Republic of Iraq
Ministry of Oil
Ministry of Electricity
Ministry of Industry and Minerals

Study on "Gas Master Plan (Natural Gas Utilization Plan)" in the Republic of Iraq Final Report(Summary)

July, 2015

Japan International Cooperation Agency
(JICA)

TOYO ENGINEERING CORPORATION

MITSUI&CO., LTD

7R
JR
15-016

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CONTENTS

The Rate of Exchange

currency	2013/03	2013/04	2013/05	2013/06	2013/07	2013/08	2013/09
USD	¥91.84	¥94.19	¥97.84	¥101.03	¥98.07	¥98.10	¥98.04
EUR	¥120.15	¥120.55	¥127.92	¥131.21	¥127.76	¥130.10	¥130.22
IQD	¥0.079	¥0.082	¥0.084	¥0.088	¥0.085	¥0.084	¥0.085

currency	2013/10	2013/11	2013/12	2014/01	2014/02	2014/03	2014/04
USD	¥98.29	¥98.25	¥102.19	¥104.71	¥102.46	¥102.20	¥102.82
EUR	¥132.94	¥135.08	¥138.88	¥143.30	¥139.47	¥139.84	¥141.43
IQD	¥0.086	¥0.085	¥0.089	¥0.090	¥0.089	¥0.088	¥0.087

currency	2014/05	2014/06	2014/07	2014/08	2014/09	2014/10	2014/11
USD	¥102.58	¥101.68	¥103.41	¥102.39	¥103.77	¥109.45	¥109.06
EUR	¥142.01	¥138.32	¥138.49	¥137.18	¥136.90	¥138.85	¥137.52
IQD	¥0.089	¥0.088	¥0.088	¥0.088	¥0.091	¥0.095	¥0.094

currency	2014/12	2015/01	2015/02	2015/03	2015/04	2015/05	2015/06
USD	¥117.58	¥120.48	¥117.93	¥119.03	¥119.64	¥118.96	¥123.96
EUR	¥146.87	¥146.91	¥133.23	¥134.68	¥129.83	¥131.21	¥135.33
IQD	¥0.103	¥0.105	¥0.102	¥0.103	¥0.104	¥0.103	¥0.108

Abbreviation

Abbreviation	Content
bpd	bbl/d (1 bbl = 159 liter)
BOPD	Barrel Oil per Day
CBI	Central Bank of Iraq
CC	Combined Cycle Generation
CO_2	Carbon Dioxide
C/P	Counter Part
DCS	Distributed Control System
DE	Diesel Engine Generation
Df/R	Draft Final Report
DPMO	Deputy Prime Minister Office
EPC	Engineering, Procurement and Construction
FDP	Final Development Plan
FS	Feasibility Study
GAP	Gas Allocation Plan
GDP	Gross Domestic Product
GHG	Green House Gas
GMP	Gas Master Plan
GOR	Gas Oil Ratio
GT	Gas Turbine Generation
IC	Interconnection
IEA	International Energy Agency
IENA	Iraq Energy Academy
IMEC	Inter Ministry Energy Committee
INES	Integrated National Energy Strategy
IOC	International Oil Companies
JICA	Japan International Cooperation Agency
kTPA	Thousand tons per annum
LPG	Liquefied Petroleum Gas
MM	Million
MMbpd	Million barrel per day
MMscfd	Million standard cubic feet per day
MoE	Ministry of Electricity in Iraq
MoIM	Ministry of Industry and Minerals in Iraq
MoO	Ministry of Oil in Iraq
MOU	Memorandum of Understanding

Abbreviation	Content
NOC	National Oil Companies
Phase-1	This survey
Phase-2, 3	Subsequent detailed survey
PMAC	Prime Minister Advisory Committee in Iraq
scf(p)d	Standard cubic feet per day ; sft^3/day
SGC	South Gas Company
SOC	South Oil Company
STG	Steam Turbine Generation
TSC	Technical Service Contract
URR	Ultimate Recoverable Resources or Ultimate Recoverable Reserves

1. Introduction

This Report presents the results of the Phase-1 survey and analysis concerning the overall feasibility as to the effective utilization of natural gas (including both associated and non-associated gas produced in oil & gas fields) of Iraq as a whole. This study has been conducted by the JICA Study Team in collaboration with Iraq Ministries. While the Republic of Iraq has prepared the Integrated National Energy Strategy (INES) in June 2013 which forecasts the future energy policy of the country, this Report analyzes the effective utilization of natural gas up to around 2030, on the basis of the information provided in INES, information provided by Ministry of Industry and Minerals (MoIM) and Ministry of Electricity (MoE) as well as of analysis of the outlooks given by IEA, etc.

This analysis (referred to as "Gas Master Plan; GMP Phase-1") has been commenced in March 2013 and finished in June 2015 as final. The back grounds for such long period taken can be described as below.

March 2013	GMP Phase-1 research started
June 2013	Kick-off Meeting held in Baghdad
September 2013	Field survey and data acquisition from MoE
October 2013	Field survey and data acquisition from MoIM
	Expedite data from Ministry of Oil (MoO)
April 2014	Election for New Ministers
June 2014	High Level Safety Issues due to invasion of Islamic State (IS)
April 2015	Final Review Meeting in Beirut with MoIM and MoE
May 2015	Explanation to Oil Minister
May 2015	Discussion with Director General of Studies, Planning & Follow up Directorate in MoO

The analysis results up to December 2013 are described from chapter 1 through chapter 4 in detail. The study could not be finalized because of the situation of Iraq due to new cabinet election in April 2014 and Islamic State (IS) invasion since June 2015. Almost one year passed after it, and the survey result has been updated in chapter 5 using the latest information.

As for the gas sector in Iraq, a comprehensive and quantitative demand and supply plan is not yet developed whereby the production and treatment of associated gas resulting from the development of oil fields by the government of Iraq and international oil companies, and the demand in each industry sector and region are well balanced. As a result, since no facilities are installed in the country for effective utilization of gas, the majority of associated gas currently produced is left unutilized, being burnt to the

atmosphere. This results in a great economy loss and also causes adverse effect on the environment. According to the monthly report issued by the Ministry of Oil, more than 60% of associated gas is flared without being effectively used. The volume of the flared gas will further increase according to the increase of crude oil production until fulfillment of the gas treatment infrastructure development.

Table 1(1): Current Production of Crude Oil and Associated Gas

Crude oil production (average)	3.21 million barrel per day
Associated gas (AG) production	1,963 MMscfd
Flare gas	1,371 MMscfd
Ratio of Flare gas to AG production	69.8 %

(source: Ministry of Oil: August 2013)

Based on the characteristics and quantity of associated gas produced under these conditions, it is necessary to develop a demand and supply plan to clearly indicate the amount to be used in each industry. Thus, acquisition, consolidation and analysis of information will be carried out through this survey, so as to establish a demand and supply plan that will be comprehensive, quantitative and, at the same time, consistent in terms of the upstream and downstream sectors.

Quantitative study requires a precise review of the supply side, so that, as mentioned under Item 3.1.1, reference was made to the existing materials already provided, reported information, literatures, and materials received from the South Oil Company, on the basis of which, review was made of the supply side. On the other hand, the demand side study was conducted on the basis of INES being the official national strategy reflecting the intention of the government of Iraq, as well as the master plan prepared by each ministry. As for the downstream plan, priority was given as a matter of course, on the fulfillment of power demand as the basis for industrial activities. INES also refers to this point, stating that the top priority shall be given to resolving the power shortage as otherwise it would be a great handicap for the development of industries.

INES is positioned as an official strategic document of the government of Iraq, and an anniversary event was held in commemoration of its publication (in Baghdad on June 12, 2013). The representative of the Team also participated in this event as the project implementer. It is believed that this survey is also positioned as an extension of this INES, and thus, the Team is in the position of performing specific and quantitative analysis, while INES is expected to conduct general qualitative analysis. In other words, the Iraq authorities expected to implement technical analysis independently from the viewpoint of an investor, so as to establish a plan for the facilities and infrastructure as well as for a specific gas demand.

Finally, on an understanding that a step by step process is required in preparing the gas master plan, this study started as a first step with the survey of a comprehensive gas demand and supply balance throughout the country. In addition, regional specific study will be made separately in continuation, where industries to be develop in the region are a major concern, so as to allow area specific gas demand and supply plan to be looked into.

For instance, the entire territory of Iraq is divided into four regions (north, west, middle and south regions), so as to study a gas demand and supply plan best suited to each regional characteristic. According to this division, the west region that is close to the Syrian border is known to include dangerous areas and also a large number of undeveloped oil and gas fields, while the region is less populated when compared with other regions. A future task will be to determine what kind of industries should be developed in such regions, and to study if gas demand exists, and finally to establish a network or the facilities on the supply side. In other words, even after ensuring a demand and supply balance, those important problems still remain, i.e. whether the existing facilities will operate for effective distribution, and what kind of additional or new facilities plan will be found necessary.

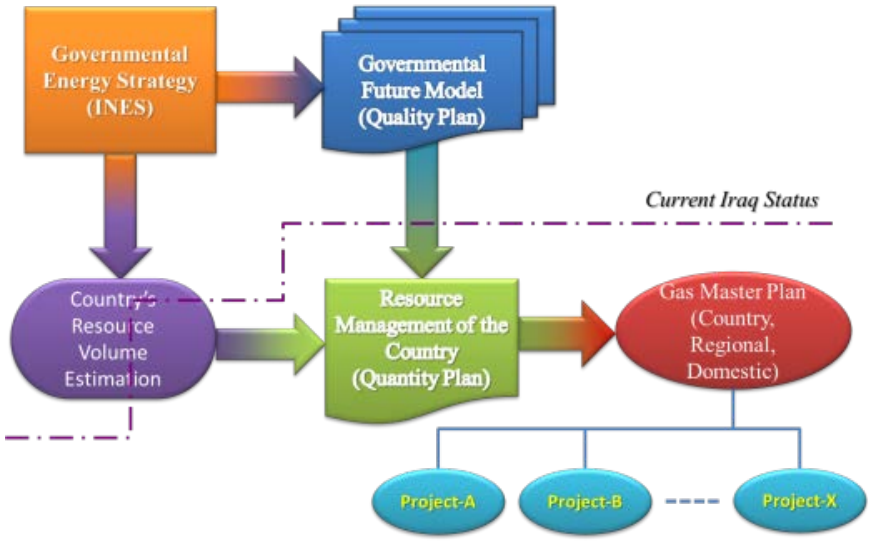


Figure 1(1) Gas Master Plan Implementation Road Map
(source: prepared by the study team)

According to the above figure, it is expected by Iraq to execute projects A to X in preparing the final Gas Master Plan, but in fact, they will be implemented when executing the future preparation work. As for the detailed contents of these projects, consultation with Iraqi staff is required to determine on what design stage to implement them, which shall be determined in the next Phase.

<Step by step preparation of Gas Master Plan as draft>

Phase-1 : To configure a comprehensive gas demand and supply balance for the entire Iraq territory

Phase-2 : To divide the territory into four regions, and to establish a gas demand and supply plan in consideration of regional characteristics

Phase-3 : To establish a demand and supply plan where industrialization plans at each area are combined with the supply facilities (infrastructure)

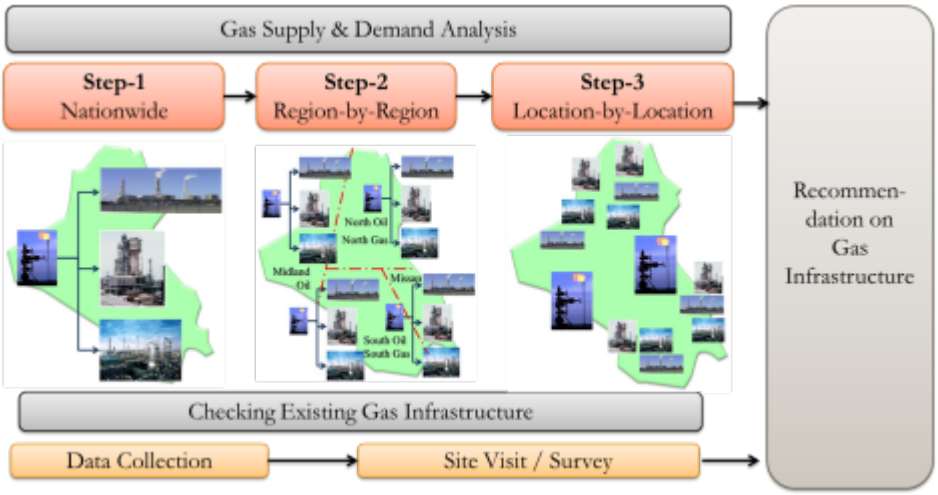


Figure 1(2): Relation of each steps of gas master plan
(source: prepared by the study team)

Phase-2 study will be made in consideration of regional characteristics. But at the same time, information on the existing gas facilities (including pipelines) is required to perform a gas demand and supply analysis. In some cases, site survey and facilities planning should be performed at any Phase. Related information primarily relies on the information supplied by the Ministry of Oil, so that site survey concerning actual facilities needs to be conducted as a part of future work.

2. Gas Supply Side (Upstream Sector) and Gas Demand Side (Downstream Sector)

(1) Upstream study

As mentioned under item 3.1.3, the production is obtained from the associated gas and non-associated gas in consideration of annual changes in the gas components (C1, C2, C3, C4, C5+, H2S), and then a demand and supply plan is prepared while taking into account the fractions and annual changes of each component, on the basis of which the downstream will be examined.

Table 2(1) : Example of gas component and gas demand
(source: prepared by the study team)

Notation of component	Name of component	Typical applications
C1	Methane	Power generation fuel, raw material for fertilizer plant, liquefied natural gas (LNG)
C2	Ethane	Ethylene and its derivative products
C3	Propane	Liquefied petroleum gas (LPG), raw material for petrochemical products
C4	Butane	Liquefied petroleum gas (LPG), raw material for petrochemical products
C5+	Heavier component	Natural gas liquid (NGL)

Depending on each component, applications are determined, and the demand side plan is to be changed. Basically, the supply side amount is a decisive factor, so that the downstream industry plan shall be made on the basis of the amount of component available. If not, the demand and supply balance cannot be ensured and will not contribute to a restoration and development of Iraq.

Properties of gas components in the south and the north can be a subject when considering regional characteristics. Gas produced in the south contains a large amount of ethane as a raw material for petrochemical products, while methane is the major component of gas in the north. It is thus believed that a petrochemical project will be implemented using gas in the south. However, the construction of a complex in the south may not have value unless the volumes for both export and local consumption of the products are assumed. In this respect, consultation will be held with the Iraq authorities at the time of preparing the Gas Master Plan.

As a matter of fact, changes in gas production affect the study of the downstream. As a result, the upstream gas supply side shall be examined on the basis of the current data. On the other hand, if data are not available, an overall amount of gas is calculated including a certain assumption, while a long term gas estimation to allow for the demand side planning was made on the basis of the development plans (PDP: Preliminary Development Plan, FDP: Final Development Plan). However, the Final Development Plan shall be submitted in future to the government of Iraq in the course of development of other production concession in Iraq, which assumes that the downstream side shall be re-examined while incorporating the information included in FDP. This work needs to be conducted as an extension of this survey. Since development of the upstream is generally performed with uncertainties, this sort of process is normal, that is, during the course of implementing the development plan, the well source information is updated from time to time.

In calculating the amount of gas to be sent to the downstream sectors, it is necessary to determine the net amount by subtracting from the gas production at each production filed on the amount of gas consumed as fuel for power generation to be used for the development of the concession. In this survey, however, this could not be confirmed, so that assumption was made on the basis of experience and knowledge of TOYO.

(2) Downstream study

This study has been conducted while confirming the intention of Iraq in relation to the effective gas utilization plan on the downstream side. INES, which reflects the intention of Iraq, has been referred as an important reference.

INES describes the future downstream plan, while the master plans prepared by each ministry are proposed individually. Thus, INES and the master plan of each ministry should be fully understood before confirming the intention of the Ministry of Oil, the Ministry of Electricity and the Ministry of Industry and Minerals as the counterparts of this study. However, because of limited gas supply, there arise interests or political influences among various ministries. Iraq is currently facing a significant shortage of electric power due to increase in population and activation of each industrial sector. Thus, a stabilized supply of electric power is essential to ensure further industrial development. This is the reason why the Ministry of Electricity and the Ministry of Industry and Minerals have set up their own master plans. In this study, the top priority is given to meeting the demand of electric power.

Figure 2(2) : Correlation chart of study team
(source: prepared by the study team)

In this study, not only the Ministry of Oil as the ministry in charge, but also the Ministry of Industry and Minerals and the Ministry of Electricity (gas users) should participate. In the first place, a comprehensive review mainly by the Ministry of Oil is conducted, while the demand and supply plan by the Ministry of Industry and Minerals and the Ministry of Electricity are made on the basis of INES in many instances. It is also necessary to review the demand side plan through consultation with the Iraqi team.

As illustrated above, the Deputy Prime Minister Office as the proponent of this survey has the Inter Ministry Energy Committee (IMEC), which is in charge of coordinating various ministries. It is true that the Ministry of Oil is the leading ministry in this study, but operation of IMEC under the Deputy Prime Minister Office is inevitable when coordination among ministries is required.

In other words, continuation of this survey requires close coordination between each ministry of the government of Iraq.

3. Information Acquisition and Analysis Method

3.1 Information Acquisition and Analysis Method

3.1.1 Acquisition and analysis of existing data

Existing materials, reported information and literature that are publicly available are gathered as much as possible in advance and used for internal pre-investigations works and additional information from Iraq counterpart may be used for the study of a gas master plan, at the same time, to be used for contributing to form a general understanding on the present and future Iraq oil and gas industry. General information is obtained mainly through websites, and what's more, materials presented and published in related seminars are utilized as much as possible and those are acquired at best effort. The related data include oil and gas reserves, production amount, imports/exports amount, domestic consumption and electric power consumption, as well as information on the downstream sectors. Information was obtained on the basic policy concerning Iraq-related sectors in relation to the current on-going projects and future plans, so as first to deepen understanding on the overall picture. Major sources of information referred include the World Energy Outlook Iraq Special Report 2012 published by IEA, "Natural Gas Markets in the Middle East and North Africa" by Oxford University 2011, the regular reports on Iraq issued by JOGMEC (Japan Oil, Gas and Metals National Corporation), and Integrated National Energy Strategy (Executive Summary 2013).

In addition to the above, materials that are not published but referred to include those received from the South Oil Company in relation to the Iraq Oil Evacuation Study, the contract for which TOYO has awarded.

Missing information or latest information on the existing materials is communicated to the government of Iraq in advance as a form of Request and Questionnaire, so as to obtain related information at the time of site survey. Prior to acquisition of important information, a necessary procedure such as confidential information non-disclosure agreement is taken, which applies also for questionnaires.

3.1.2 Analysis of data necessary for gas demand analysis

Critical information essential to the review of a gas demand and supply plan includes the development of oil and gas fields and their production with its annual changes, the electrical power demand with its annual changes, raw materials and fuel in the petrochemical and related industries on the demand side, as well as the restoration, future plan and the basic policy based on Iraq's energy strategy.

Production of associated gas from oil fields and non-associated gas from gas fields forms a basic supply source of gas supply, but in some cases, gas import should also be taken into consideration. Information related to the production of associated gas from oil fields includes information on the oil field operation or development plan as well as crude oil production, the gas-oil ratio (GOR ;Gas-Oil-Ratio), the gas separation and treatment process configuration, and the amount of net gas to be supplied (Net Gas=Total Produced Raw Gas – Gas used for field operations). Examination on the demand side requires information on the composition of gas produced (Raw gas), so as to comprehend the type of gas to be used, that is, the amount of each component of gas to be supplied. It is also necessary to obtain information on the gas supply infrastructure, in particular, information on the current and future plan of the pipeline network to distribute gas from the supply point to each gas consumer and the related facilities. Since at present a greater part of gas is left for gas flaring without being effectively utilized, related information has also been obtained to gain an understanding on the actual situation.

Since 2009, the government of Iraq has opened the concession areas to international oil development companies for bidding process, and up to now, four bids (license rounds) were performed. As a result, contracts were awarded for 19 oil and gas production concessions where development or drilling work is now under way. Since the development plans seem to contain the amount of gas to be supplied, gas compositions, gas treatment method as well as internal consumption, the great effort was made to obtain such information. Information necessary in this regard includes the plateau production target, the time to start plateau production and its time period.

As for gas consuming industries, information on power generation, petrochemicals and fertilizer sectors have been collected, but other industrial fields such as iron and steel, non-metals, and construction materials (cement, brick) have also been taken into consideration, as appropriate. Among these industrial sectors, a top priority is given to information on the demand and supply of electric power and the current situation surrounding the infrastructure, as well as on the future plan, as the demand and supply of electric power is an urgent issue at the moment. Reference was made to the results of surveys on the following two projects that were conducted for JICA by TOYO and Mitsui.

◆Preparatory survey on the construction of a fertilizer plant and a logistics terminal development project in Iraq (completed in FY2012)

◆Preparatory survey on a chemical fertilizer project in the middle west industrial sector (completed in FY2009)

In some cases, private power generation equipment may be installed in each oil and gas field, or in the oil storage or oil transportation base, and surplus power, may be fed to the national grid. Related information was not obtained.

At the time of review of the definitive gas demand and supply plan to follow this survey, information on the gas supply points (Tie-in points) and gas consuming areas is essential to examine the gas distribution and related infrastructure. Thus such information should be acquired as far as possible, however, information is not available.

3.1.3 Method to determine the gas production and its composition

The amount of gas to be supplied from limited information is calculated as follows:

1) Basic calculation method

The production of associated gas is obtained by the oil production of each oil field multiplied by the gas production ratio (GOR: gas-oil-ratio), which gives the amount of gas (Raw gas) to be produced at a wellhead point.

$Gp = Op \times GOR$

where

Gp	:Raw gas production scfd
Op	:Oil production BOPD
GOR	:Gas-oil-ratio scf/barrel

Note) In principle, the units to be used for oil and gas production are kBOPD (kilo barrel per day), and MMscfd (million standard cubic feet per day), respectively.

2) Associated gas

Associated gas is produced along with the production of oil, and is calculated using the above formula as a gas to be separated under the condition of a gas separator at surface conditions. Although a certain amount of gas is dissolved in oil after separation, it is neglected because oil is stabilized (de-gassing) during storage and before delivery. Associated gas includes solution gas or dissolved gas that remains dissolved in oil under the reservoir conditions, and cap gas present on the upper portion of oil, both of which are regarded equally as associated gas to be calculated using the above formula.

GOR depends to a large extent on the characteristics of the formation where oil is extracted, so that in this study, oil is roughly classified into medium and light crude oil and heavy crude oil, and GOR for both of them are summed up to be used for

calculation. Generally speaking, it is understood that the lighter oil and the lower reserve pressure result in the larger GOR.

3) Non-associated gas

This is gas that forms a gas phase in the gas field at reservoir conditions, and part of it condenses at surface conditions. Data on gas separated are available, which will be used to calculate gas production, while neglecting the liquid condensate when calculating the amount of gas.

4) Calculation of gas production for each component

It is necessary to calculate the production of each gas component for each downstream application of gas such as fuel for power generation, petrochemical and fertilizer plants. The production of each gas component is obtained by the raw gas production multiplied by vol% (mol %) of each component (refer to the formula below).

Gpc = Gp x vol% / 100
where
Gpc :Component gas production scfd

The amount of calculated gas corresponds to the amount of a 100% pure component gas obtained on the raw gas basis. However, since a downstream gas treatment plant has not perfect separation efficiency, the actual amount of gas for each component will be calculated according to the actual separation performance. In this case, de-methanizer, de-ethanizer, de-propanizer, and de-butanizer processes are considered to be used, while moisture content is removed in the dehydration process.

Components of gas to be considered include C1 (methane), C2 (ethane), C3 (propane), butane (C4), heavier components (C5+) and hydrogen sulfide (H2S), while the remained components as liquid residue after separation of C4 lighter in the gas treatment plant will be counted in natural gas liquids (NGL). Propane and butane are defined as LPG (liquefied petroleum gas), while mixtures of methane and ethane are defined as dry gas. In some cases, dry gas may be further separated to obtain methane for liquefied natural gas (LNG).

5) Gas Compositions

As the compositions of raw gas to be used in the above formula differ depending on the properties of each oil and gas field, individual data should be used in principle. However, if no data is available, data from similar gas and oil fields may be used instead. The gas composition also varies depending on the characteristics of the

formation where the oil is extracted, so that in this study, oil is roughly classified into medium and light crude oil and heavy crude oil, and the components for both of them are considered to be used for calculation. It is generally understood that the lighter oil contains the larger light hydrocarbon content.

6) Home-use gas

It is expected that some gas will be consumed for local gas-fired power generators in each oil and gas field. Some gas will be also used for plant heating purpose in field. Although the power and heating requirements vary for each project plan, the following are applied for home-use gas consumption.

Oil field: 20% of C1 and C2 out of produced gas
Gas field: 10% of C1 and C2 out of produced gas

It is understood that gas turbine-driven generators will be used, where C2 lighter is preferred as a fuel, which is “sweet” dry gas without sulfur content, so that raw gas should be treated inside of the oil and gas fields. In this connection, information will be collected as to the how gas is treated in the existing and developing oil and gas fields on the next phase.

If gas injection is applied as a means for EOR (enhanced oil recovery) to improve the oil recovery rate, net gas supply for sales will be substantially reduced, so that such shall be considered for the gas production calculation, if known in advance. Be noted that the raw gas is directly re-injected to the reservoir as usual.

7) Gas treatment facilities in oil and gas fields

Fluid in a wellhead is considered to be sent to a separator where gas (raw gas) is separated, and the gas is then classified into the components (dry gas, LPG, NGL) after passing through compression, desulfurization, dehydration and distillation. In some areas, raw gas may be collected in a central gathering station located outside the oil and gas field where desulfurization, dehydration and distillation may intensively take place. Information related to such existing facilities or to the on-going projects is also necessary particularly in examining the infrastructure.

3.2 Site Survey Report

Information materials, which was collected from meetings with counterpart for multiple times is summarized below. In this study a major mission is to collect information and data, therefore, this survey is not done by visiting each sites, but is based on the materials, such as INES, gathered officially.

3.2.1 Collection of oil field development plan, oil and gas production and composition data

On June 11, 2013, the Phase-1 kickoff meeting was held at the office of the Ministry of Oil, Baghdad, where representatives of the Ministry of Oil, the Ministry of Electricity, the Ministry of Industry and Minerals, the South Gas Company, and the North Gas Company attended from Iraq side. Chairman was Mr. Sadik. H. Al-Yassiri, Director General, Studies, Planning & Follow up Directorate. JICA Study Team explained on the basis of the inception report, requesting that data necessary for study should be received by June 20, 2013. Major points related to the discussion as to the reception of necessary materials, which were asked to be revealed, were pointed out in the meeting as follows.

1) Before submission of information materials, NDA (Non-disclosure Agreement) shall be concluded with the Ministry of Oil (immediately after the conference, a draft was submitted, but not signed yet).

2) The final development plan of the oil and gas fields under development by the international oil companies or the national oil companies could not be submitted at the moment. First of all, the oil and gas development plan by the national oil companies are still being prepared, thus taking a long time. It will be updated as appropriate during the course of review of the Gas Master Plan (GMP). Thus, the Phase-1 study will be made on the basis of the existing materials and those received from the South Gas Company at the time of facilities planning of crude oil evacuation from the south.

3) Request was made to receive answers to the questionnaire submitted in advance.

4) Request was made to show the INES Final Report. At the occasion of the INES launch ceremony, only the executive summary report was distributed. However since then the final report has been received afterwards.

5) From premises for making Gas Master Plan that the target crude oil production as the basis for the amount of gas supply was determined to be 9.0 MMBOPD (2020), while other cases would be taken into consideration during the course of the review of GMP.

6) North Gas Company (NGC) requested to look into the possibility of recovering sulfur from the raw gas, and to utilize the sulfur as a product. Then sulfur, which is contained in the gas would be recovered by a method of sulfur recovery, the production will be calculated and further study will be conducted in the next phase of

study.

7) NGC further requested to study if dome gas (cap gas) could be used as a source of gas supply. Only a portion of the dome gas is recovered as associated gas during oil production, so study will be made to recover the balance when oil production ends. This will be taken up in further details during the phase-2 and 3.

8) From the viewpoint of ensuring stable supply of gas, a request was made to study the method to store gas. Since storage in the form of gas phase would require a huge volume, the basic idea is to store it after liquefaction. Another possibility would be to pressurize and inject the gas into the cap gas layer of depleted oil fields, which will also be a subject of further study.

The second site survey was carried out aiming to receive further information and updates at Baghdad from 22nd September 2013 for 4 days. The study team met with representatives from the Ministry of Oil (MoO), Electricity (MoE) and Industry & Minerals (MoIM) and discussed current status on the related projects, requested data and the related materials acquisition.

Meeting Schedule:

Date	Iraq side	Venue
22nd.	MoO	MoO Conference Room
23rd.	MoIM	MoIM Conference Room
24th	MoO/MoE	MoO Conference Room
25th	MoO	MoO Conference Room

During the meeting with MoO representatives, the team verbally obtained some latest information mainly on northern oil & gas fields data which the team did not receive much information till then. Finally the team requested MoO to review the several summary tables prepared by the team and agreed to receive those informations by 1st October 2013. (Afterwards, because of MoO side inconvenience, the team has not obtained written data officially yet.) Two Minutes of meeting were signed on 25th September.

Attendees from MoO

Mr. Hashim Farag Al-Musawi, Manager, Planning
Mr. Rashid Kh Mohamoud, Studies, Planning & Follow up Dir., Gas Section
Ms. Hanan Naji Saryan, Studies, Planning & Follow up Dir.
Ms. Nasser Azeez Zabar, Studies, Planning & Follow up Dir.
Mr. D. Duha Sachi, Studies, Planning & Follow up Dir. (24th. Only)

Data to MoO for review

(1) Summary table of the international bidding results for oil & gas fields (1st. to 4th.)
(2) Plateau production target table for oil and gas fields
(3) Simplified gas treatment flow for northern area
(4) Simplified gas treatment flow for southern area
(5) Gas handling system of each oil & gas fields and summary table of products (Current & Future)
(6) Gas composition data of each oil & gas fields used for the gas component production
(7) Summary table of estimated gas production amount on the selected years

Major topics

(1) Kurdistan region shall be excluded from the study since Kurdistan government has dedicated development plan.
(2) Some production data of the northern oil & gas fields were obtained.
(3) National gas pipeline routes and size data were obtained.
(4) Northern and southern central gas treatment system data were obtained.
(5) Information on import pipeline of natural gas from Iran was obtained.
(6) Gas consumption for operational use in the fields should be 20% of the total produced gas.

During the meeting with MoIM representatives, the study team received a presentation with regard to the projected plan for petrochemical complexes all over the Iraq, and agreed to sign on a “Non-Disclosure Agreement (NDA)”, so that the team will obtain the related data afterwards. A draft NDA prepared by the team was signed later on with some amendment, then the team obtained a summary of the projects planned by MoIM. The minutes of the meeting also signed during the stay in Baghdad.

Attendees from MoIM

(1) Mr. Mohd Abdullah Mohd Zain, Deputy Minister
(2) Mr. AbdulKarim Al-Obaidi, Expert for Deputy Minister Office
(3) Mr. Ra’ed K. Ibrhim, Chief Engineer for SIDCCO
(4) Mr. Munadhil Sh. Al-Obaid, Engineer
(5) Mr. Gailan K. Hamza, Chief Engineer
(6) Mr. Selwa S. Tameel, Chief Engineer

Major topics

(1) Complexes of Petrochemical, Ammonia, Urea, and Methanol are projected and the required volume of the natural gas for feed and fuel were obtained.
(2) Information regarding an industrial area in southern area was obtained.
(3) As for the feed for petrochemical complexes, an option to use naphtha (liquid

feed) is included.

(4) Other industries such as steel, cement, etc. are handled by other section's in MoIM

(5) MoIM explained that a plan to export the petrochemical products was considered feasible by the market research conducted.

The meeting was held at MoO conference room by joining to the MoO representatives.

During the meeting with MoE representatives, the team obtained a summary sheet of the future plan of the power stations till 2019 including station name, station type, fuel and fuel consumption.

Attendees from MoE

(1) Mr. Alaa D. Ali, Planning & Studies Office

Major topics

(1) Current total nameplate capacity is 17 GW, however operable capacity is limited to 8 GW because of old facilities. MoE is planning to refurbish the stations one by one.

(2) 40 new power stations will be constructed by 2020. 11.7 GW are produced by steam turbines and 10.122 GW by gas turbines. Some of them will use imported gas from Iran. Together with oil-fired thermal plants, the total capacity will be 40 GW by 2020. (Inclusive diesel generator ;1.853 GW)

(3) Currently Iraq is importing 1.7 GW power from Turkey & Iran.

3.2.2 Gas utilization plan for power generation, petrochemicals, fertilizer and other industrial sectors

(1) For power generation

According to INES, the total capacity of existing power stations was 7 GW at the end of 2012, while by 2016, additional 40 stations with the total capacity of 22 GW will be constructed. These additional power stations will in principle be gas-fired using steam turbines and gas turbines, but with an additional function of oil-fired as appropriate. Flexibility in selecting the fuel will be an important consideration for the time being, because the gas-related infrastructure is still under development It is the main reason that the supply of gas may still be restricted. It is therefore envisaged to enhance the backup supply capacity to 15% by 2016 and onward. From 2016 and onward it is planned to construct combined cycle power stations which are considered to be environment-friendly with higher generation efficiency. As a result, the dependence on natural gas for power generation will be increased from the current rate of one-quarter to four fifths by 2030.

The expansion plan of power generation capability is indicated in Figure-3.2.2(4) (Exhibit ES-8 of INES Summary).

The capability margin is expected to turn from negative to zero around 2014, and then will gradually grow to 9-17-15%. In 2016, power import will stop, and in 2022, there will be no more diesel-engine power generation.

It is also planned that the share of steam turbines and gas turbines will gradually decrease (while maintaining the same capacity), while combined cycle power generation is expected to grow, and in 2030, the overall power generation capacity will be 42 GW.

If the transmission end efficiency of a steam turbine, a gas turbine and a combined cycle system is assumed to be 32.7%, 26.7% and 43.8%, respectively, the amount of gas required is assumed to be as follows.

Table 3.2.2(1): Provisional Estimation of Gas Required for Power Generation (2030)

Type of power generation	Share (%)	Generation capacity (GW)	Net thermal efficiency (%)	Amount of required gas (MMscfd)
Steam turbine	11	42x11%= 4.62	32.7	1,197
Gas turbine	24	42x24%=10.08	26.7	3,200
Combined cycle	58	42x58%=24.36	43.8	4,713
Total		39.06		9,110

(source: prepared by the study team)

The total power generation capacity with renewable energies is expected to be around 2 GW by 2030. This necessary volume of gas production will be reviewed elaborately whether it would be consistent with gas production plan. As written above, partial export of gas or revision of gas power ration should become necessary.

Simplified schematic drawings are provided below for steam turbine, gas turbine and combined cycle system, respectively.

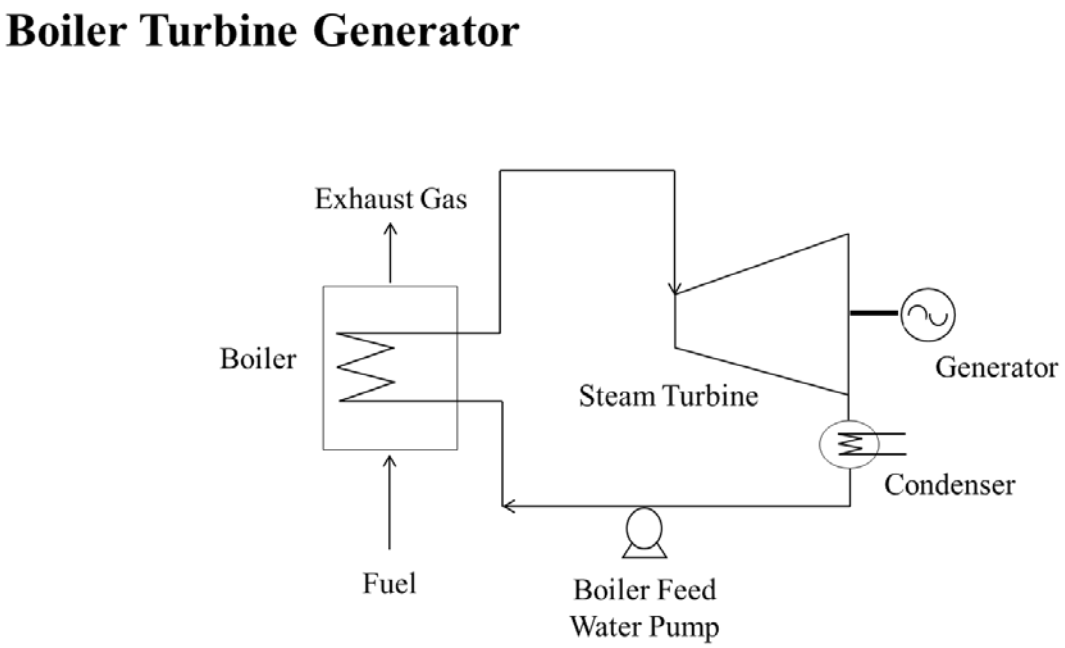


Figure-3.2.2(1): Schematic Diagram for Steam Turbine Generator System
(source: prepared by the study team)

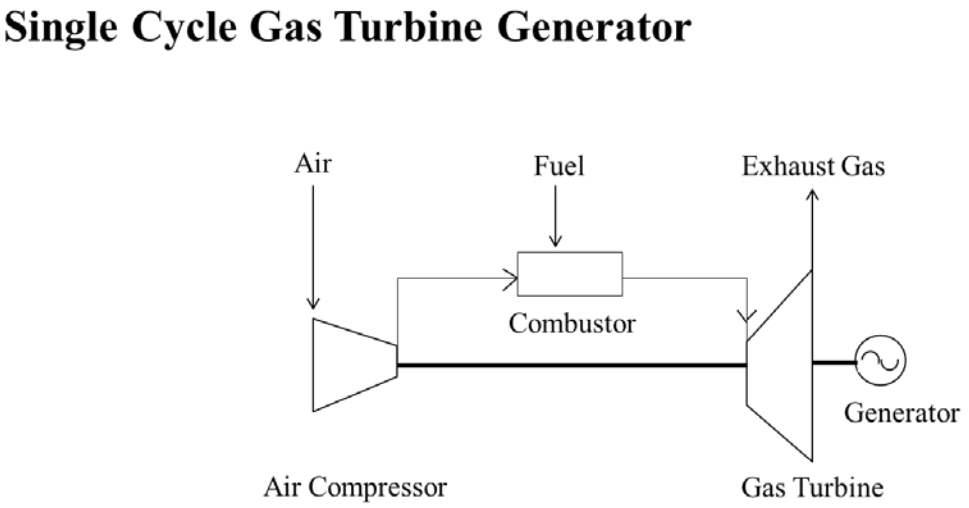


Figure-3.2.2(2): Schematic Diagram for Single Cycle Gas Turbine Generator
(source: prepared by the study team)

Combined Cycle Gas Turbine Generator

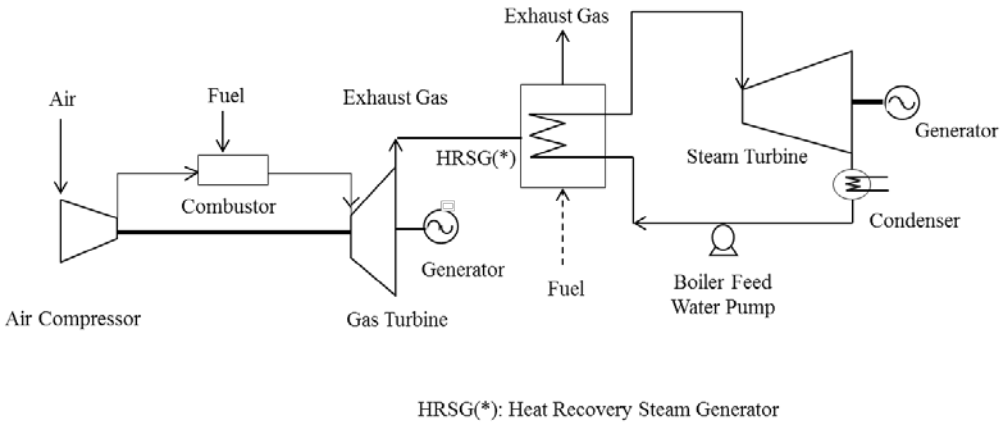


Figure-3.2.2(3): Schematic Diagram for Combined Cycle Gas Turbine Generator (source: prepared by the study team)

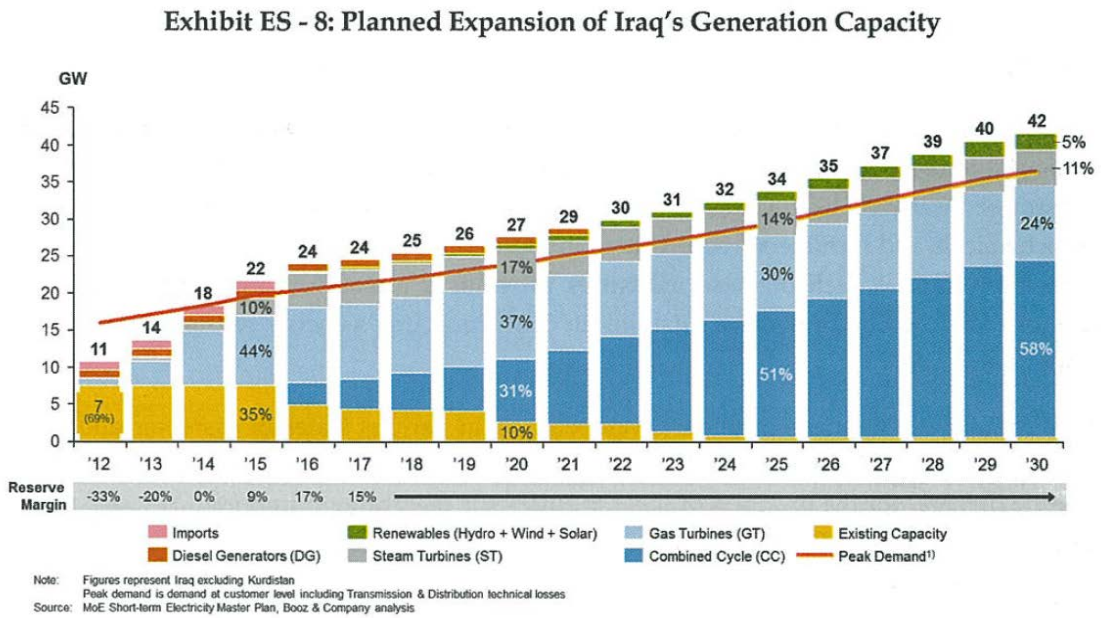


Figure-3.2.2(4): Expansion Plan of Iraq's Generation Capacity (source: INES Summary, Exhibit ES-8)

On the other hand, the study team obtained the information from Ministry of Electricity (MoE), which mentions the future development plan of Power Plant Installed Capacity.

The next figure is prepared to compare the INES installed capacity build-up plan (Exhibit5-20) with future MoE plan considering the existing capacity at 2012.

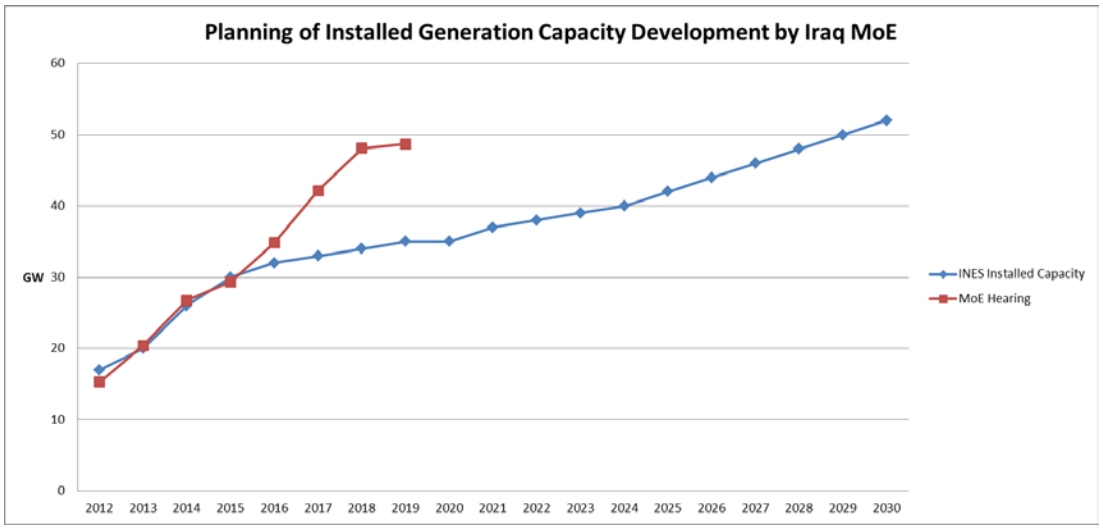


Figure-3.2.2(5): Comparison of INES vs MoE data
(source: prepared by the study team based on INES Final and MoE plan)

The figure reveals that both plans are well synchronized from 2012 through 2015 and that MoE plan is more rapidly increased than INES after 2016. According to MoE plan, gas turbine generators will be installed mainly in 2013 through 2015 and it will be suggested that associated gas for will be effectively utilized. Therefore, in this gas utilization planning, electricity capacity build-up plan in INES is reasonable and should be basis of the case study.

(2) For petrochemical industry

Since the current production of petrochemicals in Iraq is restricted, the majority of domestic demand of 188 thousand tons per year depends on imports. According the world ethylene plant information surveyed and released by the Oil & Gas Journal, the situation in Iraq is “unknown” (Oil & Gas Journal, July 1, 2013), while in the surrounding countries, several large scale ethylene plants using ethane as the raw material and having a capacity exceeding 1,000 thousand tons per year are operated or planned. However, even in these Middle East regions, the supply of ethane is slightly decreasing, so that more costly heavy naphtha is considered to be used instead. This means that Iraq is expected to enjoy an advantage in the world markets because of her sufficient supply capability of ethane gas.

INES presents the development plan of the petrochemical industry. The planned capacities in terms of petrochemical products are: 8,000 thousand tons/year (raw material: ethane), and 3,000 thousand tons/year (raw material: methanol). It is assumed that the

petrochemical process with ethane as the raw material is used for producing ethylene through ethane cracking and that the process with methane as the raw material is used for producing methanol through synthesis reaction. As those production capacities will be more than the domestic demand, the plan is mainly intended for enhancing exports. Accordingly, off-taker of the product or off-take of products by Production Partners could be seen the key factor.

Intermediate products and off gas produced in the refinery also have an impact on the gas demand and supply balance. Current oil refining capacity in Iraq is around 750 kBOPD and is not sufficient enough to supply petroleum products to the domestic market, therefore main products such as LPG, Gasoline, Jet fuel and diesel are now imported from international markets. There are three large scale refineries, Beiji, Doura and Basra, which has more than 100 kBOPD capacity, and others with very small capacity and with simple process configuration (10 to 30 kBOPD) are scattered through all the areas in Iraq. MoO has a plan to construct 4 modern refineries with more than 150 kBOPD capacity in Kirkuk, Karbara, Missan and Nassiriya by 2020, and the total oil refining capacity is supposed to be around 1,500 kBOPD, by which Iraq would be a self-sufficient country as far as petroleum products.

Hereunder, some overlooks were made about the refined products which could be feedstock of the petrochemical industries;

(1) Off-gas (C2 Lighter)

Normally all the off-gas from refining processes is consumed as refinery fuels after sweetening unless the refinery has a specific gasification or conversion processes, LPG and/or the fuel oil are used for the balancing purpose. Most of the gas components contained in the crude oil produced are separated at the crude oil production site, therefore the amount of gas components in the refinery feed are very few, however the refinery that has Catalytic Reforming and/or Fluidized Catalytic Cracking (FCC) processes will produce some additional gas components. As the off-gas from reforming process contains much of hydrogen, and the gas is used as hydrogen source for hydrotreating processes.

(2) LPG (C3 & C4)

As mentioned above, most of LPG fractions contained in the crude oil produced are separated and processed at the crude oil production site and only a small portion of the fraction is fed to the refinery, however some amount of the said fraction are produced in the conversion type processes such as FCC and Reformer. LPG from reformer is sweet and saturated, therefore it straightly blended to the LPG products. LPG from FCC contains un-saturated fractions,

then after separation, the un-saturated fraction is used as feed stock of petrochemical processes or internal fuel, and the saturated fraction is used as blending stock of the LPG petroleum products. Particularly, it is expected that propylene fraction can be extracted from the FCC LPG for the polypropylene feed stock, but the propylene volume is relatively small and limited.

(3) Naphtha (C5+)

Normally naphtha fraction is further separated into light naphtha and heavy naphtha and the latter is the feedstock of Reformer unit after hydrotreated. Reformate product has higher octane number because of aromatics components and then be a main blending stock for the gasoline product as well as the FCC gasoline product. A competitive use of reformate product is for the feed stock of the aromatics complex to produce BTX, for which further processing units are required. As a whole, gasoline demand is much larger than that of BTX, therefore the gasoline production is a first priority, then the balance would be feed stock of the BTX complex, subject to the planning of the refinery configuration and capacity as well as market research.

Light naphtha mainly composed of C5 fraction can be further processed, for example, Isomerization, to enhance octane number for a gasoline blending stock, while a majority is a feed stock of naphtha cracker. In the region where plenty of C2 gas is available, ethane cracker is more viable than naphtha cracker, however, naphtha cracker can produce wider olefins than ethane cracker. Light naphtha fraction is quite similar to the NGL and condensate produced at the crude oil production site, and possible options of light naphtha utilization are a) export, b) feedstock of naphtha cracker, c) feedstock of condensate refinery, and d) to spike into the crude oil export.

A wider linkage between refining, petrochemical and upstream industry could be considered as far as gas resources concerned, however, this study focused on the resources from upstream only for the base demand and supply balance.

The study team got the information from Ministry of Industry and Minerals (MoIM) for the present and future petrochemical development plan.

The study team compared the INES plan with MoIM data, which was provided by MoIM at the second site survey for Ethylene Capacity Build-up Plan.

The comparison reveals that MoIM development plan is milder than it of INES, however, 5.5 million ton/y of ethylene plant production is almost similar in Japan. An average production capacity in Middle East is proximate 80kg per capita and therefore,

the study team assumed 3.0 million ton/y should be minimum case for Ethylene plant capacity in Iraq at 2030.

Finally case study has been done based on the highest case (INES), middle case (MoIM), and minimum case.

Table 3.2.2(2) : Ethylene Production Capacity in major countries and areas (kg per capita)

kg per Capita	2004	2005	2006	2007	2008	2009	2010	2011	2012
Japan	59	59	60	60	60	60	60	59	60
Korea	118	122	125	147	153	152	155	156	162
China	5	5	7	8	8	8	10	12	12
Thailand	30	35	35	36	37	38	67	67	66
Indonesia	2	2	2	2	3	2	2	2	2
India	2	2	2	2	2	2	3	3	4
Malaysia	66	66	65	65	63	62	61	62	61
Australia	22	22	22	21	21	21	20	22	22
Middle East	49	53	53	58	67	90	107	81	83
USA	94	96	94	95	94	89	85	84	83
Canada	165	163	162	157	164	153	151	150	148
Maxico	13	11	13	12	12	12	12	12	11
Brazil	16	19	19	19	20	20	21	20	21
World Total	17	18	18	19	19	19	21		

(source: prepared by the study team based on the statistics of METI, Japan)

The similar analysis has been made for methanol plants.

The plan of MoIM consists of three new plants and almost half capacity of INES plan. Methanol market analysis in Middle East can support MoIM planning.

(3) For fertilizer industry

INES plans to expand the fertilizer industry to 6,300 thousand tons/year by 2030 (equivalent to Ammonia 11,200 ton/day on 330day/year basis). If an assumption is made to produce urea as the typical chemical fertilizer from methane as the major component of natural gas, the amount of methane gas required will be 1.919 million tons/year, as the typical yield rate of urea is 0.305 tons-gas per ton-urea. The above amount of methane gas is equivalent to 268MMsfcd.

Table 3.2.2(3) : Provisional Estimation of Gas Required for Fertilizer (2030)

Scale of fertilizer industry (ton/year)	Equivalent to urea (ton/year)	Urea produced from dry gas (ton-gas/ton-urea)	Amount of required dry gas (ton/year)	Amount of required gas (MMscfd)
6,300,000	6,300,000	0.305	1,919,000	268

(source: prepared by the study team)

As of 2010, Iraq has three fertilizer plants, with the total production capacity at the

moment being 300 thousand tons/year, which is equal to half the current domestic demand, with the rest being imported. As is the case of petrochemical industry, Iraq's fertilizer industry is expected to enjoy an advantage in the world markets in the future because of her sufficient supply capability of natural gas as the raw material.

INES shows the development plan of fertilizer industry. In 2017, the domestic demand will be satisfied, and a surplus capacity could be exported if gas supply is ensured.

According to the report of "Preparatory Survey on the Construction of a Fertilizer Plant and a Logistics Terminal Development Project in Iraq" (PPP infrastructures project) realized jointly in March 2013 by the member companies of this study, TOYO and Mitsui, the following conditions were confirmed as to the raw materials for a fertilizer plant with a production capacity of 2,700 tons/day of ammonia (out of which, 1,700 tons is utilized for urea production and 1,000 tons for export) and 3,000 tons/day of urea.

Table 3.2.2(4) : Example of Parameters of Iraq PPP Fertilizer Plant

Fertilizer plant specification		
Ammonia production	2,700 tons/day	1,700 tons is for urea production 1,000 tons for export
Urea production	3,000 tons/day	
Raw material consumption		
Natural gas consumption	83,000Nm3/hour	
Fuel oil consumption	11,000kg/hour	
Raw water consumption	2,400m3/hour	

(source: JICA report of the Preparatory Survey on the Construction of a Fertilizer Plant and a Logistics Terminal Development Project in Iraq (PPP infrastructures project, March 2013)

The configuration of the fertilizer plant is given below.

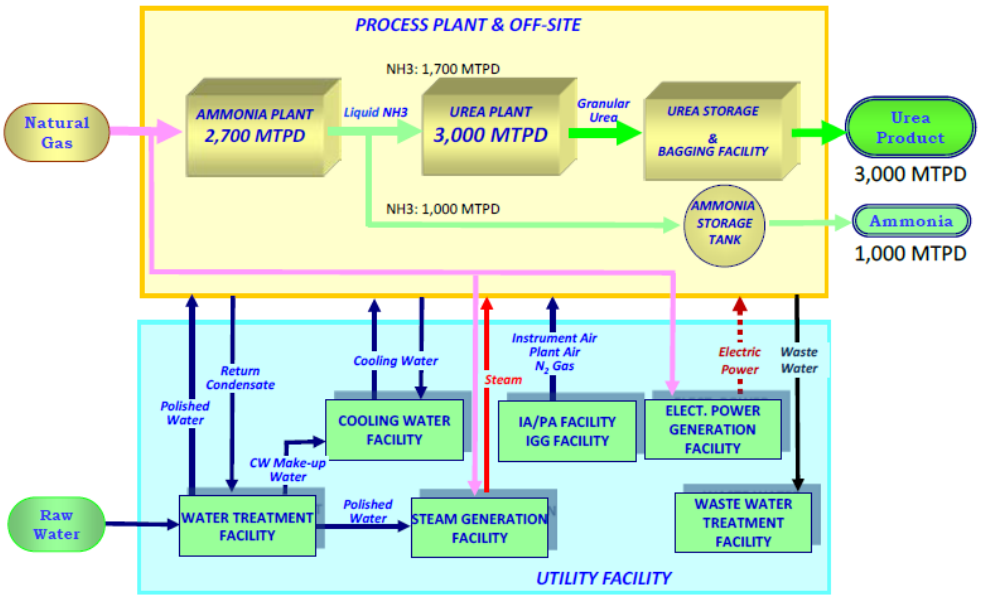


Figure-3.2.2(6) : Configuration of Iraq Fertilizer Plant

(source: JICA report of the Preparatory Survey on the Construction of a Fertilizer Plant and a Logistics Terminal Development Project in Iraq (PPP infrastructures project, March 2013)

The fertilizer plant development plan was provided from MoIM at the second site survey.

Case study has been done based on the MoIM build-up plan.

(4) For cement industry

INES plans to expand the cement industry to 65 million tons/year by 2030.

As of 2010, Iraq has 7 million tons/year cement production facilities, which corresponds to half of the domestic demand of 13.5 million tons/year, with the rest being imported. As is the case of the petrochemical industry, Iraq's cement industry is supported by a plentiful supply of cheaper natural gas as the raw material and is expected to enjoy advantage in the world markets, because of relatively cheap transportation cost and a huge amount of fuel and limestone.

However, INES assumes fuel oil as a fuel for cement industry, and thus, no study was made of gas utilization plan in this study.

(5) For iron and steel industry

INES plans to enhance the production capability of iron and steel to 10.2 million tons/year by 2030.

Since Iraq has no working iron and steel production capability at present, the domestic demand of 2 million tons/year depends entirely on import. In terms of cheap fuel

cost and the concept of “local production, local consumption”, domestic products are believed to be competitive when compared to imported goods, but Iraq does not seem to be in a competitive position for exporting to overseas markets.

Table 3.2.2(5) : Provisional Estimation of Gas Required for Iron & Steel (2030)

Scale of iron & steel industry (ton/year)	Required gas for steel (ton/ton)	Amount of Required gas (Ton/year)	Amount of required gas (MMscfd)
10,200,000	0.437	4,454,000	622

(source: prepared by the study team)

The study team analyzed the probability of development plan of iron and steel industry of INES in comparison with other Middle East countries.

The existing steel plant in Iraq is only one plant located in Khor Al-Zubair, Basra, capacity of which is 1 million ton/y, but it is not working. INES also shows this existing plant rehabilitation plan. However, Iraq imports all of required steel at this moment and it equals to 1.2 billion USD/year. Iraq has a plan to supply whole domestic demand of steel by domestic manufacturing. According to World Steel Association, production of steel (direct reduced iron) in Middle East area in 2012 are;

Iran:	11.6 million ton/year
Qatar:	2.4 million ton/year
Saudi Arabia:	5.0 million ton/year
UAE:	3.0 million ton/year
Total in ME	22.0 million ton/year.

It looks exaggerated that INES plan will produce about 50% of Middle East production capacity, however, it reveals the INES plan can be likelihood since the past development speed in Middle East can be compared with plan in INES as shown in Figure-3.2.2(7). Then INES plan is reasonable, and the plan will be considered for natural gas demand/supply balance calculation.

In this study, the capacity build-up plan described in INES is applied for supply and demand balance.

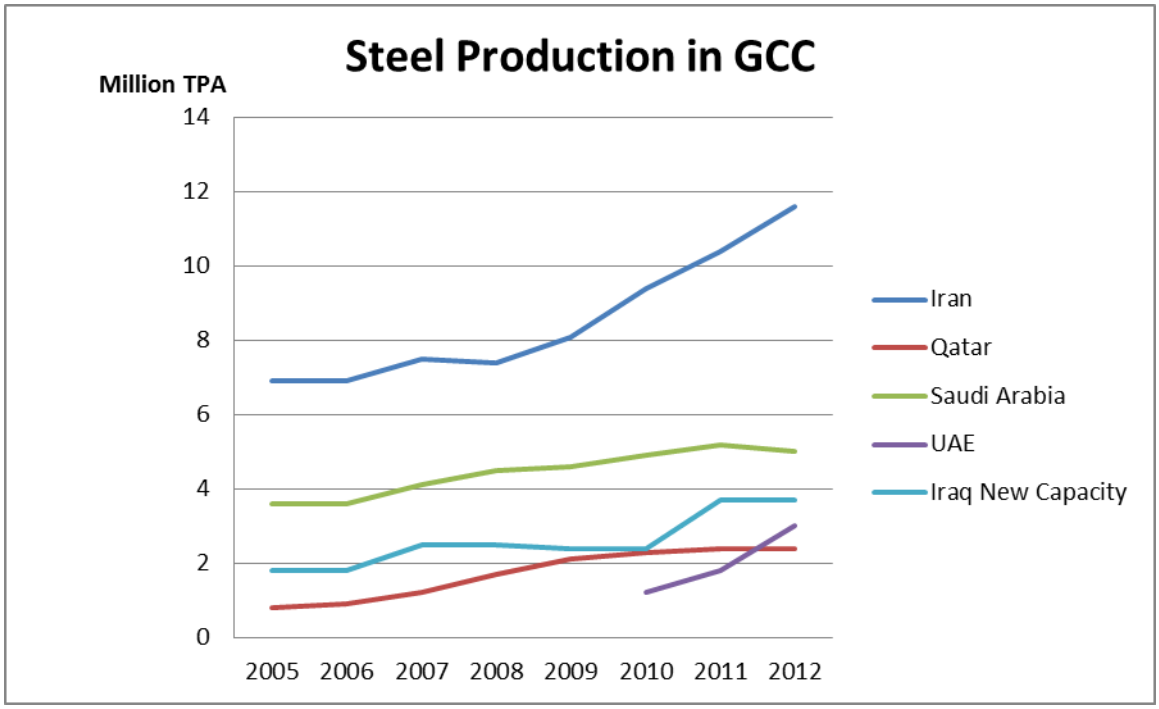


Figure-3.2.2(7): Capacity Build-up Speed in ME Steel Development and INES
(source: prepared by the study team according to World Steel Association data and INES)
(note: figure of Iraq is shifted in parallel form capacity in 2012-2019 planned)

(6) For aluminum industry

INES plans to enhance the production capability of aluminum to 1.0 million tons/year by 2030.

Although Iraq has no aluminum industry at present, she is in a favorable position internationally in terms of the energy-consuming aluminum industry because of her rich and cheap energy sources.

Table 3.2.2(6): Provisional Estimation of Gas Required for Aluminum Industry (2030)

Scale of aluminum industry (ton/year)	Required gas for Aluminum (ton/ton)	Amount of required gas (ton/year)	Amount of required gas (MMscfd)
1,000,000	2.01	2,012,000	281

(source: prepared by the study team)

INES presents the development plan of aluminum industry. In 2022, the domestic demand will be satisfied, with about half of the products planned to be exported if natural gas supply is ensured.

Similar as steel, the study team analyzed the probability of aluminum capacity

development in INES.

According to USGS (US Geological Survey), average annual consumption of aluminum in the developed countries such as Japan, USA, Germany and France is proximate 30 kg per capita and that of Iran is expected proximate 11 kg per capita in 2025. Assuming the population in Iraq in 2030 will be grown up to 40 million people, overall demand in Iraq in 2030 will be 400,000 ton annually and it meets the demand in INES.

The statistics in USGS Mineral Yearbook 2007 shows aluminum production in 2006 are;

Bahrain:	860,000 t/y
Egypt:	252,000 t/y
Iran:	205,000 t/y
UAE:	861,000 t/y.

The development plan in Iraq will be 500,000 t/y capacity plant to be built one after one to meet one million tons per year. The plan is likely comparing with other ME countries. Feedstock for aluminum should be alumina instead of bauxite considering the environmental issue.

(7) For brick industry

INES plans to enhance the production capability of brick to 72 million tons/year by 2030.

As of 2012, Iraq has brick production facilities with a capability of 29 million tons/year. On the other hand, recent brick demand is 43 million tons/year, and by 2030, it is anticipated to reach 65 million tons/year due to restoration demand. In consideration of transportation cost, it is believed that imported brick will be replaced by domestic ones.

However, INES assumes fuel oil as a fuel for brick industry, and thus, no study was made of gas utilization plan in this study.

INES Final presents the development plan of brick industry. In 2015, the domestic demand will be satisfied, and surplus capacity could be further supplied to growing domestic market.

4. Result of Survey and Analysis (from March 2013 to December 2013)

4.1 Analysis of Acquired Data

4.1.1 Website information

A wide range of information has been referred to, out of which only the major sites are given below.

1) Homepages of Iraq government

The homepages referred to include that of the Ministry of Oil, the Ministry of Industry and Minerals, the Ministry of Electricity, the South Oil Company, the North Oil Company, Missan Oil Company, the Midland Oil Company, the South Gas Company, the North Gas Company, State company for Oil Project, State Oil Marketing Company, etc. Reference was made to the website of the Ministry of Oil in search of information on international bid for development, and other recent trends related to the latest production of crude oil and gas, export and domestic demand, actual situations on gas flaring (monthly reports), as well as crude oil and gas-related projects. The websites of the Ministry of Electricity and the Ministry of Industry and Minerals provided the latest situations for reference on the power supply and demand and the downstream industrial fields, while the websites of State Oil Marketing Company provided the current information on the amount of crude oil exports, export costs, export destinations and oil products imports, while the website of Oil & Gas Construction Company was referred to for the latest information on the on-going projects. The website of each oil company was also referred to for the overview of facilities under their control. As a general impression of these homepages, it is though that they would be more informative when with an English edition.

2) Homepages of private companies related to Iraq oil and gas development

The homepages referred to include that of the Basra Gas Company, international oil development companies, and other design and general contractors, etc. which are engaged in the development of oil and gas in Iraq. From the website of the Basra Gas Company, information was obtained on the background of the establishment of this project and of the latest contracts, and also information on the actual status of site survey activities. However, no detailed information was acquired from other international oil development companies. Such information was referred to as appropriate as backup source of information related to that of the Ministry of Oil.

3) Homepages of international energy-related organizations

Reference was made to the latest information and published statistical data concerning

the recent world and region-wise energy supply and demand provided by IEA, EIA, OPEC, the World Bank, British Petroleum, Japan Oil, Gas and Metals National Corporation (Japan), etc.

4.1.2 Press information

Reference was made to Iraq oil and gas related articles in news publications since 2004, such as Iraq Business News, Gulf Oil & Gas News, as well as others as appropriate. These articles are stored in chronological order according to the major industrial fields such as oil and gas development, infrastructure, oil refinery, and electric power, so as to allow ready reference.

Information on the past background and the latest trend in each sector obtained from these articles is served as supportive evidence to various types of information. Reference was made to information on the bid and tender for production concessions, the progress of various oil and gas field development projects, the status of contracts signed with design and general contractors, information on production targets, production and exports, policies of the government of Iraq, and on domestic security. Acquired information also includes activities in the Kurdistan district.

4.1.3 Information obtained from published reports and literatures

Reports that are made public on Iraq's oil and gas are obtained as much as possible, and referred to, which include a general overview on the postwar restoration of Iraq, statistical data, an overview on the oil and gas field reserves and the current and future development, an overview on the related infrastructure, as well as current and future plans of the downstream, in particular of electric power demand. These reports were mainly downloaded from the respective websites, but materials distributed at various seminars and books are also included.

The following are major reports:

- IEA World Energy Outlook Special Report, Iraq Energy Outlook 2012
- EIA US Energy Information Iraq 2013
- INES Executive Summary and Final Report (June 2013)
- BP Statistical Review 2013
- Oxford Report, Natural Gas Markets in the Middle East and North Africa, Oxford Institute for Energy Study, 2011
- Iraqi Ministry of Oil Fossil Fuel Resources (Latest Estimate)
- OPEC Annual Report 2011
- Gas Industry in Iraq, 1st. IENA Workshop 2013

- ◆ Iraq Gas Markets, 2012, GlobalData
- ◆ Investment Overview Iraq, National Investment Commission
- ◆ Iraq & Kurdistan Electricity Master plan September 2011, Istanbul
- ◆ Outlook & Status of Iraq Petrochemical Industry, Iraq Future Energy Istanbul
- ◆ Iraq Future of the Energy Sector, November 2011
- ◆ IHS Chemical, Upstream/Downstream Poster

4.2 Analysis of the amount of gas supply

Although it was intended to receive at the kick-off meeting and site survey the materials required for the study of gas supply, in particular materials related to the development plans of each oil and gas field, these were not yet available. The INES Final Report had also been expected but the only material distributed at the INES launch ceremony was its executive summary, to which reference is made for the general conclusion on each energy sector and the direction for future study. Since then the final report has been received

The 2nd Site Survey was carried out in September 2013 and some additional data were obtained from MoO, MoE and MoIM. In relation to the gas supply, the following data and information were obtained and they are to be reflected to the study;

(1) Oil & gas fields in Kurdistan area are excluded from the study
(2) Some additional data on the fields operated by Iraq States companies
(3) A latest information on the national gas pipeline network
(4) Gas import plan from Iran
(5) Required gas volume for the oil and gas field operation

Since new materials are not available on the annual development of gas production as a basis for study, the existing materials and the public documents were used. The existing materials that are referred to are:

- the preliminary development plan obtained from the South Oil Company for the system review work of the crude oil evacuation project in the south region; where TOYO was involved as the contractor, and
- the Iraq infrastructure report (prepared in 2011-2012)

These materials include the major oil fields that produce nearly all the domestic production, of which the production of crude oil in the south equals about 12 MMbpd. Since then, the target crude oil production of major oil fields was revised, the study data was revised accordingly. As the target production and the time to achieve the same as well

as the plateau production period were revised and made public, the annual production growth has been made on this basis. As for GOR, gas composition and operational-usage consumption, assumption was made as related information was not available. Thus, the study in Phase-1 is based only on rough numerical data. As new data are made available in the future, the related numerical data will be renewed, so that in the Phase-2 and 3 studies, a supply and demand balance is expected to be prepared on the basis of the new data.

Since the development plan of the south oil fields to be developed by the Iraq National Oil Development Company is not in our hand yet, assumption was made on the basis of information from the South Oil Company. This information also includes data on the eastern and middle oil fields. As for the north oil fields, website-based general information and the data obtained at the 2nd Site Survey were used for estimation.

Since there is no data on gas field development plan at all, except for an article on Akkas gas field in the Oil & Gas Journal, the annual gas production growth was made on this information together with website-based information.

4.2.1 Overview on Iraq gas reserve

Various numerical figures are reported on Iraq gas reserve. According to an article "Natural Gas Production in Iraq" (Oil & Gas Journal, 2006):

Proven reserve:	110 Tcf
Probable reserve:	150 Tcf (approximate)

The type of gas reported is: associated gas 70%, non-associated gas 20% and dome gas 10%. The above proven reserve and the gas type are found in many reports.

World Energy Outlook Iraq Special Report 2012 says that the proven reserve of the conventional type natural gas in entire Iraq at 2011 is 121 Tcf, which means a slight increase (refer to the below table).

Proven reserve:	121 Tcf
Ultimate reserve:	280 Tcf
Accumulated production:	18 Tcf
Remaining reserve:	262 Tcf

As per the material distributed at the first IENA workshop organized and held by the Ministry of Oil in Baghdad on May 26, 2013, the proven reserve is 120 Tcf, equivalent to 1.5% of the world and rank 13th, out of which associated gas is 75% and non-associated gas 25%. As the above numerical figures show a fairly good agreement with those of the

regional resources, it is understood that this report is based on the IEA data.

According to the summary from the final report distributed at the INES launch ceremony, the reserves of conventional natural gas are:

Proven reserve: 112 Tcf (world 12th rank)
Estimated reserve : 280 Tcf *1 (world 5th rank)
*1: Corresponds to URR in the material by IEA. In the summary of the INES report, this is indicated as “additional”, but the net additional seems to be (280-112＝168 Tcf).

BS Statistical Review 2013 presents the following data on the proven reserve:

Year	Tcf	Share %	Boe *1
1992	109.1	-	100.0
2002	112.6	-	115.0
2011	126.7	-	143.1
2012	126.7	1.9	150.0

*1 Boe; Barrels oil equivalent and includes condensate & NGL

As for the proven reserves, two figures are currently reported as mentioned above: 112 Tcf and 126 Tcf. For instance, the final report (revised on April 2, 2013) by EIA (US Energy Information Administration) presents 126 Tcf as data from Oil & Gas Journal, however the below June 2013 report revised it to be 137 Tcf as a result of review made by the Ministry of Oil.

Iraq Increases Gas Reserves
Posted on 20 June 2013.
Iraq’s Ministry of Oil has reportedly announced that Iraqi gas reserves reached to 137 trillion standard cubic feet due the increase in exploration sites.
Spokesman Asim Jihad said investment and development operations comprised of three stages to reach the peak of production.
Earlier, oil under-secretary Fayadh Hassan said that Iraq is trying to be one of the main gas producing countries.
(source: Aswat al-Iraq)

<Conclusion>

1) As is seen from the above articles, the reserve is to be revised as the exploration progresses, so that a close watch on the future trend needs to be kept. At the moment, it is reasonable to regard the latest reserve as about 120 Tcf, while keeping observation on the data to be announced by the Ministry of Oil.

2) IEA reports that the cumulative production up to now occupies only 6% of the ultimate reserve, which means that gas development is just on the starting point.

3) 64% of the proven reserve is found in the south, out of which the five super-giant oil fields (West Qurna, Rumaila, Majnoon, Zubair and Nahr Umr) occupy 76%. All the gas produced from these five oil fields is associated gas. In this connection, about 74% of the gas reserve in the entire Iraq is associated gas, which means that development of non-associated gas has effectively not been started.

4) As mentioned later, the infrastructure for gas recovery has not been well developed due to damage caused by the war and the crude oil development preferential strategy, a large portion of produced gas is left for flaring. As of August 2013, all the flared gas is associated gas, in other words, resources to be effectively utilized are left for useless burning, resulting in economic loss and adverse effect on the environment. Thus, urgent measures should be taken.

4.2.2 Overview on Iraq gas production

A greater part of gas in Iraq is associated gas produced together with oil production. At present, the top priority is focused on urgent increase in the export of crude oil which gains almost all the national income required for the postwar restoration, while effective utilization of gas is well behind.
Now, the background on the crude oil production target is reviewed.

(1) Current crude oil production and gas flaring

The Ministry of Oil officially announces monthly data on crude oil production, crude exports, domestic consumption, and gas production records. Past data back to around 2009, which corresponds to the time when crude oil development was re-started, reveal the traces of the postwar restoration. As earlier data is not available, other statistics such as OPEC data are the only means. The following report is that dated August 2013, which presents as below.

Table 4.2.2 (1) Current actual data by MoO Iraq (August 2013 Average)

(August 2013)

State Companies	Unit	NOC / MDOC	SOC / MOC	TOTAL
Crude Oil production	kBPD	659	2,548	3,207
Crude Oil Export	kBPD	271	2,308	2,579
Supply to Refineries	kBPD	322	304	627
Supply to Power Stations	kBPD	54	91	145
Gas Production	MMscfd	483	1,480	1,963
Gas Flared	MMscfd	248	1,123	1,371
Gas Flared Percentage	%	51	76	70
Gas Oil Ratio	scf/B	733	581	612

Remarks

NOC	North oil Company
MDOC	Midland Oil Company
SOC	South Oil Company
MOC	Missan Oil Company

Production rate in August 2013 has recorded the maximum since 2009.

(source: prepared by the study team)

Monthly crude oil production is 3.207 MMBOPD, while the production of gas is: 483 MMscfd in the north and the middle, and 1,480 MMscfd in the south and the east, with the total being 1,963 MMscfd, that is, the south and the east occupy about 79%. It should be noted in this connection that 1,371 MMscfd of gas produced is left for flaring without being effectively utilized, which corresponds to about 70% of all the gas produced. The overall gas-oil ratio is given for reference: 733 scf/bbl in the north and the middle, and 581 scf/bbl in the south and the east, and 612 scf/bbl as average for the entire Iraq. It is observed from the above that about 600 scf/bbl of gas is produced for the average crude oil production. It is also understood that the gas ratio is relatively high in the north and the middle, which is also supported by the past numerical figures. However, the following points are not observed from the above data: (1) breakdown of oil and gas fields as a focus for regional statistics, (2) whether or not non-associated gas is included, although gas is described as associated gas in the report, (3) whether or not the Kurdistan district is included in the statistics. These points will be confirmed in future.

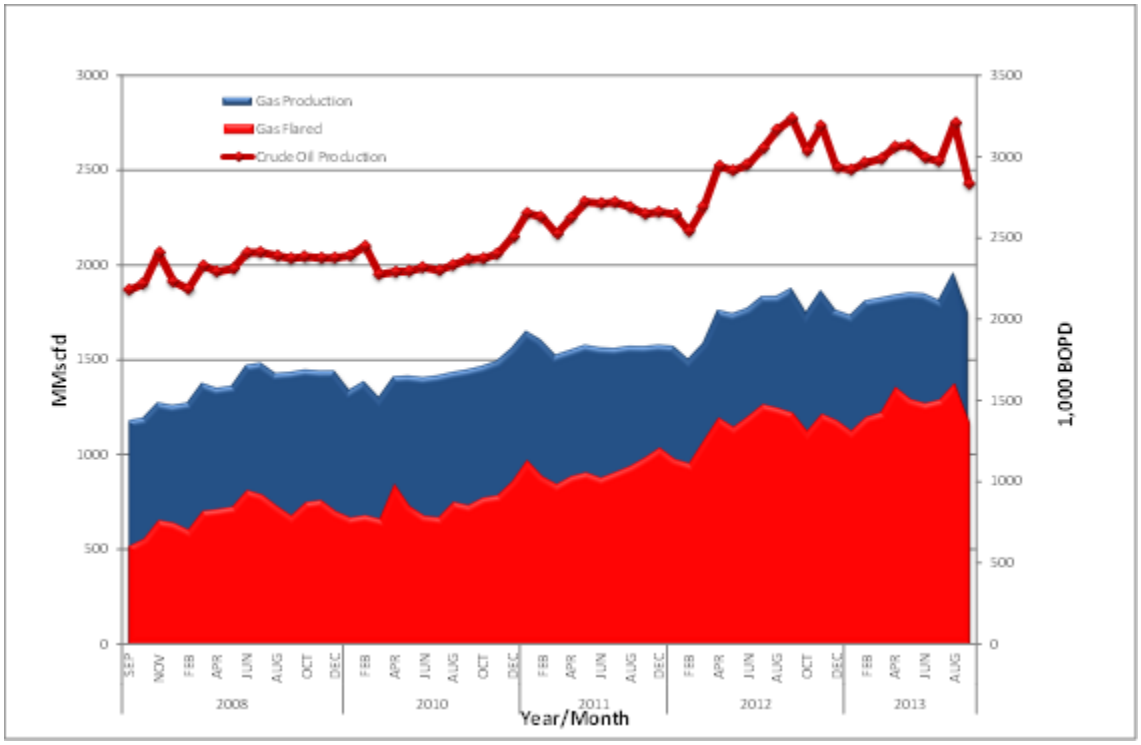


Figure-4.2.2 (1) Transition of Gas Production and Gas Flaring
(source: prepared by the study team)

(2) Four year plan

The four year plan formulated in 2011 by the Ministry of Oil set a targeted crude oil production increase to 6.5 MMBOPD in 2014 from the current value of 2.75 MMBOPD, which basically follows the trend to achieve the production of 12 MMBOPD by 2017. On the other hand, the forecast gas production in 2014 is 4,000 MMscfd of associated gas, 500 MMscfd of non-associated gas, 4,500 MMscfd in total. This forecast corresponds to the total sum of the production target for each contracted oil field awarded to international oil companies as a result of the open bid round for production concessions made in 2009, and is larger than the current production in Saudi Arabia

Table-4.2.2 (2) Iraq MoO 4 Years Development Plan

Years	Unit	2011	2012	2013	2014	Remarks
Crude Oil Production	MMBPD	2.75	3.30	4.50	6.50	
Non-Associated Gas	MMscfd	375	375	375	500	2 Gas fields development (Mansuriyah, Akash) in 2014
Associated Gas	MMscfd	1,400	2,000	2,700	4,000	
Gas Total	MMscfd	1,775	2,375	3,075	4,500	
Export Capacity						
South	MMBPD	1.75	2.60	4.44	5.00	*1
North	MMBPD	0.65	0.65	0.65	0.65	Rehabilitate P/L for Capacity up to 1.0 MMBPD.
Total	MMBPD	2.40	3.25	5.09	5.65	

*1 Phase 1 : To install (2) 48" Subsea P/Ls and (3) SPMs. 1st Step in End 2011, 2nd Step by 4Q2013
Phase 2 : To install (1) 48" Subsea P/L between FAO & ABOT with (1) diversion to KAAOT and (1) divirsion to 4th SPM by 2Q2013.
FAO Tank Farm :To install Central Pumping Satation & 24 Tanks.

(source: JOGMEC Report, etc.)

(3) License rounds for oil and gas fields development

Since 2009, the production concessions of the domestic oil and gas fields are made open to international oil development companies, followed by the commencement of bidding rounds. As of the end of June 2013, the results of four bid rounds were announced, and up to now, the contracts for 19 concessions have been concluded. The objective of the bid includes exploration and development of green oil and gas fields, in addition to rehabilitation and production increase of the existing operating oil and gas fields (brown fields). Most of the winning international oil development companies have established an international consortium consisting of multiple enterprises, although some of them are individual companies. The form of contract is a TSC (Technical Service Contract), where the oil development companies are under an obligation of attaining the target production by a specified time and also of maintaining the period for maximum production, for which they receive a remuneration fee per barrel ($/bbl). The term of contract is 20 - 25 years. The contents of contract are slightly modified in each bid round to allow smooth bidding operation. The results of the license round were shown on the table 4.2.2 (3) to (6).

In addition to the above, there is an independent on-going bid operation for the production concession of Nasiriya oil field, which is in the form of a joint contract with the construction of a related oil refinery.

5th and 6th bid rounds are planned in Iraq, where new production concessions and those not awarded in the previous rounds are included as the target concessions, and thus, the Study Team will keep following the progress. It is believed that these bid rounds will basically proceed in step with the national strategy and implementation of the national restoration program.

The results of each bid round are given below. The target crude oil production as per the 1st and the 2nd bid rounds amounts to 11,790 kBOPD (Kurdistan area is not included.). If the crude oil production from the oil field covered in the 4th bid is added thereto, the total will be 12 MMBOPD or more. According to the press information at the time, the total target production will be equal or more than the production in Saudi Arabia in 2017, however, in 2012, Iraq decided to revise down the target oil production of the southern super giant fields, so that total production will be less than those of the original bid rounds contracts.

Table-4.2.2 (3) Result of 1st bid round (June 29 and 30, 2009)

Field Name	Contracters	Main Target	Production 2009	Target production	Reserves Bbbl
Rumaila	BP, CNPC	Oil	1,000	2,850	17.8
West Qurna 1	EM, Shell	Oil	270	2,325	8.6
Zubair	Eni, Oxy, Kogas	Oil	205	1,200	4.0
Missan Group	CNOOC, TPAO	Oil	86	450	1.6
1st. round total			1,561	6,825	32.0

(source: prepared by the study team)

Table-4.2.2 (4) Result of 2nd bid round (December 11 and 12, 2009)

Field Name	Contracters	Main Target	Production 2009	Target production	Reserves Bbbl
West Qurna 2	Lukoil, Statoil *1	Oil	0	1,800	12.9
Majnoon	Shell, petronas	Oil	55	1,800	12.6
Halfaya	CNPC, Petronas, Total	Oil	3	535	4.1
Garaff	Petronas, Japex	Oil	0	230	0.8
Badra	Gazprom, Kogas, Petronas, TPAO	Oil	0	170	0.1
Qaiyarah	Sonangol	Oil	2	120	0.9
Najmah	Sonangol	Oil	0	110	0.9
Ahdab *2	CNPC	Oil	115	200	0.7
2nd. round total			175	4,965	33.0

*1 Statoil phased out in Mar 2012

*2 Single source contract

(source: prepared by the study team)

Table-4.2.2 (5) Result of 3rd bid round (October 20, 2010)

Field Name	Contracters	Main Target	Production 2009	Target production	Reserves Bbbl
Mansuriyah	Kuwait Energy, Kogas, TPAO	Gas	0	na	3.3
Akkas	Kogas, KazMunaiGas	Gas	0	na	2.1 - 4.0
Siba	Kuwait Energy, TPAO	Gas	0	na	0.1
3rd. Round total			0	na	max 74

(source: prepared by the study team)

Table-4.2.2 (6) Result of 4th bid round (May 30 and 31, 2012)

Field Name	Contracters	Main Target	Production 2009	Target production	Reserves Bbbl
Block 8	Pakistan Petroleum	Oil/Gas	na	na	na
Block 9	Kuwait Energy/Dragon/TPAO	Oil	na	na	na
Block 10	Lukoil/Inpex	Oil	na	na	na
Block 12	Bashneft/Premier	Oil	ma	na	na

(source: prepared by the study team)

(4) IEA energy outlook 2012 (Iraq Special Report)

On the other hand, international organizations including IEA forecast slightly lower production, probably in consideration of various restrictions such as limitation due to OPEC's production quota, and possible delay in establishing the infrastructure for extraction of crude oil. As per the report by World Energy Outlook 2012 (IEA), the production forecasts of crude oil and gas are as follows.

Oil Production & Export (MMBOPD)

(MMBOPD)

Year	2011		2020		2035	
	Production	Export	Production	Export	Production	Export
Central Scenario	2.7	1.9	6.1	4.4	8.3	6.3
High Case	-	-	9.2	7.1	10.5	7.9
Delayed Case	-	-	4.0	2.7	5.3	3.8

Gas Production & Export (Bcm/year)

(Bcm)

Year	2011		2020		2035	
	Production	Export	Production	Export	Production	Export
Central Scenario	9	0	41	2	89	17
High Case	-	-	63	8	114	37
Delayed Case	-	-	18.0	0	49	7

The main feature of the four years plan in terms of improvement of infrastructure is the completion of the new construction and expansion of a marine export facility from the Northern Persian Gulf. This construction is now on progress as per phases. In 2012, a part of the work was completed, resulting in a slight increase in crude oil exports. However, there is a doubt over achieving the export target by the planned date as the corresponding infrastructure such as storage tank and pipeline construction looks to be delayed.

In 2012, after reviewing the IEA report, the government of Iraq reviewed the crude oil production plan. As a result there has been a change in direction of the policy, that is, not to aim at the maximum production of crude oil, but to maximize the income from crude oil. As a result, a new production objective has been set forth to achieve 9.0 – 9.5 MMBOPD in the time period of 2017 to 2020, which is more challenging than about 6.0 MMBOPD in the central scenario found in the IEA's report. In preparing the IEA's Iraq Special Report, related parties of the government of Iraq also participated.

(5) INES Report

On the other hand, the Deputy Prime Minister Office of Iraq entrusted Booz & Company (USA) with the development of INES financed jointly the World Bank and Iraq government, with a view to establishing a national strategy consistent not only with crude oil but energy as whole, and in June 2013, this work was completed with the launch of the final report. As per this report (summary), the crude oil production is forecast as follows, out of which the report recommends the medium case. In response to this proposal, the government decided to promote the crude oil production of 9 MMBOPD by 2020 as the basis, so as to establish a concrete strategy in each energy domain.

High Cace	13 MMbpd	by 2017
Medium Case	9 MMbpd	by 2020
Low Case	6 MMbpd	by 2025

A major part of produced gas is associated gas. Its production in 2009 was about

1,700 MMscfd, major part of which was left for flaring. Since gas production will rapidly grow together with increasing production of crude oil in future, it is an urgent issue to implement the effective utilization strategy.

<Conclusion>

1) According to an announcement of the Ministry of Oil, gas production in August 2013 was 1,963 MMscfd, about 70% of which is left for flaring without effective utilization. The main reason for this is the fact that the infrastructure such as gas treatment facilities is not well developed. Thus, an urgent development of the infrastructure is needed due to economy loss and environment protection.

2) In 2011, the Ministry of Oil formulated a four years plan, which envisages crude oil production of 6.5 MMBOPD in 2014, associated gas production of 4,000 MMscfd and non-associated gas production of 500 MMscfd.

3) In 2009, the Ministry of Oil started to introduce international bidding so as to develop oil and gas concessions, and at present, contracts with international oil development companies were concluded for 19 production concessions (oil and gas). As a result, the target crude oil production from the winning bidders will amount to about 12 MMBOPD, which is larger than the current production in Saudi Arabia. The amount of associated gas will be about 7,200 MMscfd. Additionally an international bid round for Nassiriya Integrated Development is in progress.

4) With participation of the related parties of the government of Iraq, IEA World Energy Outlook Special Report, Iraq Energy Outlook 2012 envisages crude oil production of 6.1 MMBOPD and natural gas production of 41 Bcm/y (about 4,000 MMscfd) in 2020 as the central scenario. In response to this report, the government of Iraq decided to revise down the target oil production to 9.0 - 9.5 MMBOPD for the time period of 2017 to 2020, with the gas production modified accordingly.

5) On the basis of funding by the World Bank, the government of Iraq prepared INES incorporating energies besides crude oil, with its final report completed in June 2013. This report envisages a crude oil production of 9 MMBOPD by 2020 as the medium case. The current gas production is about 1,700 MMscfd, and it is estimated that the peak will occur in 2017 onward as the medium case, and it will reach about 8,000 MMscfd by 2020. Thus, it is determined to prepare and implement a concrete and individual gas master plan on this basis.

4.2.3 Gas production forecast

(1) Amendment of TSC of southern super-giant fields

Since 2012, in order to make a downward modification of the crude oil production target for the entire Iraq, consultations were held between the Ministry of Oil and related international oil development companies. Concerning the five super-giant fields in the south, the contracts were revised against the production target set in the original contract as shown in the table below. Data reported as of July 2013 is summarized as follows, which means that the production reduction of these five oil fields amounts to about 2.8 MMBOPD. All of these fields are covered in the 1st and the 2nd bid rounds. As a result of this downward modification, the 2020 crude oil production targets covered in the 1st and the 2nd bids are reduced from around 12 to 9 MMBOPD, which seems to be in line with the INES central scenario.

Table-4.2.3 (1) Amendment of TSC target production

Field Name	Contracters	Main Target	License round	Original target prodcution kBOPD	Year plateau start	Period Plateau	Amended target prodcution kBOPD *1	Year plateau start	Period plateau	Production reduction kBOPD
Rumaila	BP, CNPC	Oil	1	2,850	2015	7	2,100	2,017	13	750
West Qurna 1	EM, Shell	Oil	1	2,325	2016	7	1,800	2,019	11	525
Zubair	Eni, Oxy, Kogas	Oil	1	1,200	2016	8	850	2,017	13	350
West Qurna 2	Lukoil, Statoil *1	Oil	2	1,800	2017	13	1,200	2,018	19	600
Majnoon	Shell, petronas	Oil	2	1,800	2017	10	1,200	2,017	20	600
Total				9,975			7,150			2,825
*1 As of 2013 July										

(source: prepared by the study team)

(2) Estimate of gas production

Impact on gas production caused by the above-mentioned modification in crude oil production can be estimated. Since all the oil fields above are covered in this objective, gas is classified into associated gas. As mentioned earlier, the amount of reduction in gas production will roughly be as follows, with an assumption of the overall average gas-oil ration to be 600 scf/bbl.

2,825 (kBOPD) x 600 (scf/bbl) / 1000= 1,695 MMscfd

Based on GESA (General Engineering Services Agreement) with the South Oil Company, TOYO is in charge of the study of infrastructure for evacuating crude oil in the south. In this regard, the preliminary development plan of each oil field was received as the material for GESA purpose. On the basis of the oil production profile of these development plans, and also in consideration of the above reduction in target production,

gas production profiles are prepared with an assumption made as to the gas-oil ratio. In studying the infrastructure for evacuating crude oil, several oil fields in the south (including those in the middle and the east) as well as those in the north (excluding those in Kurdistan) that are being developed or operated by Iraq herself are included as target fields for this study, in addition to the oil fields covered in the above international bid rounds. As for gas fields, the production data are classified and prepared on the basis of assumption while referring to information on international bids and literature.

The following data and information were referred for the basis to make gas production profile.

1) The oil & gas production target and period data in the international bid rounds and those amendments.
2) Oil production profile data in the preliminary development plan received from South Oil Company.
3) Production target data and information obtained during the 2nd Site Survey conducted in September 2013 at Baghdad.
4) Information on the Plan of natural gas import from Iran obtained the same site survey.

Fig 4.2.3 (1) shows crude oil production profile based on the above data (excludes Kurdistan region) and indicates that the peak oil production in 2026 and 2020 will be about 11.7 and 10.8 MMBOPD respectively, which exceeds 9 MMBOPD announced by Iraqi Government in 2012. Looking into this discrepancy, the following reasons are envisaged.

(1) The oil production of 9 MMBOPD may mean the total oil target production of the bid rounds (1st to 4th) results only. Summation of the original target oil production was about 12 MMBOPD and Iraqi Government revise down the target to 9 MMBOPD, namely, other oil fields developed or operated by State Oil Companies are not counted on this figure, or those full development may be postponed after depletion of the said oil fields.

(2) The target oil production rate by State Oil Companies may be too high.

Since oil production forecast will directly affect the associated gas production which composes major part of the Iraqi whole gas production, the study team would like Iraqi Government to clarify the point, however, in either reason, the team will keep our estimate of the gas supply volume which shall be a basis of the downstream gas utilization study by adopting a suitable safety factor. The figures would be updated during the course of the

Phase-2, 3 study if necessary.

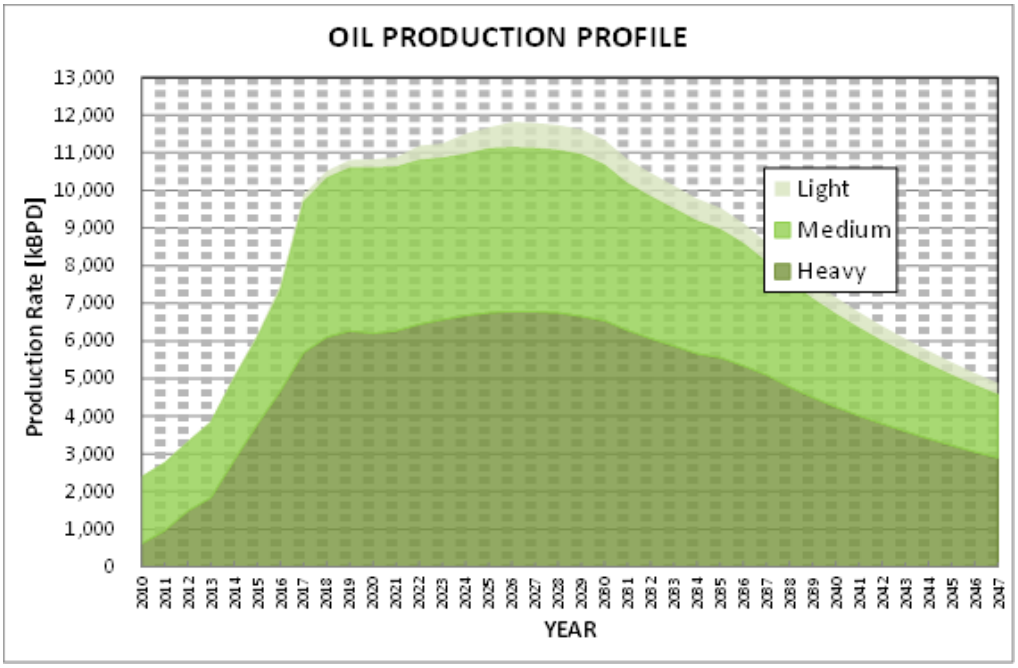


Fig 4.2.3 (1) Crude oil production Profile (source: prepared by the study team)

In order to allow the downstream demand to be studied, component-wise production was estimated using the gas compositions. As for associated gas in the oil fields, the properties of oil and gas compositions differ depending on the producing geological formations, and also data on the gas compositions in each oil and gas field, so that associated gas is roughly classified into heavy crude oil and medium/light crude oil, for which typical compositions are applied.

The amount of gas where 20% of associated gas and 10% of non-associated gas are subtracted from the gas production in term of methane and ethane components for operational use in the fields.

In 2029 and after, the oil and gas fields under developed will leave the plateau production area and enter the depletion area, so that the following measures are required to maintain a sustainable and stable supply of gas.

1) Additional development of discovered but undeveloped oil reserves within the existing oil and gas fields.

Details are to be determined as a continuation of the existing development plan after evaluation of development of undeveloped oil reserves.

2) Exploration and development of new oil and gas fields.
Implementation of international bid rounds for new oil and gas concessions and re-bid of concessions not awarded in the 4th bid round. In particular, the exploration and development of the western regions of Iraq is a future issue.

3) Adjustment of supply and demand balance through natural gas imports.
Study of the possibility for import of natural gas from neighboring countries and review of necessary infrastructure.

4) Storage of surplus natural gas.
Study of the storage of surplus natural gas intended for adjustment of supply and demand balance, such as storage by pressure-up and injection of gas onto the top of depleted oil fields having gas-cap, or storage as liquefied natural gas.

Setting of the capacity of facilities on the demand side in each sector requires a deliberate consideration in view of the transition of gas supply and product demand. Given that not all of the produced gas can be effectively utilized because of restrictions, the peak gas production in the current plan should not be adopted, but a capacity a little lower with a certain allowance should be set.

As it is estimated that the fuel demand for power generation will continuously increase, a more stable supply of fuel is needed. The majority of fuel gas to be supplied is associated gas, which is affected to a great extent by the fluctuations of crude oil production. It is thus necessary to seek multiplication or parallel use of power supply sources, for instance, combination of renewable energies, wind power, hydro power, and mixed combustion of gas and oil.

It is essential to include real-time monitoring of the supply and demand of electric power, sufficient supply of fuel gas, operating conditions of related oil and gas fields, and of the related networks. And there should be established timely analysis and estimation of near future fluctuations. Information infrastructure to output necessary instructions to the related organizations is required.

<Conclusion>

1) The contract conditions on the 1st to 4th bid rounds for oil and gas concessions were revised, and downward modification of the production target of major oil fields was also agreed. The five target oil fields are Rumalia, West Qurna 1, 2, Zubair and Majnoon, with a total reduction in production of about 2.8 MMBOPD, which is in line with the total

revised production target of 9 MMBOPD by 2020. As a result, the production of associated gas also decreases correspondingly.

2) In estimating the transition of gas production, five out of 33 oil fields and 4 gas fields were taken as objectives. Kurdistan region was excluded. The peak productions around 2029 will be: 7,562 MMscfd of associated gas, 830 MMscfd of non-associated gas with a total of 8,392 MMscfd. After subtraction of operational use of dry gas, there will be 6,402 MMscfd of associated gas, 758 MMscfd of non-associated gas with a total of 7,160 MMscfd.

3) As far as the target oil and gas fields are concerned, the production will go down from 2029 onward, causing a disadvantage for sustainable supply of gas. As a result measures to keep the peak production are required such as exploration of new oil and gas fields, continuous development of discovered but undeveloped oil and gas fields, and development of appropriate downstream industries from the viewpoint of long term demand, as well as importation and stock of natural gas.

4) Since major supply of gas depends on the production of crude oil, it is necessary to have multiple supply sources, and particularly in case of electric power use, a long term plan to ensure alternative fuel source of supply other than gas is required, so as to ensure stable supply even when the production of crude oil is restricted for some reason. On the other hand, if the on-going development of oil fields does not progress smoothly, continuous availability of associated gas forming the greater part of the overall supply of gas may be endangered. Thus, essential measures to be taken include smooth construction of the infrastructure related to the development, production and export of crude oil, follow-up of the progress of development work of major oil fields. In particular, on-schedule progress of the execution of CSSP project (Common Seawater Supply Project) is essential for crude oil production and construction of the infrastructure for crude oil evacuation as well as establishment of an appropriate management system and organization for oil fields and infrastructures through-out the country.

4.2.4 Gas supply infrastructure

(1) Gas Treatment facilities before Iran-Iraq war

During the period between 1970 and 1990, Iraq constructed the following gas treatment facilities in the south and the north as gas infrastructure, that is, the NAGP (North Area Gas Project) and the SAGP (South Area Gas Project). Before this period, Iraq had a gas treatment facility attached to the super-giant south oil field (North Rumaila) and a small scale gas treatment base in near-by Khor Al Zubair (KAZ). The capacity of the gas

treatment facilities are given in the table below.

Table-4.2.4 (1) Capacity of gas treatment facility in Iraq
(source: Natural Gas Markets in Middle East and North Africa,
Oxford Institute of Energy Study, 2011)

Project Name	Capacity MMscfd	Remarks
NAGP	536	1970s
SAGP	1,050	1985 completed, Feb1990 in service
Existing	494	Khor Al Zubair & N-Rumaila plants
Total	2,080	Total Raw gas

Furthermore the country installed, in Umm Qasr in the south, the facilities to receive and export separated LPG and NGL (IRT/IST: Iraq Receiving/Storage Terminals), which were constructed on the basis of engineering by TOYO. However, due to the war after the construction, IRT/IST did no longer operate as expected, and a part of the facilities are now used as storage for LPG import.

The products produced in the above facilities and the production rate are shown in the table below.

Table-4.2.4 (2) Products of Gas treatment facilities in Iraq

Products Slates before War		
Raw gas & Products	Unit	Production
Troughput (Raw gas)	MMscfd	2,080
Dry gas	MMscfd	1,560
LPG	MTA	5.5
NGL	MTA	2.28
Sulfur	kTA	500

(source: Natural Gas Markets in Middle East and North Africa,
Oxford Institute of Energy Study, 2011)

The ratio of major users of products produced in the 1990s are shown in the table below. In addition to the above gas treatment facilities, a major gas source is reported to have been cap gas (dry natural gas) in Jambur oil field in the north.

Table-4.2.4 (3) The ratio of major users of products

Unit %	1995	1999
Power Generation	25.5	35.2
Industrial feedstock	35.2	25.8
Industrial fuel	3.4	2.2
Oil industry (Fuel & Feed)	35.9	36.7
Others	0.07	0.01
Export	0	0

(source: Natural Gas Markets in Middle East and North Africa,
Oxford Institute of Energy Study, 2011)

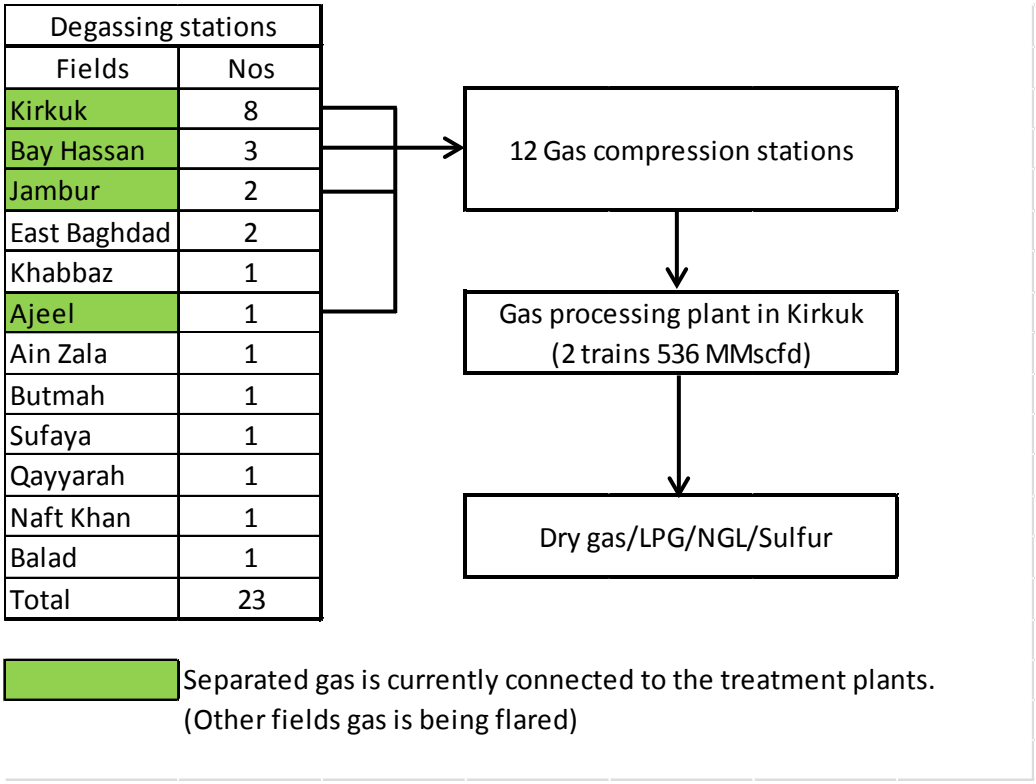
(2) Gas treatment facilities 2013

As per the websites of the North Oil Company and the North Gas Company, the facilities in the north have one or several gas separation trains in each oil and gas field (23 trains in all). After subtraction for operational-usage, the separated gas is sent via a gas compression station in each oil and gas field to the central gas treatment facility in Kirkuk in the form of raw gas, where it is separated, after dehydration, into dry gas (C1, C2), liquefied petroleum gas (LPG), and natural gasoline (NGL), before being delivered to end users through pipelines. The central gas treatment facility is equipped with a sulfur removal/recovery system for sweetening of gas. The central gas treatment plant composed of 2 trains and the total capacity is 546 MMscfd and currently receives gas from 4 fields, Kirkuk, Bai Hassan, Jambur and Ajeel fields, while gas produced from other fields are flared at the site and it is planned to connect to the plants in the future.

It is believed that the gas treatment facilities in this district remain as they were in the 1970s as mentioned earlier, and no upgrade, rehabilitation and comprehensive maintenance works have been carried out up to now. Therefore existing plant cannot operate at the design capacity. Iraqi Government has a plan to expand the treatment capacity by double as well as to rehabilitate the plant as necessary.

Table-4.2.4 (4) Northern & Central (32.5 Latitude north) gas processing unit

Degassing stations	
Fields	Nos
Kirkuk	8
Bay Hassan	3
Jambur	2
East Baghdad	2
Khabbaz	1
Ajeel	1
Ain Zala	1
Butmah	1
Sufaya	1
Qayyarah	1
Naft Khan	1
Balad	1
Total	23



(source: prepared by the study team)

The SAGP project (Design capacity ; 1,050 MMscfd) in the south was constructed in the 1970s and completed in 1985, but operation only started in 1990, and is currently operating along with the existing N-Rumaila and Kohr Al Zubair gas plants. There are 26 gas separation trains in total.

Table-4.2.4 (5) Southern (32.5latitude south) gas processing units

Degassing stations		Total 11 Fields
Fields	Nos	Remarks
S-Rumaila	7	with gas compression stations
N-Rumaila	7*1	with gas compression stations
Zubair	7	with gas compression stations
West Qurna	3	
Majnoon	2	
Abu Ghurab	2	
Luhais	1	
Nhar Umar	1	
Fakka	1	
Amara	1	
Halfaya	1	
Total	26	

*1 Includes two (2) intermediate degassing stations

(source: prepared by the study team)

The central gas treatment facility in Southern Iraq is composed of 2 plants, North Rumaila NGL Plant and Khor Al Zubair LPG Plant. Figure below shows a block flow of the above. The design capacity is 1,050 MMscfd, however, it is reported that current actual capacity is only 400 MMscfd, because of damages and poor maintenance so far including compressor stations. It is noted that, in Iraq, State Oil Companies control and operate up to degassing stations, then the separated gas is handed over to State Gas Companies who also control all the down flow system.

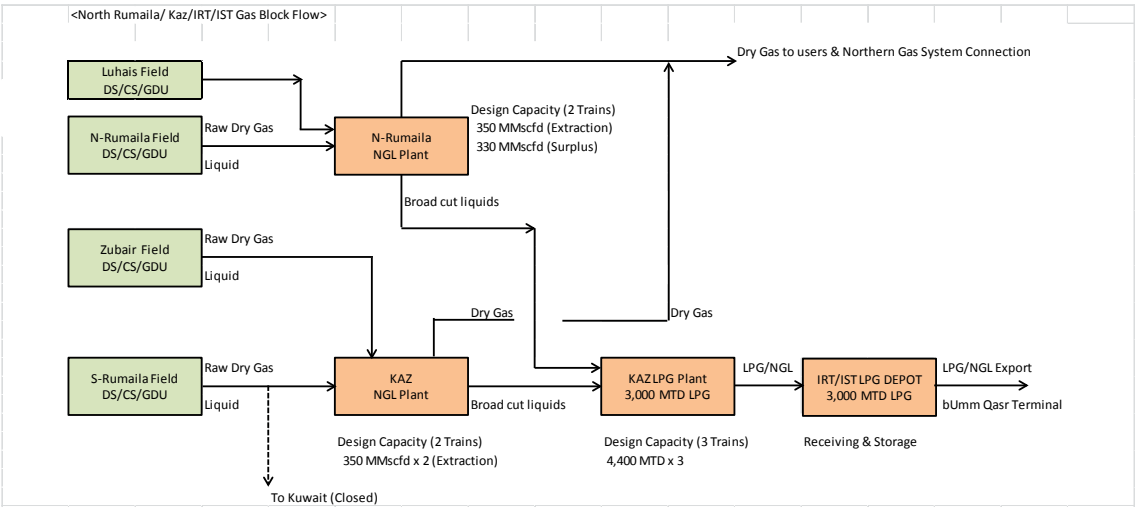


Figure-4.2.4 (1) Block flow of the Southern gas processing plants

(source: prepared by the study team)

A majority of the oil and gas fields that are being re-developed or are to be newly developed in the international bid round in 2009 onward are planned to be subjected to refurbishment or expansion of the gas separation trains, and at the same time, to incorporate the installation of contractually self-made gas treatment equipment (INES Summary). The gas treatment equipment separates gas into dry gas, LPG and NGL after compression, and finally is connected to the trunk pipeline network. A part of dry gas is used for operational-usage consumption. Sulfur removal/recovery equipment is also planned to be installed. Details of each plan are to be confirmed in the final development stage. It is noted that gases produced WQ1, Zubair and Rumaila are supposed to be directly sold to BGC as raw gas, therefore these 3 oil fields have not install their own gas treatment plants.

Gas from isolated oil and gas fields will be connected to the feed system of a centralized gas treatment facility if available nearby, or to a trunk gas pipeline after gas treatment if running in the vicinity. Otherwise in some cases, it will be left for gas flaring for the time being. The Akkas gas field development plan envisages a single package consisting of the installation of a gas-driven power generation plant in the vicinity where the gas is supplied. Further details will be discussed with Iraqi Government and reviewed for implementation during phases-2 and 3.

(3) Gas pipeline network

According to various public information, the major pipelines described in the Oxford Report 2010 and the existing domestic trunk gas pipelines and a pipeline map (Prepared by MoO as of 2011) obtained at the 2nd Site survey are summarized on the basis of information from various sources.

◆ North-south connecting pipeline (Strategic Pipeline)

This pipeline was installed to transport surplus gas produced in the southern major gas producing region to a major consuming region (mainly the north district including Baghdad). It is believed to be operating at present, but no information is available as to any damage caused by the war. This pipeline is connected from the Khor Al Zubiar and N-Rumaila facilities in the south to the north pipeline network via Depot K3 in Haditha. According to another source, 18” pipeline around Haditha is heavily damaged. That is, the route runs along the pipeline corridor, the same as the strategic pipeline for crude oil. A new 42” gas pipeline is also planned to run along the same route. (refer to the new export pipeline further routing to Syria, Jordan and Turkey)

Iraq Strategic Gas Pipeline (1)	18” x 600 km Dry gas (Existing)
Iraq Strategic Gas Pipeline (2)	24” x 600 km Dry gas (Existing)

◆ Baghdad-supply gas National Pipelines

These pipelines are directly connected from the Khor Al Zubiar and N-Rumaila facilities in the south to Baghdad as a large consuming region, and are believed to be two of the oldest pipelines run along with the SAGP project. The pipelines are heavily damaged caused by the war and there is a plan to install a new pipeline.

National Gas Pipeline	42” x 300 km	Dry gas (Existing)
National Gas Pipeline	48” x 300 km	Dry gas (Planned)

Along with the above pipelines, and extending to Umm Qasr through the southern gas treatment plants and IRT/IST, several LPG and NGL pipelines are in place as below. According to the design materials, LPG/NGL pipelines are common use by block operation.

Pipeline Kirkuk - Baghdad	8” x 300 km LPG/NGL (Existing)
Pipeline Kirkuk - Baghdad	14” x 300 km LPG/NGL (Existing)
Pipeline Baghdad - KAZ	14” x 600 km LPG/NGL (Existing)
Pipeline IRT/IST – Umm Qasr	20” x 20 km C3 Liq. (Existing)
Pipeline IRT/IST – Umm Qasr	20” x 20 km C4 Liq. (Existing)
Pipeline IRT/IST – Umm Qasr	20” x 20 km C3 Gas (Existing)
Pipeline IRT/IST – Umm Qasr	20” x 20 km C4 Gas (Existing)
Pipeline IRT/IST – Umm Qasr	20” x 20 km NGL (Existing)

◆ North pipeline

This pipeline is connected from Kirkuk gas treatment facility to the above mentioned K3, and is also branched from K2 to Baghdad as a large consuming region. A pipeline from K2 (Beiji) to Mousl power station is installed. (16”)

Kirkuk Gas Pipeline	16” x 300 km Dry gas (Existing)
Kirkuk Gas Pipeline	18” x 300 km Dry gas (Existing)

◆ Syria gas export pipeline

This is a pipeline branched at Depot K3 in the west and is laid across the Syrian border, but is currently closed. No information is available as to the size and damage. There are two 16” pipelines from near the border to Akashat fertilizer plant.

◆ Kuwait pipeline

This pipeline was used to transport gas in the south (raw gas) to a gas treatment facility in Al Ahmadi (Kuwait) as power generation fuel and LPG, but is currently closed because of damage and a political problem due to the war. Although it is recently reported that this pipeline will be restored after lifting of sanctions by the United Nations.

Kuwait Gas Export Pipeline	40” Raw Gas

◆ New Syria･Jordan･Turkey export pipeline (plan)

With a view to multiplication of crude oil transport routes and because of the limited capacity of export facilities in the south, Iraq is currently carrying out a feasibility study on the installation of a new south-north crude oil pipeline and an export pipeline to Jordan, Syria and Turkey. It is also reported that Iraq will lay a gas pipeline in parallel with these crude oil pipelines, and at the same time, will additionally install a depot along the north-south connecting pipeline. It is believed that this pipeline will be used for fuel gas (dry gas), but it is not known if gas export is also taken into consideration.

◆ Gas pipeline for Taji Power plant

It is reported that, at a lecture in Japan (JCCP Symposium) in 2013, the President of SCOP presented a list of the completed gas pipelines, showing fuel gas (dry gas) pipeline from Rumaila in the south to Taji Power Station, Baghdad. It is also said that this pipeline supplies gas to seven power generation plants along the way (Refer to the above National gas pipeline). The above list also mentioned that the gas pipeline from Zubair 1 depot in the south to the Fao depot was also completed.

Rumaila - Taji Gas Pipeline	48” x 557 km Dry Gas (New)
Zubair 1 - Fao Gas Pipeline	18” x 105 km Gas (New)

◆ Missan Pipelines

There are some dry gas pipelines connecting Missan oil fields and Majnoon. The pipelines are not connected to the southern gas treatment and it seems to supply gas to the local power plants and industrial plants near located Missan area. The detail information shall be obtained during the future study.

◆Idea on other pipelines

Several reports make reference to the following three pipelines, but further details are unknown because of the lack of detailed information. It is only believed that they show just a future possibility, except gas import pipeline from Iran.

1) Gas import pipeline from Iran

According to the press information October 2013, gas import plan from Iran is soon be

realized. Iraq MoO & Iran agreed to import Iranian gas and to start 2nd, quarter 2014 for a short term period (4 years). The background of this agreement is that Iraq likes to fulfill a shortage of fuel gas to supply power plants in Iraq till Iraqi fields development completion by which enough gas will be recovered and supplied, while Iran likes to export surplus gas to the neighboring countries. 56" gas pipeline inside Iran has already been constructed and waiting for 2 connecting pipelines to north Baghdad and south Basra crossing the border currently in progress. The volume of the import gas 800 to 850 MMscfd at the beginning and will be increased more than 1,400 MMscfd later on and will be supplied to power plants for fuel. It is anticipated that gas import will not be necessary when Iraq starts gas recovery and minimizing gas flaring, however, these pipelines supposed to be re-utilized for the future gas export through north and west borders to EU gas market.

2) NABUCCO Pipeline

NABUCCO Pipeline Project is aiming to connect gas pipelines from Caspian sea, through Middle East, to EU and Iraqi gas is planned to connect to the project pipeline crossing the northern border through Turkey. This is a kind of diversification plan for Iraq to export surplus gas in the future, however, few progress is seen towards the realization of the project.

According to SOMO presentation at the Energy Academy Workshop held at Baghdad in May 2013, outline of the plan is as follows;

1) Pipeline route :from Turkey, through Rumania, Bulgaria, Hungary and to Austria
2) Length :3,300 ~ 4,000 km
3) Pipe size :56"
4) Capacity :31 Bcm per year
5) Investment :€7.6 Billion

3) Arab Gas Pipeline (AGP)

AGP project is to construct 36" pipelines from Egypt to Jordan, Syria and to Turkey with total length of more than 1,000 km and the construction works are planned to carry out in phased manner. Iraq is considering the project an optional route to export surplus gas through northern border. The capacity is supposed to be 12 Bcm per year.

(4) Basra Gas Company

Basra Gas Company (BGC) was founded several years ago as a Shell･Mitsubishi joint company, and the final contractual agreement was signed in 2013. The plan envisages that BGC will purchase gas from the South Oil Company and will separate it

into dry gas, methane-rich gas, LPG and NGL after treatment, so as to return dry gas back to the South Oil Company to meet the domestic demand, while LPG and NGL will be exported by BGC. BGC also has an idea to install an LNG plant to increase exports.

An interview (Iraq Oil Report) on March 19, 2013 with Mr.Ali Khudhier, Director General of the South Gas Company (SGC), revealed that initially priority will be given to the recovery of gas that is currently being flared. At present, about 1,100 MMscfd of associated gas is produced in the south, out of which about 400 MMscfd is treated at an existing gas treatment facility, with all the remaining 700 MMscfd left for flaring. If left as it is, flare gas will increase together with increasing production of crude oil.

The South Gas Company is purchasing associated gas from three of the super-giant oil fields under development: Rumaila, West Qurna-1, and Zubiar. The maximum total amount of gas from these three fields is estimated to be about 3,000 MMscfd (after review of the crude oil production targets). Other oil fields; Majnoon, WQ 2, Halfaya and Garraf, will have their own gas treatment facilities, so that they will transport gas directly to the South Gas Company.

<Conclusion>

1) In the 1970s and 80s, central gas treatment facilities were constructed in the north and the south, part of which are currently operating. However, as the entire amount of produced gas is not treated, about 70% remains untreated and left for flaring. It is therefore vital that, together with refurbishment and expansion of existing facilities, independent gas treatment facilities shall be installed for newly developed oil and gas fields with a large amount of existing production, so as to connect the facilities to the gas network after gas separation.

2) Given that the south has a large production of gas, while demand is high in the north, the north-south connecting network trunk pipeline is important. On the contrary, in the case of isolated areas, the supply and demand is to be realized within each area, or as an alternative the gas is converted to electricity on or close to site and then connected to an electric power network. Selection of gas piping or electric cable may be determined in consideration of economic efficiency. A new project for constructing the north-south connecting pipeline is in progress.

3) Basra Gas Company is already established in the south, and it is envisaged to treat associated gas from three super-giant oil fields after incorporating the existing gas treatment facilities, so as to deliver dry gas for domestic demand through the South Gas Company, while LPG and NGL are planned to be exported.

4) A plan for importing natural gas from Iran, a neighboring country is on-going. There are also plans to resume gas exports to Kuwait, Syria and Jordan, and resumption of gas exports from the north to Turkey, or installation of a new pipeline. What is required is to prepare an optimum, long term gas master plan after considering the supply and demand in Iraq, as well as sustainable production of gas.

5) The following steps are envisaged in order to make a gas piping plan in Iraq, such as gas demand calculation, setting of amount of gas supply, selection of transport and supply method, determination of maximum service pressure and pipe diameter, selection of route, together with planning of the pipeline related equipment such as block valves, booster stations as well as a communication system and maintenance strategy.

4.3. Calculation of net gas supply amount

4.3.1. Introduction

In this Section, on the basis of gas production data (annual gas production and composition) estimated under Section 4.2, the amount of gas to be supplied to the downstream plants is estimated for each type of gas fraction, that is, dry gas, ethane, propane, butane and C5+.

Fractions required for the gas demand in the downstream plants differ depending on the plant characteristics. Thus, study of gas supply and demand balance requires the estimation of supply and demand for each gas fraction and the analysis of supply and demand balance.

4.3.2. Estimation of supply of each gas fraction

(1) Composition and flow rate of supplied gas

Data estimated under Section 4.2 is used as the amount and composition of gas to be produced in the well source

(2) Estimation of production of each gas fraction

At the gas treatment plants, impurities such as moisture and acidic gas are removed from the gas produced in the well source, and then the gas is separated into each type of

gas fraction, that is, dry gas, ethane, propane, butane and C5+ NGL.

Generally speaking, gas treatment plants are roughly classified into the following three categories according to the fractions of gas produced therein, while the ratio of production per fraction of gas depends on the type of a gas treatment plant.

1) Ethane recovery plant
Produces dry gas (mainly methane), ethane, propane, butane and C5+ NGL.

2) LPG recovery plant
Produces dry gas (mainly methane and ethane), propane, butane and C5+ NGL.

3) Dew point control plant
Produces dry gas (mainly methane, ethane and a small amount of LPG) and C5+ NGL. Depending on the dew point of dry gas and the specification of products from C5+ NGL vapor pressure, extraction and production of LPG are also performed in this plant.

Estimation basis of the production of gas fractions for each type of gas treatment plant are shown below.

1) Ethane recovery plant

An ethane recovery plant is installed in case of need for the recovery of ethane as the raw material for ethylene plants. Since recovery of ethane from feed gas requires condensation of ethane fraction as a low boiling point component, it is necessary to maintain feed gas under a high pressure and low temperature condition

Figure-4.3.2(1) shows the general flow of an ethane recovery plant.

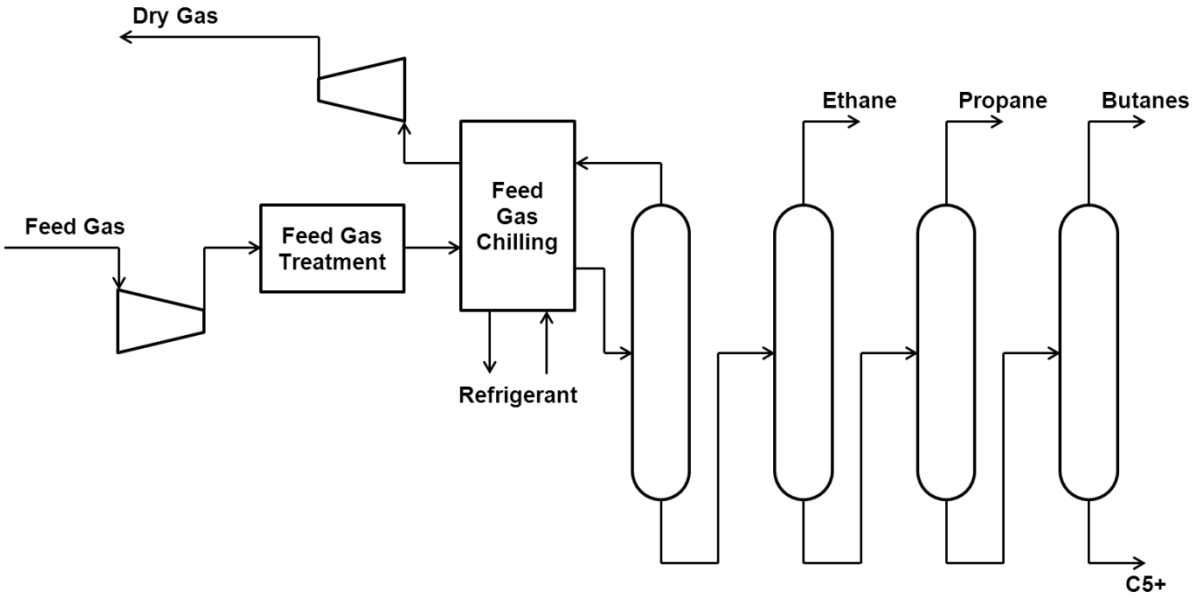


Figure-4.3.2(1): General Flow of Ethane Recovery Plant
(source: prepared by the study team)

After pressurization and removal of impurities (mainly moisture and acidic gas) as needed, feed gas is cooled at the feed gas chiller, to be fed to the demethanizer. C2+ NGL recovered in the demethanizer is separated into respective fractions at the downstream distillation equipment.

The amount of each gas fraction produced in an ethane recovery plant is estimated as shown Table 4.3.2(1) so as to be compatible with the specification.

Table 4.3.2(1): Specification of Each Gas Fraction Produced in Ethane Recovery Plant
(source: prepared by the study team)

Ethane Product		
Recovery %		Not less than 90
Composition		
CO2	mol%	< 3.0
Methane	mol%	< 2.0
Ethane	mol%	> 92.5
Propane	mol%	< 2.5
Propane Product		
Propane Recovery %		Not less than 99.5
Composition		
Ethane	mol%	< 0.5
Propane	mol%	> 98.5
Butanes	mol%	< 1.0
Butane Product		
Butane Recovery %		Not less than 99.5
Composition	mol%	
Propane	mol%	< 2.0
Butanes	mol%	> 97.1
Pentanes	mol%	< 0.9
C5+ Product		
Composition		
Butanes	mol%	< 0.5

2) LPG recovery plant

An LPG recovery plant is installed in case of need for the recovery of LPG. Since recovery of LPG requires condensation of propane and butane fractions, it is necessary to maintain feed gas under a high pressure and low temperature condition. However, as these fractions have a higher boiling point compared to ethane, the operating pressure and temperature condition are less severe than that of an ethylene recovery plant.

Figure-4.3.2(2) shows the general flow of an LPG recovery plant.

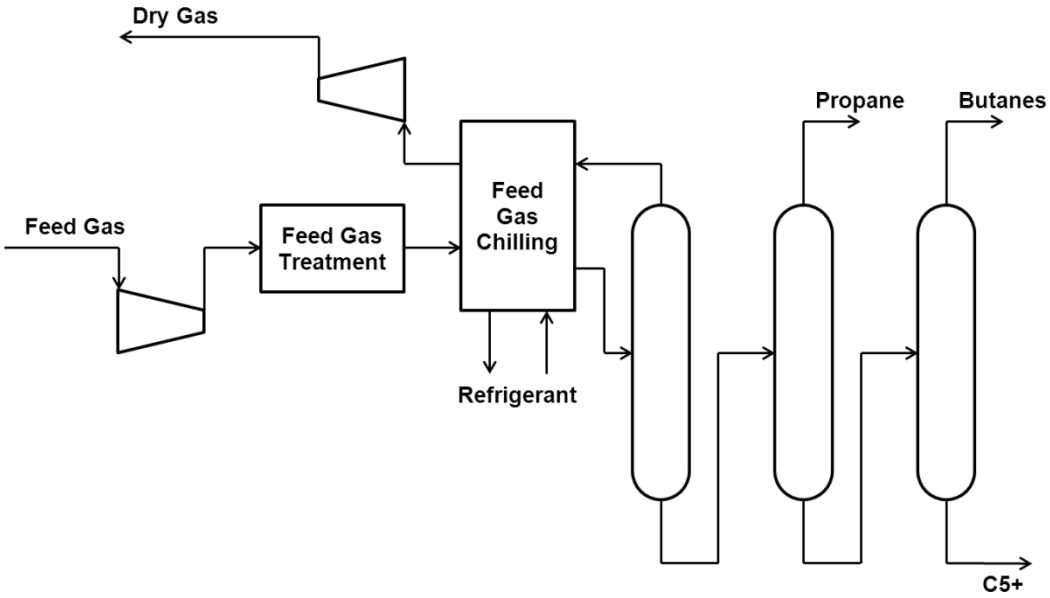


Figure-4.3.2(2): General Flow of LPG Recovery Plant
(source: prepared by the study team)

After pressurization and removal of impurities (mainly moisture and acidic gas) as needed, feed gas is cooled at the feed gas chiller, to be fed to the deethanizer. C3+ NGL recovered in the deethanizer is separated into respective fractions at the downstream distillation equipment.

The amount of each gas fraction produced in the LPG recovery plant is estimated as shown Table 4.3.2(2) so as to be compatible with the specification.

Table 4.3.2(2): Specification of Each Gas Fraction Produced in LPG Recovery Plant
(source: prepared by the study team)

Propane Product		
Propane Recovery %		Not less than 95
Composition		
Ethane	mol%	< 0.5
Propane	mol%	> 98.5
Butanes	mol%	< 1.0
Butane Product		
Butane Recovery %		Not less than 99.5
Composition	mol%	
Propane	mol%	< 2.0
Butanes	mol%	> 97.1
Pentanes	mol%	< 0.9
C5+ Product		
Composition	mol%	
Butanes	mol%	< 0.5

3) Dew point control plant

A dew point control plant is installed only in case of need for the production of dry gas. After removal of impurities, the dew point and pressure of feed gas are adjusted to be compatible with the dry gas specification. Heavy components extracted for dew point adjustment are separated and refined as appropriate, and delivered as product.

Figure-4.3.2(3) shows the general flow of a dew point control plant.

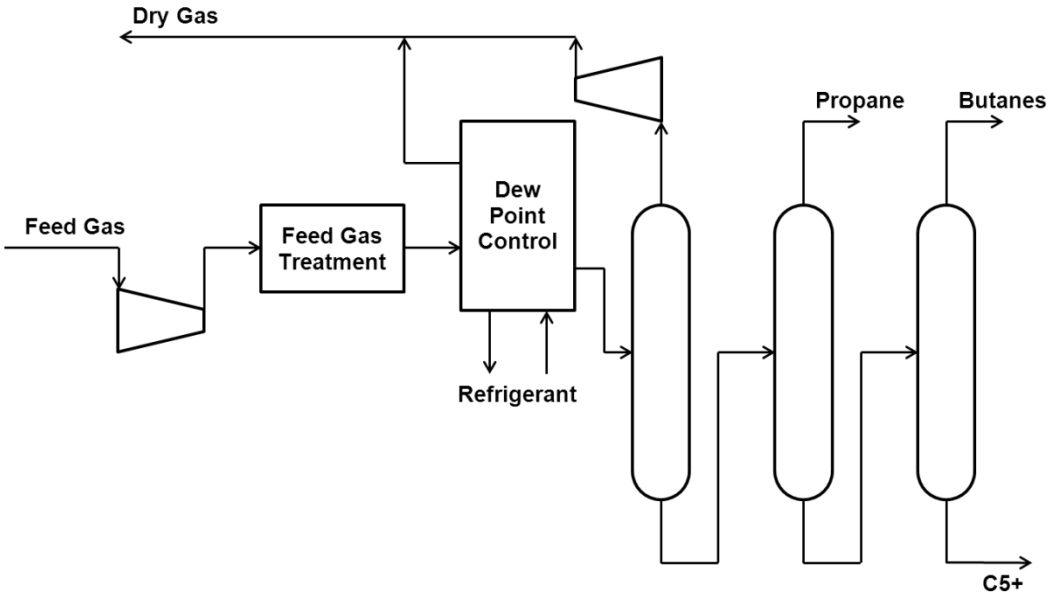


Figure-4.3.2(3): Dew Point Control Plant Flow
(source: prepared by the study team)

In this study, the specification of dry gas is set so that the dew point is -8°C (at 70 kg/cm2G) or less. The compositions of recovered propane, butane and C5+ are as shown in Table 4.3.2(3).

Table 4.3.2(3): Specification of Each Gas Fraction Produced in Dew Point Control Plant
(source: prepared by the study team)

Propane Product		
Composition		
Ethane	mol%	< 0.5
Propane	mol%	> 98.5
Butanes	mol%	< 1.0
Butane Product		
Composition		
Propane	mol%	< 2.0
Butanes	mol%	> 97.1
Pentanes	mol%	< 0.9
C5+ Product		
Composition		
Butanes	mol%	< 0.5

(3) Estimation of self-usage consumption at gas treatment plant

On the assumption that fuel to be used as power for a gas treatment plant operating generators and rotating machinery is fed by dry gas produced in that plant, the net dry gas production from the gas treatment plant is estimated by subtracting the in-plant consumption from the total dry gas produced.

Depending on the degree of pressurization and cooling of feed gas as well as the number of distillation towers, the fuel consumption rate for each type of gas treatment plant in this study is defined as given in Table 4.3.2(4).

Table 4.3.2(4): Self-usage Consumption Rate of Dry Gas at Gas Treatment Plant
(source: prepared by the study team)

Gas Plant Type	Self-Usage	
	Associated Gas	Non Associated Gas
	%	%
Ethane Recovery	15.0	8.0
LPG Recovery	11.0	6.0
Dew Point Control	8.0	4.0

4.4. Evaluation and Selection of gas utilization plan

On the basis of the demand forecast data of the downstream plants described in the INES Report and information obtained from MoIM and MoE, estimation is made in this Item of the demand of each gas fraction at the downstream plants.

Also by comparing with the production of each gas fraction estimated under Section 4.3, analysis is made of the supply and demand balance in Iraq.

4.4.1. Demand forecast of each gas fraction at downstream plants

On the basis of the data for annual demand growth for the downstream plants described in the INES Report and data from MoIM and MoE, estimation is made here of the demand of each gas fraction.

The following plants using gas fractions are selected as the target downstream plants.

- Power Generation Plant
- Methanol Plant
- Ammonia/Urea Plant
- Ethylene Plant (Ethane Cracker)
- Steel Plant
- Aluminum Plant
- LPG Plant

(1) Power Generation Plant

1) Demand forecast of power generation

Data indicated in Figure-4.4.1(1) is used for the evolution of power generation capacity in Iraq.

This figure represents the power generation evolution for each type of power generation, but this study takes up only the power generated by gas turbines and combined cycle system using gas fraction (dry gas and LPG) as the fuel.

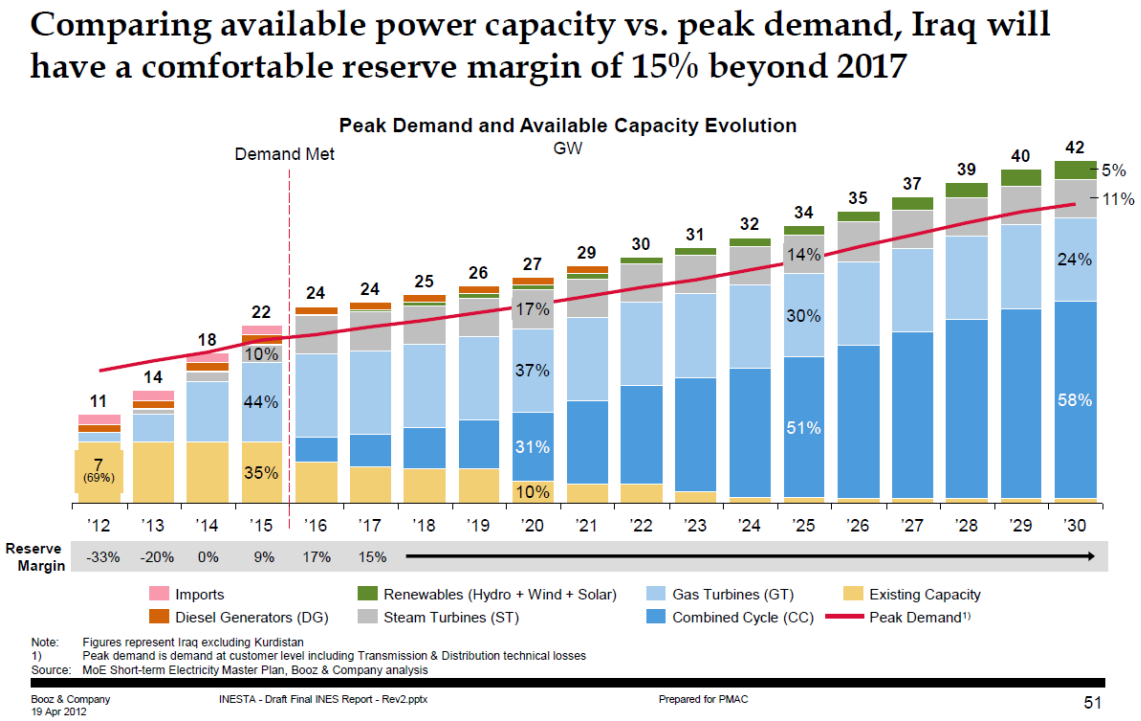


Figure-4.4.1(1): Demand Forecast of Electric Power in Iraq
(source: INES Final Report Executive Summary Exhibit ES-8)

2) Estimation basis of each gas fraction necessary for power generation

Based on the demand forecast of power generation shown in Figure-4.4.1(1), estimation is made of the dry gas demand. The numerical figures indicated in Table 4.4.1(1) are used as the generation efficiency of gas turbine, combined cycle and steam turbine systems.

Table 4.4.1(1): Power Generation Efficiency
(source: prepared by the study team)

Power Generation Plant Type	Power generation efficiency
	%
Simple Cycle Gas Turbine	33
Combined Cycle	54
Steam Turbine	40

The numerical figures indicated in Table 4.4.1(2) are described in INES Ex2-19 and used as the power loss from the power generation plant to the end-user.

Table 4.4.1(2): Power loss (source: prepared by the study team)

	Power loss
	%
Distribution Loss	13
Transmission Loss	6

3) Estimation of each gas fraction necessary for power generation

The transition of demand of dry gas fraction in power generation is shown in Figure-4.4.1(2).

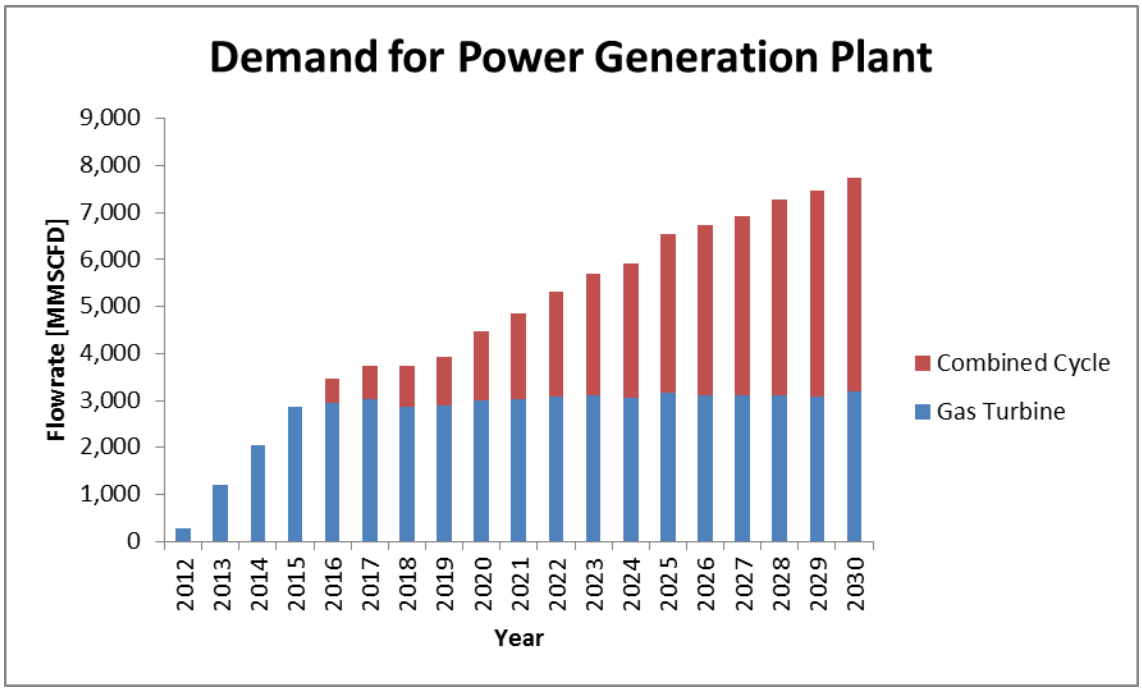


Figure-4.4.1(2): Transition of Demand of Dry Gas Fraction in Power Generation
(source: prepared by the study team)

(2) Methanol Plant

1) Demand forecast of methanol

The transition of capacity build-up of methanol plants based on the planning of Ministry of Industry and Minerals (MoIM) has been applied. No methanol production is considered before 2016.

2) Estimation basis of each gas fraction necessary for methanol production

Gas fractions necessary for methanol production are as follows.

- Raw material: dry gas
- Utility fuel gas other than for electric power supply: dry gas
- Power generation fuel gas for necessary electric power supply: dry gas

In this study, the numerical figures indicated in Table 4.4.1(3) are used as dry gas consumption for unit methanol production.

Table 4.4.1(3): Consumption of Gas Fraction for Methanol Production
(source: prepared by the study team)

Target	Gas fraction used	Consumption for unit methanol production
		Unit / ton-MeOH
Feed	Dry Gas	7.16 MMkcal
Fuel	Dry Gas	1.02 MMkcal
Power*	Dry Gas	30 kWh

* for process use only

3) Estimation of demand of each gas fraction in methanol production

The amount of each gas fraction necessary for production in methanol plants is as shown in Figure-4.4.1(3).

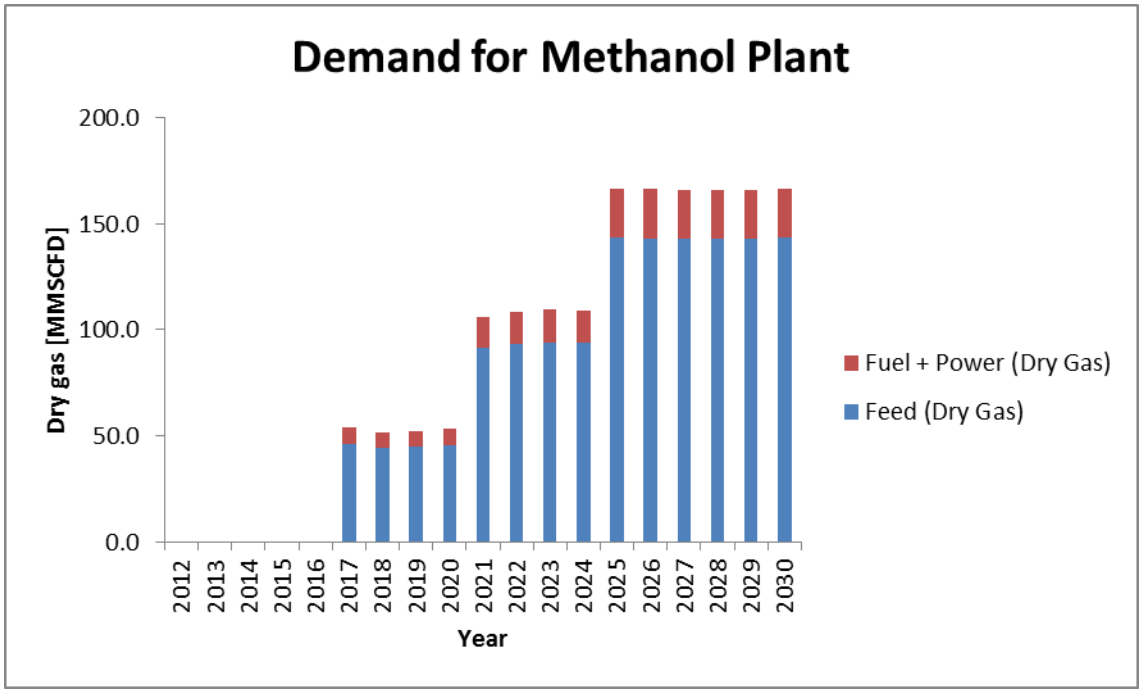


Figure-4.4.1(3): Transition of Demand of Dry Gas Fraction in Methanol Production
(source: prepared by the study team)

(3) Ammonia/urea plant

1) Demand forecast of ammonia/urea

Capacity build-up plans of urea fertilizers based on MoIM hearing is applied. No urea production is considered before 2016.

2) Estimation basis of each gas fraction necessary for urea production

Gas fractions necessary for urea production are as follows.

- Raw material: dry gas
- Utility fuel gas other than for electric power supply: dry gas
- Power generation fuel gas for necessary electric power supply: dry gas

In this study, the numerical figures indicated in Table 4.4.1(4) are used as dry gas consumption for unit urea production.

Table 4.4.1(4): Consumption of Gas Fraction for Urea Production
(source: prepared by the study team)

Target	Gas fraction used	Consumption for unit urea production
		Unit / ton-Urea
Feed	Dry Gas	3.46 MMkcal
Fuel	Dry Gas	0.902 MMkcal
Power*	Dry Gas	96 kWh

* for process use only

3) Estimation of demand of each gas fraction in urea production

The amount of each gas fraction necessary for urea production in an ammonia/urea plant is as shown in Figure-4.4.1(4).

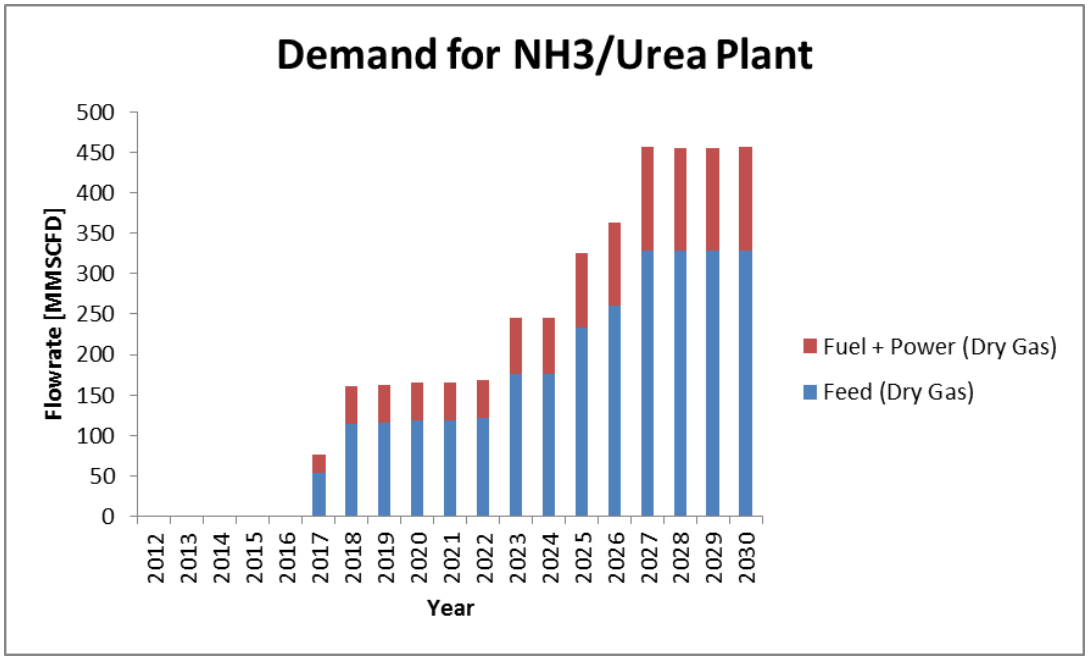


Figure-4.4.1(4): Transition of Demand of Dry Gas Fraction in Urea Production
(source: prepared by the study team)

(4) Ethane cracker (ethylene plant)

1) Demand forecast of ethylene

The planning of MoIM is used for demand forecast of ethylene. No ethylene is produced before 2018.

2) Estimation basis of each gas fraction necessary for ethylene production

Gas fractions necessary for ethylene production are as follows.

- Raw material: ethane
- Utility fuel gas other than for electric power supply: dry gas
- Power generation fuel gas for necessary electric power supply: dry gas

In this study, the numerical figures indicated in Table 4.4.1(5) are used as ethane and dry gas consumption for unit ethylene production.

Table 4.4.1(5): Consumption of Gas Fraction for Ethylene Production
(source: prepared by the study team)

Target	Gas fraction used	Consumption for unit ethylene production
		Unit / ton-Ethylene

Target	Gas fraction used	Consumption for unit ethylene production
Feed	Ethane	1.32 ton-Ethane
Fuel	Dry Gas	0.62 MMkcal
Power*	Dry Gas	61 kWh

* for process use only

3) Estimation of demand of each gas fraction in ethylene production

The amount of each gas fraction necessary for production in ethylene plants is as shown in Figure-4.4.1(5) and Figure-4.4.1(6).

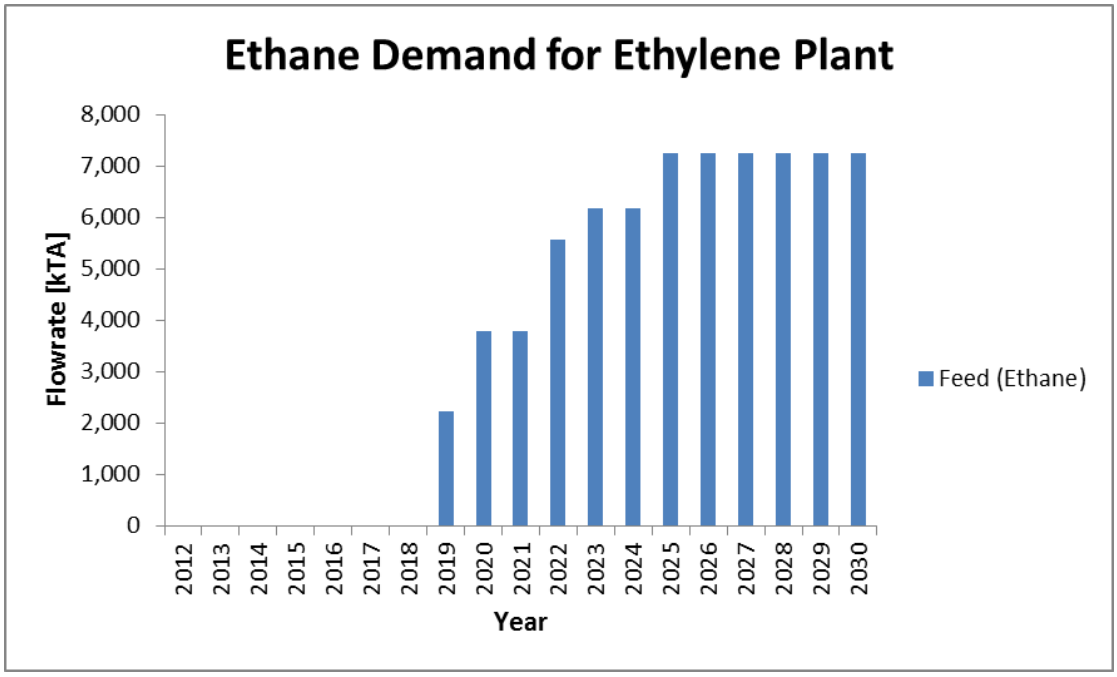


Figure-4.4.1(5): Transition of Demand of Ethane Fraction in Ethylene Production (source: prepared by the study team)

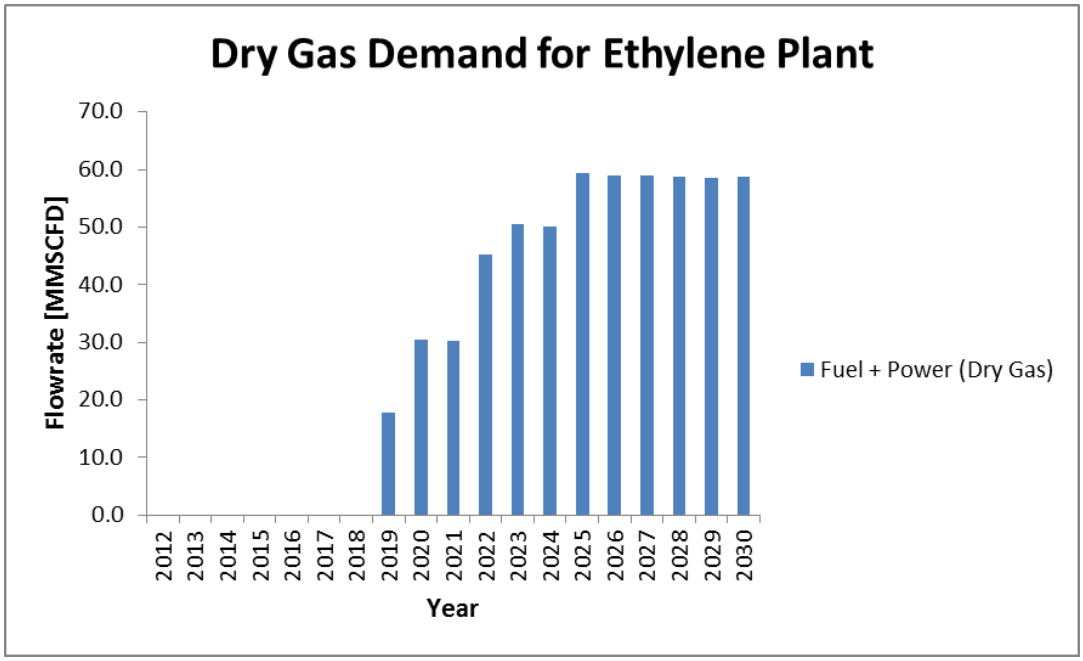


Figure-4.4.1(6): Transition of Demand of Dry Gas Fraction in Ethylene Production (source: prepared by the study team)

(5) Steel plant

1) Demand forecast of steel

Data indicated in INES is used for demand forecast of steel.

2) Estimation basis of each gas fraction necessary for steel production

Gas fraction necessary in a steel plant are as follows.

- Utility fuel gas other than for electric power supply and reduction gas: dry gas
- Power generation fuel gas for necessary electric power supply: dry gas

In this study, the numerical figures indicated in Table 4.4.1(6) are used as dry gas consumption for unit steel production.

Table 4.4.1(6): Consumption of Gas Fraction for Steel Production
(source: prepared by the study team)

Target	Gas fraction used	Consumption for unit steel production
		Unit / ton- Steel
Fuel and reduction gas	Dry Gas	2.77 MMkcal

Target	Gas fraction used	Consumption for unit steel production
		Unit / kTPA-Steel
Power	Dry Gas	0.022 MMscfd Dry Gas

3) Transition of demand of each gas fraction in steel production

The amount of each gas fraction necessary for production in steel plants is as shown in Figure-4.4.1(7).

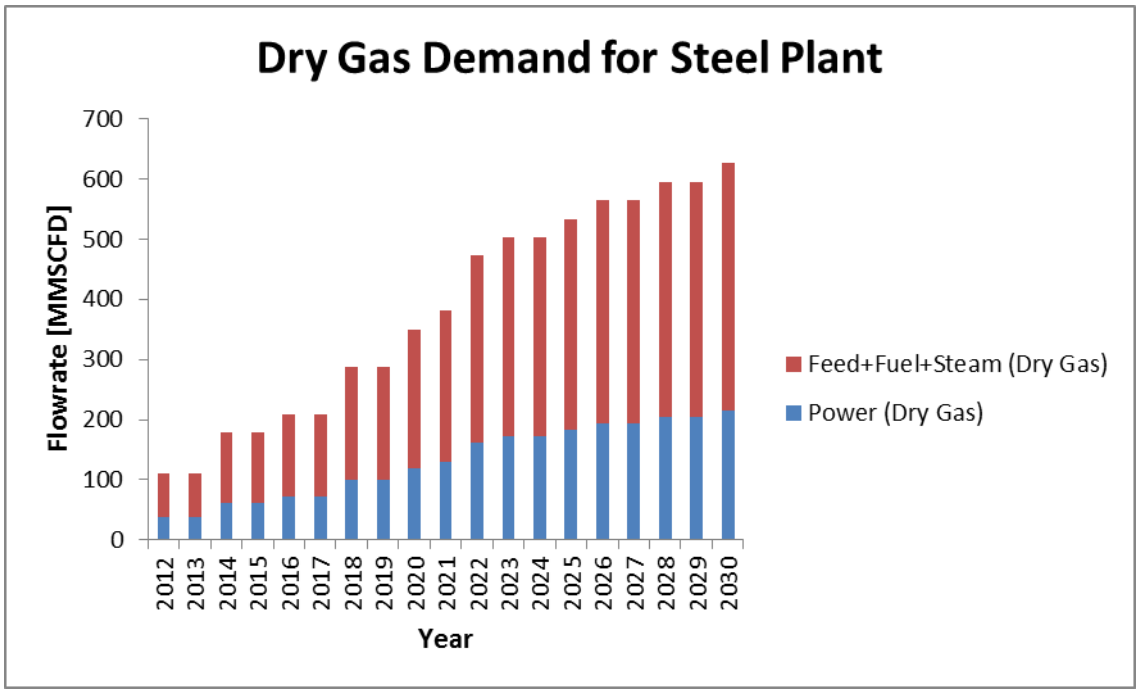


Figure-4.4.1(7): Transition of Demand of Dry Gas Fraction in Steel Production
(source: prepared by the study team)

(6) Aluminum plant

1) Demand forecast of aluminum

Data indicated in INES is used for demand forecast of aluminum.

2) Estimation basis of each gas fraction necessary for aluminum production

Gas necessary in aluminum plants is as follows.

- Power generation fuel for necessary electric power supply: dry gas

In this study, the numerical figures indicated in Table 4.4.1(7) are used as dry gas consumption for unit aluminum production.

Table 4.4.1(7): Consumption of Gas Fraction for Aluminum Production
(source: prepared by the study team)

Target	Gas fraction used	Consumption for unit steel production
		Unit / kTPA- Aluminum
Power	Dry Gas	0.28 MMSCFD-Dry Gas

3) Transition of demand of each gas fraction in aluminum production

The amount of gas fraction necessary for production in aluminum plants is as shown in Figure-4.4.1(8).

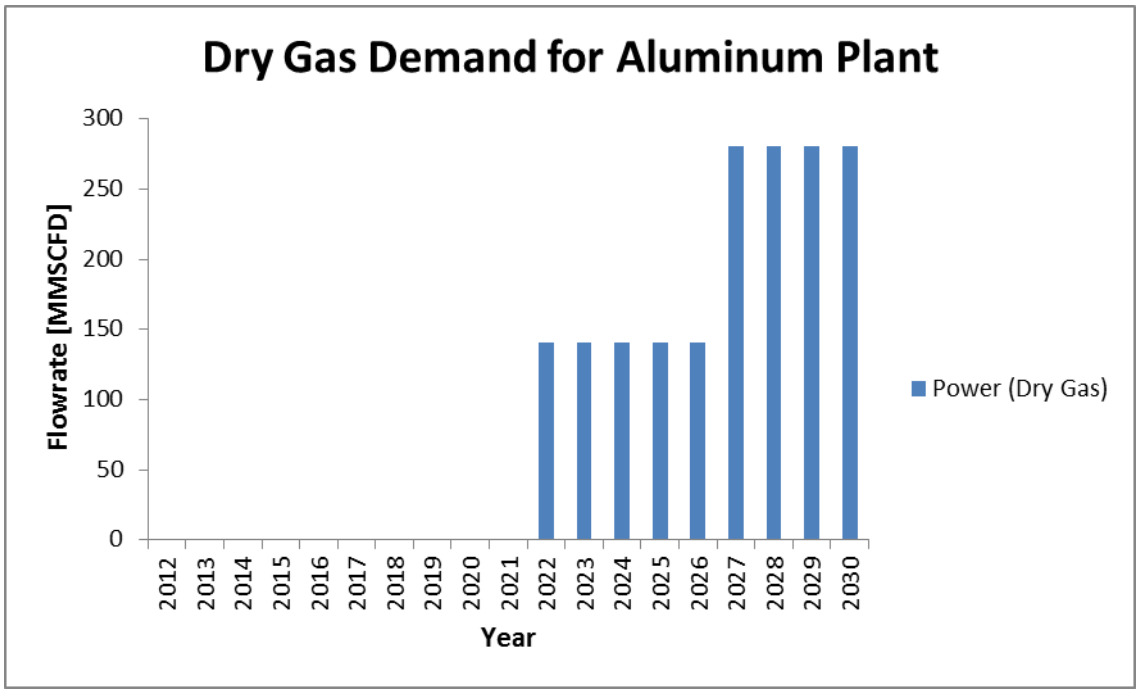


Figure-4.4.1(8): Transition of Demand of Dry Gas Fraction in Aluminum Production (source: prepared by the study team)

(7) LPG Plant

1) Demand forecast of LPG (as retail)

The demand forecast of LPG (as retail) has been assumed with literatures by the study team.

2) Estimation basis of each gas fraction necessary for LPG (as retail) production

Each gas fraction necessary for LPG production is estimated on an assumption that LPG components are propane 50% and butane 50%.

3) Transition of demand of each gas fraction necessary for LPG (as retail)

The amount of each gas fraction necessary for production of LPG (as retail) is as shown in Figure-4.4.1(9).

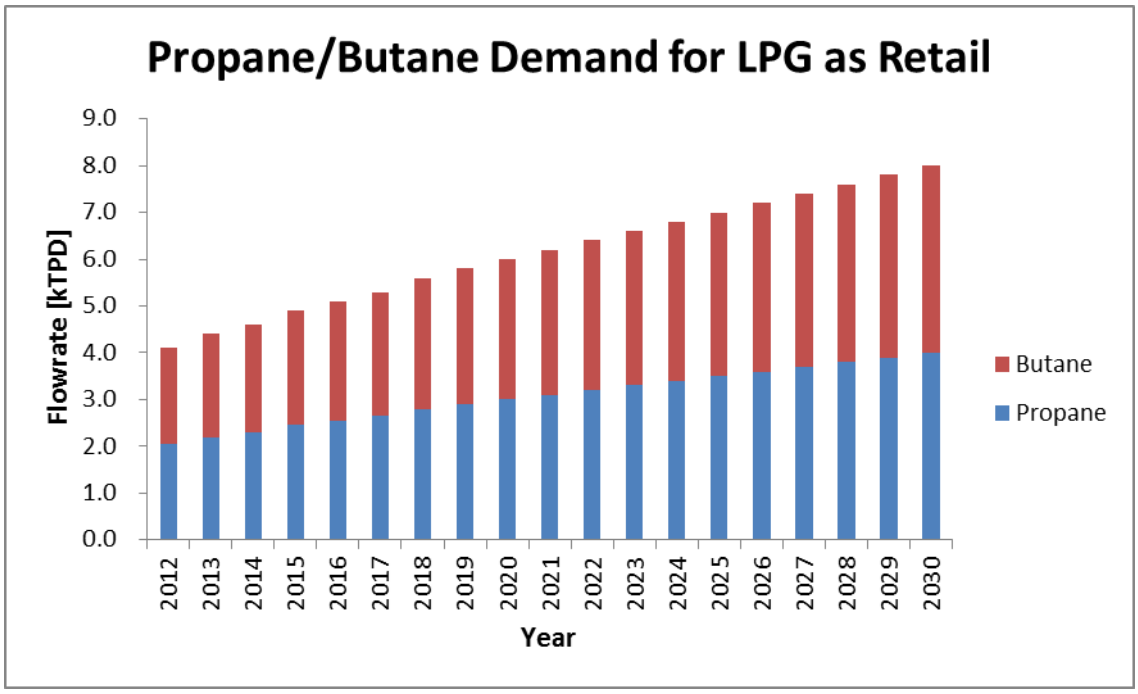


Figure-4.4.1(9): Transition of Demand of Propane/Butane Fraction for LPG (as retail) (source: prepared by the study team)

4.4.2. Supply and demand balance

The transitions of demand of each gas fraction in Iraq are described as below prepared on the basis of the supply of each gas fraction indicated in Section 4.3 and also of the demand of each gas fraction in the downstream plants estimated in Section 4.4.1.

Estimation of the supply of each gas fraction is made on the following assumptions.

- The ratio of each gas fraction produced in gas treatment plants is as defined in Section 4.3.
- 90% of the produced associated gas and non-associated gas is considered to be fed to gas treatment plants as shown in Section 4.2.
- The ratio of the type of gas treatment plants (ethane recovery, LPG recovery, and dew point control) is set so as to cover the annual demand of ethylene.
- The demand of gas treatment plants as shown in Section 4.4.1.
- Fuel for gas turbine and combined cycle power generation can be supplied from dry gas.
- Fuel for steam turbine power generation is assumed to be fuel oil.

(1) Estimation of supply and demand balance of dry gas

Until 2019, the supply and demand balance of dry gas is in excess of supply, but from 2020, a supply shortage will occur. This is because dry gas production will reach its peak in 2019, while demand continues to grow in accordance with the production rise of

downstream plants.

Transition of the demand for each downstream plant is given in Figure-4.4.2(2).

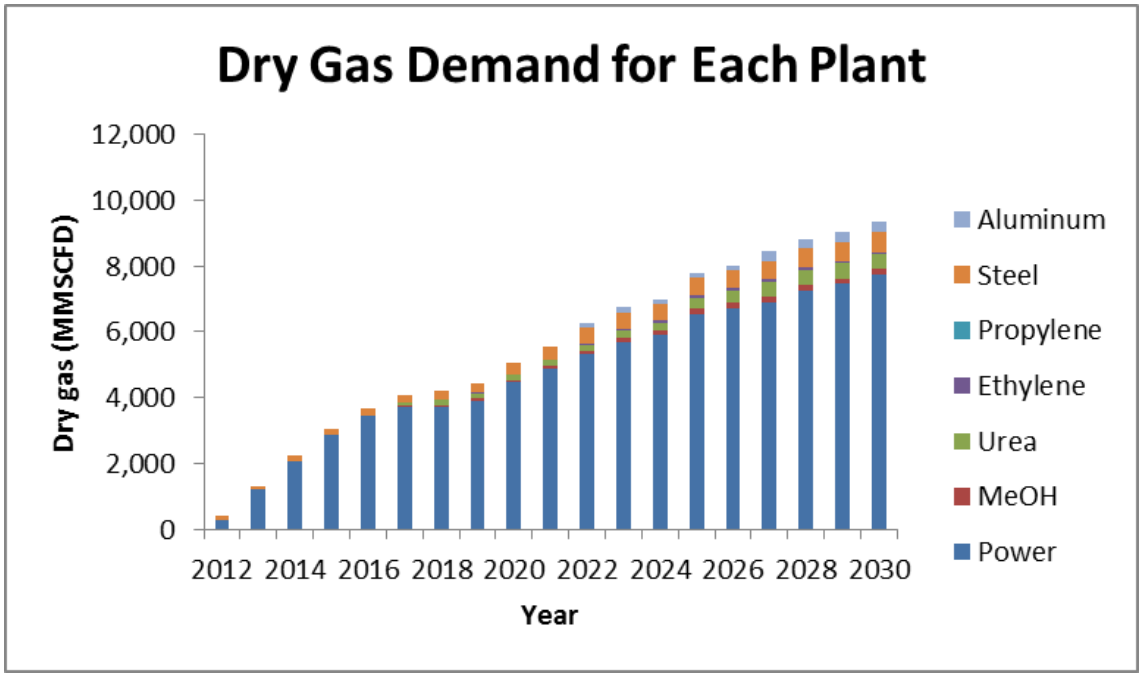


Figure-4.4.2(1): Transition of the Demand by Each Downstream Plant
(source: prepared by the study team)

As is observed from Figure-4.4.2(1), the major part of the demand of dry gas is for power generation fuel.

(2) Estimation of supply and demand balance of ethane fraction

As indicated in the prerequisite, the forecast demand and supply balance of ethane fraction shows agreement between demand and supply because the amount of ethane necessary for ethylene production is adjusted so as to be in exact proportion.

(3) Estimation of supply and demand balance of LPG (propane/butane) fraction

It is found that propane fraction and butane fraction remain in excess of supply, throughout the period.

4.4.3. Consideration

The results of analysis of the supply and demand of each fraction as indicated in Section 4.4.2 have revealed the following trends.

a) Dry gas will be in excess of supply until 2019.
b) Dry gas will be in short supply from 2020.
c) Propane fraction and butane fraction will remain in excess of supply, throughout the period.

(1) Measures against excess supply of dry gas

If surplus dry gas is exported, the annual amount of exports will be as shown in Figure-4.4.3(1).

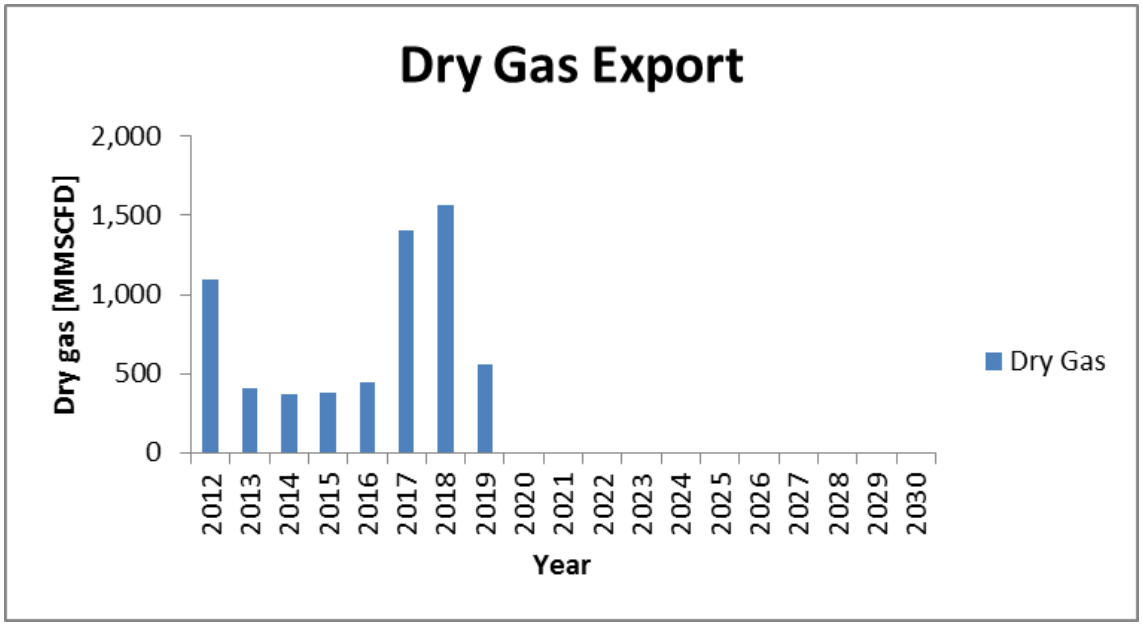


Figure-4.4.3(1): Amount of Exported Dry Gas Export
(source: prepared by the study team)

Because of greater demand growth of dry gas compared to its increase in production, the amount of exportable dry gas decreases year by year, and in 2020, no exports will be made. Thus, in order to be able to adjust the surplus amount by export, it is necessary to confirm if flexible contractual conditions are accepted so as to regulate the volume of exports.

(2) Measures against short supply of dry gas

If shortfall of dry gas from 2020 is covered by the development of new gas fields, the amount of dry gas required will be as shown in Figure-4.4.3(2).

That is, the development of new gas fields will be required to supply the dry gas shown in Figure-4.4.3(2).

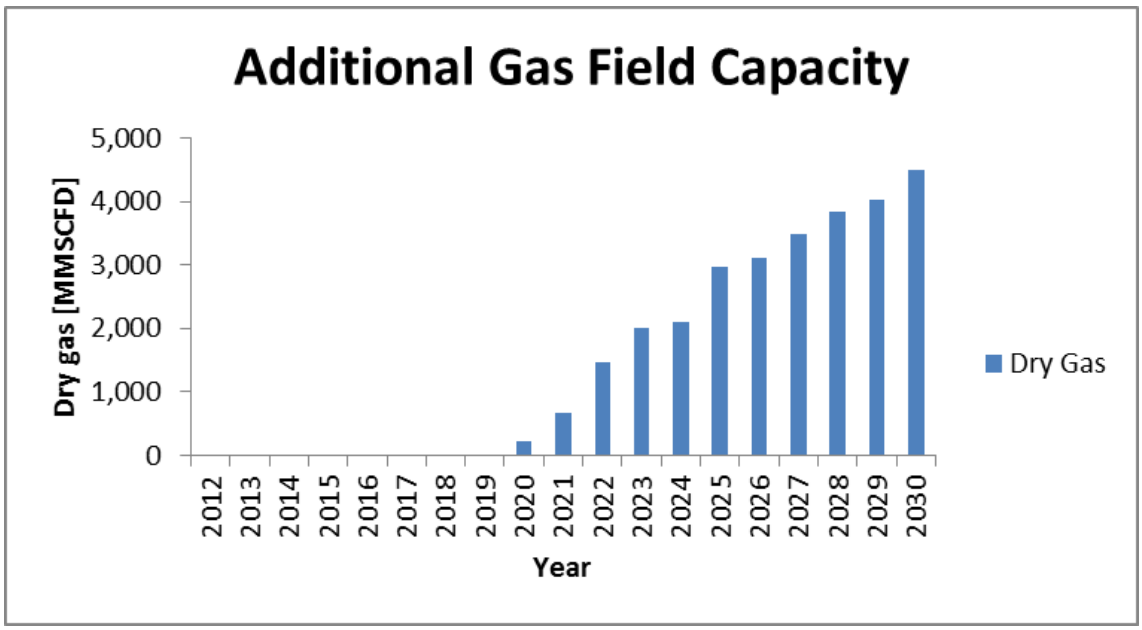


Figure-4.4.3(2): Amount of Dry Gas Required to be Supplied by New Gas Fields (source: prepared by the study team)

(３) Measures against excess supply of LPG

If surplus propane/butane is exported as LPG, the volume of exports shown in Figure-4.4.3(3) and Figure-4.4.3(4) will be required.

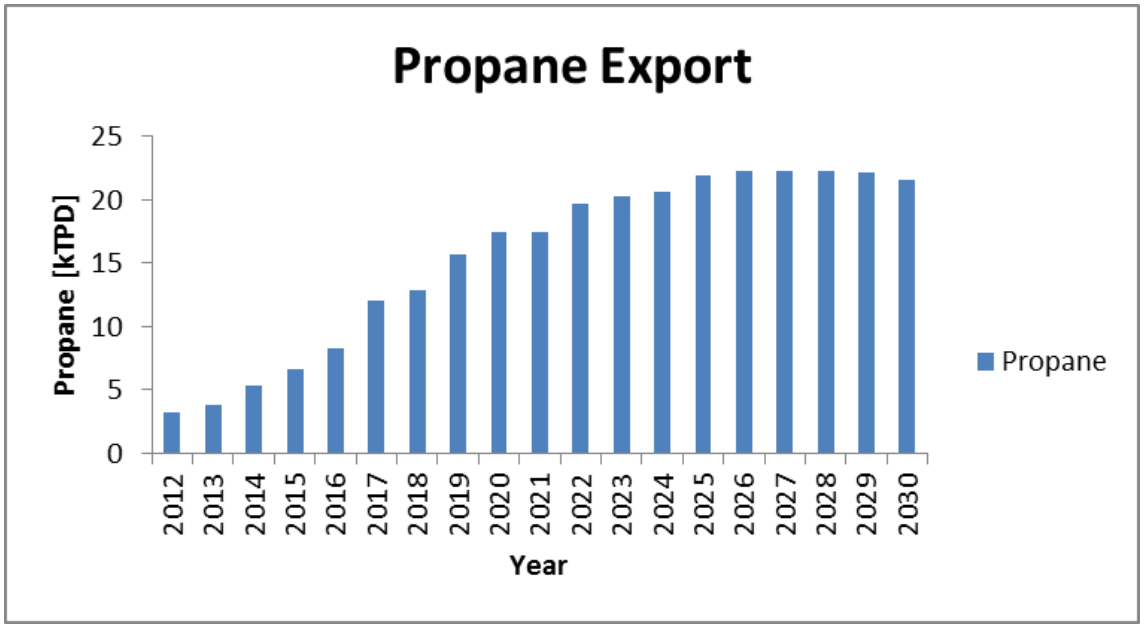


Figure-4.4.3(3): Amount of Propane Export

(source: prepared by the study team)

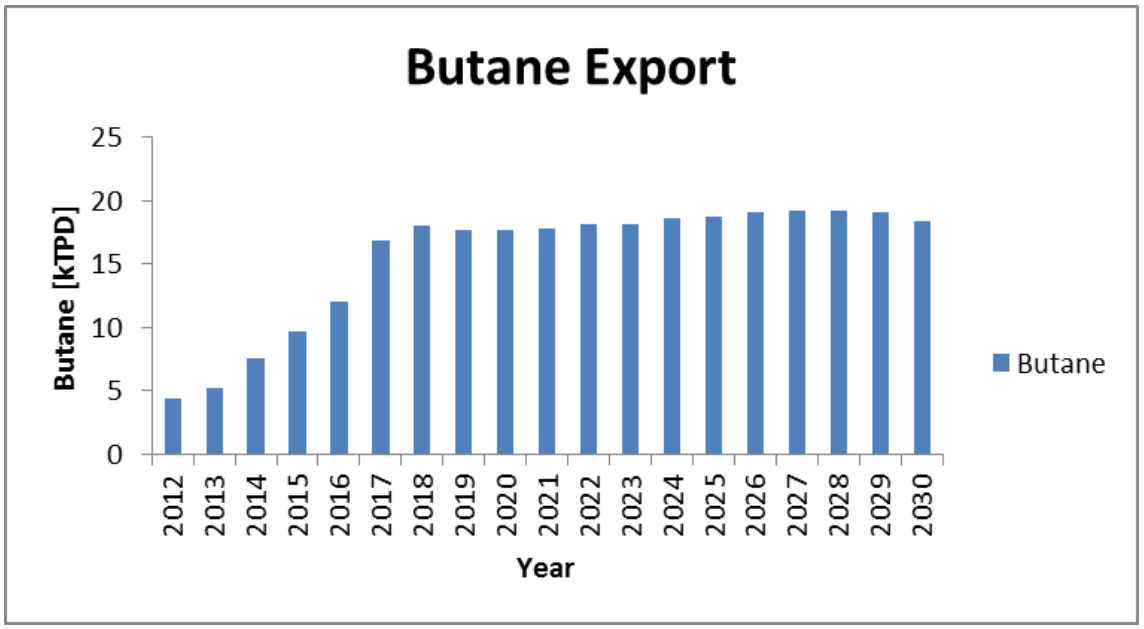


Figure-4.4.3(4): Amount of Butane Export

(source: prepared by the study team)

(1) Resolution of excess supply of dry gas by adjusting gas production (study 1)

Excess supply of dry gas estimated to continue up to 2019 needs to be adjusted by export or by flaring.

However, the above mentioned measures should be avoided, because export of dry gas generally requires a long term supply contract as a prerequisite, while flaring causes an environmental concern.

Thus, the following cases are discussed as measures to adjust gas production with a view to utilizing the excess dry gas.

- Period of surplus dry gas supply will be applied as fuel gas firing for steam turbine power generation
- If still surplus after above application, non-associated gas production, which is not related to oil production will be adjusted.
- If non-associated gas production adjustment is found inadequate, associated gas will be adjusted, but in this case, oil production will also be adjusted accordingly.

It is found that the following measures, if taken, could utilize the surplus supply of dry gas.

- Dry gas is utilized as fuel for steam turbine power generation from 2013 through 2019. Complete dry gas utilization in 2013, 2014, 2017 and 2018. Partial dry gas utilization in 2015, 2016 and 2019for steam turbine power generation.
- Production rate of non-associated gas is adjusted in 2014, 2017 and 2018.

(2) Resolution of short supply of power generation dry gas by using surplus LPG (study 2)

From 2020, short supply of dry gas occurs, where the majority of demand is for fuel for power generation as indicated in Figure-4.4.2(1), while LPG will remain in excess supply throughout the period。

Thus, a case study was made where surplus LPG is used as fuel for power generation, which remains in short supply.

The prerequisites for the above study are as given below.

- Only surplus LPG is used to cover the shortfall of dry gas.
- LPG is supplied as fuel in place of dry gas only when dry gas is found insufficient.
- LPG-powered power generation is limited only to power generation using simple cycle gas turbine-driven power generation.

When using surplus LPG as power generation fuel, shortfall of dry gas is improved, however, it will be in short supply again from 2023.

(3) Resolution of supply shortfall of dry gas for power generation by using fuel other than gas fraction (study 3)

As a result of the study made in Item 2), the use of surplus LPG could not completely cover the dry gas demand. Thus, in order to cover the shortfall of power generation fuel, another case study is made where the demand of dry gas/LPG as a power generation fuel is reduced, while increasing the ratio of power generation using fuels other than dry gas/LPG.

The prerequisites for the above study are as given below.

- Additional power generation shall be introduced using fuel other than dry gas/LPG after 2023 to cover shortfall.

Electric power generated by other fuels is as shown in Figure-4.4.3(5).

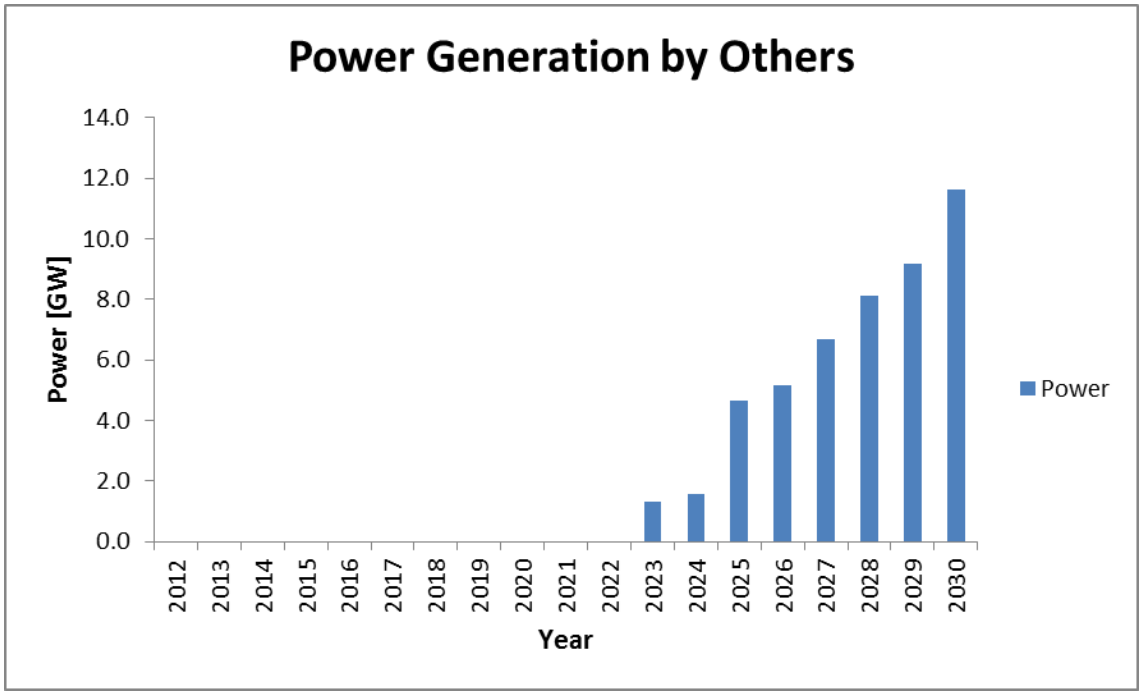


Figure-4.4.3(5): Supply and Demand balance of by other fuels fraction
(source: prepared by the study team)

(4) Resolution of short supply of dry gas by adjusting production of Ethylene for export (study 4)

One reason for short supply of dry gas for power generation is the use of ethane fraction for producing ethylene product.

It is found that planning of MoIM is more conservative than that of INES, however, 5.5 million tons/year of ethylene still seems to be an oversupply for Iraq. Table 4.4.3(1) shows that the production capacity in Middle East is around 80 kg per capita, thus 3.0 million tons/year of ethylene capacity is considered as a suitable size based on the Iraqi population in 2030.

Table 4.4.3(1) Ethylene Production Capacity in Major Countries and Area (source: prepared by the study team based on statistics of METI, Japan)

kg	per Capita	2004	2005	2006	2007	2008	2009	2010	2011	2012
	Japan	59	59	60	60	60	60	60	59	60
	Korea	118	122	125	147	153	152	155	156	162
	China	5	5	7	8	8	8	10	12	12
	Thailand	30	35	35	36	37	38	67	67	66
	Indonesia	2	2	2	2	3	2	2	2	2
	India	2	2	2	2	2	2	3	3	4
	Malaysia	66	66	65	65	63	62	61	62	61
	Australia	22	22	22	21	21	21	20	22	22
	Middle East	49	53	53	58	67	90	107	81	83
	USA	94	96	94	95	94	89	85	84	83
	Canada	165	163	162	157	164	153	151	150	148
	Maxico	13	11	13	12	12	12	12	12	11
	Brazil	16	19	19	19	20	20	21	20	21
	World Total	17	18	18	19	19	19	21		

Therefore, case study has been done as Plan of INES is high case, Plan of MoIM is middle case and Production of 3.0 million tons/year ethylene production at 2030 is low case.

Thus, in order to resolve the dry gas supply shortage, a case study was made where the production rate of ethylene is reduced, while production-curtailed ethane/propane fractions are used as dry gas or LPG fraction.

The prerequisites for the above study are as given below.

- Ethane which is utilized as feedstock to ethylene plant, will be supplied to power generation, instead.
- LPG can be utilized in power generation while only dry gas shortfall cases.
- Production rate of ethylene should be maintained to meet the specific scenarios.

The results of High case study shows that dry gas will be shortfall after 2023 as similar as Middle case.
In case of Low case, supply and demand gap will be slightly improved, however, shortfall will occur after year 2025.

4.4.4. Conclusion

Based on the results of analysis of gas production under Section 4.2, and on the demand forecasts presented in the INES Report under Section 4.4.1, the supply and demand balances for 2012 - 2030 were studied, and the following observations are obtained.

- Dry gas will be in excess supply up to 2019, thus requiring the adjustment of gas production or export of dry gas. However, this excess supply could be mitigated by followings;
  - Utilize excess dry gas as steam turbine power generation fuel in partial or total from 2013 through 2019.
  - Adjust the non-associated gas production in 2014, 2017 and 2018.
- From 2020, dry gas will be in short supply.
- Throughout the period, LPG will be in excess supply.
- Short supply of dry gas could be mitigated by using excess LPG for power generation; however from 2023, power generation fuel will be in short supply again.
- The above short supply could be mitigated by covering the shortfall of power generation fuel by using fuels other than dry gas/LPG.
- Short supply of dry gas could be mitigated by reducing the amount of ethylene production rate for export.

Based on the study results above, the gas production capacity cannot satisfy the complete demand scenarios described in INES and plans provided by MoE and MoIM simultaneously. It is required to seek the resolution reflected priority and reality so that a long-term supply and demand balance shall be established.

The higher priority has been put in INES as electricity, methanol as liquid product and fertilizer for agriculture advancement and petrochemical sector can be adjusted in order to maintain the sustainable supply and demand balance for a long-term basis.

5. Survey after January 2014 with Conclusion of Phase-1 Study and Proposal to Subsequent Phases

5.1 Summary

In the previous chapters, the natural gas supply and demand balance was studied for whole of Iraq based on the received and gathered information up to December 2013. On the other hand, Iraq faced a lot of unexpected political and environmental changes within this one year, and planned oil fields and infrastructure development were not progressed to the expected schedule. By considering the time frame with this background, the following issues are extracted.

(1) Flare gas volume is likely to increase, such as actual record in December 2014, more than 1,500mmsfcd was flared for the associated gas, which is serious issue to be solved not only for effective energy utilization, but also for environmental problem.
(2) Gas supply resource is mainly from the associated gas from oil production fields, therefore, gas production volume is depended upon oil production volume. Since increasing in oil production amount is a national energy strategy, increasing in associated gas production amount will be forced accordingly.
(3) For materializing future blue picture in the Integrated National Energy Strategy, gas infrastructure such as gas processing plant, gas pipeline and storage/export system should be rehabilitated and developed, but actual development is not progressed to the expected schedule.

For the above issues, the development plan should be revised based on the actual situation, and executed by considering priority of the plan in the mid & long term schedule point. On the other hand, effective utilization of flaring gas should be considered as an urgent issue to be solved in the near term.

For effective utilization for flaring gas, there are two options;

(1) Gas export to neighboring countries
(2) Gas injection into the oil fields

Gas infrastructure development is mandatory for both options, therefore, gas pipeline, gas processing plant rehabilitation and development should be progressed for the potential gas consumers as gas infrastructure development.

For the gas pipeline development, it could be executed together with oil pipeline development, which is effective in economy and time, and also be matched with Iraqi energy strategy of the oil export acceleration.

Mid & long term development plan and individual project should be studied and discussed in Gas Master Plan Phase-2.

5.2 Conclusion of Phase-1 based on Survey after January 2014

5.2.1 Re-estimation of Upstream Data

The study results are described through chapter 4 using the available data in 2013, Integrated National Energy Strategy, INES, and overall supply-demand balance in Iraq nation-wide. After that, one year passed and available data has been changed due to the re-estimation of field development plans, certain delay of the planned projects, and its related environment. Therefore, updating the data and acknowledging the actual situation is summarized in this chapter through the discussion with related members of Iraq ministries.

As mentioned above, 80% of Iraqi natural gas resource is produced from the associated gas from the oil production fields. Therefore, gas production amount study should be started from oil production analysis. Oil production profile was changed from INES, therefore, gas balance on supply and demand was also changed and updated from the originally estimated balance in 2013.

(1) Causes of Re-estimation of Gas Production Rate

Six major causes can be considered to re-estimate the gas production rate after 2013 through the beginning of 2015 as followings.

- Amendment of IOC Contract in southern major oil fields
- Selection of oil production brand for offsetting oil price fall
- Delay of infrastructures projects accompanied with oil & gas fields development
- Delay of development for downstream section (gas utilization project)
- Invasion of Islamic State (IS) after mid of 2014, especially in northern area
- Iraq new administration

A part of IOC contract amendments has been reflected in the previous chapter, however, additional revised information is available. Table 5.2.1(1) shows such amendment information. Amendment can be seen in several aspects and three major revisions related with gas production capability are, 1) decreasing the target of oil production plateau, 2) change of plateau reaching year from 2017 to 2020, 3) prolongation of the plateau period.

Plateau figure used in the previous evaluation exceeds 10 MMBPD and it

is more than 9 MMBPD as described in INES. On the other hand, oil production downward revision supposes to be decided due to the delay of oil evacuation system for export, which is difficult situation for produced oil to export without the infrastructure. Since the end of 2014, because of oil price depression, it was selectively produced only for popular oil brand. Furthermore, it is sometimes reported that it will be difficult to achieve the plateau target in 2020 due to the low oil price, delay of development for IS invasion and the construction of oil production infrastructures. Therefore, there is uncertainty for the production profiles. However, in this report the best available data at present has been used.

Table 5.2.1(1) TSC Amendment Summary
(source: prepared by the study team based on JOGMEC and et al)

Field Name	Contracters	Main Target	License Round	Original Target Prodcution kBD	Year Plateau Start	Period Plateau	Updated Target Prodcution kBD	Updated Year Plateau start	Updated Period Plateau	Prod. Reduction from Original kBD
Rumaila	BP, CNPC	Oil	1	2,850	2015	7	2,100	2020	13	750
West Qurna 1	EM, Shell	Oil	1	2,325	2016	7	1,600	2020	13	725
Zubair	Eni, Oxy, Kogas	Oil	1	1,200	2016	8	850	2020	14	350
West Qurna 2	Lukoil, Statoil *1	Oil	2	1,800	2017	13	1,200	2020	16	600
Majnoon	Shell, petronas	Oil	2	1,800	2017	10	1,000	2020	NA	800
Halfya	CNPC, Petronas, Tota	Oil	2	535	2015	13	400	2020	16	135
Total				10,510			7,150			3,360
Iraq total				12,220			8,120			4,100

The infrastructures accompanied with gas production facilities are, 1) Gas processing Plants, 2) gas transferring infrastructure for treated gas in each oil field 3) temporary storage and distribution to individual gas user. In case of 1) above, Basra Gas Company (BGC) is expected to rehabilitate the existing gas processing plant as well as install new ones for three target oil fields, such as Rumaila, West Qurna 1 and Zubair. For other oil fields, individual gas treatment facility will be installed for each oil field based on the technical service agreement. On the other hand, there is no information about the plan in the oil fields, which are developed by Iraqi state oil companies. The gas processing facilities in individual oil fields will be completed before plateau production start, but it is not earlier than 2020. Therefore most of gas will be flared unless there is sufficient gas processing capability and materialization of gas end user plan. It is a severe issue from the view point of environment protection and economy loss.

In case of 2) above, gas gathering system from each oil field, there is not sufficient evaluation as to whether gas is gathered for centralized point or the branches from individual oil fields are connected to the national strategic gas pipeline. Facilities related with 3) above are gas gathering facilities in each area, which cannot be planned without above 2) results. Iranian gas import is reported to commence within 2015, however one

year delay from the original plan is scheduled based on the interview with the related Ministries. Gas import contract was revised from 15 years to 5 years for the end-users. Furthermore, newly discovered gas fields after INES published, therefore, gas production volume supposes to be increased after 2020 from the current expectation.

Associated gas production has been increased based on the oil production volume, while the plans and studies for the end-user are delayed. Therefore, produced gas cannot be utilized, and then flared to atmosphere at this moment. In addition, construction of gas feed facilities takes a lot of time. Many power generation plants changed those fuel from gas to crude oil because the shortage gas is foreseen in the report of INES., resulting in reduction of number of gas consumer.

Political and environmental stability for the nation is essential for Industrial development, but IS occupies the northern and western Iraq including oil fields which are producing oil presently. It affects delay of new development plans and withdrawal of IOC. It is reported that development in Akkas gas field in northwest has been suspended and that Sonangol has withdrawn from oil field development in Najma, Quayarah in northern Iraq. Re-estimation of gas supply amount is considered to postpone the plateau time to 2035 since the situation of these areas are uncertain although the development activities will continue. No capacity expansion is assumed in the existing oil fields for the preservation of resources.

Kurdistan area is excluded from this Phase-1 study due to the discussion results with Iraq MoO in May 2015, even though Kurdistan government and Iraq government reached reconciliation after the last election in April 2014. The northern export oil pipeline cannot be utilized, however, another oil pipeline, which has been constructed by KRG, can be utilized to export the oil through Turkey from last year under the agreement between Iraq government and KRG. The oil export from northern Iraq can contribute to the gas production rate to some extent. However, in this study report Gas Production Profile is added only from the oil fields controlled by North Oil Company.

(2) Start Year of Plateau in Oil & Gas Fields, Production Rate and Periods

The start year of plateau in oil and gas fields, production rate and periods have been re-estimated. Based on these oil production scenarios the associated gas production profile can be estimated. The oil production profile will be reviewed periodically to sustain the Iraq natural resources based on the results of new development plans and oil field development progress.

(3) Oil Production Profile

Figure 5.2.1(1) shows the oil production profile after re-estimation. The plateau will begin from 2020 and maintain until 2035 since the southern giant oil field development plan has been shifted from 2017 to 2020. Plateau production rate is expected as 9 MMBPD in 2020 and it is similar with the plan of Iraq government considering domestic consumption and export. It is found that plateau will sometimes overshoot more than 10 MMBPD and it can be adjustable to prolong the plateau periods by suppressing the production rate. The crude oil is categorized into three types based on the API gravity.

<API Gravity>

Light crude	>37
Medium crude	≧28 & ≦37
Heavy crude	<28

Light crude has characteristics of higher Gas Oil Ratio (GOR) resulting in higher gas production rate, however, most of Iraq crude is categorized in medium and heavy crude. An average GOR through entire Iraq oil is estimated about 600 scf/bbl, which is recognized to be maintained for longer period.

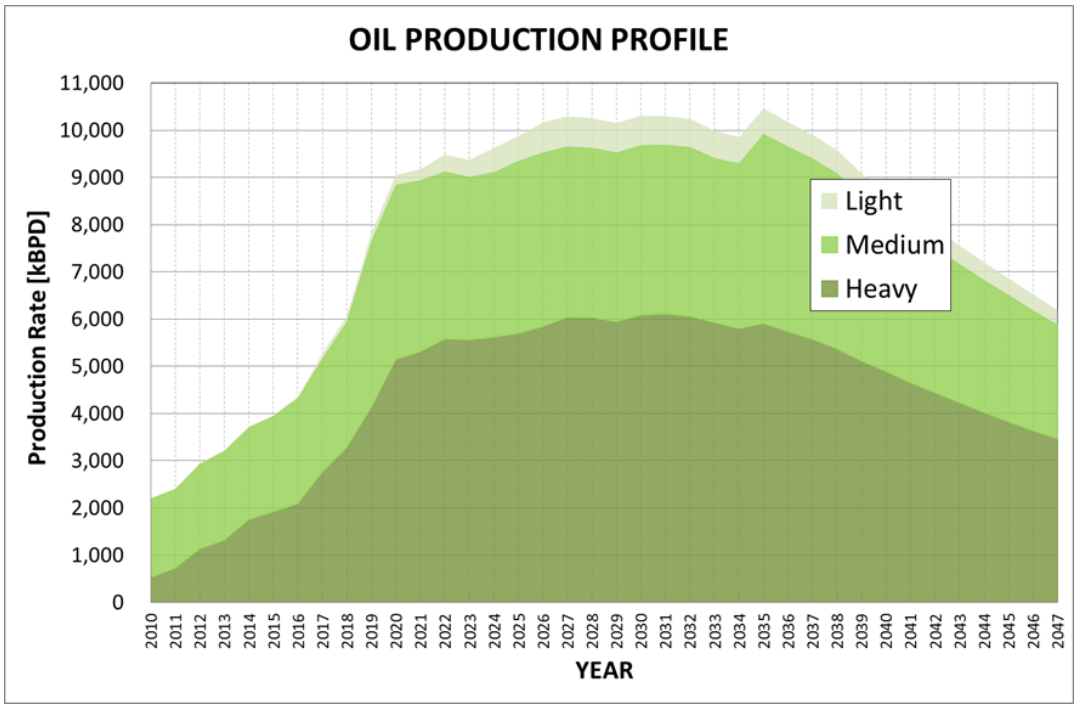


Figure 5.2.1(1) Oil Production Profile
(source: prepared by the study team)

(4) Gas Production Profile

The gas fields under development in Iraq are the three fields of Akkas, Mansuriyah and Siba. The plateau time is specified in 2020 due to the delay of development. Iranian

gas import is included in table of gas fields for study purpose. The majority of gas comes from associated gas with oil fields. Main gas is dry gas containing methane (C1) plus ethane (C2) and production rate is about 5,000 MMscfd in 2020. Total gas production rate is calculated up to 6,000 MMscfd including LPG and NGL. The difference is the content of LPG and NGL, being as much as 1,000 MMscfd. The gas production rate will increase gradually by 2035 and dry gas reaches 6,000 MMscfd. If production rate will be suppressed on the level of 2020, the starting point of decline can be postponed. It is difficult to estimate the decline rate after plateau period due to a lack of information, therefore, it is assumed 0.5% per year for study purpose. When there is no information on gas compositions or GOR in each field, similar and average composition data has been applied. If new information becomes available, it is essential to replace and update such valuable information for more precise evaluation. A part of dry gas is subtracted for self-consumption in the fields.

< Assumption of self-consumed Dry Gas >

Oil Fields	20%
Gas Fields	10%

(5) Flaring Gas Transition

Gas production volume will be increased definitely incremental to the oil production rate in future. On the other hand, delay of development for the gas distribution infrastructure, as mentioned above, huge gas volume is discharged to atmosphere by flaring. Based on this mutual understanding, INES mentions that gas expected to be shortage for the demand in 2014, but gas flaring has not be stopped yet.

During the last one year gas flaring rate is increased based on oil production increment. Figure 5.2.1(6) shows the flaring gas transition up to January 2015 based on the web information provided by Iraqi Ministry of Oil. It is obviously expected with the current condition that gas flaring should be continued unless the completion of Basra Gas Company (BGC) or gas recovery projects included in each IOC’s individual oil field development plan and gas consumer’s project. Utilization of gas during this period should be studied and planned separately, and will be described later in this report.

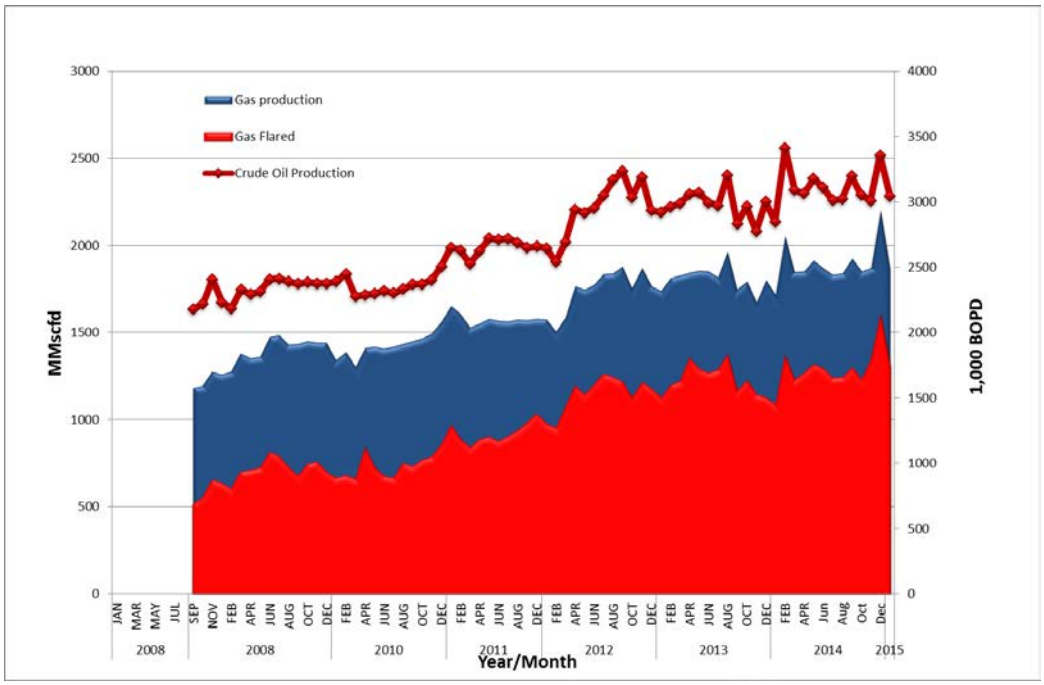


Figure 5.2.1(2) Transition of Flaring Gas as well as Oil & Gas Production (source: prepared by the study team based on Web page of Iraq MoO)

(6) Conclusion of Gas Production Profile

- It is found in 2015 that a lot of gas separated from oil fields is flared without recovery and that due to the delay of infrastructure plan/study for end-users, gas consumed volume is limited. In addition, the amount of flared gas is expected to increase proportionally as the oil production increases since there is not sufficient capacity expansion of the existing gas processing facilities. Considering current progress speed, expansion for gas processing plant of Basra Gas Company, which can be treated by 50% of south regional production, there is no potential end-user except the completion of downstream facilities, therefore, flaring gas could not be expected to decrease. Up to now, in the several plans, mentioned in INES, no actual study is conducted for "Oil production enhancement by gas injection to oil reserves", and "Gas export to the neighborhood countries" can be basis of the plan and establishment for short-term gas utilization.

- More than 80% of current gas production comes from the associated gas from oil production, therefore, gas production rate is fluctuated depend on oil production rate. Oil production rate will be increased to production plateau in future, in this result, gas production rate will be increased.

- During INES development, investigation was not sufficiently conducted for gas production from gas reserves. At this moment, gas production from gas reserves is only approximately 20% of total gas production rate. In future, gas production from gas reserves will be increased. In case gas supply and demand balance will be updated by production rate added to total gas production profile after 2025 with this report, industrial development plan can be prepared by longer term gas supply and demand.

- Associated gas production rate reaches to plateau in 2020 as well as oil production and it will increase until 2035, then it will decline. This phenomenon is influenced with the assumption of production planning of assigned oil and gas fields. It is important to prolong the plateau periods by adjusting the production plans.

- The plateau periods can be prolonged by;
  - Applying Improved Oil Recovery (IOR) or Enhanced Oil Recovery (EOR) for existing fields
  - Production start of explored oil and gas field
  - Explore new oil and gas fields

The total gas availability to downstream is calculated as 90% of upstream production rate considering upset of oil fields and downtime.

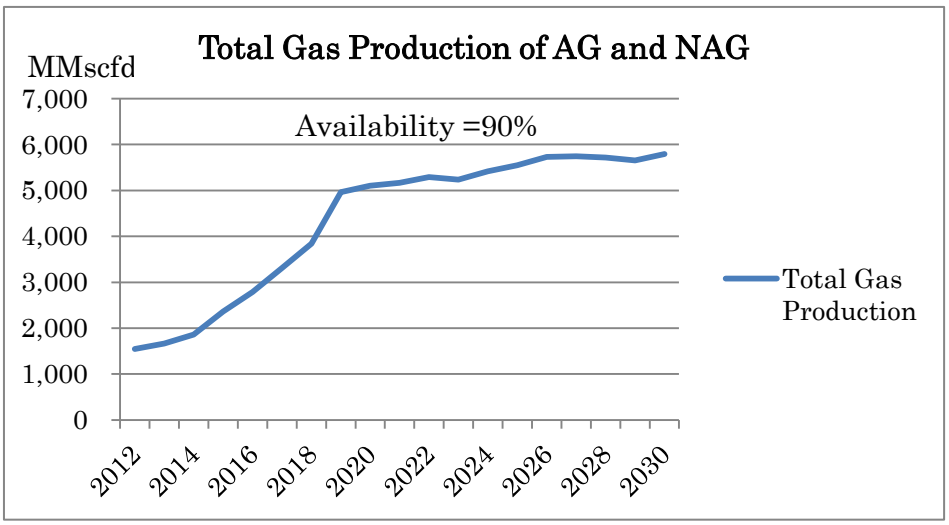


Figure 5.2.1(3) Total Gas Production of AG and NAG
(source: prepared by the study team)

5.2.2 Re-estimation of Downstream Sectors

(1) Development plans in Downstream Sectors

After the meetings with MoO, MoIM and MoE in September and October 2013, the meetings were held in April and May 2015 again and some updated data has been informed from MoIM and MoE. The completion time of petrochemical plants and power plants development are updated.

In case of petrochemical development, it is postponed for one to three years other than PC-4.

The new information was provided from MoE describing the power generation capacity build-up based on the different fuel types. The plan does not go beyond 2020, however, present plan can be compared with that of INES in Figure 5.2.2(1) as below and it is found that overall capacity build-up is similar with each other.

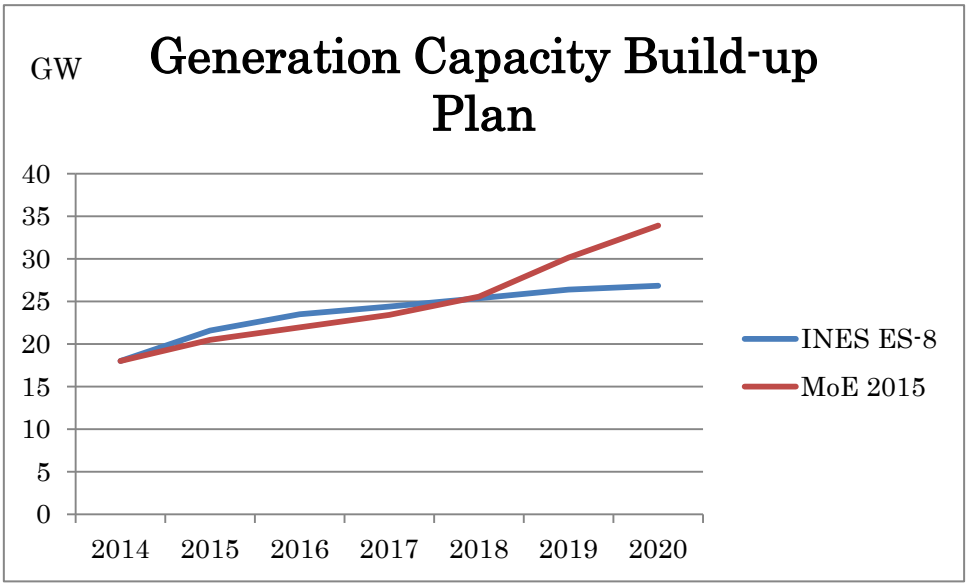


Figure 5.2.2(1) Comparison with INES and MoE Information in April 2015
(source: prepared by the study team based on MoE data in April 2015)

On the other hand, gas fired gas turbine portion is limited in future plan and most of new installation power generation will be covered by liquid fuel.

The Gas Master Plan (GMP) in Iraq always requires adjustment of upstream conditions and downstream planning. GMP Phase-1, this report, took a long time from the beginning in March 2013 to finalize in May 2015. In-between, the conditions have been changed time to time due to new Iraq administration and IS invasion to force the delay of projects.

This study, Phase-1, concludes using the following assumptions in highlight.

- Gas Production Rate is based on re-estimated data in 2015
- Petrochemical plant development schedule is based on MoIM information
- Gas consumption for power generation up to 2020 is based on MoE information
- Dry gas balance study is based on INES as well as real development status

The Figure 5.2.2(2) shows the case of dry gas balance if all projects are well-developed based on the scenarios in MoIM and power generation build-up in INES.

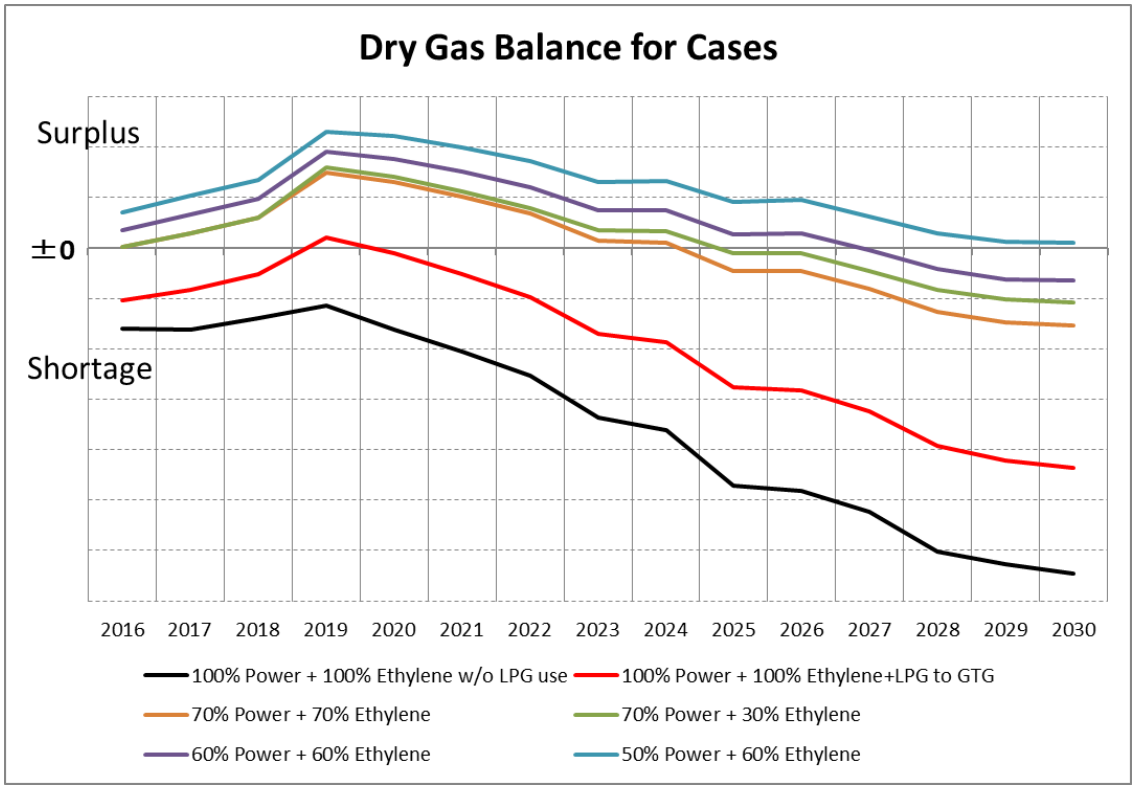


Figure 5.2.2(2) Dry Gas Balance based on the Planning of MoIM and INES
(source: prepared by the study team)

On the above Figure, 100% represents the planned capacity of INES as original and latest one of MoIM. Therefore, if 70% capacity is considered for the study, dry gas requirement is decreased accordingly.

The study shows the following results when projects specified in INES will be realized.

- Dry gas will be shortage through the project periods up to 2030 considering gas

consumption by the power generation build-up and the steel production.

- LPG will be separated and produced more than its domestic consumption through 2030.
- LPG can supplement the shortage of dry gas for power generation during limited periods.
- Natural gas balance will be achieved, if downsizing to 70% of power generation development plan in INES, early time of INES plan in particular.
- Downsizing to 70% of ethylene plant capacity development plan of MoIM from actual planning view.

On the other hand, if downstream facilities already installed based on INES scenario and worked at this moment, feed gas volume should be shortage from demand and then, flared gas should not exist. However, it is a fact that some of plants such as steel facilities are not working. In addition to the execution based on INES plan from now on, the study based on the real progress of projects in INES and data provided by MoE shows in Figure 5.2.2(3) and it is found that surplus gas can be expected even in early time. Furthermore, if the project will be delayed by 3 years, 5 years and 7 years, the surplus gas will be increased and a lot of gas should be flared in worst case. It should be avoided from the view point of the environment protection and economy loss. That is, balance can be surplus or shortage according to base conditions and it is essential to have short term planning and long term countermeasures.

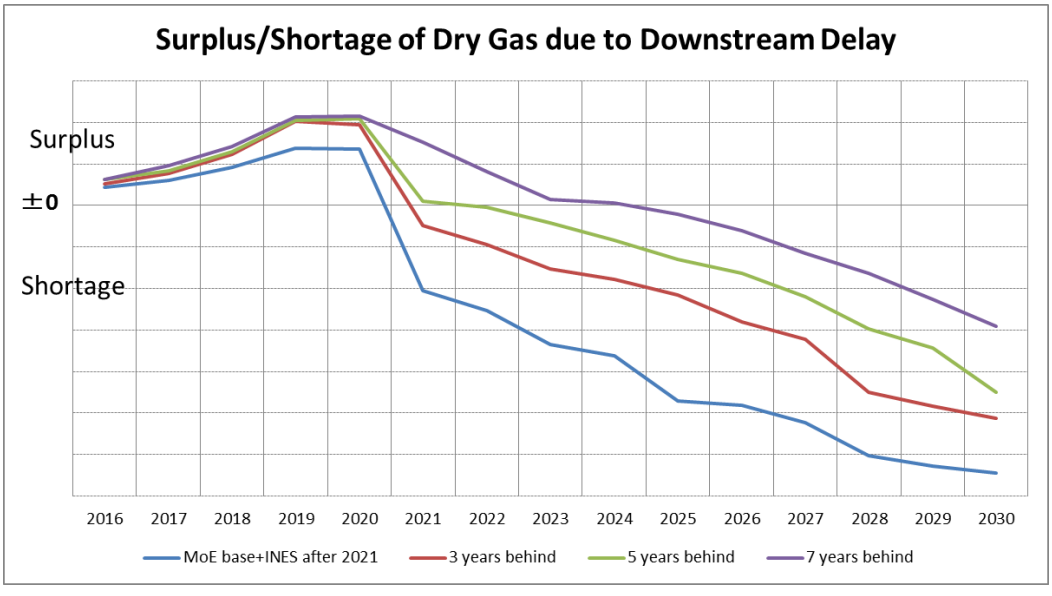


Figure 5.2.2(3) Simulation of Gas Balance due to Delay of Projects
(source: prepared by the study team)

Through this study of GMP Phase-1, because insufficient sharing of the information

among Iraqi Ministries, it is confirmed that there is discrepancy of understanding between the explanation of gas shortage in INES and the actual situation of huge gas flaring. In case considering utilization of this valuable gas resource, information sharing between supply and demand side is most important. Therefore, discussion among the entire concerned ministries including Iraq Energy Committee and such function is necessary for further discussion.

Moreover, effective utilization of valuable energy resource and commercializing, monetizing, of the current flaring gas should be necessary. For the purpose, following countermeasures are recommended.

- To reduce the gas flaring, if infrastructure will be provided,
  1) Gas export to neighboring countries
  2) Gas Injection into the existing oil fields for IOR/EOR to increase oil production or supply to the existing facilities after rehabilitation

After the downstream facilities will be developed, the supply of gas will be shortage, then, the following countermeasures are considered.

- Replace the power generation gas turbine from simple cycle to combined cycle to improve the efficiency since power plant will be major consumer in future in order to mitigate the time of gas shortage.
- Downsize petrochemical plant capacity
- LPG and/or ethane can be utilized for power generation fuel for supplement
- Gas import for a short period to eliminate the imbalance

The study has revealed that there will be a shortfall of dry gas in the future if all requirement in INES and project planning of MoIM are implemented. The resolution should take into account diversification of fuel and system requirements for power generation including residual oil utilization provided from newly planned refinery plant. It requires the comprehensive view points among the related organizations.

The gas depending society requires the stable operation and production of oil, especially in Iraq. Once the stoppage of oil production happens, it will force the downstream sectors to be shut down immediately. To avoid this, it is necessary to install the gas storage facilities to maintain the gas supply pressure.

It is essential to diversify the fuel mixture for power generation to establish the stable power generation, supply and distribution considering with economic point of view.

This report provides the study results based on the available information including INES, data from MoIM and MOE in September and October 2013. These data were updated in April 2015 again by the meeting with MoIM and MoE. The present oil

production plan of 9 MMBPD in 2020 cannot satisfy the requirement of INES and MoIM fully and therefore reconstruction of scenarios including alternative ideas is mandatory. The two big gas consumers are power generation and petrochemical plants, and those downsizing or postpone of development will be considered.

It is assumed that 90% of produced gas can be recovered for supplying to downstream sectors and compared with the scenarios of INES, however, it should be also considered that the recovery of natural gas will take a long time effort and cost. That is, rehabilitation and remedy of gas recovery facilities are a mandatory requirement. In some occasion, stranded oil fields may happen where gas recovery is not feasible.

5.3 Proposal to Subsequent Phases

The purpose of Phase-1 report is to reveal and investigate the overall gas balance, especially associated gas according as the oil production scenarios. Phase-1 study covers the Iraq nation-wide gas balance. Iraq Government approved INES in June 2013 where the development plans of power generation capabilities, C1 chemical plant development including methanol and urea fertilizer, ethylene plant as petrochemical, and steel and aluminum for reconstruction. The natural gas in Iraq consists of 70 ~ 80% from associated gas and gas production is highly dependent on the oil production rate.

The Iraqi revenue will be earned by exporting oil to foreign countries to reconstruct the nation after wars. However, energy of associated gas is corresponding to more than 10% of total energy of crude oil, that means, 70% of the associated gas volume is wasted by flaring. It cannot be neglected issue for huge energy waste and environmental problem. Therefore, it is very important to recover the flared gas while oil production rate will increase.

Under this situation, it is necessary for Iraq Government to obtain GMP as the fact findings on the viability of projects provided on INES and by related Ministries. Soon after INES preparation, this study has been conducted by JICA fund as Gas Master Plan Phase-1. Concrete Gas Master Plan will require the cooperation among the entire Iraqi ministries including, but not limited, Ministry of Oil (MoO), Ministry of Industry and Minerals (MoIM), Ministry of Electricity (MoE), Iraq Energy Committee, and other concern parties.

GMP may require three phase development for concrete project scenarios and individual phase definition shall be determined prior to commencement.

Phase-1 : Nation-wide gas balance analysis and each project reality has been evaluated in this report with extracting issues for future development and recommendation.

Phase-2：Updating oil & gas production profile

Regional development plan to be established based on regional features in Iraq industries, consumption trend, population density, export terminals, natural gas, and feedstock supply chain

Location to be fixed to install the gas gathering and separation facilities

Conceptual study of the capacity and distribution system including pipeline network

Phase-3：Prioritize the individual projects

Planning to achieve the economic feasibility based on site selection, construction schedule analysis, and plant capacity with project finance

On the other hand, discrepancy was revealed in this Phase-1 report between the situation on INES establishment and current situation, then gas utilization study for short term of 10 to 15 years should be conducted to make sure gas supply and demand balance before starting Phase-2. If this kind of study is not conducted before Phase-2 commencement, further natural gas will be flared for some period due to the current delay of infrastructure planning, which causes waste valuable energy resources to the atmosphere. By planning this short-term study immediately, reflecting to Phase-2 study, materialization of INES in healthy condition can be achieved.

(1) Crude oil production is most important method to earn foreign currency in Iraq, therefore, this development is most important factor for economic stability. To achieve stable oil production effectively, most important method is maintenance of pressure for oil reserves. Water flooding is current method for this pressure maintenance. But it is dependent upon the characteristic of oil fields, and it is not effective method for overall maintenance of the pressure. On the other hand, it was confirmed that gas cap of upper side of Mishrif oil layer, which is basis of oil production pressure, is now decreasing in pressure. In addition to water flooding, for equalization of pressure reserves and increase for effect of water flooding, gas cap revitalization is necessary. For this resource, flaring gas, especially for dry gas utilization is most recommended. Mishrif oil layer is existing around Iraq southern part to middle, the overall pressure increasing by gas capping development is assumed to protect pressure concentration on some part of the oil reserve, which causes destruction of the reserves. Therefore, not only for individual oil field application, analysis of overall Mishrif layer pressure balance is required for effective gas injection, which investigation can be initiated by Iraqi Ministry of Oil.

(2) Gas volume cannot be so large for above mentioned (1) gas injection. Monetization of current flaring gas can be financial resource for planning basis of Iraqi economic development in future, which can compensate lost revenue for IS invasion measures and

crude oil price depression. In addition, to materialize this plan earlier, most effective way is gas export to neighboring countries to earn foreign currency as described in INES. For this purpose, Kuwait should be a first country to discuss on this matter suggested in INES. As per investigation, Kuwait is now planning to import LNG in future, that means, it is confirmed that gas resource is not sufficient. In another point, Iraq can make possible to realize “Reduction of Flaring Gas”, and “Achieving financial resource for future infrastructure”. It was reported officially that current Iraqi government already had MOU with Kuwait for gas treatment. This short-term utilization plan can be effective for compensation of lower oil price and financial resource for Phase-2 development and materialization.

After development and materialization of the short-term gas utilization plan, according to the re-estimation in chapter 5.2, overall gas balance is achievable with adjustment of the downstream demand. However, to implement the plan in actual realization phase, some study and issue to be solved, and Gas Master Plan activities shall be continued until comprehensive industrial development scenarios can be established. For this purpose, the subsequent follow-up activities in Phase-2 and Phase-3 are recommended.

(3) The detailed study is required to recognize the constraints and conditions, where projects provided in INES will be realized or not. There is no plan of the natural gas utilization in Iraq previously and thus the study will be conducted for the existing gas processing facilities and newly constructed facilities such as ethane recovery plant separately in Phase-2.

(4) The associated gas is produced in the individual oil field and the gas processing plant can be installed in individual fields or as common facilities for several fields. It is important to classify the individual case or commonly grouping case. This analysis shall be done in Phase-2.

(5) The relative relation between natural gas processing facilities and individual projects shall be established to achieve the effective utilization of natural gas. This grouping of oil field and processing plant shall be done in Phase-2.

(6) INES describes the simultaneous development in the various industries and it requires the ethane recovery project and pipeline project prior to other industries development. If the new scenarios can be found by Phase-2 analysis, such scenarios shall be transferred into Phase-3 as better resolutions and completed.

(7) It is mandatory requirement of gas pipeline network to achieve the individual projects. Especially the effective utilization of the existing pipeline network influences the schedule

and budgetary requirement in the new projects. It shall be investigated in Phase-2 precisely. The information gathering is essential since the limited data only is available. Gas pipeline study shall be included in the Phase-2 as well as rehabilitation ideas.

(8) The study of marketing of products such as ethylene derivatives, urea fertilizer based on merits and demerits shall be done in Phase-2.

(9) The logistics of product export is very important when the project implementation will be commenced. The study of logistics will be done in Phase-2, the Gas Master Plan will be more substantial and practical.

5.4 JICA Support Program

This study has been commenced with JICA fund in order to survey the present situation and to establish the natural gas effective utilization scenarios. Iraq has keen interest in establishment of national energy strategy and integrated national objectives for accelerating reconstruction of country. JICA support program is so useful that Iraq National Strategy can apply the Japanese developed knowledge and technologies.

5.5 Handling of Confidential Information

The development plan and oil fields data in Iraq are highly confidential information and absolutely proprietary of Iraq Government. Therefore, obtained data shall be controlled and managed with Non-Disclosure Agreement (NDA) and no data can be disclosed unless otherwise written approval from Iraq DPMO or any other ministry and JICA.

5.6 Others

It was limited and difficult on site survey due to safety concern in Iraq and in the next Phase more detailed and precise field survey are required in a longer period covering pipeline installation conditions with area and nodes. It is biggest concern that safety issues shall be eliminated before survey. It is mandatory requirement that local support from Iraq officers shall be provided to overcome the safety issues.