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Eastern Petrochemical Company (SHARQ)
Saudi Methanol Company (AR-RAZI)
Power and Water Utility Company for Jubail and Yanbu (MARAFIQ)
Saudi Basic Industries Corporation (SABIC)
Jubail Industrial College (JIC)

Preliminary Survey for the Technical Assistance related to the Private Sector Investments in Saudi Arabia

FINAL REPORT
(Summary Version)

October 2015

Japan International Cooperation Agency

UNICO International Corporation
Central Japan Industries Association
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List of Abbreviation

5S	:	Seiri (Sort), Seiton (Straighten), Seisou (Shine), Seiketsu (Standardize), Shitsuke (Sustain)
ARAMCO	:	Saudi Arabian Oil Company
AR-RAZI	:	Saudi Methanol Company
bbl	:	barrel
BEMS	:	Building Energy Management System
BFW	:	Boiler Feed Water
BMP	:	Behavior Modeling for Productivity
BOD	:	Biological Oxygen Demand
BTW	:	Boiler Water
C. Resid	:	Chlorine Residual
CF	:	Cartridge Filter
CJIA	:	Cetral Japan Industries Association
COD	:	Chemical Oxygen Demand
CSW	:	Cooling Sea Water
DAC	:	Development Assistance Committee
DAF	:	Dissolved Air Floatation
DCS	:	Distributed Control System
DM	:	Demineralized Water
EG	:	Ethylene Glycol
EHSS	:	Enviroment, Healty, Safety and Security
EPC	:	Engineering Procurement Construction
GHG	:	Green House Gas
GT	:	Gas Turbine
GTCC	:	Gas Turbine Combined Cycle
GTG	:	Gas Turbine Generator
HDPE	:	High Density Polyethylene
HIPF	:	Higher Institute for Plastics Fabrication
HRD	:	Human Resource Development
HVAC	:	Heating, Ventilation, Air Conditioning
IE	:	Industrial Engineering
IWW	:	Industrial Wastewater
IWPP	:	Independent Water and Power Producer
IWTP	:	Industrial Wastewater Treatment Plant
JCM	:	Joint Credit Mechanism
JIC	:	Jubail Industrial College
JICA	:	Japan International Cooperation Agency
JSMC	:	Japan Saudi Arabic Methanol Company
Jubail-1	:	Jubail Industrial City-1
Jubail-2	:	Jubail Industrial City-2
JWAP	:	Jubail Water and Power Company
KPI	:	Key Performance Indicators
KSA	:	Kingdom of Saudi Arabia
LDPE	:	Low Density Polyethylene
LED	:	Light Emitting Diode
LLDPE	:	Liner Low Density Polyethylene
M. Alkali	:	Total Alkalinity
MARAFIQ	:	Power & Water Utility Company for Jubail & Yanbu
MBR	:	Membrane Bio Reactor
MED	:	Multiple-Effect Distillation
MF	:	Micro Filtration
MFM	:	Micro-filtration membrane

MLSS	:	Mixed Liquor Suspended Solid
MTBF	:	Mean Time Between Failures
NEDO	:	New Energy and Industrial Technology Development Organization
NFM	:	Nano-filtration membrane
OCG	:	Oriental Consultants Global Co., Ltd.
OJT	:	On the Job Training
OLF	:	Olefin
O&M	:	Operation and Maintenance
PAC	:	Poly Aluminum Chliride
PCS	:	Power Conditioning System
PDCA	:	Plan, Do, Check and Action
PE	:	Polyethylene
pH	:	Potential hydrogen
PM	:	Productive Maintenance
PTW	:	Potable Water
PV	:	Photovoltaics
QM	:	Quality Management
RC	:	Royal Commission for Jubail and Yanbu
RCER	:	Royal Commission Environmental Regulation
RO	:	Reverse Osmosis
ROM	:	Reverse osmosis membrane
SABIC	:	Saudi Basic Industries Corporation
SAR	:	Sodium Adsorption Ratio
SAR	:	Saudi Arabia Riyal
SDI	:	Silt density index
SEC	:	Saudi Electricity Company
SHARQ	:	Eastern Petrochemical Corporation
SHEM	:	Safety, Health & Environment Management
SPC	:	Special Purpose Company
SPDC	:	SPDC Ltd
SQCD	:	Safety, Quality, Cost, Delivery
SRT	:	Sludge Retention Time
ST	:	Steam Turbine
STG	:	Steam Turbine Generator
SWCC	:	Sea Water Conversion Corporation
SWI	:	Sea Water Intake
SWTP	:	Sanitary Wastewater Treatment Plant
TDS	:	Total Dissolved Solids
TPM	:	Total Productive Maintenance
TQM	:	Total Quality Management
T-N	:	Total Nitrogen
TOC	:	Total Organic Carbon
UF	:	Ultra Filtration
UFM	:	Ultra-filtration membrane
Unico	:	Unico International Corporation
WRPC	:	Water Reuse Promotion Center
WWT	:	Wastewater Treatment
ZLD	:	Zero Liquid Discharge

Exchange rate: US$1.00 = SAR 3.75

SAR1.00 = JPY 33

Chapter 1 Outline of the Study

Chapter 1　Outline of the Study

1.1　Background and Purpose of Study

1.1.1　Background

Jubail Industrial City in Saudi Arabia accommodates, among others, two companies, AR-RAZI and SHARQ, which were established for the purpose of manufacturing petrochemical products, under the Economic and Technical Cooperation Agreement in 1975 signed by the Government of Saudi Arabia and the Government of Japan and as joint venture between Saudi Arabia Basic Industries Corporation (SABIC) and Japanese investors/companies (hereinafter referred to as the "Project"). Since then, the companies have been symbolizing economic cooperation between the two countries for more than 30 years.

The Project has been making significant progress and achievements and boasts substantial contributions in the following areas.

i. Promotion of Saudi Arabia's industrialization (the country has become one of the world leading producers of petrochemicals through the realization and success of the Project)

ii. Contribution to job creation in Saudi Arabia (SHARQ has produced more than 1,000 jobs and AR-RAZI more than 500)

iii. Technology transfer to Saudi Arabia (technology transfer and human resource development has progressed as originally planned)

In relation to this Project, JICA invests, as its overseas investment project, in two companies that make investment in AR-RAZI and SHARQ as Japanese partners, Japan Saudi Arabia Methanol Company, Inc. (JSMC) and SPDC Ltd. (SPDC), respectively.

Today, Jubail Industrial City, where the two petrochemical companies are operating, experiences substantial deterioration of some of their facilities and equipment after the lapse of more than 30 years since their establishments in 1979. In particular, there seems to be a strong need for detailed examination of infrastructure facilities, including waterworks, wastewater treatment, recycled water, water saving, and energy saving. Maintaining reliable infrastructure facilities in the industrial estate is considered to be essential for the Project's sustainable operation and further development.

While Saudi Arabia is Japan's principal source for crude oil, the two countries have established a strong partnership. When Prime Minister Abe visited the country at the end of

April 2013, a joint statement was issued by the two countries with regard to the strengthening of the comprehensive partnership between the two countries. It expressed a firm commitment to the reinforcement of the partnership in broad areas of politics, economy, culture and human exchange, together with bi-lateral cooperation in the areas of energy saving, renewable energy, and nuclear power and cooperation between universities and research institutes.

Under these circumstances, JICA – as an investor in the Project - has decided to examine infrastructure facilities and equipment relating to the Project, to evaluate possibility of improving their usefulness and performance by using Japanese technologies, and to make proposals and recommendations for sustainable operation of SHARQ and AR-RAZI. In addition, it was decided to conduct study of MARAFIQ – a Saudi company related with the Project – and SABIC – a Project partner – for the purpose of making relevant proposals and recommendations. Also, to develop proposals and recommendations for Saudi companies and organizations relating to the Project in the areas of human resource development and Japanese-style management, JICA has decided to make proposals for human resource development using Jubail Industrial College (JIC), which serve as a supply source of human resources for companies operating in the industrial city, including SHARQ and AR-RAZI. (The examination and study of the infrastructure facilities, development of proposals and recommendations covering infrastructure upgrading and human resource development are generally referred to as the "Study.")

1.1.2 Purpose of the Study

The primary objective of the Study is summarized as follows.

(1) To examine operating conditions of infrastructure facilities in the Industrial City, especially in relation to the Project for the primary objective of determining adequacy of their performance and capability, the current state of environmental management and security, and operation and maintenance of existing plant facilities and equipment, with an aim to identify and analyze major issues identified from the above examination.

(2) On the basis of the above, to propose infrastructure maintenance and upgrading required for or useful to sustainable operation of SHARQ and AR-RAZI, together with improvement of productivity. Note that the proposals to be made will be primarily concerned with energy saving, water saving, recycling, and similar areas where Japanese companies are said to have an advantage, and should embrace various types of operation and management, including feasibility of a private-public partnership (PPP) project and private investment.

(3) To study content, quality and the operating status of educational programs provided by SHARQ, AR-RAZI and JIC and to identify and analyze issues. To propose a human resource development program to help solve each issue identified, which should include the following types:

- Human resource development program
- Japanese-style management program (including Japanese-style work management and improvement of work efficiency, and maintenance and improvement of the work environment)
- Human resource development program concerning renewable energy (in particular solar energy) in Saudi Arabia

Note that the Study was originally expected to cover Royal Commission in Jubail, which operates and manages the Jubail industrial areas including the Industrial City, but it has been excluded due to RC's request.

1.2 Study's Methodology, Organization, and Schedule

1.2.1 Study's Methodology

The Study started on November 12, 2014 and was conducted for ten months and half until the end of September 2015. The basic work flow is illustrated in Figure 1-1.

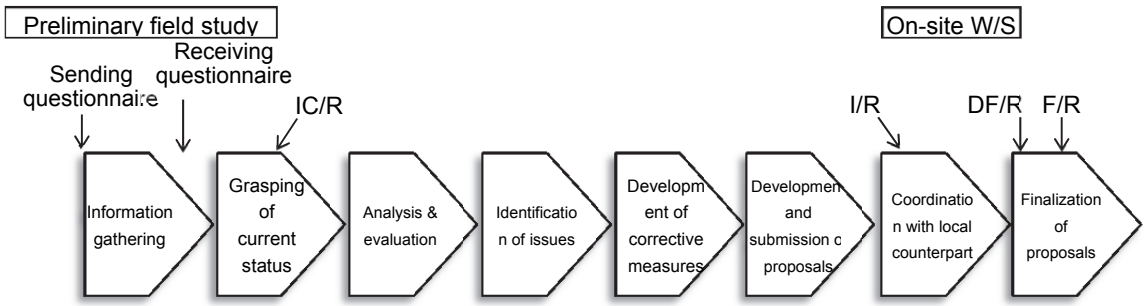


Figure 1-1 Basic Work Flow

Source: Prepared by the JICA Study Team

1.2.2 Study Items

The Study was originally designed to cover eight key areas, namely industrial city planning, education (Japanese-style management), safety and security planning, water supply planning (water saving), wastewater treatment/water recycle planning, electricity and energy

saving, renewable energy/solar power generation, and education on the power generation method.

Then, as a result of discussion with local counterparts, industrial city planning was found not to have a specific need for new proposals after the preliminary study from logistical perspectives, partly because Royal Commission – a key potential partner for the study – decided not to participate in the study, partly because SHARQ and AR-RAZI transport their (liquid) products through the pipelines to a port of shipment, which show little need for improvement in terms of logistics, and partly because SABIC's terminal service company, Sabtank, is expanding the Jubail industrial port at the cost of $450 million and SBIC has already its own logistics plan for the entire industrial city.

As for water supply and industrial water planning (water saving), wastewater treatment/water recycling planning, it has been decided to bring two items together to improve planning efficiency and coordination, partly because water for the industrial city is supplied by MARAFIQ as service water, and partly because the Study plans to promote water saving by reusing water discharged from facilities and equipment of SHARQ, AR-RAZI, and MARAFIQ as industrial water.

As a result, the key items and companies to be covered under the Study have been revised as follows.

Table 1-1 Key Areas and Companies to be Covered by the Study (revision)

(o: to be covered; x: not covered)

	SHARQ	AR-RAZI	MARAFIQ	SABIC	JIC
Advanced education (Japanese-style management)	○	○	×	Note 1	○
Safety management / security planning	○	○	×	Note 1	×
Wastewater treatment / recycled water	○	○	○	Note 1	×
Electricity / energy saving	○	○	○	Note 1	×
Renewable energy / solar power generation	○	○	○	○	○
Solar Power Generation Education	×	×	×	×	○

Note 1: The results of examination and evaluation on SHARQ and AR-RAZI will be reported to SABIC

Source: Prepared by the JICA Study Team

1.2.3 Study Team and Organization

Some study team members have been changed after the start of the Study, and the latest members and their parent organizations are shown in Figure 1-2. In addition to 14 full-time members, various tasks are commissioned to Chubu Electric Power Co., Inc., Chiyoda Corporation, and Environment Business Consultants.

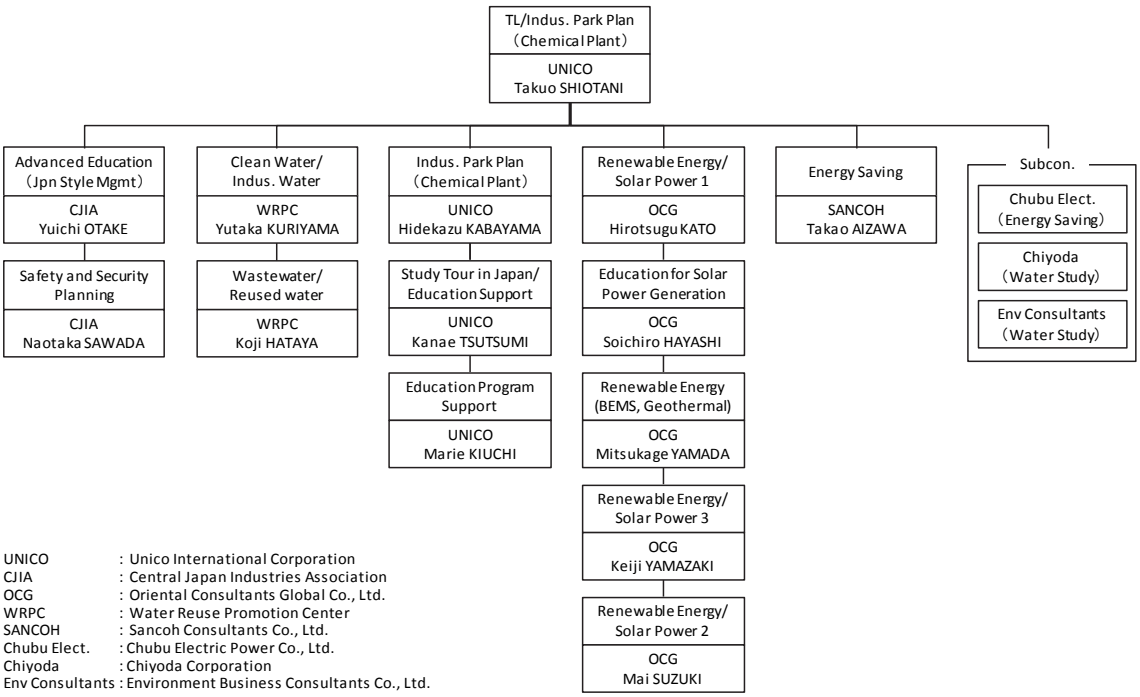


Figure 1-2 Study Team Organization

Source: Prepared by the JICA Study Team

1.2.4 Study Schedule

The study schedule including activities that have already undertaken is summarized as follows.

Implementation period	Work category	Major activities
November 12 – December 2014	Preliminary work in Japan	Meeting with JPDC, JSMC and other related organizations in Japan, information gathering and assortment, preparation for the first field study, preparation of questionnaires for local counterparts and related parties
December 19 – 26, 2014	First field study	Meeting with local counterparts and related parties, and grasping of local conditions
January 2015	First-phase work in Japan	Preparation and submission of Inception Report and preparation for the second field study
January 24 – February 1, 2015	Study Tour Program in Japan	Eleven persons of local counterpart organizations in Saudi Arabia will be invited to Japan for collection of local data and information and meeting with related parties in Japan
January 30 – February 28, 2015	Second field study	Presentation on Inception Report to local counterparts and collection of local information and data
March – May 2015	Second-phase work in Japan	Analysis and examination of the results of the second field study, preparation of a long list of projects to be considered, and narrowing-down of considered projects
May 25 – June 12, 2015	Third field study	Presentation of considered projects to local counterparts and collection of further data and information for narrowing down of the long list
June 13 – end of August 2015	Third-phase work in Japan	Analysis and examination of the results of the third field study, detailed examination of considered projects for narrowing down, and preparation and submission of Interim Report
August 28 – September 8, 2015	Fourth field study	Presentation of proposed projects to local counterparts (workshop) and collection of their opinions
September 9 – October 2015	Fourth-phase work in Japan	Preparation of Draft Final Report and Final Report

1.3 Description of Activities by Work Category

1.3.1 First Field Study (Preliminary Study) (December 19 – 26, 2014)

The first field study was conducted between December 19 and 26, 2014, by five consultants (Mr. Shiotani, Mr. Kabayama, Mr. Kato, Mr. Hayashi, and Mr. Kuriyama). Major activities undertaken are as follows.

December 20: Meeting with Mr. Mishima, head of JICA Riyadh office, to obtain data and information on organizations to be covered by the Study, and other relevant information; and request for cooperation in relation to the obtaining of visas for Saudi members to enter Japan as part of the Study (program to invite local counterparts to Japan).

December 21: Visit to SABIC's head office and meeting with Vice President Awadh M. Al-Maker; meeting with Mr. Takahashi, Japanese Minister to Saudi Arabia, and Mr. Okabe, Energy Attache of Japanese Embassy, to outline the Study, collect related information, and request cooperation

December 22: Visit to SABIC's R&D Center

December 23: Meeting with Mr. Mohammed Al-Qahtani, General Manager of SHARQ, and Mr. Mohammed Al-Hassany, General Manager to outline the Study, followed by questions and answers, and a bus tour on plants (including further discussion and collection of plant information); and courtesy call on Royal Commission

December 24: Meeting with Vice President Otake of AR-RAZI and other personnel for discussion and questions and answers, a bus tour on plants (including further discussion and collection of plant information); and meeting with Mr Mohammed Mahmood Khaja Sr., Technical Advisor of MARAFIQ, and other personnel

December 25: Meeting with Mr. Abdullah S.Al-Mutairi, General Manager of SABIC-Jubail; presentation on "Approach to Sustainable Program in Saudi Arabia" from Mr. Louay Abdulrahim, Managing Director of Azmeel Holding

Note that it has been agreed to conclude a non-disclosure agreement (NDA) prior to the provision of technical information between JICA and each of the three counterpart organizations (SHARQ, AR-RAZI, and MARAFIQ) using SABIC's standard form. During the field study period, then, the agreements signed by JICA were delivered to the three organizations.

1.3.2 First-phase Work in Japan (January 2015)

1.3.2.1 Discussion between JICA and consultants

On January 9 and 16, JICA and consultants held discussion and confirmed the progress on the preparation of documents relating to the second field study as follows.

- Planning/reporting/coordination on information gathering from related companies in Japan
- (1) detailed adjustment of the program to invite local counterparts to Japan; (2) the program schedule; (3) confirmation on the invitation list; and (4) coordination relating to hotels and other arrangements in Japan
- Coordination with regard to questions to local counterparts (SHARQ, AR-RAZI and SABIC) and related organizations (MARAFIQ and JIC), and confirmation on the arrangement for subsequent visits to companies and organizations to which visits have not been made during the preliminary study
- Confirmation with regard to contractual revisions in response to the addition of field study activity for 28 days (January 30 – February 26, 2015) and the changes in the program to invite local counterparts to Japan (schedule, period, members, etc.)

1.3.2.2 Information gathering from related companies in Japan

Relevant information was gathered from the following companies that operated in Saudi Arabia, as follows.

January 14: Yokogawa Electric Corporation and Yokokawa Solution Service, with regard to their business activities in the Middle East including Saudi Arabia (including Jubail) (in particular, success stories regarding “visualization,” and relations with SABIC and JIC)

January 16: Fujitsu Research Institute, with regard to the current conditions of water and electricity supply in industrial estates in Saudi Arabia, including major issues

January 20: SPDC, with regard to general information on local counterparts (SHARQ and AR-RAZI)

January 21: Chiyoda Corporation, with regard to industrial water, energy saving, human resource development, and related information in Jubail

January 28: Kobe Steel, with regard to equipment supply to Saudi Arabia (including Jubail)

January 29: Tokyo Electric Power, with regard to an ongoing power supply master plan in Saudi Arabia and other general information on power distribution

1.3.3 Study Tour Program in Japan (January 24 – February 1, 2015)

For a period of nine days between January 24 and February 1, 2015, a total of eleven persons representing the counterpart organizations, namely four persons from SHARQ, two from AR-RAZI, three from MARAFIQ, and two from SABIC were invited to Japan. It was designed to collect local information including present conditions and needs, while gathering data and information on the present plant facilities and equipment as well as a general interest in Japanese technology and Japanese-style management. Also, a seminar was held under the title of "Japanese-style Management and Economic Development in Postwar Japan," and the mission visited companies that had close relationship with Saudi Arabia.

The overall program schedule is presented in Table 1.2. In the first half (January 25-26), the mission attended meetings with consultants who were engaged in the Study and Japanese investors. In the second half (January 27-30), presentations on Japan's advanced technologies were made, together with field tours on various manufacturers including discussion. On the final day, the mission members reviewed the program activities in the form of presentation.

Table 1-2 Itinerary of Study Tour

Date	Time	Program	
Jan. 24 Sat.		—	Arrived in Japan
Jan. 25 Sun.	9:00 ～10:00	—	Orientation
	10:00 ～13:30	Discussion	Hearings of the current situation / Q&A session
	13:30 ～15:30	Lecture	"Japanese-style Management" & "Japan's Postwar Economic Development"
Jan. 26 Mon.	10:00 ～11:00	Discussion	Meeting w/ JSMC & Mitsubishi Gas Chemical (MGC)
	13:30 ～14:30	Discussion	Meeting w/ Mitsubishi Chemical
	15:00 ～16:00	Discussion	Meeting w/ SPDC
	16:30 ～17:30	Discussion	Meeting w/ Mitsubishi Corp.
Jan. 27 Tue.	10:00 ～11:30	Discussion	Meeting w/ JICA Briefing on JICA's assistance to Middle East
	15:00 ～17:00	Site visit	Sekiso Corporation (plastic molding company)
Jan. 28 Wed.	9:30 ～11:40	Site visit	Toyota Motor Plant Tour
	14:00 ～15:30	Site visit	Central Load Dispatching Center, Chubu Electric Power Co., Inc.
Jan. 29 Thu.	10:00 ～11:30	Site visit	Kawagoe Thermal Power Station, Chubu Electric Power Co., Inc.
	14:00 ～16:00	Site visit	SCMAGLEV and Railway Park
Jan. 30 Fri.	9:00 ～11:00	Site visit	Mega Solar Power Plant
	12:00 ～15:00	—	Arab Islamic Institute

Jan. 31 Sat.		－	Independent study
Feb. 1 Sun.	15:00 ～17:00	Presentation	Wrap-up Meeting & Closing Ceremony
		－	Left for Saudi Arabia

Source: Prepared by the JICA Study Team

The program's outline and key objectives are summarized in Table 1-3.

Table 1-3 Outline of the Study Tour in Japan

Objective	Component programs and outlines	
1) Exchange of views with consultants engaged in the Study	Research and study	a. Hearing of the Saudi counterpart companies by consultants
	Presentation	b. Wrap-up meeting
2) Exchange of views with Japanese investors	Meeting	c. Visit to Mitsubishi Gas Chemical (attended by JSMC executives) d. Visit to Mitsubishi Chemical e. Visit to SPDC f. Visit to Mitsubishi Corporation g. Visit to JICA and guidance on "JICA Support in the Middle East
3) Field tour on Japan's advantaged technology	Lecture	h. Japanese-style management and economic development in postwar Japan
	Field tour	i. Sekiso j. Toyota Motomachi plant k. Chubu Electric Power's central load dispatching office l. Chubu Electric Power's Kawagoe thermal power plant m. SCMAGLEV and Railway Park n. Kawasaki large-scale solar power station

Source: Prepared by the JICA Study Team

Each component program has been conducted as follows.

a. Hearing of the Saudi counterparts by consultants with regard to their current conditions (program category: study)
   Representatives of the four local counterpart companies sat at different tables and met representatives of the four consulting firms for exchange of views and information gathering.

b. Wrap-up meeting (program category: study and presentation)
   On the final day of the program, representatives of the four companies presented opinions and views on what interested them most in the field tours as well as Japanese technologies and techniques that they found to be applicable to Saudi Arabia.

c. Visit to Mitsubishi Gas Chemical, attended by JSMC executives (program category: meeting)

The mission members were received by JSMC executives, including the chairman, and directors of a MGC group company specialized in natural gas-based chemical products. A video program, followed by presentation, was shown to introduce MGC's natural gas-based chemical business. Then, discussion was made on key issues relating to natural gas development in Saudi Arabia and opportunity for use of related raw materials other than natural gas.

d. Visit to Mitsubishi Chemical (program category: meeting)

At Mitsubishi Chemical, two personnel of Petrochemical Infrastructure Department introduced the company's business by using documents distributed to the mission members, followed by questions and answers. In particular, representatives of SHARQ explained various issues facing the company, namely the emergence of competitors, the need for comply with new laws and regulations, the need to meet energy efficiency and sustainability requirements, including water saving, and asked Mitsubishi Chemical for its possible contributions to dealing with such issues. Mitsubishi responded that cooperation would be feasible in the areas of water recycling and wastewater treatment.

e. Visit to SPDC (program category: meeting)

At SPDC, the mission members were welcomed by many employees led by the president. Presentation was then made, including introduction of HIPF. The mission members expressed gratitude to SPDC for its technical assistance via HIPF. At the same time, questions were asked as to what kind of contribution SPDC could make for successful instillation of Japanese-style management and human resource development in Saudi Arabia.

f. Visit to Mitsubishi Corporation (program category: meeting)

The mission members were received by two personnel of Saudi Petrochemical Business Department of Chemicals Group, who explained Mitsubishi's petrochemical business by using video. The mission members posed questions as to possible contribution by Mitsubishi Corporation to energy saving and reuse of industrial wastewater, which are major issues relating to the Jubail Industrial City. They also expressed strong interest in Mitsubishi's solar power generation technology.

g. Visit to JICA, with guidance on "JICA Support in the Middle East" (program category: meeting)

At first, video presentation was made on JICA's activities, and Mr. Iwasaki, Deputy Director, Middle East Division 2, Middle East and Europe Department, explained JICA's support for the Middle East and North African countries, together with five key components of support targeting Saudi Arabia, namely human resource development,

the environment, public health and science/technology, culture/sports, and investment. Then, Mr. Takahashi, Director of Private Sector Investment Finance Division 2, Private Sector Partnership and Finance Department, discussed JICA's PPP project policy and examples of overseas investment and loan initiatives on SHARQ and AR-RAZI.

h. Japanese-style management and economic development of postwar Japan (program category: lecture)
Lecture was started with discussion on Japanese-style management, including its key characteristics (such as to turn difficulty to opportunity) and a general outline of Japanese history (from the Age of the Meiji Restoration to the Second World War, then to the Last Decade (Two Decades). Then, key Kaizen techniques used at Japan's production facilities, including 5S, TQM, TPM, and lean production system, have been outlined, followed by advice with regard to key points of field tours to be made in the subsequent period.

i. Visit to Sekiso Corporation (program category: field tour)
The mission visited Sekiso Corporation in Okazaki City, Aichi Prefecture, which made plastic parts, damping and soundproofing materials, and fiber mold products for Toyota and other automakers. The company received the Deming award in 2014, which was considered as the world highest ranking award in the area of TQM. After the briefing on the company's business and projects in a meeting room, the mission members toured the factory.

j. Visit to Toyota Motomachi Plant (program category: field tour)
Led by a full-time guide, the mission members first visited a welding line using the latest technology, following by coating and assembly lines, and observed production of different models on a single line. During the tour, they heard the guide's explanation on key elements of Toyota's production system, "just-in-time" and "Toyota-style automation."

k. Chubu Electric Power's central load dispatching office (program category: field tour)
Located on the highest floor of Chubu Electric Power's head office, the central load dispatching office plays a key role in management of power supply and demand by balancing electricity production and consumption. After video presentation on a general outline of the load dispatching office, the power supply and demand planning process was explained, including estimation of power consumption based on the analysis of weather conditions, seasonal change, social trends, and business trends, and the development of power generation plans on an annual, monthly, weekly and daily basis. Finally, the mission members observed actual operation in the load dispatching center, through glass.

l. Chubu Electric Power's Kawagoe thermal power plant (program category: field tour)

After a general outline of the power plant, its key features were explained: the power plant bears a burden of generating electricity to make up for loss of electricity due to the suspension of nuclear power plants after the Great East Japan Earthquake; it is eighth largest in the world; and it imports LNG for power generation and sales to outside factories. Then, the mission member walked through the power plant, followed by a bus tour on LNG storage/gasification plant and unloading piers.

m. SCMAGLEV and Railway Park (program category: field tour)
The mission members first watched a video "Professionals Supporting Tokaido Shinkansen," which showed the efforts of Shinkansen operation and maintenance teams to ensure punctuality, safety and comfortability of Shinkansen, followed by the museum director's greeting and speech outlining JR Tokai's profiles. Then, led by the museum staff, they toured the museum that displayed Shinkansen and SCMAGLEV technologies, including a mini-theatre in the SCMAGLEV section that simulates riding experience at 500km per hour.

n. Kawasaki large-scale solar power plant (program category: field tour)
Due to bad weather (snow), the mission members looked at a mega-solar power plant from the inside under the guidance of staff of Kawasaki Eco Life Future Museum, followed by exhibitions relating to energy saving and resource recycling.

The major results of the entire program, including reactions by the mission members, are summarized as follows.

- In the course of discussion with the consultants, opinions were expressed as to possible areas of Japan's technical assistance to cope with issues faced by the Jubail Industrial City and Saudi Arabia.
- In particular, strong interest was shown in the areas of solar power generation, geothermal power generation, and wastewater treatment, and many hoped to continue information exchange in the future.
- It has been highly valued that the mission members were able to discuss with top management of Japanese investors, with deeper mutual understanding and trust.
- The field tour on Japan's advantage technology was able to spur interest in Japanese-style management and human resource development, which supported technological development. At the same time, the program provided opportunity to raise awareness of Saudi's current state that depends on a single energy source, together with the need to promote use of recyclable energy and energy saving technology.
- The program has helped motivate the mission members to understand Japanese

technology and management better, while realizing the current and future issues facing the Jubail Industrial City and Saudi Arabia, and thus to think about how Japan's expertise can be used to solve them effectively.

- The mission members have expressed impressions and thoughts at the wrap-up meeting, with some variance according to each company's business and area of interest, which generally met the expectations held by the program planner.

1.3.4 Second Field Study (January 30 – February 28, 2015)

From January 30 to February 28, 2015, the second field study was conducted under participation of eight consultants (Mr. Shiotani, Mr. Kabayama, Mr. Otake, Mr. Yoshida, Mr. Kato, Mr. Hayashi, Mr. Kuriyama, and Mr. Sakamoto). Major activities are summarized as follows.

February 3: Visit to AR-RAZI, explaining the field study schedule and outline to President Saud A. Al-Sanea and director generals, and requesting cooperation

February 4: Visit to SHARQ, explaining the field study schedule and outline to President A. Mohammad Al-Jabr and director generals, and requesting cooperation

February 5: Meeting with Mr. Salama Al-Anazi, SABIC, explaining the field study schedule and outline and requesting cooperation

February 8: Visit to SHARQ, coordinating the activity schedule in consultation with Mr. Aiman F. Khayat and hearing of current conditions relating to in-company education and training from department heads (internal audit, transportation, production (EG1/2), production (PE3/4), planning, and QA). Note that in the meetings with technology-related department heads, request was made to provide data and information on utilities and infrastructure.

February 9: Visit to SHARQ, continued hearing of current conditions relating to in-company education and training from department heads (process design, product QA, human resources and education, production PE1/2, HSE, production (DL), and utilities). In the meetings with technology-related department heads, request was made to provide data and information on utilities and infrastructure.

February 10: Visit to AR-RAZI, coordinating the activity schedule in consultation with Mr. H. S. Al-Suhaim and hearing of information on utilities and infrastructure, discussion, and submission of questionnaire

February 11: Visit to AR-RAZI, Hearing of HSE related status and information

February 12: Visit to AR-RAZI, presentation on Inception Report

February 15: Visit to SHARQ, hearing of information on utilities and infrastructure and on human resource development/education

February 16: Visit to SHARQ, hearing of information on utilities and infrastructure and on human resource development/education

February 17: Visit to AR-RAZI, hearing of information concerning utilities and infrastructure as well as human resource development; visit to SABC, briefing on Inception Report to Mr. Mohamed A. Al-Modhiyan (director) and other personnel

February 18: Visit to SHARQ, hearing of information concerning utilities and infrastructure

February 19: Visit to MARAFIQ to meet Mr. M. M. Khaja and other personnel, briefing on Inception Report; visit to SHARQ, presentation and discussion on solar power generation systems and related education

February 22: Visit to MARAFIQ, meeting to obtain and analyze information on utilities and infrastructure (water and electricity)

Visit to SHARQ, the wrap-up meeting on the second field study

February 23: Visit to AR-RAZI, meeting with Mr. Takahashi (manager)/Mr. Murata (special adviser), and Mr. Otake (Executive vice president) concerning information on utilities and infrastructure

Visit to JIC: briefing on the Study to President Dr. Adel S. Bahakeen and other personnel, and request for cooperation

February 24: Visit to AR-RAZI, the wrap-up meeting on the second field study

Visit to MARAFIQ, the wrap-up meeting on the second field study

Visit to SABIC, the wrap-up meeting on the second field study

February 25: Visit to MARAFIQ, meeting on utilities and infrastructure information

1.3.5 Second-phase Work in Japan (March – May 2015)

Based on the results of the second field study, a long list of proposed projects and programs was prepared for each field (see Appendix B for the detailed lists)

The proposed projects and programs in each long list have been divided and reorganized, in consideration of the actual needs of each company and expected effectiveness of each

proposal, to an individual list of proposed projects and programs according to the following principles and policies.

1) Proposed energy saving projects for infrastructure facilities and equipment for the purpose of promoting sustainable business continuation and productivity improvement of SHARQ and AR-RAZI should focus on power saving and water conservation (waterworks planning /industrial water), including introduction of related technologies that are widely used in Japan and show an advantage over other countries. Also, partial use of solar power generation technology will be included. Finally, selection of final proposals will take into account not only commercial feasibility but also possible contribution to the achievement of the sustainability program implemented by SHARQ and AR-RAZI.

2) Final proposals relating to wastewater treatment and production of recycled water will be selected from the viewpoint of overcoming issues realized by local stakeholders and introducing technology that Japan has a significant advantage.

3) Final proposals relating to solar power generation will be determined with reference (including commercial examples) to technologies using solar power generation, as used in Japan, for the purpose of meeting the actual needs of SHARQ, AR-RAZI, MARAFIQ, SABIC, and JIC.

4) Final proposals in the field of human resource development will focus on the following areas and will include a list of appropriate curriculums and programs for SHARQ, AR-RAZI and JICA, which will be reflected in the individual list.

- Japanese-style management program (Japanese-style business administration, improvement of work efficiency, etc.)
- Energy saving measures and education (including water and electricity)
- Solar power generation business (including other renewable energies as appropriate)

5) Final proposals relating to safety and security will be selected in due consideration of content and status of SHEM (safety, healthcare, environment management) programs implemented by SHARQ and AR-RAZI and which serve as their guidelines from safety, security and environmental perspectives, including a prospect for further improvement.

1.3.6 Third Field Study (May 25 – June 12, 2015)

During the third field study, individual lists of proposed projects and programs were

explained to local counterpart organizations, and field study was conducted for projects and programs in each list, as follows.

1) Proposed projects and programs in the field of energy saving have been explained to local counterpart organizations, including the purpose and expected result of each proposal as well as record and current state of similar projects and programs implemented in Japan. Then, field study was conducted to check applicability of each project and confirm the desire and need of each company for the purpose of selecting final proposals.

2) Proposed projects and programs in the field of wastewater treatment and production of recycled water have been explained to local counterpart organizations, including an outline of technology used and necessary equipment, together with the purpose and expected result of each proposal. Then, field study was conducted to check applicability of each project and confirm the desire and need of each company for the purpose of selecting final proposals, followed by confirmation on an entire framework and the level of finalization with each counterpart.

3) Proposed projects and programs in the field of solar power generation and renewable energy have been explained to local counterpart organizations, and field study was conducted to check applicability of solar power system instillation at field and confirm the desire and need of each company for the purpose of selecting final proposals, followed by confirmation on an entire framework and the level of finalization with each counterpart.

4) Proposed projects and programs in the field of human resource development and education have been explained to local counter organizations, including a curriculum and program suitable for each company, in consideration of potential effectiveness of each program and the desire and need of each company, while showing the expected benefit and effect, together with applicable examples in Japan.

5) In the fields of safety and security, SHEM systems and their implementation status will be examined for each item of the SHEM guidelines, together with confirmation on a cause for any problem facing the current practice and possible improvement measures. Specific issues will be identified on the basis of evaluation on each department in terms of achievement by managers of established goals and morale, and level of vitalization of each department.

1.3.7 Third-phase Work in Japan (June – August 2015)

On the basis of the results of the third field study, proposed projects and programs were evaluated through the selection process, while reflecting JICA's comments, and were narrowed down to a final list, which was included in Interim Report. Interim Report was prepared and presented to JICA, with revision as required.

1) Final proposals in the field of human resource development were selected with focus on the following areas and included a list of appropriate curriculums and programs for each company.
   - Japanese-style management program (Japanese-style business administration, improvement of work efficiency, etc.)
   - Energy saving as well as water treatment
   - Solar power generation (including other renewable energies as applicable)

2) Final proposals in the field of safety and security were made from the viewpoint of achieving established goals and targets and setting model workshops to promote a program to revitalize the workplace, on the basis of information obtained from the field study.

3) Final proposals in the field of water/wastewater treatment and recovery of recycled water were selected in consideration of possibility to overcome issues facing the counterpart organizations and to introduce technology that Japan shows a significant advantage.

4) Final proposals in the field of energy saving for infrastructure facilities and equipment for the purpose of promoting sustainable business continuation and productivity improvement of SHARQ and AR-RAZI focused on power saving, including introduction of related technologies that are widely applied in Japan and show an advantage over other countries.

5) Final proposals relating to solar power generation covered the entire industrial city, including SHARQ, AR-RAZI by taking into account actual use of relevant technology in Japan, especially successful cases, with the viewpoint of meeting the needs of the industrial city.

On the basis of the results of the above study and evaluation, the program selection for the respective areas was made as follows.

Human resource development/education (Japanese-style management, electricity/energy saving, wastewater treatment/recycled water)

Japanese-style management: Programs for managers and supervisors (KAIZEN and 5S), with focus on fostering of companywide discipline and good behavior, including training in Japan

Water/wastewater treatment: Low interest in water-related technical training at both SHARQ and AR-RAZI

Electricity/energy saving: Interest in the study team's proposals shown by both SHARQ and AR-RAZI.

As for Japanese-style management education for JIC, three programs were considered, namely a 12-day training program in Japan for JIC executives and professors, a 25-day training program in Japan for JIC instructors, and a 29-day program in Saudi Arabia. A training program for JIC students was dropped from consideration after consultation with JIC, as it was considered to be too advanced.

Safety and security planning

Based on the results of evaluation of the SHEM programs that are implemented by SHARQ and AR-RAZI, proposals were developed to ensure more efficient implementation.

Water/wastewater treatment

Technical examination and evaluation was made for the following proposals that had been confirmed by the field study for each of the three companies.

SHARQ: Treatment of wastewater from the polyethylene and Olefin processes to recycle industrial water and reduce consumption of portable water as the result

AR-RAZI: Treatment of wastewater (discouraged from the lagoon) to reduce dilution water and reduce consumption of portable water as the result

MARAFIQ: Retreatment of treated wastewater by the company to recover industrial water

Electricity/energy saving

Technical study and evaluation was carried out for the following proposals that were confirmed by the field study for each of the three companies.

SHARQ: Rotating machines (pumps in seawater cooling systems and compressors), boilers, transformers, air-conditioning equipment, lighting systems and fixtures

AR-RAZI: Rotating machines (pumps in seawater cooling systems and compressors), boilers, transformers, air-conditioning equipment, lighting systems and fixtures

MARAFIQ: Rotating machines (Blowers in wastewater treatment systems and compressors), transformers, air-conditioning equipment, lighting systems and fixtures

Solar power generation and education

Technical study and evaluation was carried out for the following proposals that were confirmed by the field study for JIC and four companies.

SHARQ: Application of solar panels on roofs of parking facilities, geothermal energy and building energy management system (BEMS), and development of the education program

AR-RAZI: Application of solar panels on roofs of parking facilities and geothermal energy and BEMS, and development of the education program

MARAFIQ: Application of solar panels on roofs of O & M offices and parking facilities, geothermal energy and BEMS

SABIC: Application of solar panels on roofs of employee housings, geothermal energy and BEMS

JIC: Application of solar panels in the campus and development of the education program

1.3.8 Fourth Field Study (August 28 – September 8, 2015): Local Workshops

During the fourth field study, the considered proposals for the respective companies were explained and discussion on each of the areas was held toward the finalization of the proposals.

1) The final proposal contents in the field of energy saving, including the significance and purpose as well as the current state of implementation and popularity in Japan with respect to each proposed item, were explained to the local counterparts and respective companies. In addition, along with a feasibility study, the Team confirmed their interest in implementation or adoption and finalized the proposal contents.

2) The final proposal contents in the field of water saving and recycled water, including the technical summary, the outline of necessary devices, and an intended purpose and effect, were explained to the local counterparts and respective companies. Additionally, along with a further study, the Team confirmed that the proposal met the demands and willingness of each company and finalized the proposal contents.

3) The final proposal contents in the field of renewable energy i.e., solar power generation were explained to the local counterparts and respective companies. Furthermore, along with a further study of equipment installation, the Team confirmed that the proposal met the demands and willingness of each company and finalized the proposal contents.

4) The adequacy of the proposals in the field of human resource development and education were assessed for each local counterpart and company based on the individual

lists. Then, the Team explained the suggested curriculum and programs to each of the companies, along with the significance and expected effects as well as examples of application in Japan, and finalized the proposal contents.

5) With regard to the field of safety and security, the Team explained the contents of the proposal that had been revised based on the interview results on performance and implementation status of the system about each item of the SHEM guidelines separately to finalize the proposal contents.

1.3.9 Fourth-phase Work in Japan (September – October 2015)

On the basis of the results of the fourth field study, the final edition of each proposal and final report (FR) are being prepared, while reflecting JICA's comments.

In prior to the abovementioned finalization, each proposal has been confirmed by and got approved from JICA.

Based on the results of the above study and evaluation, the current state of the respective areas is summarized as follows.

Human resource development/education (Japanese-style management, electricity/energy saving, wastewater treatment/recycled water)

Japanese-style management: Efforts are focused on the case study programs in Japan for senior managers and managers, managers' role recognition program, Japanese-style management program in Jubail for supervisors (KAIZEN and 5S), and companywide discipline program.

Water/wastewater treatment: Due to the low interest in water-related technical training at both SHARQ and AR-RAZI, the proposal of this item was dropped.

Electricity/energy saving: Despite the interest in the study team's proposals shown by both SHARQ and AR-RAZI, it was not sufficient enough to offer a specific suggestion and the proposal of this item was dropped.

Safety and security planning

Based on the results of evaluation of the SHEM programs that are implemented by SHARQ and AR-RAZI, proposals were developed to ensure more efficient implementation.

Water saving/wastewater treatment

Finalization is underway for the following proposals that have been confirmed by the field study for each of the three companies.

SHARQ: 1. Treatment of wastewater from the polyethylene and olefin processes to recycle industrial water and reduce consumption of portable water
2. Treatment of wastewater from the polyethylene process to recycle industrial water and reduce consumption of portable water
3. Treatment of wastewater from the polyethylene process to recycle irrigation water and reduce consumption of portable water as the result

AR-RAZI: Treatment of wastewater including ammonia (discharged from the lagoon) to reduce dilution water and reduce consumption of portable water as the result

MARAFIQ: Retreatment of treated wastewater by the company to recover as industrial water

Electricity/energy saving

Finalization is carried out for the following proposals that have been confirmed by the field study for each of the three companies.

SHARQ: Rotating machines (Pumps in seawater cooling systems and compressors), boilers, transformers, air-conditioning equipment, lighting systems and fixtures

AR-RAZI: Rotating machines (Pumps in seawater cooling systems and compressors), boilers, transformers, air-conditioning equipment, lighting systems and fixtures

MARAFIQ: Rotating machines (Blowers in wastewater treatment systems and compressors), transformers, air-conditioning equipment, lighting systems and fixtures

Solar power generation and education

Finalization is carried out for the following proposals that have been confirmed by the field study for JIC and four companies.

SHARQ: Application of solar panels on roofs of parking facilities, highly efficient lighting and building energy management system (BEMS)

AR-RAZI: Application of solar panels on roofs of parking facilities and geothermal heat pump, highly efficient lighting and BEMS

MARAFIQ: Application of solar panels on roofs of O & M offices and parking facilities

SABIC: Application of solar panels on roofs of employee housings, highly efficient lighting and water reclamation system

JIC: Application of solar panels in the campus and development of the education program

1.4 Summary of Proposals

Formal projects and programs developed on the basis of the results of the field studies and proposed to counterpart organizations in Saudi Arabia are summarized in Table 1-4. Detailed description of each proposal is discussed in Chapter 3.

Table 1-4 Summary of Proposals

	SHARQ	AR-RAZI	MARAFIQ	SABIC	JIC
Education (Japanese-style management)	Proposal of training programs in Japan and Jubail for senior managers, managers, and supervisors <Contents (participanst/course/location/duration)> 1. Senior managers/Japanese-style management case study in Japan/12 days 2. Managers/Japanese-style management case study in Japan/29 days 3. Managers/role recognition in Jubail/6 days 4. Supervisors/5S, KAIZEN, Decipline in Jubail/17 days 5. Managers/Japanese-style management in Jubail/25 days	Proposal of training programs in Japan and Jubail for senior managers, managers, and supervisors <Contents (participants/course/location/duration)> 1. Senior managers/Japanese-style management case study in Japan/12 days 2. Managers/Japanese-style management case study in Japan/29 days 3. Managers/role recognition in Jubail/6 days 4. Supervisors/5S, KAIZEN, Decipline in Jubail/17 days 5. Managers/Japanese-style management in Jubail/25 days		Explanation on the proposals for SHARQ and AR-RAZI Proposal of expanded application of the edcation programs to SABIC's affiliates Explanation about Lean Production System (as provision of relevant information)	Proposal of training programs Courses for JIC management and instructors in Japan and JIC (open seminars for business people) Courses for JIC students are to be considered in the future <Contents (participants/course/location/duration)> 1. JIC management & professors/Japanese-style management case study in Japan/12 days 2. JIC lectureres/Japanese-style management case study in Japan/29 days 3. Business peple/role recognition in Jubail/6 days 4. Business people/5S, KAIZEN, Decipline in Jubail/17 days 5. JIC lecturers/Japanese-style management in Jubail/25 days Possibility of cost-sharing technical assistance
Wastewater treatment (education)	Deleted prior to the fourth field study	Deleted prior to the fourth field study			
Energy saving (education)	Same as above	Same as above			
Safety management / security planning	Development of KAIZEN culture by use of SHEM The first-year activity will be carried out in a model section/unit (around 30 workers), with an aim to complete the PDCA cycle in a year, followed by examination of possible application to other sections on the basis of the actual results.	Development of KAIZEN culture by use of SHEM The first-year activity will be carried out in a model section/unit (around 30 workers), with an aim to complete the PDCA cycle in a year, followed by examination of possible application to other sections on the basis of the actual results.		Explanation on the proposals for SHARQ and AR-RAZI Proposal of expanded application of the training programs to SABIC's affiliates	
Water treatment / recycle water	Proposal of polyethylene and olefin wastewater reclamation system and its cost study Study of demineralizers for possible potable water conservation Development of water balance visualization	Proposal of reclamation system for wastewater from the methanol plant and its cost study Study of demineralizers for possible potable water conservation	Proposal of reclamation system for industrial wastewater, its reclamation effect, and costu study Examination on possibility of organic sludge reduction by changing the amount of organic agents to be used Examination on possible improvement of dehydration system	Explanation on the proposals for SHARQ and AR-RAZI Proposal of expanded application of the proposals for SHARQ and AR-RAZI to SABIC's affiliates	
Energy saving	Proposal of items for energy saving: 1. Pumps (VFD introduction) 2. Compressors (VFD introduction, optimization of set pressure, and reduction of air leakage) 3. Boilers (VFD introduction to forced draft fans, optimization of traps, valve insulation) 4. Transformers (change to top-runner type) 5. Air-conditioning equipment (highly efficient equipment, optimization of room temperature (24℃), installation of sunshades for outdoor equipment) 6. Lighting fixtures (replacement of mercury lamps to LED, motion censors)	Proposal of items for energy saving: 1. Pumps (VFD introduction) 2. Compressors (VFD introduction, optimization of set pressure, and reduction of air leakage) 3. Boilers (optimization of traps, valve insulation) 4. Transformers (change to top-runner type) 5. Air-conditioning equipment (highly efficient equipment, optimization of room temperature (24℃), installation of sunshades for outdoor equipment) 6. Lighting fixtures (replacement of mercury lamps to LED, motion censors)	Proposal of items for energy saving: 1. Change of aeration system for wastewater treatment 2. Compressors (optimization of set pressure and reduction of air leakage) 3. Transformers (change to top-runner type) 4. Air-conditioning equipment (highly efficient equipment, optimization of room temperature (24℃), installation of sunshades for outdoor equipment) 5. Lighting fixtures (replacement of mercury lamps to LED, motion censors)	Explanation on the proposals for SHARQ and AR-RAZI Proposal of expanded application of the proposals for SHARQ and AR-RAZI to SABIC's affiliates	
Renewable energy/solar power generation	Proposal for installation of solar power panels on roofs of parking facilities around administration building and use of highly efficient lighting and BEMS. Preparation of system diagram, layout plan, equipment plan, preliminary cost estimates (initial and maintenance), and implementation plan	Proposal for installation of solar power panels on roofs of parking facilities around administration building and use of geothermal heat pump, highly efficient lighting, and BEMS Prepartation of system diagram, layout plan, equipment plan, preliminary cost estimates (initial and maintenance), and implementation plan	Proposal for istallation of solar power panels on roofs of the O & M office building and parking facilities Preparation of system diagram, layout plan, equipment plan, preliminary cost estimates (initial and maintenance), and implementation plan	Explanation on the proposals for SHARQ and AR-RAZI Proposal of expanded application of the Solar Power application to SABIC's affiliates Proposal of reforming employee housing to apply solar power genereation, highly-efficient lighting fixtures, water reclamation system Preparation of basic design, layout plan, equipment plan, preliminary cost estimates (initial and maintenance), and implementation plan	Proposal for installation of solar power panels in the plaza in front of the library Preparation of system diagram, layout plan, equipment plan, preliminary cost estimates (initial and maintenance), and implementation plan
Solar power generation education					Proposal of educational programs for JIC professors and lecturers (29 days program in Japan and 19 day at JIC) Student training program is to be considered in the future Considering the use of Cost Sharing Technology Association

Source: Prepared by the JICA Study Team

Chapter 2 General Profiles of Saudi Arabia and Companies and Organizations Covered by the Study

Chapter 2 General Profiles of Saudi Arabia and Companies and Organizations Covered by the Study

2.1 General Profiles of Saudi Arabia

2.1.1 Kingdom of Saudi Arabia

2.1.1.1 General

As of the end of 2014, proved reserves of petroleum in the world amounted to 1.7 trillion bbl., of which Saudi Arabia ranked second with 267 billion bbl. (15.7% share) next to Venezuela (298 billion bbl. 17.5%), followed by Canada (172.9 billion bbl. and 10.2%), Iran (9.3%), Iraq (8.8%), and Russia (6.1%). Saudi Arabia's crude oil production totaled 11.5 million bbl. per day, the second largest in the world next to the United States (11.64 million bbl. per day). On the other hand, the country's natural gas production amounted to 288 trillion cubic feet (tcf) and ranked fifth next to Iran, Russia, Qatar, and the United States, boasting a firm position as a primary energy resource supplier in the world. (Source: based on BP Statistical Review of World Energy 2015).

2.1.1.2 Government

Saudi Arabia is a monarchy founded in 1932. The head of state is the King (currently the seventh ascended to the throne in January 2015). The Consultative Assembly of Saudi Arabia (150 members) serves as national assembly and submits opinions and views on general matters relating to national administration. The Council of Ministers serves as government body equivalent to the cabinet, where the King serves as chairman. Saudi Arabia is fiscally rich, while it is reportedly making some moves toward democracy, including the announcement of social welfare policy and the suffrage to women. The judicial system is governed by Islam and consists of "Islamic court" under the Ministry of Justice, the Board of Grievances under the direct control of the King, and committees under various ministries and agencies. The recent move is that, under an imperial order in 2005 with regard to the reform of the judicial system, the Law concerning the Judicial System and the Handling of Grievances was approved in 2007, which authorized the introduction of the three-tiered trial system and the establishment of specialized courts (criminal, commerce and labor).

Meanwhile, job security for a growing number of young people is becoming one of the most important challenges for the country, and various reforms have been initiated, including the strengthening of the Saudization policy[1], intensification of efforts to develop non-oil sectors,

[1] August 9, 2014, Japan Cooperation Center for the Middle East

human resource development, privatization, and inducement of foreign capital and investment[2].

2.1.1.3 Economy

The Saudi Arabian economy is dominated by crude oil and petroleum products, which accounted for around 85% of the country's total exports in 2013, which remains unchanged. In Jubail, Yanbu, Rabigh, and other areas, massive investment has been made to build world class petroleum and petrochemical industries, which products are a major source of foreign currency revenues, while driving diversification and privatization of the country's industrial sector[3].

Major socioeconomic indicators of the country are shown in Table 2-1 to summarize its key profiles and trends.

Table 2-1 Socioeconomic Indicators of Saudi Arabia

Land area	2.15 million square kilometers (5.7 times that of Japan)
Climate type	Continental and desert
Capital	Riyadh
Population	29,370,000 (in 2014, World Bank)
Races	Arab (Saudi) 73%, Asian 20%, African 1%, and European 1%
Religion	Islam
Language	Arabic (official language)
Politics and foreign relations	
Year of independence	Founded in 1927 (changed to the Kingdom of Saudi Arabia in 1932)
Constitution	National Foundation Law (enacted in March 1932, under the basic principles of the Koran and the Sharia)
Type of government	Monarchy
Head of state	King Salman bin Abdualziz Al Saud (ascended to the throne in January 2015 as the seventh King)
Government organization	Prime minister (served by the King) and ministers including Foreign Minister Adel Bin Ahmad Al Jubail
National assembly	Consultative assembly of Saudi Arabia (without legislative power), consisting of 150 members, including 30 female members who were appointed for the first time in January 2013
Foreign relationship	Assuming the central role in the Islamic world by maintaining two holy places within its territory and holding moderate and cooperative

[2] August 2013, Embassy of Japan in Saudi Arabia, Ministry of Foreign Affairs of Japan

[3] Based on Ministry of Foreign Affairs, "Web. Kingdom of Saudi Arabia" and JPEC Petroleum Energy, "Petroleum and Energy Industries in Saudi Arabia," Agency for Natural Resources and Energy, "Primary Energy Trend"

	relationships with West countries, only one G20 member among Arabian countries
Economy	
Nominal GDP	Approximately $752.5 billion (2014, IMF)
Per capita GDP	$24,454 (2014, estimate by IMF)
GDP growth rate (real)	4% (2014, IMF)
Inflation rate	5% (2011, WB)
Unemployment rate (excluding foreign workers)	11.7% (2014, SAMA)
Foreign trade	Exports - $367 billion (2013, MOF) Imports – $153.1 billion (2013, MOF)
Major trade items	Exports - Crude oil, petroleum products, LPG Imports - Machinery, equipment, automobiles, foodstuffs, silver products, textile products
Major trade partners	Exports - U.S., Japan, China (2014, SAMA) Imports – U.S., China, Germany, Japan (2014, SAMA)
Currency	Saudi Riyal (SAR)
Exchange rate	1$ = 3.75SAR (fixed)
Economy profiles	1. World major supplier of energy sources with the world largest crude oil reserves, production and exports 2. Job creation for growing young population is one of the major issues and efforts are being made, such as Saudization, human resource development, privatization, and inducement of foreign capital
Relationship with Japan	
Exports to Japan	5,015.3 billion yen (2014, trade statistics by Japanese MOF)
Imports from Japan	804.9 billion yen 2014, trade statistics by Japanese MOF)
Japanese residents residing in Saudi Arabia	966 (June 2015)

Source: based on JETRO, “Economic Trend in Saudi Arabia,” (June 5, 2015), and Ministry of Foreign Affairs, “Kingdom of Saudi Arabia,” (June 12, 2015)

2.1.2 Jubail Industrial City

The Jubail Industrial City is located in the Eastern Province (capital – Dammam; population of 4.4 million), which is one of the thirteen provinces of Saudi Arabia. Located 96km northwest of Dammam, 490km east of the national capital, Riyadh, and 1,360km east of Mecca, it consists of industrial and residential districts. Population of Jubail including the industrial city is reportedly around 338,000. The industrial area attracts investment and technology from around 40 countries and constitutes the largest industrial concentration that represents 7% of the country's GDP. The industrial area accommodates 24 schools and educational institutions and 14 shopping centers, with gold courses in the outskirts.

As shown in Figure 2-1, the Jubail Industrial City is divided into Jubail 1 and an adjacent (southwest side) Jubail 2 (expanded city). Jubail 1 was developed under the responsibility of the Royal Commission for Jubail and Yanbu (RC), which was established in 1975, and was constructed under the assistance of Bechtel Corporation of the U.S. At present, it accommodates iron and steel, petroleum refining, petrochemical plants, and related facilities. SHARQ and AR-RAZI, which are joint ventures between Japanese and Saudi companies, and MARAFIQ, which is a utilities supplier for on-site plants and other facilities, are located within the Jubail 1 site. Jubail 2 is currently constructed under the supervision of RC for completion scheduled in 2022, and some plants are already operated or are planned to be operated in near future. Companies currently operating in the Jubail Industrial City are summarized as follows.

- SABIC-related companies: 18 companies including petrochemical, chemical, fertilizer, and steel industries (see Table 2-2 for company names)
- Saudi Aramco-related companies: Petroleum refining and petrochemical (SASREF [4], Sadara Chemical Co.,, Sahara Petrochemicals, SATROP[5]).
- Chevron Philips-related companies: Petroleum refining and petrochemical (Saudi Chevron Philips Co., Saudi Polymers Co, Jubail Chevron Philips Co., Petrochemical Conversion Co.)
- Companies supplying electricity and water: MARAFIQ (public corporation specialized in electricity and water supply, invested by RC, Saudi Aramco, SABIC, Public Investment Fund, and 7 private investors)

[4] Saudi Aramco Shell Refinery Co.
[5] Saudi Aramco Total Refining and Petrochemical Co.

Liquid products as well as solid products including plastics and fertilizer produced in the Jubail Industrial City are mostly exported. They are shipped through a variety of ports in Saudi Arabia, including the King Fahd Industrial Port (located east of the industrial city), the Jubail Commercial Port, the King Abdulaziz Port (Dammam) (some of solid products), and the Jeddah Port on the west coast (after inland transportation of 1,500km). Shipment data in 2012 are shown below.

- King Fahad Industrial Port: 45.9 million tons (solid 13.6 million tons and liquid 32.3 million tons)
- Jubail Commercial Port: 6.8 million tons (solid 1.6 million tons, general cargo 1.7 million tons, and container 3.8 million tons)
- King Abdulaziz Port : 27.4 million tons (solid 6.3 million tons, general cargo 5.2 million tons, and container 15.6 million tons)
- Jeddah Port : 62.7 million tons (solid 6.3 million tons, general cargo 5.1 million tons, and container 49 million tons)

(Source: Prepared on the basis of information available on the websites of RC and Saudi Arabia Port Authority)

Source: "Jubail Industrial City", http://www.idcworld.com/jubail.htm

Figure 2-1 Overview of the Jubail Industrial City

2.2 General Profiles of Companies and Organizations Covered by the Study

2.2.1 SHARQ（Eastern Petrochemical Company）

SHARQ was established in September 1981 as joint venture of SABIC (50%) and Japan-Saudi Petrochemical JV (SPDC), which consists of various Japanese investors[6]. It is located in the Jubail Industrial City and has 1,729 employees as of the end of 2014. At present, it has the following world-class production facilities.

Table 2-2 SHARQ's Production Facilities (2015)

Products	Production capacity
Linear low-density polyethylene (LLDPE)	1,150,000 tons/year
High density polyethylene (HDPE)	400,000 tons/year
Mono ethylene glycol (MEG)	2,050,000 tons/year
Ethylene	1,300,000 tons/years

Source: Prepared on the basis of information available from SPDC's website and JICA project evaluation (2010)

SHARQ's LLDPE and MEG plants were constructed from March 1983 to May 1985. Construction of the ethylene plant started in October 1983, with completion in June 1985 and the start of commercial production on January 1, 1987. Then, its production capacity was increased three times, in January 1, 1995 (the restart of commercial operation), in January/July 2000 (ditto), and in April 2010 (ditto), to the above capacity. It is steadily operated at present.

According to "the Future World Demand Trend of Petrochemical Products (General)" published by the Japanese Ministry of Economy and Industry in April 2015, overall demand for the above four products in Japan are estimated below, which suggests substantial production capacities of SHARQ:

- Ethylene 6,005,000 tons/year
- LDPE (including LLDPE) 1,767,000 tons/year
- HDPE 875,000 tons/year
- EG (including MEG) 440,000 tons/year

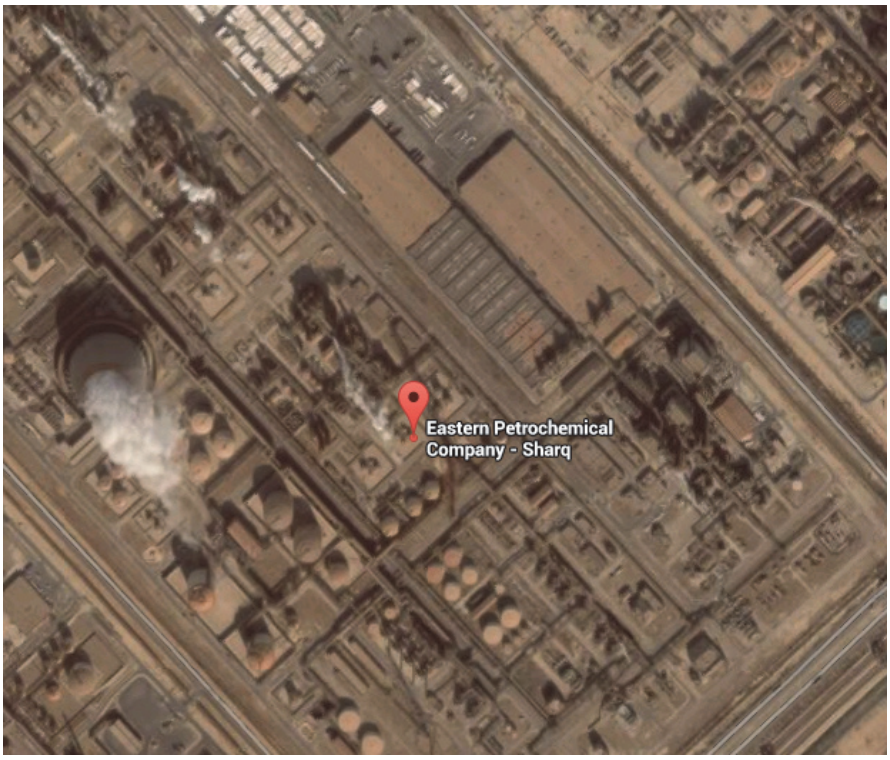
One third of the products made by SHARQ are purchased by SPDC for marketing to

[6] A Japanese company established for the purpose of investment in SHARQ by JICA, Mitsubishi Corporation, Mitsubishi Chemical Company, and other Japanese investors

various countries including Japan, China, and India.

Also, SHARQ's employment is dominated by Saudi Arabians (more than 92% as of the end of 2010), thus contributing to the country's key policies, namely expansion of local employment by means of Saudization, and promotion of technology transfer.

At the same time, SHARQ makes strenuous efforts to achieve the goals (targeted for 2025 with 2010 as the base year) according to SABIC's sustainability strategy, which is considered as key measures to implement the country's energy saving policy[7].



Source: 2015 Google map

Figure 2-2　Aerial View of SHARQ

2.2.2　AR-RAZI（Saudi Methanol Company）

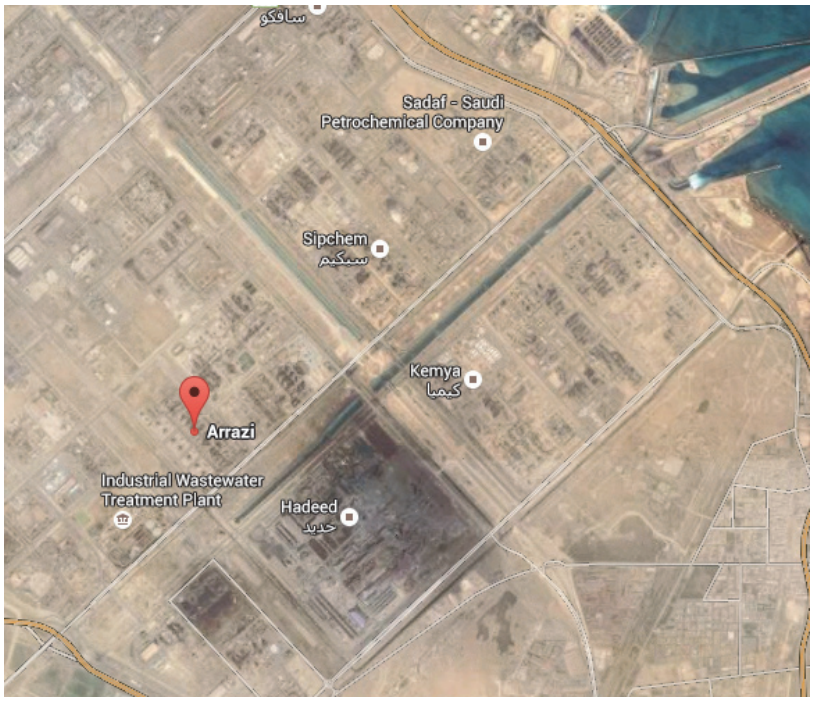
AR-RAZI was established in December 1979 as joint venture of SABIC (50%) and Japan Saudi Arabia Methanol Company (JSMC), which consists of various Japanese investors.　It is located in the Jubail Industrial City.

[7] In 2012, the Saudi Energy Efficiency Program (SEEP) was launched under the leadership of the Ministry of Petroleum and Mineral Resources and in cooperation of related ministries and agencies including Saudi Energy Efficiency Center (SEEC).

Construction of the first plant (640,000 tons/year) was started in April 1980 and was completed in January 1983, and commercial operation was commenced in July. Then, the second plant (640,000 tons) started commercial operation in June 1992, followed by the third plant (850,000 tons/year) in April 1998, the fourth plant (850,000 tons/year) in October 1998, the fifth plant (1,700,000 tons/year) in November 2008. The present production capacity totals 4,680,000 tons/year.

Japan imports an entire amount of ethanol that it uses, totaling 1,720,000 tons per year (MOF's trade statistics in 2014), of which 998,000 tons (57%) are imported from Saudi Arabia.

JSMC, the Japanese investment partner, is an investment company established by JICA, Mitsubishi Gas Chemical Company and other companies. MGCC's technology is entirely used in AR-RAZI's production facilities and equipment. Since the construction of the first plant, technology transfer has been progressed through operator training in Japan and other programs.



Source: 2015 Google map

Figure 2-3 Aerial View of AR-RAZI

AR-RAZI has been contributing to the employment of local people in an effort to promote the country's Saudization policy. Also, it strives to achieve the goals (targeted for 2025 with 2010 as the base year) according to SABIC's sustainability strategy, which is considered as key measures to implement the country's energy saving policy.

2.2.3 SABIC (Saudi Basic Industries Corporation)

Saudi Basic Industries Corporation (SABIC) was established in 1977 as joint venture between the Saudi government and foreign companies, owning 70% and 30% respectively at present. It manages production of petrochemical, iron and steel, fertilizers and other products and serves as the largest supplier of industrial materials in the Middle East. With the Saudi government as the major shareholder, SABIC has been privatized and is listed in the local stock exchange.

As of 2013, the company had 63 world-class plants globally, known as an integrated chemical manufacturer with around 40,000 employees and total annual sales of $50 billion. As shown in 2.2-3, it owns 17 plants in Jubail and 2 in Yanbu, which are operated by its subsidiaries to make a variety of products shown in the list.

Table 2-3 SABIC's Subsidiaries and Products in Jubail and Yanbu

Company	Location	Partnership	Products
1. Al-Bayroni Al-Jubail Fertilizer Co.	Jubail	A 50/50 SABIC joint-venture with Taiwan Fertilizer Co.	Ammonia, urea, 2-ethyl hexanol and DOP
2. AR-RAZI Saudi Methanol Co.	Jubail	A 50/50 SABIC joint-venture with a consortium of Japanese companies led by Mitsubishi Gas Chemical Co.	Chemical-grade methanol
3. Gas National Industrial Gases Co.	Jubail	SABIC (70%) and a group of Saudi Arabian private-sector companies (30%)	Oxygen, nitrogen, argon and krypton / xenon (Al-Jubail); Oxygen and nitrogen (Yanbu)
4. Hadeed Saudi Iron and Steel Co.	Jubail	A wholly owned affiliate of SABIC	Steel rebar, wire rod, hot-rolled coils, cold-rolled coils, galvanized coil, and flat-steel products
5. Ibn Al-Baytar National Chemical Fertilizer Co.	Jubail	50/50 SABIC joint-venture with SAFCO	Ammonia, urea, compound fertilizer, phosphate, and liquid fertilizer
6. Ibn Sina National Methanol Co.	Jubail	SABIC (50%), CTE (50% - owned by Elwood Insurance Ltd., 25%, and Texas Eastern Arabian Ltd., 25%)	Chemical-grade methanol and MTBE
7. Ibn Zahr Saudi European Petrochemical Co.	Jubail	SABIC (80%), Ecofuel-Italy (10%), Arab Petroleum Investment Corp. APICORP (10%)	MTBE and polypropylene

8. Kemya Al-Jubail Petrochemical Co.	Jubail	A 50/50 SABIC joint-venture with ExxonMobil (USA)	Polyethylene and ethylene
9. Petrokemya Arabian Petrochemical Co.	Jubail	A wholly owned affiliate of SABIC	Ethylene, polystyrene, butane-1, propylene, butadiene, benzene, polyethylene, VCM, E-PVC, S-PVC, and ABS
10. Sadaf Saudi Petrochemical Co.	Jubail	A 50/50 SABIC joint-venture with Shell Chemicals Arabia, LLC (an affiliate of Royal Dutch Shell)	Ethylene, crude industrial ethanol, styrene, caustic soda, ethylene dichloride, and MTBE
11. SAFCO Saudi Arabian Fertilizer Co.	Jubail	SABIC (42.99%), GOSI and Public Pension Agency (15.4%), public shareholders (41.61%)	Ammonia, urea, and urea formaldehyde
12. Saudi Kayan Saudi Kayan Petrochemical Co.	Jubail	SABIC (35%), Al-Kayan Petrochemical Co. (20%), public shareholders (45%)	Ethylene, propylene, polypropylene, LDPE, HDPE, ethylene glycol, acetone, polycarbonate (PC), ethanolamines (EOA), ethoxylates, bisphenol A, benzene, normal butanol, and natural detergent alcohol (NDA)
13. SHARQ Eastern Petrochemical Co.	Jubail	A 50/50 SABIC joint-venture with a consortium of Japanese companies led by Mitsubishi Corp.	Ethylene, propylene, aromatics (BTX), ethylene glycol (mono, di, tri), linear low-density polyethylene (LLDPE), and high-density polyethylene (HDPE)
14. Shrouq Saudi Japanese Acrylonitrile Co.	Jubail	SABIC (50%), ASAHI Kasei Chemicals Corp. (30%) and Mitsubishi Corp. (20%)	Chemicals
15. SOCC Saudi organometallic Chemical Co.	Jubail	A 50/50 joint-venture between Saudi Specialty Chemicals Co. and Albemarle Netherlands BV	Tri-ethyl aluminum (TEAL)
16. Specialty Chem Saudi Specialty Chemicals Co.	Jubail	Wholly owned affiliate of SABIC (Arabian Petrochemical Co. – Petrokemya, 99%, and SABIC	Tri-ethyl aluminum (TEAL), TPO / PP compounds, PC compounds, ABS

		Industrial Investments Company 1%)	compounds, and specialty products
17. United Jubail United Petrochemical Co.	Jubail	SABIC (75%), Pension Fund (15%), General Organization of Social Insurance (10%)	Ethylene, polyethylene, ethylene glycol (EG), and linear alpha olefins (LAO)
18. SABTANK SABIC Terminal Services Co.	Jubail	SABIC and Vopak (Netherland) joint-venture	Logistics (Liquid materials)
19. Yanpet Saudi Yanbu Petrochemical Co.	Yanbu	A 50/50 SABIC joint-venture with Mobil Yanbu Petrochemical Company (an affiliate of ExxonMobil Chemical, USA)	Ethylene, polyethylene, ethylene glycol, polypropylene, pyrolysis gasoline, and propylene
20. Yansab Yanbu National Petrochemical Co.	Yanbu	SABIC (51%), public shareholders or owned by others(49%)	Ethylene, propylene, ethylene glycol (mono, di, tri), linear low-density polyethylene (LLDPE), high-density polyethylene (HDPE), polypropylene, butene-1, butane-2, benzene, toluene / xylene mixture, and MTBE

Source: SABIC website "Annual Report & Accounts 2013"

In 2010, SABIC established the following sustainability strategy goals focusing on conservation as measured by four key indices (GHG, energy, water and materials) in 2025 (with 2010 as the base year), from the standpoint that its business was founded upon use of non-regenerative hydrocarbons as raw materials and energy sources.

- GHG emission: 25% reduction
- Energy consumption: 25% reduction
- Water consumption: 25% reduction
- Materials loss: 50% reduction
  (flare burning, venting, etc.)

2.2.4 MARAFIQ

MARAFIQ was established in 2000 as a joint venture specializing in supply of utilities[8] and launched electricity and water supply service in Jubail and Yanbu. At present, it operates the following services in the two industrial areas.

Jubail
- Seawater cooling system
- Service water/industrial water supply
- Wastewater treatment (industrial /household wastewater)
  (Electricity is supplied by SEC[9])

Yanbu
- Seawater cooling system
- Service water/industrial water supply
- Wastewater treatment (industrial and household wastewater)
- Electricity generation and distribution

MARAFIQ is primarily responsible for operation, management, construction, and addition/expansion of utilities systems and equipment, together with supply to industrial, commercial and residential areas of Jubail and Yanbu.

Utilities services provided for the Jubail Industrial City are summarized as follows.

2.2.4.1 Seawater Cooling System

Two pump stations are operated along the shores of Jubail (each has 14 seawater intake pumps with total capacity of 30 million m3 per day, or 1.25 million m3 per hour) and supply cooling water for industrial facilities via a 12km long canal.

Each plant in the industrial estate uses cooling water supplied MARAFIQ in a closed seawater/pure water thermal exchange cycle, which is then discharged to the sea through a canal.

2.2.4.2 Service Water/Industrial Water Supply System

In Jubail, an IWPP plant[10] (combining a gas turbine combined cycle power generation plant and a seawater desalination plant, with capacities shown below) is operated to supply electricity and water to the industrial estate.

[8] MARAFIQ is capitalized by Royal Commission for Jubail and Yanbu (RC), SABIC, Saudi Aramco and Public Investment Fund (PIF), and seven private sector investors as Power and Water Utility Company for Jubail and Yanbu

[9] Saudi Electricity Company

[10] Independent Water and Power Producer, owned by Joint Venture (MARAFIQ, SEC Public Investment Fund of Ministry of Finance, International Suez Consortium (Suez Energy International, Kuwait & Saudi Arabia Companies))

Power plant: Capacity ····· 2,745MW

Plant configuration: ···· Block 1 GTCC (GT 3 units + ST 1 unit)[11]

Block 2 GTCC (GT 3 units + ST 1 unit)

Block 3 GTCC (GT 3 units + ST 1 unit)

Block 4 GTCC (GT 3 units + ST 1 unit)

Total GT 12 units + ST 4 units

Seawater desalination plant: Capacity ····· 800,000m3/day

Plant configuration: Multi-effect evaporator distillation (MED), 27 desalination units

The IWPP plant is operated and managed by JWAP[12] and electricity and water produced is delivered to Tawreed[13], from which 100% of electricity is supplied to SEC, and 37.5% of desalinated water (300,000m3 per day) to the Jubail Industrial City as service by MARAFIQ) and 62.5% (500,000m3 per day) to eastern provinces (as service provided by SWCC[14].

The entire supply system for service water and industrial water, which are together referred to as potable water) consists of water tanks that have the total storage capacity of 1,050,000 m3 (11 tanks x 95,000 m3) and two pump stations[15] (562,000m3).

2.2.4.3 Wastewater Treatment Systems

There are two wastewater treatment systems under operation, IWTP8 for industrial wastewater[16] and SWTP9 for household wastewater[17]. Industrial wastewater is collected through pipeline networks installed throughout the industrial estate and is sent to a treatment plant through 220 lift stations and 58 pump stations. It is treated at the IWTP9 plant (daily processing capacity of 60,000m3) to water quality that meets the Royal Commission Environment Guideline. Likewise, household wastewater is treated at the SWTP9 plant (daily processing capacity of 72,000m3). Treated water is partially reused for tree planting and industrial water.

Note that electricity is supplied by SEC, without the involvement of MARIFQ, from the IWPP plant to the Jubail Industrial City and other areas including factories, houses, commercial facilities, and public facilities. (Source: based on MARAFIQ's website)

[11] GTCC: Gas Turbine Combined Cycle, GT: Gas Turbine, ST: Steam Turbine

[12] Jubail Water and Power Company

[13] Tawreed (MARAFIQ Water and Supply Company fully owned by MARAFIQ)

[14] Saline Water Conversion Company

[15] North West Pumping Station Stage (NWPS) I & II and East Pumping Station (EPS)

[16] Industrial Waste Water Treatment Plant

[17] Sanitary Waste Water Treatment Plant

Source: 2015 Google map

Figure 2-4 Aerial View of MARAFIQ's IWTP Plant

2.2.5 Jubail Industrial College（JIC）

In 1978, Royal Commission established a training center for skilled workers in Jubail in response to the country's industrialization. In 1982, the training center was renamed to the Royal Commission Jubail Human Resources Development Institute. It then became Jubail Industrial College (JIC) in 1998 to provide full-fledged engineering and business education for the purpose of meeting the needs in the Jubail Industrial City and eastern provinces.

Then, two advanced educational institutes were established to enhance engineering education, namely Jubail Technical Institute (JTI) in 2004 and Jubail University College (JUC) in 2006.

JIC's objective is to supply human resources in the areas of engineering and business with sufficient knowledge and advanced training and aims to provide advanced education and training programs that meet the needs of individuals and labor markets, while keeping good cooperation with business organizations, industries, society and other stakeholders.

JIC issues two degrees, Associate of Science (AS) and Bachelor of Science (BS), each of which consists of the following courses.

Associate of Science
- Manufacturing Engineering Technology
- Mechanical Maintenance Engineering Technology
- Electrical Power Engineering Technology
- Instrumentation and Control Engineering Technology
- Chemical Engineering Technology
- Industrial Chemistry Technology
- Polymer Engineering Technology
- Accounting
- Marketing
- Office Management
- Computer Information and Technology
- Non-Destructive Testing and Evaluation Engineering Technology

Bachelor of Science
- Mechanical Engineering Technology
- Chemical Engineering Technology
- Electrical Engineering Technology
- Instrumentation and Control Engineering Technology

JIC is in partnership with foreign universities, including Troy University and Northern Kentucky University (U.S.), Edexcel of UK, University of Central Lancashire, Nanyang Polytechnic (Singapore).

Source: Jubail Industrial College, "JIC Bulletin 2014"

Figure 2-5 Aerial View of JIC and General View of JIC Campus

Chapter 3 Results of Research and Outline of Proposals

3.1 SHARQ

Chapter 3 Results of Research and Outline of Proposals

3.1 Research on Infrastructure Improvement and Human Resource Development Programs for Stable Business Continuity and Productivity Enhancement of SHARQ

3.1.1 Education (Japanese-style Management)

3.1.1.1 Background of Research and Outline of Final Proposal

In order to prepare a proposal for Japanese-style human resource development program for SHARQ, during the preliminary research stage from November 2014 to January 2015, the JICA study team ("Study Team") identified a wide variety of programs that were potentially applicable to the company. Then, when the Saudi participants, including those from SHARQ, visited Japan for the study tour in January, the Study Team arranged various site visits to show them the actual sites of Japanese-style management implementation as well as its tangible effects, along with a lecture on the same theme. The Saudi members visited such companies as Toyota Motor Corporation, Sekiso Corporation (plastic molding company), and Chubu Electric Power Co., Inc. The participants not only got a strong impression from technological capabilities of Japanese companies but also were able to confirm that technological development and day-to-day operation were closely related to Japanese-style management as well as Japan's original operation approach for manufacturing plants.

During the second field study in February 2015, the Study Team once again presented key features, effects, and examples of educational programs about Japanese-style management and operation to SHARQ members so as to facilitate their understanding and evoke their interest. Subsequently, from March to May 2015, considering SHARQ's current situation and problem consciousness, which were confirmed through the dialogue during the second field study, the Study Team prepared a proposal for the training curriculum as a long list of total 140 days and 48 subjects that were considered appropriate for the company. The proposal was submitted to SHARQ via email prior to the third field study in June 2015.

The Study Team exchanged opinions with SHARQ members based on the program proposals in advance and narrowed them down to a short list according to applicability to and actual needs of SHARQ. As a result, the Study Team and SHARQ members came to share the recognition that it would be effective to invite SHARQ employees to Japan to additionally present and propose technologies and management approaches unique to Japan in the form of afield study. At the same time, the Study Team decided to include programs that would help SHARQ to solve operational problems as well as those unique to Japan, such as 5S, KAIZEN, and discipline.

After the meeting, the Study Team organized the programs into the following seven courses and submitted to SHARQ in August 2015. In September, the Study Team reached an agreement with SHARQ during the workshop conducted jointly with the company. Furthermore, the proposal contents were presented to SABIC as well, whose consent was given during the fourth field study.

Course 1: Japanese-style Management Case Study Program in Japan for Senior Managers
Course 2: Japanese-style Management Case Study Program in Japan for Managers
Course 3: Managers' Role Recognition Program
Course 4: 5S Program
Course 5: KAIZEN Program
Course 6: Discipline Program
Course 7: Japanese-style Management Program in Jubail

Although SHARQ has been in an effort to increase productivity by applying various approaches, the methods that have demonstratedenough evidence of effectiveness are primarily those widely adopted in Europe and the U.S.. On the other hand, Japanese-style management is still to prove effectivenessin the country. As the Western-style management training usually consists of the conventional educational styles, it is different from Japanese style, which focuses on an OJT that provides trainees with an opportunity for learning and growth through field-base, practical work. In this recognition, the Study Team has prepared a list of programs which were unique to Japanese style management and manufacturing control, such as role recognition, KAIZEN, and discipline, as a result of the dialogues with SHARQ. It is expected that, through future discussions, Japanese-style management is adopted as part of SHARQ's human resource development programs, which would lead to a visible effect.

Moreover, in prior to the fourth field study, SABIC made contact with the Study Team and expressed their interest in Lean Production System. Thus, the Study Team presented major methods used for the system (e.g. 5S, 7 types of waste, visual management, daily management and changing point management, Kanban, and value map), introduction examples, and a simulation exercise. SABIC expressed interest and noted that they would like to examine the possibility of introducing the system to SHARQ and AR-RAZI as model enterprises. It is therefore considered to be a good idea to materialize human resource development programs that incorporate Lean Production System as the starting point, while discussing the feasibility of the aforementioned 7 courses in the future.

3.1.1.2 Content of Study

(1) Preliminary work in Japan (from November 2014 to January 2015)

1) Preparation of the study tour in Japan

The Study Team planned a study tour that took place in January 2015 in which 4 personnel from SHARQ participated.

i Selection of topics and preparation of materials and questionnaires for a lecture about Japanese-style management during the study tour

ii Selection of sites for visited and arrangements of field tours that showcase Japanese-style management and operation during the study tour. The following sites were included in the final list:

- Toyota Motor Corporation/ Motomachi Plant
- Toyota Motor Corporation/ Toyota Kaikan Museum
- Sekiso Corporation/ plastic molding company
- Central Japan Railway Company/ SCMAGLEV and Railway Park
- Chubu Electric Power Co., Inc./ Central Load Dispatching Center
- Chubu Electric Power Co., Inc./ Kawagoe Thermal Power Station

2) Implementation of the study tour in Japan

The following tasks were carried out during the study tour that took place in January 2015:

i Lecture on Japanese-style management
ii Preliminary study of participants' interest in Japanese-style management
iii Site visits
iv After-tour study of participants' interest in Japanese-style management at the end of the tour

As a result of the studies described above as well as interviews with the participants, their areas of interest were confirmed as follows:

- Strategic management, including "Breakthrough thinking"
- KAIZEN and waste eradication
- Japanese-style human resource development
- Organizational design and systematization
- Leadership and motivation
- Management system design
- Toolkits for quality and productivity improvement
- Company-wide improvement activities, i.e. Total Quality Management, Total Productive Maintenance and Lean Production System

(2) Second field study (from February 2 to 16, 2015)

1) Focal points of the SHARQ study during and after the second field study

a. Human resource development through job analysis

The role of a manager in developing human resources related with job description, competency evaluation and promotion system was researched. Refer to the later sections from 2) to 4) described below for details.

b. TQM as management system

The Study Team examined the structure of TQM, which SABIC had introduced to SHARQ, to identify the way of implementation and the degree of contribution to corporate performance. However, the actual study was postponed to the third field study. Refer to the section 5) described below for details.

c. TPM

Though the Study Team was planning to study how and to what extent TPM in the petrochemical plant was implemented, together with overall equipment efficiency (OEE), 5S, scheduled maintenance, and preventive maintenance, but the actual study was carried over to the subsequent field studies. Refer to the section 5) described below for details.

d. Lean Production System

The Study Team studied what kind of benefits Lean Production System would produce for the petrochemical plant. The actual study was then carried out during the subsequent field studies. Refer to the section 5) described below for details.

2) Interview findings

As a result of the interviews, the following points were found:

i. The company has a global competitive advantage in terms of QCD and production volume.

ii. SHARQ's management system incorporates business objectives and KPIs based on SABIC's TQM system. The progress situation of each indicator is visualized. For example, indicators showing positive signs are displayed in green and those negative in red. Business objectives consist of 90 control items managed with the balance score card. Managers control 60 items out of 90 and hold meetings when they face problematic situations.

iii. SHARQ considered the implementation of Western-style TPM. Major methods, such as OEE, mean time between failures (MTBF), and PM analysis, are understood and encompassed in the KPI.

iv. As for human resource development, various programs are applied, including OJT for entry-level employees and other training programs for technicians, managers and senior managers, respectively.

v. The company utilizes a framework to evaluate employees based on personal achievement and value.

3) Human resource development

The outline of major human resource development programs implemented at SHARQ is shown below:

- Newly Hired Employees
- BOTP (Basic Operating Program)/EHSS→JTQ/Monitoring/IDP/In-house training
- OJT
- Training Plan Presentation
- SHEM in house training
- JQP (Job Qualification Program) Total qualification operator
- Emergency Rescue training
- Simulation training
- Development program at Mitsubishi Chemical Corporation factory in Japan
- IDP (Individual develop program) TRACCESS
- Exchange of Knowledge
- SUCSESSION PLAN
- SEeD (SABIC Engineer early Development Program)
- CAT (Competency Analysis)
- Others (6Σ, Conflict management, and 7 Habits)

4) Areas for improvement

- Objectives to be executed by managers to enhance the company's global competitive edge
- Priority among the business objective
- Way of application of the strategic control items to their action plans and to what extent they put such items into practice
- Managers' role to identify or find problems against the change in a situation
- Necessity of appropriate human resource development programs depending on the hierarchy and job type
- Importance to understand the targets of the entire firm and try to address issues in collaboration with other departments to achieve the corporate goals

5) Outline of findings of the second field study

TQM adopted by SHARQ seems to have a more advanced structure and system than that of current Japanese styles. With regard to TPM, in spite of extensive research, the Study Team was unable to fully formulate a proposal that incorporates the installation of Japanese-style TPM because of the necessity of a further research to determine its effectiveness. Thus, the Study Team planned to propose appropriate methods after conducting the 5S evaluation during the third field study.

As for Lean Production System, it is clearly applicable to acomplicated assembly process that uses a large number of workers. On the other hand, it seems a little difficult to find its effectiveness at SHARQ's petrochemical plant, where each process is connected by pipes with few workplaces that are attended by workers. Thus, while it is meaningful to introduce the concept and the way of thinking based on the system but a further consideration is necessary with regard to actual implementation.

If Lean Production System is introduced, what is needed to assure the success s a significant change in mindset of managers, who play an important role in day-to-day operation. Additionally, case studies of Japanese companies that achieved solid results would be helpful for the purpose of understanding a detailed picture of 5S and discipline, which are fundamentals of work, and to get to learn actual cases of implementation and achievement in Japan.

While SHARQ members commented in response to the proposed training programs, , "We know very well about the method" or "We have already applied the system" , they showed strong interest in the actual examples of execution in Japan. In short, the Study Team obtained an impression that there was difference in the degree of "knowing" and "applying" between Saudi Arabia and Japan.

(3) Second-phase of work in Japan (from late February to May 2015)

Analyzing the results of the second field study, the Study Team reorganized the educational programs into 48 items for being proposed to SHARQ in the future, based on the company's current situation and problem consciousness. Then, detailed contents, duration, target, and expected effect of each program were compiled in a long list (a proposed long list), along with verification examples in Japan. This list was emailed to SHARQ in prior to the third field study.

(4) Third field study (from May 27 to June 1, 2015)

During the third field study, the Study Team carried out 5S evaluation as well as research and study to determine he degree of interest in the Japanese-style management programs listed below, including items continuously studied from the previous field study.

1) Japanese-style management program

The Study Team explained to the SHARQ members the structure, training methods and contents of each program along with the previously submitted long list and clarified their areas of interest. The following is a list of programs of their particular interest. They specifically expressed strong interest in a paradigm shift related to innovation.

- Breakthrough Thinking
- Business Start-up Simulation
- Corporate Culture and Behavior Modeling Productivity (BMP)
- Quality Management
- 5S & Visual Management
- KAIZEN in Operation Procedure
- Field Study in Japan

The SHARQ members said that they understood the proposed programs submitted by the Study Team for the most part. With regard to TPM, however, the SHARQ members stated that a system called SABIC Reliability Recognition Program (SRRP) had been established by one of SABIC departments, "Maintenance Center Excellence (MCE)." Thus, they did not show an interest in Japanese-style TPM.

2) 5S evaluations

5S evaluations were conducted concerning equipment, devices, tools and the inspection tools in a mechanical department, all of which are focal points of 5S. The score was 75 points out of 100. This is an acceptable level for effective work but there is a still room for improvement. The major findings are as follows:

<Maintenance workshops>

- Maintenance equipment, passages, and workshops are clearly distinguished.
- There are no metal trashes in the workshop.
- The equipment operation adopts a backup system with one reserved operator.
- The cutting bytes are stored in lockable desk drawers
- No display of the name and the amount of each tool and device is found.
- Necessary tools are kept in the toolbox
- The lockers are not tidy enough. Some wastes are found.
- Color-coded garbage boxes for waste and metal are installed.

< Warehouse>

- The warehouse of the replenishment parts is a very large, five-story building, and its fourth and fifth floors are set aside for the future use.

- All materials, molds, and maintenance parts are controlled by bar-codes and the location of each item is designated.
- The procurement lead time of each item is properly controlled. The maximum stock and the ordering point are determined.
- Inventory days are about three months on average. The inventory turnover rate of each item is unconfirmed.

As a whole, their current level of achievement is significantly high in terms of inventory control of tools and equipment. However, there is still some room for improvement such as the layout and guarding of lockers, the improvement in assignment of of storing locations according to the frequency of use, the inventory turnover rate of parts, and determination of the number of tools or management methods of cutting bytes.

3.1.1.3 Final Proposal

(1) Proposal for training programs

As a result of the third field study, the final proposal to SHARQ was made as shown below, based on the proposed long list. With regard to Lean Production System, the Study Team proposes consulting service to facilitate its implementation.

Table 3.1.1-1 Final Proposal of Training Programs

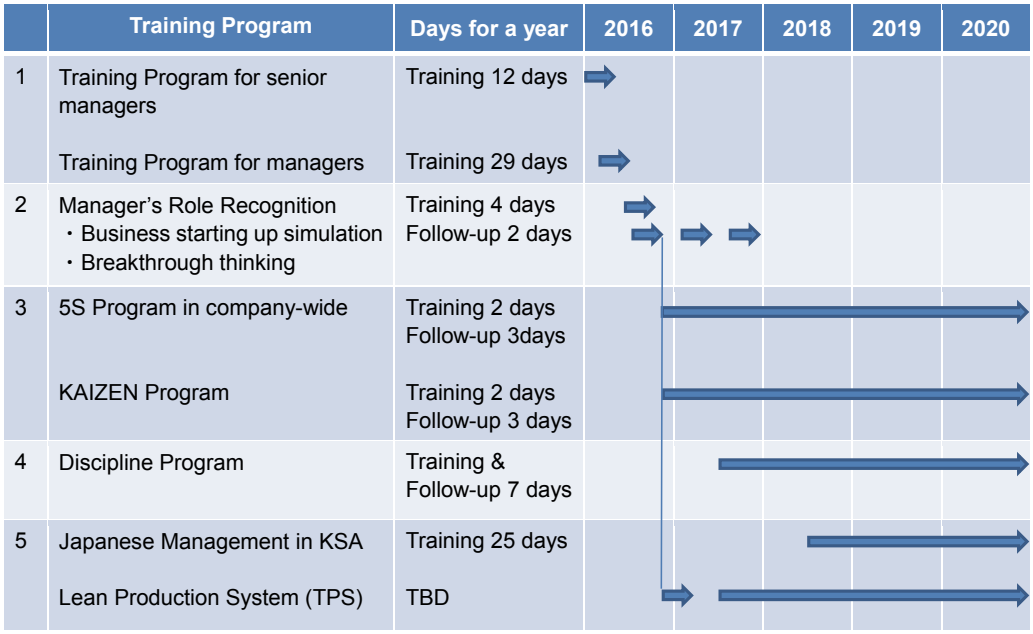
Course Title		Participants	Location
Course 1	Japanese-style Management Case Study Program	Senior managers	Japan
Course 2	Japanese-style Management Case Study Program	Managers	Japan
Course 3	Managers' Role Recognition Program	Managers	Jubail
Course 4	5S Program	Supervisors	Jubail
Course 5	KAIZEN Program	Supervisors	Jubail
Course 6	Discipline Program	Supervisors	Jubail
Course 7	Japanese-style Management Program	Managers	Jubail

(Source: JICA Study Team, CJIA)

(2) Proposal for consulting service on Lean Production System

It is proposed that, at the start,senior managers and managers visit Japan to familiarize themselves with the Japanese style management including Lean Production System. Then, they formulate grand designs and action plans in the next five years that contribut to creating value and safety, quality and productivity improvements, considering

5S, Kaizen, Discipline, Lean Production system and global SCM (supply chain management). Meanwhile, if it is necessary to officially introduce Lean Production System, consulting service will be proposed. It is recommended to organize a full-time project team of Lean Production System, to design a project promotion schedule, to estimate costs, and to receive consulting service on a monthly basis.



(Source: JICA Study Team, CJIA)

Figure 3.1.1-1 Schedule of Training Program

Table 3.1.1-2 Approximate Expense of Training Program

(Monetary unit: 1,000 Saudi Arabian Riyal)

Course No.	1	2	3	4	5	6	7
Duration (days)	12	29	Note 1	Note 2	Note 3	Note 4	25
Number of participants	12	12	12	12	12	12	12
Course fee	106	255	144	294	197	182	324
Travel expense for trainees	474	661	---	---	---	---	---
Travel expense for trainers	---	---	113	145	102	100	140
Local travel expense	18	24	7	16	16	15	13
Miscellaneous expense (e.g. textbooks, lecture room)	23	36	7	7	7	7	7
Coordination fee	32	79	18	36	36	36	79
Administration fee	13	32	13	27	27	27	32
Subtotal	666	1,087	303	525	385	367	595
Consumption tax (8%)	53	87	24	42	31	29	48

Total	**719**	**1,174**	**327**	**567**	**416**	**396**	**643**

(Source: JICA Study Team, CJIA)

Note 1: Japanese consultants visit Jubail 3 times during 6 months to hold a total of 6 days of lecture.

Note 2: Japanese consultants visit Jubail 4 times during 6 months to hold a total of 5 days of lecture

Note 3: Japanese consultants visit Jubail 3 times during 6 months to hold a total of 4 days of lecture.

Note 4: Japanese consultants hold 7-day lecture and measure the impact within 6 months.

Since the Study Team is requested to lead the establishment of 5S and KAIZEN at production site, in the case that there is a need for preliminary meetings. In such case, additional costs may be charged.

3.1.2 Safety Management / Security Planning

The survey and analysis of this field were conducted from a standpoint of management. Having recognized that the Safety, Health and Environment Management (SHEM), which SABIC has promoted at its affiliate companies, through advance information gathering, we consider focusing on SHEM to be the best in this field and have developed the survey and analysis on SHEM into proposals.

3.1.2.1 Survey Results

(1) Outline of findings

With operation at all of the affiliates taken into consideration, SHEM has been well developed by covering an entire range of elements relating to risk management. The IT infrastructure to support the system is maintained at high levels. All interviewees on the survey were found to accept SHEM as an "excellent" system. According to them, no items require an immediate action.

A high rating can be given in terms of SHEM as a whole. However, individual interviews on SHEM elements revealed a significant number of managers and other responsible people of the system consider constructive approach to improve the system and the implementation aspects of each element. Picturing the ideal condition of each element helps recognize a gap between the ideal and current status. Analyzation of the cause of the gap and implementation of appropriate countermeasures against it are effective for making improvements. In addition, the comparison between your efforts for risk management and the general Japanese way of improvement helped recognize a certain level of difference. Further effects can be expected when the merits of both ways are suitably combined.

Analysis of this survey and major inputs into the proposal are summarized below. Judging them in a comprehensive manner, the proposal is to be described.

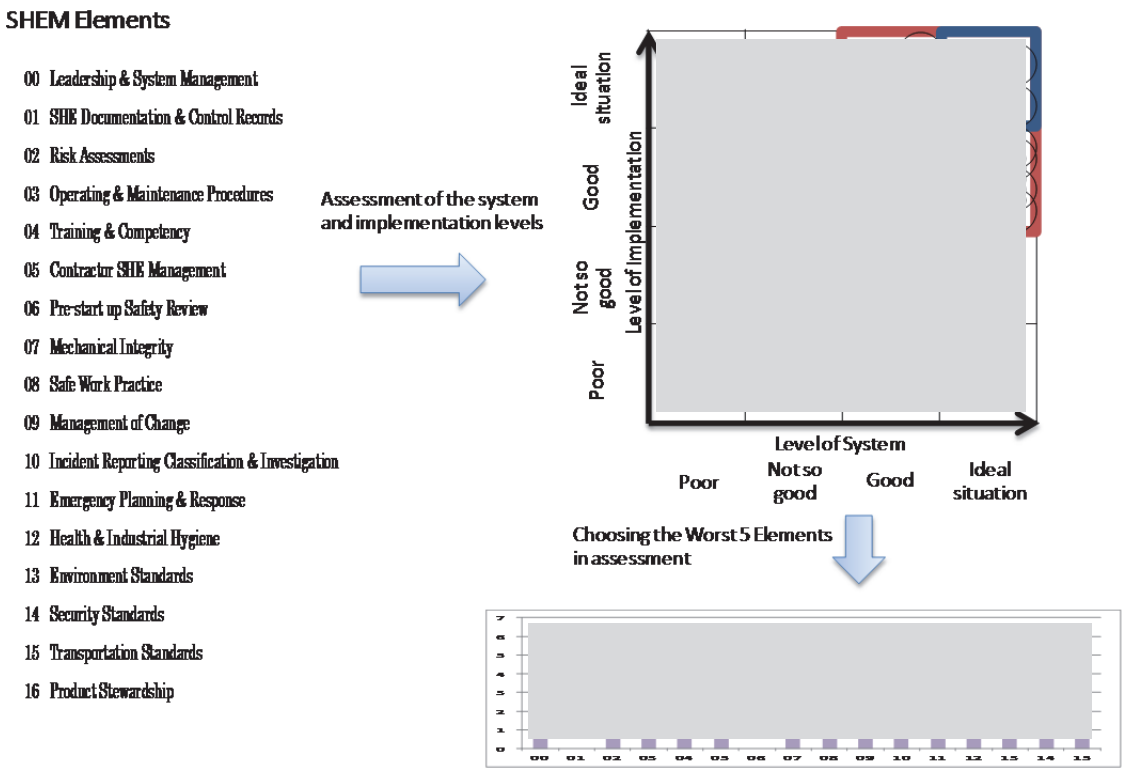
a) Our experiences and concepts in terms of risk management consulting in Japan
b) SHEM-related items
   - Survey on SHEM elements
   - Documents related to SHEM
   - Interview with EHSS Dept. Managers and others in charge of it
c) Others
   - Interview with senior managers about the survey on education (Japanese Method of Management) (including the survey related to SHEM elements)
   - Meetings with Japanese staff members
   - Company visits (Affiliated companies within Jubail Industrial City and related companies in Japan)

(2) Key points of findings

1) Survey on SHEM elements

In terms of the system and implementation aspects of SHEM elements, two managers and seven other responsible people were requested to assess their current status and give their opinions about any problems they may have. Their assessment is summrized in Figure 3.1.2-1 (top right). X and Y axes show the assessed system levels and implementation levels respectively. The plots in the blue box indicate that both their system and implementation levels are at ideal stages, while those plotted in the red box are judged to be good though there is still room for improvement. Those plotted outside of the red box reveal that effective improvement measures are strongly recommended.

After their assessment of SHEM elements, the respondents were also requested to choose their worst five elements, the result of which is shown in Figure 3.1.2-1 (bottom right). "04 Training & Competency" was chosen by 6 respondents, accounting for the higest percentage. Many voiced that they wanted more opportunities for human resource development or that they should develop more personnel competence for improving each element. Items 13 to 15 were also mentioned often because they were recently added and drew attention from the respondents.



(Source: CJIA JICA Study Team)

Figure 3.1.2-1 Survey Results on SHEM Elements

2) Comparison of present risk management and Japanese method

Some differences between the current method for target achievement in the area of risk management and the generally applied Japanese method were found from this survey. Table 3.1.2-1 shows the key differences, which are summarized as follows.

- As for SHEM, SABIC and its affiliates have sufficient highly-professional staff members of Safety & Security, who independently support the worksites. In Japan, on the other hand, the worksite staff independently acts with the help of a small number of professional staff of Safety & Security.
- The well-arranged Off-JT in SHEM provides highly-professional training, while in Japan OJT is primarily used as it provides what worksite people directly need.
- When an unexpected incident occurs, SHEM focuses on prompt reporting to and optimal response by a specialist, while in Japan priority is placed on voluntary efforts to be made by workplace staff to prevent reoccurrence of the same incident.
- On assessment of appropriateness, internal and external auditing is regarded important by SHEM, while in Japan self-inspection at each workplace is regarded as important.

Table 3.1.2-1 Comparison of Efforts for Risk Management

		SHEM	General Japanese style
Safety & Security	Charac-teristics	Specialized section & a sufficient size of staff	A small number of staff
	Merit	Able to provide detailed support to worksites	Develop autonomy of work sites ⇒ Worksites strengthen their workplaces by introducing comprehensive measures of Safety & Security and others
Risk assessment	Charac-teristics	Support by EHSS Department	A main role played by worksites
	Merit	Less variation in risk analysis of each worksite thanks to the support by highly professional staff	Risk assessment focused on worksite tasks ⇒ Workplace Kaizen by employees there based on risk analysis with their current problems and past troubles taken into consideration
Human resource development	Charac-teristics	Off-JT as a center Good preparation of training courses	OJT of actual tasks as a center
	Merit	Acquisition of a wide range of expertise	Acquisition of skills necessary for actual tasks ⇒ Skill upgrading of instructors through instruction and worksite Kaizen while instructing
Response to an incident	Charac-teristics	Focus on report within a limited time	Focus on prevention of reoccurrence
	Merit	Speedy information sharing	Worksite Kaizen through prevention of reoccurrence
Assessment of appropriate-ness	Charac-teristics	(Internal/External) Auditing as a center	Daily self-inspection as a center
	Merit	Objective evaluation	Worksite Kaizen through speedy response to problems

1

(Source: CJIA JICA Study Team)

On the whole, staff with highly professional expertise of various fields plays a primary role according to SHEM. In Japan, however, staff of each workplace independently carries

out necessary activities. In this case, they make Kaizen by themselves in their own workplace by means of conducting the activities even if their expertise of various fields is not so high. Therefore, it is one of the characteristics of the Japanese style that any activity of worksite staff can lead to Kaizen.

3.1.2.2 Outline of the Study Team's Suggestion

(1) Essential features of the suggestion

The Study Team's suggestion is "Worksite Kaizen activities based on SHEM." The suggestion does not mean any change in the system of SHEM. It is to incorporate the concepts of Kaizen, a feature of the Japanese style management, into the SHEM activities whose level has been highly valued. The activity is designed to reduce the burden of EHSS Department and, without increasing their staff, encourage them to work on a new measure, promote 5S's activity and improve Safety, Quality, Cost, Delivery (SQCD) of the workplaces. It is unlikely to realize an immediate effect, while tangibleood results can be expected in the long run if the effort is continued on a sustainable basis. This activity will help build up a culture where field workers voluntarily practice make Kaizen at their worksites.

As an approach of Kaizen activities from the Safety and Security field, focusing on the following four themes is recommended in view of the findings so far and risk management elements.

1) Risk assessment

Worksite staff independently initiates and practices Kaizen at their workplace by identifying potential risks and taking measures against them with their daily problems and previous troubles taken into consideration, while receiving support from EHSS. It is possible to control risks closely allied to the worksites and make Kaizen in their own workplaces when the staff, preferably all the members, analyze risks with consideration of daily issues and past troubles through discussion and put their head together to hammer out measures.

2) Response to unexpected incidents

While reporting promptly on an unexpected incident, worksite staff voluntarily makes efforts to prevent its reoccurrence. Their imminent and chilling danger ("Hiyari-hatto") which fortunately did not cause any accident are supposed to be dealt with in the same way. On this occasion, if the staff, preferably all the members, participate in this activity, Kaizen will be made at the worksite..

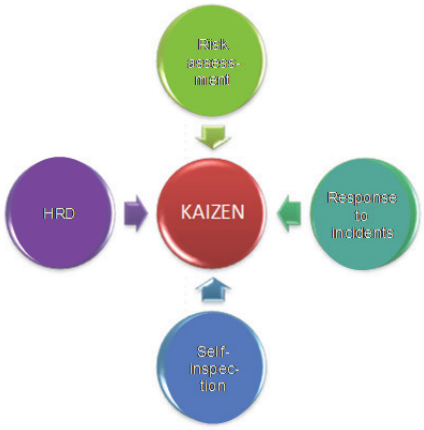
3) Self-inspection

In addition to taking corrective action against what was pointed by the auditor, the worksite staff should set up the points for self-inspection, such as items (including 5S's), frequency, conductors, and procedures for self-inspection, carry out the self-inspection, and take corrective actions. The enhancement of self-inspection makes timely corrections possible. Again, on this

occasion, if the staff, preferably all the members, participate in this activity, Kaizen will be made at the worksite.

4) Human Resource development

In addition to the current full-fledged Off-JT, OJT should be added so that HRD can be realized since the training similar to the actual tasks is available. This method would be applied to both EHSS Department and worksites. The workplaces actively adopt OJTs into their activities to make on-the-site Kaizen through 1) to 3) above. EHSS Department, on the other hand, can conduct OJT through assistance to the frontline by involving themselves in the process of 1) to 3) above of supporting workplaces. For example, 1) is an OJT to extract, focus, and develop measures to the risks. This method would enable instructors to develop their practice of teaching by themselves, to practice Kaizen within the workplace through the instructions and to realize the betterment of communication among those involved since managers or senior workers teach their subordinates or juniors in person.



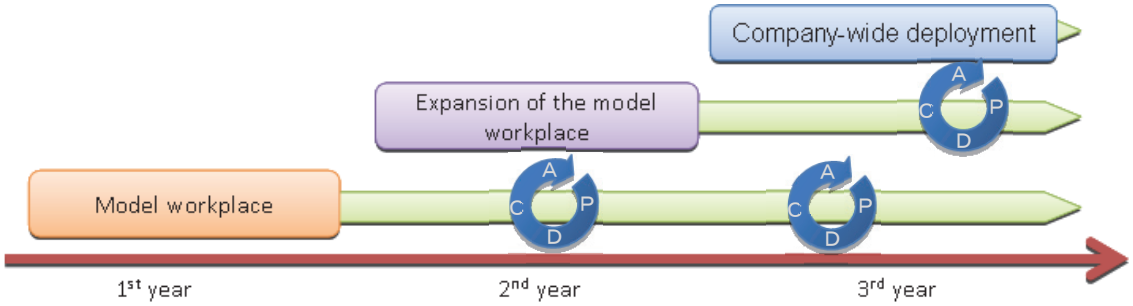
(Source: CJIA "JICA Study team")

Figure 3.1.2-2 Approaches to KAIZEN

(2) Support plan for activity

1) Activity plan

A three-year activity is recommended as shown in Figure 3.1.2-3. With the rule of running and completing a PDCA cycle once a fiscal year as a core, the activity is to be started with the establishment of a model workplace in the first year, followed by the expansion of the model workplace in the second year, and in the third year to deploy it across the company.



(Source: CJIA JICA Study Team)

Figure 3.1.2-3 3-year activity schedule

Figure 3.1.2-4 shows the activity schedule for the first year. In the first year, a model workplace activity should be promoted (a workplace with around 30 people working and EHSS Dept. staff).

		1	2	3	4	5	6	7	8	9	10	11	12
P	Measure planning on 4 themes	→	→	→	→	→	→	→					
D	Implementation of the measure								→	→	→	→	→
C	Check of implementation progress										→	→	
A	Correction of nonconformities											→	→

(Source: CJIA JICA Study Team)

Figure 3.1.2-4 First Year Activity Plan

2) Support plan

Support for the 1st year activity is suggested as following:

- On-the-spot supporting service by the consultant in charge
- Frequency of on-the-spot support
  - Visit to the site once in 1 to 2 months (Use of Web conferences at suitable timings)
  - Half-day supporting service x 5 days per visit
- Contents of the on-the-spot supporting service
  - Confirmation of performance progress and problem solution since the previous visit
  - Explanation of the work theme of this time and its trial
  - On-the-site observation of the model workplace and advice on Kaizen
  - Confirmation of the work contents to be performed by the next visit, etc.

(3) Objective of the plan

Not to implement any new additional system, but to implement Japanese Kaizen relating to safety by integrating with the existing system, such as KPI and SHEM.

(4) Proposed activities of the plan

- Promote awareness on safety to build safety culture throughout the SHARQ organization
- Promote Kaizen activities to be more preventive and involvement of workers
- Promote more automation and semi-automation including POKAYOKE

(5) First step of the plan

- Comprehend the existing system and decide the model workplace.
- Formulate the activity plan identifying necessary training

(6) Expected effects

The followings can be expected through this activity:

1) Upgraded operational level of safety and security

SHEM can be operated in a manner much closer to each workplace thanks to the combination of the established highly-professional support by EHSS Department and the independent efforts by the staff of each workplace. SHEM operation will be deepened and responses will be made quickerin various aspects including the following:

a) Strengthening of safety culture across the organization
b) Instillation of Japanese-style Kaizen activities (prevention of occurrence and reoccurrence)
c) Advancement of automation and semi-automation including POKAYOKE

2) Promotion of on-the-site Kaizen

All the four themes recommended here lead to the worksite Kaizen. Through the four themes, 5S can be promoted and improve SQCD can be improved.

3) Less burden on EHSS Department

Independent efforts made by each workplace will reduce the burden of EHSS Department. EHSS Department can devote itself to the improvement of quality of its tasks and to initate new actions or tasks without increasing the staff.

4) Ability development of workplace staff

When the current full-fledged Off-JT and well-prepared OJT at each workplace are strongly combined, the set ofabilities required by the tasks will be developed. Instructors are required to carry out a number of preparation activities for OJT, which will help develop them by themselves. While they conduct OJT, they can afford to pay attention to Kaizen points of the workplace.

5) Lower turnover rate of employees

The direct involvement of staff of each workplace in Kaizen activitieswithin their own place makes them feel attached to their workplace and their motivation becomes stronger. These experiences will lower the turnover rate of employees.

(7) Expenses

When two consultants in charge provide service for the first-year support, the approximate cost is estimated as follows.

Table 3.1.2-2 Cost Estimates

(SAR)

Details	Basis of calculation		Unit rate	Expenses
On-the-site support	9 times / year x (Half-day job x 5 days) / visit	45 days	15,000	675,000
Support on Web conferences	6 times / year x (Half-day job x 2 days) / visit	12 days	10,000	120,000
Traveling expenses	Flight tickets and others	9 roundtrips	54,000	486,000
	Accommodation expenses (9 times x 6 nights)	54 nights	2,400	129,600
	Allowance for moving days (9 times x 4 days)	36 days	3,000	108,000
Others	Support planning, report making, etc.	1 set	150,000	150,000
			Total	1,668,600

(Source: CJIA JICA Study Team)

3.1.3 Wastewater Treatment / Recycled Water

With respect to SHARQ's performance on water-saving as required by the Sustainability Program, it is expected that the company achieve the reduction target by 2015 although it temporarily exceeded the acceptable level in 2014.

However, since a specific plan and schedule for the period after 2015 has not been prepared, the future challenge is to draw up a concrete roadmap to achieve the final target in 2025.

Taking all the above into consideration, the Study Team reports the results of the survey, which is conducted with an aim to make recommendations for improvement to produce clean, industrial water as well as proper treatment of industrial waste water.

3.1.3.1 Survey Results

(1) Water supply

All the water used by SHARQ is supplied by MARAFIQ based on the water supply agreement with MARAFIQ. The supplied water is not classified as portable water (PTW) and industrial water but the total volume is provided as PTW.

In the agreement, maximum and minium water consumptions are stipulated. Even if actual water consumption is less than the minimum consumption as agreed, SHARQ has to bear the cost for minimum consumption. According to SHARQ members, reduction of the minimum consumption was discussed and agreed to meet the current demand.

It is less than the minimum consumption set under the agreement, so that SHARQ is in a state of overpayment in comparison to the actual water usage.

(2) Water balance

SHARQ receives PTW and uses it within the plant, and discharges wastewater to Industrial Wastewater Treatment Plant (IWTP) through pipelines. Royal Commission Environmental Regulation-2010（RCER-2010）regulates wastewater quality discharged to IWTP, which are applicable to all companies operating in Jubail Industrial City.

(3) Industrial Wastewater

SHARQ complies with the wastewater regulation of Royal Commission for all industrial wastewater discharged to IWTP

(4) Consideration of proposals

The following 5 cases were considered and evaluated with regard to reclamation of industrial wastewater.

Case 1 Water Reclamation of all industrial wastewater (mixture of three type of wastewater)

Case 2 Water reclamation of all EG wastewater
Case 3 Water reclamation of PE wastewater and OLF wastewater
Case 4 Water Reclamation of PE wastewater for industrial use
Case 5 Water Reclamation of PE wastewater for irrigation use

As a result of consideration regarding the above five cases, Case 3, 4 and 5 have been confirmed in terms of project feasibility. From the viewpoint of amount of reclamation water, Case 3 is the most recommendable.

Outlines of each case are as follows:

Case 1 Water reclamation of all industrial wastewater (mixture of three types of wastewaters)

According to the explanation by a SHARQ member, SHARQ has already considered the reclamation of all industrial wastewater including EG wastewater, OLF wastewater and PE wastewater. It is clear that reclaimation of all industrial wastewater obtains the most of reclaimed water. However, according to the result of our study, quality of remained wastewater to be discharged to IWTP does not meet the requirements in the Royal Commission regulation in case of all of industrial wastewater to be reclaimed. Therefore, it was determined that the reclamation of all industrial wastewater seemed inappropriate. The reason for this is the difference of quantity and quality of wastewater.

Case 2 Water reclamation of all EG wastewater

Reclamation of all EG wastewater was studied. Brine from RO in the reclamation process can be discharged to MARAFIQ by mixing with PE and OLF wastewater. However, even temporarily, in case of fluctuating the quantity or quality of EG wastewater, there is a risk of failing to meet the Royal Commission regulation. Since quantity of EG wastewater is the largest and also pollution level is more severe than those of other wastewaters, impact on the brine is remarkable. The fluctuation of quantity and quality of three type of wastewater should be surveyed carefully. A larger volume of wastewater and highepollution would cause an increase in the size of the wastewater treatment facility.

Case 3 Water reclamation of PE and OLF wastewater

Reclamation of mixture of PE and OLF wastewater was studied. As a result of the study, a certain amount of wastewater can be reclaimed and recovered for industrial water. Quantity of reclaimed water depends on quantity and quality which should be acceptable for discharging to IWTP. This case meets the Royal Commission regulation.

Case 4 Water Reclamation of PE wastewater for industrial use

Pollution level of PE wastewater is lower and quality is very clean comparing to other wastewater, though quantity of PE wastewater is less than other wastewater. By limiting the type

of wastewater, steady reclamation can be realized. In this case, reclamation of wastewater can be obtained by relatively small amount of investment because of simple pretreatment such as coagulation and MBR+RO.

Case 5 Water Reclamation of PE wastewater for irrigation use

Application of treated water from the MBR outlet for irrigation water was studied. Since the quality of PE wastewater is relatively clear, treated water from the MBR outlet can be used for irrigation water. After filtration of MBR outlet water, microorganisms such as bacteria and other suspended materials can be separated.

3.1.3.2 Proposals

Summary of proposed projects is as follows:

Table 3.1.3-1 Summary of Proposed Projects

	Proposed projects	Required costs	Investment recovery
1	Water reclamation of PE wastewater and OLF wastewater	Facility 31.4 mil. SAR Operation 1.40 mil. SAR/year	8 years
2	Water Reclamation of PE wastewater for irrigation use	Facility 12.5 mil. SAR Operation 0.36 mil. SAR/year	7 years
3	Water Reclamation of PE wastewater for irrigation use	Facility 15.0 mil. SAR Operation 0.44 mil. SAR/year	11 years

(Source: JICA Study Team)

3.1.4 Energy Saving

To study the proposals in the field of energy saving for SHARQ, the Study Team gathered general information about the company as part of a preliminary study from November to mid-December 2014 and tentatively selected priority items to be studied. During the first site visit, the Study Team learned about local conditions. Furthermore, based on the information obtained from SHARQ members who visited for the study tour in Japan held in January 2015, the Study Team determined a general direction of the study.

During the second site survey in February 2015, the Study Team obtained information about energy consumption, related facilities, operation and maintenance, etc. through discussion with the SHARQ management and the related parties. Considering such information and the current situation and issues found through the discussions as well as plant survey, the Study Team prepared a long list of 58 candidate projects ("Long List") during the period from March to May 2015 and submitted it by email to SHARQ in June prior to the third site survey.

During the third site survey in June 2015, the Study Team exchanged opinions with SHARQ based on the long list, and selected 13 items composed of pumps, compressors, boilers, trasformers, air conditioners, lighting fixtures, etc. as possible energy saving projects. Furthermore the Study Team confirmed the basic concepts of the final proposals to be submitted to SHARQ through discussion with them about specifications and data relating to equipment and substation at site for selection of applicable technologies.

Based on the above activities, the Study Team developed 13 energy saving related projects and submitted them as a draft proposal to SHARQ in August 2015. SHARQ and the Study Team discussed the proposed projects at the workshop meeting in September 2015, and eventually confirmed 13 projects as shown in Table 3.1.4-1. The Study Team also explained to SABIC about these projects at the meeting with SABIC, and obtained their consent.

3.1.4.1 Results of the Field Survey

SHARQ and the Study Team discussed the possible areas of energy saving measures indicated in the Long List submitted by the Study Team and carried out the plant site survey. As a result, the both parties reached an agreement on energy saving measures in the following facilities and equipment: (1) seawater cooling system, (2) rotating equipment including pumps and compressors, (3) boilers and steam lines, (4) transformers, (5) air conditioners and (6) lighting fixtures.

The Study Team explained to SHARQ about the result of the study for possible energysaving measures during the forth site visit, and eventually compiled the proposed projects incorporating comments by SHARQ as shown in Table 3.1.4-1. Meanwhile, according to the

record of SHARQ's sustainability performance, it is expected that they will not reach its target in 2015 though they achieved it for the period from 2011 to 2014. SHARQ will be therefore required to make streneous effort to achieve it after 2016.

Table 3.1.4-1 List of Proposed Projects

	Proposed items	Facility cost estimates	Annual cost saving
		1,000SAR	1,000SAR/y
1	**Rotating equipment - Seawater cooling system**		
	1) Introduction of VFD on pumps	14,000	1,370
2	**Rotating equipment - Compressor**		
	1) Proper adjustment of the setting pressure	0	243
	2) Introduction of VFDs to the compressors	4,300	162
	3) Air leakage prevention	0	486
3	**Boiler**		
	1) Intruduction of VFDs to the FDFs	6,400	1,806
	2) Diagnosis of trap operation and development and implementation of the modification strategy	Depend on situation	1,807
	3) Insulation of valves	300	161
4	**Transformers**		
	1) Relacement of old transformers with higher efficiency one	122,700	1,815
5	**Air conditioners**		
	1) Replacement with high-efficient equipment	117,800	3,146
	2) Protection of outdoor units from direct sunlight	230	235
	3) appropriate room temperature setting	0	245
6	**Lighting fixtures**		
	1) Replacement of mercury lamp with LED lamp	214,800	8,711
	2) Installation of motion sencers for interior lighting	1,100	131
	Total	481,630	20,318

3.1.4.2 Summary of the Proposals

(1) Rotating equipment – In seawater cooling system (SWCS)

The plant utilities systems and facilities include a cooling cycle process with two types of SWCS application, i.e. plate-type heat exchangers (PLEX) where seawater is used as coolant, seawater cooling towers (SWCT). There is opportunity energysaving by the use of VFD in the seawater pumps.

Proposed project	Introduction of VFD on pumps

(2) Rotating equipment – In compressors

Compressed air is used both for instrumentation and process faciliites and equipment. Air pressure of compressors is set with a more than enough margin in consideration of pressure loss through the filters and the dryers. As a result of the on-site investigation, the air pressure was kept steady. If sufficient stability can be maintained, it will eliminate a need to set a margin and the pressure setting point thus can be reduced. In turn, reduction of pressure can promote energy saving. Moreover, since the plant blows out air to relieve excessive pressure, it is feasible to effectively modulate the air pressure by means of VFD. Furthermore, the compressed air is supplied throughout the plant through pipelines, which is why air leakage occurs frequently. Thus, energysaving can be accomplished through daily monitoring and prevention of air leakage.

Prospective projects	1) Proper adjustment of the setting pressure 2) Introduction of VFDs to the compressors 3) Air leakage prevention

(3) Boilers

High-pressure and low-pressure steams are generated by boilers and are supplied for use by process equipment as well as utilities. The air flow of the forced draft fans (FDFs) of the boilers is controlled by dampers. Therefore, it is possible to improve energy efficiency through the introduction of VFD. Also, with a number of steam traps in the plant, the volume of produced steam can be reduced by implementing comprehensive diagnosis of the operation (favorably once a year) as well as making a database of the diagnostic outcomes, and creating a mechanism to plan and carry out the modification strategy based on the database.

Proposed project	1) Introduction of VFDs to the FDFs 2) Diagnosis of trap operation and development and implementation of the modification strategy 3) Insulation of valves

(4) Transformers

Transformers are installed throughout the plant. The majority of them have been in use for more than 30 years since the commencement of the commercial operation of the plant, so that it is possible to save energy by replacing them with new transformers with higher efficiency.

Proposed project	Replacement of old transformers with higher efficiency ones

(5) Air conditioners

In the plant, a number of air conditioners made by various manufacturers are installed and some of them seem to have been used for an extended period of time. In consideration of availability of air-conditioning equipment with remarkably improved efficiency, it is possible to achieve a significant energy saving effect by replacing the preresent air-conditioners with the new ones. In addition, most of the outdoor units are located on the roof and are subject to insolation. Installation of shadings is expected to make a positive impact on energy conservation. the SABIC guideline requires the room temperature to be set at adequate levels, but the actually set temperature is lower than that in the guideline. Strict enforcement of the temperature setting is thus expected to promote energy saving.

Proposed project	1) Replacement with high-efficient equipment 2) Protection of outdoor units from direct sunlight 3) Appropriate room temperature setting

(6) Lighting fixtures

Downlight fluorescent lamps and straight tube fluorescent lamps are used in the administration building, etc. and they use reflective plates to be more energy effective than incandescent lamps. On the other hand, since a lot of mercury lamps are used throughout the plant, the company can save more energy by changing the existing lamps to LED and/or metal halide lamps. Moreover, installation of motion detectors makes it possible to take advantage of its automatic turn-off feature and turn on minimum lightings, which can lead to further energy conservation.

Proposed project	1) Replacement of mercury lamp with LED lamp 2) Installation of motion sensors for interior lighting

(7) Others

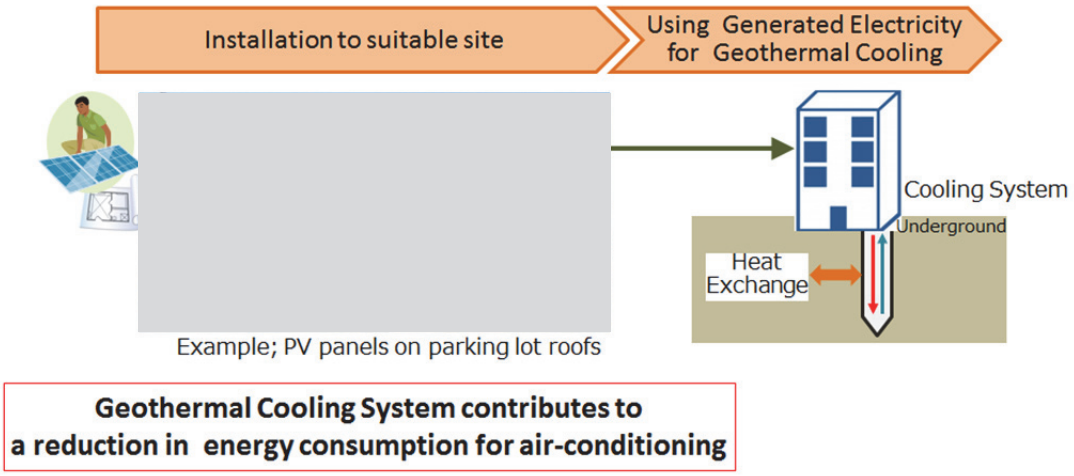
The sections that produce significant heat loss, such as steam lines, bulbs, and heat exchangers, are designed to properly retain heat. The plant has various aspects to minimize energy loss through exhaustive heat recovery, including boiler feed-water preheating through drain recovery as well as introduction of economizers. In addition to hardware, it is observed that all the employees have strong awareness of energy saving. For instance, they thoroughly analyze energy data and set a benchmark in order to build the checking systems based on the identified trend. With regard to the water usage, water conservation is implemented by installing aerators to the faucets and auto-flush toilets to the restrooms. These facts indicate that essential energy-saving activities arefirmly in placethroughout the plant.

For further energy conservation, it is worth attempting to introduce a system that can linearly cope with changes as well as to utilize the most recent highly-efficient devices. So far as compressors, boilers, and pumps are concerned, the plant has established a system, which is capable of responding and to adjusting the number of appliances in operation with constant load monitoring. A proposed idea is introduction of a self-adjustable system by means of VFDs and sensors. Also, since the efficiency of transformers and air conditioners has been dramatically improved in recent years, upgrading to the newest equipment will produce a substantial energy saving effect.

3.1.5 Renewable Energy/Solar Power Generation

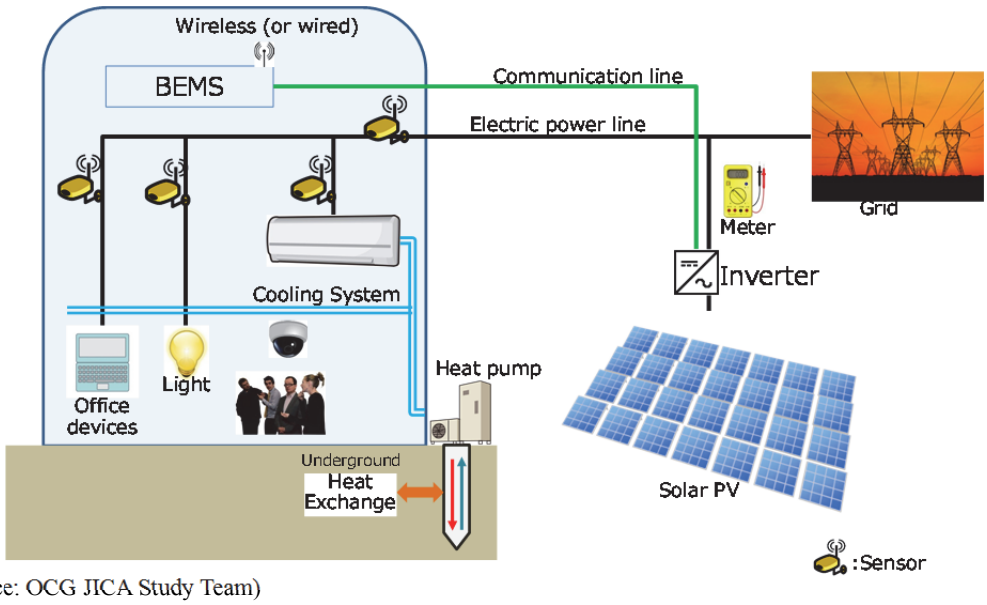
3.1.5.1 Summary of Survey Results

We have proposed the installation of solar panels on parking lot roofs and geothermal cooling systems (Figure 3.1.5-1). Through discussion, it was decided to install a Building Energy Management System (BEMS) that utilizes solar panels and geothermal energy in administration buildings, as shown in Figure 3.1.5-2.



(Source: OCG JICA Study Tem)

Figure 3.1.5-1 Proposal for Solar Panels on Parking Lot Roofs and Cooling System



(Source: OCG JICA Study Team)

Figure 3.1.5-2 BEMS Efficiently Utilizes Solar Panels and Geothermal Energy

3.1.5.2 Summary of Proposal

One quarter of oil produced in Saudi Arabia is consumed within the country, and domestic consumption is rapidly growing due to an increasing demand for electricity. It is suggested that the country may change from a petroleum exporting country to a net importer by 2038. In light of such trend, urgent development of renewable energy sources (in particular, photovoltaics) is called for to reduce domestic consumption of fossil fuels led by oil and natural gas. Moreover, it is important to not only develop renewable energy sources, but also promote energy efficiently as part of national policy. SHARQ also aims to reduce CO_2 emissions by 25 percent per production (ton) by 2025 through the Sustainability Program.

Considering the above targets for both the entire country and SHARQ, the Study Team offers a whole-package proposal that introduces Building Energy Management System (BEMS), solar panels, geothermal heat pumps and high-efficiency lighting to administration building areas. This package contains renewable energy, such as solar panels and geothermal, and promotes energy efficiency through BEMS and high-efficiency lighting to meet the national-level requirements.

Each component will be installed as follows:

Solar panels will be installed on parking lot roofs around the administration building. An air conditioning facility that utilizes a geothermal heat pump will be installed underground, below the front garden or courtyard of the administration building.

Building lighting will be replaced with motion sensor LED lighting, and BEMS will be installed to visualize the building's electricity consumption and promote renewable energy efficiency.

Electricity generated by solar panels will connect to the existing SHARQ distribution grid. According to the scale of demand for electricity in SHARQ, photovoltaics will not cause reverse power flow. Thermal energy generated by a geothermal heat pump will link to the existing air conditioning system to save electricity consumption. An air conditioning system utilizing the latest turbo refrigerator was recently installed in the administration building and additional surveys regarding collaboration and comparison between these systems will need to be conducted. Replacing the existing lighting with LED lighting will significantly promote the saving of electricity; adding a motion sensor to automatically turn off lights when no employees are present will also increase savings. As mentioned above, solar panels, geothermal heat pumps and high-efficiency lighting will improve electricity consumption, but the installation of BEMS will visualize changing electricity consumption. BEMS improves understanding of the details of the building's energy consumption and promotes further reduction of electricity consumption. BEMS can be used to draw up a usage plan promoting energyconscious attitudes among employees, and increase energy efficiency by utilizing the Plan, Do, Check, Act (PDCA) cycle.

3.1.5.3 Explanation of Each Item for Proposal

(1) Title of Proposal

Energy Saving System Utilizing Renewable Energy (Solar Power/ Geothermal)

(2) Content of proposal (detail description)

(a) Photovoltaics

Solar panels will be installed mainly on the roofs of parking lots.

The wirings from the installed solar panels are linked to junction boxes and electricity is transmitted to a substation for photovoltaics. In the substation, Power Conditioning Systems (PCSs) are installed to convert direct current (DC) of photovoltaics into alternating current (AC). In addition, a transformer to boost the power converted into the alternating current up to 4.16kV from 200V is installed. The power of photovoltaics converted into AC and boosted in the substation is sent to the existing distribution grid in Substation No. 7.

(b) Geothermal Heat Pump

A geothermal heat pump is a central cooling system that transfers heat to the ground. It uses the earth as a heat sink. The temperature in the ground below a certain depth is roughly equal to the mean annual air temperature at the surface. The geothermal heat pump utilizes the temperature difference between the underground and air.

A geothermal heat exchanger is buried under the front yard or courtyard of the administration building. The thermal energy obtained by the geothermal heat pump is connected to the existing Heating, Ventilation and Cooling (HVAC) system, or thermal energy is connected to a building equipped with a conventional HVAC system.

(c) High-efficiency Lighting

Existing lighting, such as incandescent light bulbs and fluorescent lamps in the administration building are replaced with high-efficiency LED lighting. The LED lighting is equipped with motion sensors that automatically turn off lights when no person is present.

(d) Building Energy Management System (BEMS)

Efficient and intelligent energy management in a building can bring considerable benefits. BEMS is a system to monitor and control the building's energy use. The system is capable of controlling and monitoring a HVAC, lighting or other facility. Real-time view into facility operations and deep trend analysis provide data-driven insight to optimize energy management strategies and minimize operational costs. Adapting BEMS in a commercial building in Japan has resulted in a maximum 20 percent reduction of electricity usage.

BEMS consists of an electricity meter, communication line and a computer. Power consumption by lighting is measured for each floor of the administration building. Communication lines to transmit power measured by electricity meters to the computer are laid in the administration building and, in order to transmit power generated by photovoltaics to the computer, a communication line is laid between the PCS and the computer. The computer is installed in the administration building, and the measured power is displayed on a monitor.

(3) Purpose/Expected Effectiveness

Renewable energy generation equipment (solar power/geothermal) is to be installed in an effort to save electricity produced by fossil fuel and reduce CO_2 emissions.

(a) Photovoltaics

Electricity from photovoltaics directly contributes to a decreased use of fossil fuel for electricity generation.

(b) High-efficiency Lighting

In Japan, it is reported that replacement of the conventional lighting with high-efficiency lighting has resulted in a 49 percent reduction of electricity usage. When 50 percent of the existing conventional lighting units in the administration building are replaced with high-efficiency ones, estimated 112MWh of electricity can be saved.

(c) Geothermal Heat Pump

Adapting geothermal heat pumps for use with conventional HVAC systems in Japan has resulted in a 50 percent reduction of electricity usage. In other words, the estimated reduction of electricity usage is 355kWh/m^2. However, comparable effectiveness may not be achieved in the SHARQ administration building since the latest type of centrifugal chiller has been installed. It is recommended that tthermal energy from the geothermal heat pump be utilized in other buildings that use a conventional HVAC system (e.g. reception building).

(d) BEMS

It is also reported that visualization of electricity usage through BEMS resulted in 20% reduction of electricity usage in Japan.

Table 3.1.5-1 summarizes the effectiveness per year for each item. Effectiveness of geothermal generation is not included for the reason what was mentioned in 4.3 (3) (c).

Table 3.1.5-1 Estimated Effectiveness (per year)

Item	CO_2 emission (ton)
Photovoltaics	2,678
High-efficiency lighting	85
BEMS	908
Total	3,671

(Source: OCG JICA Study Team)

Contribution to SHARQ Sustainability Program

The total electricity saving to be achieved by implementing all the proposed projects is equivalent to approximately 79 percent of the annual electricity usage in the administration building. This means that CO_2 emissions can be reduced by 79 percent. This reduction can be counted as part of SHARQ's Sustainability Program target of a 25 percent reduction in CO_2 emissions by 2025.

Contribution to Business Continuity Planning

Natural disasters, exceeding assumption incident, or other incidents may stop the flow of electricity from SEC, but , the administration building is able to continue operation by using electricity supplied from photovoltaics in daytime.

Contribution to encouraging energy-saving awareness of SHARQ employees

BEMS will realize monitoring/visualization of electricity consumption and store electricity consumption profiles for future analysis. In addition, PDCA should be implemented. Human resource development will also be necessary to promote PDCA from top management to all employees. BEMS can be a powerful tool for human resource development in the field of energy saving. Periodical and detailed analysis leads to ideals and proposals for further improvement of energy usage and results in tangible energy saving, which is evident from many cases in Japan.

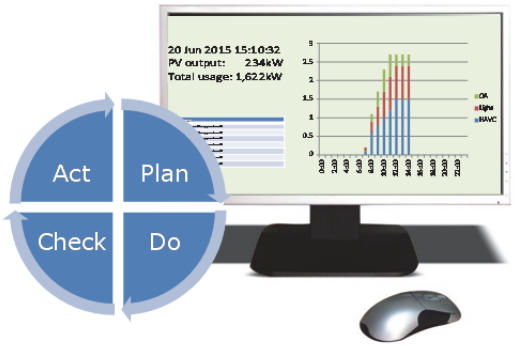


Figure 3.1.5-3 Sample Screen of BEMS

(Source: OCG JICA Study Team)

(4) Initial Cost

Table 3.1.5-2 shows the initial cost of each proposed item.

Table 3.1.5-2 Initial Cost of Each Item

Item	Cost (SAR)
Photovoltaics	
High-efficiency lighting	
BEMS	
Total	13,974,600

*1: Half of the lightings in the administration building, assuming that each unit is 80W

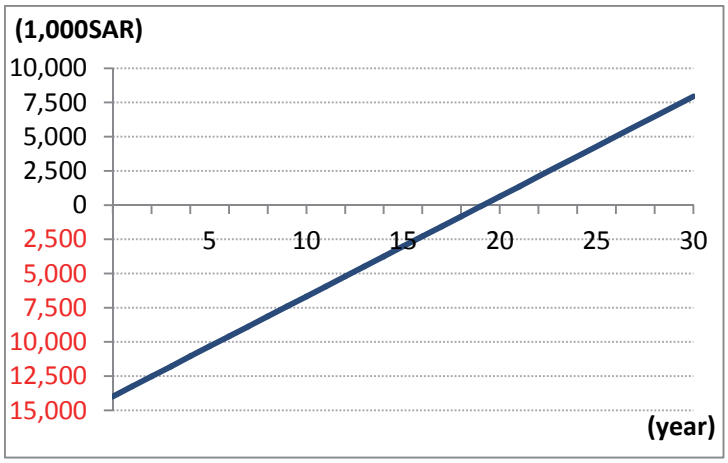
(Source: OCG JICA Study Team)

The return on investment is estimated in several cases as follows.

Case-1: Payback period due to electricity saving (on the basis of electricity prices in Saudi Arabia)

Based on the information about electricity prices in Saudi Arabia provided by SHARQ, electricity saving, and the initial cost, the expected payback period is 20 years.

Payback period = (Initial cost / Saving in electricity price)



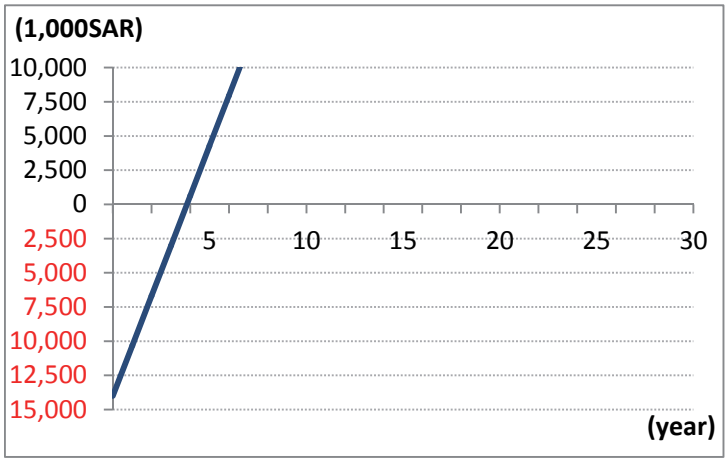
(Source: OCG JICA Study Team)

Figure 3.1.5-4 Investment-Return Estimation (based on electricity price in Saudi Arabia

When the Joint Crediting Mechanism scheme described below is applied, the initial cost can be 50 percent reduced and the payback period can be estimated at 10 years.

Case-2: Payback period due to electricity saving (on the basis of electricity price in Japan)

In case electricity price in Japan is applied, the expected payback period is 4 years.

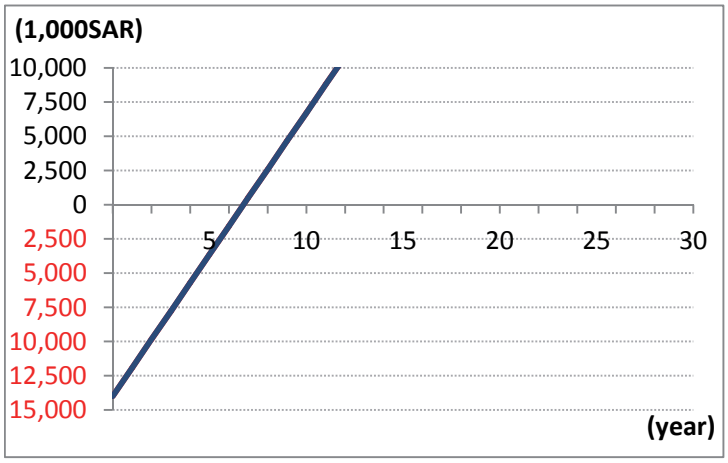


(Source: OCG JICA Study Team)

Figure 3.1.5-5 Investment-Return Estimation by electricity price in Japan

Case-3: Payback period due to electricity saving (by crude oil equivalent)

Energy saving can be explained as reduction of opportunity loss for fossil fuels consumed in power plants. According to crude oil equivalent, the expected payback period will be 1/2.8(*) of that in considering electricity price, that is, 7 years.



(Source: OCG JICA Study Team)

Figure 3.1.5-6 Investment-Return Estimation by Crude Oil Equivalent

* Crude oil equivalent; Price of electricity purchased from SEC and price of crude oil to generate the same amount of electricity are as follows.

Crude oil to generate electricity: 1.6 barrel / MWh

Crude oil price: 262.5 SAR / barrel

Crude oil price: 420 SAR / MWh (= 1.6 x 262.5)

Electricity price: 150 SAR / MWh

Price ratio (crude oil/electricity): 2.8 (= 420 / 150)

(5) Implementation Schedule

Table 3.1.5-3 shows the schedule for implementing the proposed projects, whichis divided into several phases. The whole schedule will take approximately eighteen months.

Table 3.1.5-3 Implementation Schedule

Item	Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Photovoltaics	Initial Site survey for implementation																		
	Basic design and 2nd site survey																		
	Detailed design																		
	Construction																		
Geothermal heat pump	Initial Site survey for implementation																		
	Basic design and 2nd site survey																		
	Detailed design																		
	Construction																		
BEMS	Initial Site survey																		
	Basic and detailed design																		
	Construction																		
High-efficiency ligting	Initial Site survey																		
	Basic and detailed design																		
	Construction																		

(Source: OCG JICA Study Team)

(6) Action for the next step

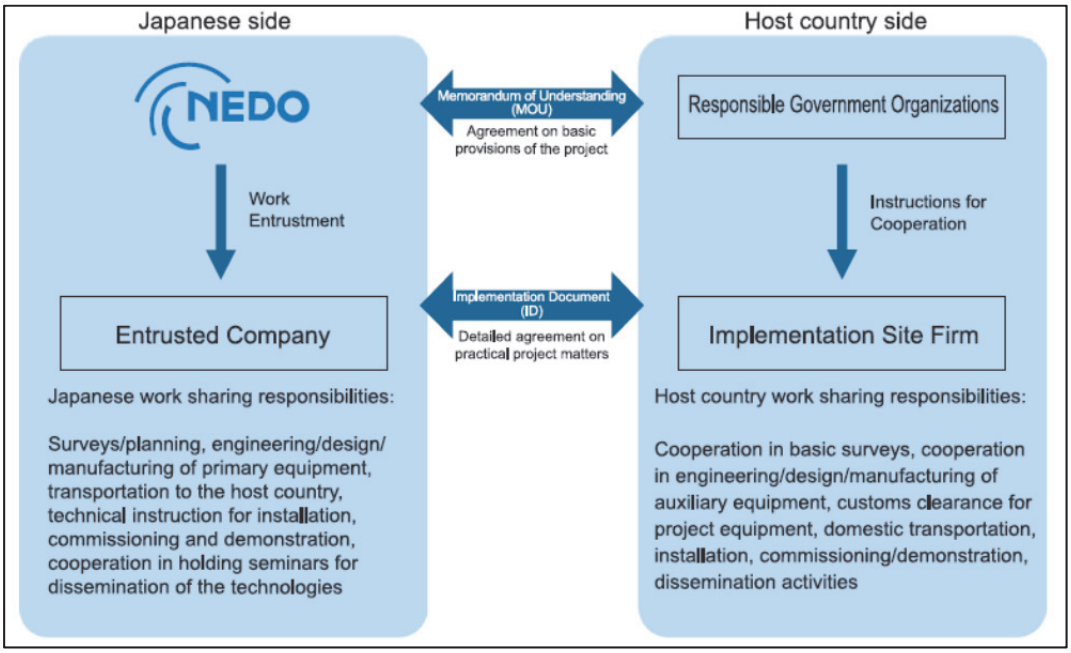
The JICA study team considers detailed survey and feasibility study on the proposed project to be required actions for the next step.

As a concrete step, JICA and its consultant team suggest that the possibility of utilizing support schemes of the Japanese government be considered for the proposed project, provided that it is approved and selected for the support schemes, for example “International Project for Increasing the Efficient Use of Energy (Ministry of Economy, Trade and Industry)” and “Joint Crediting Mechanism (JCM) Feasibility Study (Ministry of Economy, Trade and Industry, New Energy and Industrial Technology Development Organization and Ministry of Environment)” (see appendix for more information).

The entire study cost and up to 50 percent of the initial investment cost will be financed by using the support schemes of Japan. JICA is willing to provide cooperation and assistance for SHARQ in connection therewith.

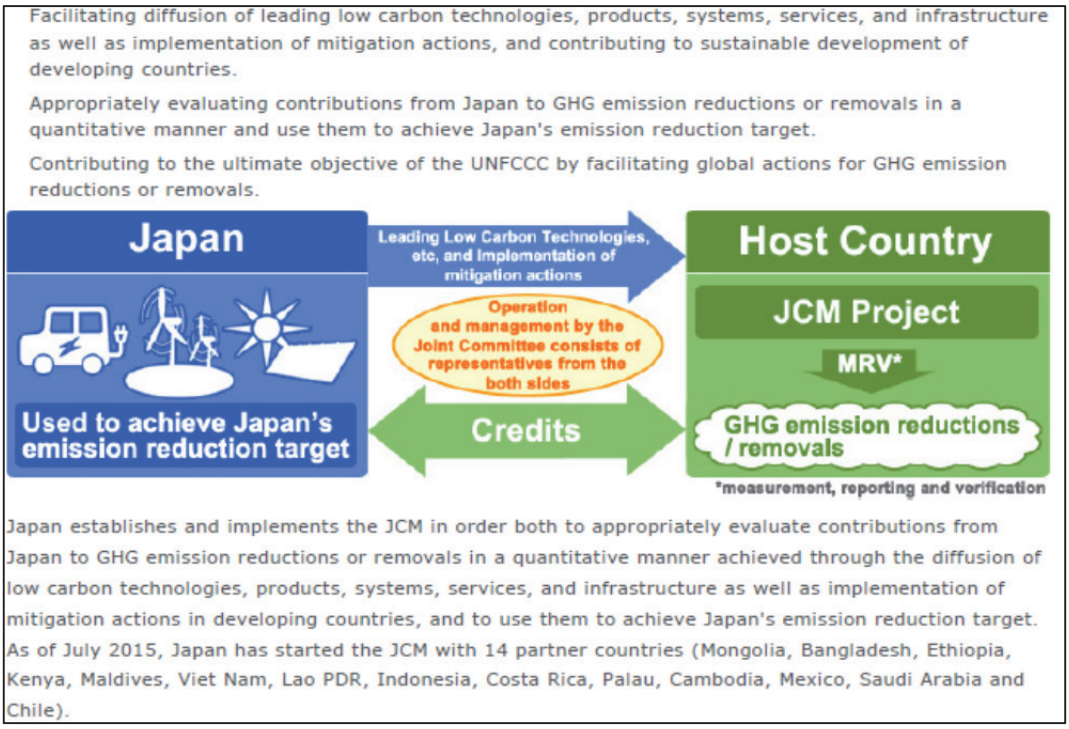
Appendix

- International Project for Increasing the Efficient Use of Energy (Implementation Concept)-



(Source: New Energy and Industrial Technology Development Organization (NEDO), http://www.nedo.go.jp/english/publications_brochures_index.html)

-Basic Concept of the Joint Crediting Mechanism (JCM)-



(Source: New Mechanism Platform, http://www.mmechanisms.org/e/initiatives/jcm.html)

3.2 AR-RAZI

3.2 Research on Infrastructure Improvement and Human Resource Development Programs for Stable Business Continuity and Productivity Enhancement of AR-RAZI

3.2.1 Education (Japanese-style Management)

3.2.1.1 Background of Research and Outline of Final Proposal

In order to prepare a proposal for Japanese-style human resource development program for AR-RAZI, during the preliminary research stage from November 2014 to January 2015, the JICA study team ("Study Team") identified a wide variety of programs that were potentially applicable to the company. Then, when the Saudi participants, including those from AR-RAZI, visited Japan for the study tour in January, the Study Team arranged various site visits to show them the actual sites of Japanese-style management implementation as well as its tangible effects, along with a lecture on the same theme. The Saudi members visited such companies as Toyota Motor Corporation, Sekiso Corporation (plastic molding company), and Chubu Electric Power Co., Inc. The participants not only got a strong impression from technological capabilities of Japanese companies but also were able to confirm that technological development and day-to-day operation were closely related to Japanese-style management as well as Japan's original operation approach for manufacturing plants.

During the second field study in February 2015, the Study Team once again presented key features, effects, and examples of educational programs about Japanese-style management and operation to AR-RAZI members so as to facilitate their understanding and evoke their interest. Subsequently, from March to May 2015, considering AR-RAZI's current situation and problem consciousness, which were confirmed through the dialogue during the second field study, the Study Team prepared a proposal for the training curriculum as a long list of total 140 days and 48 subjects that were considered appropriate for the company. The proposal was submitted to AR-RAZI via email prior to the third field study in June 2015.

The Study Team exchanged opinions with AR-RAZI members based on the program proposals in advance and narrowed them down to a short list according to applicability to and actual needs of AR-RAZI. As a result, the Study Team and AR-RAZI members came to share the recognition that it would be effective to invite AR-RAZI employees to Japan to additionally present and propose technologies and management approaches unique to Japan in the form of afield study. At the same time, the Study Team decided to include programs that would help AR-RAZI to solve operational problems as well as those unique to Japan, such as 5S, KAIZEN, and discipline.

After the meeting, the Study Team organized the programs into the following seven courses and submitted to AR-RAZI in August 2015. In September, the Study Team reached an agreement with AR-RAZI during the workshop conducted jointly with the company.

Furthermore, the proposal contents were presented to SABIC as well, whose consent was given during the fourth field study.

Course 1: Japanese-style Management Case Study Program in Japan for Senior Managers
Course 2: Japanese-style Management Case Study Program in Japan for Managers
Course 3: Managers' Role Recognition Program
Course 4: 5S Program
Course 5: KAIZEN Program
Course 6: Discipline Program
Course 7: Japanese-style Management Program in Jubail

Although AR-RAZI has been in an effort to increase productivity by applying various approaches, the methods that have demonstratedenough evidence of effectiveness are primarily those widely adopted in Europe and the U.S.. On the other hand, Japanese-style management is still to prove effectivenessin the country. As the Western-style management training usually consists of the conventional educational styles, it is different from Japanese style, which focuses on an OJT that provides trainees with an opportunity for learning and growth through field-base, practical work. In this recognition, the Study Team has prepared a list of programs which were unique to Japanese style management and manufacturing control, such as role recognition, KAIZEN, and discipline, as a result of the dialogues with AR-RAZI. It is expected that, through future discussions, Japanese-style management is adopted as part of AR-RAZI's human resource development programs, which would lead to a visible effect.

Moreover, in prior to the fourth field study, SABIC made contact with the Study Team and expressed their interest in Lean Production System. Thus, the Study Team presented major methods used for the system (e.g. 5S, 7 types of waste, visual management, daily management and changing point management, Kanban, and value map), introduction examples, and a simulation exercise. SABIC expressed interest and noted that they would like to examine the possibility of introducing the system to AR-RAZI and SHARQ as model enterprises. It is therefore considered to be a good idea to materialize human resource development programs that incorporate Lean Production System as the starting point, while discussing the feasibility of the aforementioned 7 courses in the future.

3.2.1.2 Content of Study

(1) Preliminary work in Japan (from November 2014 to January 2015)

1) Preparation of the study tour in Japan

The Study Team planned a study tour that took place in January 2015 in which 2 personnel from AR-RAZI participated.

i Selection of topics and preparation of materials and questionnaires for a lecture about Japanese-style management during the study tour

ii Selection of sites for visited and arrangements of field tours that showcase Japanese-style management and operation during the study tour. The following sites were included in the final list:

- Toyota Motor Corporation/ Motomachi Plant
- Toyota Motor Corporation/ Toyota Kaikan Museum
- Sekiso Corporation/ plastic molding company
- Central Japan Railway Company/ SCMAGLEV and Railway Park
- Chubu Electric Power Co., Inc./ Central Load Dispatching Center
- Chubu Electric Power Co., Inc./ Kawagoe Thermal Power Station

2) Implementation of the study tour in Japan

The following tasks were carried out during the study tour that took place in January 2015:

i Lecture on Japanese-style management
ii Preliminary study of participants' interest in Japanese-style management
iii Site visits
iv After-tour study of participants' interest in Japanese-style management at the end of the tour

As a result of the studies described above as well as interviews with the participants, their areas of interest were confirmed as follows:

- Strategic management, including "Breakthrough thinking"
- KAIZEN and waste eradication
- Japanese-style human resource development
- Organizational design and systematization
- Leadership and motivation
- Management system design
- Toolkits for quality and productivity improvement
- Company-wide improvement activities, i.e. Total Quality Management, Total Productive Maintenance and Lean Production System

(2) Second field study (from February 2 to 16, 2015)

1) Focal points of the AR-RAZI study during and after the second field study

With respect to an interview mentioned in the inception report, the AR-RAZI side picked up four core members of the management system and arranged two-hour long

interviews with each one of them. The focal points of the study, including the interview, are listed below. While a. and b. were covered during the second field study, c. and d. were conducted during the third and fourth field study, respectively.

a. Human resource development through job analysis
The role of a manager in developing human resources related with job description, competency evaluation and promotion system was researched.

b. TQM as management system
The Study Team examined the structure of TQM, which SABIC had introduced to AR-RAZI, to identify the way of implementation and the degree of contribution to corporate performance. However, the actual study was postponed to the third field study.

c. TPM
Though the Study Team was planning to study how and to what extent TPM in the petrochemical plant was implemented, together with overall equipment efficiency (OEE), 5S, scheduled maintenance, and preventive maintenance, but the actual study was carried over to the subsequent field studies.

d. Lean Production System
The Study Team studied what kind of benefits Lean Production System would produce for the petrochemical plant. The actual study was then carried out during the subsequent field studies.

2) Interview findings

- The company has global competitive advantage in terms of QCD and production volume.
- AR-RAZI's management system is SABIC's TQM system, which incorporates business objectives.
- Although AR-RAZI implemented Japanese-style TPM, they quit after one year and decided to switch from Japanese to Western-style of TPM.
- As for human resource development, various programs are applied, including OJT for entry-level employees and other training programs for technicians, managers and senior managers, respectively. Based on the managers' way of thinking, development of subordinates means encouraging them to participate in seminars and they play little emphasis on development of subordinates through their job.
- The company utilizes a framework to evaluate employees based on personal achievement and value, but it might be unreasonable to apply it to all the employees.
- It is unclear how the following 4 points of SABIC's value are implemented:
  - Empowerment by training and leadership skill

- Curious, Challenge conventional thinking
- Seeking new way to uncover opportunities
- Developing extraordinary breakthroughs

3) Study of Management System

The outline of the management system of AR-RAZI is described as below:

a. Organizational hierarchy

- Staff
- Line (e.g. general manager, senior managers, managers, engineers, superintendents, and specialists)

  Under control of a general manager, HRD and EHSS are positioned with responsibilities and authority for recruitment, trainings, and safety.

b. Business Objectives and Business Objectives Performance

- For mid- to long-term and annual targets, senior managers establish KPIs for each department, confirming SABIC's policy and utilizing the balance score cards. Then, they make clear the responsibility of each department and set the targets after interdepartmental coordination. Business objectives consist of 90 control items managed with the balance score card. Managers control 50 items out of 90.
- The progress situation of each indicator is visualized on the PC monitors. Managers hold quarterly meetings to share their progress. With regard to the daily management, the achievements are color-coded and they have to consider how they can reach the unachieved targets.

c. Performance evaluation of Business Objectives

SABIC's assessment system of performance and code of conduct is shown below:

- Individual evaluation based on normal distribution (Talent Review Process)
- All the employees are evaluated on a 3-point scale of value and 5-point scale of performance.

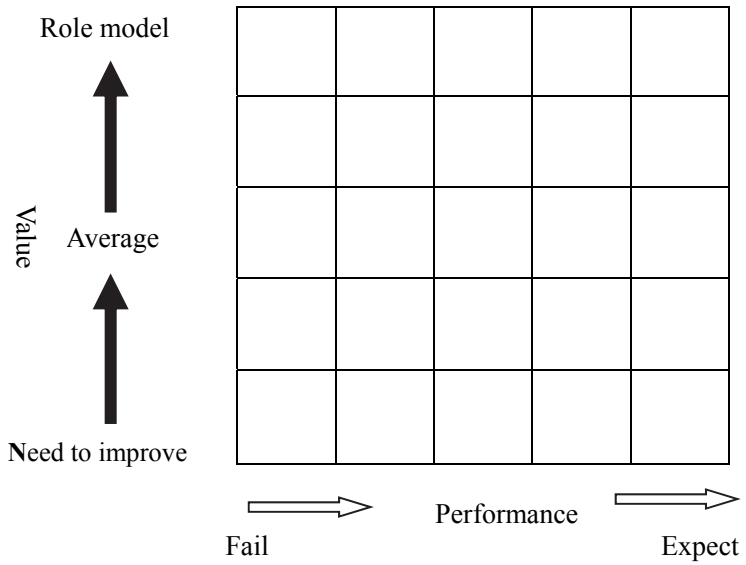


Figure 3.2.1-1 Value and Performance

(Source: JICA Study Team, CJIA)

The detailed description of the four values follows:

- Inspire
  - Winning attitude
  - Passionate approach
  - Empowerment by training and leadership skill
- Engage
  - Respect and Values differences
  - Commitment and understanding
  - Connect SABIC to Community
- Create
  - Curious, Challenge conventional thinking
  - Seeking new way to uncover opportunities
  - Finding innovative solutions
- Deliver
  - Developing extraordinary breakthroughs
  - Focus on flawless execution
  - World class environmental responsibility, health and safety

d. Human Resource Development

The human resource development programs implemented by AR-RAZI are as follows:

- Newly Hired Employee
- BOTP（Basic Operating program）/EHSS→JTQ/Monitoring/IDP/In house training

- OJT
- Training Plan Presentation
- SHEM in house training
- JQP (Job Qualification program)　Total qualification operator
- Emergency Rescue training
- Simulation training
- Development program at MGC factory in Japan
- IDP（Individual　develop program）　TRACCESS
- Exchange of Knowledge
- SUCSESSION PLAN
- SEeD
- CAT Competency Analysis
- Others　6Σ,Conflict management, 7 Habits

4)　Feedback to AR-RAZI based on the Interview and Study Findings (February 12, 2015)

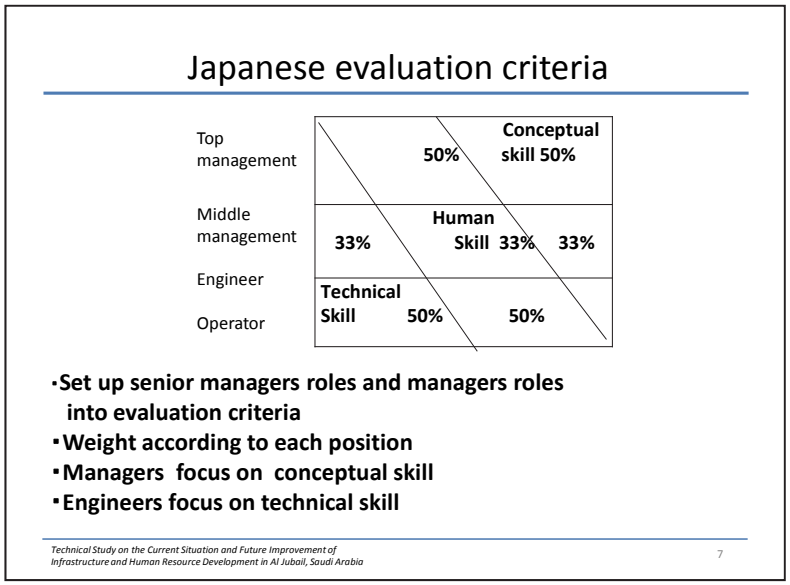
The Team provided feedback on interview findings to the AR-RAZI attendants. At the same time, supplement explanation about the Japanese-style management was provided. The details follow:

a. Comments and explanation about the role recognition program

The Team explained the importance of achieving results through recognition and implementation of managers' roles as well as the significance of methods of evaluating managers' competency and performance. Then, the Team stated that it would be necessary to assure the following points with senior managers and managers based on SABIC's measurement of value and performance:

- Mission of the department and managers' roles
- Contribution to enhancement of customer satisfaction and global competitive edge
- Breakthrough of current obstacles and its reflection to the performance
- Way of collaboration with other departments
- Way of developing subordinates through their job

AR-RAZI's management system and human resource development programs are well-structured, but it is still questionable to what extent the managers' roles are implemented and results are brought. Moreover, mentioning that managers' most important evaluation criteria should be conceptual skill while operators and technicians need to focus on technical skills, the Team presented Japan's approach to evaluation criteria (Figure 3.2.1-2). Thus, the Team determined to include managers' role recognition program in the proposal.



(Source: JICA Study Team, CJIA)

Figure 3.2.1-2 Japanese Evaluation Criteria

b. Presentation of 5S and discipline programs

While AR-RAZI has a great collection of training programs for managers, there are limited opportunities for the on-site level. It is recommended to consider training programs that stimulate a company-wide attempt to reform specialists' and operators' behavior instead of some sort of mental training.

c. Case study of Japanese companies

The Team also suggested visits to and case studies of Japanese companies achieving superior performance.

(3) Second-phase of Work in Japan (from March to May 2015)

Analyzing the results of the second field study, the Team reorganized the educational programs into 48 items to be proposed to AR-RAZI during the following field study, based on the company's current situation and problem consciousness. Then, detailed contents, duration, target, and expected effect of each program were compiled in a long list, along with verification examples in Japan. This list was emailed to AR-RAZI in prior to the third field study.

(4) Third Field Study (from May 26 to 28, 2015)

During the third field study, the Team carried out the 5S evaluation as well as research of the degree of interest in the Japanese-style management programs listed below, including

continuously researched items from the previous field study.

1) AR-RAZI's Response to the Long List

The Team explained to the AR-RAZI members the structure, training methods and contents of each program along with the previously submitted long list and clarified their areas of interest. Their major responses were as follows:

- Breakthrough thinking was highly evaluated as a method of concrete development because SABIC focuses on breakthrough as one of the most important values.
- AR-RAZI has never executed any type of business simulation program. Marketing programs are conducted by SABIC. However, both of AR-RAZI and the Team reached agreement that it was very important for managers to understand whole business mechanism and acquire fundamentals of finance.
- Business start-up simulation attracted an interest, including conflict management and the 360-degree assessment.
- AR-RAZI also showed their interest in 5S so that the Team suggested implementing the discipline program through 5S activities and obtained consent from the AR-RAZI members. Also, both sides agreed that the training method of 5S would be determined based on the result of the 5S evaluations to be conducted on May 28.

On the other hand, the items that did not catch their interest or those which the Team could not confirm effectiveness to AR-RAZI were as follows:

- Organizational design and payment system are already well-organized by SABIC but the performance indicators have room for improvement.
- TQM has been established as SABIC's management system. 90 KPAs are employed and the stage of completion is managed by the computer as part of visual management.
- OEE of TPM reaches between 95 and 98%. The MTBF is calculated and the PM analysis is executed.
- Regarding Lean Production System, it would be necessary to study as one of the business models but they do not have any future plan to incorporate it.

2) 5S Evaluation

5S evaluations were conducted concerning equipment, devices, tools and the inspection tools in mechanical department, all of which form the foundation of 5S. The score was 23/100 points. The major findings are as follows:

- The locations of only a small part of tools are indicated.
- Multiple tools are mixed up in one location.
- Name and quantity of tools are not indicated on tool boxes.
- As tool boxes are not tidy enough to confirm whether any tools are missing.

- There are flaws in the equipment management.
- Individual tool boxes of bicycles are also not well-organized.
- Only one operator works on cutting equipment and was not in operation when the Team visited. The Team cannot help wondering how they train successors.

The score is low, but great effectiveness would be achieved if AR-RAZI employees could reveal hidden problems through implementation of 5S activities.

3.2.1.3 Final Proposal

(1) Proposal for training programs

As a result of the third field study, the final proposal to AR-RAZI was made as shown below, based on the proposed long list. With regard to Lean Production System, the Study Team proposes consulting service to facilitate its implementation.

Table 3.2.1-1 Final Proposal of Training Programs

Course Title		Participants	Location
Course 1	Japanese-style Management Case Study Program	Senior managers	Japan
Course 2	Japanese-style Management Case Study Program	Managers	Japan
Course 3	Managers' Role Recognition Program	Managers	Jubail
Course 4	5S Program	Supervisors	Jubail
Course 5	KAIZEN Program	Supervisors	Jubail
Course 6	Discipline Program	Supervisors	Jubail
Course 7	Japanese-style Management Program	Managers	Jubail

(Source: JICA Study Team, CJIA)

(2) Proposal for consulting service on Lean Production System

It is proposed that, at the start,senior managers and managers visit Japan to familiarize themselves with the Japanese style management including Lean Production System. Then, they formulate grand designs and action plans in the next five years that contribut to creating value and safety, quality and productivity improvements, considering 5S, Kaizen, Discipline, Lean Production system and global SCM (supply chain management). Meanwhile, if it is necessary to officially introduce Lean Production System, consulting service will be proposed. It is recommended to organize a full-time project team of Lean Production System, to design a

project promotion schedule, to estimate costs, and to receive consulting service on a monthly basis.

	Training Program	Days for a year	2016	2017	2018	2019	2020
1	Training Program for senior managers	Training 12 days					
	Training Program for managers	Training 29 days					
2	Manager's Role Recognition ・Business starting up simulation ・Breakthrough thinking	Training 4 days Follow-up 2 days					
3	5S Program in company-wide	Training 2 days Follow-up 3days					
	KAIZEN Program	Training 2 days Follow-up 3 days					
4	Discipline Program	Training & Follow-up 7 days					
5	Japanese Management in KSA	Training 25 days					
	Lean Production System (TPS)	TBD					

(Source: JICA Study Team, CJIA)

Figure 3.2.1-3 Schedule of Training Program

Table 3.2.1-2 Approximate Expense of Training Program

(Monetary unit: 1,000 Saudi Arabian Riyal)

Course No.	1	2	3	4	5	6	7
Duration (days)	12	29	Note 1	Note 2	Note 3	Note 4	25
Number of participants	12	12	12	12	12	12	12
Course fee	106	255	144	294	197	182	324
Travel expense for trainees	474	661	---	---	---	---	---
Travel expense for trainers	---	---	113	145	102	100	140
Local travel expense	18	24	7	16	16	15	13
Miscellaneous expense (e.g. textbooks, lecture room)	23	36	7	7	7	7	7
Coordination fee	32	79	18	36	36	36	79
Administration fee	13	32	13	27	27	27	32
Subtotal	666	1,087	303	525	385	367	595
Consumption tax (8%)	53	87	24	42	31	29	48
Total	**719**	**1,174**	**327**	**567**	**416**	**396**	**643**

(Source: JICA Study Team, CJIA)

Note 1: Japanese consultants visit Jubail 3 times during 6 months to hold a total of 6 days of lecture.
Note 2: Japanese consultants visit Jubail 4 times during 6 months to hold a total of 5 days of lecture
Note 3: Japanese consultants visit Jubail 3 times during 6 months to hold a total of 4 days of lecture.
Note 4: Japanese consultants hold 7-day lecture and measure the impact within 6 months.

Since the Study Team is requested to lead the establishment of 5S and KAIZEN at production site, in the case that there is a need for preliminary meetings. In such case, additional costs may be charged.

3.2.2 Safety Management / Security Planning

The survey and analysis of this field were conducted from a standpoint of management. Having recognized that the Safety, Health and Environment Management (SHEM), which SABIC has promoted at its affiliate companies, through advance information gathering, we consider focusing on SHEM to be the best in this field and have developed the survey and analysis on SHEM into proposals.

3.2.2.1 Survey Results

(1) Outline of findings

With operation at all of the affiliates taken into consideration, SHEM has been well developed by covering an entire range of elements relating to risk management. The IT infrastructure to support the system is maintained at high levels. All interviewees on the survey were found to accept SHEM as an "excellent" system. According to them, no items require an immediate action.

A high rating can be given in terms of SHEM as a whole. However, individual interviews on SHEM elements revealed a significant number of managers and other responsible people of the system consider constructive approach to improve the system and the implementation aspects of each element. Picturing the ideal condition of each element helps recognize a gap between the ideal and current status. Analyzation of the cause of the gap and implementation of appropriate countermeasures against it are effective for making improvements. In addition, the comparison between your efforts for risk management and the general Japanese way of improvement helped recognize a certain level of difference. Further effects can be expected when the merits of both ways are suitably combined.

Analysis of this survey and major inputs into the proposal are summarized below. Judging them in a comprehensive manner, the proposal is to be described.

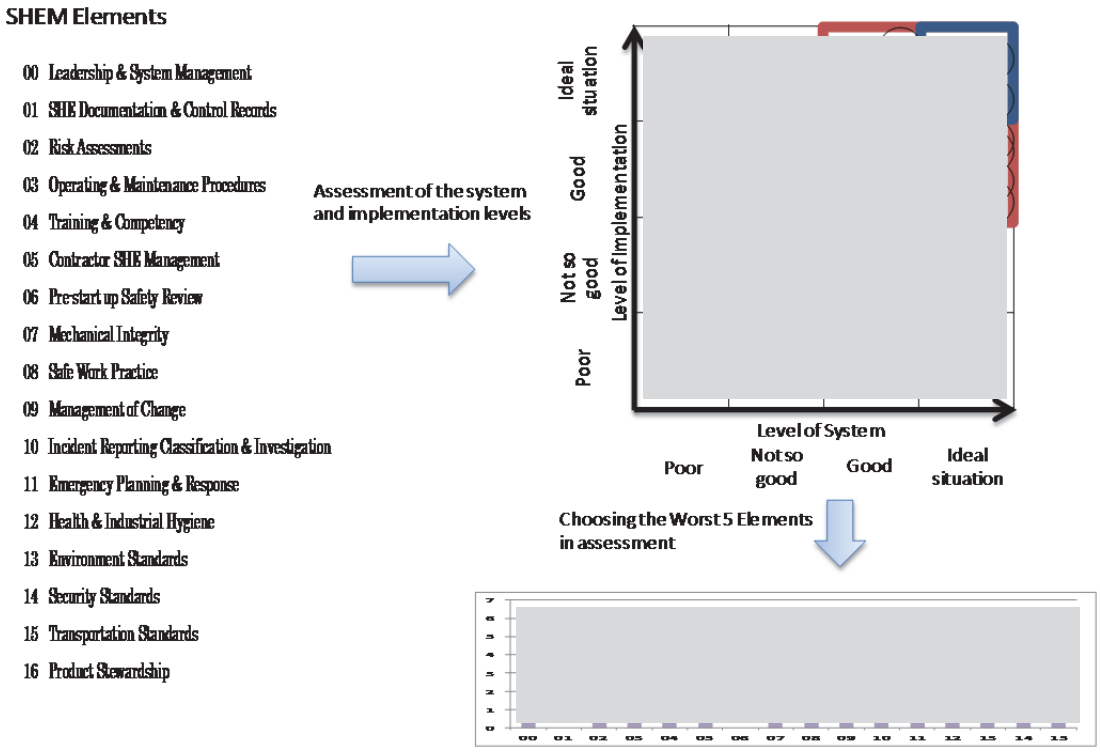
a) Our experiences and concepts in terms of risk management consulting in Japan
b) SHEM-related items
   - Survey on SHEM elements
   - Documents related to SHEM
   - Interview with EHSS Dept. Managers and others in charge of it
c) Others
   - Interview with senior managers about the survey on education (Japanese Method of Management) (including the survey related to SHEM elements)
   - Meetings with Japanese staff members
   - Company visits (Affiliated companies within Jubail Industrial City and related companies in Japan)

(2) Key points of findings

1) Survey on SHEM elements

In terms of the system and implementation aspects of SHEM elements, two managers and seven other responsible people were requested to assess their current status and give their opinions about any problems they may have. Their assessment is summrized in Figure 3.2.2-1 (top right). X and Y axes show the assessed system levels and implementation levels respectively. The plots in the blue box indicate that both their system and implementation levels are at ideal stages, while those plotted in the red box are judged to be good though there is still room for improvement. Those plotted outside of the red box reveal that effective improvement measures are strongly recommended. This result is understandable from the fact that this company is so active in the activity that it won a prize related to SHEM in the competition held among SABIC affiliates.

After their assessment of SHEM elements, the respondents were also requested to choose their worst five elements, the result of which is shown in Figure 3.2.2-1 (bottom right). "02 Risk Management" was chosen by 7 respondents, accounting for the higest percentage. Those who chose it have recognized that analyzing risks and upgrading the level of response to them in order to quest for a higher level of SHEM. Items 16 Product Stewardship was also mentioned often because they were recently added and drew attention from the respondents.



(Source: CJIA JICA Study Team)

Figure 3.2.2-1 Survey Results on SHEM Elements

2) Comparison of present risk management and Japanese method

Some differences between the current method for target achievement in the area of risk management and the generally applied Japanese method were found from this survey. Table 3.2.2-1 shows the key differences, which are summarized as follows.

- As for SHEM, SABIC and its affiliates have sufficient highly-professional staff members of Safety & Security, who independently support the worksites. In Japan, on the other hand, the worksite staff independently acts with the help of a small number of professional staff of Safety & Security.
- The well-arranged Off-JT in SHEM provides highly-professional training, while in Japan OJT is primarily used as it provides what worksite people directly need.
- When an unexpected incident occurs, SHEM focuses on prompt reporting to and optimal response by a specialist, while in Japan priority is placed on voluntary efforts to be made by workplace staff to prevent reoccurrence of the same incident.
- On assessment of appropriateness, internal and external auditing is regarded important by SHEM, while in Japan self-inspection at each workplace is regarded as important.

Table 3.2.2-1 Comparison of Efforts for Risk Management

		SHEM	General Japanese style
Safety & Security	Charac-teristics	Specialized section & a sufficient size of staff	A small number of staff
	Merit	Able to provide detailed support to worksites	Develop autonomy of work sites ⇒ Worksites strengthen their workplaces by introducing comprehensive measures of Safety & Security and others
Risk assessment	Charac-teristics	Support by EHSS Department	A main role played by worksites
	Merit	Less variation in risk analysis of each worksite thanks to the support by highly professional staff	Risk assessment focused on worksite tasks ⇒ Workplace Kaizen by employees there based on risk analysis with their current problems and past troubles taken into consideration
Human resource development	Charac-teristics	Off-JT as a center Good preparation of training courses	OJT of actual tasks as a center
	Merit	Acquisition of a wide range of expertise	Acquisition of skills necessary for actual tasks ⇒ Skill upgrading of instructors through instruction and worksite Kaizen while instructing
Response to an incident	Charac-teristics	Focus on report within a limited time	Focus on prevention of reoccurrence
	Merit	Speedy information sharing	Worksite Kaizen through prevention of reoccurrence
Assessment of appropriate-ness	Charac-teristics	(Internal/External) Auditing as a center	Daily self-inspection as a center
	Merit	Objective evaluation	Worksite Kaizen through speedy response to problems

1

(Source: CJIA JICA Study Team)

On the whole, staff with highly professional expertise of various fields plays a primary

role according to SHEM. In Japan, however, staff of each workplace independently carries out necessary activities. In this case, they make Kaizen by themselves in their own workplace by means of conducting the activities even if their expertise of various fields is not so high. Therefore, it is one of the characteristics of the Japanese style that any activity of worksite staff can lead to Kaizen.

3.2.2.2 Outline of the Study Team's Suggestion

(1) Essential features of the suggestion

The Study Team's suggestion is "Worksite Kaizen activities based on SHEM." The suggestion does not mean any change in the system of SHEM. It is to incorporate the concepts of Kaizen, a feature of the Japanese style management, into the SHEM activities whose level has been highly valued. The activity is designed to reduce the burden of EHSS Department and, without increasing their staff, encourage them to work on a new measure, promote 5S's activity and improve Safety, Quality, Cost, Delivery (SQCD) of the workplaces. It is unlikely to realize an immediate effect, while tangibleood results can be expected in the long run if the effort is continued on a sustainable basis. This activity will help build up a culture where field workers voluntarily practice make Kaizen at their worksites.

As an approach of Kaizen activities from the Safety and Security field, focusing on the following four themes is recommended in view of the findings so far and risk management elements.

1) Risk assessment

Worksite staff independently initiates and practices Kaizen at their workplace by identifying potential risks and taking measures against them with their daily problems and previous troubles taken into consideration, while receiving support from EHSS. It is possible to control risks closely allied to the worksites and make Kaizen in their own workplaces when the staff, preferably all the members, analyze risks with consideration of daily issues and past troubles through discussion and put their head together to hammer out measures.

2) Response to unexpected incidents

While reporting promptly on an unexpected incident, worksite staff voluntarily makes efforts to prevent its reoccurrence. Their imminent and chilling danger ("Hiyari-hatto") which fortunately did not cause any accident are supposed to be dealt with in the same way. On this occasion, if the staff, preferably all the members, participate in this activity, Kaizen will be made at the worksite..

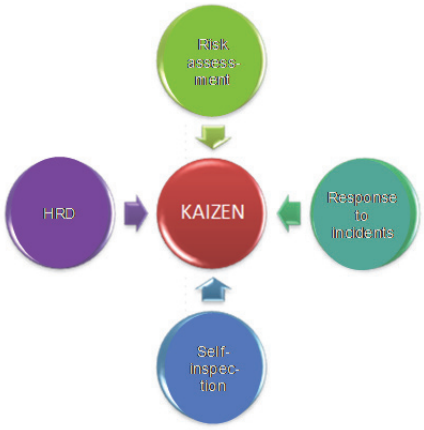
3) Self-inspection

In addition to taking corrective action against what was pointed by the auditor, the worksite staff should set up the points for self-inspection, such as items (including 5S's), frequency, conductors, and procedures for self-inspection, carry out the self-inspection, and take corrective actions. The enhancement of self-inspection makes timely corrections possible. Again, on this

occasion, if the staff, preferably all the members, participate in this activity, Kaizen will be made at the worksite.

4) Human Resource development

In addition to the current full-fledged Off-JT, OJT should be added so that HRD can be realized since the training similar to the actual tasks is available. This method would be applied to both EHSS Department and worksites. The workplaces actively adopt OJTs into their activities to make on-the-site Kaizen through 1) to 3) above. EHSS Department, on the other hand, can conduct OJT through assistance to the frontline by involving themselves in the process of 1) to 3) above of supporting workplaces. For example, 1) is an OJT to extract, focus, and develop measures to the risks. This method would enable instructors to develop their practice of teaching by themselves, to practice Kaizen within the workplace through the instructions and to realize the betterment of communication among those involved since managers or senior workers teach their subordinates or juniors in person.



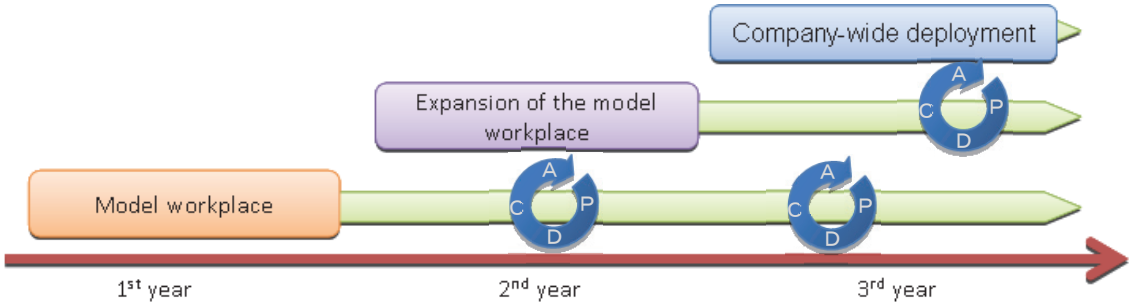
(Source: CJIA "JICA Study team")

Figure 3.2.2-2 Approaches to KAIZEN

(2) Support plan for activity

1) Activity plan

A three-year activity is recommended as shown in Figure 3.2.2-3. With the rule of running and completing a PDCA cycle once a fiscal year as a core, the activity is to be started with the establishment of a model workplace in the first year, followed by the expansion of the model workplace in the second year, and in the third year to deploy it across the company.



(Source: CJIA JICA Study Team)

Figure 3.2.2-3 3-year activity schedule

Figure 3.2.2-4 shows the activity schedule for the first year. In the first year, a model workplace activity should be promoted (a workplace with around 30 people working and EHSS Dept. staff).

		1	2	3	4	5	6	7	8	9	10	11	12
P	Measure planning on 4 themes	→	→	→	→	→	→	→					
D	Implementation of the measure								→	→	→	→	→
C	Check of implementation progress										→	→	
A	Correction of nonconformities											→	→

(Source: CJIA JICA Study Team)

Figure 3.2.2-4 First Year Activity Plan

2) Support plan

Support for the 1st year activity is suggested as following:

- On-the-spot supporting service by the consultant in charge
- Frequency of on-the-spot support
  - Visit to the site once in 1 to 2 months (Use of Web conferences at suitable timings)
  - Half-day supporting service x 5 days per visit
- Contents of the on-the-spot supporting service
  - Confirmation of performance progress and problem solution since the previous visit
  - Explanation of the work theme of this time and its trial
  - On-the-site observation of the model workplace and advice on Kaizen
  - Confirmation of the work contents to be performed by the next visit, etc.

(3) Objective of the plan

Not to implement any new additional system, but to implement Japanese Kaizen relating to safety by integrating with the existing system, such as KPI and SHEM.

(4) Proposed activities of the plan

- Promote awareness on safety to build safety culture throughout the AR-RAZI organization
- Promote Kaizen activities to be more preventive and involvement of workers
- Promote more automation and semi-automation including POKAYOKE

(5) First step of the plan

- Comprehend the existing system and decide the model workplace.
- Formulate the activity plan identifying necessary training

(6) Expected effects

The followings can be expected through this activity:

1) Upgraded operational level of safety and security

SHEM can be operated in a manner much closer to each workplace thanks to the combination of the established highly-professional support by EHSS Department and the independent efforts by the staff of each workplace.

2) Promotion of on-the-site Kaizen

All the four themes recommended here lead to the worksite Kaizen. Through the four themes, 5S can be promoted and improve SQCD can be improved.

3) Less burden on EHSS Department

Independent efforts made by each workplace will reduce the burden of EHSS Department. EHSS Department can devote itself to the improvement of quality of its tasks and to initate new actions or tasks without increasing the staff.

4) Ability development of workplace staff

When the current full-fledged Off-JT and well-prepared OJT at each workplace are strongly combined, the set ofabilities required by the tasks will be developed. Instructors are required to carry out a number of preparation activities for OJT, which will help develop them by themselves. While they conduct OJT, they can afford to pay attention to Kaizen points of the workplace.

5) Lower turnover rate of employees

The direct involvement of staff of each workplace in Kaizen activitieswithin their own place makes them feel attached to their workplace and their motivation becomes stronger. These experiences will lower the turnover rate of employees.

(7) Expenses

When two consultants in charge provide service for the first-year support, the approximate cost is estimated as follows.

Table 3.2.2-2 Cost Estimates

(SAR)

Details	Basis of calculation		Unit rate	Expenses
On-the-site support	9 times / year x (Half-day job x 5 days) / visit	45 days	15,000	675,000
Support on Web conferences	6 times / year x (Half-day job x 2 days) / visit	12 days	10,000	120,000
Traveling expenses	Flight tickets and others	9 roundtrips	54,000	486,000
	Accommodation expenses (9 times x 6 nights)	54 nights	2,400	129,600
	Allowance for moving days (9 times x 4 days)	36 days	3,000	108,000
Others	Support planning, report making, etc.	1 set	150,000	150,000
			Total	1,668,600

(Source: CJIA JICA Study Team)

3.2.3 Wastewater Treatment / Recycled Water

To study the proposals in the field of wastewater treatment / recycled water for AR-RAZI, the Study Team gathered general information about the company as part of a preliminary study from November to mid-December 2014 and tentatively selected priority items to be studied. During the first site visit, the Study Team learned about local conditions. Furthermore, based on the information obtained from AR-RAZI members who visited Japan for the study tour held in January 2015, the Study Team determined a general direction of the study.

During the second site survey in February 2015, the Study Team obtained information about water balance, water consumption, related facilities, operation and maintenance, etc. through discussion with the AR-RAZI management and the related parties. Considering such information and the current situation and issues found through the discussions as well as plant survey, the Study Team prepared a long list of candidate projects ("Long List") during the period from March to May 2015 and submitted it by email to AR-RAZI in June prior to the third site survey.

During the third site survey in June 2015, the Study Team exchanged opinions with AR-RAZI based on the long list, and selected reduction of dilution water by treatment for the wastewater as a proposed item. For further sudy for the proposed item, the Study Team conducted the wastewater analysis, site survey and confirmation of the basic concepts of the final proposals to be submitted to AR-RAZI through discussion with them about specifications and data relating to equipment and substation at site for selection of applicable technologies.

This chapter provides findings and recommendations as well as proposals by the Study Team from the viewpoint of contribution to AR-RAZI with respect to the water treatment and recycled water in line with the sustainability program which AR-RAZI has been implementing.

3.2.3.1 Outline of the Investigation

In order to get a whole picture of water use, the water balance was examined. Then, from a standpoint of water saving, the items described below were studied for the following purposes: i) reduction of industrial water dilution, ii) consideration of operational method of the demineralization facility, and iii) wastewater treatment.

(1) Water balance

To explore the possibility of water-saving and recycling at AR-RAZI, the water balance was examined to get a holistic view of water use and amount of consumption. The investigation was carried out based on the data provided by the company as well as a series of interviews.

(2) Industrial Water

With the view to study the possibility of reuse of waste water, the Study Team investigated the quantity and quality of drainage water. The way of research was analysis of the data provided by AR-RAZI, interviews, and water quality analysis. Particularly, at the hearing of the current situation (January 25, 2015) during the study tour in Japan, AR-RAZI raised the issue of the plant effluent.

(3) Demineralized facility

The Study Team examined the difference between the quality of potable water (PTW) and required quality of inlet water of demineralized water facility, and the capability of the demineralized water facility and time span of its regeneration so as to explore the possibility of water saving at the demineralized facility.

3.2.3.2 Survey Results

(1) Water supply

All the water for AR-RAZI is supplied by MARAFIQ based on the contracts between them. The supplied water is not classified into PTW and industrial water but the total volume is provided as PTW.

The maximum and minimum amount of usage are set in the contract. Even if the actual used amount is lower than the minimum, the company is supposed to pay the fee for the minimum amount.

(2) Water balance

Large part of water received from MARAFIQ is provided to the demineralized facility to be used in the production process. The rest is utilized as supplement for cooling water and drinking water as well as reserved for fire fighting use. Additionally, steam used in the process is recycled as condensate water. Wastewater is discharged to the IWTP.

(3) Industrial water

Industrial wastewater is collected individually from each plant, then, depending on the wastewater quality, each is discharged to IWTP.

1) Natural gas

AR-RAZI receives natural gas from ARAMCO.

2) Removal system for desolved material of wastewater

The following are general methods for wastewater treatment to remove desolved material of wastewater.

- Distillation method

- Stripping mothod
- Biological treatment

3) Thermometry of wastewater

Generally speaking, temperature has influence on biological process. As a result of research on the actual case in Jubail area, the highest average montly water temperature is 34.5℃(August) and the lowest is 24.9℃(January). And growth of bacteria determines success of failure of the biological process. Based on the academic data, the optimal temperature for the growth of bacteria is 35℃ and the growth rate at 45℃ is equivalent to the rate at 20℃. Therefore, bacteria is considered to be able to grow at 45℃. If temperature of water exceeds 45℃, there is a possibility of microorganism inactivation butit is unlikely that microorganisms are immediately destroyed. And it is possible that nitirc bacteria, which are high-temperature-resistant, grow preferentially. From the above, biological process is applicable at temperature as high as about 40℃.

3.2.3.3 Survey Results

AR-RAZI familiarizes itself with the entire water balance. The Study Team has realized that AR-RAZI could save water by reducing dilution water, though they have consumed large volume dilution water for wastewater treatment. The Study Team has proposed wastewater treatment method for reducing such dilution water. Since AR-RAZI is well aware of method of an efficient operation of deminelized water facility, the Study Team would like to recommend replacement of ion exchange resin having more exchange capacity.

As a result of the study, outlines of the proposals are as follows:

Table 3.2.3-1 Summary of Study Projects

	Study projects	Expected water saving	Cost estimate	Payback period
1	Wastewater treatment	90 m^3/h	Facility 29.5 mil. SAR Operation 5.7 mil. SAR	17 years
2	Operation optimization of demineralized water facility	Possible but remarkable effects are not expected	---	---

(Source: WRPC JICA Study Team)

3.2.4 Energy Saving

To study the proposals in the field of energy saving for AR-RAZI, the Study Team gathered general information about the company as part of a preliminary study from November to mid-December 2014 and tentatively selected priority items to be studied. During the first site visit, the Study Team learned about local conditions. Furthermore, based on the information obtained from AR-RAZI members who visited for the study tour in Japan held in January 2015, the Study Team determined a general direction of the study.

During the second site survey in February 2015, the Study Team obtained information about energy consumption, related facilities, operation and maintenance, etc. through discussion with the AR-RAZI management and the related parties. Considering such information and the current situation and issues found through the discussions as well as plant survey, the Study Team prepared a long list of 54 candidate projects ("Long List") during the period from March to May 2015 and submitted it by email to AR-RAZI in June prior to the third site survey.

During the third site survey in June 2015, the Study Team exchanged opinions with AR-RAZI based on the long list, and selected 14 items composed of pumps, compressors, boilers, trasformers, air conditioners, lighting fixtures, etc. as possible energy saving projects. Furthermore the Study Team confirmed the basic concepts of the final proposals to be submitted to AR-RAZI through discussion with them about specifications and data relating to equipment and substation at site for selection of applicable technologies.

Based on the above activities, the Study Team developed 13 energy saving related projects and submitted them as a draft proposal to AR-RAZI in August 2015. AR-RAZI and the Study Team discussed the proposed projects at the workshop meeting in September 2015, and eventually confirmed 14 projects as shown in Table 3.2.4-1. The Study Team also explained to SABIC about these projects at the meeting with SABIC, and obtained their consent.

3.2.4.1 Results of the Field Survey

AR-RAZI and the Study Team discussed the possible areas of energy saving measures indicated in the Long List submitted by the Study Team and carried out the plant site survey. As a result, the both parties reached an agreement on energy saving measures in the following facilities and equipment: (1) seawater cooling system, (2) rotating equipment including pumps and compressors, (3) boilers and steam lines, (4) transformers, (5) air conditioners and (6) lighting fixtures. Although maintenance for each facility has been periodically conducted and some equipment has been renovated, most of the equipment have remained since its inauguration. It is therefore considered possible to save energy by renewing facilities and improving the operation.

The Study Team explained to AR-RAZI about the result of the study for possible energy saving measures during the forth site visit, and eventually compiled the proposed projects incorporating comments by AR-RAZI as shown in Table 3.2.4-1.

Table 3.2.4-1 List of Proposed Projects

	Proposed items	Facility cost estimates	Annual cost saving
		1,000SAR	1,000SAR/y
1	**Rotating equipment - Seawater cooling system**		
	1) Introduction of VFD for SW intake pumps	1,400	400
	2) Introduction of VFD for SW primary circ. pumps	14,700	4,556
2	**Rotating equipment - Compressor**		
	1) Replacement of the lower efficient compressor with VFD compressor	4,000	113
	2) Proper adjustment of the setting pressure	0	23
	3) Air leakage prevention for P1 & P2	0	28
	4) Air leakage prevention for P3-5	0	1,926
3	**Boiler**		
	1) Diagnosis of trap operation and development and implementation of the modification strategy	Depend on situation	1,716
	2) Insulation of valves	500	285
4	**Transformers**		
	1) Relacement of old transformers with higher efficiency one	3,700	122
5	**Air conditioners**		
	1) Replacement with high-efficient equipment	17,400	626
	2) Protection of outdoor units from direct sunlight	48	52
	3) Appropriate room temperature setting	0	54
6	**Lighting fixtures**		
	1) Replacement of mercury lamp with LED lamp	60,700	2,297
	2) Installation of motion sencers for interior lighting	200	23
	Total	102,648	12,198

3.2.4.2 Summary of the Proposals

(1) Rotating equipment – In seawater cooling system (SWCS)

The plant utilities systems and facilities include a cooling cycle process with two types of SWCS application, i.e. plate-type heat exchangers (PLEX) where seawater is used as coolant, seawater cooling towers (SWCT). Furthermore, since some PLEX have not insulated, heat release loss could be prevented by covering PLEX.

Proposed project	1) Introduction of VFD for SW intake pumps

	2) Introduction of VFD for SW primary circulation pumps

(2) Rotating equipment – In compressors

Air pressure of compressors is set with a more than enough margin in consideration of pressure loss through the filters and the dryers. As a result of the on-site investigation, the air pressure was kept steady. If sufficient stability can be maintained, it will eliminate a need to set a margin and the pressure setting point thus can be reduced. In turn, reduction of pressure can promote energy saving. Furthermore, the compressed air is supplied throughout the plant through pipelines, which is why air leakage occurs frequently. Thus, energysaving can be accomplished through daily monitoring and prevention of air leakage.

Prospective projects	1) Introduction of VFDs to the compressors 2) Proper adjustment of the setting pressure 3) Air leakage prevention

(3) Boilers

High-pressure, middle-pressure and low-pressure steams are generated by boilers and are supplied for use by process equipment as well as utilities. With a number of steam traps in the plant, the volume of produced steam can be reduced by implementing comprehensive diagnosis of the operation (favorably once a year) as well as making a database of the diagnostic outcomes, and creating a mechanism to plan and carry out the modification strategy based on the database. As some valves for steam piping have not been insulated, it is possible to further save energy by insulating valves with thoroughness.

Proposed project	1) Diagnosis of trap operation and development and implementation of the modification strategy 2) Insulation of valves

(4) Transformers

Transformers are installed throughout the plant. The majority of them have been in use for more than 30 years since the commencement of the commercial operation of the plant, so that it is possible to save energy by replacing them with new transformers with higher efficiency.

Proposed project	Replacement of old transformers with higher efficiency ones

(5) Air conditioners

Most of the outdoor units are located on the roof and are subject to insolation. Installation of shadings is expected to make a positive impact on energy conservation. the SABIC guideline requires the room temperature to be set at adequate levels, but the actually set temperature is lower than that in the guideline. Strict enforcement of the temperature setting is thus expected to promote energy saving.

Proposed project	1) Replacement with high-efficient equipment 2) Protection of outdoor units from direct sunlight 3) Appropriate room temperature setting

(6) Lighting fixtures

Downlight fluorescent lamps and straight tube fluorescent lamps are used in the administration building, etc. and they use reflective plates to be more energy effective than incandescent lamps. On the other hand, since a lot of mercury lamps are used throughout the plant, the company can save more energy by changing the existing lamps to LED and/or metal halide lamps. Moreover, installation of motion detectors makes it possible to take advantage of its automatic turn-off feature and turn on minimum lightings, which can lead to further energy conservation.

Proposed project	1) Replacement of mercury lamp with LED lamp 2) Installation of motion sensors for interior lighting

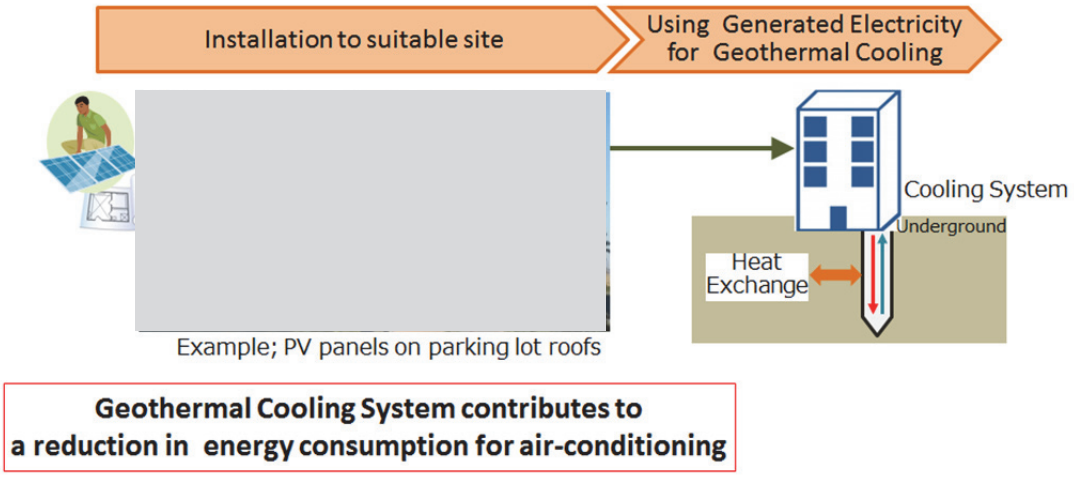
(7) Others

Windbreak rooms are furnished at the entrances of building to control the load of air conditioners by cutting outside air. Double pane window glass is in use. With approximately 10m of hollow layer, such windows prevent heat from breaking in from outside the buildings. At restrooms, aerator and auto flush seats are furnished. Generally speaking, basic energy saving measures have been taken.

3.2.5 Renewable Energy/Solar Power Generation

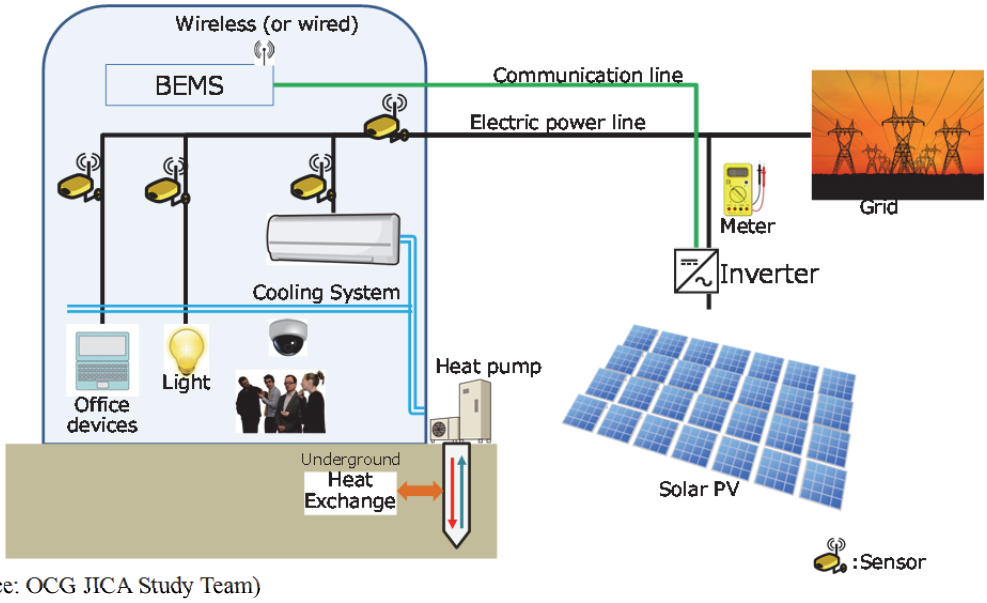
3.2.5.1 Summary of Survey Results

We have proposed the installation of solar panels on parking lot roofs and geothermal cooling systems (Figure 3.2.5-1). Through discussion, it was decided to install a Building Energy Management System (BEMS) that utilizes solar panels and geothermal energy in administration buildings, as shown in Figure 3.2.5-2.



(Source: OCG JICA Study Tem)

Figure 3.2.5-1 Proposal for solar panels on parking lot roofs and cooling system



(Source: OCG JICA Study Team)

Figure 3.2.5-2 BEMS efficiently utilizes solar panels and geothermal energy

3.2.5.2 Summary of Proposal

One quarter of oil produced in Saudi Arabia is consumed within the country, and domestic consumption is rapidly growing due to an increasing demand for electricity. It is suggested that the country may change from a petroleum exporting country to a net importer by 2038. In light of such trend, urgent development of renewable energy sources (in particular, photovoltaics) is called for to reduce domestic consumption of fossil fuels led by oil and natural gas. Moreover, it is important to not only develop renewable energy sources, but also utilize energy efficiently as part of national policy. AR-RAZI also aims to reduce CO2 emissions by 25 percent per production (ton) by 2025 through the Sustainability Program.

Considering the above targets for both the entire country and AR-RAZI, the Study Team offers a whole-package proposal that introduces Building Energy Management System (BEMS), solar panels, geothermal heat pumps and high-efficiency lighting to administration building areas. This package contains renewable energy, such as solar panels and geothermal, and promote energy efficiency through BEMS and high-efficiency lighting to meet the national-level requirements.

Each component will be installed as follows:

- Solar panels will be installed on parking lot roofs around the administration building.
- An air conditioning facility that utilizes a geothermal heat pump will be installed underground, below the front garden or courtyard of the administration building.
- Building lighting will be replaced with motion sensor LED lighting, and BEMS will be installed to visualize the building's electricity consumption and promote renewable energy efficiency.

Electricity generated by solar panels will connect to the existing AR-RAZI distribution grid. According to the scale of demand for electricity in AR-RAZI, photovoltaics will not cause reverse power flow and no electric power control is necessary. Therefore, no battery will be installed. Thermal energy generated by a geothermal heat pump will link to the existing air conditioning system to save electricity consumption. Replacing the existing lighting with LED lighting will significantly promote the saving of electricity; adding a motion sensor to automatically turn off lights when no employees are present will also increase savings. As mentioned above, solar panels, geothermal heat pumps and high-efficiency lighting will improve electricity consumption, but the installation of BEMS will visualize changing electricity consumption. BEMS improves understanding of the details of the building's energy consumption and promotes further reduction of electricity consumption. BEMS can be used to draw up a usage plan promoting energy-conscious attitudes among employees, and increase energy efficiency by utilizing the Plan, Do, Check, Act (PDCA) cycle.

3.2.5.3 Explanation of Each Item for Proposal

(1) Title

Energy Saving System Utilizing Renewable Energy (Solar Power/ Geothermal)

(2) Contents of proposal (detail description)

(a) Photovoltaics

Solar panels will be installed on the roofs of parking lots. The wirings from the installed solar panels are linked to junction boxes and electricity is transmitted to a substation for photovoltaics. In the substation, Power Conditioning Systems (PCSs) are installed to convert direct current (DC) of photovoltaics into alternating current (AC). In addition, a transformer to boost the power converted into the alternating current up to 6.6kV from 200V is also installed. The power of photovoltaics converted into AC and boosted in the substation is sent to the existing distribution grid in 6.6kV Area Substation.

(b) Geothermal Heat Pump

A geothermal heat pump is a central cooling system that transfers heat to the ground. It uses the earth as a heat sink. The temperature in the ground below a certain depth is roughly equal to the mean annual air temperature at the surface. The geothermal heat pump utilizes the temperature difference between the underground and air.

A geothermal heat exchanger is buried under the front yard or courtyard of the administration building. The thermal energy obtained by the geothermal heat pump is connected to the existing Heating, Ventilation and Cooling (HVAC) system.

(c) High-efficiency lighting

Existing lighting, such as incandescent light bulbs and fluorescent lamps in the administration building are replaced with high-efficiency LED lighting. The LED lighting is equipped with motion sensors that automatically turn off lights when no person is present.

(d) Building Energy Management System (BEMS)

Efficient and intelligent energy management in a building can bring considerable benefits. BEMS is a system to monitor and control the building's energy use. The system is capable of controlling and monitoring a HVAC, lighting or other facility. Real-time view into facility operations and deep trend analysis provide data-driven insight to optimize energy management strategies and minimize operational costs. Adapting BEMS in a commercial building in Japan has resulted in a maximum 20 percent reduction of electricity usage.

BEMS consists of electricity meters, communication line and a computer. Electricity meters are installed where electricity is measured. Power consumption by lighting is measured for each floor of the administration building. Communication lines to transmit power measured by electricity meters to the computer are laid in the administration

building and, in order to transmit power generated by photovoltaics to the computer, a communication line is laid between the PCS and the computer. The computer is installed in the administration building, and the measured power is displayed on a monitor.

(3) Purpose/Expected Effectiveness

Renewable energy generation equipment (solar power/geothermal) is to be installed in an effort to save electricity produced by fossil fuel and reduce CO2 emissions.

(a) Photovoltaics

Electricity from photovoltaics directly contributes to a decreased use of fossil fuel for electricity generation.

(b) Geothermal Heat Pump

Adapting geothermal heat pumps for use with conventional HVAC systems in Japan has resulted in a 50 percent reduction of electricity usage. In other words, estimated reduction of electricity usage is 355kWh/m2.

(c) High-efficiency lighting

In Japan, it is reported that replacement of the conventional lighting with high-efficiency lighting has resulted in a 49 percent reduction of electricity usage. When all of the existing conventional lighting units in the administration building are replaced with high-efficiency ones, estimated 51MWh of electricity can be saved.

(d) BEMS

It is also reported that visualization of electricity usage through BEMS resulted in 20% reduction of electricity usage in Japan. Based on this report, the following electricity is expected to be saved.

Table 3.2.5-1 summarizes the effectiveness per year for each item.

Table 3.2.5-1 Estimated Effectiveness (per year)

Item	CO2 emission (ton)
Photovoltaics	1,219
Geothermal heat pump	554
High-efficiency lighting	39
BEMS	204
Total	2,015

(Source: OCG JICA Study Team)

Contribution to AR-RAZI Sustainability Program

The total electricity saving to be achieved by implementing all the proposed projects exceeds the annual electricity usage in the administration building. This means that CO2 emissions can be reduced by 100 percent. This reduction can be accounted as part of AR-RAZI's Sustainability Program target of a 25 percent reduction in CO2 emissions by 2025.

Contribution to Business Continuity Planning

Natural disasters, exceeding assumption incident, or other incidents may stop the flow of electricity from SECbut, the administration building is able to continue operation bu using electricity supplied from photovoltaics in daytime.

Contribution to encouraging energy-saving awareness in AR-RAZI employees

BEMS will realize monitoring/visualization of electricity consumption and store electricity consumption profiles for future analysis. In addition, PDCA should be implemented. Human resource development will also be necessary to promote PDCA from top management to all employees. BEMS can be a powerful tool for human resource development in the field of energy saving. Periodical and detailed analysis leads to ideals and proposals for further improvement of energy usage and results in tangible energy saving, which is evident from many cases in Japan.

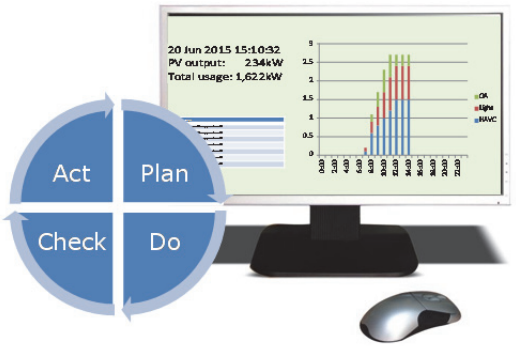


Figure 3.2.5-3 Example Screen of BEMS

(Source: OCG JICA Study Team)

(4) Initial cost

3.2.5-2 shows the initial cost of each proposed item.

Table 3.2.5-2 Initial cost of each item

Item	Cost (SAR)
Photovoltaics	---

Photovoltaics	---
Geothermal heat pump	---
High-efficiency lighting	---
BEMS	---
Total	8,243,825

(Source: OCG JICA Study Team)

Items of operation & maintenance are periodical cleaning of solar panels, periodical checking of electrical equipment, operation of BEMS, replacing electrical equipment and so on. In general, operation & maintenance cost per year will be up to 10 percent of initial cost. Further investigation is necessary for estimating the operation & maintenance cost.

The return on investment is estimated in several cases as follows.

Case-1: Payback period due to electricity saving (on the basis of electricity prices in Saudi Arabia)

Electricity prices in Saudi Arabia are assumed based on the information provided by AR-RAZI. According to electricity savings and the initial cost, the expected payback period is 21 years.

Payback period = (Initial cost / Saving in electricity price)

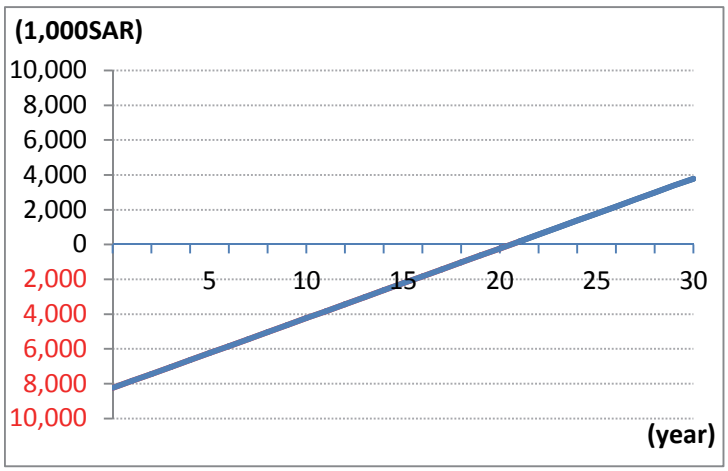


Figure 3.2.5-4 Investment-Return Estimation (based on electricity price in Saudi Arabia)

(Source: OCG JICA Study Team)

When the Joint Crediting Mechanism scheme described below is applied, the payback period can be estimated at 11 years.

Case-2: Payback period due to electricity saving (on the basis of electricity price in Japan)

In case of electricity price in Japan, the expected payback period would is 5 years.

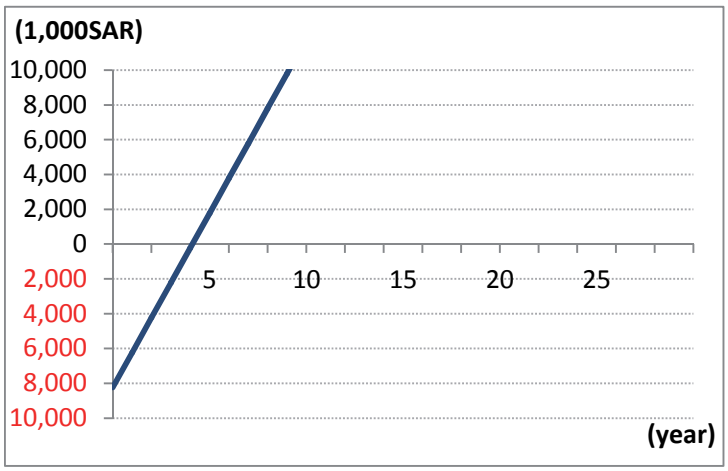


Figure 3.2.5-5 Investment-Return Estimation by electricity price in Japan

(Source: OCG JICA Study Team)

Case-3: Payback period by electricity saving (by crude oil equivalent)

Energy saving can be explained as reduction of opportunity loss for fossil fuels consumed in power plants. According to crude oil equivalent, the expected payback period will be 1/2.8(*) of that in considering electricity price, that is, 8 years.

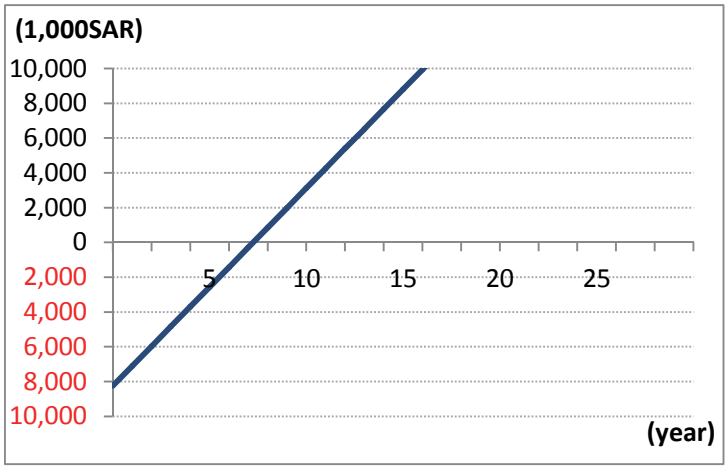


Figure 3.2.5-6 Investment-Return estimation as crude oil equivalent

(Source: OCG JICA Study Team)

* Crude oil equivalent; Price of electricity purchased from SEC and price of crude oil to generate the same amount of electricity are as follows.

Crude oil to generate electricity: 1.6 barrel / MWh

Crude oil cost: 262.5 SAR / barrel

Crude oil cost: 420 SAR / MWh (= 1.6 x 262.5)

Electricity cost: 150 SAR / MWh

Cost ratio (crude oil/electricity): 2.8 (= 420 / 150)

(5) Implementation Schedule Table

Table 3.2.5-3 shows the schedule for implementing the proposed projects, which is divided into several phases. The whole schedule will take approximately eighteen months.

Table 3.2.5-3 Implementation Schedule

Item	Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Photovoltaics	Initial Site survey for implementation	■																	
	Basic design and 2nd site survey		■	■	■														
	Detail design					■	■	■											
	Construction								■	■	■	■	■	■	■	■	■	■	■
Geothermal heat pump	Initial Site survey for implementation	■																	
	Basic design and 2nd site survey		■	■	■														
	Detail design					■	■	■											
	Construction								■	■	■	■	■	■	■	■	■	■	■
BEMS	Initial Site survey											■							
	Basic and detail design												■	■	■				
	Construction															■	■	■	■
High-efficiency ligting	Initial Site survey													■					
	Basic and detail design														■	■			
	Construction																■	■	■

(Source: OCG JICA Study Team)

(6) Action for the next step

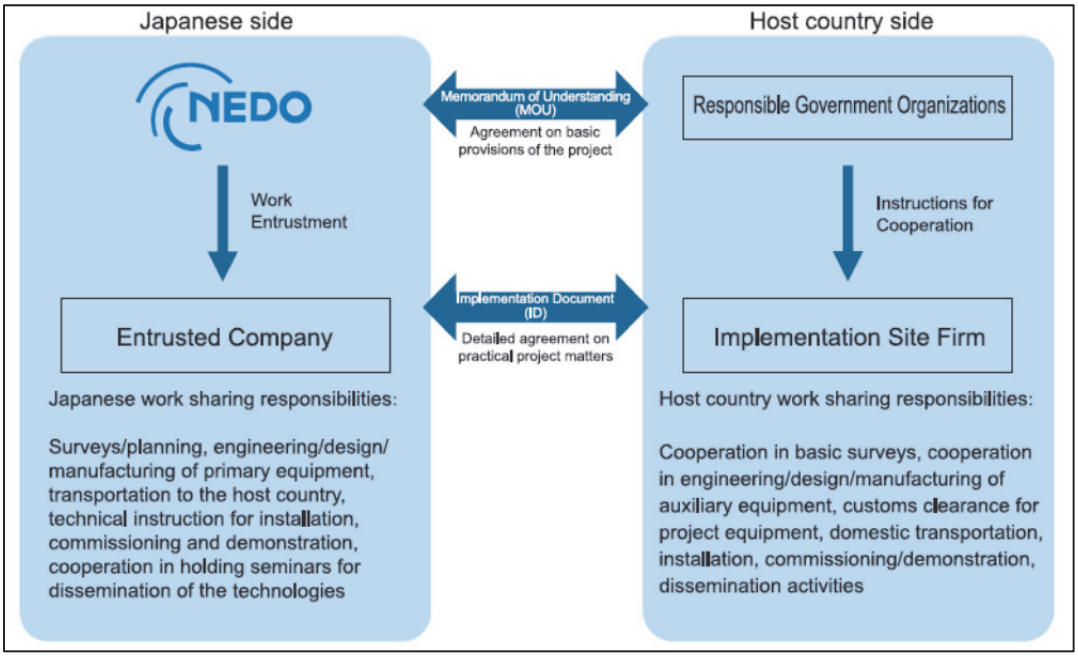
The JICA study team considers detailed survey and feasibility study on the proposed project to be required actions for the next step.

As a concrete step, JICA and its consultant team suggest that the possibility of utilizing support schemes of the Japanese government be considered for the proposed project, provided that it is approved and selected for the support schemes, for example “International Project for Increasing the Efficient Use of Energy (Ministry of Economy, Trade and Industry)” and “Joint Crediting Mechanism (JCM) Feasibility Study (Ministry of Economy, Trade and Industry, New Energy and Industrial Technology Development Organization and Ministry of Environment)” (see appendix for more information).

The entire study cost and up to 50 percent of the initial investment cost will be financed by using the support schemes of Japan. JICA is willing to provide cooperation and assistance for AR-RAZI in connection therewith.

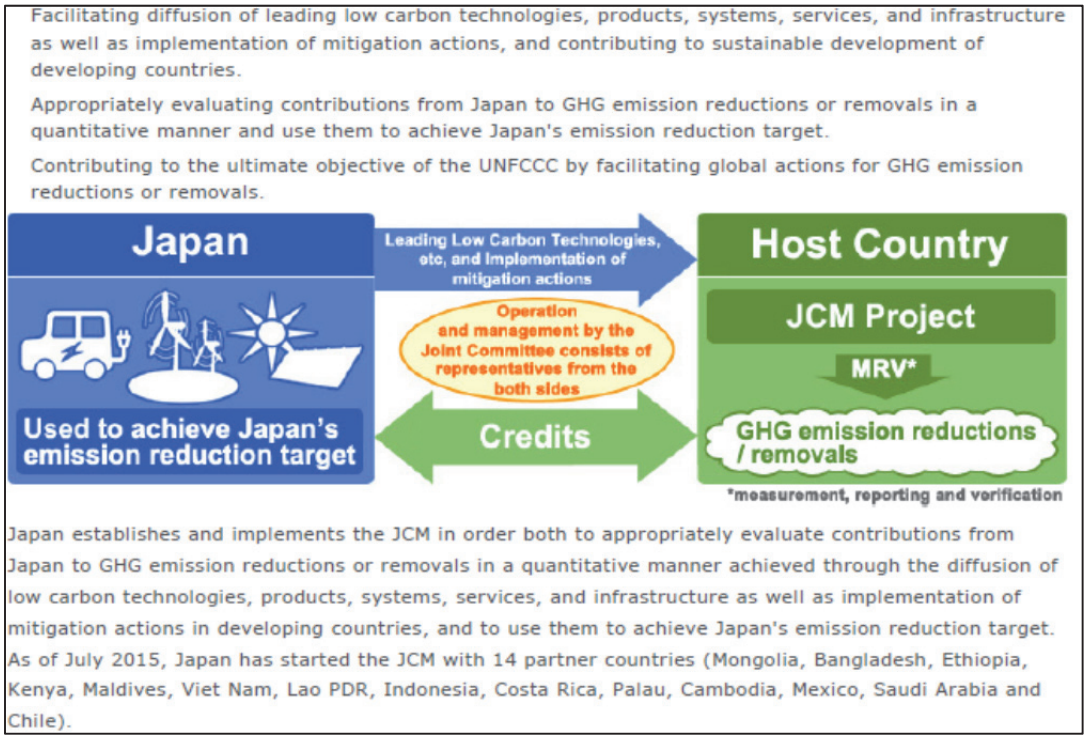
Appendix

- International Project for Increasing the Efficient Use of Energy (Implementation Concept)-



(Source: New Energy and Industrial Technology Development Organization (NEDO), http://www.nedo.go.jp/english/publications_brochures_index.html)

-Basic Concept of the Joint Crediting Mechanism (JCM)-



(Source: New Mechanism Platform, http://www.mmechanisms.org/e/initiatives/jcm.html)

3.3 MARAFIQ

3.3 Research on Infrastructure Improvement for Productivity Enhancement of MARAFIQ

3.3.1 Wastewater Treatment / Recycled Water

To study the proposals in the field of wastewater treatment/recycled water for MARAFIQ, the Study Team gathered general information about the company as part of a preliminary study from November through mid-December 2014 and tentatively selected priority items to be studied. During the first site visit, the Study Team studied and confirmed local conditions. Furthermore, based on the information obtained from MARAFIQ personnel who visited for the study tour in Japan held in January 2015, the Study Team determined a general direction of the study.

During the second site survey conducted in February 2015, the Study Team obtained data and information with regard to water balance, water consumption, water flows, related facilities, operation and maintenance, and major issues through discussion with the MARAFIQ management and the related parties. On the basis of the data and information, together with the current situation and issues identified through the discussion as well as plant survey, the Study Team made a long list of 8 candidate projects ("Long List") during the period from March to May 2015 and submitted it by email to MARAFIQ in June prior to the third site survey.

During the third site survey in June 2015, the Study Team exchanged opinions with MARAFIQ based on the long list, and selected 3 candidate projects for further study; Treated water from stage-3 reclamation system, Review of sludge dewatering system and Change of a coagulant.

Based on the above activities, the Study Team developed 3 water treatment/recycle water related project proposals and submitted them to MARAFIQ in August 2015. MARAFIQ and the Study Team discussed on the proposed project proposals at the workshop meeting in September 2015, and agreed as summarized in Table 3.3.1-1.

3.3.1.1 Outline of Site Survey

The Study Team conducted site survey and hearing on facility configulation, and obtained relevant data and information at site.

(1) Overall Flow

Since the construction of Stage 1 facility for treatment of industrial wastewater in the first half of the 1980s, MARAFIQ expanded its facilities by adding Stages 2 and 3. As a result, overall flow has become very complex, which the Study Team studied.

(2) Process flow and water quality in stages 2 and 3

At present, major facilities are Stages 2 and 3. The Study Team conducted site survey and hearing on process flow at the Stages 2 and 3 facilities, water balance, analysis of treated water and operation data.

(3) Sludge dehydration facility

Reduction of sludge is a major issue for MARAFIQ. The Study Team studied specifications of facilities and equipment, together with chemicals used for the operation, to determine a possible decrease in sludge discharge from the dehydration facility.

(4) Applicable Versions of Royal Commission Environment Regulation (RCER)

An applicable version of RCER depends on the year of construction of a facility. Applicable versions of RCER for Stages 1, 2 and 3 are different because they were built in different years. The Study Team surveyed applicable versions of RCER for the facilities and checked an applicable RCER in case of mixed wastewater from Stages 2 and 3.

3.3.1.2 Survey Results

(1) Overall Flow

Currently MARAFIQ have received industrial wastewater from 24 companies in the industrial area of Jubail 1 by way of pump stations. Industrial wastewater from the three PSs is treated for homogenization by using lagoons in stage 1 and transferred to Inlet Work (IWK). After that, industrial wastewater is divided into stages 2 and 3 for treatment.

(2) Process flow and water quality in stages 2 and 3

On average in 2014, 40% of wastewater were treated in stage 2. Main process in stage 2 is aerobic treatment mainly composed of aeration process and in the last stage, ozonization is carried out.

On the other hand, the rest 60% were treated in stage 3 where coagulation and aerobic treatment, Dissolved Air Floatation (DAF), Fenton, Glanuled Activated Carbon (GAC), and Chlorination treatment facilities are installed. It is therefore considered to be full-fledged treatment facilites and equipment. Since Fenton treatment is not operated on a regular basis and is used on judgement with the activated carbon treatment.

Stage 2 was installed around 30 years ago and is configured by a simple process. As a result, quality of treated water quality instage 2 is not at the same level as that obtained from stage 3.

(3) Sludge dehydration facility

The current operated facility uses abelt press.

(4) Applicable RCER Version

RCER versions applicable to effluent from each stage are 1999, 2004 and 2010, respectively according to the construction year.

3.3.1.3 Summary of Proposal

Based on the plant site visit, interview with MARAFIQ personnel and data and information provided by MARAFIQ, the Study Team conducted study with focusing on development of feasibility proposals that can contribute to MARAFIQ's operation and management. As the result of the study, the Study Team has developed project proposals that are expected to produce significant benefits, as outlined, in Table 3.3.1-1.,

Table 3.3.1-1 Summary of Study Projects Agreed

	Proposed projects	Cost estimate	Payback period
1	Treated water from stage3 reclamation system	Facility 144.4 mil. SAR Operation 10.8 mil. SAR/y	3 years
2	Review of dewatering system (belt press → filter press)	---	---
3	Change of a coagulant (aluminum sulfate → PAC)	Facility 19.2 mil. SAR Operation 0.15 mil. SAR/y	6 years

(Source: JICA Study Team, WRPC)

3.3.2 Energy Saving

To study the proposals in the field of energy saving for MARAFIQ, the Study Team gathered general information about the company as part of a preliminary study from November through mid-December 2014 and selected priority items to be studied. During the first site visit, the Study Team studied and confirmed local conditions. Furthermore, based on the information obtained from MARAFIQ personnel who visited for the study tour in Japan held in January 2015, the Study Team determined a general direction of the study.

During the second site survey in February 2015, the Study Team obtained data and information concerning energy consumption, related facilities, operation and maintenance, etc. through discussion with the MARAFIQ management and the related parties. On the basis of the above data and information, together with the current situation and issues found through the discussions as well as plant survey, the Study Team prepared a long list of 42 candidate projects ("Long List") during the period from March to May 2015 and submitted it by email to MARAFIQ in June prior to the third site survey.

During the third site survey in June 2015, the Study Team exchanged opinions with MARAFIQ based on the long list, and selected 9 items covering compressors, trasformers, air conditioners and lighting fixtures as pontential energy saving projects. Furthermore the Study Team confirmed the basic concept of the final proposals to be submitted to MARAFIQ through discussion with them about specifications and data relating to equipment and substation at site for selection of applicable technologies.

Based on the above activities, the Study Team developed 9 energy saving related project proposals and submitted them to MARAFIQ in August 2015. MARAFIQ and the Study Team discussed the project proposals at the workshop meeting in September 2015, and agreed on and approved 9 projects as listed in Table 3.3.2-1.

3.3.2.1 Results of the Field Survey

MARAFIQ owns a number of facilities for seawater intake and water supply. Through the first and second site surveys and discussion with MARAFIQ personnel about the possible areas of energy saving efforts indicated in the Long List submitted by the Study Team, the Study Team has identified that the following facilities and equipment to be possible targets: (1) pump, (2) compressor, (3) transformer, (4) air conditioners and (5) lighting fixtures.

The Study Team explained to MARAFIQ about the result of the study on the nine potential energy saving measures during the forth site visit, and compiled the project proposals as shown in Table 3.3.2-1.

Table 3.3.2-1 List of Proposed Projects

	Proposed items	Facility cost estimates	Annual cost saving
		1,000SAR	1,000SAR/y
1	**Rotating equipment - Biological air compressor**		
	1) Utilize blower for aeration	25,500	1,344
2	**Rotating equipment - DAF & ibstrumnt air compressor**		
	1) Proper pressure setting	0	20
	2) Air leakage prevention for P3-5	0	40
3	**Transformers**		
	1) Relacement of old transformers with higher efficiency one	30,400	280
4	**Air conditioners**		
	1) Replacement with high-efficient equipment	2,900	33
	2) Protection of outdoor units from direct sunlight	100	5
	3) Appropriate room temperature setting	0	5
5	**Lighting fixtures**		
	1) Replacement of mercury lamps with LED lamps	11,000	446
	2) Installation of motion sencers for interior lighting	100	3
	Total	70,000	2,175

(Source: JICA Study Team)

3.3.2.2 Summary of the Proposals

(1) Rotating equipment - In seawater intake system (SWI system) and wastewater treatment (WWT)

SWI system

WWT consists of SWI pumps and electrolysis chlorine generators equipped with filters. Intake seawater (SW) after chlorine treatment for disinfection is pumped up above the SW level by a SWI pump system. It is the biggest electricity consumer in the system, and treated water is transported to the industrial city through canals used to circulate cooling water for plants. The number of pumps operated is controlled by a constant-speed unit so that pumps are operated only when the water level of the canal is above the SW level. Note that the SWI pumps are manufactured with minimum allowance design, and thus the energy-saving effect by introducing VFD[1]s in this area seems to be marginal.

Biological WWT air compressors

At the WWT facilities, a number of compressors are installed for aeration and instrumentation.

Highly compressed air, higher than the required pressure, is used for waste water treatment, which is why the energy-saving effect can be expected from the modification of the

[1] Variable frequency drive

aeration system.

Proposed project	Utilization of blower for aeration system

(2) Rotating equipment – DAF[2] & Instrumental air compressor

The compressed air is supplied throughout the WWT by pipelines through which air leakage happens extensively. Thus, energy saving can be achieved by means of daily monitoring and leakage prevention measures. The pressure setting point of compressors is higher than those of the compressed air used both for instrumentation and process areas. If actual operation pressure is reduced, therefore, it can lead to significant energy saving.

Proposed projects	1) Proper pressure setting 2) Check of air leakage prevention

(3) Transformers

MARAFIQ receives electricity at high voltages that are transformed within its facilities. The majority of transformed electricity is used for operation of seawater intake pumps, SW electrolysis and other small-capacity pumps. The present transformers are aging due to operation for more than 30 years since the commencement of commercial operation, so that it is conceivable to save energy significantly by replacing them with latest, high-efficiency transformers. In addition, 28 old transformers are currently operated at SWI facilities. Again, the refurbishing of these transformers is expected to produce considerable energy saving benefits.

Proposed project	Replacement of aged transformers with highly-efficient ones

(4) Air conditioners

Buildings in the facility are furnished with air conditioners, consisting of air cooled heat pumps and package-type air conditioners, where there is opportunity for energy saving by replacing them with highly-efficient units. Also, most outdoor units are located on the roof and are under the influence of isolation. Thus, installation of shadings can make a positive impact on energy conservation. The temperature setting is supposed to be highr than those of the

[2] Dissolved Air Flotation

SABIC guideline, though the equipment is actually set at lower levels. Strict enforcement of temperature setting would thus enable energy derived from air-conditioningoperation. In addition, strict enforcement of energy saving regulations, such as shutting of the doors and the cleaning of air conditioner filters on a daily basis is expected to serve as powerful support for energy saving.

Proposed projects	1) Replacement with highly-efficient equipment 2) Protection of outdoor units from direct sunlight 3) Optimization of room temperature (24 °C)

(5) Lighting Fixtures

Straight tube fluorescent lamps, which are more energy efficient than incandescent lamps, are used in the buildings. On the other hand, since a lot of mercury lamps are utilized throughout the facilities, there is good opportunity for evergy saving through the use of LED lamps. Moreover, installation of motion detectors, by taking advantage of its auto-off feature, would result in minimum levels of lightings, which would then lead to further energy conservation. In addition, periodical maintenance of fixtures, such as cleaning of reflective plates, may serve as an additional instrument for s energy saving.

Proposed projects	1) Highly-efficient use of the LED lamps 2) Application of motion detectors to the lightings in the administration building, etc.

(6) Others

An energy saving measure is taken by introducing VFD to the pumps. MARAFIQ is very conscious of energy saving with regard to plant operation and adjusts its operation mode frequently. In addition, thers is still opportunity to save energy by enforcing proper rules for maintenance of utilities facilities as well as load control of air conditioners.

3.3.3 Renewable Energy/Solar Power Generation

3.3.3.1 Summary of Survey Results

Currently, solar panels are not installed in MARAFIQ. MARAFIQ is eager to install solar panels at a water treatment plant. The Study Team has presented examples of water treatment plants in Japan that have installed solar panels. As a result of discussion, 8 candidate sites for solar power plants have been selected as shown in Table 3.3.3-1.

Table 3.3.3-1 Candidate sites for solar power plants

Sites		Setting place	Remarks
1	O&M office buildings A	Building roof Parking lots	One of 3 existing office buildings in Jubail area
2	O&M office buildings B	Building roof Parking lots	One of 3 existing office buildings in Jubail area
3	O&M office buildings C	Building roof Parking lots	One of 3 existing office buildings in Jubail area
4	Staff houses	Houses roof	260 houses for staffs
5	New HQ office building (Completion in 2017)	Building roof Parking lots	Required coordination with current plan
6	Water storage tanks	On tanks	Attention to loading on a tank
7	Canal	Covering the canal	Civil engineering works needed (long-term installation)
8	Water treatment plant	Covering basins	Attention to water treatment operation

(Source: Prepared by JICA Study Team, OCG, based on the data provided by MARAFIQ)

As the next step, discussion was made with regard to the installation of a solar power plant in one of the eight candidate sites. The project will become the first solar power plant for MARAFIQ.

"O&M office buildings A" appears to be the most suitable MARAFIQ facility to install solar panels.

3.3.3.2 Summary of the Proposal

One quarter of oil produced in Saudi Arabia is consumed within the country, and domestic oil consumption is rapidly growing due to an increasing demand for electricity. Saudi Arabia could possibly turn from a petroleum exporting country to a net importer by 2038. Under these circumstances, urgent development of renewable energy (in particular, photovoltaics) is critical for the country to save domestic consumption of fossil fuels, such as oil and natural gas. Moreover, it is important to not only install renewable energy, but also utilize energy efficiently as part of national policy. It was confirmed that MARAFIQ was willing to install photovoltaics

in its early stage along with the national policy. In consideration of these factors, the Study Team proposed a pilot project where solar panels would be installed on the roofs of parking lots and distribution building in "O&M office building A" area.

Electricity generated by solar panels will connect to the existing MARAFIQ power grid. According to the scale of demand for electricity in MARAFIQ, photovoltaics will not cause reverse power flow.

3.3.3.3 Description of Project Proposals by Item

(1) Name of Proposal

Energy Saving System Utilizing Renewable Energy (Solar Power).

(2) Content of Proposal (in Detail)

Solar panels will be installed primarily on the roofs of parking lots and distribution building in the "O&M office building A" area. The wiring from the installed solar panels is connected to junction boxes and the generated power is transmitted to a substation for photovoltaics. In the substation, Power Conditioning Systems (PCSs) are installed to convert direct current (DC) photovoltaics into alternating current (AC). In addition, a transformer to boost the power converted into the alternating current will also be installed. The AC photovoltaics boosted in the substation is sent to the existing distribution grid in the existing Main LV Switchgear.

(3) Purpose/Expected Effectiveness

Renewable energy is to be installed in an effort to save electricity produced by fossil fuel and reduce CO_2 emissions. Electricity from photovoltaics directly contributes to a decrease in use in use of electricity generated by using fossil fuels. Table 3.3.3-2 summarizes the project's estimated effectiveness per year for each item.

Table 3.3.3-2 Estimated Effectiveness (per year)

Item	CO_2 emission (ton)
Photovoltaics	413

(Source: JICA Study Team, OCG)

(4) Initial cost

Table 3.3.3-3 shows the initial cost of each proposed item.

Table 3.3.3-3 Initial cost of each item

Item	Cost (SAR)
Photovoltaics	2,036,364

(Source: JICA Study Team, OCG)

Investment return is estimated in several cases as follows.

Case-1: Payback period by electricity saving (based on electricity price in Saudi Arabia)

For this case, the electricity price in Saudi Arabia is used. According to electricity savings and initial cost, the expected payback period is 25 years.

Payout period = (Initial cost / Saving electricity price)

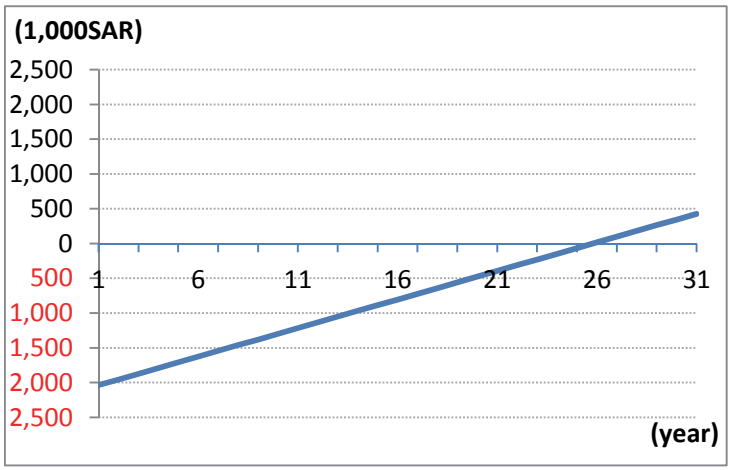


Figure 4-3 Investment-Return estimation by electricity price in Saudi Arabia

(Source: JICA Study Team, OCG)

Case-2: Payback period by electricity saving (based on electricity price in Japan)

The expected payback period is 5 years if the electricity price in Japan is applied.

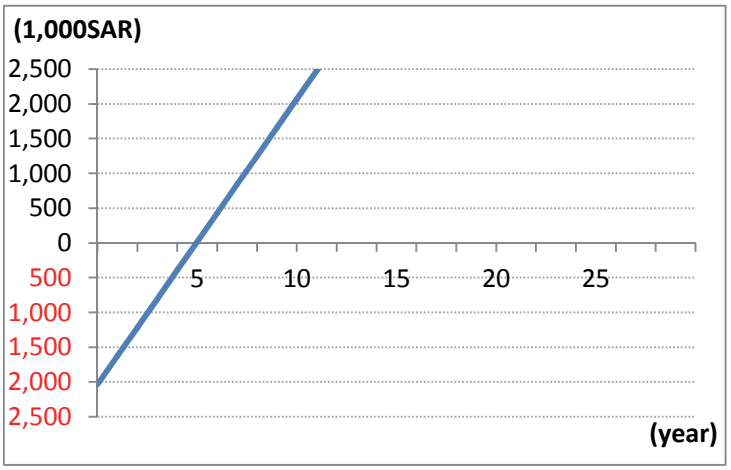


Figure 4-4 Investment-Return Estimation by electricity price in Japan

(Source: JICA Study Team, OCG)

Case-3: Payback period by electricity saving (based on crude oil equivalent)

Energy saving can be explained as reduction of opportunity loss for fossil fuel consumed in a power plant. Based on the crude oil equivalent, the expected payback period will be 1/2.8(*) of that based on the electricity price, that is, 9 years.

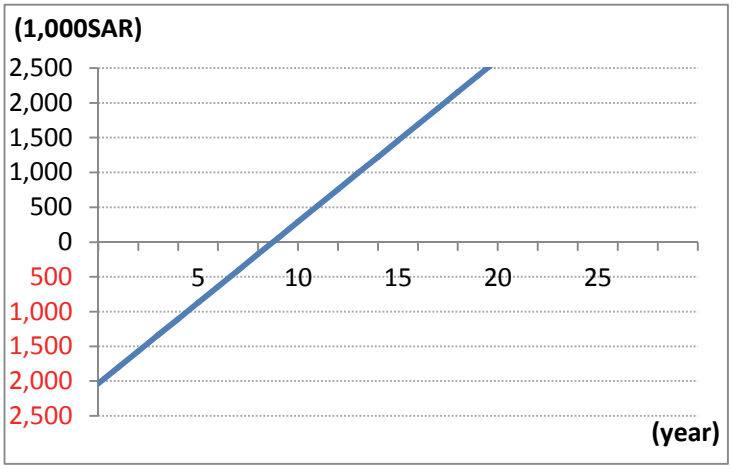


Figure 4-5 Investment-Return estimation as crude oil equivalent

(Source: JICA Study Team, OCG)

* Crude oil equivalent; Price of electricity purchased from SEC and price of crude oil to generate the same amount of electricity are as follows.

Crude oil to generate electricity: 1.6 barrel / MWh

Crude oil cost: 262.5 SAR / barrel

Crude oil cost: 420 SAR / MWh (= 1.6 x 262.5)

Electricity cost: 150 SAR / MWh

Cost ratio (crude oil/electricity): 2.8 (= 420 / 150)

The expected payback period based on the crude oil cost will be 1/2.8 of that based on the electricity cost.

(5) Implementation Schedule

Table 3.3.3-4 shows a preliminary implementation schedule for the proposed projects, which is divided into several phases. The total project period will be approximately eighteen months.

Table 3.3.3-4 Implementation Schedule

Item	Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Photovoltaics	Initial Site survey for implementation	■																	
	Basic design and 2nd site survey		■	■	■														
	Detail design					■	■	■											
	Construction								■	■	■	■	■	■	■	■	■	■	■

(Source: JICA Study Team, OCG)

(6) Action for the next step

The Study Team sees that detailed survey and feasibility study on the proposed project are to be actions required for the next step.

3.4 SABIC

3.4 Research and Report for SABIC

The Study Team reported to SABIC about activities conducted by the Study Team and presented the proposals submitted to SHARQ and AR-RAZI. It is considered that the proposals for SHARQ and AR-RAZI are also applicable to other affiliates of SABIC.

3.4.1 Wastewater Treatment / Recycled Water

Based on the activities undertaken to date, the Study Team reported to SABIC on the result of the study for SHARQ and AR-RAZI as follows.

3.4.1.1 SHARQ

The following 3 projects were sumitted to SHARQ as a result of study on reclamation of wastewater.

- Reclamation of PE wastewater to reduce sludge generation
- Optimization for operation of demineralized water facility
- Confimation of entire water balance (mismatch)

After discussion with SHARQ at the meeting in August 2015, the Study Team submitted to SHARQ the following 3 project proposals.

Table 3.4.1-1 Summary of Proposed Projects for SHARQ

	Proposed projects	Required costs	Investment recovery
1	Water reclamation of PE wastewater and OLF wastewater	Facility 31.4 mil. SAR Operation 1.40 mil. SAR/year	8 years
2	Water Reclamation of PE wastewater for irrigation use	Facility 12.5 mil. SAR Operation 0.36 mil. SAR/year	7 years
3	Water Reclamation of PE wastewater for irrigation use	Facility 15.0 mil. SAR Operation 0.44 mil. SAR/year	11 years

(Source: JICA Study Team)

As for thewater demineralization facility, the Study Team recommended, on the basis of the study, the replacement of the existing anion exchange resin with cation exchange resin.

SHARQ confirmed that they would check an entire water balance by themselves.

3.4.1.2 AR-RAZI

The Study Team proposed the following 2 projects for AR-RAZI to address their

long-standing issues to be solved.

- Wastewater treatment
- Optimization for operation of water demineralization facility

Table 3.4.1-2 shows the results of the study for 2 projects.

Table 3.4.1-2 Evaluation Summary of the Studied Projects for AR-RAZI

	Proposed projects	Contribution to sustainability program	Required costs
1	Wastwater treatment	17%	Facility 31.4 mil. SAR Operation 1.40 mil. SAR/year
2	Optimization for operation of water demineralization facility	As a result, particular effect could not be found.	---

(Source: JICA Study Team)

As for optimization for operation of the water demineralization facility, AR-RAZI has been operating the facility by using ion exchange resins with an extended regeneration interval. As a result, no particular effect was found from the study.

On the other hand, in addition to the above proposal for wastewater treatment, it was recommended that the existing concrete pit and lagoon be used for the proposed project as an option.

3.4.2 Energy Saving

Both SHARQ and AR-RAZI have a number of utilities facilities. The Study Team reported to SABIC on the proposals that had been submitted to them. Final proposed items for energy saving are summalized below. For details, refer to Section 3.1.4 for SHARQ and Section 3.2.4 for AR-RAZI.

Table 3.4.2-1 Project Proposals for SHARQ

	Proposed items for energy saving	
	Report to SABIC	Final Proposal
Rotating equipment - Seawater Cooling system	• Introduction of VFDs on pumps	Same as on the left
Rotating equipment – Compressor	• Proper adjustment of the setting pressure • Introduction of VFDs to the compressor • Air leakage prevention	Same as on the left

Boiler	• Introduction of VFDs to the FDFs • Insulation of valves • Diagnosis of steam trap operation	Same as on the left
Transformer	• Replacement of old transformer with high-efficient one	Same as on the left
Air conditioner	• Replacement with high-efficient equipment • Protection of outdoor units from direct sunlight • Appropriate room temperature setting	Same as on the left
Lighting fixture	• High-efficient use of the mercury lamps in the plant • Application of motion detectors to the lightings in the administration bldg.	Same as on the left

(Source: JICA Study Team)

Table 3.4.2-2 Project Proposals for AR-RAZI

	Proposed items for energy saving	
	Report to SABIC	Final Proposal
Rotating equipment - Seawater Cooling system	• Introduction of VFDs on seawater intake pumps • Introduction of VFDs on primary circulation pumps	Same as on the left
Rotating equipment – Compressor	• Introduction of VFDs to the compressor • Proper adjustment of the setting pressure • Air leakage prevention	Same as on the left
Boiler	• Introduction of VFDs to the FDFs (Note 1) • Diagnosis of steam trap operation • Insulation of valves	• Diagnosis of trap operation • Insulation of valves
Transformer	• Replacement of old transformer with high-efficient one	Same as on the left
Air conditioner	• Replacement with high-efficient equipment • Protection of outdoor units from direct sunlight • Appropriate room temperature setting	Same as on the left
Lighting fixture	• High-efficient use of the mercury lamps in the plant • Application of motion detectors to the lightings in the administration bldg.	Same as on the left

(Source: JICA Study Team)

Note 1: It is found that a primary mover is a steam tubine (ST) not a motor. Since VFD cannot be installed because of ST, the item has been deleted from the energy saving-related projects proposals.

3.4.3 Renewable Energy/Solar Power Generation

3.4.3.1 Summary of Study Results

We explained our proposal for SHARQ and AR-RAZI to SABIC. SABIC understood that our proposal concerning the installation of photovoltaics and geothermal cooling system, would be potential effective in saving domestic consumption of fossil fuels. It will also become the first case of renewable enrgy for SABIC.

SABIC finds the installation of a residential photovoltaic system as a desirable course of actionm and regards "building-integrated photovoltaic panel solution" as a feasible solution as pointed out in Sustainable Report. Therefore, discussion was extended to renewable energy installation for use in SABIC staff house. The Study Team explained the proposal of installing photovoltaics and geothermal cooling system to SABIC's staff house, which interested SABIC personnel. The Study Team conducted site survey on SABIC's staff house. In conclusion, feasibility of photovoltaics and geothermal cooling system installation was confirmed.

3.4.3.2 Summary of Proposal

One quarter of oil produced in Saudi Arabia is consumed within the country, and domestic oil consumption is rapidly growing due to an increasing demand for electricity. Saudi Arabia could possibly turn from a petroleum exporting country to a net importer by 2038. Under these circumsntaces, urgent development of renewable energy (in particular, photovoltaics) is critical for the country to save domestic consumption of fossil fuels, such as oil and natural gas. Moreover, it is important to not only install renewable energy, but also utilize energy efficiently as part of national policy. SABIC also aims to reduce CO_2 emissions by 25 percent per production (ton) by 2025 through the Sustainability Program.

Considering the above target of Saudi Arabia and SABIC, we offer a whole-package proposal that introduces photovoltaics, geothermal heat pump, high-efficient lighting and reuse water system into the SABIC staff house. The package contains renewable energy, such as solar panels and geothermal, and high-efficiency lighting to meet the requirements of Saudi Arabia.

Each component will be installed as follows:

Solar panels will be installed on employee's house roof. An air conditioning system which utilizes a geothermal heat pump will be installed underground. High-efficiency lighting such as LED with motion sensor will also be installed. In addition, a reuse water system will be installed for water recycling.

3.4.3.3 Description of Project Proposals by Item

(1) Name of Proposal

The System for Effectively Utilizing Renewable Energy (Solar power / Geothermal)

(2) Contents of Proposal (in Detail)

(a) Photovoltaics

Solar panels will be installed in the red areas highlighted in the layout plan, primarily on the house roof. Power Conditioning Systems (PCSs) to convert direct current (DC) of photovoltaics into alternating current (AC) are installed. The converted AC power is then sent to the distribution board.

(b) Geothermal Heat Pump

A geothermal heat pump is a central cooling system that transfers heat to the ground. It uses the earth as a heat sink. The temperature in the ground below a certain depth is roughly equal to the mean annual air temperature at the surface. The geothermal heat pump utilizes a temperature difference between the underground and air.

A geothermal heat exchanger is buried in the underground around SABIC staff house. The thermal energy obtained by the geothermal heat pump is utilized for a HVAC system.

(c) High-efficiency lighting

The LED lighting is equipped with motion sensors that automatically turn off lights when nobody is present.

(d) Reuse water system

A reuse water system will be installed for water recycling. Recycled water willbe used for sprinklers, toilets and other domestic uses.

(3) Purpose/Expected Effectiveness

Renewable energy (solar power/geothermal) is to be installed in an effort to save electricity produced by fossil fuel and reduce CO_2 emissions. According to the site survey conducted in June 2015, the estimated annual electricity usage of the staff house is shown in Table 3.4.3-1.

Table 3.4.3-1 Estimated Annual Electricity Usage in Staff House

(MWh/year)

Total	HVAC system	Lighting	Others
16	11	4	1

(Source: JICA Study Team, OCG)

Expected effectiveness of each item is described below.

(a) Photovoltaics

Electricity from photovoltaics directly contributes to a decrease in use of fossil fuel for power generation.

(b) High-efficiency lighting

In Japan, it is reported that replacement of the conventional lighting with high-efficiency one has resulted in a 49 percent reduction of electricity usage.

(c) Geothermal heat pump

Adapting geothermal heat pumps for use with conventional HVAC systems in Japan has resulted in a 50 percent reduction of electricity usage. In other words, the estimated reduction of electricity usage is 355kWh/m^2.

(d) Reuse water system

BOD (Biochemical oxygen demand) ≤ 5ppm and water processing capacity of 0.5 m^3/day– 4.0m^3/day is achieved in Japan

Table 3.4.3-2 summarizes the effectiveness per year for each item. Effectiveness of geothermal and reuse water systems are not included in Table 3.4.3-2 because further survey of staff house is required for accurate estimation.

Table 3.4.3-2 Estimated Effectiveness (per year)

Item	CO_2 emission (ton)
Photovoltaics	11.1
High-efficiency lighting	1.5
Total	12.6

(Source: JICA Study Team, OCG)

Power generation capacity of photovoltaics almost equals to the estimated electricity usage in SABIC staff house. Therefore, SABIC staff house can be considerd as Zero Emission House.

(4) Initial cost

Table 3.4.3-3 shows the initial cost of each proposed item.

Table 1.4.3-3 Initial Cost Estimation by Item.

Item	Cost (SAR)
Photovoltaics	---
High-efficiency lighting	---
Reuse water system	---
Total	116,060

(5) Implementation Schedule

Table 3.4.3-4 shows a preliminary implementationschedule for the proposed projects, which is divided into several phases. The total project period will be approximately one year.

Table 3.4.3-4 Implementation Schedule

Item	Month	1	2	3	4	5	6	7	8	9	10	11	12
Photovoltaics	Initial Site survey				■								
	Basic design and 2nd site survey					■	■						
	Detail design							■	■				
	Construction									■	■	■	■
Geothermal heat pump	Initial Site survey	■											
	Basic design and 2nd site survey		■	■	■								
	Detail design					■	■	■					
	Construction								■	■	■	■	■
High-efficiency ligting	Initial Site survey							■					
	Basic and detail design								■	■			
	Construction										■	■	■
Septic tank	Initial Site survey				■								
	Basic and detail design					■	■						
	Construction							■	■				

(6) Action for the next step

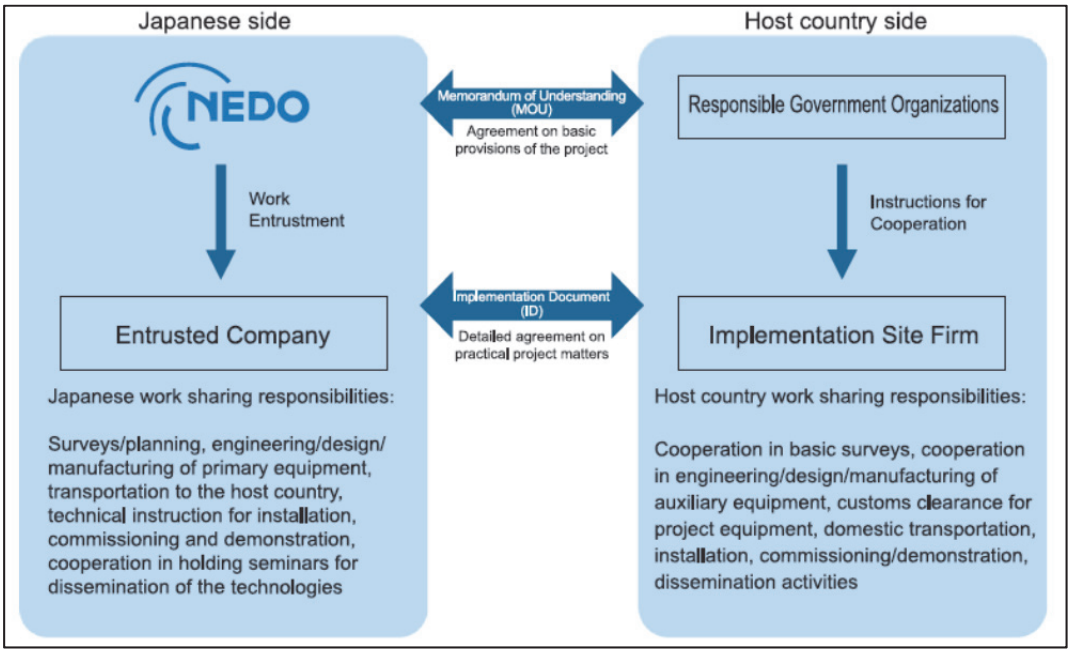
The Study Team sees that detailed survey and feasibility study on the proposed project are to be actions required for the next step.

As a definitive step, JICA and its consultant team suggest that the Saudi counterpart seek for utilization of the support scheme provided by the Japanese government, provided that the project is selected as a project eligible for such support scheme (see appendix for more information).

100 percent of the cost relating to preliminary study and up to 50 percent of the initial investment cost will be financed under the support scheme. JICA is willing to cooperate with SABIC on the proposed project if requested.

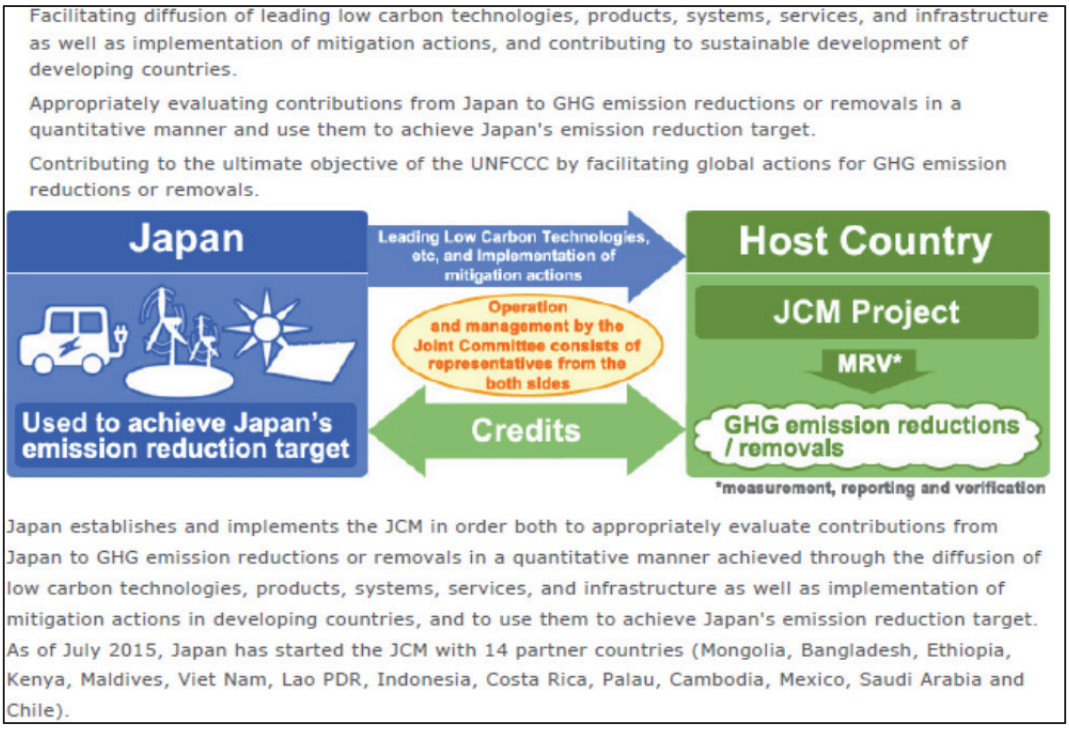
Appendix

- International Project for Increasing the Efficient Use of Energy (Implementation Concept)-



(Source: New Energy and Industrial Technology Development Organization (NEDO), http://www.nedo.go.jp/english/publications_brochures_index.html)

-Basic Concept of the Joint Crediting Mechanism (JCM)-



(Source: New Mechanism Platform, http://www.mmechanisms.org/e/initiatives/jcm.html)

3.5 Jubail Industrial College (JIC)

3.5 Research on Human Resource Development Programs of JIC

3.5.1 Education (Japanese-style Management)

3.5.1.1 Background of Research and Outline of Final Proposal

In order to formulate a proposal concerning Japanese-style management programs for Jubail Industrial College (JIC), the field study was conducted based on the list of programs that the Study Team had selected at the preliminary research stage. The Team introduced to the JIC members the features and effects of Japanese-style management education programs, which is still unfamiliar to JIC, as well as practical examples of implementation at industry and academia so as to foster JIC members' understanding and stimulate their interest.

Reflecting the dialogue with JIC during the second field study, with their current situation and interest in mind, the Team picked up appropriate programs for the College and reorganized them into lectures and trainings of total 140 days with 48 subjects and sent them to the JIC members via email. At the same time, considering its characteristic as a higher education institution, the Team also designed and presented a one-year curriculum for JIC students by redesigning the abovementioned programs.

Upon the third field study, the Team exchanged opinions with the JIC members based on the draft report previously submitted to them and affirmed the direction of proposal, whose structure is summarized below. During the following phase of work in Japan, the proposal contents were finalized. Then, and the Team confirmed the JIC's basic understanding during the fourth field study in September 2015.

i Target participants: JIC management, professors, and lecturers. In the case of open seminar, corporate people in Jubail would be targeted.
ii Method of implementation: Case study in Japan, JIC's internal seminar and/or open seminar to public
iii Program contents: the following 7 courses

Course1: Japanese-style Management Case Study Program (location: Japan, target: JIC management and professors)
Course 2: Japanese-style Management Case Study Program (location: Japan, target: JIC lecturers)
Course 3: Managers' Role Recognition Program (open seminar) (location: JIC, target: corporate people)

Course 4: 5S Program (open seminar) (location: JIC, target: corporate people)
Course 5: KAIZEN Program (open seminar) (location: JIC, target: students and corporate people)
Course 6: Discipline Program (open seminar) (location: JIC, target: students and corporate people)
Course 7: Japanese-style Management Program (location: JIC, target: JIC lecturers)

The main target of the courses is no longer students for the following reasons: 1) all the programs are advanced for students without work experience in the business field and 2) they would have no hands-on opportunities to apply knowledge acquired. Additionally, JIC demonstrates a commitment to provide collaborative trainings with corporations, including SABIC, SHARQ, and AR-RAZI, which is why part of programs are planned in the form of open seminar.

Since the advantage of Japanese-style management and education have been recognized neither at JIC nor in the Jubail area, it would be effective to increase awareness about Japanese style by providing key persons with an opportunity to visit Japan and publicizing the essence of Japanese elements. At the same time, it would be ideal to implement the programs to the technically possible extent.

3.5.1.2 Research Output

(1) Second-phase work in Japan (from late February to May 2015)

With an eye to meetings during the third field study, the Team formulated a year-long curriculum (90 minutes×twice a week×30 weeks) and study tours (10 days and 40 days) for students to learn Japanese-style management and submitted them to the JIC management via email. In addition, the Team arranged an appointment with the JIC management during the third field study in order to make a detailed explanation about the proposal and explore the possibility of alliance.

(2) Third field study (May 31, 2015)

The JIC members received the Team to have a three-hour long valuable meeting. Major topics discussed during the meeting are shown below:

i Japanese-style management program
- Structure of Japanese-style management program

- Subjects of interest to SHARQ and AR-RAZI

ii Methods of implementation and possibility of cooperation with outside organizations
- Intensive courses through cooperation with industries
- Field study in Japan on the theme of Japanese-style management (10 days)
- Field study in Japan on the theme of Japanese-style management (30-40days)
- One-year curriculum of Japanese-style management for students
- Information sharing of teaching method among professors
- Collaboration with universities in Japan

iii Explanation about the features of Japanese-style management
- Business starting-up simulation
- Breakthrough thinking
- 5S & Visual management
- Lean production system

In the course of discussion with JIC, the Team received the following comments:

- The proposed contents seems to be slightly too advanced for the JIC students.
- Would it be possible to modularize each subject to make the programs more adaptive? For example, it would be an idea to divide into four stages, depending on the level of difficulty.
- It is difficult to make judgement at this moment to pick up subjects most suitable to JIC. The JIC would like to examine the proposal, considering possible participants, such as corporate managers, JIC members, professors, and students.
- JIC needs to think about ways of raising funds to implement the courses. With regard to financial aid, JICA mentioned that they would explore the possibility of cost-share technical assistance.

Also, opinions were expressed on the possibility of funding from businesses in the case that JIC offers its venue to carry out the programs.

(4) Fourth field study (September 2, 2015)

i The Team introduced programs suitable to JIC with a clear description of expected participants of each course. In addition, the contents of the presentations for SHARQ and AR-RAZI were described.

ii The following three programs were proposed to JIC along with quotations:
- Training program in Japan for JIC management and professors

- Training program in Japan for JIC lecturers
- Training program in KSA for JIC lecturers

iii The following points were explained to JIC:

- Since KSA is no longer on the DAC List of ODA Recipients, in principle, it is difficult for JICA to provide the country with financial aid.
- Therefore, the proposal to JIC has been formulated on the assumption of the JIC's responsibility for funding. Having said that, JICA could assist some administrative arrangements.
- On the other hand, JICA is considering some form of support for this program so that JICA might be able to bear 30% of the cost, including personal expenses for Japanese staff. This issue is presently under consideration within the current framework. In the case that JICA provides any financial assistance, it will be notified from the Japan side.

3.5.1.3 Final Proposal based on Results of Field Studies

(1) Final proposal of training program

Japanese-style management is a management method of production sites so that, even though students take the course, they have little chance to use the method in real situations. This is why a Japanese-style management program is not common at the undergraduate level in Japan while some graduate schools offer such courses. Thus, the training is designed as Japanese-style management program in collaboration with industries and focuses on unique methods to Japanese-style management and production control, such as role recognition, KAIZEN, and discipline.

According to SABIC, Hadeed Steel Plant, SABIC's affiliate, has introduced 5S and the maintenance section of SADAF has introduced Lean Production System. Based on these backgrounds, a member of SABIC indicated his intention to explore the possibility to initiate Lean Production System at SHARQ and AR-RAZI as model. In order to accommodate such rise in interest in Japanese-style management, it seems valuable for JIC to hold lectures open to general business people.

To sum up, the Team proposes the seven training courses, three of which are for JIC management and teachers and others are for business people, as a final proposal. Its detail is summarized in the Table 3.5.1-1.

Table 3.5.1-1 Final Proposal of Training Programs

Course Title		Participants	Location
Course 1	Japanese-style Management Case Study Program	JIC management and professors	Japan
Course 2	Japanese-style Management Case Study Program	JIC lecturers	Japan
Course 3	Managers' Role Recognition Program	Business people (open seminar)	Jubail
Course 4	5S Program	Business people (open seminar)	Jubail
Course 5	KAIZEN Program	Students and business people (open seminar)	Jubail
Course 6	Discipline Program	Students and business people (open seminar)	Jubail
Course 7	Japanese-style Management Program	JIC lecturers	Jubail

(Source: JICA Study Team, CJIA)

(2) Approximate expense of training program

The approximate expense of the training program is summarized in Table 3.5.1-2 below. These figures are included in the material distributed at the workshop during the fourth field study.

Table 3.5.1-2 Approximate Expense of Training Program

(Monetary unit: 1,000 Saudi Arabian Riyal)

Course No.	1	2	3	4	5	6	7
Duration (days)	12	29	Note1	Note2	Note3	Note4	25
Number of participants	12	12	12	12	12	12	12
Course fee	106	255	144	294	197	182	324
Travel expense for trainees	474	661	---	---	---	---	---
Travel expense for trainers	---	---	113	145	102	100	140
Local travel expense	18	24	7	16	16	15	13
Miscellaneous expense (e.g. textbooks, lecture room)	23	36	7	7	7	7	7
Coordination fee	32	79	18	36	36	36	79
Administration fee	13	32	13	27	27	27	32
Subtotal	666	1,087	303	525	385	367	595
Consumption tax (8%)	53	87	24	42	31	29	48
Total	**719**	**1,174**	**327**	**567**	**416**	**396**	**643**

(Source: JICA Study Team, CJIA)

Note 1: Japanese consultants visit Jubail 3 times during 6 months to hold a total of 6 days of lecture.

Note 2: Japanese consultants visit Jubail 4 times during 6 months to hold a total of 5 days of lecture

Note 3: Japanese consultants visit Jubail 3 times during 6 months to hold a total of 4 days of lecture.

Note 4: Japanese consultants hold 7-day lecture and measure the impact within 6 months.

3.5.2 Renewable energy /Solar Power Generation

The Study Team understood JIC's need to install solar system for solar power generation education. At the same time, the Study Team determined the feasibility of solar installation through a site survey.

3.5.2.1 Summary of Survey Results

Installation site should meet the following conditions:

i. Student accessibility
ii. Installation will not prevent future JIC campus renovation plans.
iii. Prominent display for environmental enlightenment

As a result of discussion with JIC, the most likely installation site would be in front of the campus library.

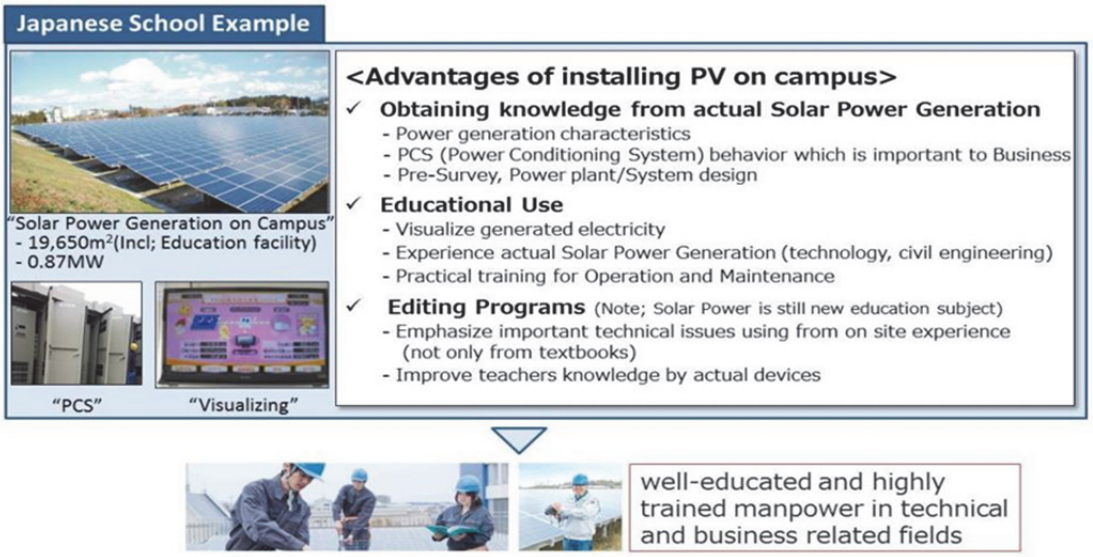


Figure 3.5.2-1 Cases of photovoltaics education in Japan

(Source: OCG JICA Study Team)

3.5.2.2 Summary of Proposal

Solar system will be installed in front of the library. Electricity generated by the solar system will be connected to the existing JIC distribution grid. According to the scale of demand for electricity in JIC, photovoltaics will not cause reverse power flow.

3.5.2.3 Explanation of Each Item for Proposal

(1) Name of Proposal

Effectively Utilizing Renewable Energy (Solar Power).

(2) Contents of Proposal

Solar power generation

(3) Purpose/Expected Effect

Renewable energy (solar power) is to be installed in an effort to save electricity produced by fossil fuel and reduce CO2 emissions.

Table 3.5.2-1 Estimated Effectiveness (per year)

Item	CO2 emission (ton)
Photovoltaics	61

(Source: OCG JICA Study Team)

(4) Initial cost

Table 3.5.2-2 shows the initial cost of each proposed item.

Table 3.5.2-2 Initial cost of each item

Item	Cost (SAR)
Photovoltaics	303,030

(Source: OCG JICA Study Team)

(5) Implementation Schedule

Table 3.5.2-3 shows the schedule for implementing the proposals. The schedule is divided into several phases. Total schedule will be approximately twelve months.

Table 3.5.2-3 Implementation Schedule

Item	Month	1	2	3	4	5	6	7	8	9	10	11	12
Photovoltaics	Initial Site survey for implementaion	■											
	Basic design and 2nd site survey		■	■									
	Detail design				■	■							
	Construction						■	■	■	■	■	■	■

(Source: OCG JICA Study Team)

(6) Action for the next step

The renewable energy field will become an important business market in the Kingdom. Installing solar power generation on JIC campus will be studied by JIC. JICA study team has suggested a technical cooperation between Saudi Arabia and Japan for further study.

The example of a technical cooperation image between Saudi Arabia and Japan is shown in Figure 3.5.2-3.

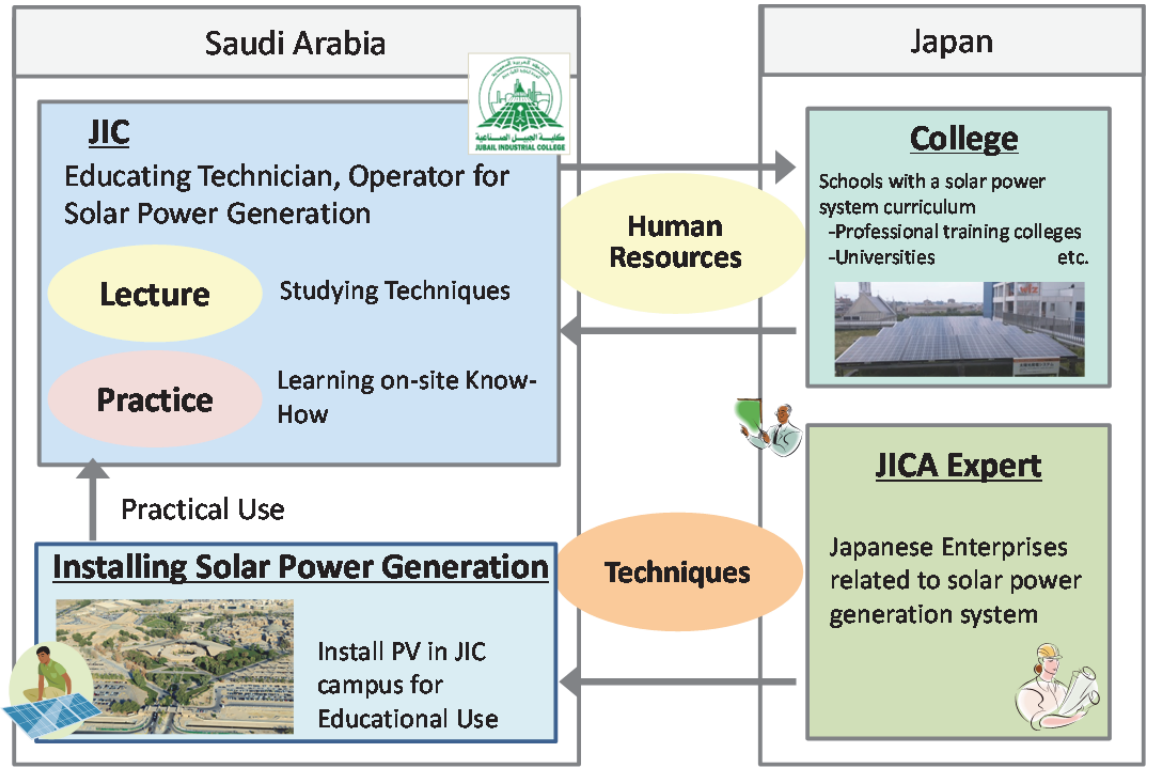


Figure 3.5.2-2: Technical cooperation image between Saudi Arabia and Japan

(Source: OCG JICA Study Team)

3.5.3 Solar Power Education

3.5.3.1 Summary of Survey results

The Study Team suggested and discussed the introduction of solar power generation education. Through discussion, the Study team have cleared business stages and encouraged employment creation on solar power generation as shown in Figure 3.5.3-1 and Figure 3.5.3-2.

As a result of consultation, the Study Team understand the renewable energy field will become an important business market in the Kingdom. Therefore, technical transfer about solar power generation for JIC instructors is considered an effective provision for developing human resources of this subject. The Study Team offer a proposal for a Training Program for Solar Power Generation Education for JIC instructors as described below.

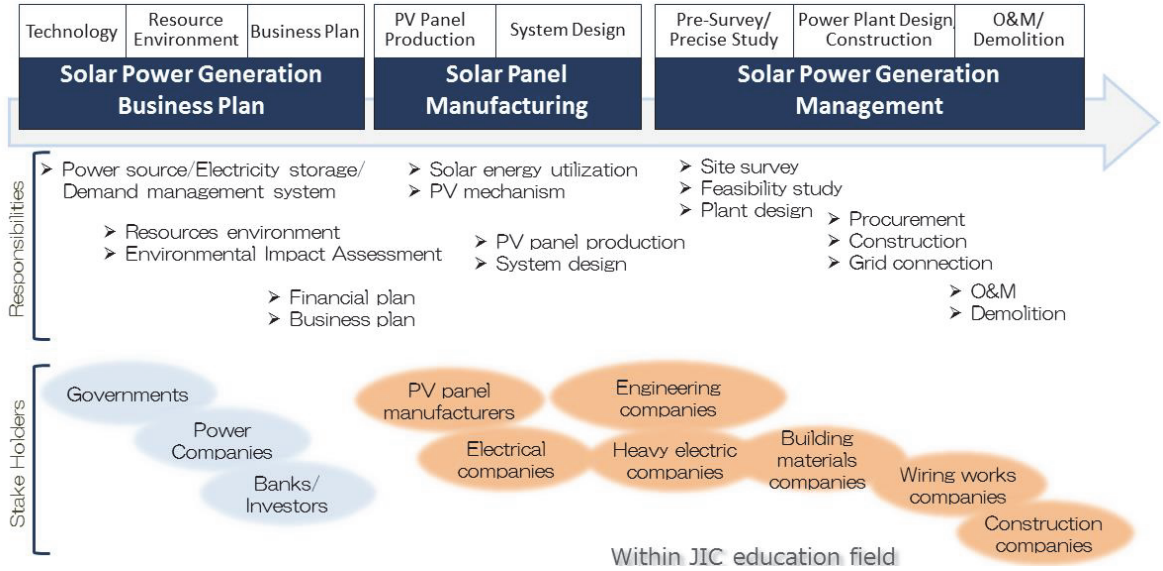


Figure 3.5.3-1: Solar power generation business stages

(Source: SEC)

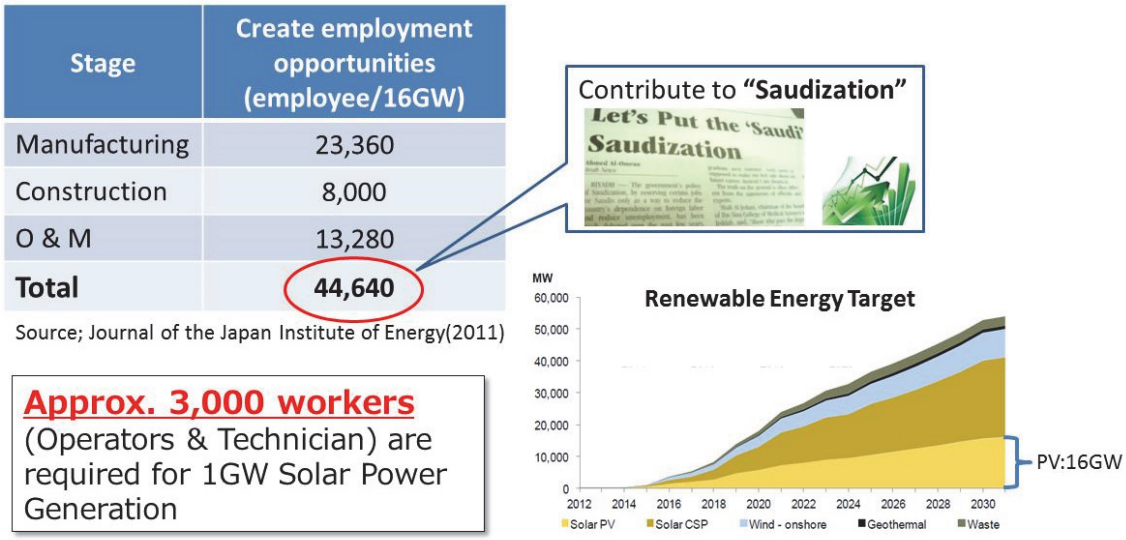


Figure 3.5.3-2: Encourage employment creation by solar power generation

(Source: SEC)

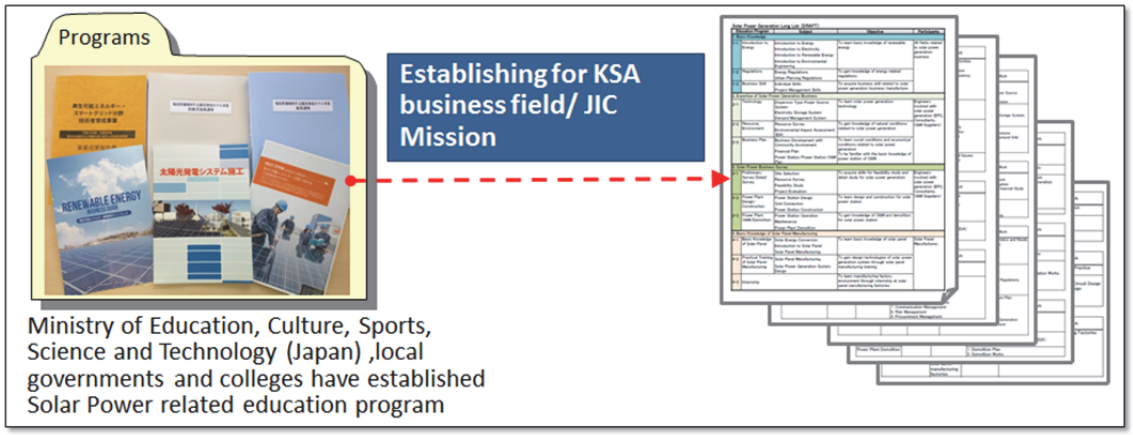


Figure 3.5.3-3: Establishing solar power generation education curriculum through Japanese experience and Saudi Arabia circumstances

(Source: OCG JICA Study Team)

3.5.3.2 Explanation of Each Item for Proposal

(1) Name of Proposal

Training Program for Solar Power Generation Education

(2) Content of Proposal (in Detail)

The training program has two phases, (a) Study in Japan and (b) Study in Saudi Arabia.

(a) Study in Japan

Learning from existing Japanese power plants and experiences are beneficial subjects in order to develop solar power education.

The program details and schedule are shown in Table 3.5.3-1 and Table 3.5.3-2.

Table 3.5.3-1: Training program; Study in Japan

Program Title	Study in Japan
Duration	29 days
Target persons	JIC instructors (Faculty of Electrical Power, Instrumentation & Control, and Manufacturing Engineering)
No. of participants	6
Objective	To obtain Solar Power Generation basic knowledge and Instrumentation & Control skills through studying Japanese curriculum and existing power plants. To train instructors for providing well-educated and highly trained manpower in technical and business related fields.
Main Topics	• Orientation • Energy related policy and regulations • Basic knowledge for Solar Power Generation • Outline of Solar Power Generation System • Solar Power Generation System Design • Solar Power Generation System Instrumentation • Safety and Health • On-site survey, construction training, O&M training

Table 3.5.3-2: Schedule of the training program in Japan

Day		Subjects
1	Mon	Orientation, Solar Power Generation in Japan
2	Tue	Renewable energy policy and regulation
3	Wed	Renewable energy policy and regulation
4	Thu	Technical basic knowledge for solar power generation
5	Fri	Technical basic knowledge for solar power generation
6	Sat	Off
7	Sun	Off
8	Mon	Solar power generation system outline / design
9	Tue	Solar power generation system design
10	Wed	Solar power generation system instrumentation
11	Thu	Solar power generation system instrumentation
12	Fri	Solar power generation system instrumentation
13	Sat	Off
14	Sun	Off
15	Mon	Safety and Health / On-site observation
16	Tue	On-site Construction training
17	Wed	On-site Construction training
18	Thu	On-site Construction training
19	Fri	On-site Construction training
20	Sat	Off
21	Sun	Off
22	Mon	On-site Construction training
23	Tue	On-site Construction training
24	Wed	On-site Construction training
25	Thu	On-site Construction training
26	Fri	On-site O&M training
27	Sat	Filed trip to The next generation energy parks
28	Sun	Filed trip to The next generation energy parks
29	Mon	Evaluation and wrap up for the program

(b) Study in Saudi Arabia

Understanding the renewable energy circumstances of Saudi Arabia is important in order to create an effective solar power generation education curriculum.

The program details and schedule are shown following Table 3.5.3-3 and Table 3.5.3-4.

Table 3.5.3-3: Training program; Study in Saudi Arabia

Program Title	Study in Saudi Arabia
Duration	19 days
Target persons	JIC instructors (Faculty of Electrical power, Instrumentation & Control, and Manufacturing Engineering)
No. of participants	6
Objective	To study Solar Power Generation Education for KSA through KSA circumstances and Japanese curriculum. To train instructors for providing well-educated and highly trained manpower in technical and business related fields.
Main Topics	• Orientation • Energy related policy and regulations • Solar power business market (industry, community, stake holders) • Solar Power Generation System Design • Solar Power Generation System Instrumentation • Safety and Health • On-site survey • Construction, O&M know-how • Discussion; HRD for Solar power business in KSA • Building curriculum

Table 3.5.3-4: Schedule of the training program in Saudi Arabia

Day		Subjects
1	Sun	Orientation, Renewable energy situation in the world
2	Mon	Renewable energy policy in KSA (Presentation by JIC instructors)
3	Tue	Solar power business market
4	Wed	Technical basic knowledge for solar power generation for Solar power business market in KSA
5	Thu	Technical basic knowledge for solar power generation for Solar power business market in KSA
6	Fri	Off
7	Sat	Off
8	Sun	Estimation for Solar power generation amount in KSA
9	Mon	Solar power generation system outline / design
10	Tue	Solar power generation system instrumentation
11	Wed	Field Case study (Site Visit), Safety and Health
12	Thu	Field Case study (Site Visit), construction and O&M know-how
13	Fri	Off
14	Sat	Off
15	Sun	Small group activities (Discussion; HRD for Solar power business in KSA)
16	Mon	Small group activities (Discussion; HRD for Solar power business in KSA)
17	Tue	Building curriculum for Solar power generation education
18	Wed	Building curriculum for Solar power generation education
19	Thu	Evaluation and wrap up for the program

(3) Purpose/Expected Effect

Renewable energy education is still a relatively new subject. In Japan, a new curriculum was developed from existing education courses related to solar power generation.

Through the training program for JIC instructors, solar power generation education will be studied through related courses, highlighted in red in Figure 3.5.3-4.

Figure 3.5.3-4: Solar power generation related course of JIC

(Source: OCG JICA Study Team)

(4) Initial cost

Tables 3.5.3-5 and 3.5.3-6 show the cost of training programs:

Table 3.5.3-5: Cost of Training program in Japan

Duration of Training	29 days
Number of Participants	6
Item	Cost (SAR)
Training Fee	112,000
Program & Material Development	210,000
Travel Expenses	250,000
Total	572,000

(Source: OCG, JICA Study Team)

Table 3.5.3-6 Cost of Training program in Saudi Arabia

Duration of Training	19 days
Number of Participants	6
Item	Cost (SAR)
Training Fee	84,200
Program & Material Development	210,000
Travel Expenses	75,900
Total	370,100

(Source: OCG, JICA Study Team)

(5) Implementation Schedule

Table 3.5.3-7 shows the schedule for implementing the proposals.

Table 3.5.3-7: Implementation Schedule

Item	1			2			3			4		
Program & Material development	■	■	■	■								
Study in Japan					■	■	■					
Study in Saudi Arabia									■	■		

(Source: OCG, JICA Study Team)

(6) Action for the next step

The Japanese Official Development Assistance (ODA) for Saudi Arabia after 35 years of continuous technical cooperation achievements in the Kingdom has been terminated since 2010. However, JICA cost-sharing basis program can support technical cooperation in Saudi Arabia.

In order to implement the training program for solar power generation education for JIC instructors, JICA team suggests that JIC will apply JICA cost-sharing basis program. Under the JICA cost-sharing basis program, implementation costs are shared between Saudi Arabia and Japan.

The example of a technical cooperation image between Saudi Arabia and Japan is shown in Figure 3.5.3-5.

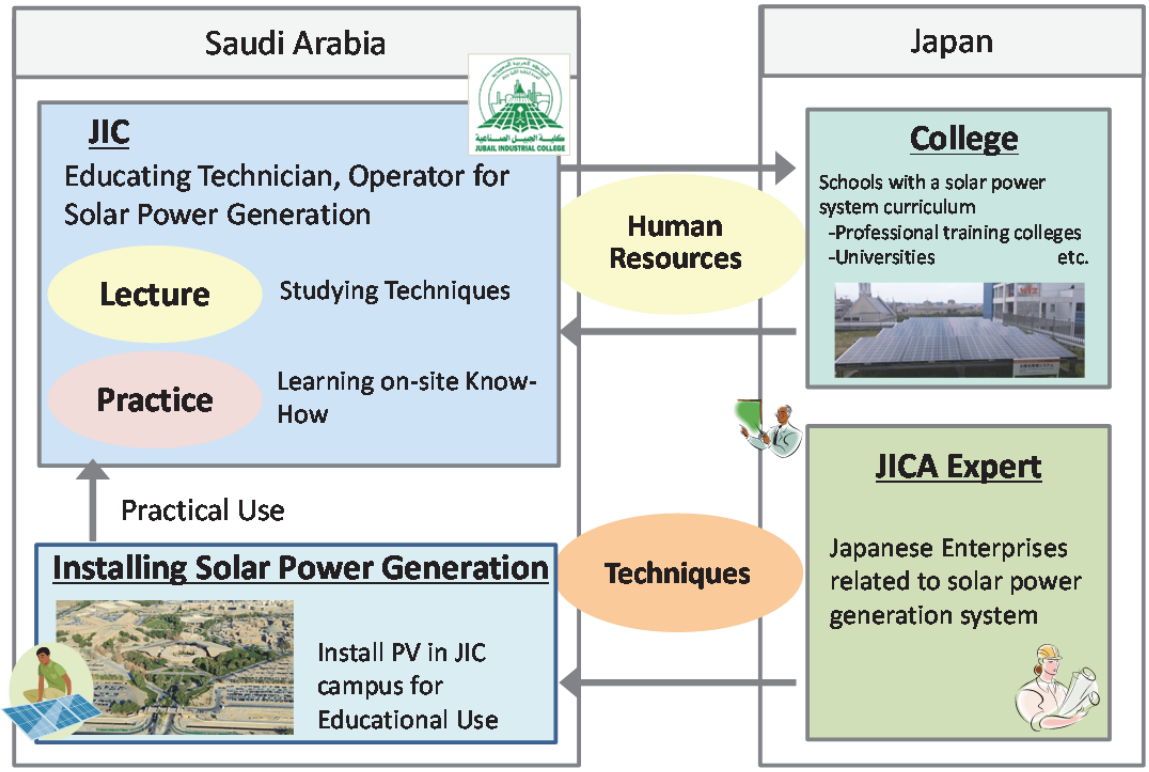


Figure 3.5.3-5: Technical cooperation image between Saudi Arabia and Japan

(Source: OGC JICA Study Team)