Study on Economic Partnership Projects in Developing Countries in FY2017

Study on Power and Water Supply on Barge at Tema Port in Republic of Ghana

Final Report

February 2018

Prepared for:
Ministry of Economy, Trade and Industry

Prepared by:
Mitsubishi Heavy Industries, Ltd.
Preface

This report is to compile the outcome of “Study on Economic Partnership Projects in Developing Countries in FY2017”, which Mitsubishi Heavy Industries, Ltd. (MHI) was entrusted for the FY2017 project by Ministry of Economy, Trade and Industry (METI).

The study, “Study on Power and Water Supply on Barge at Tema Port in Republic of Ghana” is to investigate the feasibility of the power and water supply business, using the offshore thermal power generation and seawater desalination equipment in order to solve the specific issue of demand and supply gap of power and water at Tema Port in Republic of Ghana.

Republic of Ghana has achieved remarkable economic growth in the African regions with the background of rapid population increase and stable democratic government. On the other hand, thus, there are people and companies that is difficult to access stable electric power and water supply, in rural and coastal area.

We propose Power and Water on Barge, first in the world. It consists of thermal power generation equipment and seawater desalination equipment together on the barge mooring offshore, and supplies power and drinking water. The facility is furnished in shipyard, and installed at site. Minimum site work is necessary, those are only mooring, power and water connections. That enables short delivery period with less risks of land acquisition and site work delay, often occurs at developing countries.

In this study, we studied business feasibility on power and water supply business, based on hearing and discussion with persons in Republic of Ghana, on information of demand and supply of The investigation is to study the feasibility of the project as discussing and interviewing Republic of Ghana on the demand information, economic situation, and their interest on the business.

We hope that this report would contribute to proceed to the project and be a reference for persons in our country.

February 2018

Mitsubishi Heavy Industries, Ltd.
Project Map

Resource: Google Map (2018)
<table>
<thead>
<tr>
<th>Abbreviation</th>
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</tr>
</thead>
<tbody>
<tr>
<td>METI</td>
<td>Ministry of Economy, Trade and Industry</td>
</tr>
<tr>
<td>PPP</td>
<td>Public Private Partnership</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
</tr>
<tr>
<td>NPP</td>
<td>New Patriotic Party</td>
</tr>
<tr>
<td>HIPC</td>
<td>Heavily Indebted Poor Countries</td>
</tr>
<tr>
<td>IMF</td>
<td>International Monetary Fund</td>
</tr>
<tr>
<td>USAID</td>
<td>United States Agency for International Development</td>
</tr>
<tr>
<td>AU</td>
<td>African Union</td>
</tr>
<tr>
<td>ECOWAS</td>
<td>Economic Community of West African States</td>
</tr>
<tr>
<td>USA</td>
<td>United States of America</td>
</tr>
<tr>
<td>UK</td>
<td>United Kingdom of Great Britain and Northern Ireland</td>
</tr>
<tr>
<td>OECD</td>
<td>Organisation for Economic Co-operation and Development</td>
</tr>
<tr>
<td>JETRO</td>
<td>Japan External Trade Organization</td>
</tr>
<tr>
<td>JICA</td>
<td>Japan International Cooperation Agency</td>
</tr>
<tr>
<td>SPC</td>
<td>Special Purpose Company</td>
</tr>
<tr>
<td>RO</td>
<td>Reverse Osmosis</td>
</tr>
<tr>
<td>SWRO</td>
<td>Sea Water Reverse Osmosis</td>
</tr>
<tr>
<td>PFD</td>
<td>Process Flow Diagram</td>
</tr>
<tr>
<td>SDI</td>
<td>Silt Density Index</td>
</tr>
<tr>
<td>UF</td>
<td>Ultrafiltration</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
</tr>
<tr>
<td>FRP</td>
<td>Fiber Reinforced Plastics</td>
</tr>
<tr>
<td>UV</td>
<td>Ultraviolet</td>
</tr>
<tr>
<td>LNG</td>
<td>Liquefied Natural Gas</td>
</tr>
<tr>
<td>ReGAS</td>
<td>Regasification</td>
</tr>
<tr>
<td>GTCC</td>
<td>Gas Turbine Combined Cycle</td>
</tr>
<tr>
<td>IPP</td>
<td>Independent Power Producer</td>
</tr>
<tr>
<td>STEP</td>
<td>Special Terms for Economic Partnership</td>
</tr>
<tr>
<td>IWP</td>
<td>Independent Water Producer</td>
</tr>
<tr>
<td>CAPEX</td>
<td>Capital Expenditure</td>
</tr>
<tr>
<td>OPEX</td>
<td>Operating Expenditure</td>
</tr>
<tr>
<td>FIRR</td>
<td>Financial Internal Rate of Return</td>
</tr>
<tr>
<td>EIRR</td>
<td>Economic Internal Rate of Return</td>
</tr>
<tr>
<td>FEED</td>
<td>Front End Engineering Design</td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>------------------------------</td>
</tr>
<tr>
<td>EPC</td>
<td>Engineering, Procurement &amp; Construction</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>Operation &amp; Maintenance</td>
</tr>
<tr>
<td>MHI</td>
<td>Mitsubishi Heavy Industries, Ltd.</td>
</tr>
</tbody>
</table>
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Executive Summary

Republic of Ghana has achieved remarkable economic growth in the African regions with the background of rapid population increase and stable democratic government. On the other hand, the budget and management for public utilities, like power and water, including technical issue, is not enough for stable supply to support economic growth; thus, there are people and companies that is difficult to access stable electric power and water supply, in rural and coastal area.

We propose Power and Water on Barge, first in the world. It consists of thermal power generation equipment and seawater desalination equipment together on the barge mooring offshore, and supplies power and drinking water. The facility is furnished in shipyard, and installed at site. Minimum site work is necessary, those are only mooring, power and water connections. That enables short delivery period with less risks of land acquisition and site work delay, often occurs at developing countries.

In this study, we studied business feasibility on power and water supply business, based on hearing and discussion with persons in Republic of Ghana, on information of demand and supply of The investigation is to study the feasibility of the project as discussing and interviewing Republic of Ghana on the demand information, economic situation, and their interest on the business.

Expected Project Site

Source : Edited by MHI based on United Nations Office Project Services「Environmental Sensitivity Map for Coastal Areas of Ghana」(2004)
For the project location, it is assumed that a candidate location is the coast of Tema Port, that is the international port in vicinity of Accra city, capital of Republic of Ghana, and heavy industry zone locates near the port. For discussion with persons in Republic of Ghana, we assumed 2 cases described below;

Case 1 <Yen Loan Case>
Small Size Power and Water on Barge for temporary/emergency use
Transmitting Power 4,300kW, Water 10,000m³/day
Business Scale approximately 60 Million USD

Case 2 <PPP Case>
Regular Size Power and Water on Barge for power and water supply business
Transmitting Power 33,000kW, Water 50,000m³/day
Business Scale approximately 600 Million USD (for 20 years)

We made preliminary financial and economic evaluations for each cases above.

Case 1<Yen Loan Case> is a business operated by public sector. Then criterion of business feasibility is set as “FIRR of business period 20 years is more than zero”. To satisfy the criterion, fees of power and water is calculated, under a certain assumptions. As a result, when Grant Aid by Japanese Government is adopted for CAPEX, calculated electricity fee is 0.15USD/kWh and water fee 1.0USD/m³. The result seems to be relatively competitive, compared with exiting IPP and IWP. When STEP Yen Loan is adopted for CAPEX, calculated electricity fee is 0.26USD/kWh and water fee 1.7USD/m³.

Case 2<PPP Case> is essentially a private business. Then criterion of business feasibility is set as “FIRR of business period 20 years is more than interest rate”. To satisfy the criterion, fees of power and water is calculated, under a certain assumptions. As a result, calculated electricity fee is 0.25USD/kWh and water fee 1.7USD/m³. The result is the same level as STEP Yen Loan Case. It is necessary to be accepted by government and off-takers.

We discussed with persons in government of Republic of Ghana. Some persons are interested in our plan of business scheme and specifications. In order to proceed to the project, some actions are necessary such as: more precise forecast of power and water demand, determination of project site,
and improvement of financial situations of government and public operation companies. With such activities, if Government of Republic of Ghana proactively asks to proceed to the project to Japanese Government, it is expected to be a chance to export quality infrastructure and doing business in West Africa, for Japanese companies.
Chapter 1  Overview of Republic of Ghana and Sector

(1) Economic and Financial Situation of Republic of Ghana

Republic of Ghana is low middle-income country with 1,480 USD of Gross National Income per person, located in West Africa. It has achieved one of the fastest economic growth, among African countries. GDP increased to 249.8% (37.543 billion USD as of 2015) and the population increased by 28.1% (27,409,800 as of 2015) in the past 10 years (2005 – 2015). The main industries are agriculture and mining. Agriculture accounts for approximately 20% of GDP and about 50% of employment. Republic of Ghana is a typical primary product depending country. Major export goods are gold, oil, cacao and timbers. Prices of those are unstable due to variation of international market conditions and weather. Commercial production of oil started recently in Dec. 2010. In 1990s, Republic of Ghana applied for debt relief through the expanded Heavily Indebted Poor Countries (HIPC) Initiative due to international price stagnation of gold and cacao and higher oil import price. (Source: Fundamental Data of Republic of Ghana, cited from website of Ministry of Foreign Affairs of Japan, 2018)

Stable democratic government administration in Republic of Ghana is one of the driver of faster economic growth. Since 1992, the election of the President has been conducted peacefully. Onwards, and the government was changed between the ruling and opposition parties through voting in Jan. 2001. The present president, Akufo-Addo won from New Patriotic Party (NPP) in election in Dec. 2016 to change the administration. At that time, the regime change occurred. At present, under the financial support program by International Monetary Fund (IMF) and support from the United States Agency for International Development (USAID), the fundamental fiscal consolidation, focusing on energy sector, and the local economic promotion measure under the catch phrase, “One District, One Factory” are promoted.

Republic of Ghana is based on unaligned neutrality and focuses on the relationship with neighboring countries as a major member of African Union (AU) and Economic Community of West African States (ECOWAS) (it was an ECOWAS chair country in 2014 and AU chair country in 2007). Main exporting countries are India, Switzerland, China, Netherlands, and France. Main importing countries are China, Netherlands, USA, India, and France. Major importing goods are machinery, oil, and foods. In addition, it actively receives the support from USA, UK, Canada, Denmark, and Japan, which are main donors for the bilateral aid. Recently it has close relationship with China as actively engaged in borrowing foreign currency borrowing from China with the bauxite interests as collateral.

(2) Overview of Project Subjected Sector

The government budget and management for public utilities, like power and water, is not enough for stable supply to growing demand, and the gap between demand and supply in power and water tends to be expanding. According to World Bank Data and OECD Statistics, power access rate is 78.3% (as of 2014) and water access rate is 80% of the people in Republic of Ghana. Especially in suburbs of the capital, Accra, where it is concentrated area of population and industry, it faces the issue of often power outage and water supply suspension. It is the important problem to be solved since the previous administration. On the other hand, the government of Republic of Ghana announced the statement on sharing emergency power supply through power grids to the ECOWAS countries, such as a neighbor country, Republic of Togo, then, improvement of power supply is necessary. Towards solution of such problem, USAID provides support for reforming public utility company like Electricity Company of Ghana and Ghana Water Company. In future,
Independent Power Producer (IPP) and Independent Water Producer (IWP) operated by private company, supply more power and water efficiently.

(3) Situation of Subject Area

There are 2 international ports in Republic of Ghana; Tema Port, located in the south east of the country and Sekondi-Takoradi Port, located in the south west of the country. According to “Investing in Ghana 2017” issued by Ghana Investment Promotion Centre, approximately 80% of exports and imports are handled at Tema Port.

Tema Port is located in the south east and 24km away from Accra, the capital. The port has 12 berths for international carriers and 1 berth for oil tanker. Breakwaters of total 5 km length are installed. Seafood processing factory, cement manufacturing facility, and grain storage tower are located in the nearby area. At the time of the study, Meridian Port Services, the port operator, is implementing large-scale expansion of logistic yards until in June 2019.

According to the Ghana Free Zone Board, Tema Export Processing Zone of 4.8km² area, is set. The Board promotes to invite manufacturers, service provider, and exporters. Tenants of Export Processing Zone would receive the benefit of one-stop services, including tax relief, quarantine service, and immigration process. There is information by the Board that a Chinese ceramic processing factory considers to be a tenant.

According to the explanation of Ghana Free Zone Board, currently planned power outage and water suspension are occurred about twice per week, which is one of causes of not attracting business much, and there are some locations, which has not started the land reclamation yet in the design area. Photos of Tema Area, taken by mission, are shown in Fig 1.1 – 1.4.

![Fig1.1 Tema Heavy Industry Zone](Photo by mission)
![Fig1.2 Tema Heavy Industry Zone (developing)](Photo by mission)
![Fig1.3 Tema Port Area](Photo by mission)
![Fig1.4 Tema Port Area](Photo by mission)
Chapter 2  Study Methodology

(1) Subjects

This study includes contents described below;

1) Study on situation and supply/demand prediction of the sector
2) Study of required specification
3) Preliminary design of facility and cost estimation
4) Study of finance scheme and feasibility
5) Study of environmental and social impact
6) Project Promotion

(2) Methodology

Ministry of Economy, Trade and Industry (METI) of Japanese government commissioned this study to Mitsubishi Heavy Industry (MHI). MHI recommissioned a part of study to Nomura Research Institute, Ltd. MHI reports to METI.

MHI implements this study including methodology described below;

- Literature and open information search
- Visit to Republic of Ghana and discussion with local persons
- Discussion with Japanese organizations JETRO, JICA, etc.
(3) Schedule

Study schedule is shown in Table 2.1.

Table 2.1 Study Schedule

<table>
<thead>
<tr>
<th>(Domestic Activity)</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Study on Situation and Supply/Demand Prediction of the Sector</td>
<td>Aug</td>
<td>Jan</td>
</tr>
<tr>
<td>2. Study of required specification</td>
<td>Sep</td>
<td>Feb</td>
</tr>
<tr>
<td>3. Preliminary design of facility and cost estimation</td>
<td>Oct</td>
<td></td>
</tr>
<tr>
<td>4. Study of finance scheme and feasibility</td>
<td>Nov</td>
<td></td>
</tr>
<tr>
<td>5. Study of environmental and social impact</td>
<td>Dec</td>
<td></td>
</tr>
<tr>
<td>6. Project Promotion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discuss with JETRO, JICA, etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Report preparation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Local Visit)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st Local Visit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2nd Local Visit</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Chapter 3 Justification, Objectives and Technical Feasibility of the Project

(1) Background and Necessity of the Project

As described in Chapter 1, Republic of Ghana has achieved remarkable economic growth in the African regions with the background of rapid population increase and stable democratic government. On the other hand, the budget and management for public utilities, like power and water, including technical issue, is not enough for stable supply to support economic growth; thus, there are people and companies those are is difficult to access stable electric power and water supply, in rural and coastal area. That is one of the factors that hinders economic growth.

Ghana Free Zone Board promotes Tema Export Prosessing Zone to aquire foreign currency. Then it is important to improve fundamental infrastructure for power and water supply. Power and Water on Barge may be one of the solution. When the result of this study is feasible, it is expected to enhance economic growth of Republic of Ghana.

(2) Basic Policy and Decision on the Project Contents

It is important that the benefit for national economy of Republic of Ghana is confirmed, and that it has social and economic rationality of both Republic of Ghana and Japan.

This study is a feasibility study of power and water supply business with Power and Water on Barge. Based on information of demand and supply of power and water by republic of Ghana, we plan business scheme and facility specification. There is no reference experience of whole set of Power and Water on Barge, then stepwise approach is more realistic that start from small size Yen Loan Case, afterwards proceed to regular size PPP case.

(3) Project Overview

Power and Water on Barge is a power and water supply system, on a barge moored offshore, equipped both thermal power plant and sea water desalination plant. The facility is furnished in shipyard with good equipment for assembly, and installed at site. Minimum site work is necessary, those are only mooring, power and water connections. That enables short delivery period with less risks of land acquisition and site work delay, often occurs at developing countries.

We assumed 2 cases described below, of business scheme and typical specifications, in order to discuss with persons in Republic of Ghana.

Case 1 <Yen Loan>
Small Size Power and Water on Barge for temporary/emergency use
Transmitting Power 4,300kW, Water 10,000m³/day
Business Scale approximately 600 Million USD

Case 2 <PPP>
Regular Size Power and Water on Barge for power and water supply business
Transmitting Power 33,000kW, Water 50,000m³/day
Business Scale approximately 6 Billion USD (for 20 years)
Coast near Tema Port area is assumed for expected project site. (Fig 3.1)

Fig. 3.1 Expected Project Site

Source: Edited by MHI based on United Nations Office Project Services
(4) Various Necessary Study Items

1) Study of Required Specifications

For the needs assessment with Republic of Ghana, the following 2 cases are set as representative specifications since it was necessary to show the typical specifications and business scheme.

① Small-size Equipment for Emergency and Temporary Use (Fig.3.2)

- Power Generator: diesel engine
- Fuel: heavy oil
- Power transmission: 4,300kW
- Seawater desalination: 10,000m³/day
- Finance: <Yen Loan Case>
- Owner/operator: government organization of Republic of Ghana

![Fig.3.2 Image of Small-size Equipment for Emergency and Temporary Use](image)

By MHI

② Regular-size Equipment for Electricity and Clean Water Supply (Fig.3.3)

- Power Generator: Gas turbine combined cycle
- Fuel: Liquefied Natural Gas (LNG)
- Power transmission: 33,000kW
- Seawater desalination: 50,000m³/day
- Finance: <PPP Case>
- Owner/operator: SPC led by private sector, participated by public organization (PPP scheme)

![Fig.3.3 Image of Regular-size Equipment for Power and Water Supply](image)

By MHI
We held discussion with persons in Republic of Ghana on their interest on the project, as showing the aforementioned typical specifications at the local study. There were many opinions; however, the site and size were not determined, then we continued to study the technical aspects with the set typical specifications.

2) **Study of Specification for Small-size Equipment for Emergency and Temporary Use**

   It is assumed that the government organization owns and operates the equipment. It is used for power and water supply in the area, where there is no infrastructure for power and water, or temporary suspended due to disasters.

   Because the usage is for emergency and temporary use, the fuel for power generator is heavy oil since it is easy to distribute without existing infrastructure. The standard capacity of seawater desalination is set at 10,000m³/day although it is fairly easy to adjust the number of containers, depending on needs.

   As to the capacity of power generator, the surplus will be supplied to the grid after providing power required for the seawater desalination equipment.

   Although the transmitting power quantity can be adjustable, based on the needs, power transmission to grid is set at 4,300kW after deducting power required for the seawater desalination equipment, from the power generation capacity 5,880kW.

① **Power Generator**

   The power generation equipment is heavy oil-fired diesel engine, and “18KU30A” is selected from the MHI KU series. The KU series is a product of MHI group, Mitsubishi Heavy Industries Engine & Turbocharger, Ltd., and it will contribute low cost power generation, stable energy supply, and meeting environmental requirements.

   Specification and view of KU Series diesel engine is shown in Fig. 3.4. Specification and view of selected flame 18KU30A is shown in Fig.3.5. The fuel property required for the KU series engine is shown in Fig.3.6.
**Fig 3.4** Specification and View of KU Series Diesel Engine

<table>
<thead>
<tr>
<th>Model</th>
<th>12KU30A</th>
<th>14KU30A</th>
<th>16KU30A</th>
<th>18KU30A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generator Frequency (Hz)</td>
<td>60</td>
<td>50</td>
<td>50</td>
<td>60</td>
</tr>
<tr>
<td>No. of Cylinders</td>
<td>12</td>
<td>14</td>
<td>16</td>
<td>18</td>
</tr>
<tr>
<td>Bore x stroke (mm)</td>
<td>300 x 380</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RPM</td>
<td>720</td>
<td>750</td>
<td>720</td>
<td>750</td>
</tr>
<tr>
<td>Generator Rated output (kWe)</td>
<td>3,760</td>
<td>3,920</td>
<td>4,380</td>
<td>4,570</td>
</tr>
<tr>
<td>Engine Weight (Metric Ton)</td>
<td>40</td>
<td>40</td>
<td>54</td>
<td>54</td>
</tr>
<tr>
<td>NOx Emissions (ppm)*1</td>
<td>710 – 780 (Oc: 15%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steam Generation @0.69 MPaG (kg/hr)*2</td>
<td>1,470</td>
<td>1,670</td>
<td>1,870</td>
<td>2,100</td>
</tr>
</tbody>
</table>

*1: NOx value to be determined referring to local regulations.
*2: These figures are for reference only. Actual figures shall be confirmed depending on design conditions.

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**Fig 3.5** Specification and View of 18KU30A Diesel Engine

<table>
<thead>
<tr>
<th>Model</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>12KU30A</td>
<td>6,365</td>
<td>2,090</td>
<td>4,605</td>
<td>1,700</td>
</tr>
<tr>
<td>14KU30A</td>
<td>7,145</td>
<td>2,090</td>
<td>3,720</td>
<td>1,700</td>
</tr>
<tr>
<td>16KU30A</td>
<td>7,885</td>
<td>2,090</td>
<td>3,720</td>
<td>1,700</td>
</tr>
<tr>
<td>18KU30A</td>
<td>8,339</td>
<td>2,090</td>
<td>3,720</td>
<td>1,700</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>KU30A</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.of Cylinder</td>
</tr>
<tr>
<td>Output</td>
</tr>
<tr>
<td>Bore x Stroke</td>
</tr>
<tr>
<td>RPM</td>
</tr>
<tr>
<td>Voltage</td>
</tr>
</tbody>
</table>

By MHI
### Fig 3.6 Requirement for Fuel Oil

#### Required quality for fuel oil

Properties at the time of acceptance are shown in the following table.

<table>
<thead>
<tr>
<th>Item</th>
<th>Heavy fuel oil</th>
<th>Diesel Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Recommended properties</td>
<td>Limit properties</td>
</tr>
<tr>
<td>Specific gravity 15°C kg/L</td>
<td>≤ 0.005</td>
<td>≤ 0.001 ¹</td>
</tr>
<tr>
<td>Kinematic viscosity mm²/s (cSt) at 50°C</td>
<td>≤ 250</td>
<td>≤ 300</td>
</tr>
<tr>
<td>Reacond</td>
<td>Neutral</td>
<td>Neutral</td>
</tr>
<tr>
<td>Pour point °C</td>
<td>≤ 20</td>
<td>≤ 30</td>
</tr>
<tr>
<td>Flash point °C</td>
<td>≥ 60</td>
<td>≥ 70</td>
</tr>
<tr>
<td>Water Vol.%</td>
<td>≤ 0.2</td>
<td>≤ 1.0</td>
</tr>
<tr>
<td>Carbon residue Wt.%</td>
<td>≤ 10</td>
<td>≤ 10</td>
</tr>
<tr>
<td>Ash Wt.%</td>
<td>≤ 8</td>
<td>≤ 8</td>
</tr>
<tr>
<td>Sulphur Wt.%</td>
<td>≤ 0.05</td>
<td>≤ 0.1</td>
</tr>
<tr>
<td>Vanadium ppm</td>
<td>≤ 100</td>
<td>≤ 300</td>
</tr>
<tr>
<td>Sodium ppm</td>
<td>≤ 1/3 of Vanadium</td>
<td>≤ 1/3 of Vanadium</td>
</tr>
<tr>
<td>Aluminum + Si ppm</td>
<td>Total ≤ 15</td>
<td>Total ≤ 15</td>
</tr>
<tr>
<td>Nitrogen Wt.%</td>
<td>≤ 0.2</td>
<td>≤ 0.2</td>
</tr>
<tr>
<td>CCAI ≤ 830</td>
<td>≤ 845</td>
<td>≤ 830</td>
</tr>
<tr>
<td>Calorific Number X [¹]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zinc mg/kg</td>
<td>total ≤ 40</td>
<td>≥ 35</td>
</tr>
<tr>
<td>Phosphorus mg/kg</td>
<td>total ≤ 50</td>
<td>&lt;= 15</td>
</tr>
<tr>
<td>Calcium mg/kg</td>
<td>total ≤ 50</td>
<td>&lt;= 15</td>
</tr>
<tr>
<td>TSP (TSE) Wt.%</td>
<td>≤ 0.05</td>
<td>≤ 0.1</td>
</tr>
</tbody>
</table>

1: Applicable lowest limit for kinematic viscosity is 2.2 mm²/s (cSt) at 50 °C.
2: Also, Calorific number measured by (TSE-CN) or (ISO) must be at least 845 or more.
3: Even if the specific gravity is less than limit property, confirms the (TSE-CN), Zn, P, Ca and TSP security in case that specific gravity is more than 0.975 kg/L.
4: If sulphur is less than 0.05%, confirm the analyzed result of (TSE-CN) (or Calorific index) security.

By MHI
Seawater Desalination Equipment Plan

Summary of RO Membrane type seawater desalination system is described as follows.

(i) Basic Process Flow

The PFD of the RO Membrane type seawater desalination system is shown in Fig3.7. Process flow is shown in Table 3.1. Containerized SWRO system is used, which is designed by Metito, which is the affiliated company of MHI (see Appendix).

<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>Unit</th>
<th>Flow Rate</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Raw seawater</td>
<td>m³/h</td>
<td>984</td>
<td>Water intake</td>
</tr>
<tr>
<td>2</td>
<td>Drinking water</td>
<td>m³/h</td>
<td>417</td>
<td>10,000m³/day</td>
</tr>
<tr>
<td>3</td>
<td>UF membrane backwash</td>
<td>m³/h</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>RO membrane brine</td>
<td>m³/h</td>
<td>509</td>
<td>Concentrated seawater</td>
</tr>
</tbody>
</table>

By MHI

(ii) Process Summary

The summary of process for RO type seawater desalination equipment is described as follows.

(a) Equipment Configuration

The system consists of Pre-treatment equipment, RO unit and Post treatment equipment.

(b) Pre-treatment Equipment

Hypochlorite solution, generated with electrolyzer, is injected in the raw water line to prevent bacteriological contamination and the development of Algae Slime in the raw water line. Afterwards, the raw water is fed to Ultra Filtration (UF) Modules. During UF processing, dirt material is removed to Silt Density Index (SDI) value (lower than approx. 4), which can be supplied to RO unit. UF backwash is equipped to restore the membrane performance with cleaning at periodical interval. Chemical enhanced backwash is also equipped to keep backwash efficiency.

(c) RO Unit (Desalination Equipment)

Each RO Unit consists of a high pressure pump, energy recovery devices and RO membranes. Seawater from Pre-treatment Equipment is boosted to required level by a high pressure pump and energy recovery devices. With energy recovery devices, energy is recovered from rejected brine pressure. Afterwards, permeated water is fed to Post-treatment Equipment.
(d) Post-treatment Equipment
Permeated water is re-mineralized with lime \((\text{Ca(OH)}_2)\) and dosed with chlorine for final disinfection. Sodium Hypochlorite is dosed so as to maintain permitted level of residual chlorine in the product drinking water.

(iii) Arrangement Plan
Containerized SWRO system in standard 40ft ISO container (Capacity 2000m3/day/container) is located on main deck. Tanks for drinking water, cleaning and flushing and auxiliaries are located on lower deck, for arranging in compact space.
3  Barge and General Arrangement Plan

The floating thermal power generation and seawater desalination plant, which is a barge plant with the power generation plant and seawater desalination plant, has its basic structure of (1) power generation plant, (2) seawater desalination plant, (3) operation room/offices for personnel and relevant facilities and optionally (4) LNG/fuel oil storage tank, (5) loading unit, and (6) LNG regasification unit, it is a moored floating plant to produce and supply power and drinking water. It enables to secure the power indispensable for the seawater desalination unit and at the same time it enables to share surplus power for the area where the plant is installed, based on the power generation demand. Depending on the installed location, there may be existing gas/fuel oil supply lines, for that case, it may be unnecessary to install the unit (4), (5) and (6). The characteristics of the floating type plant are the following: minimized land use, shorter construction and building period at a local site, and associated excellent economy, compared to that of onshore power plant and seawater desalination plant. By the optimized design on barge specification, it enables to install at the shallow water depth area at a depth of 7 – 8 meters, and it is easy to relocate it, due to the demand change of electric power and water.

See the Fig 3.8 for general view of trial design of the offshore thermal power plant and seawater desalination apparatus as small-size equipment for emergency and temporary use, the Fig 3.9 for the 3D external view, and the Fig 3.10 for installation image view, based on the trial design.

The barge main dimension is the following, as a result of the trial designing.

Vessel length x beam x depth: approx. 76.0m x 39.0m x 5.0m

Office building, including the aforementioned generator engine for the power generation unit and control room (left side: stern) and seawater desalination unit (right side: bow) are arranged on the barge deck as well as a crane for handling goods. The dimension of entire barge is optimized by being creative in directions of element machineries and installing auxiliary machineries and tank as many as possible in the ship. For the capacity of each tank, it is assumed that clear water can be supplied continuously to the existing system, and drinking water is stored for 4 hours’ worth in the unit, and rated power is secured for 1 week worth with an assumption that fuel oil for power generation can be supplied every week. For the mooring method, it is assumed that it can handle the barge quaking and displacement with multi-point mooring, using fiber ropes on the assumption to install in the port, where it is relatively calm ocean weather. Pile type (piling method) or mooring with mooring lines is to be adopted as considering the barge shaking and plant operational conditions, based on the climate and geographical conditions of installed location.
Fig 3.8  Layout Example of Small Size Power and Water on Barge

By MHI
Fig 3.9   3D View of Small Size Power and Water on Barge

By MHI
Fig 3.10  Installation Image View of Small Size Power and Water on Barge

By MHI
3) **Regular-size Equipment for Power and Water Supply**

It is assumed to use power and water supply business, operated by SPC led by private sector, participated by public organization (PPP scheme), as IPP and IWP. So it is located an area where substantial volume of demand is forecasted.

Fuel is liquefied natural gas (LNG), which emits low amount of CO₂ with low cost of energy expected, and along with adopt of high efficient Gas Turbine Combined Cycle (GTCC).

Rated power output is 41,000kW, considering of ambient temperature and seawater temperature. The capacity of seawater desalination equipment is 50,000m³/day as a standard, although it can be freely adjustable, based on the needs. If using the container type, more than 25 RO containers are required, the arrangement will be redundant, and it causes CAPEX increase because a barge size gets larger. So we adopt modular arrangement with larger unit capacity compared with container type.

Although the transmitting power quantity can be adjustable, based on the needs, power transmission to grid is set at 33,000kW after deducting power required for the seawater desalination equipment, from the power generation capacity 41,000kW.

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① **Power Generation**

The power generation equipment is natural gas-fueled GTCC, and H-25 of MHI group is selected for its gas turbine. H-25 is the high-performance gas turbine used for utility and industry since 1988, and one of the product line-ups from Mitsubishi Hitachi Power Systems, Ltd., which enables to use wide variety of fuels from distilled to natural gas and is used for 60Hz/50Hz power generation needs. Used in combined cycle power generation plant, it enables to achieve the higher energy efficiency.

See the Fig 3.11 for the view of H-25 gas turbine, the Fig. 3.12 for its example of system configuration as a combined cycle system, and the Table 3.2 for the specification and performance example.
Table 3.2  Specification and Performance Example of Combined Cycle System

<table>
<thead>
<tr>
<th>Combined Cycle Configuration</th>
<th>1 on 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Turbine</td>
<td>H-25</td>
</tr>
<tr>
<td>Heat Recovery Steam Generator</td>
<td>Double Pressure</td>
</tr>
<tr>
<td>Steam Turbine</td>
<td>Mixed Pressure</td>
</tr>
<tr>
<td>Fuel</td>
<td>Gas</td>
</tr>
<tr>
<td>Ambient Condition</td>
<td>Pressure 1,013hPa</td>
</tr>
<tr>
<td></td>
<td>Temperature 15℃/Relative Humidity 60%</td>
</tr>
<tr>
<td>Generator Power Output</td>
<td>43.8MW</td>
</tr>
<tr>
<td>Efficiency (HHV)</td>
<td>50.2%</td>
</tr>
</tbody>
</table>

By MHI

② Seawater Desalination Equipment Plan
Summary of RO Membrane type seawater desalination system is described as follows.

(i) Basic Process Flow
The PFD of the RO Membrane type seawater desalination system is shown in Fig3.12. Process flow is shown in Table 3.3. The system is designed by Metito, which is the affiliated company of MHI (see Appendix).

Table 3.3  Process Flow (50,000m³/day)

<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>Unit</th>
<th>Flow Rate</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Raw seawater</td>
<td>m³/h</td>
<td>4906</td>
<td>Water intake</td>
</tr>
<tr>
<td>2</td>
<td>Drinking water</td>
<td>m³/h</td>
<td>2084</td>
<td>50,000m³/day</td>
</tr>
<tr>
<td>3</td>
<td>UF membrane backwash</td>
<td>m³/h</td>
<td>276</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>RO membrane brine</td>
<td>m³/h</td>
<td>2546</td>
<td>Concentrated seawater</td>
</tr>
</tbody>
</table>

By MHI

(ii) Process Summary
The summary of process for RO type seawater desalination system is described as follows.

(a) Equipment Configuration
The system consists of Pre-treatment equipment, RO unit and Post treatment equipment.

(b) Pre-treatment Equipment
Hypochlorite solution, generated with electrolyzer, is injected in the raw water line to prevent bacteriological contamination and the development of Algae Slime in the raw water line. Afterwards, the raw
water is fed to Ultra Filtration (UF) Modules. During UF processing, dirt material is removed to Silt Density Index (SDI) value (lower than approx. 4), which can be supplied to RO unit. UF backwash is equipped to restore the membrane performance with cleaning at periodical interval. Chemical enhanced backwash is also equipped to keep backwash efficiency.

(c) RO Unit (Desalinization Equipment)

Each RO Unit consists of a high pressure pump, energy recovery devices and RO membranes. Seawater from Pre-treatment Equipment is boosted to required level by a high pressure pump and energy recovery devices. With energy recovery devices, energy is recovered from rejected brine pressure. Afterwards, permeated water is fed to Post-treatment Equipment.

(d) Post-treatment Equipment

Permeated water is re-mineralized with lime (Ca(OH)₂) and dosed with chlorine for final disinfection. Sodium Hypochlorite is dosed so as to maintain permitted level of residual chlorine in the product drinking water.

(iii) Arrangement Plan

Enough depth is kept for RO unit with co-engineering with barge structure and SWRO system arrangement, RO unit, tanks for drinking water, cleaning and flushing and auxiliaries are located on the lower deck. This arrangement is effective to prevent UV deterioration of FRP pressure vessel and FRP piping in SWRO system.
3 Barge and General Arrangement Plan

Even for the regular-size plant for electric power and drinking water supply, the same concept is basically applied for its planning as the aforementioned small-size equipment for emergency and temporary use. However, the high efficient gas turbine combined cycle power generation unit, using LNG for its fuel is adopted as considering it is highly likely for the regular-size plant to be utilized for a long term permanent power supply, and the feature is equipped with LNG loading/storage unit and LNG gasification unit for ancillary facilities.

See the Fig. 3.14 for general view of trial design for The floating thermal power and desalination plant as regular-size plant for electric power and drinking water supply, the Fig. 3.15 for the 3D external view, and the Fig. 3.16 for installation image view, based on the trial design.

The barge main dimension is the following, as a result of the trial designing.

Vessel length x beam x depth: approx. 229.0m x 37.0 m x 17.5m

The aforementioned power generation unit (center area) and seawater desalination plant (right side: bow) are arranged on the barge top deck and a pressure-resistant cylindrical LNG tank is installed on stern. In order to segregate between the power generation unit area and LNG tank area, the office building, including a control room, is arranged in between them for considering safety aspect. Moreover, as same as the small-size plant, the dimension of the barge is optimized by being creative in directions of element machineries and installing auxiliary machineries and tank as many as possible inside of the hull. For the capacity of each tank, drinking water can be stored for 4 hours’ worth purified water with the same concept of the small-size plant. On the other hand, for LNG used for power generation fuel, the capacity is set for the LNG tank with an assumption that supply interval being 1 month as considering the existing supply infrastructure is not well arranged for LNG, compared to that of fuel oil, and it is difficult to handle it.
Fig 3.14
Layout Example of Regular Size Power and Water on Barge

By MHI
Fig 3.15  3D View of Regular Size Power and Water on Barge

By MHI
4) Manufacturing and Installation Process

One of the features of offshore installation is that most of the processes are carried out at a factory and shipyard where the environment is well equipped and minimized the local construction. Assembled power generators at a specialized factory and seawater desalination equipment are delivered and loaded at the shipyard for constructing the barge. At the local site, prepare equipment for barge mooring, power line for connection, and clean water equipment and the almost completed barge is towed from the shipyard to the site.

5) Maintenance Plan

Barge does not have a driving gear and is operated at the fixed location. Although the body of the barge needs to get periodically inspected and repaired, it is unnecessary to check in dry dock, like a general ship. The inspection of the barge can be confirmed at the site moored. Periodically, it is necessary for power generator and seawater desalination equipment, to inspect, exchange consumable parts, and repair them. This facility is not equipped with back-up systems during the maintenance period; thus, the power and water supply will be suspended during the maintenance period (typically around 30 days per year).
6) **Comparison with Onshore Equipment**

The following is the feature of Power and Water on Barge located offshore, compared to the onshore equipment.

① No need to acquire land
② High quality and short delivery period because of constructed in shipyard
③ Smaller risk for delivery period and cost, because the local construction is only mooring and connection of power and water
④ Less civil work at site
⑤ Easy to decommission
⑥ As a result, easy to relocate when the demand and situation changes.

On the other hand, the following is the challenges.

① Although the cost of barge ship increases, it is assumed that there are many sites where they have more advantages with offshore installation when considering negotiations, costs, and risks of construction period delay on the issue of acquiring or trading off for leasing the land for onshore installation.
② Maintenance of barge is necessary, but it is small portion negligible among maintenance of whole equipment.

There are many delivery and operation experience of onshore power generator and onshore seawater desalination equipment respectively. Although there is no operation experience for combination of offshore power generation, offshore seawater desalination equipment, the component equipment is matured, then it is unnecessary to take a step for technical demonstration, however, it is recommended to check to set the verification period with the first commercial unit.

The risk factors are assumed for the offshore installation, such as influence of barge swinging due to wind, waves, and external force to barge and mooring devices. Those factors should be considered at engineering.

(5) **Effect of Stable Energy Supply of Japan by Executing the Project**

Republic of Ghana is the energy supplying country, which produces oil and natural gas. The country is not a direct energy resource exporting country for Japan, but it will lead to contribute global stable energy supply by having the country’s stable economic growth. This project is expected to contribute on the global and Japanese stable energy supply in an indirect manner by contributing the country's economic growth through the improvement of power and water infrastructure in Republic of Ghana.
Chapter 4 Evaluation of Environmental and Social Impacts

(1) Present State Analysis in terms of Social Impacts

The final consumers of power and water are assumed to be residents and industries in Tema area. The present status on power and water demand and supply is described in Chapter 1.

Water for Tema area is supplied from Volta River. The water quantity depends on rain in the upstream region of Volta River, and it is affected by the climate. The water quality in the river does not meet Drinking Water Contaminants – Standards and Regulations provided by United States Environmental Protection Agency, which is used for the standard of drinking water in the country, according to "Environmental and Social Impact Assessment Report" issued by Premier Resource Consulting in Aug. 2017. Residents cannot drink tap water, but drink bottled water.

(2) Environment and Social Impacts from the Project

Once the power and water supply project is executed, with Power and Water in Barge, it is expected to improve the residential and industrial environment for stable supply to enhance economic growth.

The following is the factors of environmental influences by installing Power and Water on Barge.

① Influence on marine weather (waves, tides, and etc.) by barge mooring on a certain location for a long period
② Influence on marine creature by barge mooring on a certain location for a long period of time
③ Exhausted gas influence from oil or natural gas-fueled thermal power generator
④ Noise/vibration influence from thermal power plant generator
⑤ Heat influence from heat exchanger (air-cooling tower or condenser) for cooling thermal power generator
⑥ Concentrated salt water influence from seawater desalination equipment
⑦ Suspended waste influence collecting near intake of seawater desalination equipment
⑧ Noise/vibration of seawater desalination equipment

During the visit of Republic of Ghana, discussion was held with specialists from Ghana Environmental Protection Agency in Republic of Ghana on the factors of environmental influence. Ghana Environmental Protection Agency has a track record of conducting an assessment of environmental impacts on onshore thermal power generator, onshore seawater desalination equipment, and offshore diesel power generator vessels that are moored at a certain locations for long period, and they are operated actually in Republic of Ghana without serious environmental influence.

It is considered that it enables to operate Power and Water on Barge without severe environmental influence after following the procedures of environmental assessment, which already experienced proof in Republic of Ghana.

As shown in following sections, the information was obtained on environment and social law and regulations and procedures from the specialists of Ghana Environmental Protection Agency.
Summary of Legal Regulations on Environmental Quality Management in Republic of Ghana and Necessary Measures for Satisfying the Regulations

1) Summary of Environment and Social Impact Procedure in Republic of Ghana

In Republic of Ghana, any business organization, which may impact on the environment and society in the country is obligated to conduct the Environmental and Social Impact Assessment beforehand, based on the Environmental Protection Agency Act 1994 (Act 490) and Environmental Assessment Regulations 1999 (LI 1652).

The following is to be conducted, based on the Environmental and Social Impact Assessment Process as procedures in Republic of Ghana.

① Collection of relevant necessary information on the project and equipment
② Identifying critical business influencers and assessing potential environmental and social impacts
③ Identifying mitigation measures on the critical impact or applicable impacts and studying initiatives for sustainable environment control
④ Environmental audit
⑤ Conducting the Environment and Social Impact Assessment
⑥ Implementing the review for the Environment and Social Impact Assessment
⑦ Issuing the licensure from Ministry of Environment

For the aforementioned official process, it is general to conduct the following approach in Republic of Ghana.

① Conducting interviews with a chief of community, residents, and some identified organizations
② Holding a public hearing
③ Having direct dialogues
④ Individual consultations with relevant supervisors, regulatory agencies and etc.
⑤ Conducting field inspections, surveys and interviews to gather primary data and information on the various aspects of the project operation and expected environmental performance
⑥ Conducting physical measurement, observation, sampling and analytical investigation of environmental parameters and resources to confirm the conditions for baselines

Article 41(k) of the Constitution of Ghana requires that all citizens are to protect and safeguard the natural environment of the Republic of Ghana, and as such the main project implementing body is expected to do the same.

2) Government/Administration Framework Overview in Republic of Ghana

The key Ministries and administrative agencies relevant to the project include the following.

① Ministry of Energy and Petroleum

The Ministry is responsible for providing and enacting policies for the power, energy and petroleum sectors of the economy. The Ministry formulates, implements, monitors and evaluates the sector policies. The Ministry works with other stakeholders to enact policies and regulations, which provide support to stakeholders in the sectors. The relevant agency, which work under the Ministry to promote power generation
and supply include the Energy Commission.

② Ministry of Environment, Science, Technology and Innovation

The Ministry has responsibilities for the environment, immigrants, scientific research and innovations. Environmental Protection Agency (EPA) is a government agency under this ministry.

③ Environmental Protection Agency

The Agency is a government agency with a purpose of regulating, protecting and reinforcing the country’s environmental sectors in particular and seeking common solutions for global environment problems under Ministry of Environment and Science Technology and Innovation.

④ Fisheries Commission

It is mandated to regulate and manage utilization of the fishery resources of Ghana and coordinate the related polices for promoting and enforcing policies related to fishing and fishery resources management.

⑤ Ghana Ports and Harbours Authority

The Authority is mandated to build, operate, maintain and regulate seaport facilities in Ghana. The Tema Port is operated, maintained and expanded by a joint venture company funded by the authority, which is the site for this project.

⑥ Ghana Investment Promotion Centre

The Centre is mandated with responsibility of promoting, encouraging, coordinating and monitoring all investment activities. It is a government agency to facilitate the smooth investment environment, and the Centre further provides attractive incentive framework for promoting investments and secure transparent market as coordinating with relevant agencies in Ghana.

⑦ Ghana Grid Company Limited

The Company is a national firm, which exclusively operates electrical grids that mutually connected in the country.

The company functions to transmit electric power to consumers from wholesale suppliers; and is to plan electrical grids and necessary investments under the instructions from the Ministry of Energy and Petroleum.

3) Environment Act

Republic of Ghana introduced the National Environmental Policy in order to secure the sustainable economic development without damaging the social conditions and environment.

The policy sets the ideas, such as improvements of environment for Ghana citizens, life conditions, and quality of life. The National Environmental Action Plan and the following regulations are established for its concrete executions.

① the Environmental Assessment Regulations (LI 1652, 1999)

The ESIA process is legislated through the Environmental Assessment Regulations. The ESIA Regulations require that all activities likely to have an adverse effect on the environment must be subjected to environmental assessment and issuance of a permit before commencement of the activity.
The Regulations are structured in mainly two parts. The first part defines the requirements and steps for EIA process for an environmental permit in relation to the activities of existing undertakings and new undertakings. The process starts with screening, evaluating applications in relation to location, size, land use, technology and possible output as well as the concerns of the general public, and it regulates to assess them. The second part of the Regulations describes the requirements for preliminary environmental report and environmental impact statement. A scoping report outlining the scope of the proposed undertaking and the terms of reference shall be submitted prior to environmental impact statement. Public hearing and submission of the environmental impact statement shall follow and an environmental permit valid for 18 months is issued. The format of the environmental management plan shall be determined by the Agency. The Regulations require persons to submit annual environmental reports in respect of the undertaking to the Agency starting from the end of the first year of the commencement of the activity.

2. Fees and Charges (Amendment) Instrument 2015 (LI 2228)

It provides regulations for the Fees and Charges applied for granting Environmental Permit by EPA. It includes to regulate penalty in case of violating the Act.

3. Other Relevant Environment and Social Regulations

The following is the other relevant Acts for environment and social process for the project.

a) Environmental Assessment in Ghana, a Guide to Environmental Impact Assessment Procedures
b) General Environmental Quality Standards for Industrial or Facility Effluents, Air Quality and Noise Levels
c) Fees and Charges Amendment Act (LI 2228)
d) National Climate Change Policy (2013)
e) The Environmental Protection Agency Act (Act 490)

4) Regulation on Resource Control and Pollution

Biodiversity and Wildlife Legislations; the relevant legislation which regulate biodiversity and wildlife in Ghana relating to the project is the Fisheries Act 2002, Act 625. Fisheries Act, 2002 (Act 625) mandates the establishment and administration of the fisheries commission as well as financial provisions. The Act regulates fisheries management and development and includes provisions related to fishing vessels, aquaculture and recreational fishing, licensing of fishing vessels. The Act also contains provisions for establishment of fishing zones, methods, seasons for fishing, and conservation measures.

Section 93 of the Fisheries Act requires that the Fisheries Commission is informed of any activity with potential impacts on fishery resources and provided with mitigation strategies by proponents of the project; that is to say, it is to provide the services (foods, income and employment).

5) Relevant Agency on Energy and Water

The Ministry of Energy is the highest executive body responsible for formulating, monitoring and evaluating policies, programs and projects in Ghana’s energy sector. There are other public Agencies working to
support the activities of the Ministry of Energy.

a) The Energy Commission and Ghana Grid Company

The Energy Commission is established by the Energy Commission Act (Act 541), is responsible for making policy recommendations to the Government to regulate the development and utilization of energy resources in Ghana. The Commission institutes rules, standards and procedures as well as grants licenses for generation, transmission, wholesale supply and distribution of electricity. The Commission has an Inspectorate Division to inspect premises to ensure that the provisions of the act are complied with.

This country has the following regulations, the Electricity Transmission (Technical, Operational and Standards of Performance) Rules, established in 2008, the Electricity Regulation, and the National Electricity Grid Code, established in 2009. The Electricity Transmission rules are to establish the requirements, procedures, practices and standards that govern the development, operation, maintenance, and use of the high voltage national interconnected transmission system. The Electricity Regulation provides the planning, reliability, general safety, and overall regulation of the electricity market. The National Electricity Grid Code, 2009 is designed to guide and regulate the activities of electricity transmission utilities and independent system operators in order to facilitate competition in power generation.

The requirements for the National Interconnected Transmission System (NITS), steps, and standards are regulated, and the public power transmission firm, Ghana Grid Company is also operated, based on the regulation.

① The Public Utility Regulatory Commission

The Public Utility Regulatory Commission (PURC) is responsible for regulating utility tariffs in the country; Public Utility and Regulatory Commission Act (Act 538), 1997. The Commission is the body with oversight responsibilities for the provision of the highest quality of electricity and water services to consumers. The objectives of PURC include:

a) Providing guidelines for rates to be charged for the provision of utility services;
b) Examining and approving electricity and water rates;
c) Protecting the interest of consumers
d) Monitoring and enforcing standards of performance for the provision of utilities services;
e) Promotion of fair competition among public utilities
f) Receiving and investigating complaints and settling disputes between consumers and public utility;

6) Regulation on Ocean

Ghana Maritime Authority Security Act 2004 (Act 675) is established for reinforcing marine safety and security, and it regulates for the safety of ships and port facilities, based on the International Ship and Port

It is required to comply with the regulation and standard in Ghana’s international trade port, such as Tema Port and Secondi-Takoradi Port. Based on the Ghana Shipping Act, 2003 (Act 645), it is mandated for Ghanaian ships to submit a ship security plan and international security certificate and for all ships planning to enter into Ghana port to submit an international ship security certificate and to comply with security standards.

Both regulations are under Ghana Maritime Authority, and they require to submit necessary documents.

The project would be situated at the Tema Fishing Harbour and therefore would be required to operation in compliance with the international and national maritime regulations to ensure maritime security and safety at the port facilities.

7) Other Relevant Domestic Regulations in Republic of Ghana

The following is other relevant regulations in Republic of Ghana. In addition, there is no regulation to require a certain ratio of local employments at this point.

① Ghana National Fire Service Act, 1997 (Act 537), s.33(b)
② Labour Act 2009 Act 651;
③ Local Government Act 462 1993;
④ The Public Utilities Regulatory Commission (PURC), Act 538 (1997)
⑤ Electricity Transmission (Technical, Operation and Standards of Performance) Rules. 2008 L.I. 1934
⑥ L.I. 1937: Electricity Regulations, 2008

8) Other Relevant International Regulations

Republic of Ghana has adopted various international regulations, and it is required to comply with the International Finance Corporation Performance Standard. The following is the components of the standard.

- Standard-1: Assessment and Management of Environmental and Social Risks and Impacts
- Standard-2: Labor and Working Conditions;
- Standard-3: Resource Efficiency and Pollution Prevention;
- Standard-4: Community, Health Safety and Security;
- Standard-5: Land Acquisition and Involuntary Resettlement;
- Standard-6: Biodiversity Conservation and Sustainable Management of Living Natural Resources;
- Standard-7: Indigenous Peoples; and
- Standard-8: Cultural Heritage.

The following guidelines of the IFC, are also relevant to the Project:
- The IFC General EHS Guidelines, dated April 30th, 2007;
- The IFC EHS Guidelines for Thermal Power Plants, dated December 19th, 2008;
- The IFC EHS Guidelines for Shipping, dated April 30, 2007;
- The IFC EHS Guidelines for Ports, Harbors and Terminals, dated April 30, 2007;
- The IFC EHS Guidelines for Electric Power Transmission and Distribution, dated April 30th, 2007; and
- The IFC Workers’ accommodation.
Chapter 5 Financial and Economic Evaluation

(1) Cost Estimates

1) <Yen-Loan Case> using the Small-Scale Facility for Emergency/temporary Use

As a result of discussion with government officials of Republic of Ghana, a multiple locations were identified as candidates; however, the site has not been finalized yet. Though there is some uncertainty of sea condition for design and site work scope, based on an assumption to locate at typical coast near Tema Port, CAPEX is 60 million USD for facility and 5 million USD for site work for mooring and connection. The initial capital is 66 million US dollars, including the US $1 million in initial operating capital.

The large ratio accounted for OPEX is fuel fee. The price of fuel, heavy oil, is assumed to be 60 USD/barrel. Setting the higher heating value of heavy oil is 41.5MJ/ℓ, per volume price of heavy oil becomes 0.38 USD/ℓ.

For other OPEX fees, consider operator cost, maintenance fee for power generator and seawater desalination equipment, fixed maintenance cost like barge inspection, disposing industrial wastes (suspended materials in raw seawater), and chemical injection fee for water, etc.

The assumed OPEX, based on the experience of MHI, is shown in Table 5.1

The load factor is set at 50% (4,380 hours/year) in view of the usage for emergency and temporary use.

Based on the aforementioned assumptions, it is concluded that the annual OPEX is 3.7 million USD.

<table>
<thead>
<tr>
<th>Item</th>
<th>Expected Values</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operator Cost</td>
<td>400,000 USD/year</td>
<td>per year</td>
</tr>
<tr>
<td>Generator Maintenance Cost</td>
<td>20 USD/MWh</td>
<td>per generated energy</td>
</tr>
<tr>
<td>Seawater Desalination Equipment</td>
<td>60 USD/1,000m³</td>
<td>per water production</td>
</tr>
<tr>
<td>Fixed Maintenance Cost</td>
<td>420,000 USD/year</td>
<td>per year</td>
</tr>
</tbody>
</table>

2) <PPP Case> with Regular-scale Facility for Power and Water Supply

Based on assumption to locate at typical coast near Tema Port, CAPEX is 200 million USD for facility and 10 million USD for site work for mooring and connection. The initial capital is 211 million USD, including the US $1 million in initial operating capital.

As to OPEX, the LNG price is assumed as 10 USD/ MMBtu for the fuel fee. Setting the higher heating value of natural gas is 42MJ/m³, LNG unit price becomes 0.40 USD/ m³. For other OPEX fees, consider operator cost, maintenance fee for power generator and seawater desalination equipment, barge inspection, fixed maintenance cost like barge inspection, disposing industrial wastes (suspended materials in raw seawater), and chemical injection fee for water, etc. The assumed OPEX, based on the experience of MHI, is shown in Table 5.2
The load factor is set at 80% (7,008 hours/year) since it is desirable to secure the high value to increase revenue as power and water supply business.

Based on the aforementioned assumptions, it is concluded that the annual OPEX is 7.9 million USD.

### Table 5.2 Expected OPEX with Regular-Scale Facility for Power and Water Supply Equipment

<table>
<thead>
<tr>
<th>Item</th>
<th>Expected Values</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operator Cost</td>
<td>1,000,000 USD/year</td>
<td>per year</td>
</tr>
<tr>
<td>Generator Maintenance Cost</td>
<td>10 USD/MWh</td>
<td>per generated energy</td>
</tr>
<tr>
<td>Seawater Desalination Equipment</td>
<td>60 USD/1,000m³</td>
<td>per water production</td>
</tr>
<tr>
<td>Maintenance Cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Injecting Chemical Cost for Water</td>
<td>70 USD/1,000m³</td>
<td>per water production</td>
</tr>
<tr>
<td>Fixed Maintenance Cost</td>
<td>1,360,000 USD/year</td>
<td>per year</td>
</tr>
</tbody>
</table>

(2) Preliminary Financial and Economic Analysis Result

1) Small-size Equipment for Emergency and Temporary Use (Yen Loan Case)

For the emergency and temporary use small-size equipment, it is assumed that the government organization own and operate. Since it is a public business, price setting for power and water is calculated with the criterion of “FIRR of business period 20 years is more than zero”. To satisfy the criterion, fees of power and water is calculated, under a certain assumptions.

For financing CAPEX, it will be (1) grants from Japanese government or (2) utilization of STEP yen loans. Major assumption for each financial scheme is shown in Table 5.3. Results of price setting for meeting criterion and FIRR for 20 years are shown in Table 5.4.

### Table 5.3 Assumptions of Small-Scale Facility for Emergency/Temporary Use

<table>
<thead>
<tr>
<th>Item</th>
<th>Financial Scheme</th>
<th>Grant from JP Gov.</th>
<th>STEP Yen Loan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Granted amount (million USD)</td>
<td>①</td>
<td>60</td>
<td>—</td>
</tr>
<tr>
<td>Investment amount (million USD)</td>
<td>②</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Loan amount (million USD)</td>
<td>4</td>
<td>64</td>
<td></td>
</tr>
<tr>
<td>Applied Interest</td>
<td>3%</td>
<td>0.1%</td>
<td></td>
</tr>
<tr>
<td>Deferral Period</td>
<td>1 year</td>
<td>1 year</td>
<td></td>
</tr>
<tr>
<td>Payback Period</td>
<td>5 years</td>
<td>10 years</td>
<td></td>
</tr>
<tr>
<td>Depreciation method</td>
<td>Fixed value, 20 years</td>
<td>Fixed value, 20 years</td>
<td></td>
</tr>
</tbody>
</table>
Table 5.4 Calculation Result for Small-Scale Facility for Emergency/Temporary Use

<table>
<thead>
<tr>
<th>Item</th>
<th>Financial Scheme</th>
<th>③ Grant from JP Gov.</th>
<th>④ STEP Yen Loan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Price (USD/kWh)</td>
<td></td>
<td>0.15</td>
<td>0.26</td>
</tr>
<tr>
<td>Water Price (USD/m³)</td>
<td></td>
<td>1.0</td>
<td>1.7</td>
</tr>
<tr>
<td>Operating Income (20-yr average)</td>
<td>4,730,000 USD/year</td>
<td>8,150,000 USD/year</td>
<td></td>
</tr>
<tr>
<td>Operating Margin Ratio (20-yr ave.)</td>
<td>5%</td>
<td>6%</td>
<td></td>
</tr>
<tr>
<td>FIRR 20 years</td>
<td>0.5%</td>
<td>0.8%</td>
<td></td>
</tr>
</tbody>
</table>

Although there is no public data for procurement price from existing IPP and IWP, it seems to be that the price level for both power and water might be competitive against other IPPs and IWPs, in case of (1) grants from Japanese government considering discussion with persons of Republic of Ghana. In case of (2) utilization of STEP yen loan, the price setting will be higher mainly for including depreciation cost. Compared to that of the existing IPPs and IWPs, it seems that the amount is more inexpensive because the government commission sets lower price for electricity and water to small amount users from the perspective of national welfare; however, burden of Electric Company of Ghana and Ghana Water Company is larger and as a result, the supply amount from tax will be increased.

2) Regular-size Equipment for Supplying Power and Water (PPP case)

For the regular-scale facility for power and water supply is assumed that SPC led by private sector, participated by public organization owns and operates. (PPP scheme)

The setting price for power and water is calculated with the criterion of “FIRR of business period 20 years is more than interest rate”. Interest rate is set 3%/year with an assumption to be under the government guarantee through the project finance.

Major assumption for each financial scheme is shown in Table 5.5. Results of price setting for meeting criterion and FIRR for 20 years are shown in Table 5.6.

Table 5.5 Assumptions of Regular-Scale Facility for Power and Water Supply

<table>
<thead>
<tr>
<th>Item</th>
<th>Financial Scheme</th>
<th>Loan from Public Financial Institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment Amount (million USD)</td>
<td></td>
<td>71</td>
</tr>
<tr>
<td>Loan value (million USD)</td>
<td></td>
<td>140</td>
</tr>
<tr>
<td>Applied Interest</td>
<td></td>
<td>3%</td>
</tr>
<tr>
<td>Deferral Period</td>
<td></td>
<td>1 year</td>
</tr>
<tr>
<td>Payback Period</td>
<td></td>
<td>10 years</td>
</tr>
<tr>
<td>Depreciation method</td>
<td></td>
<td>Fixed value, 20 years</td>
</tr>
</tbody>
</table>
In order to secure the profit level of establishing Project Finance, both power and water price will be necessary to be accepted by government and off-takers.

Table 5.6 Result for Regular-Scale Facility for Power and Water Supply

<table>
<thead>
<tr>
<th>Item</th>
<th>Financial Scheme</th>
<th>Loan from Public Financial Institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Price (USD/kWh)</td>
<td></td>
<td>0.25</td>
</tr>
<tr>
<td>Water Price (USD/m³)</td>
<td></td>
<td>1.7</td>
</tr>
<tr>
<td>Operating Income (20-yr average)</td>
<td></td>
<td>32,000,000 USD/year</td>
</tr>
<tr>
<td>Operating Margin Ratio (20-yr ave.)</td>
<td></td>
<td>36%</td>
</tr>
<tr>
<td>EIRR 20 years</td>
<td></td>
<td>9.3%</td>
</tr>
<tr>
<td>FIRR 20 years</td>
<td></td>
<td>4.0%</td>
</tr>
</tbody>
</table>
Chapter 6 Planned Project Schedule

This study assumes the following 2 steps.

① <Yen-loan case> Public electricity and water supply business for emergency and temporary use with the small-scale equipment as utilizing the grants from Japanese government or STEP yen loans

② <PPP case> PPP scheme for private-led power and water supply business with regular-scale equipment as utilizing loans from Japanese government financial institutes

It is necessary for private investors that the return on investment is expected with power and water supply business. Thus, it is critical to conclude the long-term PPA with power off-taker (retailer, Electricity Company of Ghana at this time) and the long-term WPA with water off-taker (distributor, Ghana Water Company at this time) for maintaining high operation rate and revenue as well as securing high availability by introducing the high quality facility of Power and Water on Barge.

However, as mentioned in Chapter 5, the level of power and water prices for establishing private business is necessary to be understood by off-takers. When economic growth proceeds, power and water demand increases, and power and water prices are accepted by off-takers, then the business will be more feasible.

Moreover, there is no experience of whole set together of power generation, seawater desalination, located offshore. That is one of difficulties for persuading renders. It is required to have operational results and the government guarantee on the debt as one of conditions for getting funds and loans from government financial organizations. The actual experience was asked during the discussion with persons of Republic of Ghana, and it is assumed that some degree of actual operation experience is required to submit in order to obtain the debt guarantee from Republic of Ghana.

It may be possible to obtain actual operation experience from different areas in a few years. It is more feasible to introduce the step approach that is to implement the small-scale facility with ①<yen-loan>, and conduct the verifications for Republic of Ghana in order to realize the project of ②<PPP>.

It is assumed that the possibility will improve for getting the debt guarantee from Republic of Ghana and loans/funds from government financial distributors through the situations change on the feasibility and the performance records are shared.

Based on the aforementioned situations, see the following image for the earliest project schedule with an assumption of prevailing conditions for the <yen-loan>, using the small-scale facility.

<table>
<thead>
<tr>
<th>Year</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY2017</td>
<td>Needs and feasibility study (this study)</td>
</tr>
<tr>
<td>1st half of FY2018</td>
<td>Site selection</td>
</tr>
<tr>
<td>2nd half of FY2018 - 1st half of FY2019</td>
<td>FEED (Front End Engineering Design)</td>
</tr>
<tr>
<td>FY2020</td>
<td>Commencement</td>
</tr>
<tr>
<td>FY2021 - 2022</td>
<td>Completion and Operation Start</td>
</tr>
</tbody>
</table>

After the business verification of <yen-loan case>, it is followed by more concrete business study for the regular-size equipment in FY2022 and onwards with <PPP case>.
Chapter 7 Implementing Organization

(1) Overview of Implementing Organization in Republic of Ghana

There are the following organization (as of December 2017).

1) Energy Relevant Organizations
Ministry of Energy and Petroleum: Responsible authority
Electricity Company of Ghana Limited: Power retailer
Ghana Grid Company Limited: Power transmission company
Volta River Authority: Public power generation company
Energy Commission of Ghana: Licensing organization of electric power business

2) Water Relevant Organizations
Ministry of Water Resources, Works and Housing: Responsible authority
Ghana Water Company Limited: Water supply and distribution company
Public Utility Resources Commission: Decision-making organization for power and water price

(2) Organization Structure for Project Implementation in Republic of Ghana

① <Yen loan Case> Public Business, using the small-size facility

Currently under administration of Ministry of Energy and Petroleum, power generation business is operated by public organization Volta River Authority and a private IPP. Water supply business, including to secure water sources is done by Ghana Water Company under the administration of Ministry of Water Resources, Works and Housing. Since this project is to supply both power and water, it is difficult for either of public companies for power or water to be a lead of the project, and it seems to be better to create a new SPC, which is established by both parties as a joint venture. Tentative plan of organization structure is shown Fig. 7.1.

The function of SPC is to operate, maintain and manage Power and Water on Barge, and supply power and water.

Either the government of Republic of Ghana or a public company established by the government is to be the investment to SPC. It procures the fuel, heavy oil, from Ghana Oil Company, generates power and produces drinking water, and sells the power and clean water to the power retailer, Electricity Company of Ghana Limited, and water to the distributor, Ghana Water Company. The contract for the unit prices of procurement and sales, it is desirable to set them for SPC securing reasonable profits without excess or deficiency, based on the supervision for executing the policy of Republic of Ghana government. An area occupancy permission is required from the port administration, Ghana Ports & Harbours Authority when installing the facility in the port area, such as Tema Port. In regards to the equipment construction, it is preferable that EPC is to be arranged for the equipment supply of Power and Water on Barge by Japanese
manufacturer with either of case, grant or STEP yen-loan application. For O & M, including the supply of consumable parts after starting the operation, it is considered to be preferable to be ordered to EPC contractor or manufacturer, in order to maintain the quality of infrastructure and to run stable public business.

Fig 7.1 Tentative plan of organization structure (Yen-loan Case)

② <PPP Case> Private supply business, using the regular-size facility

Each business has experiences in Republic of Ghana as IPP for power supply business and as IWP for water supply business. It seems to be good for the combined business of supplying both power and water to create SPC, with calling suppliers which have experiences in each supply business in PPP scheme. Tentative plan of organization structure is shown Fig. 7.2.

The function of SPC is to operate, maintain and manage Power and Water on Barge, and supply power and water.

Investment on SPC will be invited from Japanese private companies and government organizations. Under the loan guarantee by Republic of Ghana, it is expected to get the loan from government and private financial organizations. It procures the fuel, natural gas, from Ghana National Gas Company, generates power and produces water, and sells the power and water to the power retailer, Electricity Company of Ghana Limited, and water to the distributor, Ghana Water Company. It is necessary for the business
establishment to establish the unit price contract for procurement and sales to secure reasonable profits that SPC can sustain its business, and it is expected for Republic of Ghana to get involved in negotiations with supervision for executing the government policy of Republic of Ghana. An area occupancy permission is required from the port administration, Ghana Ports & Harbours Authority when installing the facility in the port area, such as Tema Port. In regards to the equipment construction, it is preferable that EPC is to be arranged for the equipment supply of Power and Water on Barge by Japanese manufacturer with either of case, grant or STEP yen-loan application. For O & M, including the supply of consumable parts after starting the operation, it is considered to be preferable to be ordered to EPC contractor or manufacturer.

It is expected for the equipment construction to place orders to Japanese manufacturer for EPC on facility and O & M, including the supply of consumable parts.

Fig 7.2 Tentative plan of organization structure (PPP Case)
(3) Performance Evaluation and Measures for Republic of Ghana Implementing Organization

National power generating company has experiences in operating, maintaining and running the business with diesel engine or GTCC power generation, which is the main equipment of Power and Water on Barge. There are experiences of operating, maintaining, and running the business in Republic of Ghana by a private business IWP, for water supply, using seawater desalination equipment, and it seems to be that the capability exists for operating, maintaining, and running the business in the country. However, the persons in Republic of Ghana mentioned that it is recommended to get technical support in the initial phase of operations since it will be the first case to combine both the thermal power plant and seawater desalination equipment. As a measure, it is possible to dispatch engineers from Japan for a certain period of time in the initial phase of operation start; however, it will be charged, which puts pressure on the project cost. On the other hand, it is beneficial to properly maintain and manage the operations for sustainable business operation and stable supply of power and water by utilizing the trained personnel in Republic of Ghana. Thus, it is assumed to consider as one of options for utilizing JICA technical support project if meeting conditions.

It is necessary to create the holistic management system and implementation system in order to start up the business of both power and water supply, since power and water supply business are managed by different authorities.
Chapter 8 Technical Advantages of Japanese Company (Yen Loan Case)

(1) Global Competitiveness of Japanese Company and Possibility of Getting an Order for the Project

Mitsubishi Heavy Industry Group has a lot of delivery records of power generation equipment, seawater desalination equipment, and ships and barges, which are the components for Power and Water on Barge, as well as solid comprehensive engineering capabilities.

As one of examples of MHI group records, see the attached documents for orders received for thermal power plant and delivery records of MHI-made seawater desalination apparatus in Africa. (See Appendix)

It is a Japanese unique concept from Mitsubishi Heavy Industry group to load seawater desalination equipment with self-powered by thermal power generation plant on one barge although some manufacturers in the world have records of introducing the thermal power plant on barge, using diesel engine.

It is expected to demonstrate the business operation strength since reducing CAPEX as a result of short term delivery due to building at a shipyard in a planned way and few local constructions and lowering OPEX by sharing common operators for power generator and seawater desalination equipment. It is expected that MHI group obtains an order for the entire facility when the project is realized.

(2) Major Equipments and Materials expected to Procure from Japan and its Price

A contractor will reasonably and economically procure from global market, for Power and Water on Barge.

It is probable to produce diesel engines for power generation in Japan and to procure RO membranes in Japan for the small-size facility. It is probable to arrange EPC for seawater desalination equipment by overseas manufacturer, which is affiliated by Japanese companies and banks. It is probable to construct a barge at an overseas shipyard, where is well equipped and near the site, under the technical support provided by Japanese company.

It is expected to be maximum of about 10 million USD for manufacturing in Japan and around 30 million USD, including overseas manufacturing sites of Japanese corporate and affiliated overseas manufacturers, out of 60 million USD of CAPEX for the small-scale facility. If a Japanese company becomes a prime contractor for EPC, approximately 60 million USD, which is almost all amount of CAPEX is to be procured in Japan.

It is expected to be more export expansion effect, including the development to the regular-size facility once it is verified with using the small-size facility.

According to the information heard from JICA and etc. during the visit to Republic of Ghana, it is assumed that there are potential needs of Power and Water on Barge and business chance for power and water supply in coastal countries, for example, Sierra Leone, Republic of Liberia, Federal Republic of Nigeria, since there are many countries which face the challenge of power and water demand gap in the region of West Africa.

(3) Necessary Measure for Promoting to Obtain Orders for Japanese Company

It is critical to foster understanding of the officials of Republic of Ghana that it is possible for Japanese corporate to provide high quality facilities, Japanese government has an option to support the project with STEP Yen-loan, and the project would contribute on environment creation that enables sustainable power and water supply business.
In terms of the facility quality and delivery schedule, it is stressed to Republic of Ghana that it can reduce the risks, including mismatched specifications, delivery delay, by a Japanese company to handle EPC for the entire facility.

For the aspect of financing, if the conditions meet, based on the requests from the government of Republic of Ghana, it is assumed that getting the order will be promoted for a Japanese company by Japan supporting the STEP Yen-loan or any loan arrangements.
Chapter 9 Technical Advantages of Japanese Company (PPP Case)

(1) Expected Participation Form of Japanese Company

Tentative plan of organization structure is shown Fig. 7.2.(reposted). The function of SPC is to operate, maintain and manage Power and Water on Barge, and supply power and water. Either the government of Republic of Ghana or a national company established by the government is to be the investment main organization. It is assumed that the stakeholders are led by Japan side to raise investments from companies and government organizations. For constructing the facility, it is expected for SPC to arrange EPC of the facility by Japanese manufacturers and to place an order of O & M, including consumable parts supply.

Fig 7.2 (reposted) Tentative plan of organization structure (PPP Case)

(2) Advantages of Japanese Company for Project

Mitsubishi Heavy Industry Group has a lot of delivery records of power generation equipment, seawater desalination equipment, and ships and barges, which are the components for Power and Water on Barge, as well as solid comprehensive engineering capabilities.

As one of examples of MHI group records, see the attached documents for orders received for thermal power plant and delivery records of MHI-made seawater desalination apparatus in Africa.(See Appendix)

It is a Japanese unique concept from Mitsubishi Heavy Industry group to load seawater desalination equipment with self-powered by thermal power generation plant on one barge although some manufacturers in the world have records of introducing the thermal power plant on barge, using diesel engine.
It is expected to demonstrate the business operation strength since reducing CAPEX as a result of short term delivery due to building at a shipyard in a planned way and few local constructions and lowering OPEX by sharing common operators for power generator and seawater desalination equipment. It is expected that MHI group obtains an order for the entire facility when the project is realized.

(3) Necessary Measure for Promoting to Obtain Orders for Japanese Company

It is critical to foster understanding of the officials of Republic of Ghana that the project would contribute on the environment creation for sustainable business and that it is possible for Japanese company to provide high quality facilities, there are some support options in the financial aspect, such as loans from a government financial institute with preferential interest rate and loans to off-takers (electric power and water purchasing companies), and the project would contribute on the environment creation. In terms of the facility quality and delivery schedule, it is stressed to stakeholders and lenders that it can reduce the risks, including mismatched specifications, delivery delay, by a Japanese corporate to handle EPC for the entire facility. It is assumed that receiving an order will be promoted by arranging the project with a lead from Japan side for enabling to utilize those support options in the aspect of finance.
Received Order of Power Plants in Africa 2/2
(Africa Total AGT: 1,400MW  ENG:141MW  ORC:4MW)

Morocco
ORC:4MW
Ciments Du Maroc ORC: 2MW x 2

Algeria
AGT:1350MW
Sonedgaz Spa AGT: 25MW x 54

Senegal
ENG:83MW
Societé Nationale DEN: 5.0MW x 2
Kounoune DEN: 8.1MW x 9

Sierra Leone
ENG:5MW
National Power DEN: 5.0MW x 1

Liberia
ENG:10MW
Liberia Elec. DEN: 5.0MW x 2

Egypt
ENG:29MW
Eastern Comp. GEN: 5.75MW x 4
Alexmar GEN: 1.5MW x 4

Mali
ENG:9MW
Bougouni DEN: 1.75MW x 2
Nioro DEN: 1.75MW x 3

Burkina Faso
ENG:5MW
Dedougou DEN: 2.3MW x 2

Benin
AGT:25MW
Communaute Elec. AGT: 25MW x 1

Togo
AGT:25MW
Communaute Elec. AGT: 25MW x 1

AGT : Aero-Gas Turbine
GEN : Gas Engine
DEN : Diesel Engine
Delivery Record of Water Desalination

Over 2 Million m³/day Desalination Plant Supplied

- **Yanbu**
  - MSF: 110,000m³/d
  - Start: Nov 1981

- **Medina Yanbu II**
  - SWRO: 128,000m³/d
  - Start: Sep 1998

- **Rabigh IWPPP**
  - Power: 120MW x 5
  - SWRO: 192,000m³/d
  - Start: Jun 2008

- **Rabigh IWPPP Phase-II**
  - Power: 120MW x 2
  - SWRO: 96,000m³/d
  - Start: Dec 2015

- **Jeddah SWRO I/III**
  - SWRO: 113,600m³/d
  - Start: May 1989 & Mar 1994

- **Shoaiba**
  - MSF: 223,000m³/d
  - Start: Sep 1989

- **Shuqaiq-II IWPPP**
  - Power: 340MW x 3
  - SWRO: 216,000m³/d
  - Start: Feb 2011

- **QATAR**
  - Demonstration Plant
  - SWRO: 200m³/d
  - Start: Jan 2005

- **Doha West**
  - MSF: 393,120m³/d
  - Start: Mar 1985

- **Az Zour**
  - MSF: 262,080m³/d & 109,104m³/d

- **Al-Jubail I/II**
  - MSF: 611,000m³/d
  - Start: Apr 1982 & Aug 1983

- **OMAN**
  - Demonstration Plant
  - SWRO: 200m³/d
  - Start: Oct 2003
# VOLUME A: COMPANY PROFILE

## 1.1 OVERVIEW

<table>
<thead>
<tr>
<th>The Group</th>
<th>Established in 1958, Metito is one of the largest Middle East based privately owned water groups with operations spanning over 4 continents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key Markets</td>
<td>Middle East, North Africa and Asia</td>
</tr>
<tr>
<td>Incorporated</td>
<td>Guernsey</td>
</tr>
<tr>
<td>Global Headquarters</td>
<td>Dubai, United Arab Emirates</td>
</tr>
<tr>
<td>Number of Employees</td>
<td>2,500+ worldwide</td>
</tr>
<tr>
<td>Group Ownership</td>
<td>Founding Holding Companies</td>
</tr>
<tr>
<td></td>
<td>Mitsubishi Corporation</td>
</tr>
<tr>
<td></td>
<td>Mitsubishi Heavy Industry</td>
</tr>
<tr>
<td></td>
<td>Gulf Utilities International Ltd</td>
</tr>
<tr>
<td></td>
<td>International Finance Corporation</td>
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</tbody>
</table>

**Design & Build**
Specializing in custom design and manufacturing of water & wastewater treatment and desalination projects.

**Utilities**
Full service of water supply and wastewater treatment under BOT, BOO, TOT and full concession business models.
1.2 Facilities

Manufacturing

- Atmospheric tank fabrication
- Pipe work fabrication – Carbon, Stainless & Alloy
- Skid assembly
- Manufacturing of control panels & MCC

Testing Facilities

- Pipe hydro testing – Up to 100 Bar (g)
- Alignment of rotating equipment
- Temperature measurement
- Noise level measurement
- Paint DFT measurement
- RPM measurement
- Functional testing of control panels
- Dye penetrant test

Assembly section

Metito Factory - UAE
1.3 ACHIEVEMENT

1958 METITO
Founded in Lebanon; the hub of the Middle East at the time
The 1st company to develop (design, build and install) a Reverse Osmosis (RO) plant outside the USA; every 1st RO to go into any country in the Middle East was installed by Metito

1972

1999
Metito pioneers concession contracts with private entities in the GCC

2005
1st company to introduce MBR in MENA/GCC, in the iconic Palm

2006
became shareholders

2007
became shareholders

2011
becomes a wholly owned subsidiary of MUL

2014
Entered into a synergistic partnership with Mitsubishi Corporation

2015
Became Metito pioneers bulk water PPP concessions in Sub

2016
The 25th company among the Top 50 BOT developers worldwide (Global Water Intelligence)

- An IMS certified organization (ISO 9001 + ISO 14001 + ISO 18001)

- Metito has built more than 3,000 water desalination and wastewater treatment plants in over 43 countries since its inception.

- + 1500 plants built in the last 20 years; out of this + 700 for industrial sector.

- Metito is ranked in the top five in number of desalination plants installed worldwide. (by the IDA)

- Metito manages a total installed capacity exceeding 1 million m³/day at its china concessions alone
1.4 **Scope**

**World-Class Engineering Solutions, Services and products**

### Engineering Solutions
- Process Engineering
- Mechanical Engineering
- Electrical and Automation Engineering
- PLC/SCADA Control & Communications Systems
- CAD Drafting
- Hazop Studies
- Field Services
- Quality Control and Assurance
- Analysis Reports

### Manufacturing Facilities
- Atmospheric tank fabrication
- Pipe work fabrication – Carbon, Stainless & Alloy steels
- Skid assembly
- Control panels & MCC’s

### Services
- Project management
- Process engineering and design
- In-house manufacturing capabilities
- Installation and commissioning
- Operation and maintenance

### Products
- Desalination by Reverse Osmosis
- High purity demineralisers for industrial uses such as; refineries, petrochemical plants, and power plants
- Biological Wastewater Treatment plants and systems
- Nanofiltration, Ultrafiltration and Microfiltration Membrane systems
- Advanced Membrane Wastewater treatment plants
- Oily Waste Treatment by DAF / IFG / API
- Produced water treatment
- Package WTP and WWTP plants
- Zero Liquid Discharge plants

*From concept to completion, Metito undertakes all aspects of engineering under one roof and offers innovative, unique, cost effective and reliable solutions*
1.5 Recent Desalination Projects

**East Port Said – Egypt**
- Capacity: 250,000 m³/d
- Client: Water Dept. – Armed Forces
- Year: Under Execution

**El Galalah – Egypt**
- Capacity: 150,000 m³/d
- Client: Water Dept. – Armed Forces
- Year: Under Execution

**El Yosr – Egypt**
- Capacity: 80,000 m³/d
- Client: Water Dept. – Armed Forces
- Year: 2017
<table>
<thead>
<tr>
<th>Project</th>
<th>Location</th>
<th>Capacity</th>
<th>Client</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearl – Qatar</td>
<td>Qatar</td>
<td>35,000 m³ / d</td>
<td>United Development Company</td>
<td>2010</td>
</tr>
<tr>
<td>Nabq Central – Egypt</td>
<td>Egypt</td>
<td>24,000 m³ / d</td>
<td>Sharming Sharm for Touristic Investment</td>
<td>2010</td>
</tr>
<tr>
<td>Port Ghalib – Egypt</td>
<td>Egypt</td>
<td>6000 m³ / d Extendable to 18000 m³ / d</td>
<td>EMAK</td>
<td>2010</td>
</tr>
</tbody>
</table>
Toggourt - Algeria
- Capacity: 34,000 m³/d
- Client: Algerienne Des Eaux (ADE)
- Year: 2016

Tindouf - Algeria
- Capacity: 15,000 m³/d
- Client: Algerienne Des Eaux (ADE)
- Year: 2017

Lisco - Libya
- Capacity: 3000 m³/d
- Client: Libyan Iron & Steel Company
- Year: 2017
## Other Recent Projects

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Country</th>
<th>Capacity</th>
<th>Client</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Umm Wu’ Al Phosphate Project</td>
<td>KSA</td>
<td>54600 m³/day</td>
<td>Ma’aden Phosphate Company</td>
<td>2016</td>
</tr>
<tr>
<td>El Tor</td>
<td>Egypt</td>
<td>30,000 m³/day</td>
<td>Water Dept. Armed Forces</td>
<td>Under Construction</td>
</tr>
<tr>
<td>Arar Brackish Water Ro Plant</td>
<td>KSA</td>
<td>25,000 m³/day</td>
<td>UTE Co. Ltd</td>
<td>2013</td>
</tr>
<tr>
<td>South Yoloten Gas Field Dev.</td>
<td>Turkmenistan</td>
<td>2 X 8544 m³/day</td>
<td>Petrofac Engineering &amp; Construction</td>
<td>2012</td>
</tr>
</tbody>
</table>