighted (dBA)
R : Distance (m)
$A\gamma$: Barrier attenuation (dBA)
AE : Atmospheric absorption (dBA)
Noise level data of noise source

Major construction machines used for construction include cranes used for loading basic materials and the like, concrete mixers and pump cars in foundation construction works, backhoes for excavation, power generators, air compressors, etc.

Considering the ground condition, piling operation which generates high noise will not be necessary.
Table 6-33 shows the noise level of the main construction machinery and the number of machines.

Table 6-33 Noise Level of Major Construction Machinery

Work stage	Machine type	Specification	Noise level (dB)	Number of equipment
Unit 1 Installation of electric transformer equipment	Crawler crane	25-650 t	97	1
	Truck crane	45-300 t	109	2
Unit 1 Installation of turbine equipment	Crawler crane	25-650 t	97	2
	Truck crane	45-300 t	109	4
	Forklift	800 t	105	1
	Trailer	30-50 t	113	4
	Truck	2-11 t	109	6
Unit 1 Installation of heat recovery steam generator	Crawler crane	25-650 t	97	2
	Truck crane	45-300 t	109	4
	Forklift	800 t	105	1
	Trailer	30-50 t	113	4
	Truck	2-11 t	109	6
Unit 2 Installation of the cooling tower (cooling fan)	Truck crane	25-650t	97	1
	Backhoe	1.0-4.0 m^3	102	2
	Concrete pumping vehicle	100 m^3/h	110	1
	Concrete mixer	4 m^3	101	2
	Air compressor	10.6 m^3/min	106	1
	Generator	60-600kVA	101	2
Unit 2 Construction of stack	concrete pumping truck	100 m^3/h	110	1
	truck-mixer	4 m^3	101	2
Unit 2 Construction of turbine building	Crawler crane	25-650 t	97	2
	Truck crane	45-300 t	109	4
	backhoe	1.0-4.0 m^3	102	6
	concrete pumping truck	100 m^3/h	110	3
	Concrete mixer	4 m^3	101	6
Installation of the fuel tanks	Truck crane	25-650t	97	1
	Backhoe	1.0-4.0 m^3	102	2
	Concrete mixer	4 m^3	101	2
	Air compressor	10.6 m^3/min	106	1
	Generator	60-600kVA	101	2

Note: Data based on the example of gas turbine power plant of similar-scale in Japan

Source: Prepared by JICA Study Team

Calculation conditions

The calculation was conducted on the assumption that all the aforementioned machines were operating simultaneously.

Construction activities will be carried out based on a step-by-step construction schedule so that all the machinery is not operated simultaneously.

10 measurement points (No.1 ~ No.10) were selected and used for simulation at the boundary of power plant site and another 3 points (No.11 ~ No.13) in the factory and the residential area located near the power plant were also selected for simulation.

Source: obtained from Google Earth and prepared by JICA Study Team

Fig. 6-30 Location of Simulation Points

＜Results of the simulation＞

Table 6-34 shows the result of simulation of the noise level (contribution, current, and future level) related to the operation of the construction equipment. Figure 6-31 shows the distribution of noise levels.

The contribution noise level was 25 ～ 63 dB(A) at the boundary of the site, and 29 ～ 33 dB(A) in the nearby factory and the residential area. The current noise level was detected at 6 points in the boundary （No.2 ~ No.4, No.8 ~ No.10） and 3 points in the nearby factory and residential area （No.11 ~ No.13） . For 4 points on the boundary where current noise level was not detected (No.1, No.5 ~ No.7), the noise level at the nearest points (No.2,No.4) was adopted.

The noise in the boundary of the power plant site was estimated to lie between 58-62 dB (A), and 46-65 dB(A) in the nearby factory and residential area.

Future noise level was simulated through the addition of the current noise level and the contribution noise level. Future noise level is 58 ～ 65 dB(A) at the boundary, and 58 ～ 65 dB(A) in the nearby factory and residential area. Future noise level may slightly increase from the current level at certain points on the boundary, but the increase is only 4dB at the maximum.

The estimated future noise levels at all the measuring points of boundary and the nearby workplace comply with the IFC/WB guideline value (industrial area, daytime). Also, the future noise levels at the residential area satisfy the standard value of Iran and IFC/WB guideline value (residential area, daytime). The future noise level does not satisfy the noise standard for nighttime, but increase from the current noise level is not expected.

Table 6-34 Results of Simulating Noise Levels from Construction Work

Location	Point	Contribution noise level (dBA)	Current noise level(dBA)	Future noise level (dBA)	Noise standard of Iran (dBA)	IFC/WB/WB EHS Guideline General
Project Boundary	No. 1	34	62	62	Industrial zone: Day 75 Night 65	Industrial zone: Day 70 Night 70
	No. 2	42	62	62		
	No. 3	45	61	61		
	No. 4	58	61	63		
	No. 5	56	61	62		
	No. 6	63	61	65		
	No. 7	57	61	62		
	No. 8	53	59	60		
	No. 9	25	58	58		
	No. 10	36	62	62		
Residential area	No.11	33	46	46	Residential zone: Day 55 Night 45	Residential zone: Day 55 Night 45
Power plant surroundings	No. 12	29	63	63	Industrial zone: Day 75 Night 65	Industrial zone: Day 70 Night 70
	No. 13	29	65	65		

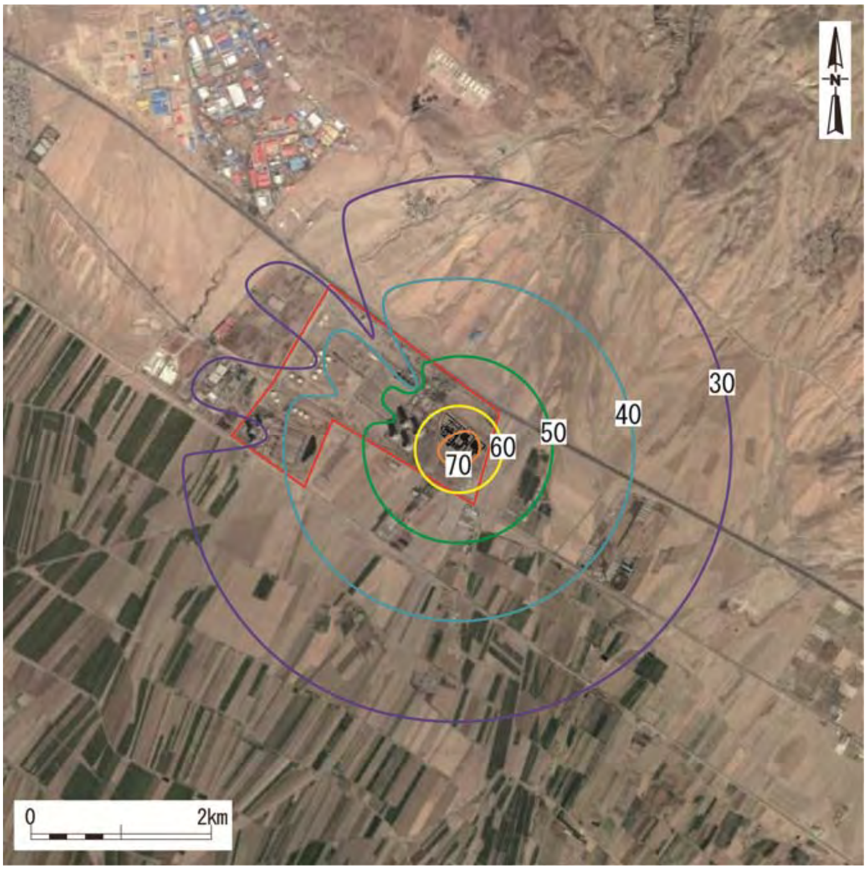
Source: prepared by JICA Study Team

Noise impact caused by construction activities will be mitigated by managing the construction schedule in order to level out the construction amount and scale.

Low noise equipment will be used as much as possible and regular maintenance will be conducted. .
Measures for reducing generation of noise, such as speed reduction of large vehicles in residential areas, will be taken, whereby vehicle noise impact will be minimized.

Construction work will be conducted in daytime to the possible extent. Considering the high bearing power of the ground, piling work producing high noise will not be conducted.

Thus, all efforts will be made to minimize the noise impact. Monitoring on noise levels in the busiest construction period will still be necessary.



Source: obtained from Google Earth and prepared by the Study Team

Fig. 6-31 Results of Simulating Noise Level (dBA) from Construction Work

<Vibration>

Vibration impact caused by construction activities will be mitigated by managing the construction schedule in order to level out the construction amount and scale.

Low vibration equipment will be used as much as possible and regular maintenance will be conducted.

Measures for reducing generation of vibration, such as speed reduction of large vehicles in residential areas, will be taken, whereby vehicle vibration impact will be minimized.

Construction work shall be conducted in daytime to the possible extent. Considering the high bearing power of the ground, piling work producing high noise will not be conducted.

Vibration may be generated from trailers and trucks.

In the example of Japan, the vibration level of 75dB at the generation source attenuates to approximately 10dB at 500 meters away, which is extremely low compared to the noise standard of Japan, 55dB. The nearest residence is 1.5km away from the site and the impact of vibration will be negligible.

(6) Land subsidence and hydrology (ground water)

At the construction stage of the power plant, water will be temporarily taken from the authorized wells used for the existing facility within the range of permission and will be minimized through water reuse.

The lowering of water level in the existing wells and land subsidence in the surrounding area of

the site are not observed. Monitoring of groundwater level will be continued.
With the above- described mitigations measures, the significant lowering of groundwater level and ground subsidence due to water intake of the construction activity is not expected.

(7) Odor
In case domestic waste from the workers' camp is not appropriately treated, it may produce foul odors. Before starting the construction work, workers will be instructed to classify and collect garbage and illegal waste disposal will be prohibited. Food and kitchen waste will be disposed on a periodic basis using containers with a cover to prevent odor and is composted and reused for fertilizer.
All the aforementioned measure measures will be taken in order to minimize the generation of odor.

(8) Terrestrial ecosystems and rare species
The site is a developed area for the existing power plant. As fauna and flora, herbaceous and rodent species were confirmed, but these species are widely inhabited in the surroundings, and not endangered species.

The surrounding area is a dry ecosystem, and this ecosystem is attributed to the land use as bare land or agricultural land proceeding in the area, and endangered species requiring special attention are not observed.

Although some of the habitats of animals and plants may disappear due to modification in the site, and air pollution, noise and vibration during construction may affect the growth of plants and behavior of animals in the vicinity, the inhabitation of these species spreads widely around the project site, and there is very little influence on the biota.

Mitigation measures for air pollution, noise and vibration, similar to the measures described in "Air pollution" and "Noise/vibration", will be implemented, and impact on the terrestrial ecosystem will be very limited.

Regarding reptiles, since there is little survey data, visual observation of the presence and absence of turtles and lizards that are endangered will be implemented on the site and nearby, for precaution.

(9) Local economy including employment and means of livelihood
The site is a developed area for the existing power plant and new land acquisition and resettlement will not occur. Local people may be employed as power plant workers. Increased purchase of materials and equipment items in the local area will activate the local economy.

The project proponent will employ as many local residents as possible and make use of the services (i.e. restaurant and catering service etc.) and purchase products and equipment offered in the local community, as much as possible in order to contribute to the local economy.

(10) Water use
Ground water intake by the project may cause continuous impact on the water use in the surrounding area, but mitigation measures will be taken as described in the chapter "Subsidence and hydrology (ground water)" and the impact of water intake will be insignificant.

In the construction period, concrete-containing waste water and oil-containing waste water may be generated, and water turbidity of the irrigation canal is predicted.

Water pollution on irrigation water caused by construction waste water will be minimized by mitigation measures cited in “Water pollution” described above and its impact on the irrigation canal is expected to be very limited.

(11) Unfair distribution of damage and benefits
The site is a developed area for the existing power plant and new land acquisition and resettlement will not occur. Unfair distribution of damages and benefits caused by compensation will not occur. If employment of local people and/or outsourcing contracts is done through unfair schemes such as personal connection of the construction company, benefit may be unfairly distributed among local people.

The employment of local people shall be conducted under publicized employment conditions to prevent unfair competition.

(12) Conflict of interests within the local area
The site is a developed area for the existing power plant and new land acquisition and resettlement will not occur. Conflicts of interests within the local area are not predicted.

Inflows of many workers from other parts of Iran or foreign countries during construction period may cause conflict with local workers, if the local customs are not followed.
The employment of local people will be enhanced as much as possible so as to limit the number of workers from outside.

Education program will be established for workers from outside to respect local customs. They will also be invited to the local events to enhance mutual understanding with local people.
The above-described mitigation measures will minimize conflict with local workers due to difference in customs.

(13) Rights of children
The site is a developed area for the existing power plant, and new land acquisition and resettlement will not occur. No particular impact is expected to take place to the rights of children.

Child labor may increase on the construction site and may lead to school abandonment.
Employment of children under the age of 15 is prohibited by the regulation of Iran, and TPPH also strictly prohibits child labor including RPC contractors.

(14)HIV/AIDS and other infectious diseases
The inflow of workers from other parts of Iran or foreign countries may induce the spread of infectious diseases. Local people should be recruited as much as possible so as to minimize the risk of infectious diseases being transmitted from external workers. Education and training concerning infectious diseases and health for workers, placement of medical facility and staffs, periodic medical check-ups should be conducted.

(15) Work environment (including labor safety)
Workers may have accidents during construction service.
The construction company will develop the safety and sanitation management plan including safety education and training and obtain approval from TPPH. Safety gears including helmet, safety shoes and earplugs shall be installed following the safety management plan. The storage of hazardous materials shall be marked with a sign board.

A manual for safe handling of machinery shall also be prepared and checked by TPPH for approval.
In case of an accident, monitoring shall be conducted.

(16) Accident
Traffic accidents may occur during operation of vehicles. As prevention measures for land traffic accidents, observation of traffic regulations, and training and education on safe driving will be implemented, as well as an appropriate vehicle operation route and schedule.

6.7.2 Operation Phase

(1) Air pollution
a. Compliance with the exhaust gas standard
Gas will be used for fuel in the power plant in normal cases, but light oil may also be used mainly in winter when gas supply is not sufficient, and that may cause impact in a wide area. When gas is used as fuel, nitrogen oxide (NOx) is generated, but sulfur oxide (SOx) and particulate matter (PM) are not emitted.

Regarding NOx emission, as nitrogen (N_2) is barely contained in fuel, N_2 contained in air reacts chemically with oxygen (O_2) and produces nitrogen monoxide (NO) and nitrogen dioxide (NO_2). It is mostly NO at the time of emission of exhaust gas, and is converted into NO_2 through photoreaction with ozone (O_3) in the air at the dispersion stage.

In case light oil fuel is used, NOx emission is similar to gas fuel. SOx emission consists mostly of sulfur dioxide (SO_2) converted from sulfur(S) contained in fuel.
Particulate matter (PM) consists of metal or unburned matter contained in light oil or heavy oil, mostly consisting of PM_{10} of 10μm radius or smaller.
A gas turbine adopted in this project will be equipped with dry type low-NOx burner as a mitigation measures for reduction of NOx level

With the mitigation measures described above, the emission concentration of air pollutant in the exhaust gas will meet the emission standard of Iran and the standard value of IFC/WB EHS guidelines (Thermal Power Plant, 2008) as described in Table 6-35.

In this project, except for emergency, gas is basically used to reduce generation of SOx and NOx. Also, by adopting a high-efficiency combined cycle, the fuel consumption is reduced and the amount of SOx, NOx and PM emitted from the power plant is reduced as a result.

Table 6-35 Emission Concentration and Emission Standard

Fuel	Item	Unit	Proposed Concentration	Emission Standards of Iran	IFC/WB EHS guidelines (Thermal Power Plant; 2008)
Gas	SOx	mg/Nm^3	0	200	-
	NOx	mg/Nm^3	51	300	51
	PM	mg/Nm^3	0	-	-
Light oil	SOx	mg/Nm^3	150	150	-- Sulfur contents in fuel:≦ 1%)
	NOx	mg/Nm^3	150	200	152
	PM	mg/Nm^3	50	150	50

Note: O_2＝15% equivalent

Source: prepared by JICA Study Team

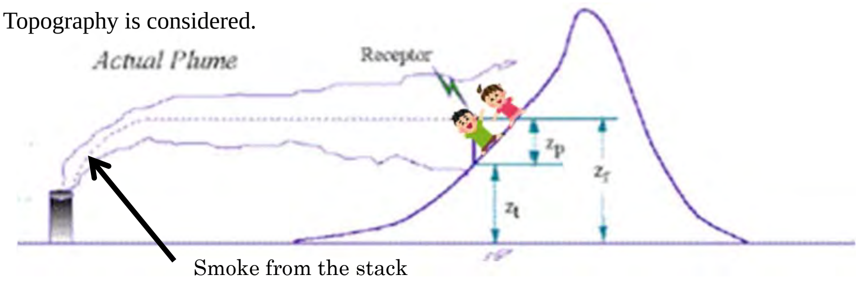
b. Estimation of impact on the air quality of the surrounding area
According to the result of air quality measurement in the surrounding, SO_2, NO_2 and PM $_{10}$concentration is below the environmental standard value of Iran even under the operation of the existing power plant. It is necessary to ensure that the compliance of the environmental standard will continue to be secured in future and to take appropriate measures for it.

The dispersion calculation will be conducted to understand the contribution concentration of the new power plant through simulation and the cumulative impact of the existing facility including contribution concentration. It is also important to take into account the condition cited below where high concentration occurs in the calculation.

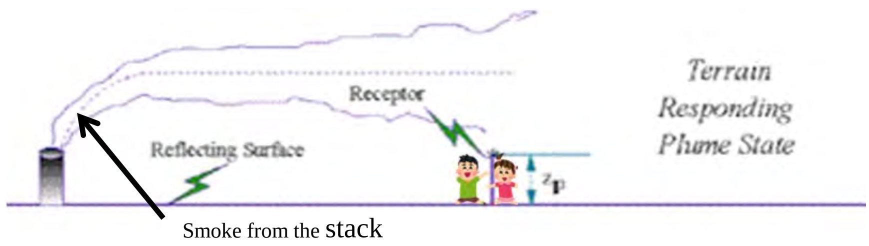
Effect of the topography
Exhaust gas emitted from the stack is dispersed up in the air and reaches the ground level. As high concentration of gas emission tends to emerge high in the air, the existence of elevated topography in the dispersion simulation area may result in higher concentration of pollutant compared to the ground level.

The schematic diagram of the topographic condition in the simulation is shown below. The impacts of geography on the exhaust gas dispersion shall be considered to avoid incorrect high concentration in the high elevation even if the impact of gas emission is negligible.

① Topography is considered.



②Topography is not considered.



Source: prepared by JICA Study Team

Fig. 6-32 Consideration of the impact of topography

In “Environmental Impact Assessment Guidelines for Power Plant” (2016) published by Ministry of Economy, Trade and Industry of Japan, the impacts of geography on the exhaust gas dispersion shall be considered in case of the topography with the conditions below:

- within 5km radius from the stack: Maximum altitude / Effective stack height (Actual stack height + Emission gas elevation height) ≧0.6
- within 20km radius from the stack: Maximum altitude / Effective stack height (Actual stack height + Emission gas elevation height) ≧1.0

Note: the effective stack height is calculated with the formula used for the regulation of SOx emission in Air Pollution Control Act in Japan.
Also, in “USERS GUIDE FOR THE AERMOD TERRAIN PREPROCESSOR (AERMAP)”（2004, EPA, U.S.A.）， it clearly states that the impact of the topography shall be considered in case inclination is 10 degrees or over based on the distance from the measurement object and the elevation, on a case-by-case basis.

This condition corresponds to the case where the measurement point is 1km from the emission source and the difference of elevation is more than 200meters.

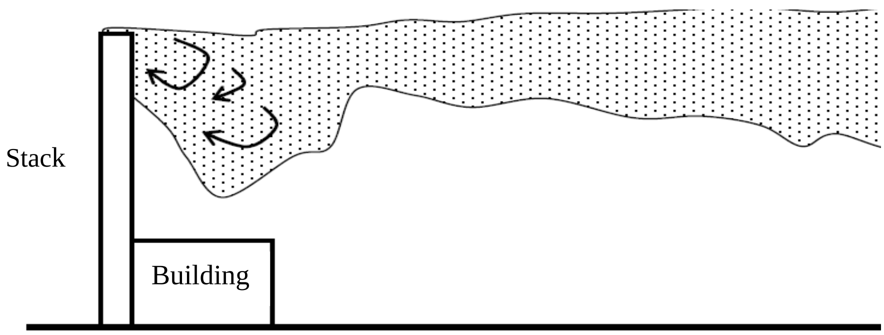
In this project, although the effective stack height is expected to be about 200 m, the impact of the topography is taken in consideration for estimation of the impact from the following viewpoints, based on the above-described knowledges of Japan and the U.S.

- There is an elevated area of more than 200m higher compared to the project site within 3km radius in the north of the power plant.
- Southern wind blowing northward is frequent.

・Downdraft / Downwash

In general, downwash reportedly occurs with a wind speed 1.5 times or more than the exhaust gas speed. The assumed exhaust gas speed in this project being 25 m/s, downwash may occur in case wind speed at the stack outlet is more than 17 m/s.

According to the meteorological survey data of the area, the occurrence of the above-described wind speed is very low, and the occurrence of downwash will be extremely small.



Source: "Nitrogen oxides total amount control manual" (Ministry of the Environment, 2000)

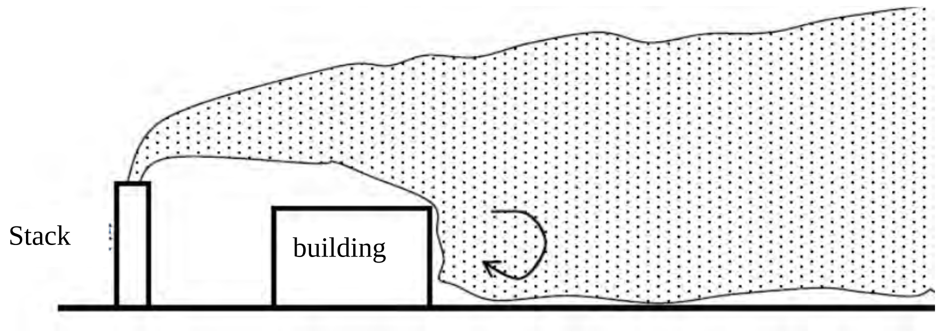
Fig. 6-33 Diagram of Downwash

In the case the stack height is low, downdraft may occur due to the presence of the surrounding building. By using the formula shown below, if the HG value is shown to be higher than the stack height, it is necessary to consider the impact of downdraft.

HG = H + 1.5L
H = Building height (m)
L = Building height or the value for the building with the lowest diameter (m)

In this project, the stack height is 60m and the turbine building and HRSG are only 23m and 28m height, respectively, and the planned stack height is 80m which is much higher than the required height of 70m for downwash prevention.

In addition, the cooling tower of the existing power plant is located in the western side of the project site, but downdraft is not predicted to occur because of warmed air rising over the stack, and therefore the impact estimation does not take into account the impact of downdraft.



Source: "Nitrogen oxides total amount control manual" (Ministry of the Environment, 2000)

Fig. 6-34 Diagram of Downdraft

＜Selection of the evaluation system ＞

The impact evaluation model for this project was selected from plume models commonly adopted in the U.S., Europe and Japan in the environmental impact assessment, and AERMOD in particular. AERMOD is an evaluation model recommended by the US-EPA and is suitable for the impact evaluation of the area including elevated area, as is the case in this project. AERMOD also takes into account the impact of downwash. This model is widely adopted abroad in the EPA and is a reference model of IFC/WB EHS guidelines. AERMOD is published as Appendix W to 40 CFR Part 51 (as revised).

＜Meteorological conditions＞

AERMOD dispersion model requires one-hour value of meteorological data (air temperature, wind speed and wind direction, etc) of at least one year's span to conduct correct estimation.

However, the meteorological measurement around the project area is conducted by Qazvin meteorological station for only three times a day regarding wind speed and wind direction, which are the essential meteorological data in the dispersion modeling. This is not sufficient for a correct evaluation.

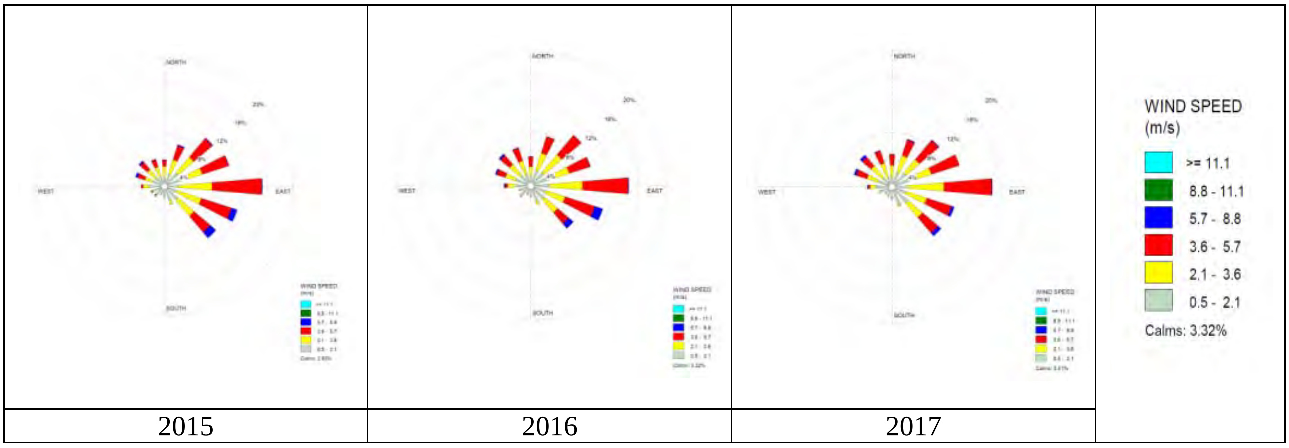
In consequence, the one-hour value in the meteorological data from the meteorological model (MM5（The Mesoscale Model)) from 2015 to 2017 will be used for calculation. MM5 is Fifth-Generation Penn State/NCAR Mesoscale Model* developed by Pennsylvania the State University and National Center for Atmospheric Research. It encompasses existing data from each region around the world and is very efficient in air quality simulation.
*The meteorological models in Mesoscale is applicable to the grid of several kilometers to several ten kilometers, is therefore suitable for the air quality simulation for this project.

The estimated frequency of wind direction and wind speed based on the weather model (MM5) is shown in Fig. 6-35 to Fig. 6-36. It indicates that east wind is dominant, followed by south-south-east and north-north-east wind, mainly eastern wind.

Wind speed is mostly within the range of 1～6 m/s, with low occurrence of wind speed exceeding 6m/s, similar to the meteorological data in Chapter 6.6.1.

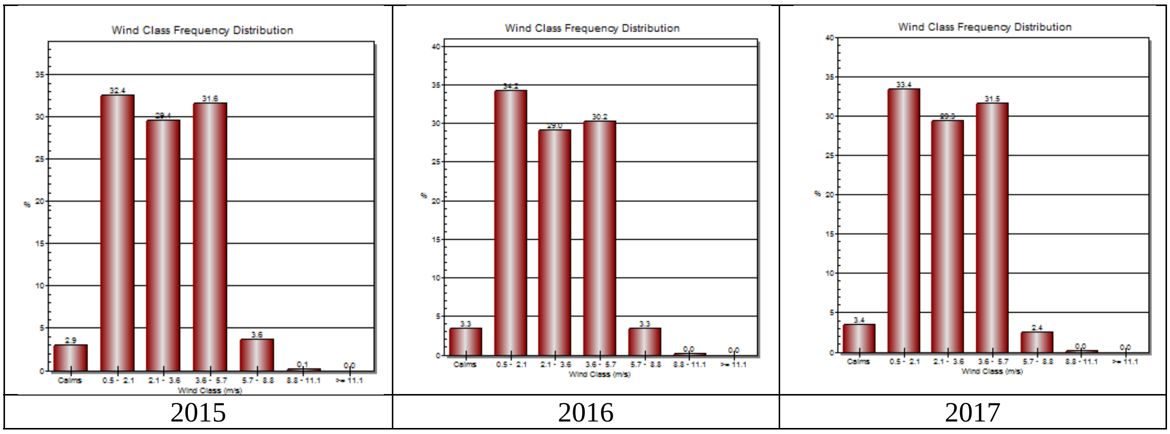
Regarding frequency of appearance of wind direction, the measurement data of Qazvin Meteorological Station cited in Chapter 6.6 may appear to differ from MM5 data due to the difference in measurement frequency (3 times a day) and direction classification (8 wind directions), but MM5 data is measured on one-hour basis and is adopted for calculation in this project.

The calculation with gas fuel and using NOx concentration of 2015, 2016 and 2017 indicated no significant difference. All calculation was conducted with one-hour basis with the data of 2017 when NOx concentration was the highest.



Source: prepared by JICA Study Team

Fig. 6-35 Simulated frequency of wind direction/speed level based on the weather model (MM5) (16 wind directions, 2015~2017).



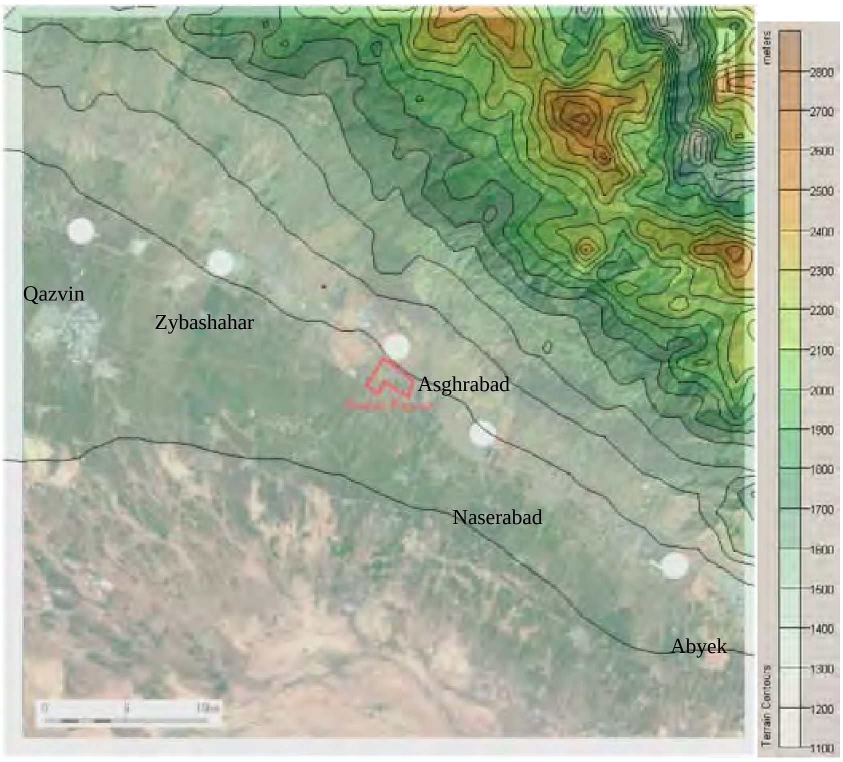
Source: prepared by JICA Study Team

Fig. 6-36 Frequency of appearance of wind speed based on the weather model MM5 (16 wind directions, 2015~2017).

＜The area of prediction calculation and topography＞

In the EIA in most countries including Japan, dispersion prediction of gas emission from the power plant is conducted within an area of 20km to 30km radius from the power plant. In this project, the area of prediction is set to 40km radius from the power plant in consideration with the impact of the existing facility.

The topography used for dispersion prediction is shown in Fig. 6-37.



Source: Obtained from Google Earth, and prepared by JICA Study Team

Fig. 6-37 Topography used for the prediction

＜Emission specification＞

Table 6-36 to Table 6-39 show the volume, temperature, speed of exhaust gas and emissions of NOx, SOx, and PM contained in gas emission from the new and existing power plant for respective fuel, under the assumption that all NOx, SOx, and PM become SO_2, NO_2, and PM_{10}, respectively.

The fuel used in the power plant in Iran is basically gas, but heavy oil and light oil is also used in many cases mainly in winter in case of shortage of fuel supply.

In this regard, the prediction of cumulative impact of the existing and the new facility is conducted for the case of gas fuel use and for the case of light/heavy oil use in both facilities. The prediction was not conducted for the case gas is used in one facility and heavy/light oil is used in the other facility.

Table 6-36 Emission specification of the new gas turbine plant.

Item	Unit	New Unit1		New Unit2	
Output	MW	560MW		560MW	
Fuel	-	Gas	Light oil	Gas	Light oil
Exhaust temperature	ºC	90	164.5	90	164.5
Exhaust speed	m/s	25.1	30.5	25.1	30.5
Stack diameter	m	6.3		6.3	
Stack height	m	80		80	
SOx emission	g/s	0	81	0	81
NOx emission	g/s	27	81	27	81
PM emission	g/s	0	27	0	27

Note: the data in the table above was calculated based on fuel type.

Source: prepared by JICA Study Team

Table 6-37 Emission specification for the existing steam power plant

Item	Unit	Unit1		Unit 2		Unit.3		Unit.4	
Output	MW	250		250		250		250	
Fuel	-	Gas	Heavy oil	Gas	Heavy oil	Gas	Heavy oil	Gas	Heavy oil
Exhaust gas temperature	ºC	123	143	123	143	123	143	123	143
Exhaust speed	m/s	27	27	27	27	27	27	27	27
Stack diameter	m	4		4		4 4		4	
Stack height	m	220		220		220		220	
SOx emission	g/s	0	142	0	89	0	169	0	148
NOx emission	g/s	102	82	127	34	131	78	127	71
PM emission	g/s	0	72.1	0	72.1	0	72.1	0	72.1

Notes : 1. Gas emission is calculated with stack diameter and gas emission speed based on the design condition.
2. Emission concentration of pollutants adopted here is the average value of the past monitoring result. PM emission concentration data in case of heavy oil use was not available and therefore set to 100 mg/Nm^3 based on the measurement result of the heavy oil thermal power plant in Japan.

Source: prepared by JICA Study Team

Table 6-38 Emission specification of the existing combined cycle power plant

Item	Unit	GT No1		GT No2		GT No3		GT No 4		GT No 5		GT No 6	
Output	MW	123.4		123.4		123.4		123.4		123.4		123.4	
Fuel	-	Gas	Light oil	Gas	Light oil	Gas	Light oil	Gas	Light oil	Gas	Light oil	Gas	Light oil
Exhaust gas temperature	ºC	125	110	125	110	125	110	125	110	125	110	125	110
Exhaust speed	m/s	25	25	25	25	25	25	25	25	25	25	25	25
Stack diameter	m	4.5		4.5		4.5		4.5		4.5		4.5	
Stack height	m	45		45		45		45		45		45	
SOx e mission	g/s	0	23	0	8	0	20	0	26	0	4	0	4
NOx emission	g/s	56	51	38	59	57	62	58	79	36	106	34	56
PM emission	g/s	0	13	0	13	0	13	0	13	0	13	0	13

Notes: 1. Gas emission (wet gas) is calculated with stack diameter and gas emission speed based on the design condition.
2. Emission concentration of SO_x and NO_x adopted here is the average value of the past monitoring result and based on the gas emission amount of the design condition. PM emission concentration monitoring data was not available and therefore set to the value similar to the existing gas turbine.

Source: prepared by JICA Study Team

＜Prediction result＞

The prediction was conducted for the ground concentration of sulfur dioxide (SO_2), nitrogen dioxide (NO_2) and particulate matter (PM_{10}) corresponding to 99%[3] value of the one-hour value

[3] *99% value: the compliance with the environmental standard value stipulated in the regulations of Iran is assessed with the measurement value excluding the top 1% value which tends to be extremely high concentration. This assessment method is adopted in Japan, EU, and the U.S. for assessment of compliance with the environmental standard.

and 24-hour value and the annual average value, under the assumption that all of the new facility and the existing facility are in operation.

a. Impact of the new power plant facility

As fuel used in this project is basically gas, the diffusion simulation of NO_2 generated in case of gas fuel is conducted. As use of light oil fuel is highly expected in winter when gas supply is not sufficient, SO_2 and PM_{10} as well as NO_2 emission is also predicted and the diffusion of 3 pollutants is simulated.

The prediction results of the contribution ground concentration are as shown in Fig. 6-39 to Fig. 6-49 and Table 6-39, and the overview is described below.

The distribution of the ground concentration indicates that the concentration is the highest at the monitoring points for air quality, and the contribution concentration at the elevated area is relatively low.

The summary of the impact assessment for each pollutant is described below.

Sulfur dioxide (SO_2)

In case light oil fuel is used, the maximum ground level concentration is 30.16μg/m^{3}for one-hour value, 11.58μg/ m^3 for 24-hour value, and 3.39μg/ m^3 for the annual average, which is approximately 15.4% (one-hour)and 2.9% (24-hour)of the environmental standard value of Iran (one-hour value196μg/ m^3, 24-hour value:395μg/ m^3) and 9.3% of the EU environmental standard value and IFC/WB guideline value (24-hour value:125μg/ m^3).

According to the IFC/WB Guidelines (General), a single project is required not to contribute more than 25% of the applicable ambient air quality standards, and compared to this threshold the present project has the contribution of 9.3% which is extremely low.

Additionally, the maximum concentration obtained by adding the present concentration to the predicted value is 145.06μg/ m^3 for one-hour value, and 102.78μg/ m^3 for 24-hour value, which is sufficiently low as compared with Iran's environmental quality standards and the IFC/WB guidelines.

Nitrogen dioxide (NO_2)

In case gas fuel is used, the maximum ground level concentration is 15.18μg/ m^3 for one-hour value, and 5.18μg/ m^3 for 24-hour value, 1.88μg/ m^3 for the annual average, which is approximately 7.6% (one-hour) and 1.9% (annual average) of the environmental standard value of Iran (one-hour value:200μg / m^3, annual average value:100μg / m^3) and 7.6% and 4.7% of IFC/WB guideline value (one-hour value:200μg / m^3, annual average value:40μg / m^3).

In case light oil fuel is used, the maximum ground level concentration is 30.16μg/ m^3 for one-hour value, and 11.58μg/ m^3 for 24-hour value, 3.39μg/ m^3 for the annual average, which is approximately 15.1%(one-hour) and 3.4% (annual average) of the environmental standard value of Iran and 15.1%(one-hour) and 8.5% (annual average) of IFC/WB guideline value.

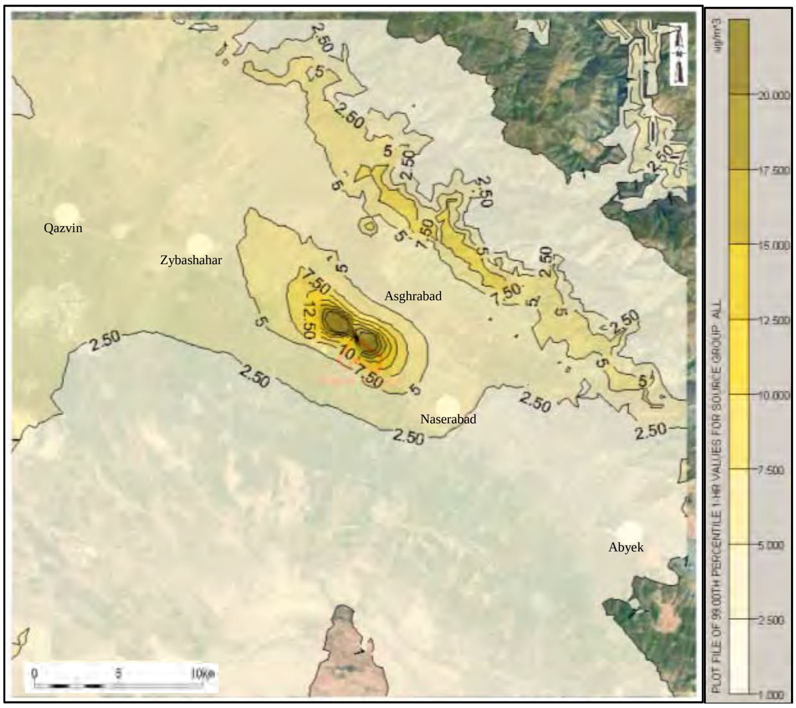
According to the IFC/WB Guidelines (General), a single project is required not to contribute more than 25% of the applicable ambient air quality standards, and compared to this threshold the present project has an extremely low contribution.

Additionally, regarding the future concentration obtained by adding the current concentration to the predicted value, the maximum future concentration calculated with the highest concentration obtained in the current monitoring data is 48.28μg/ m^3 in one-hour value in gas fuel and 63.26μg/ m^3 in one-hour value in light oil fuel, which are sufficiently lower compared with the Iran's environmental quality standard and the IFC/WB guidelines.

Particulate matter (PM_{10})
In case light oil fuel is used, the maximum ground level concentration is 3.86μg/ m^3 (24-hour value), and 1.12μg/m3(annual average)which is approximately 2.6% of the environmental standard value of Iran (24-hour value:150μg / m^3) and 2.6%(24-hour value) and 1.6% (annual average) of IFC/WB guideline value (24-hour value:150μg / m^3,annual average:70μg/m^3).

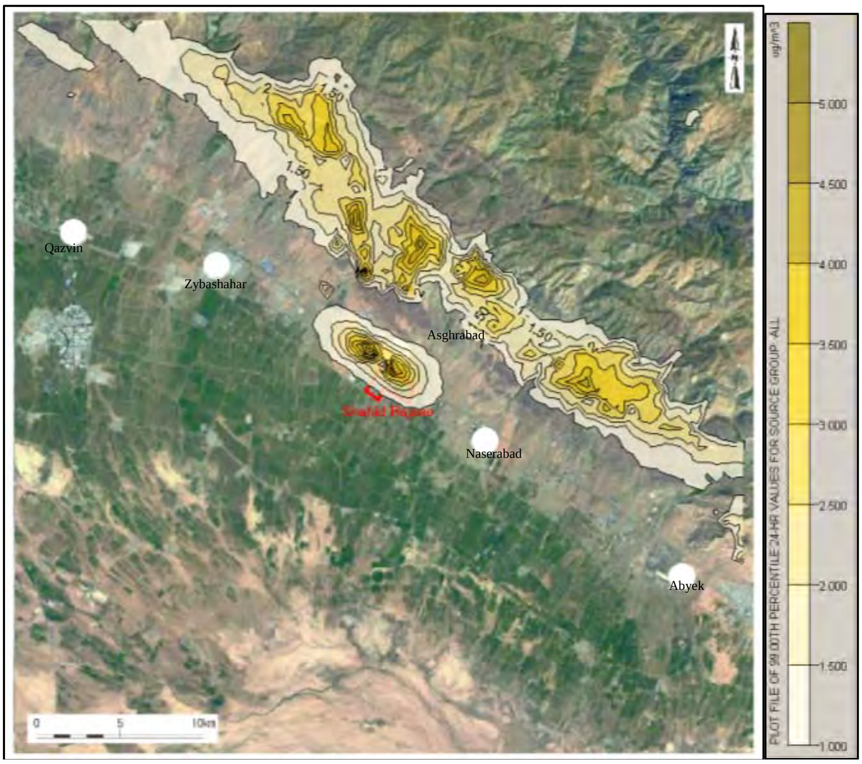
According to the IFC/WB Guidelines (General), a single project is required not to contribute more than 25% of the applicable ambient air quality standards, and compared to this threshold the present project has an extremely low contribution.

Regarding the future concentration, which is the addition of the prediction concentration and the current concentration, the maximum concentration calculated with the highest value observed in the current monitoring data is 66.96μg/ m^3, which is sufficiently low as compared with Iran's environmental quality standards and the IFC/WB guidelines.



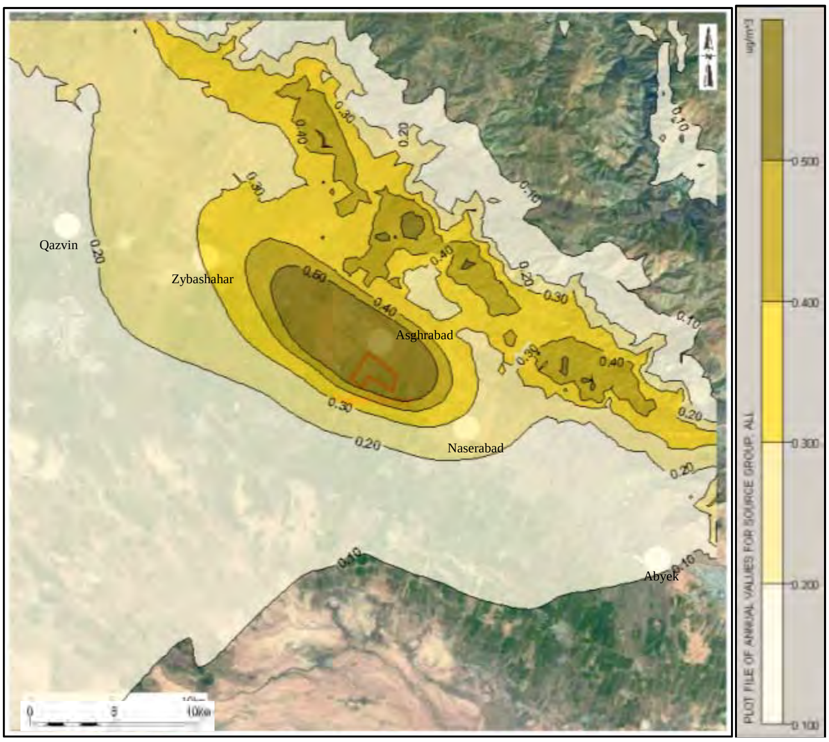
Source: obtained from Google Earth and prepared by Study Team

Fig. 6-38 Contribution Concentration of the new power plant of SO_2 at the Ground Level (1 Hour Value)(light oil fuel)



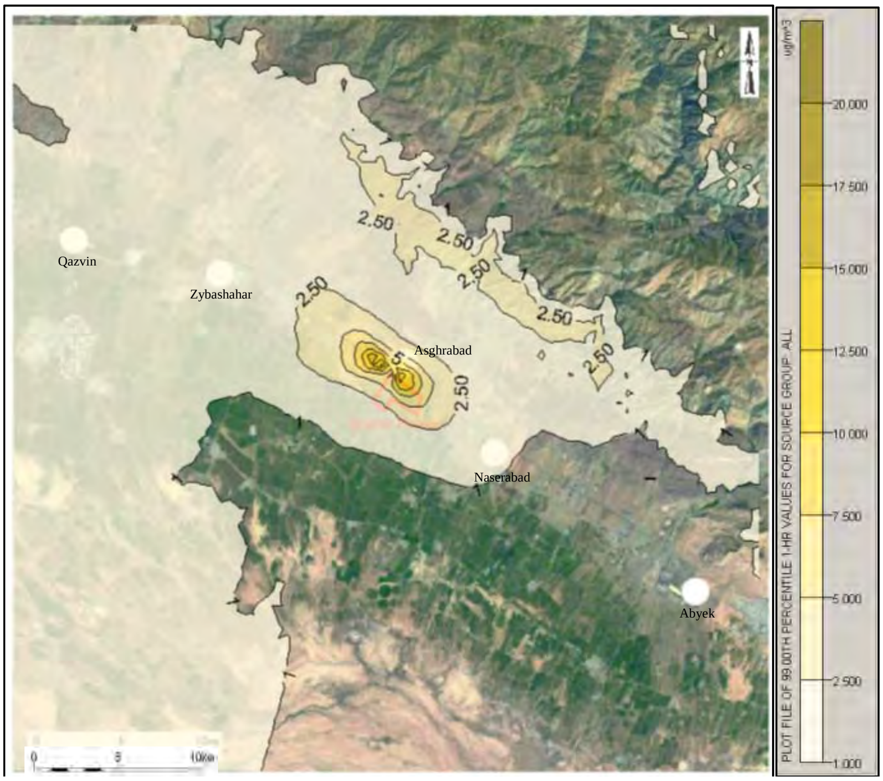
Source: obtained from Google Earth and prepared by Study Team

Fig. 6-39 Contribution Concentration of the new power plant of SO_2 at the Ground Level (24 Hour Value)(light oil fuel)



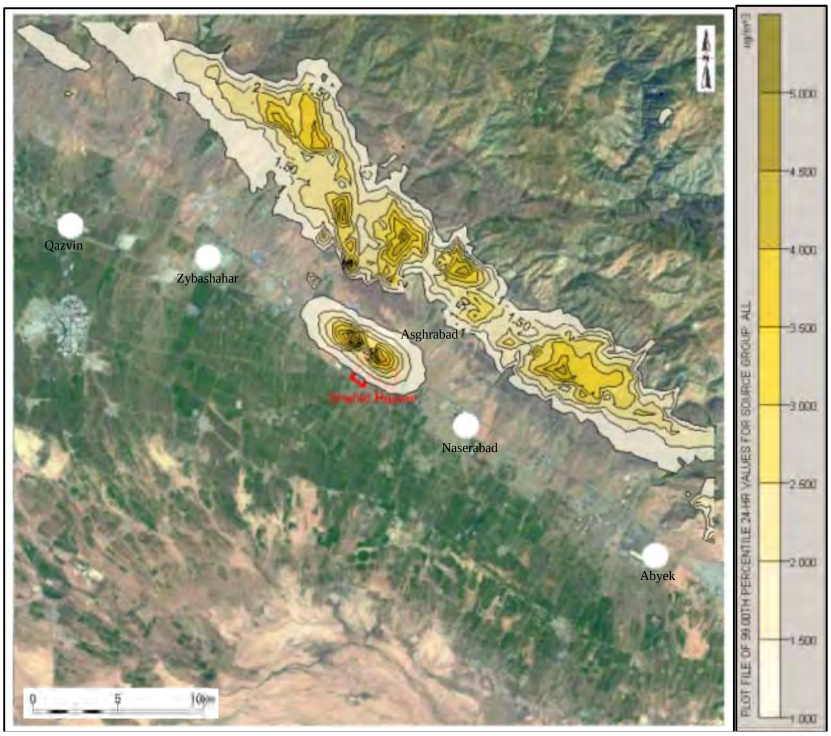
Source: obtained from Google Earth and prepared by Study Team

Fig. 6-40 Contribution Concentration of the new power plant of SO_2 at the Ground Level (1-year average)(light oil fuel)



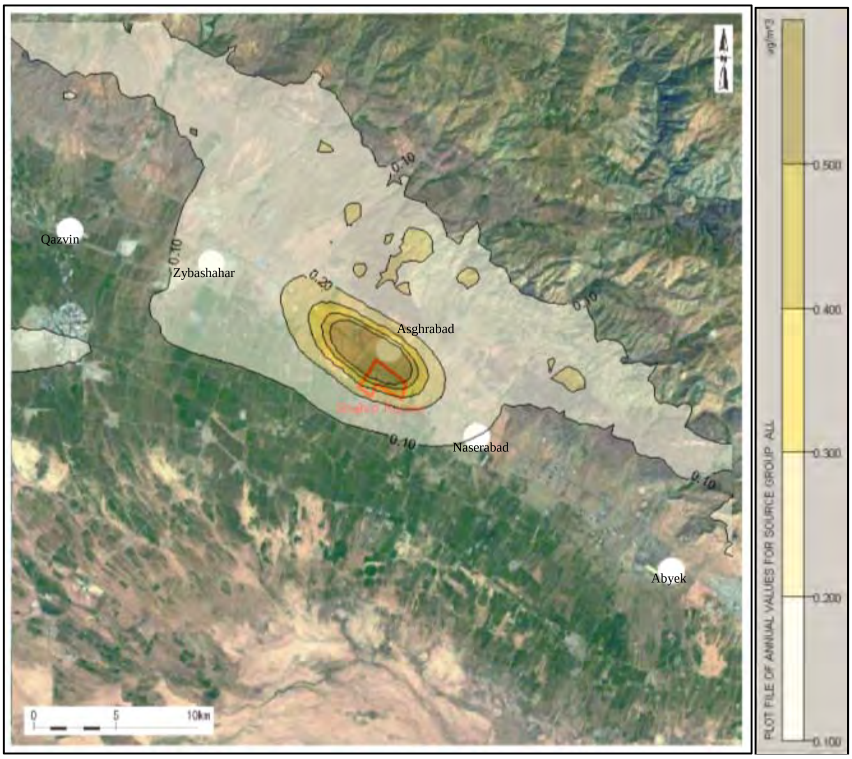
Source: obtained from Google Earth and prepared by Study Team

Fig. 6-41 Contribution Concentration of the new power plant of NO_2 at the Ground Level (1 Hour Value)(gas fuel)



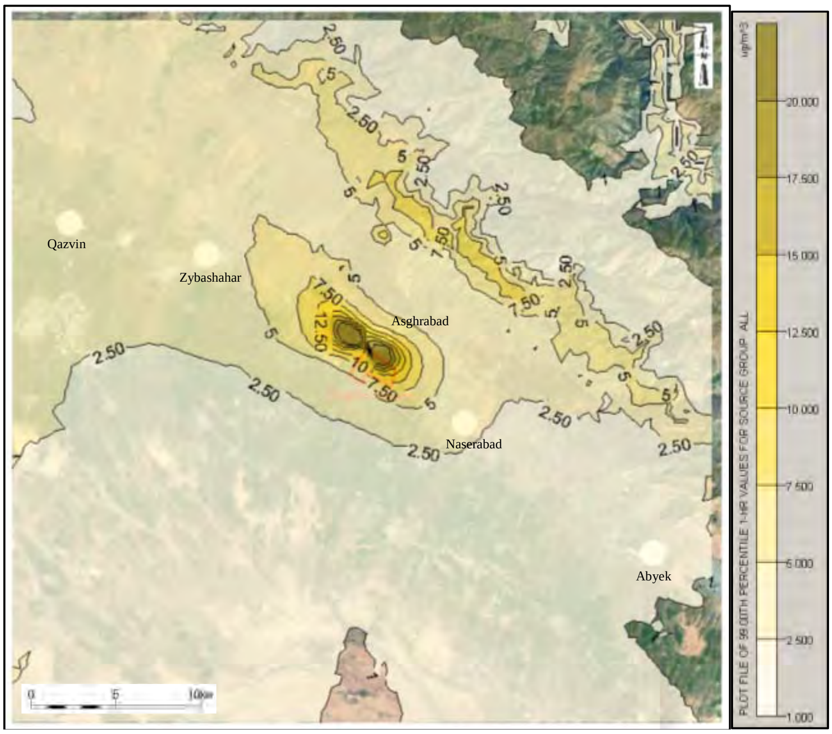
Source: obtained from Google Earth and prepared by Study Team

Fig. 6-42 Contribution Concentration of the new power plant of NO_2 at the Ground Level (24 Hour Value)(gas fuel)



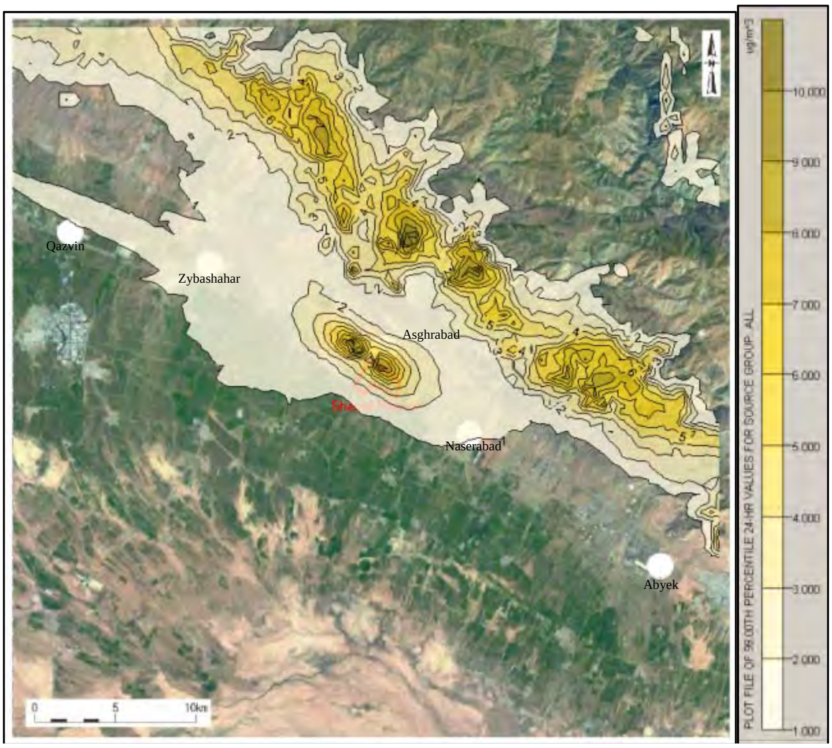
Source: obtained from Google Earth and prepared by Study Team

Fig. 6-43 Contribution Concentration of the new power plant of NO_2 at the Ground Level (1-year Value)(gas fuel)



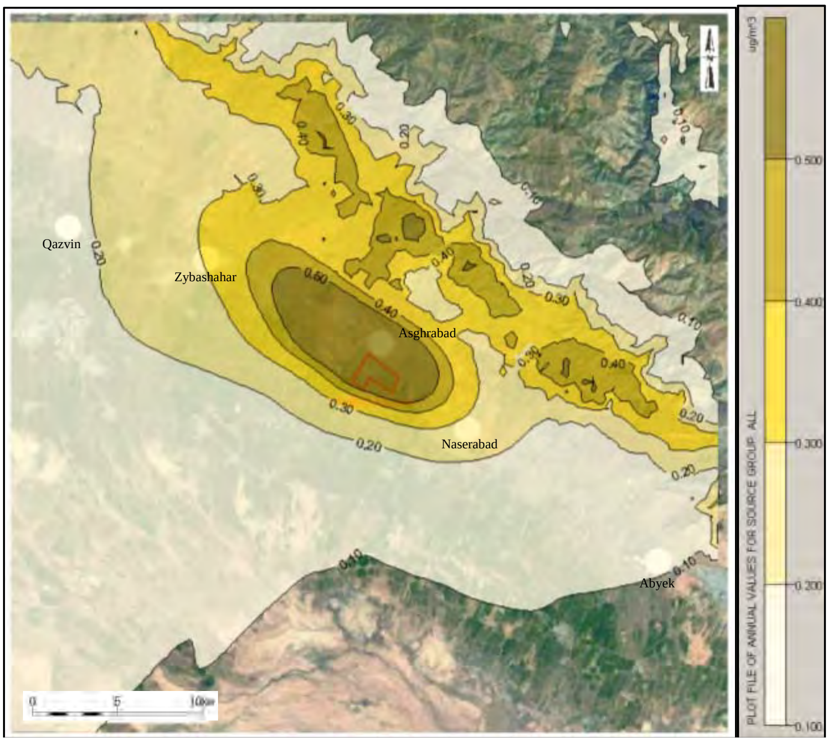
Source: obtained from Google Earth and prepared by Study Team

Fig. 6-44 Contribution Concentration of the new power plant of NO_2 at the Ground Level (1 Hour Value)(light oil fuel)



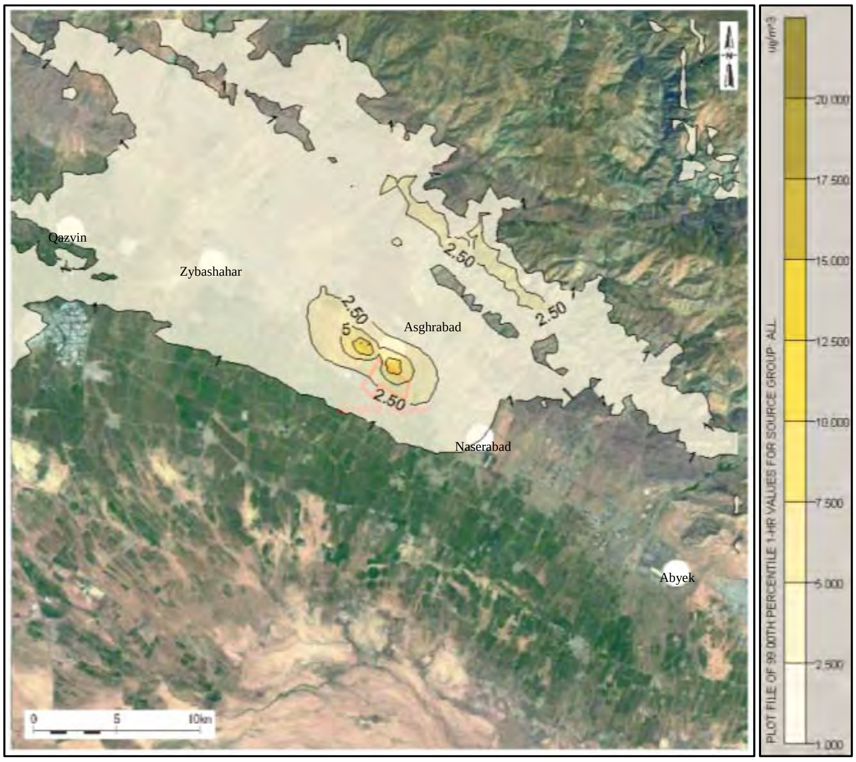
Source: obtained from Google Earth and prepared by Study Team

Fig. 6-45 Contribution Concentration of the new power plant of NO_2 at the Ground Level (24 Hour Value)(light oil fuel)



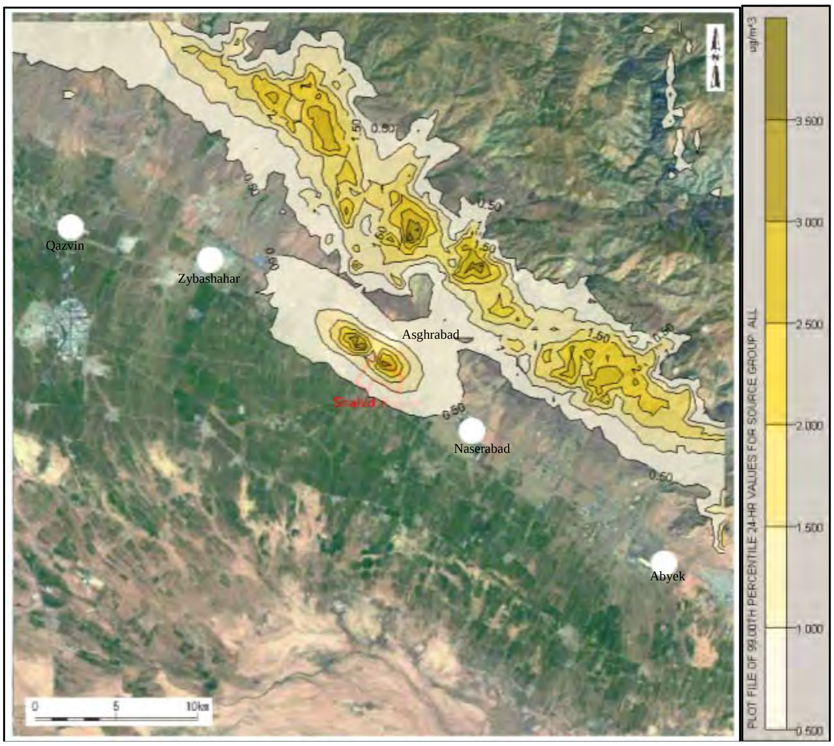
Source: obtained from Google Earth and prepared by Study Team

Fig. 6-46 Contribution Concentration of the new power plant of NO_2 at the Ground Level (1-year average)(light oil fuel)



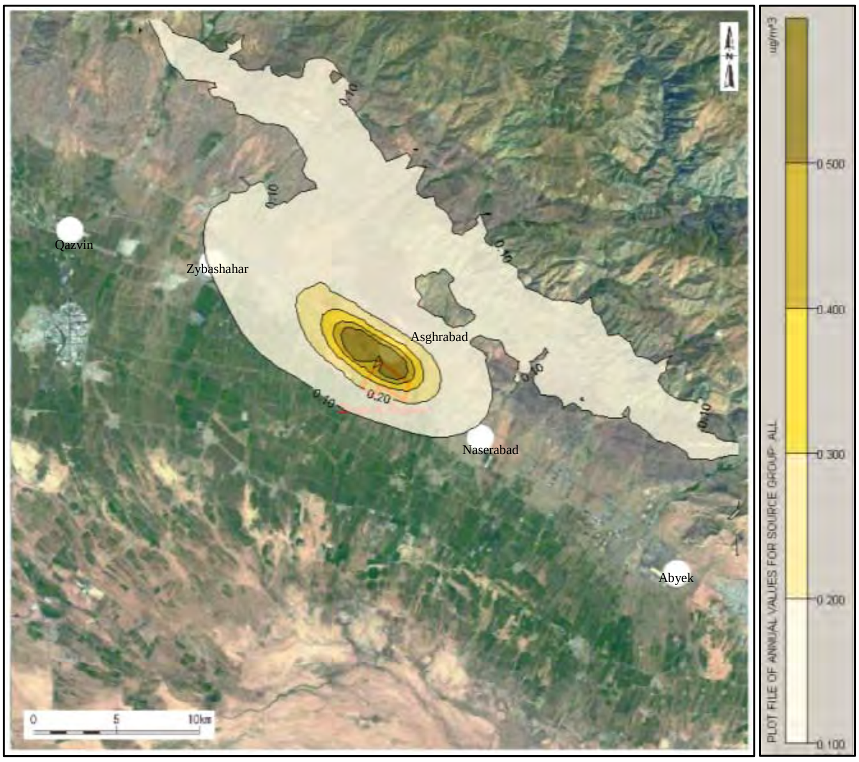
Source: obtained from Google Earth and prepared by Study Team

Fig. 6-47 Contribution Concentration of the new power plant of PM_{10} at the Ground Level (1 Hour Value)(light oil fuel)



Source: obtained from Google Earth and prepared by Study Team

Fig. 6-48 Contribution Concentration of the new power plant of PM_{10} at the Ground Level (24 Hour Value)(light oil fuel)



Source: obtained from Google Earth and prepared by Study Team

Fig. 6-49 Contribution Concentration of the new power plant of PM_{10} at the Ground Level (1-year average)(light oil fuel)

Table 6-39 Prediction Result of the Contribution Concentration of the operation of the new power plant

Pollutant	Fuel	Time category	Maximum concentration at the ground level a（μg/ m^3)	Maximum monitored concentration b（μg/ m^3)	maximum monitored concentration + Maximum concentration at the ground level a+b（μg/ m^3)	Iran's atmospheric environmental quality standard (μg/m^3)	International standard value and standard value in each country (IFC/EU/Japan)（μg/m^3)
SO_2	Light oil	1-hour value	30.16	114.9	145.06	196	-/350/350
		24-hour value	11.58	91.2	102.78	395	125/125/114
		Annual average	3.39	-	-	-	-
NO_2	Gas	1-hour value	15.18	33.1	48.28	200	200/200/-
		24-hour value	5.18	27.7	32.88	-	-/-/113
		Annual average	1.88	-	-	100	40/40/40
	Light oil	1-hour value	30.16	33.1	63.26	200	200/200/-
		24-hour value	11.58	27.7	39.28	-	-/-/113
		Annual average	3.39	-	-	100	40/40/40
PM_{10}	Light oil	1-hour value	10.05	74	84.05	-	-/-/200
		24-hour value	3.86	63.1	66.96	150	150/50/100
		Annual average	1.12	-	-	-	70/40/40

Note: The current concentration (c) in the table above was measured under the condition that all the existing power plants are in operation and includes the contribution concentration of the existing facility.

Source: prepared by JICA Study Team

B Cumulative impact of the existing facility and the new facility
The current contribution concentration of the existing facility and the predicted contribution concentration after the new facility is installed are described below, and the overview is as follows.

The current distribution of the ground concentration of sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and particulate matter (PM_{10}) indicates that the concentration is the highest at the area around the point of air quality field survey, and the contribution concentration at the elevated area is relatively low.
.
The future distribution of the ground concentration of sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and particulate matter (PM_{10}) after the installation of the new facility indicates that although one-hour value of SO_2 shows slight difference in light fuel use compared to the current concentration distribution simulation, no particular increase of concentration is predicted in other pollutants compared to the current ground concentration.

The comparison of the current status of pollutant concentration and the future concentration of the new facility with the environmental standard for respective pollutant is described below.

Sulfur dioxide (SO_2)
The maximum ground level concentration in the existing facility in case light oil and heavy oil is used is 76.38μg/m^{3}for one-hour value, 26.67μg/ m^{3}for 24-hour value, and 9.72μg/m^3 for the annual average, which is approximately 39.0%(one-hour) and 6.8%(24-hour) of the environmental standard value of Iran(one-hour value :196μg/m^3, 24-hour value:395μg/m^3) and 21.8% and 21.3%of the EU environmental standard value (one-hour value:350μg/m^3) and the IFC/WB guideline value （24-hour value：125μg/m^3）.

In case light oil fuel is used in the new facility, the maximum ground level concentration of the existing facility and the new facility is 100.85μg/m^{3}for one-hour value, 35.25μg/m^{3}for 24-hour value, and 12.07μg/m^3 for the annual average, which is approximately 51.5%(one-hour) and 8.9%(24-hour) of the environmental standard value of Iran and 28.8% of the EU environmental standard value (one-hour value:350μg/m3), 28.2%(24-hour) of the IFC/WB guideline value , showing no significant difference compared to the current status.

Regarding the future concentration, which is the addition of the prediction concentration of the existing facility and the new facility and the background concentration[4] the future concentration is 143.25μg/m^3 for one-hour value, and 77.65μg/m^3 for 24-hour value, which is in accordance with Iran's environmental quality standards、EU environmental standard and the IFC/WB guidelines value.

- Nitrogen dioxide（NO_2）

The contribution concentration of the existing facility, in case gas fuel is used, is higher compared to the case light oil is used, and the maximum ground level concentration in the existing facility is 168.83μg/m^{3}for one-hour value, 59.73μg/m^{3}for 24-hour value, and 25.15μg/m^3 for the annual average, which is approximately 84.4％(one-hour) and 25.2％(annual average) of the environmental standard value of Iran(one-hour value: 200μg/m^3, annual

4 In the three places of Naserabad, Asghrabad and Zybashahar, which have been affected to a certain extent by existing power plants, the wind from the north is dominant and SO_2 , NO_2 and PM_{10} are the minimum values in the morning, when the smoke of the power plant does not diffuse to these points, so the minimum value was taken as the background concentration

average:100μg/m^3) and 62.9% of the IFC/WB guideline value (annual average).

The maximum future ground level concentration in case gas fuel is used in the new facility is 168.83μg/$m^3$for one-hour value, 25.36μg/m^3 for annual average, which is approximately 84.%(one-hour) and 25.4%(annual average) of the environmental standard value of Iran and 63.4% of the IFC/WB guideline value (annual average), which shows no significant difference compared to the current status.
Regarding of the future concentration, which is the addition of the prediction concentration of the existing facility and the new facility and the background concentration, the future concentration is 181.10μg/m^3 for one-hour value, and 71.98μg/m^3 for 24-hour value even in the case gas fuel is used (where highest impact of emission is assumed), which is in compliance with Iran's environmental quality standards, EU environmental standard and the IFC/WB guidelines value.

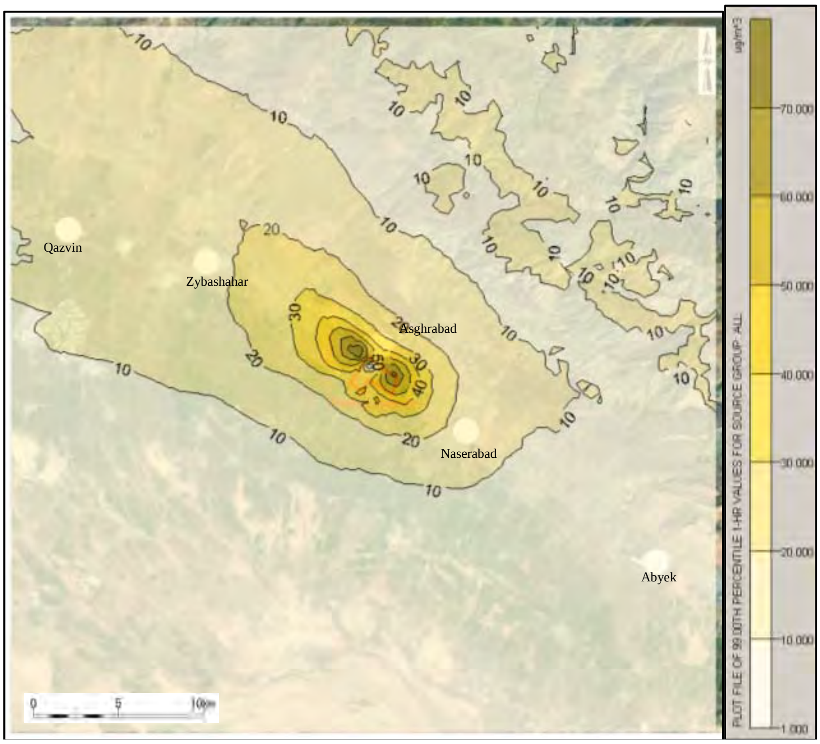
Particulate matter (PM_{10})
In case light oil fuel is used, the maximum ground level concentration of the existing facility is 34.02μg/$m^3$for one-hour value, 11.92μg/$m^3$for 24-hour value, and 5.02μg/m^3 for the annual average, which is approximately 7.9%(24-hour) of the environmental standard value of Iran(24-hour:150 μ g/m^3) and 7.2%(annual average) of the IFC/WB guideline value(annual average: 70μg/m^3).

In case light oil fuel is used in future in the new facility, the maximum ground level concentration is 34.16μg/m^3 for one-hour value, and 12.03μg/m^3 for 24-hour value, 5.16μg/m^3 for the annual average, which is approximately 8%(24-hour) of the environmental standard value of Iran and 8%(24-hour) and 7.4％(annual average) of IFC/WB guideline value, showing that the difference is extremely small.

Regarding the future concentration, which is the addition of the prediction concentration of the existing facility and the new facility and the background concentration, the future concentration is 87.13μg/m^3 for one-hour value, and 65μg/m^3 for 24-hour value, which is in compliance with Iran's environmental quality standards and the IFC/WB guidelines value.

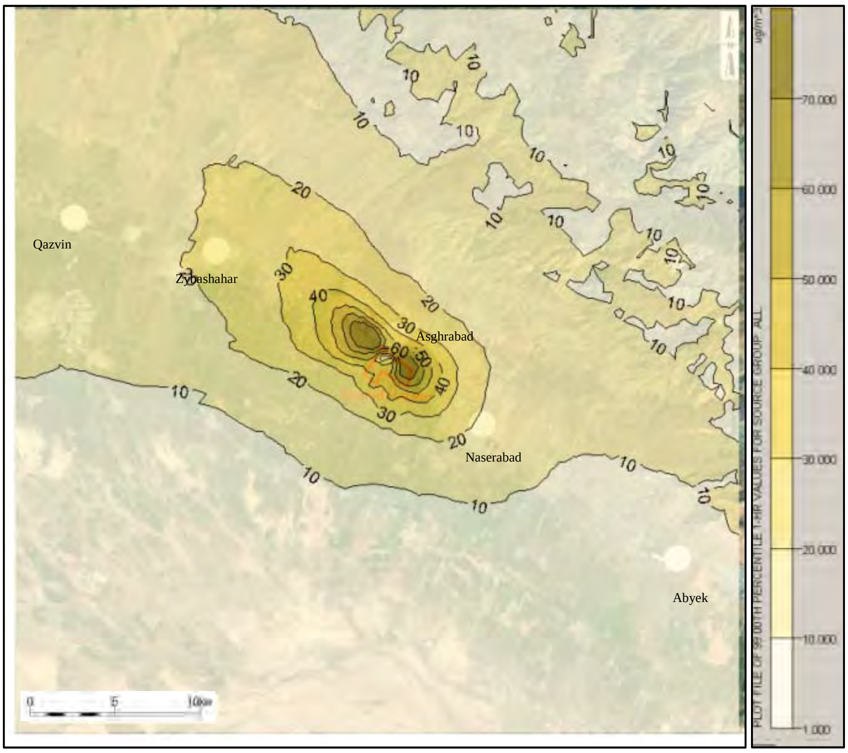
According to the results above, even when the impact of the existing thermal power plant is taken in consideration, the standard value of Iran and IFC/WB guideline value are predicted to be satisfied.
Also, it can be concluded that the impact of the new power plant to the surrounding environment is predicted to be relatively small.

In the future, in order to reduce the adverse impact on air quality, the operation of the newly installed facility shall be promoted in priority, and the operation of the existing low-efficiency facility, with attention to the result of monitoring, shall be limited only for the necessary period, and it is also necessary to consider the replacement / refurbishment of equipment or gradual stop of operation in the future.



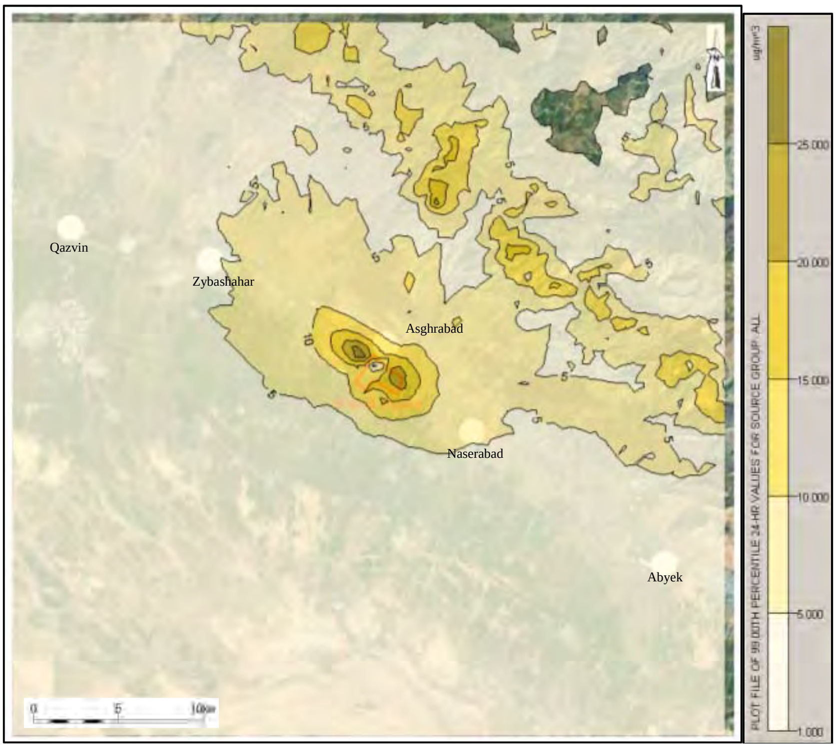
Source: obtained from Google Earth and prepared by Study Team

Fig. 6-50 Ground Level Concentration of SO_2 (1 Hour Value)(current status (existing facility:light oil and heavy oil fuel))



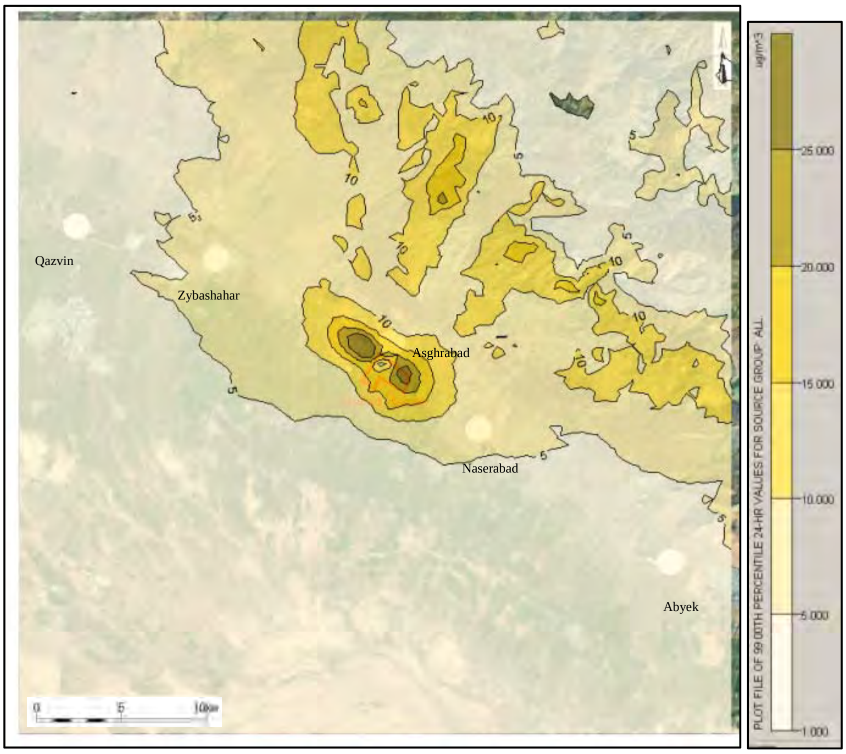
Source: obtained from Google Earth and prepared by Study Team

Fig. 6-51 Ground Level Concentration of SO_2 (1 Hour Value)(future status (existing facility:light oil and heavy oil fuel+ new facility: light oil fuel))



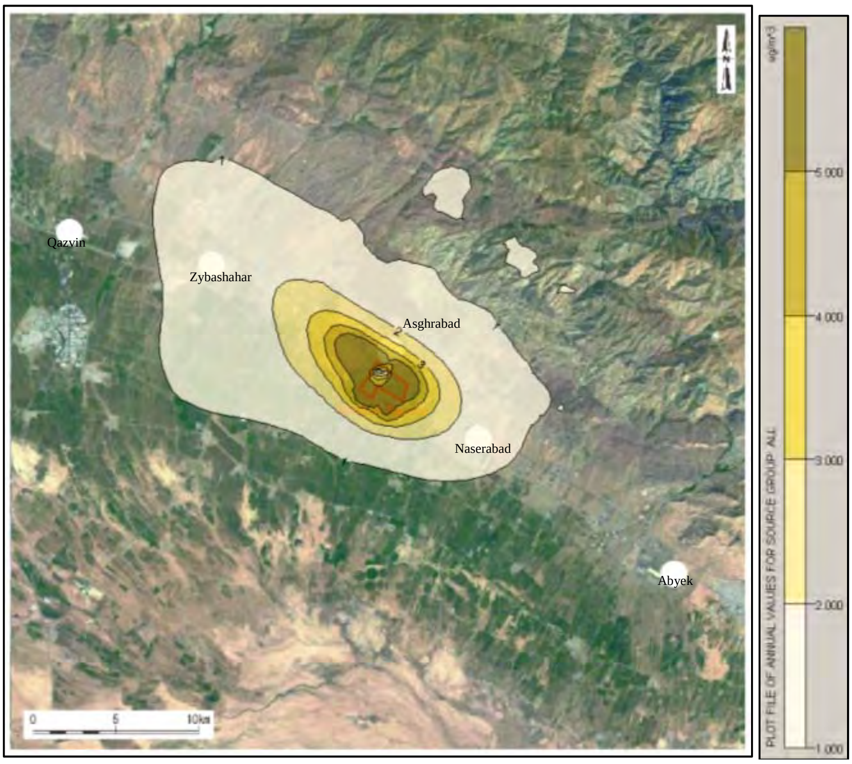
Source: obtained from Google Earth and prepared by Study Team

Fig. 6-52 Ground Level Concentration of SO_2 (24 Hour Value)(current status (existing facility:light oil and heavy oil fuel))



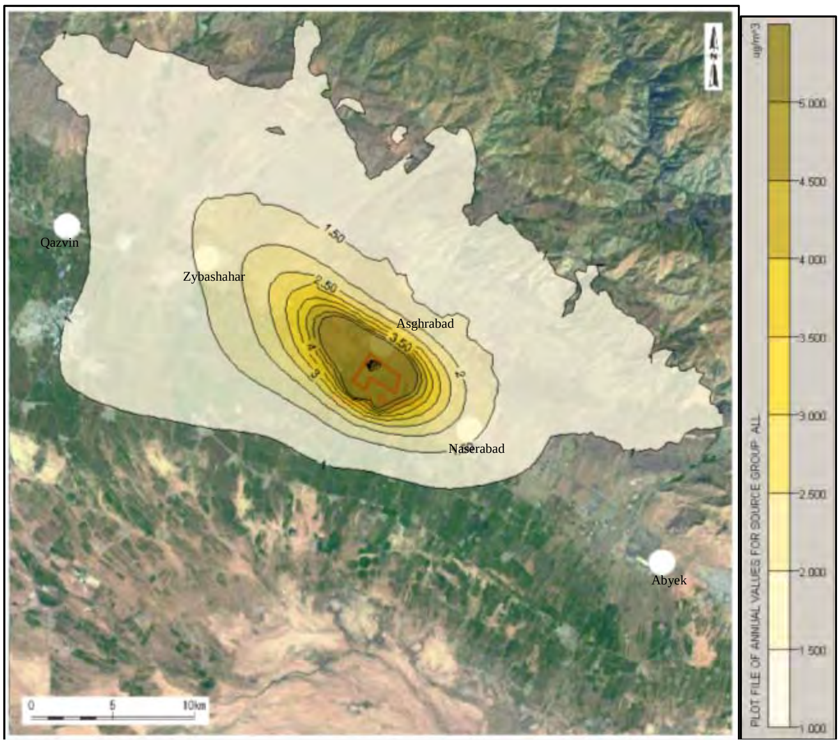
Source: obtained from Google Earth and prepared by Study Team

Fig.6-53 Ground Level Concentration of SO_2 (24 Hour Value)(future status (existing facility:light oil and heavy oil fuel+ new facility: light oil fuel))



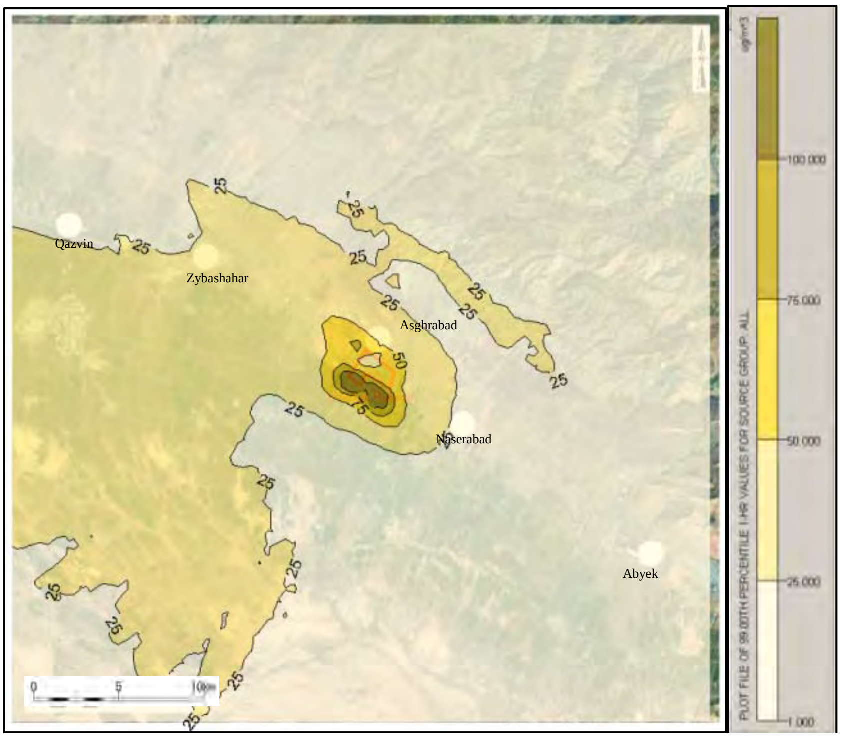
Source: obtained from Google Earth and prepared by Study Team

Fig. 6-54 Ground Level Concentration of SO_2 (annual average Value)(current status (existing facility:light oil and heavy oil fuel))



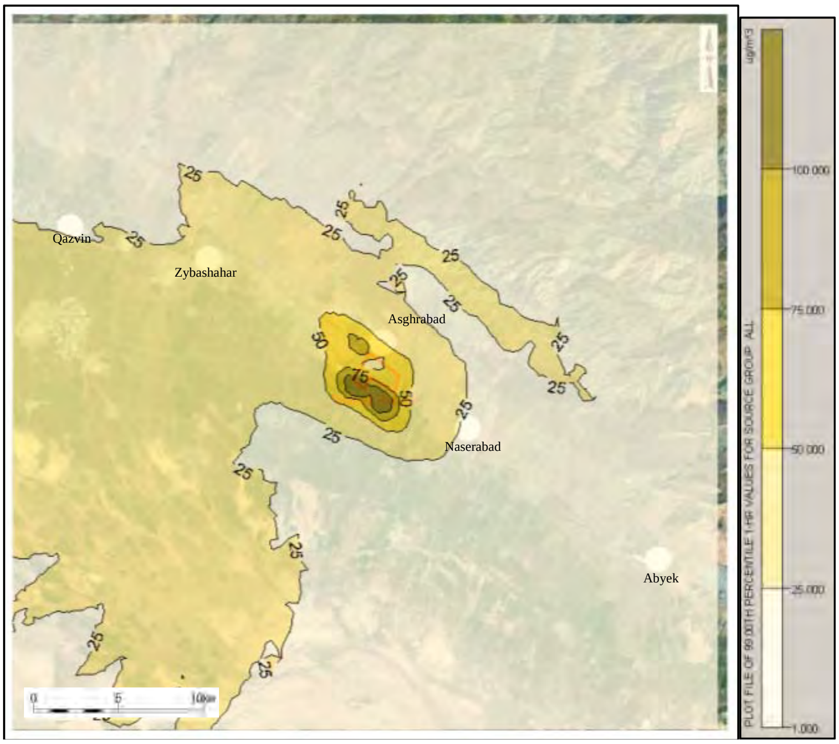
Source: obtained from Google Earth and prepared by Study Team

Fig. 6-55 Ground Level Concentration of SO_2 (annual average Value)(future status (existing facility:light oil and heavy oil fuel+ new facility: light oil fuel))



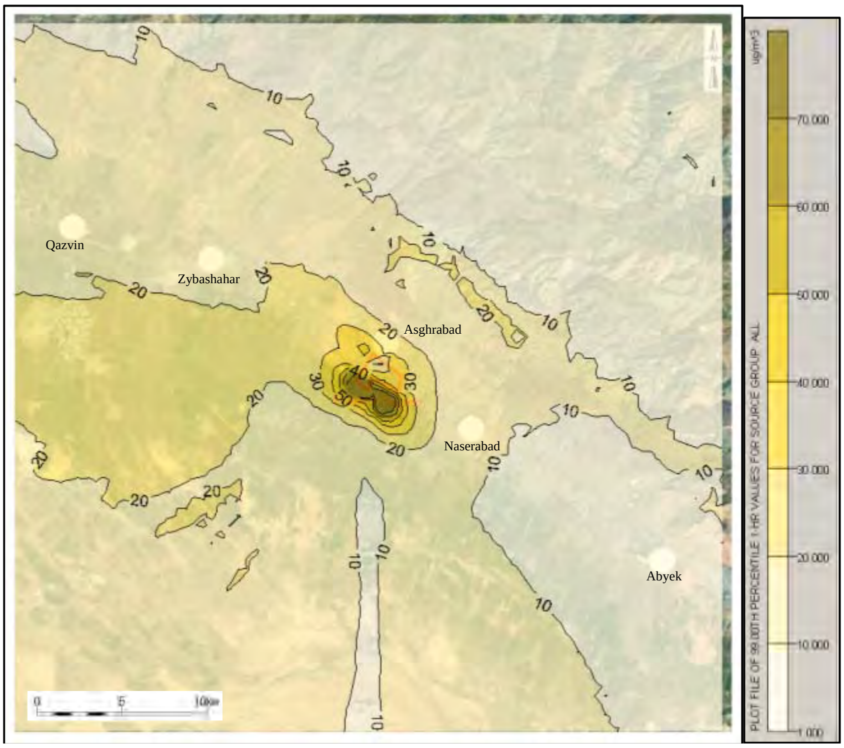
Source: obtained from Google Earth and prepared by Study Team

Fig. 6-56 Ground Level Concentration of NO_2 (1 Hour Value)(current status (existing facility:gas fuel))



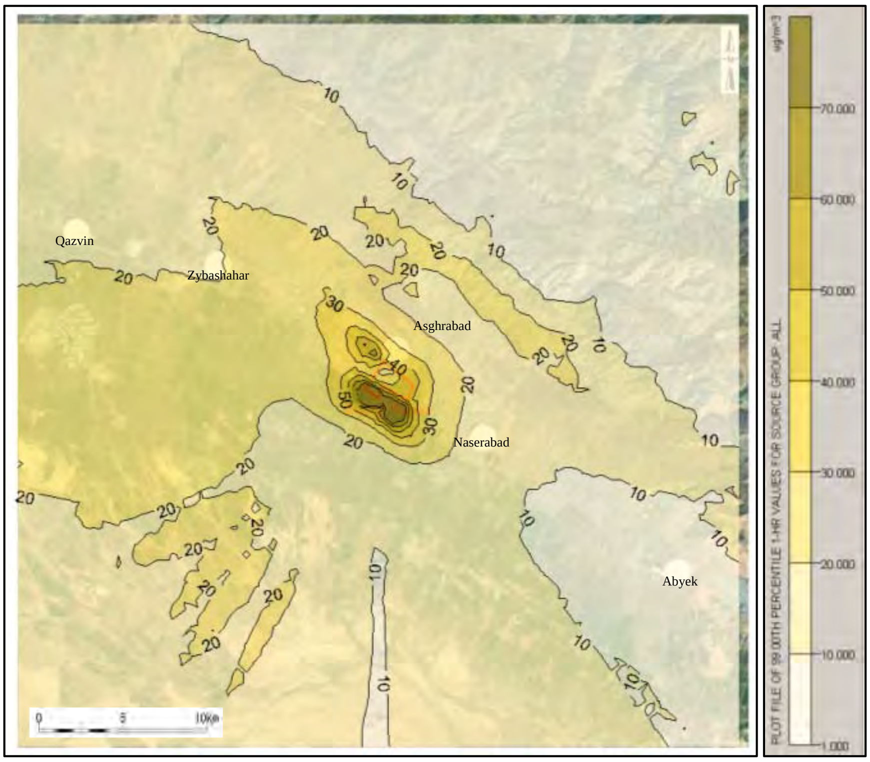
Source: obtained from Google Earth and prepared by Study Team

Fig. 6-57 Ground Level Concentration of NO_2 (1 Hour Value)(future (existing facility:gas fuel+ new facility: gas fuel))



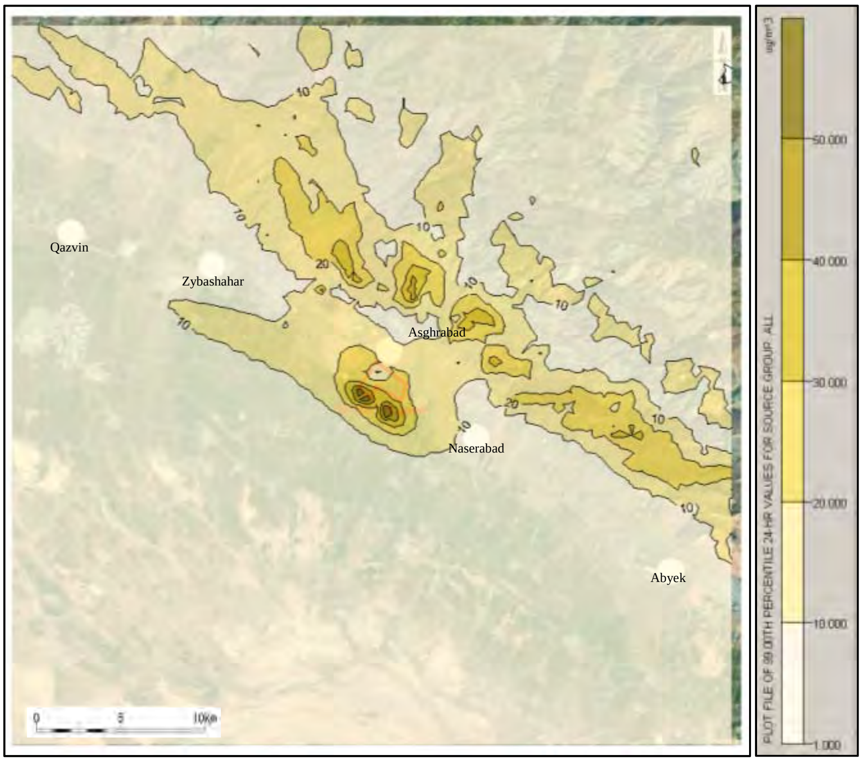
Source: obtained from Google Earth and prepared by Study Team

Fig. 6-58 Ground Level Concentration of NO_2 (1 Hour Value)(current status (existing facility:light oil and heavy oil fuel))



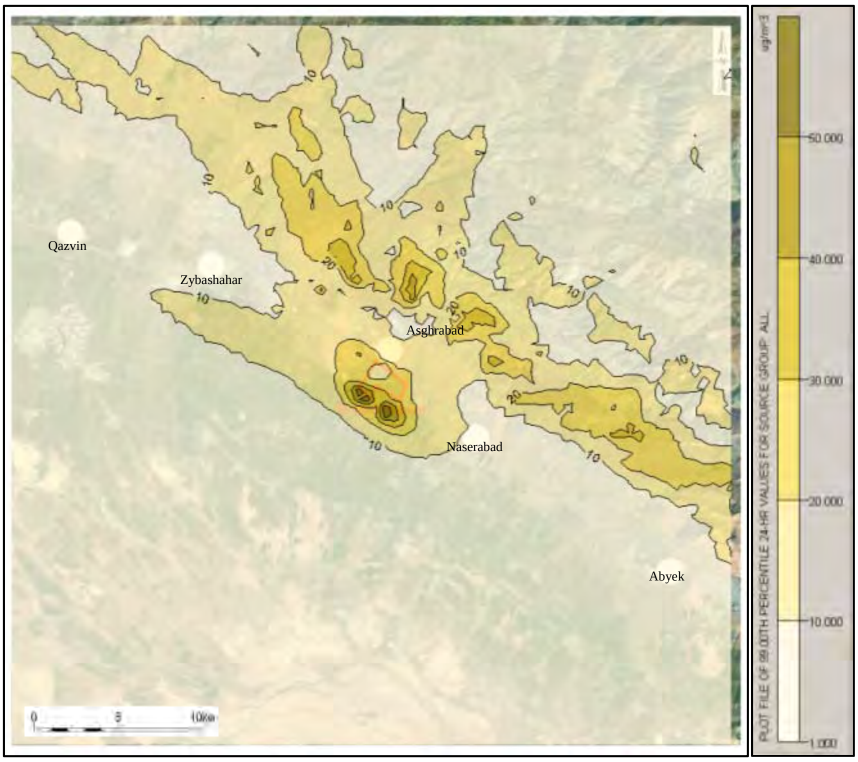
Source: obtained from Google Earth and prepared by Study Team

Fig. 6-59 Ground Level Concentration of NO_2 (1 Hour Value)(future (existing facility:heavy oil and light oil fuel+ new facility: light oil fuel))



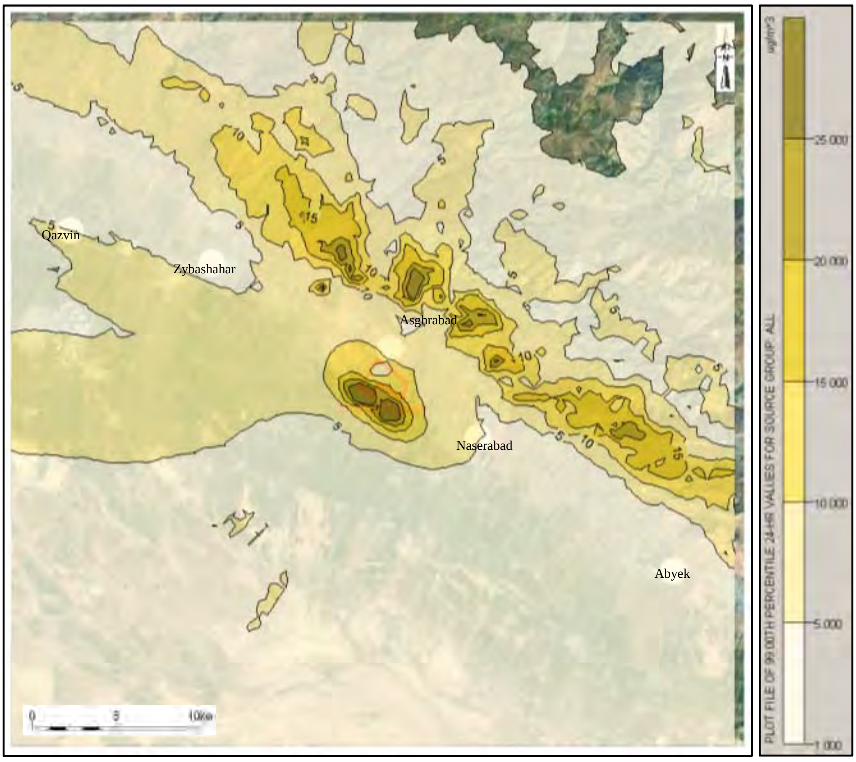
Source: obtained from Google Earth and prepared by Study Team

Fig. 6-60 Ground Level Concentration of NO_2 (24 Hour Value)(current status (existing facility:gas fuel))



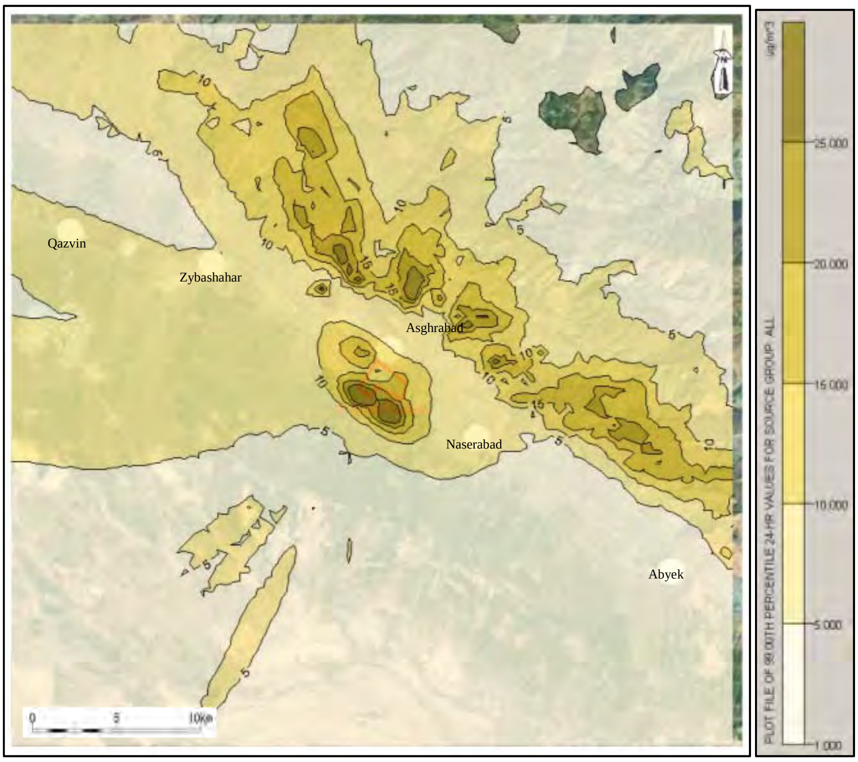
Source: obtained from Google Earth and prepared by Study Team

Fig. 6-61 Ground Level Concentration of NO_2 (24 Hour Value)(future status (existing facility:gas fuel+ new facility: gas fuel))



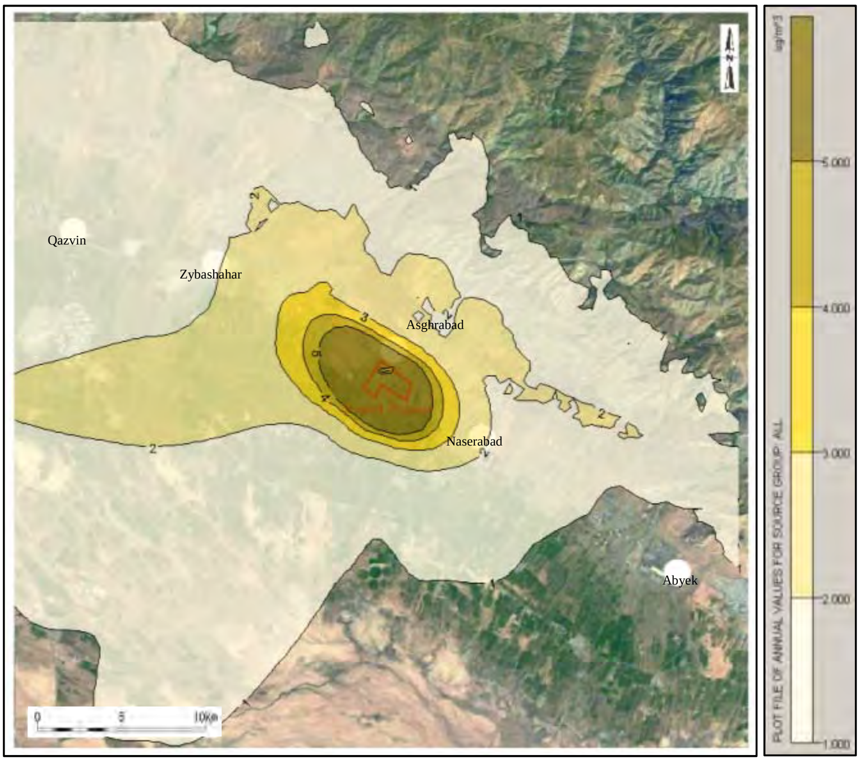
Source: obtained from Google Earth and prepared by Study Team

Fig. 6-62 Ground Level Concentration of NO_2 (24 Hour Value)(current status (existing facility: light oil and heavy oil fuel))



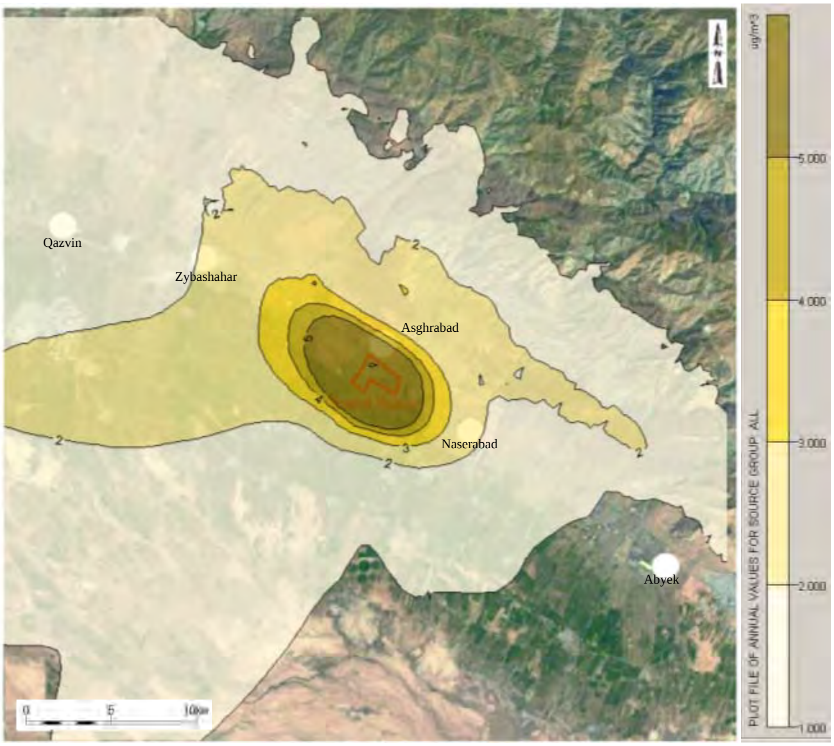
Source: obtained from Google Earth and prepared by Study Team

Fig. 6-63 Ground Level Concentration of NO_2 (24 Hour Value)(future (existing facility:light oil and heavy oil fuel+ new facility: light oil fuel))



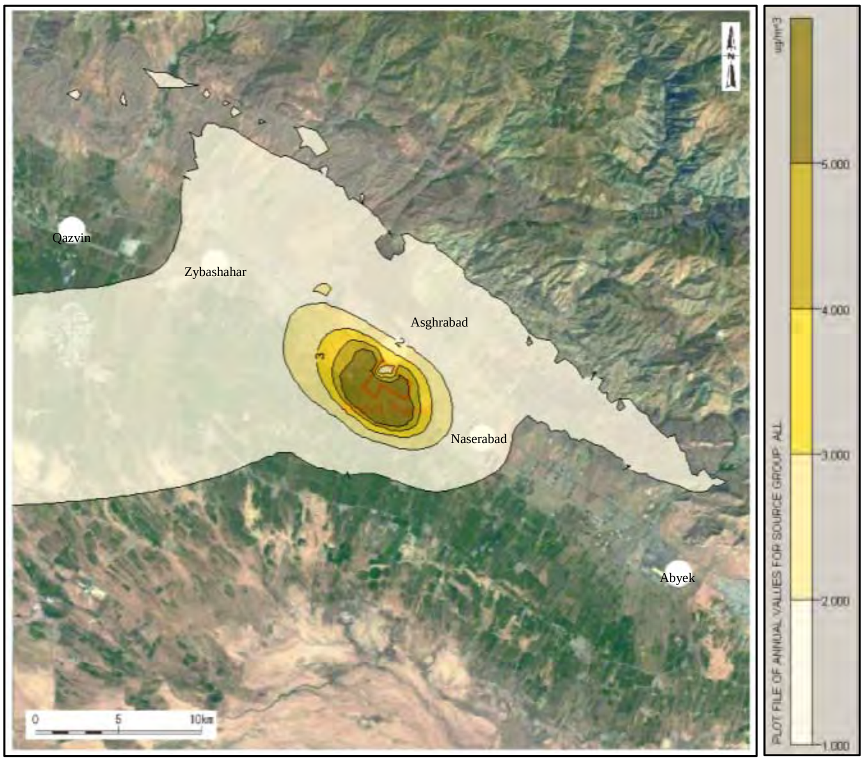
Source: obtained from Google Earth and prepared by Study Team

Fig. 6-64 Ground Level Concentration of NO_2 (annual average Value)(current status (existing facility:gas fuel))



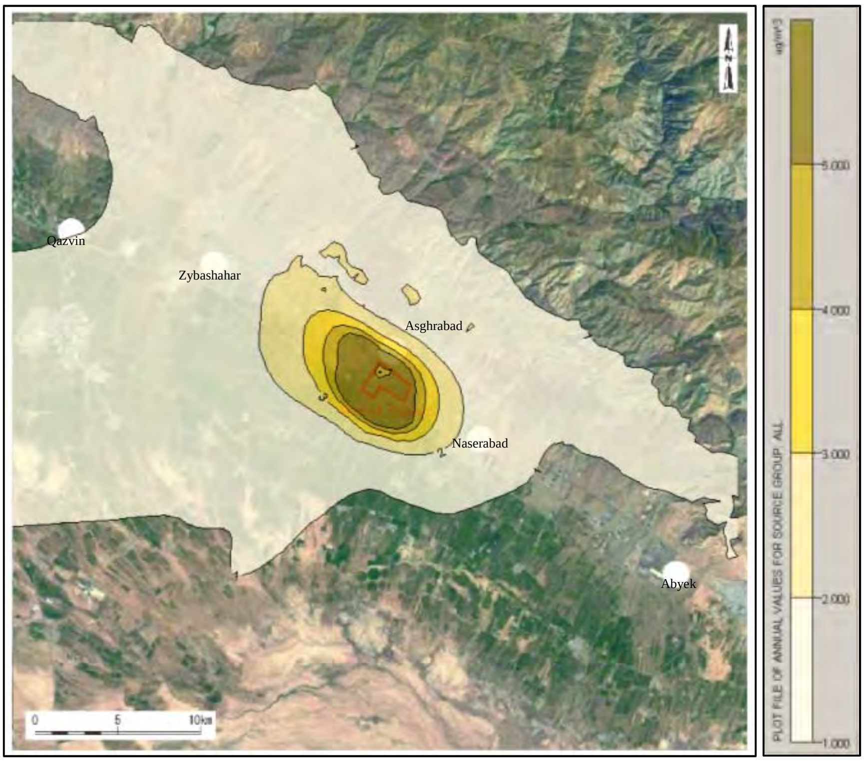
Source: obtained from Google Earth and prepared by Study Team

Fig. 6-65 Ground Level Concentration of NO_2 (annual average Value)(future (existing facility:gas fuel+ new facility: gas fuel))



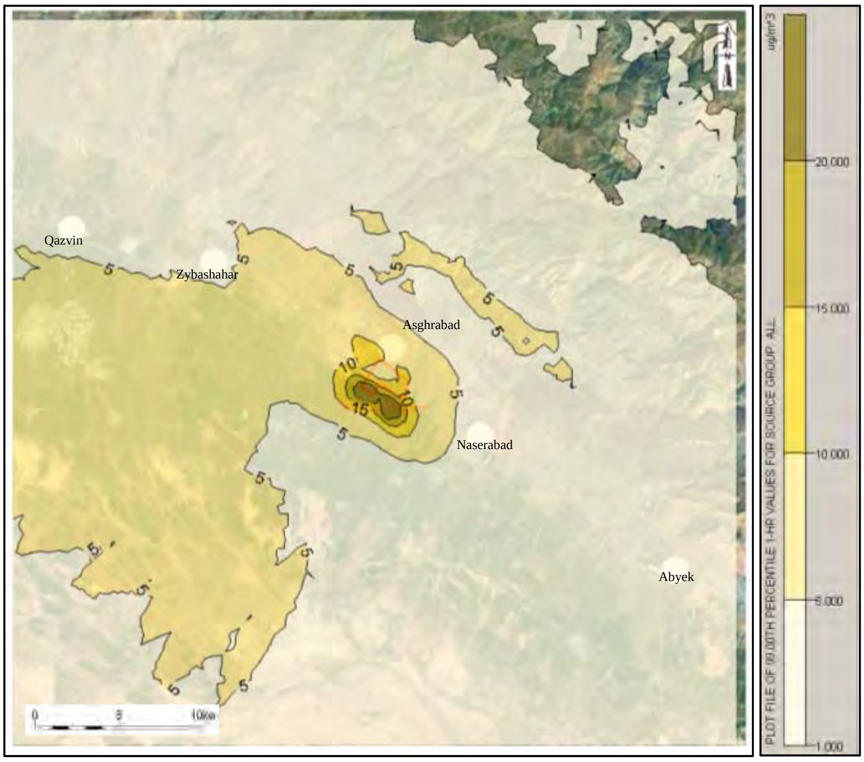
Source: obtained from Google Earth and prepared by Study Team

Fig. 6-66 Ground Level Concentration of NO_2 (24 Hour Value)(current status (existing facilitylight oil and heavy oil fuel))



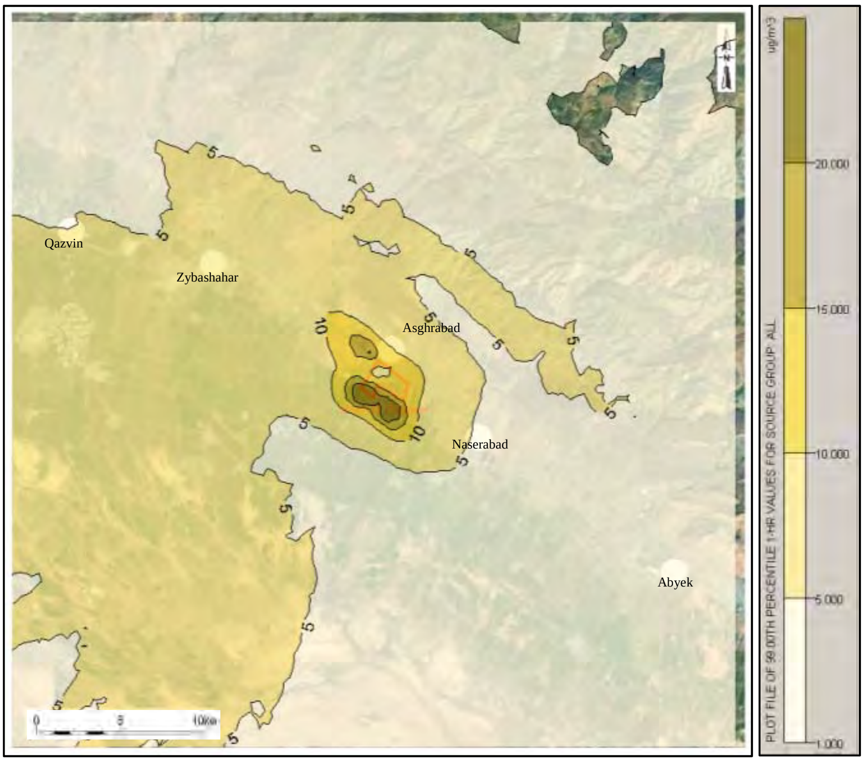
Source: obtained from Google Earth and prepared by Study Team

Fig. 6-67 Ground Level Concentration of NO_2 (24 Hour Value)(future status (existing facility:heavy oil and light oil fuel+ new facility: heavy oil and light oil fuel))



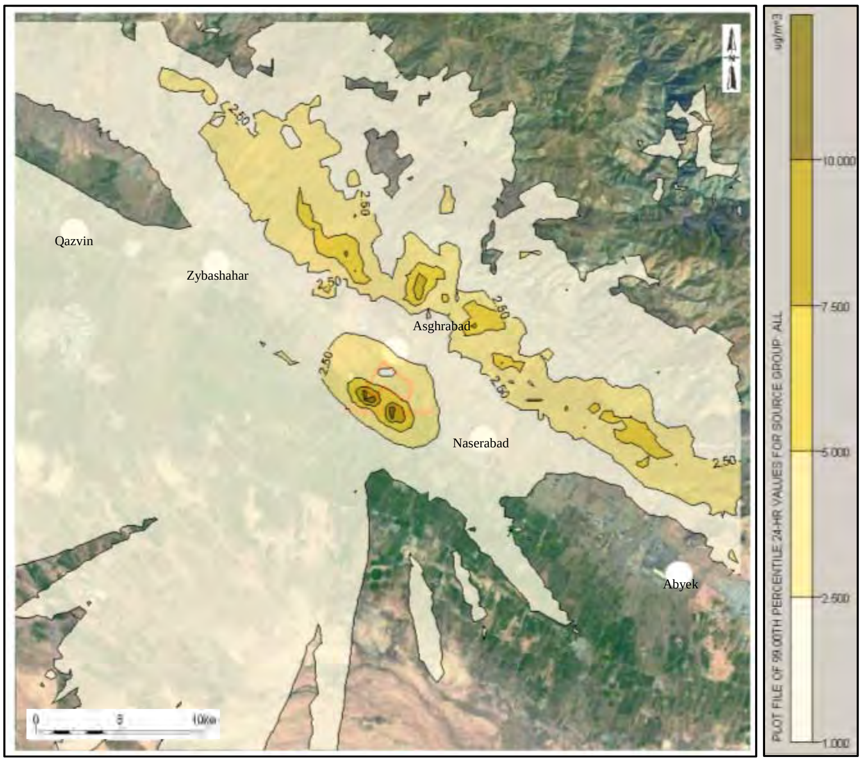
Source: obtained from Google Earth and prepared by Study Team

Fig. 6-68 Ground Level Concentration of PM$_{10}$ (1 Hour Value)(current status (existing facility:light oil and heavy oil fuel))



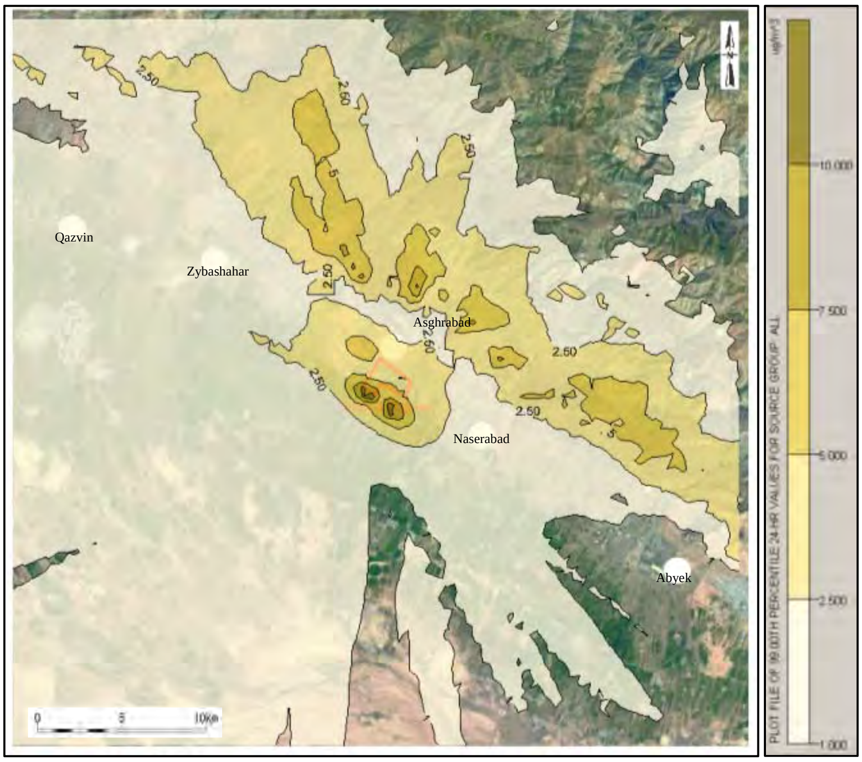
Source: obtained from Google Earth and prepared by Study Team

Fig. 6-69 Ground Level Concentration of PM$_{10}$ (1 Hour Value)(future status (existing facility:light oil and heavy oil fuel+ new facility: light oil fuel))



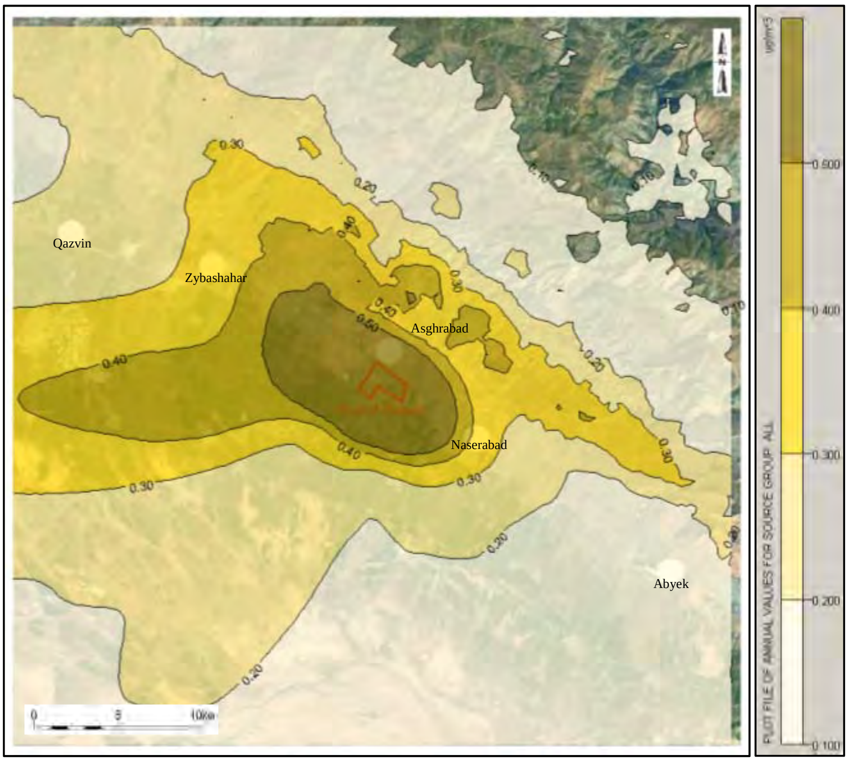
Source: obtained from Google Earth and prepared by Study Team

Fig. 6-70 Ground Level Concentration of PM_{10} (24 Hour Value)(current status (existing facility:light oil and heavy oil fuel))



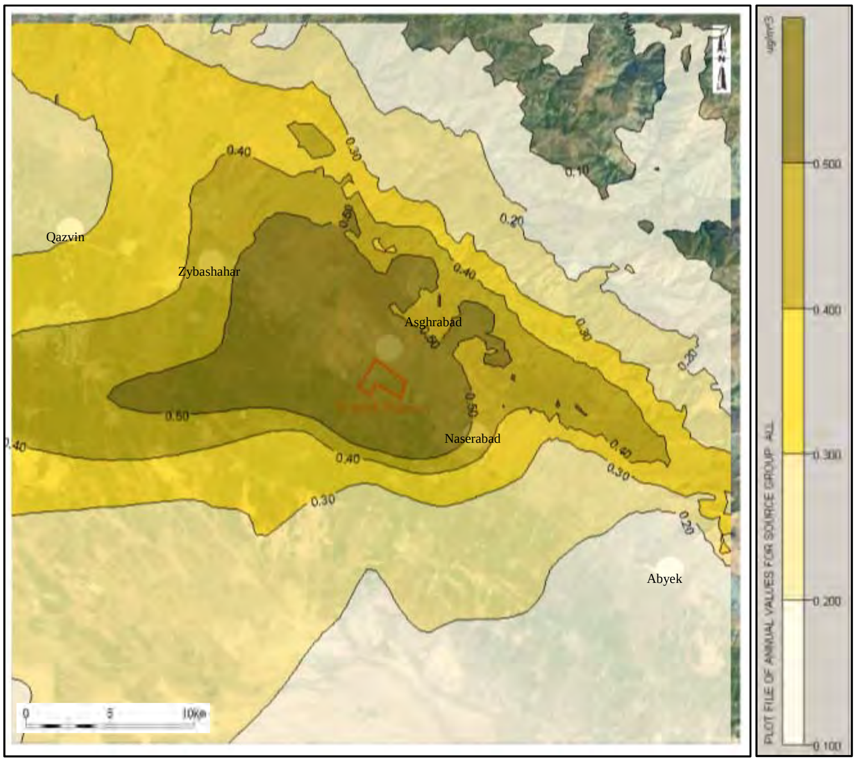
Source: obtained from Google Earth and prepared by Study Team

Fig. 6-71 Ground Level Concentration of PM_{10} (24Hour Value)(future status (existing facility:light oil and heavy oil fuel+ new facility: light oil fuel))



Source: obtained from Google Earth and prepared by Study Team

Fig. 6-72 Ground Level Concentration of PM_{10} (annual average Value)(current status (existing facility:light oil and heavy oil fuel))



Source: obtained from Google Earth and prepared by Study Team

Fig. 6-73 Ground Level Concentration of PM_{10} (annual average Value)(future (existing facility:light oil and heavy oil fuel+ new facility: light oil fuel))

Table 6-40 Prediction Result of the Contribution Concentration of the existing power plant facility and of the new power plant

Pollutant	Fuel	Time category	Maximum concentration at the ground level of the existing facility a (μg/m³)	Maximum concentration at the ground level of the existing facility and the new facility b. (μg/m³)	Background concentration (μg/m³)	Maximum future concentration b+c (μg/m³)	Iran's atmospheric environmental quality standard (μg/m³)	International standard value and standard value in each country (IFC/EU/Japan) (μg/m³)
SO_2	Light oil	1-hour value	76.38	100.85	42.4	143.25	196	-/350/350
		24-hour value	26.67	35.25	42.4	77.65	395	125/125/114
		Annual average	9.72	12.07	-	-	-	-
NO_2	gas	1-hour value	168.83	168.93	12.2	181.10	200	200/200/-
		24-hour value	59.73	59.81	12.2	71.98	-	-/-/113
		Annual average	25.15	25.36	-	-	100	40/40/40
	light oil	1-hour value	126.56	126.76	12.2	138.93	200	200/200/-
		24-hour value	43.50	43.72	12.2	55.89	-	-/-/113
		Annual average	17.97	18.44	-	-	100	40/40/40
PM_{10}	light oil Light oil	1-hour value	34.02	34.16	53.0	87.13	-	-/-/200
		24-hour value	11.92	12.03	53.0	65.00	150	150/50/100
		Annual average	5.02	5.16	-	-	-	70/40/40

Note: The background concentrations are assumed to be minimum concentration of measured values at 3 points such as Naserabad, Asghrabad and Zybashahar In the three places of Naserabad, Asghrabad and Zybashahar, which have been affected to a certain extent by existing power plants, the wind from the north is dominant and SO_2 , NO_2 and PM_{10} are the minimum values in the morning, when the smoke of the power plant does not diffuse to these points, , so the minimum value was taken as the background concentration

Source: prepared by JICA Study Team

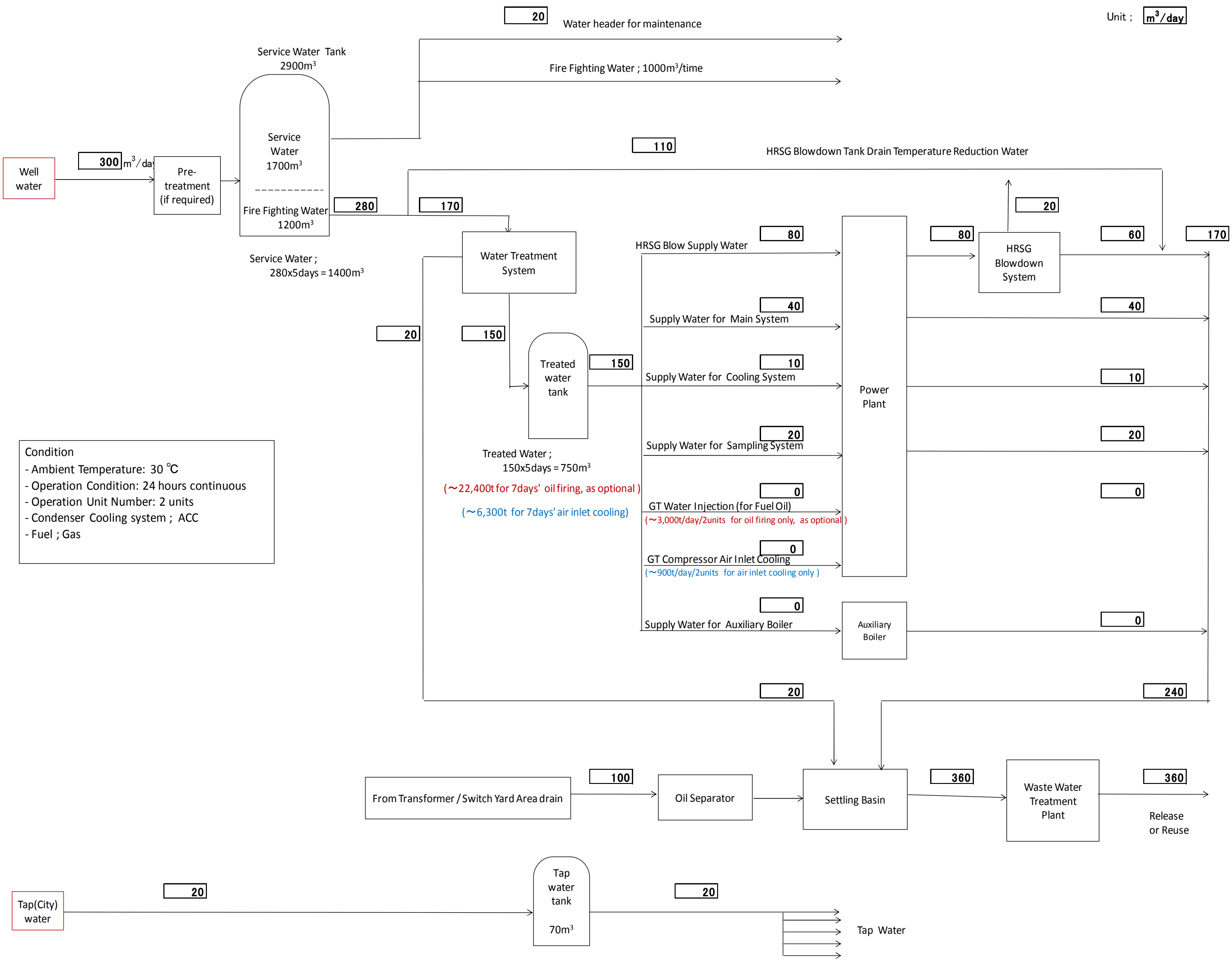
(2) Water turbidity

In the operation of the power plant, wastewater from the power plant, oil-containing wastewater and domestic sewage will be generated and the potential environmental impact is predicted.

A steam turbine will be used in the power plant, but cooling water from the condenser will be reused through forced-draft cooling fan system and thermal waste water will not be discharged and cooling water will not be intake.

Waste water mainly consists of regeneration waste water from demineralization plant and from Boilers Heat Recovery Steam Generators (HRSG), which are not large in amount in a normal operation. Oily drainage wastewater from the condenser and the light oil tank will be generated accompanying to domestic sewage from office and accommodation for staff and rain water.

The total amount of waste water will be approximately 380m^3 per day at the maximum, and the waste water discharge flow is shown in Fig. 6-74.



Source: prepared by JICA Study Team

Fig. 6-74 Waste water treatment flow

Main items associated with water quality are as follows:
・Oily drainage wastewater : oil
・Domestic sewage : SS, organic matter
・Wastewater from water purification system : SS, Acid, Alkaline
・Waste washing water from the exhaust heat recovery boiler: SS, Acid, Alkaline

Wastewater from water purification system and waste water from the exhaust heat recovery boiler is treated with neutralization and sedimentation treatment system and is examined for compliance with waste water quality standards of Iran and of the IFC/EHS Guideline for thermal power plants (2008).

Oily drainage wastewater will be collected in the wastewater treatment system for oil separation to comply with Iran's standards and IFC/EHS Guideline values for thermal power plants (2008). Domestic wastewater from worker’s camp is treated in the septic tank to comply with Iran's standards and IFC/EHS Guideline values (general, 2007).

All these waste water is discharged into the drainage tank within the existing power plant for reuse to the possible extent, or use for greening or other purpose as much as possible. If the discharge amount is found to be too large for reuse during the regular checkup, the excess water will be discharged into the irrigation canal and may be used for agriculture in the surrounding area.
With the above-described measures, the impact on water quality by the power plant operation is minimized.

(3) Waste
General waste and hazardous waste will be generated. General waste is sewerage and garbage produced from workers in the power plant. Hazardous waste includes waste oil generated from the operation and maintenance of the facilities and sludge generated through precipitation treatment at the wastewater treatment facility.

Basic mitigation measure is to develop a waste management plan including reduction of waste, promotion of recycling, and education of workers to prevent inappropriate waste disposal. Waste will be collected separately and stored in an appropriate site and method.

Specifically, paper wastes, iron scraps and waste oil will be recycled as with the case in the existing facility. Residual food is composted and reused as fertilizer in greening. All of the hazardous waste which cannot be recycled will be transported to the landfill site authorized by DOE and equipped with ground-seepage prevention within the power plant site for disposal.

As water pollution, soil pollution, odor or sanitary problems resulting from waste will be mitigated, the environmental impact will be minimized and insignificant. The monitoring of waste will be conducted regarding the type, generation amount and disposal method of waste.

(4) Soil contamination
There is a possibility of soil contamination caused by spill of lubricant oil and fuel oil which will be used for operation of the facilities.
Tank for oil will be settled in the place with concrete pavement and oil dyke around the tank.
As the above measures will be taken, the occurrence of soil contamination is minimized.

(5) Noise and Vibration
Impact of noise and vibration from the plant operation is predicted. There are no residences in the direct neighborhood of the project site, but there is a residence 1.5km north of the power plant, and sufficient consideration must be given to minimize noise impact.

〈Noise〉
The noise level related to the operation of the major equipments of the power plant is estimated using the noise level estimation model cited below.

Noise level estimation model
An estimation of the noise level was made according to Chapter6.7.1 Construction Phase.

Noise level data of noise source
The noise source related to the operation of the power plant includes stack, air filter, gas turbine, pumps, transformer, cooling fan, duct, etc. The noise level and the number of respective noise sources are shown in Table 6-41.

Table 6-41 Noise Level and the Number of the Major Equipment

Equipment	Noise level (dB)
Gas turbine (with enclosures)	87
Gas turbine generator (with enclosures)	83
Inlet air duct	87
Inlet air filter	94
GT duct (exhaust gas)	91
Generator step-up transformer	95
Unit auxiliary transformer	93
Main Stack	89
Cooling fan	88
Cool water pump	98
Gas compressor	85
Diesel oil transfer pump	86

Source: prepared by JICA Study Team

Calculation conditions
10 measurement points (No.1 ~ No.10) were selected and used for simulation at the boundary of power plant site and another 3 points (No.11 ~ No.13) in the factory and the residential area located near the power plant were also selected for simulation.

Results of simulation
Table 6-42 shows the result of the estimation of noise level (contribution, current, and future level) for each sampling point during the operation of the plant equipment. Figure 6-75 shows the noise level distribution.

Noise level generated by power plant operation is 27- 57dB (A) at the boundary and the factory in the vicinity of the power plant site, and 27-32B (A) at the factory and the residential area near the site.
As for the current noise level at the prediction point, the current noise level during construction (shown in 6.7.1) is adopted. The future noise level at the prediction points was estimated based on the current noise level and contribution noise level.

The future noise level was 58 ～ 63 dB(A) at the boundary, and 46 ～ 65 dB(A) at the nearby workplace and residential area. The future noise level exceeds the current level at only one point in the boundary, and the noise level does not differ from the current level at all the other points.

The noise levels at all the measuring points of boundary and the nearby workplace comply with the environmental standard of Iran and IFC/WB guideline value (industrial area, daytime). Also, the noise levels at the residential area satisfy the environmental standard of Iran and IFC/WB guideline value (residential area, daytime).

Regarding noise level at nighttime, the current noise level exceeds the standard value, but estimated future noise does not differ largely compared with the current noise level. Noise-generating equipment will be enclosed as much as possible and low noise type equipment will be installed. Periodic maintenance of equipment will be conducted.

Table 6-42 Results of the simulation of noise levels in the power plant

Place	Point	Noise level (dBA)	Current noise level (dBA)	Future noise level (dBA)	Noise standard of Iran	IFC/WB EHS Guideline, General
Project site boundary	No. 1	32	62	62	Industrial area; Daytime：70 Nighttime：65	Industrial area: Daytime：70 Nighttime：70
	No. 2	40	62	62		
	No. 3	38	61	61		
	No. 4	52	61	62		
	No. 5	51	61	61		
	No. 6	57	61	**63**		
	No. 7	50	61	61		
	No. 8	47	59	59		
	No.9	27	58	58		
	No.10	33	62	62		
Nearby Residential area	No.11	32	46	46	Residential area: Daytime：55 Nighttime：45	Residential area: Daytime：55 Nighttime：45
Workplace adjacent to the power plant	No.12	27	63	63	Industrial area; Daytime：70 Nighttime：65	Industrial area; Daytime：70 Nighttime：65
	No.13	27	65	65		

Source: prepared by JICA Study Team

Source: obtained from Google Earth and prepared by Study Team

Fig. 6-75 Results of Simulating Noise Level from Power Plant (Unit:dBA)

<Vibration>

The impact of vibration generated from the operation of the power plant is predicted, but the vibration level is not high. Vibration sources include gas turbine, generator and pumps. They shall be installed on a strong foundation, and low-vibration equipment will be adopted. Regular maintenance of equipment will be conducted.

In the cases of Japan, the vibration level at the source is approximately 65 dB and attenuates to approximately 0dB at 500 meters away. The nearest residence is further1.5km away from the site and the impact of vibration will be negligible.

(6) Land subsidence and hydrology (ground water)

At the operation stage of the power plant, water will be taken from the authorized wells used for the existing facility at the maximum rate of 300m^3 per day. Water intake will be conducted within the range of permission and will be minimized through water reuse.

The lowering of water level in the existing wells and land subsidence in the surrounding area of the site are not observed. The monitoring of ground water level will be continuously conducted.

With the conditions cited above, lowering of ground water level and the accompanying impact associated with water intake during operation phase is not predicted.

(7). Odor
In case domestic waste of the workers is not appropriately treated, it may produce foul odors. Workers will be strictly instructed to classify and collect garbage and illegal waste disposal will be prohibited.

Garbage will be collected and stored in a covered container and composted on a periodic basis and reused as fertilizer.. These measures will be taken to minimize the generation of odor.

(8) Terrestrial ecosystem and rare species
Power plant will generate air pollution, noise and vibration, etc. that may have impact on the terrestrial ecosystems. The surrounding area is a dry ecosystem, and this ecosystem is attributed to the land use as bare land or agricultural land proceeding in the area, and endangered species requiring special attention are not observed.

Mitigation measures for air pollution, noise and vibration will be implemented as described in the chapter “Air pollution” and “Noise and vibration” and the impact on the terrestrial ecosystem will be minimized
Regarding reptiles, since there is little survey data, visual observation of the presence and absence of turtles and lizards that are endangered will be implemented on the site and nearby, for precaution.

(9) Local economy including employment and means of livelihood
Since the site is a land developed for existing power plant, new land acquisition and resettlement will not occur.

Local people may be employed as workers by the power plant, and increased purchase of local materials and equipment items, use of local restaurants and catering service will activate local economy.

(10) Water use
Ground water intake by the project may cause continuous impact on the water use in the surrounding area, but mitigation measures will be taken as described in the chapter “Subsidence and hydrology (ground water)” and the impact of water intake will be insignificant.

In the operation of the power plant, Oily drainage wastewater from fuel and around the tank of lubricant, and domestic sewage from office and accommodation for staff will be generated and may affect water quality of irrigation water by water pollution.

Water pollution will be minimized by mitigation measures cited in “Water pollution” and its impact on irrigation water is expected to be very limited.

(11). Unfair distribution of damage and benefit
The site is a developed area for the existing power plant and new land acquisition and resettlement will not occur. Unfair distribution of damages and benefits caused by compensation should not occur. If employment of local people and/or outsourcing contracts is done through unfair schemes such as personal connection of the construction company, benefit may be unfairly distributed among local people.

The employment of the local people shall be conducted under publicized employment conditions to prevent unfair competition.

(12) Work environment (including labor safety)
In the operation phase, works at a high place or generating high noises may cause labor accidents. It is necessary to develop the safety and sanitation management plan including safety education and training. Safety gears including helmet, safety shoes and earplugs shall be provided following the safety management plan. The storage of hazardous materials shall be marked with a sign board.

(13) Accident
Fire and traffic accidents by operation of facilities and / or vehicles may occur.
Project proponent will develop oil-leakage prevention management plan. Fire-fighting facility, fire-fighting team, and fire-fighting training will be introduced.

Traffic accident mitigation measures will be implemented including development of appropriate driving routes and schedule, traffic safety education and safe driving training for workers. In a period of regular maintenance when an increased number of vehicles is expected, appropriate instruction shall be provided for the maintenance company.

(14) Impact across the borders and on climate change
CO_2 is produced by the project operation, but a high-efficiency gas turbine will be installed with the emission of 2,896,000 t-CO_2 per year. The emission reduction amount is 2,782,527 t - CO_2 per year as compared to the baseline emission of 5,678,527 t-CO_2 per year in the existing power plants.
Additionally, the total emission from thermal power generation in Iran based on the year 2015 is about 160 million t-CO_2 per year. The estimated emission from this project is only 1.8% of the total emission, and the impact is expected to be insignificant.

6.7.3 Summary of Environmental and Social Impact Assessment

The results of environmental and social impact assessment are summarized in Table 6-43.

Table 6-43 Results of Environmental Impact Assessment for the Power Plant

No.	Items	Assessment at the scoping				Assessment based survey results				The Result of Assessment
		Construction period		Operation period		Construction period		Operation period		
		Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative	
【Pollution prevention】										
1	Air pollution	D	B	D	A	D	B	D	B	Construction period: - Civil engineering work such as land formation, may cause dust, but the impact should be temporary. When wind speed exceeds about 6 m/s, dust on the ground may be lifted up. The occurrence ratio of wind speed exceeding about 6 m/s around the project site is less than 1%. - Emission of air pollutants (SOx, NOx, PM) from construction machinery and vehicles will affect air quality of the surrounding site. Operation period: - Gas and light oil will be used as the fuel at the

No.	Items	Assessment at the scoping				Assessment based survey results				The Result of Assessment
		Construction period		Operation period		Construction period		Operation period		
		Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative	
										power plant. SOx, NOx, and PM will be emitted by the operation of gas turbine, causing impact on a broad area. - According to the field survey conducted by the Survey Team, it was found that the north side of the proposed power plant site is a high-elevation area; therefore, there is a possibility that a part of the area may have high concentration of pollutants emitted from the stack, for a certain period, depending on the wind direction. The emission concentration of air pollutant in the exhaust gas will meet the emission standard of Iran or the standard value of IFC/WB EHS guidelines (thermal power plant, 2008). -Wind speeds exceeding 10m/s are extremely rare, so downwash is expected to rarely occur. - Around the stack, there is no building causing occurrence of downdraft. - The maximum concentration at the ground level of the pollutants released by the project is extremely low compared to the Iran's standard and IFC/WB guidelines. - Future maximum concentration at ground level obtained by adding the predicted concentration of the existing power plants and the new facility to the background concentration is sufficiently low as compared with Iran's standards and the EU and the IFC/WB guidelines.
2	Water pollution	D	B	D	B	D	B	D	B	Construction period: - Domestic waste water and excrement from workers, concrete effluent and oil-containing effluents are generated and may affect the water quality of the irrigation canal in the surrounding sea. Waste water will be checked to comply with the environmental standard of Iran and IFC/WB EHS guideline value. . Operation period: The impact of plant waste water, oily drainage waste water and domestic waste water generated from the operating power plant is predicted. The power plant uses a steam turbine and cooling water from the condenser will be reused through forced-draft cooling fan system so that thermal waste water will not be discharged. Waste water mainly consists of regeneration waste water from demineralization plant and from Boilers Heat Recovery Steam Generators (HRSG), which are not large in amount in a normal operation. Oily drainage wastewater from the condenser and the light oil tank will be generated accompanying domestic sewage from office and accommodation for staff and rain water.

No.	Items	Assessment at the scoping				Assessment based survey results				The Result of Assessment
		Construction period		Operation period		Construction period		Operation period		
		Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative	
										These wastewater is treated with oil separator, neutralization and sedimentation treatment system and is examined for compliance with waste water quality standards of Iran and of the IFC/EHS Guideline for thermal power plants (2008).
3	Waste	D	B	D	B	D	B	D	B	Construction period: Waste generated from the construction work will include general waste such as packing material and domestic waste, and hazardous waste such as waste oil and waste battery. Operation period General waste and hazardous waste will be generated. General waste includes domestic waste generated by the project workers within the site, and hazardous waste includes waste oil from the operation and maintenance of the facility and sludge from sedimentation of waste water treatment facility.
4	Soil pollution	D	B	D	B	D	B	D	B	Construction period: - Soil pollution may possibly be caused by leakages of lubricate collected from construction machinery, fuel oil and chemicals. Operation period: - Lubrication oil and fuel oil may be spilled and may cause contamination to the soil.
5	Noise and vibration	D	B	D	B	D	B	D	B	Construction period: - Operation of heavy equipment and trucks for transporting materials will cause noise and vibration impacts. There are no residences in the direct neighborhood of the project site, but there is a residence 1.5km north of the power plant, and sufficient consideration must be given to minimize noise impact. The estimated noise level is 58 ～ 65dB(A) at the site boundary and 46～ 63dB(A) at the nearby workplace and residence. All estimated noise levels at the boundary and the nearby workplace meet the environmental standard of Iran and IFC/WB EHS guideline standards （Industrial zone Daytime). All estimated noise levels in the residential area meet the IFC/WB EHS guideline standards （residential zone :Daytime).

No.	Items	Assessment at the scoping				Assessment based survey results				The Result of Assessment
		Construction period		Operation period		Construction period		Operation period		
		Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative	
										Vibration may be generated from trailers and trucks. The vibration level attenuates to approximately 0dB at 500 meters away, which is extremely low compared to the noise standard of Japan, 45dB. The nearest residence is 1.5km away from the site and the impact of vibration will be negligible. Operation period: Noise level is 58-63 dB (A) at the boundary and the factory in the vicinity of the power plant site, and 46-65 dB(A) at the workplace and the residential area near the site. The noise levels at all the measuring points of boundary and the nearby workplace comply with the IFC/WB guideline value (industrial area, daytime). The impact of vibration generated from the operation of the power plant is predicted, but the vibration level is not high. In the cases in Japan, the vibration level of 65dB at the source attenuates to approximately 0 dB at 500 meters away. The nearest residence is 1.5km away from the site and the impact of vibration will be insignificant.
6	Land subsidence	D	C	D	C	D	B	D	B	Construction and operation period: - Water will be taken from the authorized wells used for the existing facility within the range of permission. The lowering of water level in the existing wells and land subsidence in the surrounding area of the site are not observed. Lowering of ground water level is not observed and the ground subsidence is also not seen around the project area. The significant ground subsidence associated with water intake is not predicted.
7	Odor	D	B	D	B	D	B	D	B	Construction period and operation period: - In case domestic waste from the workers and the project staffs is not appropriately treated, it may produce foul odors.
【Natural environment】										
1	Wild life preservation area	D	D	D	D	D	D	D	D	Construction period and operation period: - The site is not located within a preservation area, nor is there a preservation area around the site.
2	Terrestrial ecosystems and rare species	D	B	D	B	D	B	D	B	Construction and operation period: - The site is a developed area for the existing power plant The flora and fauna observed within the project area includes several herbaceous species and rodents species, which are commonly seen in

No.	Items	Assessment at the scoping				Assessment based survey results				The Result of Assessment
		Construction period		Operation period		Construction period		Operation period		
		Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative	
										the wide area around the site, and no precious species are observed. The surrounding area is a dry ecosystem, and this ecosystem is attributed to the land use as bare land or agricultural land proceeding in the area, and endangered species requiring special attention are not observed. Although some of the habitats of animals and plants may disappear due to modification in the site, and air pollution, noise and vibration during construction may affect the growth of plants and behavior of animals in the vicinity, the inhabitation of these species spreads widely around the project site, and there is very little influence on the biota.
3	River ecosystems and rare species	D	D	D	D	D	D	D	D	Construction period and operation period: Water intake from the river and water discharge into the river is not expected in this project. -
4	River hydrology	D	D	D	D	D	D	D	D	Construction period and operation period: - Water will not be drawn from the rivers in this project.
5	Underground hydrology	D	D	D	D	D	D	D	D	Construction period and operation period: - water will be taken from the authorized wells used for the existing facility. Water intake will be conducted within the range of permission. The lowering of water level in the existing wells is not observed. Lowering of ground water level associated with water intake is not predicted. The monitoring of ground water level will be continuously conducted .
6	Topography and geology	D	D	D	D	D	D	D	D	Construction period and operation period: -The project is developed within the existing power plant site and the impact is not predicted.
【Social environment】										
1	Resettlement and Land acquisition	D	D	D	D	D	D	D	D	Pre-construction period, construction period, and operation period: - The site is a developed area for the existing power plant and new land acquisition and resettlement will not occur.
2	Poor People	D	D	D	D	D	D	D	D	Pre-construction period: The site is a developed area for the existing power plant and impact on poor people will not occur. Construction and operation period: No element that affects the poor people is expected.
3	Ethnic minorities	D	C	D	C	D	D	D	D	Pre-construction period, construction period, and operation period: - The site is a developed area for the existing power plant and impact on ethnic minorities will not

No.	Items	Assessment at the scoping				Assessment based survey results				The Result of Assessment
		Construction period		Operation period		Construction period		Operation period		
		Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative	
										occur. - The on-site survey shows that the area around the site is not inhabited by ethnic minorities.
4	Local economy including employment and means of livelihood	B	D	B	D	B	D	B	D	Pre-construction period The site is a developed area for the existing power plant and impact on employment and means of livelihood will not occur. Construction period and Operation period: - The project proponent will employ as many local residents as possible and make use of the services (i.e. restaurant and catering service etc.) and products offered in the local community, as much as possible which will promote local economy.
5	Land use and utilization of local resources	D	D	D	D	D	D	D	D	Pre-construction period, construction period, and operation period: - The site is a developed area for the existing power plant and use of land and local resources are not likely to be affected.
6	Water use	D	C	D	C	D	B	D	B	Construction and operation period: Ground water intake by the project may cause continuous impact on the water use in the surrounding area, but as described in the chapter “Hydrology (ground water)”, significant lowering of ground water level is not predicted.
7	Existing social infrastructure and social service	D	D	D	D	D	D	D	D	Construction period and operation period: There are Qazvin with population of 400 thousand near the project site, and the social infrastructure service such as lodging houses, medical treatment facilities, schools, sewer systems and other infrastructure are well established so that inflow of construction workers and the power plant staffs will not affect the social service.
8	Social bodies including society-related capitals and social organizations that make local decisions	D	D	D	D	D	D	D	D	Pre-construction period: - The site is a developed area for the existing power plant and impact on society-related capitals and social organizations that make local decisions will not occur. Construction period, and operation period: Any factors which may cause impact on social bodies including society-related capitals and local decision-making organization is not assumed. :
9	Unfair distribution of damage and benefit	D	B	D	B	D	B	D	B	Pre-construction period: - The site is a developed area for the existing power plant and unfair distribution of damage and benefit will not occur. Construction period and operation period: - If employment of local people is done through unfair schemes such as personal connection of the construction company, benefit may be unfairly

No.	Items	Assessment at the scoping				Assessment based survey results				The Result of Assessment
		Construction period		Operation period		Construction period		Operation period		
		Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative	
										distributed among local people.
10	Conflict of interests within the local area	D	B	D	D	D	B	D	D	Pre-construction period: - The site is a developed area for the existing power plant and conflict of interests within the local area will not occur. Construction period: - Inflows of many workers from other parts of Iran or foreign countries during construction period may cause conflict with local workers, if the local customs are not followed. Operation period: - A small inflow of workers from outside the area is predicted, and conflict with local workers due to difference in customs should not occur.
11	Cultural heritage	D	D	D	D	D	D	D	D	Construction period and Operation period: - The site is a developed area for the existing power plant and the construction site has no precious historical, cultural, or religious heritage.
12	Landscape	D	C	D	C	D	D	D	D	Construction period and Operation period: - The site is a developed area for the existing power plant, and since it was confirmed that the site has no scenic spots.
13	Gender	D	D	D	D	D	D	D	D	Pre-construction period: - The site is a developed area for the existing power plant, and disadvantage for women will not occur. Construction period, and operation period No particular impact is expected to take place regarding gender.
14	Rights of children	D	B	D	D	D	B	D	D	Pre-construction period: - The site is a developed area for the existing power plant, and impact on children's right will not occur. Construction period: - Construction work requires a large number of workers and child labor may increase on the construction site. It may lead to school abandonment. Operation period: - No child workers will be employed for simple work during operation.
15	HIV/AIDS and other infectious diseases	D	B	D	D	D	B	D	D	Construction period: - The inflow of workers from other parts of Iran or foreign countries may induce the spread of infectious diseases. Operation period: - A very small inflow of workers is expected, so the spread of infectious disease is not expected.
16	Work environment (including labor safety)	D	B	D	B	D	B	D	B	Construction period: - Workers may have accidents during construction service. Operation period: The labor accidents of workers may occur. - In the operation phase, works at a high place or

No.	Items	Assessment at the scoping				Assessment based survey results				The Result of Assessment
		Construction period		Operation period		Construction period		Operation period		
		Positive	Negative	Positive	Negative	Positive	Negative	Positive	Negative	
										generating loud noises may cause labor accidents.
【Others】										
1	Accidents	D	B	D	B	D	B	D	B	Construction period: - Traffic accidents may occur during operation of vehicles. Operation period: - Fire and traffic accidents by operation of facilities and / or vehicles may occur.
2	Cross-boundary Impact and Climate Change	D	D	D	B	D	D	D	B	Construction period: - Although CO_2 will be generated during construction, the impact shall be limited to a temporary period and is highly unlikely to have any impact across the borders and on climatic change. Operation period: - CO_2 is produced by the project operation, but a high-efficiency gas turbine will be installed. The project emission is 2,896,00 t-CO_2/y, and the reduction of emission is 2,782,527 t-CO_2/y as compared to the baseline emission of the existing power plants, 5,678,527 t-CO_2/y. Additionally, the total emission from thermal power generation in Iran based on the year 2015 is about 160 million t-CO_2 per year. The estimated emission from this project is only 1.8% of the total emission, and the impact is expected to be insignificant.

Note) Categories are classified as follows:
A: There will be a serious impact.
B: There will be a certain impact.
C: The extent of impact will be uncertain. (A further survey will be needed to make the expected impact clear.)
D: Impact will hardly be expected.

Source: prepared by JICA Study Team

6.8 Environmental Management Plan

6.8.1 Implementation System

(1) Construction Phase
At the construction phase, the power generation department of TPPH shall carefully consider all construction activities with the supervision consultant, and encourage the EPC contractor to fully understand the necessary mitigation measures and implement them.

In this regard, Project Management Team (PMT) shall be organized prior to the start of construction and an expert environmental management administrator in the PMT shall be employed. The unit will discuss and prepare mitigation measures with the supervision consultant and the EPC contractor prior to the start of construction.

A large inflow of workers is expected once construction begins. The PMT shall also function as a grievance organization seeking to understand and address any grievances from local people during the construction phase, and conduct appropriate mitigation measures.

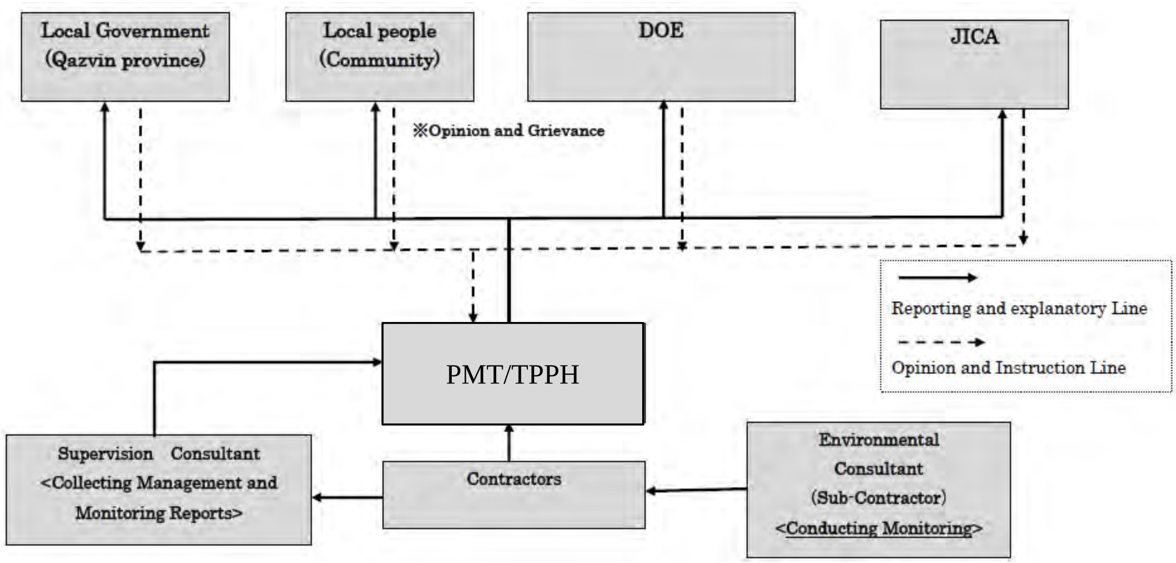
The PMT shall improve the understanding of the surrounding community regarding construction details, schedule and mitigation measures, and shall obtain local people's opinions and correct the mitigation measures as appropriate.

In order to confirm the implementation of environmental management and to consider further mitigation measures, the contractor should submit regular reports to the supervisory consultant and the PMT on the implementation status of the management plan.

The administrator of the PMT shall regularly hold explanation sessions with the local community, continuously listen to their grievances, submit reports to JICA and other relevant organizations regarding those grievances, as well as the implementation status of environmental management and environmental monitoring (described hereinafter).

If environmental problems occur due to construction work, the PMT shall confirm the cause with the contractor as soon as possible.
In order to resolve these problems, the administrator of the PMT shall instruct the contractor and consultant regarding necessary measures. If the problem is serious, TPPH may order the contractor to halt construction work until the problem is resolved.

Fig. 6-76 outlines the environmental management and monitoring implementation structure in accordance with the reporting flow during the construction phase.



Source: prepared by JICA Study Team

Fig. 6-76 Environmental Management Plan and Monitoring Implementation Structure in Construction Phase for Power Plant

(2) Operation Phase

The TPPH and power plant are responsible to develop and implement an environmental management plan that includes mitigation measures. An expert environmental management administrator in the TPPH and power plant shall be employed to ensure the environmental management plan is appropriately implemented.

The administrator shall encourage the project staffs to familiarize themselves with the environmental management plan prior to the start of plant operation, and shall regularly educate them regarding ongoing matters during the operation phase.

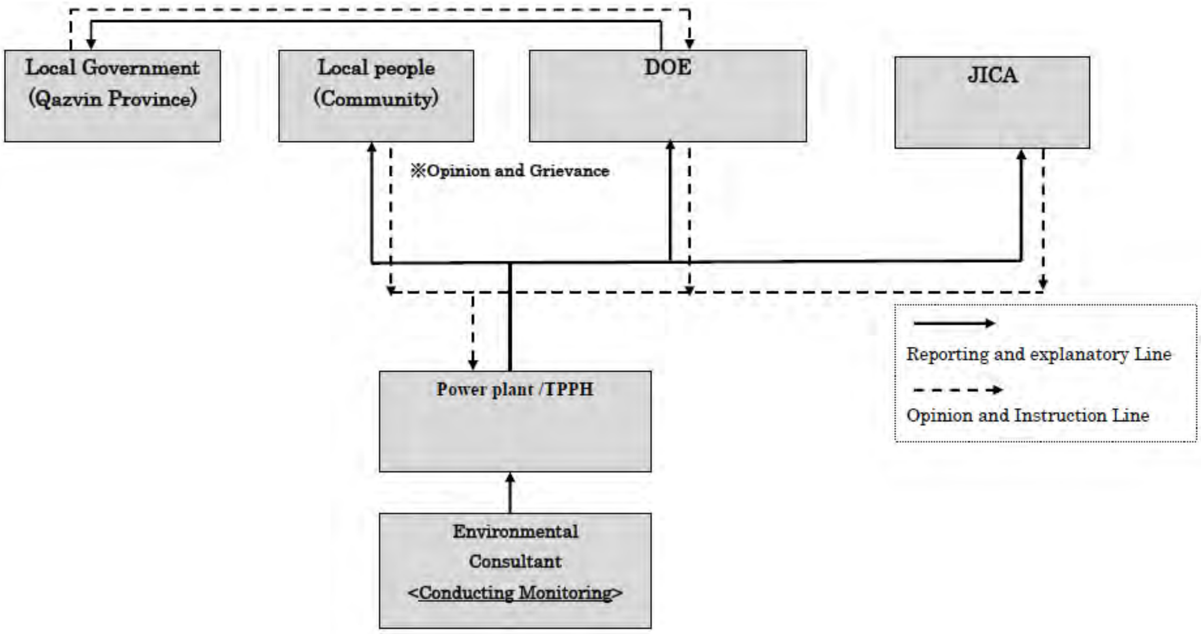
The administrator shall also function as a grievance organization and will strive to understand and address any grievances from the local people during the operation phase, and conduct appropriate mitigation measures.

The basic function of the environmental management plan is to closely cooperate with the local community, and to provide them with sufficient explanations based on positive mitigation measures, which is very important.

The administrator shall report the contents and implementation status of the environmental management plan and environmental monitoring plan described below to the director of the plant and the director of the responsible section, with the director of power plant taking final responsibility.

The administrator shall regularly provide explanations to the local community, continuously listen to their grievances, submit reports to JICA and other relevant organizations regarding those grievances, as well as on the implementation status of environmental management and environmental monitoring activities (described hereinafter).

Fig. 6-77 outlines the environmental management and monitoring implementation structure in accordance with the reporting flow during the operation phase.



Source: prepared by JICA Study Team

Fig. 6-77 Environmental Management Plan and Monitoring Implementation Structure in Operation Phase for the Power Plant

6.8.2 Environmental management plan

Table describes the environmental impact, mitigation measure, responsible organization and cost for each environmental item in construction and operation phase.

Table 6-44 Environmental Management Plan (Power Plant)

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
Construction Stage									
1	Air Pollution	1) Generation of fine particles from land preparation and other civil engineering work. 2) Exhaust gas from construction machinery and vehicles used for mobilization of equipment 3) Soot from field burning of waste	1)-3) - Ambient air quality standards (Iran) - IFC guideline values for ambient air quality (General/ 2007)	1) – 3) - Prevention of air pollution in the surrounding area	1) Dust - Generation of dust due to strong wind will be reduced with periodic watering (dry season) - Conduct washing of equipment and vehicles 2) Preventing exhaust gas emissions - Conduct periodical maintenance in the construction equipment and vehicles - Turn off engines on standby - Distribute construction work within schedule preventing concentration of work in short periods 3) Prohibit field burning of waste	1) - 3) - Construction area	1) - 3) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: TPPH/ Supervision Consultant	Expenses included in contract cost by TPPH and Contractor
2	Water Pollution	1) Wastewater from concrete 2) Oily wastewater 3) Wastewater from the construction site	1) - 3) - Water quality standards (Iran) - IFC/WB EHS guideline values for ambient air quality (General/ 2007)	1) - 3) - Prevention of water pollution of the irrigation canal	1) Installation of a neutralization tank 2) Installation of a provisional oil separator 3) Installation of a septic tank and temporary toilets for the workers	1) -3) - Construction area	1) - 3) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: TPPH/ Supervision Consultant	Expenses included in contract cost by TPPH and Contractor
3	Waste	1) General waste	1) – 2)	1)-2)	1) - 2)	1) - 2)	During	- Implementation:	Expenses

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
		generated in the construction phase (packaging, organic, etc.) 2) Hazardous waste generated in the construction phase (exhausted batteries)	- Waste management regulation (official name yet to be included in this document)	Prevention of soil and water pollution, malodors and hygiene issues	- Implement a waste management and disposal plan including education of site workers addressing waste reduction, recycling and inadequate waste disposal. -Litter separation and storage in an appropriate place and method. -Compliance with legislation regarding general waste and hazardous waste, and assuring they are adequately transported and treated in the facilities authorized by DOE, as in the case of the existing facility.	Construction area	construction phase	Contractor/ Environmental Consultant - Supervisor: TPPH/ Supervision Consultant	included in contract cost by TPPH and Contractor
4	Soil pollution	Leakage of lubricants and fuels collected by construction vehicles and other construction equipment	-Hazardous material regulation	Prevent soil pollution in the project site	Conduct the lubricants and oils collection in area where soil permeation does not occur (for examples, a concrete layer covered soil)	Construction area	During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: TPPH/ Supervision Consultant	Expenses included in contract cost by TPPH and Contractor
5	Noise and Vibration	1) Noise and vibration caused by construction machinery 2) Noise caused	1)- 2) - Noise level standards - IFC EHS guideline, noise	1)- 2) - Reduction of noise level from construction activities	1) Construction machinery - Perform construction work during daytime - Using low-noise/ low vibration equipment	1)- 2) - Construction area	1)- 2) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: TPPH/	Expenses included in contract cost by TPPH and Contractor

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
		by vehicles used for mobilization of equipment and workers	level values (General/ 2007)		2) Mobilization - Limit truck speed 1)- 2) Periodic checks and regular maintenance of construction equipment and vehicles Adjusting schedule so as to prevent the concentration of transporting vehicles on the site			Supervision Consultant	
6	Ground subsidence	Ground water intake	Water intake permission	Prevention of lowering of groundwater level and ground subsidence	Reduction of water intake by waste water reuse	Power plant	Operation period of the power plant	TPPH/ environmental Consultant	Expenses included in contract cost by TPPH and Contractor
7	Odor	Waste from construction site (domestic waste)	- Waste management regulation	Prevention of generation of malodors	- Education regarding litter separation and prohibition of illegal dumping - Organic waste will be collected and stored in a container with cap to prevent odor regarding organic waste, recipients with lids will be installed on the site and the waste periodically collected and disposed of by municipal waste company	Construction area	During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: TPPH/ Supervision Consultant	Expenses included in contract cost by TPPH and Contractor
8	Terrestrial ecosystem and rare species	1) Exhaust gas from construction machinery and vehicles used for mobilization of equipment	1) - 2) Same as “1) Air Pollution” 3) Same as “5) Noise and	1) - 2) Same as “1) Air Pollution” 3) Same as “5) Noise and	1) - 2) Same as “1) Air Pollution” 3) Same as “5) Noise and Vibration”	1)-3) Construction area	- During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: TPPH/ Supervision	Expenses included in contract cost by Contractor and TPPH

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
		2) Noise and vibration from construction machinery 3) Noise from transportation of workers and supplies	Vibration”	Vibration”				Consultant	
9	Hydrology (ground water)	Ground water intake	Water intake permission	Prevention of lowering of groundwater level	Minimization of water intake through water reuse	Construction area	Construction period	- Implementation: Contractor/ Environmental Consultant - Supervisor: TPPH/ Supervision Consultant	Expenses included in contract cost by Contractor and TPPH
10	Local economy including employment and means of livelihood	- Employment for local residents - Local supply and machinery	-	- Activation of the local economy - Increase the standard of living of the local population	- Employ as many local residents as possible - Use the services (i.e., laundry and catering services, etc.) and products offered by the local community	- Construction area	- During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: TPPH/ Supervision Consultant	Expenses included in contract cost by Contractor and TPPH
11	Water use	1) Groundwater intake 2) Wastewater from concrete 3) Oily wastewater 4) Domestic waste water from the site workers	1) Water intake permission 2)- 4) Same as “2) Water Pollution”	1)Prevention of lowering of ground water level 2)-4) Minimize the impact to fishery by preventing water pollution	1) Minimization of water intake through waste water reuse 2)- 4) Same as “2) Water Pollution”	1)-4) - Construction area	1)-4) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: TPPH/ Supervision Consultant	Expenses included in contract cost by Contractor and TPPH
12	Unfair distribution of damage and benefit	Employment distribution in the area could be unfair	-	Promote local employment and avoiding a feeling of	- Present employment opportunities with clearly explained pre-requisites	- Construction area	- During construction phase	- Implementation: Contractor/ Environmental Consultant	Expenses included in contract cost by Contractor and

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
				unfairness within the community				- Supervisor: TPPH/ Supervision Consultant	TPPH
13	Conflicts regarding benefits and damages within the region	Conflict between the local population and manpower coming from other regions	-	Cooperation with the local population	- Employ as many local residents as possible - Respect local habits and traditions - Promote cultural exchange with the local population (for instance, participating in a local event)	- Construction area and the surrounding area	- During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: TPPH/ Supervision Consultant	Expenses included in contract cost by Contractor and TPPH
14	Children's rights	Potential increase in school abandonment due to child labor	-	- Prohibit child labor	- Prohibit labor contracts with minors - Conduct periodical inspections regarding child labor	- Construction area	- During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: TPPH/ Supervision Consultant	Expenses included in contract cost by Contractor and TPPH
15	Infectious Diseases such as HIV/AIDS	- Temporary influx of migrant labor during construction may increase risk of infection	-	- Consideration of sanitation of local residents	- Education and training on workers' infectious disease and health care Installation of medical facility and medial staff. - Implementation of periodic medical check-ups	- Construction area	- During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: TPPH/ Supervision Consultant	Expenses included in contract cost by Contractor and TPPH
16	Work Conditions (Including Work safety)	High risk of labor accidents in construction work: - Handling heavy loads - Working at heights	- Work safety standards established in Iran - EHS Guidelines on the IFC/WB (General, 2007)	- Labor safety and prevention of health problems	- Prepare a manual for labor accident prevention including safety education and training: - Provide workers with appropriate protective equipment such as a helmet, safety boots, safety	- Construction area	- During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: TPPH/ Supervision Consultant	Expenses included in contract cost by Contractor and TPPH

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
		- High-noise work			belt, mask, electric shock prevention equipment, earplugs, etc. - Establish clear signs to identify the location of hazardous or toxic material - Create a “User Manual” for equipment such as cranes				
17	Accidents	Traffic accidents	-	Prevent traffic accidents	- Consider adequate traffic rules and timing - Compliance with local traffic rules and safe driving training	Roads surrounding the construction area	During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: TPPH/ Supervision Consultant	Expenses included in contract cost by Contractor and TPPH
Operational Stage									
1	Air Pollution	Operation of gas turbine generates emissions of NOx in case gas fuel is used, and emission of SOx, NOx, and PM in case light oil is used.	- Gas emission standards (Iran) - IFC/WB EHS guideline emission gas standard (Thermal power plant, 2008) -Air quality standards (Iran) -Air quality standards of IFC/WB EHS guideline(General, 2007)	- Prevention of air pollution in the surrounding area	- Introduction of Low NOx combustion technology to reduce the total emission of NO_2. - A continuous emission monitoring system (CEMS) will be installed in the duct, and emissions will be compared with international emissions standards and Iran’s standards	- Power plant	- During operational phase	- TPPH/ Environmental Consultant	Expenses of equipment included in contract cost by TPPH and Contractor. Other expenses included in the operation/maintenance cost of TPPH (2%/year of project cost).
2	Water Pollution	1) Oily water including rain water	1) - 2) - IFC/WB EHS guideline	1)-2) - Prevention of marine pollution	1) - Wastewater will be collected, and its related	1) - 2) - Power plant	1) - 2) - During operational	- TPPH/ Environmental Consultant	Expenses of equipment included in

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
		2) domestic waste water	effluent standard(Thermal power plant, 2008) -Iran's effluent standards - IFC/WB EHS guideline domestic wastewater standard(General, 2007)		neutralization, sedimentation and oil separation equipment will be installed. Treated wastewater will be periodically checked against the IFC/WB EHS standards 2) -Wastewater treatment for domestic water will be installed. The treated water will be periodically checked against IFC/WB EHS guideline and Iran's standard.		phase		contract cost by TPPH and Contractor. Other expenses included in the operation/maintenance cost of TPPH (2%/year of project cost).
3	Waste	1) Hazardous waste from wastewater treatment (sludge, oils) 2) Domestic waste from construction workers	1) - 2) - Waste management regulation	1) - 2) - Prevention of inadequate waste disposal	1) - 2) - Implement a waste management and disposal plan including education of site workers addressing waste reduction, recycling and inadequate waste disposal. -Litter separation and storage in an appropriate place and method. -Compliance with legislation regarding general waste and hazardous waste, and assuring they are adequately transported and treated in facilities authorized by DOE.	1) - 2) - Power plant	1) - 2) - During operational phase	- TPPH/ Environmental Consultant	Expenses included in the operation/maintenance cost of TPPH (2%/year of project cost)

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
					-				
4	Soil pollution	Leakage of lubricants and fuels used for operation of the facilities	-Hazardous material regulation	Prevent soil pollution in the project site	Conduct the lubricants and oils collection in area where soil permeation does not occur (for examples, a concrete layer covered soil)	Power plant	During operational phase	TPPH/ Environmental Consultant	Expenses of equipment included in contract cost by TPPH and Contractor. Other expenses included in the operation/maintenance cost of TPPH (2%/year of project cost).
5	Noise and vibration	1) Noise and vibration caused by construction machinery 2) Noise caused by vehicles used for mobilization of equipment and workers	1)-2 - IFC/WB EHS Guidelines noise level standards (General, 2007)	1)-2) - Mitigation of noise from the power plant -Mitigation of vibration from the power plant	1)-2) - Introduction of low noise type or enclosed type equipment - Maintaining equipment by periodical check - Introduction of low vibration equipment - Periodical check of equipment - Reduce vibration by selecting a solid foundation	1) - 2) - Power plant	1) - 2) - During operational phase	- TPPH/ Environmental Consultant	Expenses of equipment included in contract cost by TPPH and Contractor. Other expenses included in the operation/maintenance cost of TPPH (2%/year of project cost).
6	Land subsidence	Groundwater intake	Water intake permission	Prevention of lowering of groundwater level and ground subsidence	Reduction of water intake through waste water reuse	Power plant		- TPPH/ Environmental Consultant	Expenses included in the operation/maintenance cost of TPPH (2%/year of project cost).

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
7	Odor	Domestic waste from project workers (organic waste)	- Waste management regulation (official name yet to be included in this document)	Prevention of malodors	- Organic waste will be collected and stored in a container with cap to prevent odor. - Prohibit illegal dumping	Power plant	- During operational phase of the power plant.	- TPPH/ Environmental Consultant	Expenses of equipment included in contract cost by TPPH and Contractor. Other expenses included in the operation/maintenance cost of TPPH (2%/year of project cost).
8	Terrestrial ecosystem and rare species	1) Emissions of SOx, NOx, PM generated from the gas turbine 2) Operation of equipment generating noise 3) Operation of equipment generating vibration	1) Same as “Air Pollution” 2) - 3) Same as “ Noise and vibration”	1) Maintain conditions for the growth of native plant 2) - 3) Maintain conditions for the growth of native animals	1) Same as “Air Pollution” 2) - 3) Same as “Noise and vibration”	1) - 3) - Power plant	1) - 3) - During operational phase of the power plant	- TPPH/ Environmental Consultant	Expenses of equipment included in contract cost by TPPH and Contractor. Other expenses included in the operation/maintenance cost of TPPH (2%/year of project cost).
9	Hydrology (ground water)	Ground water intake	Water intake permission	Prevention of lowering of groundwater level	Minimization of water intake through water reuse				Expenses included in the operation/maintenance cost of TPPH (2%/year of project cost).
10	Local economy including employment	- Employment for local residents - Local supply and machinery	-	- Activation of the local economy - Increase the	- Employ as many local residents as possible - Use the services (i.e., laundry and catering	- Villages around the site - Power plant	- During operational phase of the power plant	- TPPH/ Environmental Consultant	Expenses included in the operation/maintenance cost of

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
	and means of livelihood			standard of living of the local population	services, etc.) and products offered by the local community				TPPH (2%/year of project cost).
11	Water Use	1) Plant wastewater 2) Oily water and rain water 3) Wastewater from the construction site	1) Water intake permission 2)- 3) Same as "Water Pollution"	1) Prevention of lowering of ground water level 2)-3) Minimize the impact to water quality ofthe irrigation canal by preventing water pollution	1) Minimization of water intake by waste water reuse 2)- 3) Same as "2) Water Pollution"	1)-3) Power plant	1) - 3) - During operational phase	- TPPH/ Environmental Consultant	Expenses included in the operation/maintenance cost of TPPH (2%/year of project cost).
12	Unfair distribution of damage and benefit	Employment distribution in the area could be unfair.	-	Promote local employment and avoiding a feeling of unfairness within the community	- Present employment opportunities with clearly explained pre-requisites	- Power plant	- During operational phase	- TPPH/ Environmental Consultant	Expenses included in the operation/maintenance cost of TPPH (2%/year of project cost).
13	Work Conditions (including work safety)	Labor accidents involving: Working at heights - High-noise work	- Occupational standards established in Iran - IFC/WB EHS Guidelines(General, 2007)	- Labor safety and prevention of health problems	- Prepare a manual for labor accident prevention including safety education and training: -- Provide workers with appropriate protective equipment such as a helmet, safety boots, safety belt, mask, electric shock prevention equipment, earplugs, etc. - Establish clear signs to identify the location of	- Power plant	- During operational phase	- TPPH/ Environmental Consultant	Expenses included in the operation/maintenance cost of TPPH (2%/year of project cost).

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
					hazardous or toxic material				
14	Accidents	1) Fire 2) Traffic accidents (especially at periodic inspections)		1) Fire prevention and fire extinguishing 2) Prevention of traffic accidents	1) Fire - Implement plan to prevent oil leakages - Installation of fire extinguishers - Installation of fire alarm systems - Establishment of fire brigade and training 2) Traffic accidents - Investigate adequate traffic rules and timing - Education to promote safe driving	1) Power plant 2) Roads surrounding the power plant	1) - 2) During operational phase	- TPPH/ Environmental Consultant	Expenses included in the operation/maintenance cost of TPPH (2%/year of project cost).
15	Transboundary effects and climate change	CO_2 emissions	Amount of CO_2 emissions	Reduction of CO_2 emissions per kW	Utilization of high-efficiency gas turbine	Power plant	During operational phase of the power plant	- TPPH/ Environmental Consultant	Expenses of equipment included in contract cost by TPPH and Contractor. Other expenses included in the operation/maintenance cost of TPPH (2%/year of project cost).

Source: prepared by JICA Study Team

6.9 Environmental Monitoring Plan

An Environmental Monitoring Plan will be prepared to provide guidelines for environmental management plan during construction and operation of the power plant.

The environmental components that will be monitored are those which will be negatively affected by the construction activities and to determine that the effectiveness of mitigation measures should be confirmed.

Environmental management is a sustainable way of planning, arranging, supervising, organizing, and developing the environment for the maintenance of the preservation of natural resources and the prevention or reduction of damage to the environment.

The major environmental impact, monitoring method, responsible organizations, and expenses for each environmental item in the construction and operation phases for the power plant are listed in Table 6-45.

Table 6-45 Environmental Monitoring Plan (Power plant)

No	Significant Impact to be Monitored	Monitored Parameter	Monitoring Method: Method of Collecting and Analyzing Data	Monitoring Method: Location	Monitoring Method: Duration and Frequency	Responsible Organization	Cost
Construction Phase							
1	Air pollution, terrestrial ecosystem and precious species	Air quality of the surrounding area - PM_{10}, SO_2, NO_2 - Ambient air quality standard of Iran - IFC/WB EHS guideline, ambient air quality standard (General/ 2007)	Analyzing air quality	Air quality of the surrounding area - 1 point: Residential area in the north of the power plant	-Once (1 week) in period where construction activity becomes maximum	- Implementation: Contractor/ Environmental Consultant - Supervisor: TPPH/ Supervision Consultant	Expenses included in cost by TPPH and contract cost by the Contractor. Measurement of air quality:6,000USD
2	Water pollution	-Quality of discharged water (TSS, pH, Oil, BOD, Coliforms, etc.) - Iran Wastewater discharge standards and ambient water quality standard - IFC/WB EHS guideline, wastewater standard (Thermal Power/ 2008)	- Evaluation of effect of the mitigation measure of water pollution	-Discharged water - 1 point:	-Discharged water - at the timing of discharge	- Implementation: Contractor/ Environmental Consultant - Supervisor: TPPH/ Supervision Consultant	Expenses included in cost by TPPH and contract cost by the Contractor. Measurement of water quality:2,000USD
3	Waste, Odor	- Type and volume of waste as well as disposal method - Waste management regulation	- Record of type and volume of waste as well as disposal method	- Contractor's office	- Continuously	- Implementation: Contractor/ Environmental Consultant - Supervisor: TPPH/ Supervision Consultant	Expenses included in cost by TPPH and contract cost by the Contractor.
4	Soil contamination	- Management record of oil and chemical substances. ・Leakage accident	- Record of type and volume of waste as well as disposal method	Contractor's office	- Continuously	- Implementation: Contractor/ Environmental Consultant - Supervisor: TPPH/ Supervision Consultant	Expenses included in cost by TPPH and contract cost by the Contractor.
5	Noise and Vibration	Noise level - Noise standards - IFC/WB EHS guideline, noise level standard (General/2007))	- Measurement using noise level meter	- 5 points: On the border of the site (4 points), the residential area near the	-Once (one week) in period where construction activity	- Implementation: Contractor/ Environmental Consultant - Supervisor: TPPH/ Supervision Consultant	Expenses included in cost by TPPH and contract cost by the Contractor. Measurement of noise

No	Significant Impact to be Monitored	Monitored Parameter	Monitoring Method			Responsible Organization	Cost
			Method of Collecting and Analyzing Data	Location	Duration and Frequency		
				power plant (1 point)	becomes maximum		level:5,000USD/year
6	Ground subsidence, hydrology, water use	Groundwater level of the well	Measurement of groundwater level	7 points at the existing wells	Regularly.	Implementation: Contractor/ Environmental Consultant - Supervisor: TPPH/ Supervision Consultant	Expenses included in cost by TPPH and contract cost by the Contractor.
7	Terrestrial ecosystem and precious species	-Land modification -Generation of air pollution, noise and vibration.	-Record of precious species of reptile.	-The project site and the surrounding area.	-Regularly.	-Implementation: Contractor/ Environmental Consultant - Supervisor: TPPH/ Supervision Consultant	Expenses included in cost by TPPH and contract cost by the Contractor.
8	Local economy including employment and means of livelihood, Unfair distribution of loss and benefit, Conflict of interests within the local area	-Number of workers employed from the local area and the number of the subcontractor in the local area.	-Information from the relevant organizations -Interview with the local people	-Contractor's office -Construction area	- Continuously	Implementation: Contractor/ Environmental Consultant - Supervisor: TPPH/ Supervision Consultant	Expenses included in cost by TPPH and contract cost by the Contractor.
9	Rights of children	Existence of child labor	Confirmation of the work contract of the subcontractor Record of regular patrol	-Contractor's office -Construction area	- Continuously	- Implementation: Contractor/ Environmental Consultant - Supervisor: TPPH/ Supervision Consultant	Expenses included in cost by TPPH and contract cost by the Contractor.
10	HIV/AIDS and other infectious diseases	-Record of training -Record of health check -Record of medical treatment	-Record of training -Record of health check	-Contractor's office	- Continuously	- Implementation: Contractor/ Environmental Consultant - Supervisor: TPPH/ Supervision Consultant	Expenses included in cost by TPPH and contract cost by the Contractor.
11	Work Environment	Record of accidents - Handling heavy loads	- Record of accidents	- Contractor's office	- Continuously	- Implementation: Contractor/	Expenses included in cost by TPPH and contract cost by the

No	Significant Impact to be Monitored	Monitored Parameter	Monitoring Method			Responsible Organization	Cost
			Method of Collecting and Analyzing Data	Location	Duration and Frequency		
	(Including Work Safety)	- Working at heights - Electric shock				Environmental Consultant - Supervisor: TPPH/ Supervision Consultant	Contractor.
12	Accident	-Record of accidents -Driving of vehicles	-Record of accidents	- Contractor's office	- Continuously	- Implementation: Contractor/ Environmental Consultant - Supervisor: TPPH/ Supervision Consultant	Expenses included in cost by TPPH and contract cost by the Contractor.
Operation Stage							
1	Air pollution, terrestrial ecosystem and precious species	1)Exhaust gas SOx, NOx, PM - Emission gas standards of Iran - IFC/WB EHS guideline, emission gas standard(Thermal power plant/ 2008) 2)Ambient air of the area : SO_2, NO_2, PM_{10} - Ambient air quality standards of Iran - IFC/WB EHS guideline, e Ambient air quality standards (General / 2007)	1) Exhaust gas - CEMS (Continuous Emission Monitoring System) 2) Ambient air quality analysis	1) Stack outlet 2) 5 points in the surrounding residential area (based on the prediction result and according to the measurement points of the current air quality survey)	1) Continuous measurement of gas emission 2) 4 times a year (24 hours, one week) for the first 3 years of operation	- TPPH/ Environmental Consultant	- CEMS Expense of CEMS installation included in cost by TPPH and contract cost by the Contractor. Management and measurement of CEMS included in the operation/maintenance cost of TPPH (2%/year of project cost). Air quality measurement:40,000USD$/year
2	Water pollution	-Quality of discharged water (TSS, pH, Oil, BOD, Coliforms, etc.) - Wastewater discharge standards of Iran - IFC/WB EHS Guideline, wastewater standard (Thermal Power plant, 2008)	- Evaluation of effect of the mitigation measure of water pollution	1) Discharged water - 1 point: outlet point of wastewater treatment plant	1) Discharged water -4 times a year	- TPPH/ Environmental Consultant	Water quality measurement:8,000USD$/year
3	Waste, odor	- Type and volume of waste as well as disposal method - Waste management regulation	- Record of type and volume of waste as well as disposal	- Power plant office	- Continuously	- TPPH	Expenses included in the operation/maintenance cost of TPPH (2%/year of project cost).

No	Significant Impact to be Monitored	Monitored Parameter	Monitoring Method			Responsible Organization	Cost
			Method of Collecting and Analyzing Data	Location	Duration and Frequency		
			method				
4	Soil contamination	- Management record of oil and chemical substances. ・Leakage accident	- Record of type and volume of waste as well as disposal method	- Power plant office	- Continuously	- TPPH	Expenses included in the operation/maintenance cost of TPPH (2%/year of project cost).
5	Noise and Vibration	Noise level - Noise standards - IFC/WB EHS guideline, noise level standard (General/2007))	- Measurement using noise level meter	- 5points: On the border of the site (4 points added to the existing facility), one point (residential area near the power plant)	-Four times a year	- TPPH/ Environmental Consultant	Noise level measurement:20,000USD$/year
6	Ground subsidence, hydrology, water use	Groundwater level of the well	Measurement of groundwater level	7 points at the existing wells	Regularly	Implementation: Contractor/ Environmental Consultant - Supervisor: TPPH/ Supervision Consultant	Expenses included in the operation/maintenance cost of TPPH (2%/year of project cost).
7	Terrestrial ecosystem and precious species	-Generation of air pollution, noise and vibration.	-Record of precious species of reptile.	-The project site and the surrounding area.	-Regularly.	-TPPH	Expenses included in the operation/maintenance cost of TPPH (2%/year of project cost).
8	Local economy including employment and means of livelihood, Unfair distribution of loss and benefit	-Number of workers employed from the local area	-Record of employment	-Power plant office	- Continuously	- TPPH	Expenses included in the operation/maintenance cost of TPPH (2%/year of project cost).
9	Work Environment (Including Work	- Labor accidents - Handling heavy loads - Working at heights	- Record of accidents	-Power plant	- Continuously	- TPPH	Expenses included in the operation/maintenance cost of TPPH (2%/year of project cost).

No	Significant Impact to be Monitored	Monitored Parameter	Monitoring Method			Responsible Organization	Cost
			Method of Collecting and Analyzing Data	Location	Duration and Frequency		
	Safety)	- Electric shocks					
10	Accident	-Record of fire accidents	-Record of accidents	- Power plant office	- Continuously	- TPPH	Expenses included in the operation/maintenance cost of TPPH (2%/year of project cost).
11	Transboundary effects and climate change	- Amount of CO_2 emissions	- Calculation of CO2 emission based on the fuel consumption.	- Power plant office	- Once a year	- TPPH	Expenses included in the operation/maintenance cost of TPPH (2%/year of project cost).

Source: prepared by JICA Study Team

6.10 Stakeholder Meeting

6.10.1 Scoping phase

The assumed range of impact of the project such as air pollution and noise is within the radius of 2 to 3 kilometers in construction phase. Also in the operation phase, the noise level is predicted to be sufficiently low within this range, the area of the maximum concentration in ambient air is expected to be within the range of 10 kilometer radius, and all other impacts of the project are expected to be limited within this range as well.
In this regard, the outline of the project was explained in advance to the relevant organizations and the leaders of each district within the area described above and invitation letters were sent. The summary of the explanation was distributed in advance to the leaders and the local residents were asked for participation.

The timing of holding each stakeholder meeting, the target participants, explanation contents and the outline of Q & A at the time of scoping are shown in Table 6-46 and Table 6-47.

The staffs of the environmental department in the surrounding municipality and the settlement leaders were concerned about the impact of water consumption and the air pollution in the surrounding residents and agriculture. Concerning the adaption of forced-draft cooling tower system and air quality, increase of investigation points to 5 points at different times was an important issue.

Table 6-46 Overview of the Stakeholder Meetings

Date and time	July 17, 2017
Place（plan）	Meeting room in Shahid Rajaee Power Plant
Object participants	Leaders of the settlement (4), local municipal officials in the environmental department and officials of the relevant governmental organization (DOE)(10), Local residents(3:including university professor in environmental science)
Contents of explanation	・Project overview ・Draft scoping ・Survey items and method, evaluation method, etc

Source: prepared by JICA Study Team

Table 6-47 Main questions, opinions and answers at the First Stakeholder Meeting

Questions/opinions（speaker）	Answer
It is necessary to thoroughly examine whether the future environmental pollution and water consumption will be reduced with the latest generation equipment.（local municipal officials in the environmental department）	In Qazvin province, the growth rate of electricity demand is about 10% per year. This project will reduce pollutant emissions per kwh. （TPPH）
I would like to know whether renewable energy is a better choice or not for this scale of generation capacity.（Local resident）	Regarding the power generation facility of this capacity, the stability is the most important in view of voltage of transmission line net and others, and I am confirmed that this project is the best choice. （TPPH）
What about the employment creation and impact on agriculture?（Settlement leader）	For non-experts, we are planning to employ local people as much as possible. Regarding the impact of agriculture, we believe that there will be no impact as long as the standards and guidelines of the Environment Bureau are met. （TPPH）

What kind of technology transfer is there due to the construction of the gas turbine (local resident)	This is an issue to be considered, and for construction, we are planning to employ 30% of the staff locally. （TPPH）
In order to make effective use of the results of the simulation, I propose to measure the air quality at different times at around 5 points.(environmental expert in University)	We will consider the opinion. （TPPH）
How much water consumption is expected in the new power plant? We are concerned about the impact. (municipal water office)	280m^3 per day will be consumed in the plan. Installation of the forced draft air-cooled cooling tower will be examined. （TPPH）
How much MW will be distributed to Qazvin province? (municipal officer in the relevant department)	This issue will be discussed by the relevant organization. （TPPH）

Source: prepared by JICA Study Team

6.10.2 Questionnaire survey

In the EIA procedure in Iran, information disclosure and stakeholder's meeting are not conducted. The first stakeholder meeting was mainly attended by the municipal officers and leaders of the settlement, with little participant from the general inhabitants, and no women participated.

The participation of the general inhabitants and women to the stakeholder's meeting is difficult due to the religious and customary situation in this area, and for this reason, the questionnaire was conducted with the aim of collecting as much as possible the opinions of female residents and ordinary people.
10 villages around the power station were selected and a questionnaire survey was conducted with 2 men and 2 women from each village.

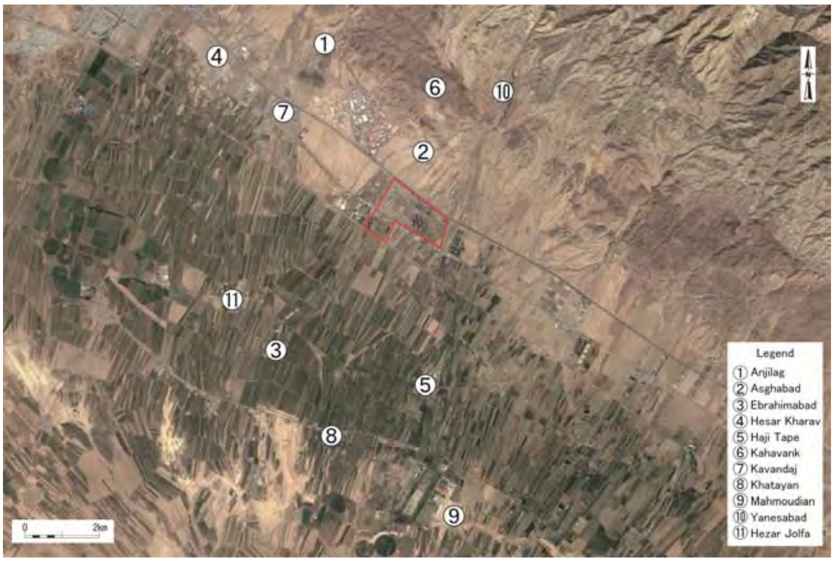
The implementation of the questionnaire had to be conducted upon prior consultation with the leader of each settlement, which was difficult in certain cases. The survey could be actually conducted for male and female among general inhabitants in 10 villages, respectively. Among them, the questionnaire was conducted in 9 villages for both man and women whereas it could be conducted for either men or women in 2 villages.

The implementation period and the target village of the survey are shown in Table 6-48 and Fig. 6-78.

Table 6-48 Implementation schedule of questionnaire survey

No.	Activity	2018									
		3	4	5	6	7	8	9	10	11	12
1	Preminlery work for interviews such as translation in Farsi and coordination meeting with our experts										
2	Coordination meeting with local leaders, and residents										
3	Interview with the males residents										
4	Coordination meeting with local leaders, for females Interview										
5	Interview with the females residents										
6	Summary Report -Household Individual Interview Survey on Socio-Economic Aspects										

Source: prepared by JICA Study Team



Source: obtained from Google Earth and prepared by Study Team

Fig. 6-78 Villages targets of questionnaire survey

The survey was conducted using questionnaire form to collect data including occupation, age, education history, electricity and fuel use situation, water use, main diseases, medical institutions, problem awareness about pollution, income, expenditure, opinions on the existing power plant and new power plant.

According to the results of the questionnaire survey from the residents, regarding the current environmental situation, dust in the air is the issue of concern, which represents the characteristics of the area with little precipitation and sand dust frequently occurs in strong wind.

Both males and females who were the subject of the questionnaire survey had mainly the following opinions about the implementation of this project at the existing power station.
· The existing power plants should be updated against contamination with the latest technology.
· The local labor force should be utilized during construction and operation.

6.10.3 EIA preparation phase

In the area around the project site, important information is conveyed through spoken communication from the settlement leader to the general residents. In this regard, prior to the second stakeholder meeting, the outline of the project will be explained to the relevant organization and the leader of the settlement so that the general people including women can learn the necessary information and are encouraged to participate to the stakeholder meeting. The EIA summary material will be disclosed on the TPPH web site for a certain period of time and opinions will be invited.
Table 6-49 and Table 6-50 show the outline of the stakeholder meeting at EIA preparation including the time of meeting, the object persons, contents of explanation and the main questions and answers.
15 people were invited including the personnel of the environmental department in the surrounding municipality and residents including women. A general understanding was obtained on that the project relates to the most advanced combined cycle power plant which enables smaller water consumption and low environmental load on ambient air, and no particular

objection was shown from the participants.

Table 6-49 Overview of the implementation of the second stakeholder meeting

Date	July 4, 2018
Place（plan）	Shahid Rajee Power Plant meeting room
Participants	Community leader（2）, department of the environment personnels of the surrounding minicipality（DOE）and related organizations （5）、local residents（15, including 8 women）
Content of explanation	Explanation of the attached document-2 in local language(Persian) ・Project overview (water use, fuel use, etc) ・Survey result（air quality, noise, ground water, etc） ・Estimation result（air quality, noise, ground water, etc） ・Mitigation measures, monitoring plan

Source: prepared by JICA Study Team

Table 6-50 Main questions, opinions and answers at the second stakeholder meeting

Questions and opinions（speaker）	Answer
The power generation of Qazvin State in the average is more than 5 times the power consumption of Qazvin State. At the peak period, the power generation is more than twice of the power consumption of Qazvin State. Qazvin profits from good wind power, and it would be more favorable to abandon the old power plant within 5 to 15 years and construct a new wind power plant. I think it is better to convert the cost for contrition of the combined cycle into construction of the wind power station which may solve many environmental problems.	The total power generation needs in Iran will reach at least 120 thousand MW by 2025. The request from the State of Iran for cooperation from Japan is to construct a new J class power plant with high technology and to modernize the present power plant, and construction of wind power or solar power plant is not included. （TPPH）
In order to maintain (secure) the power source and voltage, the power plants should be distributed over the country. Why is additional investment planned in the power development in Qazvin State? (administrative department of the municipality)	At present, the government is presenting private sector investors with the construction of combined power plants, the construction of distributed power plants, and the construction of wind power plants. The maximum output of a wind power station is 8 hours a day, and it is necessary to secure stable power production means for the remaining 16 hours, and also there is a need from the production department for a power station to generate permanent electricity. It should be noted that renewable energies are also not completely free from environmental impact. Power stations require a large land and significant land modifications. Shahid Rajaee power station occupies only 350 hectares of area. The construction of renewable power stations in some countries aims at the reduction of fossil fuels, but Iran has a large amount of gas production, and it is necessary to utilize such energy. （TPPH）
Will Japan continuously cooperate with Iran in this project? (administrative department of the municipality)	The situation in the world is changing, but we need to cooperate with Japan for the implementation of the project.
I wish the employment of the local people for construction and operation of the facility (resident, women)	It is necessary to acquire experience, training and specialized learning for employment at the power station. People who want to learn are invited to the training course, and after the end of the training course, they can take the employment test at the Ministry of Energy. We plan to hire 30% of the planned employment from the local area.

Source: prepared by JICA Study Team

6.11 Confirmation on the Land Acquisition and Resettlement Action Plan (LARAP)

(1) Power plant site
The project site is located in the site of the existing power plant and in an area where land preparation has already been completed; therefore, land acquisition will not occur.

There is no house within the site and the nearest residential area is a small village located about 1.5 km to its north and there is no residential area nearer to the power plant. Consequently, resettlement will not occur.

(2) Associated facility site
The electricity generated by this project is planned to be transmitted using the existing 400 kV transmission line and new transmission line will not be constructed.

Fuel to be used for power generation will be supplied from the gas pressure reducing facilities outside the site currently in use for the existing power plant through a new pipeline to be installed in the existing pipeline installation area in the site.

Also, gas oil will be supplied from the gas oil tank installed for the existing power plant via a pipeline planned to be newly constructed within the site. In consequence, additional land acquisition and resettlement of the local residents will not occur.

6.12 Considerations on the Schedule for Obtaining the Environmental

Regarding the EIA approval schedule, risk assessment is considered an important item, and a detailed safety analysis method, which is normally not required in the EIA in other countries, is required for the gas supply facility and the incineration facility, which are not a subject in the F/S report by the Study Team. In this regard, an additional period for implementing risk assessment will be necessary based on F/S report by employing a consultant. In consequence, TPPH considers that it will take approximately one year for obtaining the approval from DOE after receiving F/S report from the Study Team.

The EIA report will be disclosed in Persian language at the state and provincial DOE.

During the construction and operation, licensing other than EIA is not required, but the approval by TPPH is necessary for the monitoring results during construction and operation submitted from TPPH in relation to the EIA. The results of the monitoring are published at the local DOE.

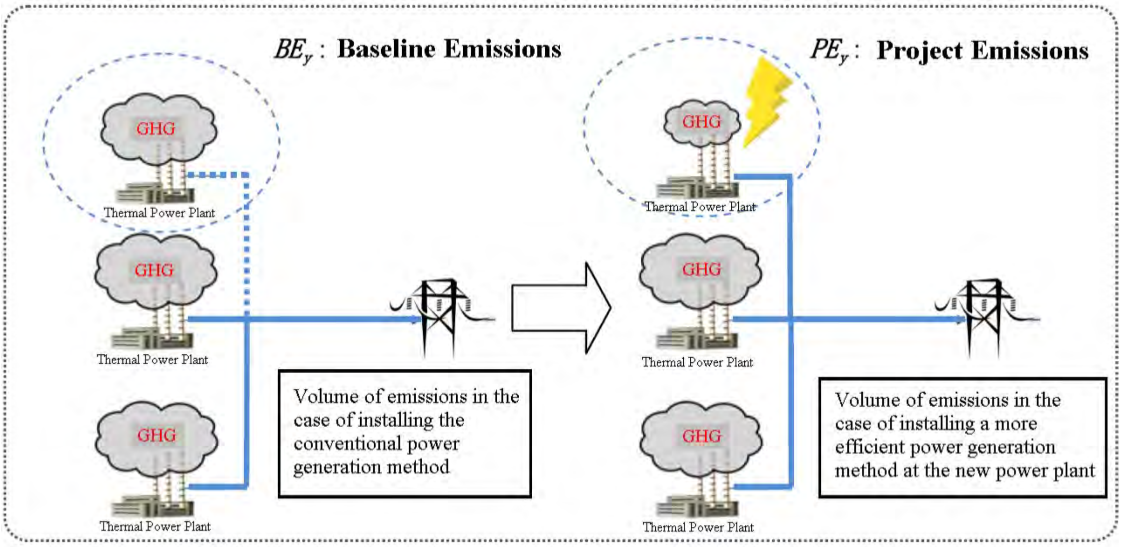
In concrete, the monitoring reports during construction and operation phase (including working safety report) will be submitted every month to DOE, and will be examined by the monitoring committee consisting of DOE and TPPH every three months.

6.13 Estimation of Greenhouse Gas Reductions

6.13.1 Methodology

This project is identified as a climate change mitigation project, and its mitigation effect was calculated in reference to “JICA Climate-FIT (Mitigation) Climate Finance Impact Tool for Mitigation, 2011”. The calculation method for greenhouse gas (GHG) emission reduction is shown below (Fig. 6-79).

ER_y: GHG emission reduction in year y achieved by project (t-CO_2/y)
BE_y: GHG emission in year y with low-efficiency power generator (t-CO_2/y) (Baseline emission)
PE_y: GHG emission in year y after efficiency improvement (t-CO_2/y) (Project emission)



Source: JICA Climate-FIT (Mitigation) Climate Finance Impact Tool for Mitigation, 2011

Fig. 6-79 Images of Emissions Reductions

(1) Baseline emission

Since the amount of power output in the grid before the start of the project is supposed not changed after the completion of the project, the power output reduced by the existing power plant shall be equivalent to the power out generated by the new power plant.

$$BE_y = EG_{BLy} \times EF_{BLy}$$

Where,

BEy: Baseline emission (GHG emission with low-efficiency existing power plants), (t-CO_2/y)

EG_{BLy}: Reduction of net electrical output by the existing power plants, which shall be equivalent to the power output of new power plant EG_{PJy}, (MWh/y)

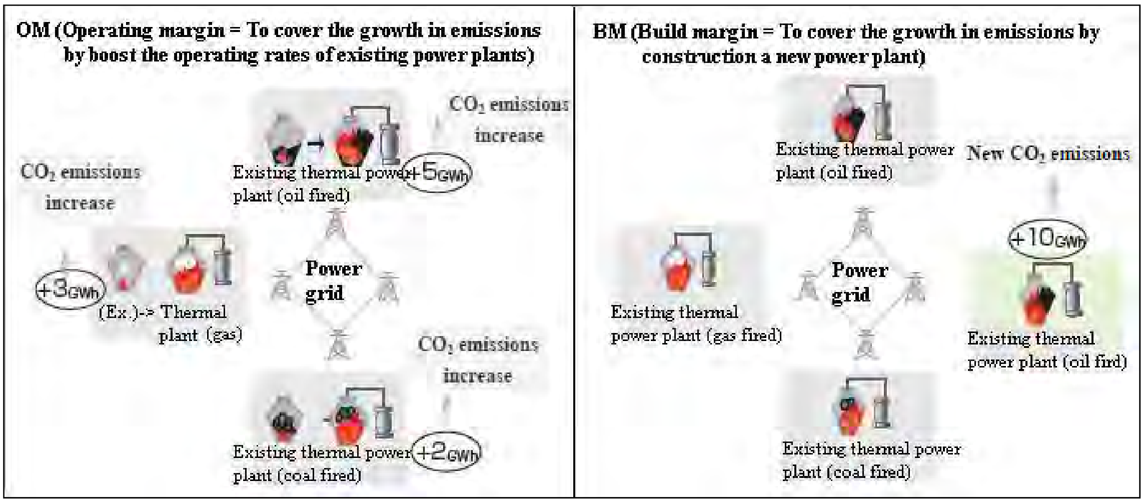
EF_{BLy}: CO_2 emission factor of the electricity for the low-efficiency power plant, (t-CO_2/MWh)

There are three options for calculations of baseline emission coefficient (t-CO_2/MWh)

Option 1 : the build margin emission coefficient (t-CO_2/MWh)

Option 2 : the combined margin emission coefficient (using a 50/50 operating margin/build margin weight)
Option 3 : emission coefficient (t-CO_2/MWh) identified as the most likely baseline scenario

The images of operating margin (OM) and build margin (BM) emissions coefficient are shown in Fig. 6-80.



Source: http://gec.jp/gec/jp/Activities/cdm_meth/pACM0002-old-080414.pdf

Fig. 6-80 Images of OM and BM

(2) Project emission

Project emission shall be determined by multiplying the net power output produced by the new power plant and the CO_2 emission factor of electricity for the new power plants.

$$PE_y = EG_{PJy} \text{ x } EF_{PJy}$$

Where,

$PE_{PJ,y}$: Project emission (GHG emission after project activity (t-CO_2/y))

$EG_{PJ,y}$: Yearly electricity generating capacity after the project (transmission end efficiency) (MWh/y)

$EF_{PJ,y}$: CO_2 emission coefficient of electricity generation (t-CO_2/MWh)

6.13.2 Calculation of project CO_2 emission factor of electricity: EFPJy

CO_2 emission coefficient of electricity for the new power plant is calculated using the planned data of CO_2 emission factor of fuel and generation efficiency and power output for the new power plant before the project starts, and the measured data shall be used after the project is completed.

CO_2 emission factor of fuel "i" shall be the same as of the baseline, since the fuel properties are the same for the both cases.

$$EF_{PJ,y} = \{COEFi / (\eta_{PJ,y/100})\}\text{x } 0.0036$$

Where,
EF_{PJy}: Project CO_2 emission factor of electricity, (t-CO_2/MWh)
$COEF_i$:CO_2 emission coefficient of fuel "i" per calorific value, (t-CO_2/TJ)
$\eta_{PJ,y}$: Planned value of generation efficiency after improvement, (%)
0.0036: Conversion factor of electric energy (megawatt hour) to thermal energy (tera-jule), (TJ/MWh)

6.13.3 Estimation of effect of greenhouse gas emissions reductions

(1) Baseline emission

IGES (Institute for Global Environmental Strategies) of Japan provides three emission factors as below for Iran.

Table 6-51 Grid CO_2 Emission Factors in Iran

Margin	Unit	Average
Combined Margin (CM)	t-CO_2/ MWh	0.669
Operation Margin (OM)	t-CO_2/ MWh	0.692
Build Margin (BM)	t-CO_2/ MWh	0.646

Source: http://pub.iges.or.jp/modules/envirolib/view.php?docid=2136

Since not only combined cycle power plants but also conventional thermal power plants are programmed for the future plan in Iran, using combined margin (CM) as baseline emission seems to be more conservative and appropriate than using build margin (BM). Therefore, we adopt here combined margin (CM) as baseline emission factor.

Baseline Emission Coefficient: 0.669 (t-CO_2/ MWh)

(2) Project emission

Regarding Shahid Rajaee GTCC, the CO_2 emission factor of fuel i: COEFi and CO_2 emission factor of electricity: $EF_{PJ,y}$ can be calculated using the same equations as for the old power plants by only changing the figure of generation efficiency from Table 6-51. The results are as shown in Table 6-52.

Table 6-52 Calculation of CO_2 emission coefficients for Shahid Rajaee Project

Item	Unit	Value	Remarks
Total power generation	MW	1,117.6	558.8MW×2
Gas turbine	MW	766.8	383.4×2
Steam turbine	MW	350.8	175.4×2
Capacity factor(CF)	%	86.7	
Higher heating value, HHV	kJ/kg	50,370	
Lower heating value, LHV	kJ/kg	45,370	
Carbon content in fuel, C%	weight%	68.90	
CO_2 emission coefficient of fuel, COEFi	t-CO_2/TJ	55.64	Note-[1)]
Net generation efficiency of new power plant, $\eta_{PJ/y}$	%	58.7	

Item	Unit	Value	Remarks
Conversion factor of electric energy (megawatt hour) to thermal energy (tera-jule)	TJ/MWh	0.0036	
CO_2 emission coefficient of electricity generation, $EF_{PJ,y}$	t-CO_2/MWh	0.3412	Note-2)

Note:

1) CO_2 emission factor of fuel i,
   COEFi = (C%/100) / LHV x (44.01/12.011) x 10^6
2) CO_2 emission factor of electricity, $EF_{PJ,y}$={COEFi / (η_{PJy} / 100)} x 0.0036

Source: prepared by JICA Study Team

(3) Trial calculation of GHG reduction

Table 6-53shows a trial calculation result of CO_2 emission reduction of the project based on the expected performance data for the combined cycle plant The baseline emission BEy is 5,678,527 t-CO_2/y, and the project mission PEy is 2,896,00 t-CO_2/y, and consequently the reduction of emission is 2,782,527 t-CO_2/y.

Table 6-53 Production and CO_2 Emission by Shahid Rajaee GTCC

Item	Unit	Value	Remarks
Gross power output of GTCC	MW	1,117.6	
Gross thermal efficiency	%	58.7	
Capacity factor	%	86.7	CF
Electricity generation	MWh	8,488,082	MWx8760x(CF/100)
Annual CO_2 emission	ton	2,896,000	Fx8760*(CF/100)x(C%/100)
Baseline CO_2 emission factor of electricity	ton/MWh	0.669	
Project CO_2 emission factor of electricity	ton/MWh	0.341	
Baseline emission, BEy	t-CO_2/y	5,678,527	
Project emission, PEy	t-CO_2/y	2,896,000	
Reduction of emission,	t-CO_2/y	2,782,527	

Source: prepared by JICA Study Team

6.14 Others

6.14.1 The checklist

Table 6-54 shows environmental checklist for the power plant.

Table 6-54 Environmental Checklist (Power plant)

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
1 Permits and Explanation	(1) EIA and Environmental Permits	(a) Have EIA reports been already prepared in official process? (b) Have EIA reports been approved by authorities of the host country's government? (c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied? (d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	(a) N (b)N (c) N (d) N	(a) - for the construction of a new power plant over 100MW, the preparation of the EIA is required . (b) - The EIA report shall be examined by Qazvin Province Environmental Department and the Department of Environment (DOE) for approval. (c) - Draft EIA is currently under preparation, and waiting for the formal procedure. (d) - There is not any environmental permit other than EIA that need to be acquired by the project proponent.
	(2) Explanation to the Local Stakeholders	(a) Have contents of the project and the potential impacts been adequately explained to the Local stakeholders based on appropriate procedures, including information disclosure? Is an understanding obtained from the Local stakeholders? (b) Have the comment from the stakeholders (such as local residents) been reflected to the project design?	(a)N (b)N	(a) Although the EIA regulation of Iran does not include regulation on the information disclosure and explanation to the local people, the stakeholder meeting was held according to JICA guidelines at the scoping phase and the EIA phase, with the participation of the leader and inhabitants of the nearby settlement, the administrative officer of Qazvin province, based on the disclosed information regarding the overview of the project, alternatives, environmental impact assessment, the summary of the environmental management plan. (b)- In view of the suggestion raised at the stakeholder meeting regarding the consideration of the possibility of reduction of groundwater use, forced-draft cooling fan system is selected in this project which requires less water use. Also, the project will adopt a state-of-the-art environmental friendly power plant reflecting the local people’s opinion.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	(3) Examination of Alternatives	(a) Have alternative plans of the project been examined with social and environmental considerations?	(a) Y	(a) - Alternative plans of the project are being examined in regard to the case of implementation and non-implementation of this project , new alternative site, generating system, cooling system of the condenser cooling water.
2 Pollution Control	(1)Air quality	(a-1) Do air pollutants including sulfur oxide (SO_2) and nitrogen oxide (NO_2) and dust emitted from the operating power plant comply with the emission standard of Iran? (a-2) Is there some area where air pollutant emitted from the power plant does not satisfy the environmental standard of Iran?	(a-1)Y (a-2)N (b)N/A	(a-1) Gas and light oil will be used as the fuel at the power plant. SOx, NOx, and PM will be emitted by the operation of gas turbine. The gas turbine adopted in this project is equipped with a low-NOx burner as a mitigation measures for reduction of NOx level. In this manner, the emission concentration of air pollutant in the exhaust gas will meet the emission standard of Iran or the standard value of IFC/WB EHS guidelines (thermal power plant, 2008). (a-2) - Gas and light oil will be used as the fuel at the power plant. SOx, NOx, and PM will be emitted by the operation of gas turbine, causing impact on a broad area. According to the field survey conducted by the Survey Team, it was found that the north side of the proposed power plant site is a high-elevation area; therefore, there is a possibility that a part of the area may have high concentration of pollutants emitted from the stack for a certain period, depending on the wind direction. -Wind speeds exceeding 10m/s are extremely rare, so downwash is not expected to occur. - Around the stack, there is no building as occurrence of downdraft. -The maximum concentration at the ground level of pollutants is extremely low compared to the Iran's standard and IFC/WB guidelines. - Future maximum concentration at ground level obtained by adding the contribution by the current power plants and the future contribution of the new facility is extremely small in increase from the current concentration , except SO_2 concentration, and will comply with Iran's standards and the IFC/WB guidelines. SO_2values may slightly increase, but the actual concentration is predicted to be in accordance with the environmental standard of Iran. (b) The project uses gas and light oil for fuel, not coal-fired power plant.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	(2) Water Quality	(a-1) Does waste water from the power plant including thermal water comply with the effluent water standard of Iran? (a-2) Is there a possibility that in certain area the environmental standard of Iran is not satisfied or high-temperature water area emerges due to water discharge? (b) In case of coal-fired power plant, does leachate from coal storage site or coal disposal site meeti the environmental standard of Iran? (c) Will any mitigation measure be conducted so as not to contaminate surface water, soil and groundwater and sea water?	(a-1) Y (a-2)N (b) N/A (c) Y	(a-1) The power plant uses a steam turbine and cooling water from the condenser will be reused through forced-draft direct cooling system so that thermal water will not be discharged. Waste water mainly consists of regeneration waste water from demineralization plant and from Boilers Heat Recovery Steam Generators (HRSG), which are not large in amount in a normal operation. Oily drainage wastewater from the condenser and the light oil tank will be generated accompanying domestic sewage from office and accommodation for staff and rain water. The total amount of waste water will be approximately 380m3 per day at the maximum. Wastewater from water purification system and waste water from the exhaust heat recovery boiler is treated with neutralization and sedimentation treatment system and is examined for compliance with waste water quality standards of Iran and of the IFC/EHS Guideline for thermal power plants (2008). Oily drainage wastewater will be collected in the wastewater treatment system for oil separation to comply with water quality standards of the IFC/EHS Guideline for thermal power plants (2008). Domestic wastewater from worker’s camp is treated in the septic tank to comply with Iran's standards and IFC/EHS Guideline values (general, 2007). All these waste water is discharged into the drainage tank, similar to the existing power plant, and reused to the possible extent for greening or other purpose. If the discharge amount is found to be too large for complete reuse during the regular checkup, the excess water will be discharged into the irrigation canal and may be used for agriculture in the surrounding area. (a-2) With the above-described measures, the area not meeting the environmental standard of Iran is barely expected. (b) The project uses gas and light oil for fuel, not coal-fired power plant.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
				(c) Waste water is treated at the waste water treatment facility so as not to contaminate surface water, soil and groundwater and sea water.
	(3)waste	(a)Is waste generated from the operation of the facility, or other waste including coal ash, plq ster which is a by-product from the flue gas desulfurization appropriately treated and disposed of according to the laws and regulations of Iran?	(a)Y	(a) Basic mitigation measure is to develop a waste management plan including reduction of waste, promotion of recycling, and education of workers to prevent inappropriate waste disposal. Specifically, paper wastes and iron scraps will be recycled as with the case in the existing facility. Residual food is composted and reused as fertilizer in greening. Small amount of sludge and waste oil will be generated from waste water treatment and is recycled, and other hazardous waste including sludge from waste water treatment, is landfilled within an anti-seepage pit authorized by DOE and built in the site.
	（4） Noise and vibration	(a) Does the level of noise and vibration meet the environmental standard of Iran?	(a)Y	(a) Future noise level, which is the addition of the current noise level of the existing facility and of the contribution noise level of the project, is almost equal to the current noise level. The noise levels at all the measuring points of boundary and the nearby workplace comply with the IFC/WB guideline value (industrial area, daytime). Also, the noise levels at the residential area satisfy the IFC/WB guideline value (residential area, daytime). Noise-generating equipment will be enclosed as much as possible and low noise type equipment will be installed. Periodic maintenance of equipment will be conducted.
	(5) Ground subsidence		(a)N	At the operation stage of the power plant, water will be taken from the authorized wells used for the existing facility at the maximum rate of 300m^3 per day . Water intake will be conducted within the range of permission and will be minimized through water reuse. The lowering of water level in the existing wells and land subsidence in the surrounding area of the site are not observed. The monitoring of ground water level will be continuously conducted .
	(6)Odor	(a) Is there a source of bad odor? Is any mitigation measure taken?	(a)Y	In case domestic waste of the workers is not appropriately treated, it may produce foul odors. Workers will be strictly instructed to classify and collect garbage and illegal waste disposal will be prohibited. Garbage will be collected and stored in a

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
				covered container and composted on a periodic basis and reused as fertilizer.. These measures will be taken to minimize the generation of odor.
3 Natural Environment	(1) Protected Areas	(a) Is the project site located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas?	(a) N	(a) The site is not located within a preservation area, nor is there a preservation area around the site.
	(2) Ecosystem	(a) Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)? (b) Does the project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions?	(a)N (b)N (c)N/A (d)N (e)N	(a) - The site is a developed area for the existing power plant and wild forest, tropical natural forest, habitat of precious species do not exist. (b) Only limited terrestrial flora and fauna are inhabited including rodents grasses. These are commonly observed, broadly-inhabiting species and no precious species are observed. Consequently, the direct impact of land alteration will be very limited. (c) The land around the project site is bare land or agricultural land, and the affected biota is not expected to be significant. (d) Water will be taken from groundwater in the power plant, not from rivers. Rivers are far from the site and the impact of ground water intake is not predicted. (e) The power plant uses a steam turbine and cooling water from the condenser will be reused through forced-draft cooling fan system so that thermal waste water will not be discharged. Water discharged into the irrigation canal will be appropriately treated and no turbidity and the impact to aquatic organism is predicted.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
		(c) If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem? (d) Are adequate measures taken to Mitigate the impact of water intake of the project(surface water, groundwater) to the aquatic ecosystem of the rivers,etc? Is any mitigation measure taken against impact on aquatic organisms?		

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
		(e) Is there any possibility that the discharge of thermal effluent, intake of large amount of cooling water, discharge of leachate causes impact on the aquatic ecosystem of the surrounding area?		
4 Social Environment	(1) Resettlement	(a) Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement? (b) Will an adequate explanation on compensation and resettlement assistance be given to affected people prior to resettlement? (c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on	(a)N (b)-(j)N/A	(a) The site is a developed area for the existing power plant and new land acquisition and resettlement is not predicted. (b)-(j) N/A

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
		socioeconomic studies on resettlement? (d) Is compensation going to be paid prior to the resettlement? (e) Are the compensation policies prepared in the document? (f) Does the resettlement plan pay particular attention to vulnerable groups or people, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples? (g) Are agreements with the affected people obtained prior to resettlement? (h) Is there an organizational framework in place to properly implement resettlement? (i) Are any plans developed to monitor the impacts of resettlement? (j) Is the grievance redress mechanism established?		
	(2) Living and Livelihood	(a) Is there a possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary? (b) are the social infrastructure service such as medical treatment facilities, schools, traffic roads are well established? If not, is there a preparation plan? (c) Is there any possibility that operation of	(a)N (b)N (c)Y	(a) The site is a developed area within the existing power plant site and new land acquisition and resettlement is not predicted. (b) - Construction period and operation period: A middle-sized city with 400 to 500 thousand habitants is located near the site, and the social infrastructure service such as lodging houses, medical treatment facilities, schools, sewer systems and other infrastructure are well established so that inflow of construction workers and the power plant staffs will not affect the social service. (c) - as increased traffic during construction phase may cause traffic jam, the

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
		large construction vehicles adversely affect the traffic of the surrounding roads? Is there any mitigation measure as necessary? (d) Is there a possibility that diseases, including infectious diseases, such as HIV will be brought due to immigration of workers associated with the project? Are adequate considerations given to public health, if necessary?	(d)Y (e)N	appropriate traffic route and driving schedule, introduction of bus for workers will be considered to reduce the number of vehicles. The route and schedule will be negotiated with the related organizations. (d) -- The inflow of workers from other parts of Iran or foreign countries may induce the spread of infectious diseases. Local people should be recruited as much as possible so as to minimize the risk of infectious diseases being transmitted from external workers. Education and training concerning infectious diseases and health for workers, placement of medical facility and staffs, periodic medical check-ups should be conducted. (e) Fishery is not conducted around the power plant site. Ground water intake by the project may cause continuous impact on the water use in the surrounding area, but mitigation measures will be taken as described in the chapter “Subsidence and hydrology (ground water)” and the impact of water intake to the groundwater use will be insignificant. Water turbidity may affect the water quality of the irrigation canal. Water pollution will be minimized by mitigation measures cited in “Water pollution” and its impact on irrigation water is expected to be very limited.
	(3) Heritage	(a) Is there a possibility that the project will damage the local archeological, historical, cultural, and religious heritage? Are adequate measures considered to protect these sites in accordance with the country’s laws?	(a)N	(a) The site is a developed area within the existing power plant site and the construction site has no precious historical, cultural, or religious heritage.
	(4) Landscape	(a) Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?	(a) N	(a) - The site is a developed area within the existing power plant site, and there is no scenic sightseeing spots in the surrounding area.
	(5) Ethnic Minorities and	(a) Are considerations given to reduce the impacts on the culture and lifestyle of ethnic	(a-b) N/A	(a) - - The site is a developed area within the existing power plant site and land

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	Indigenous Peoples	minorities and indigenous peoples? (b) Are all of the rights of ethnic minorities and indigenous peoples in relation to land and resource respected?		acquisition and resettlement will not occur. - The on-site survey shows that the area around the site is not inhabited by ethnic minorities. (b) N/A
	(6) Working Conditions	(a) Is the project proponent not violating any laws and ordinances associated with the working conditions of the country which the project proponent should observe in the project? (b) Are tangible safety considerations in place for individuals involved in the project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials? (c) Are intangible measures being planned and implemented for individuals involved in the project, such as the establishment of a safety and health program, and safety training (including traffic safety and public health) for workers etc.? (d) Are appropriate measures taken to ensure that security guards involved in the project not to violate safety of other individuals involved, or local residents?	(a) Y (b) Y (c) Y (d) Y	(a) - The project proponent will comply with regulations of Iran regarding labor safety. (b) - Safety gears including helmet, safety shoes, earplugs and electric shock prevention equipments shall be provided. The storage of hazardous materials shall be marked with a sign board. (c) - The safety and sanitation management plan including safety education and training will be developed and implemented. d) - In the power plant site, appropriately trained security guards will be assigned to protect safety of the project staffs and the local residents.
5 Others	(1) Impacts during Construction	(a) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)?	(a) Y	(a) <Noise and Vibration> Noise and vibration impact caused by construction activities will be mitigated by managing the construction schedule in order to level out the construction amount and scale. Low noise and vibration equipment will be used as much as possible and regular maintenance will be conducted. . Measures for reducing generation of noise and vibration, such as speed reduction of large vehicles in residential areas, will be taken.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
		(b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts? (c) If construction activities adversely affect the social environment, are adequate measures considered to reduce impacts?	(b) Y (c) Y	Construction work shall be conducted in daytime to the possible extent. Considering the high bearing power of the ground, piling work producing high noise will not be conducted. <Water turbidity> - The precipitation in Iran is very low and turbid water will not occur. <Dust/gas emission> Dust caused by the strong winds in the dry season can be reduced with periodic watering of the site and road. - There will be periodic maintenance and management of all construction machinery and vehicles as a way to reduce dust and exhaust gas discharged from such equipment. Adjustment of the construction schedule will be considered in advance in order to avoid the concentration of machinery and vehicles in one specific period. <Waste> Basically, a waste management and disposal program including education of workers to encourage reduction and reuse of waste and prevent inappropriate waste disposal will be developed. Waste will be collected separately and stored in an appropriate place and method. Paper wastes and iron scraps will be recycled, and other general wastes will be appropriately disposed of, as with the case in the existing facility. All of the hazardous waste will be transported to he landfill site authorized by DOE and equipped with ground-seepage prevention within the power plant site for disposal. (b) The site is a developed area within the existing power plant site mostly covered with artificial structures. Only limited terrestrial flora and fauna are inhabited including rodents grasses. These are commonly observed, broadly-inhabiting species and no precious species are observed.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
				The construction of Power plant will generate air pollution, noise and vibration, etc. that may have impact on the behavior of terrestrial ecosystems. Appropriate mitigation measures will be taken.(c) - the increased traffic during construction may cause traffic jam. The project proponent will conduct the traffic control plan including route-setting and operation schedule. Bus for transportation of workers will be operated to minimize traffic and the route and schedule of operation will be discussed with the relevant organizations.
	(2)Accident prevention	(a) In case of coal-fired power plant, will the preventive measure against spontaneous fire in coal storage prepared (sprinkler, etc)?	(a)N/A	(a) The project relates to the power plant using gas and light oil fuel, not a coal-fired plant.
	(3) Monitoring	(a) Will the proponent develop and implement a monitoring program for the items described above that are considered to have potential environmental impacts? (b) What are the items, methods and frequencies of the monitoring program?	(a) Y (b) Y	(a) - An Environmental Monitoring Plan will be prepared by the project proponent regarding the environmental items that may be affected. (b) - Main monitoring items, method and frequency are as follows;<Air pollution> ・Construction phase -SO_2、NO_2,$PM_{10}$are measured at one point in the residential area near the power plant, once (1 week) at the peak period of construction activity. ・Operation phase SO_2、NO_2,PM_{10} are measured at 5 points in the area near the power plant,4 times a year (1 week) for 3 years. -SO x 、NO x and PM will be continuously monitored on the route of smoke. <Water turbidity> ・Construction phase - TSS, pH, Oil,BOD are measured at the timing of discharge at the outlet of the wastewater treatment facility. ・Operation phase - TSS, pH, Oil ,BOD and coliforms are measured as necessary at the

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
		(c) Will the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)? (d) Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?	(c) Y (d) Y	outlet of the wastewater treatment facility. <Noise> ・Construction phase Noise level is measured on the border of the site (4 points), the residential area nearest the power plant (1 point) once (1 week) at the peak period of construction activity.・Operation phase Noise level will be measured at 4 points on the border the power plant, one point at the nearest residential area, four times a year as necessary. (c) - The proponent will establish an adequate monitoring framework including organization, personnel, equipment, and adequate budget to sustain the monitoring framework. (d) - The project proponent will periodically report implementation status of environmental management plan and environmental monitoring plan to the relevant authorities such as JICA and the relevant organization.
6 Note	Reference to Checklist of Other Sectors	(a) Where necessary, pertinent items described in the Road checklist regarding transmission and distribution of electricity should also be checked (e.g., projects including installation of electric transmission lines and/or electric distribution facilities). (b) Where necessary, pertinent items described in the Road checklist regarding port facility should also be checked (e.g., projects including installation of port facilities).	(a) N/A (b)N/A	(a) - The generated electricity is transmitted through the existing transmission facility. (b) No port facility will be installed.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	Note on Using Environmental Checklist	(a) If necessary, the impacts to transboundary or global issues should be confirmed, (e.g., the project includes factors that may cause problems, such as transboundary waste treatment, acid rain, destruction of the ozone layer, or global warming).	(a) N	(a) - CO_2 is produced by the project operation, but a high-efficiency gas turbine will be installed and CO_2 generation per kWh is lower than in the conventional power generation system. As a result of the calculation based on "JICA Climate - FIT: (mitigation) Climate Change Measure Support Tool 2011", the emission reduction amount is 2,782,527 t - CO 2 / y as compared with the case using Iran 's average power generation facility.In this manner, the cross-boundary pollution and impact on climate change will be insignificant.

Source: prepared by JICA Study Team

6.14.2 Monitoring Form

Monitoring items shall be decided based on the sector and the characteristic of the project. According to this project, monitoring items are as follows.

(1) Construction phase
①Air pollution
<Air quality>
Location: 1 point： Residential area in the north of the power plant
Regulation and guideline： Air quality standard of Iran (Air Pollution Prevention Executive Regulation (2016), IFC/WB EHS Guideline, General 2007

Unit:µg/m^3

Date	Item	Concentration (1hour)			Baseline value	Air quality standard of Iran	IFC/ EHS Guideline, General 2007	Note
		Min	Max	Average				
	SO_2					196 (1 hour) 395 (24 hour)	-(1 hour) 125(24 hour)	Once (1 week) at the peak of construction activity
	NO_2					200 (1 hour)- (24 hour)	200(1-hour) -(24 hour)	
	PM_{10}					- (1 hour) 150 (24 hour)	-(1 hour) 150(24hour)	

②Water pollution
<Waste water>
Location： 1 point: outlet of the waste water treatment facility, outlet of the temporary sedimentation tank
Regulation and guideline：Effluent standard of Iran (Water Pollution Control Rule (1984)、I), IFC/WB EHS Guideline (Thermal power plant, 2008)
Measurement date：

Item	Unite	concentration	Effluent standard of Iran	IFC/WB EHS Guideline (Thermal power plant, 2008)	Note
pH	―		6-8.5	6 –9	
TSS	mg/L		100	50	
Oil & Grease	mg/L		10	10	
Iron	mg/L		3	1	
Zinc	mg/L		2	1	
Cromium	mg/L		1	0.5	
Chlorine residue	mg/L		0.2	0.2	
Copper	mg/L		0.5	0.5	
Lead	mg/L		1	0.5	
Cadmium	mg/L		0.05	0.1	
Mercury	mg/L		Negligible	0.005	
Arsenic	mg/L		0.1	0.5	

③Waste

Location: Contractor’s office
Regulation: Waste management regulation of Iran
Reporting Date;

Item	Place of generated waste	Storage amount (Unit: t or kg)	Disposal amount (Unit: t or kg)	Disposal method and place	Remark
					Continuously

④Noise
Location：5 points: On the border of the site (4 points), the residential area near the power plant (1 point)
Regulation：Noise Protection Act (2008)、IFC/WB EHS Guideline (General, 2007)
Measurement date：

Date	Location	Noise level (Leq)	Baseline value (Leq)	Noise standard of Iran	IFC/WB EHS Guideline（General 2007)	Note
	Residential area			Residential areaDaytime:55 Nighttime: 45	Residential areaDaytime:55 Nighttime: 45	Twice at the peak of construction activity
	Site border			Industrial area Daytime: 70 Nighttime: 65	Industrial area Daytime: 70 Nighttime: 70	

⑤Groundwater
Location：7 poins at the existing water intake well
Regulation：Water Intake Permission
Measurement date：

Date	No. of water intake well	Groundwater level（m）	Baseline level (m)	Note
	1			Regularly
	2			
	3			
	4			
	5			
	6			
	7			

⑥ Terrestrial ecosystem (reptiles)Location：Contractor’s office

Reporting date：
Survey method: visual observation

Species	Observation date and time	Observation place	Remarks
Testudo graeca Linnaeus			
Testudo horsfieldii			
Eremias pleskei			

⑦Employment
Location：Contractor’s office
Reporting date：

Item	Locals	From Iran	From other countries	Remarks
Number of employee				Continuously

⑧Children’s rights
Location：Contractor’s office
Reporting date：

Item	number	Provision	Remark
Child laborer			Continuously

⑨　IV/AIDS and other infectious diseases

Item	Total number of diseases	Total number of infectious diseases	Provision	Remark
Health check				Continuously

⑩Work environment
Location：Contractor’s office
Reporting date：

Construction Contents	Inspection Item	Contents	Status	Provision	Remarks
					Continuously

(2) Operation phase

①Air pollution

<Exhaust gas>

Location：Duct、Continuous emission monitoring systems（CEMS）

Period: YYYYMMDD~YYYYMMDD

Regulations and guidelines : Exhaust Gas Standard of Iran（Standards of Air Pollution arising from Industries and Workshops (1999)）, IFC/WB EHS Guideline (Thermal power plant; 2008)

Date：

μg/m^3

Fuel	Item	Unit	Min.-Max.	Exhaust gas standard of Iran	IFC/ WB EHS Guideline (Thermal power plant; 2008)<Gas>	Note
Gas	SO x	mg/Nm^3		200	-	Continuously
	NO_X	mg/Nm^3		300	51	
Light oil	SO x	mg/Nm^3		150	-	
	NO x	mg/Nm^3		200	152	
	PM	mg/Nm^3		150	50	

Note dry gas base,O_2=15%

<Ambient air environment>

Location: 5 points in the residential area around the power plant

Regulation and guideline : Air quality standard of Iran (Air Pollution Prevention Executive Regulation (2016)),IFC/WB EHS Guideline General; 2007

Unitμg/m^3

Date	Item	Measurement concentration (1-hour)			Air quality standard of Iran	IFC/ EHC GuidelineGeneral;2007	Note
		Min	Max	Average			
	SO_2				196 (1 hour) 395 (24 hour)	-(1 hour) 125(24 hour)	4 times a year (24 hours, one week) for the first 3 years of operation
	NO_2				200 (1 hour)- (24 hour)	200(1-hour) -(24 hour)	
	PM_{10}				- (1 hour) 150 (24 hour)	-(1 hour) 150(24hour)	

②Water pollution
Location : 1 point at the outlet of the water treatment facility Related regulation and guidelines：Effluent standard of Iran(Decree No. 18/2004), IFC/WB EHS
Guideline (Thermal power plant, 2008)
Measurement date：

Item	Unit	Measurement concentration	Effluent standard or Iran	IFC/WB EHS Guideline (Thermal power plant, 2008)	Note
pH	–		6-8.5	6 –9	4 times a year
TSS	mg/L		100	50	
Oil & Grease	mg/L		10	10	
Iron	mg/L		3	1	
Zinc	mg/L		2	1	
Cromium	mg/L		1	0.5	
Chlorine residue	mg/L		0.2	0.2	
Copper	mg/L		0.5	0.5	
Lead	mg/L		1	0.5	
Cadmium	mg/L		0.05	0.1	
Mercury	mg/L		Negligible	0.005	
Arsenic	mg/L		0.1	0.5	

③Waste
Location：Power plant office
Regulation： Waste management regulation of Iran（Decree No. 13/2006）
Reporting date：

Item	Place of generated waste	Storage amount (Unit: t or kg)	Disposal amount (Unit: t or kg)	Disposal method and place	Remark
					Continuously

④Noise
Location： 5 points: 4 points at the site boundary, 1 point in the residential area
Regulation: Noise Protection Act (2008)、IFC/WB EHS Guideline(General, 2007)

Date	Location	Noise level (Leq)	Noise standard of Iran	IFC/WB EHS Guideline （General 2007)	Note
	Residential area		Residential areaDaytime:55 Nighttime: 45	Residential areaDaytime:55 Nighttime: 45	Four times a year, in the first 3 years
	Site border		Industrial area Daytime: 70 Nighttime: 65	Industrial area Daytime: 70 Nighttime: 70	

⑤Groundwater
Location：7 points at the existing water intake well
Regulation：Water Intake Permission
Measurement date：

Date	No. of water intake well	Groundwater level（m）	Note
	1		Regularly
	2		
	3		
	4		
	5		
	6		
	7		

⑥ Terrestrial ecosystem (reptiles)Location：Contractor’s office
Reporting date：
Survey method: visual observation

Species	Observation date and time	Observation place	Remarks
Testudo graeca Linnaeus			
Testudo horsfieldii			
Eremias pleskei			

⑦Employment
Location：Contractor’s office
Reporting date：

Item	Locals	From Iran	From other countries	Remarks
Number of employee				Continuously

⑧ Work environment
Location：Power plant
Reporting date：

Construction Contents	Inspection Item	Contents	Status	Provision	Remarks
					Continuously