Mangystau Power and Desalination Plant Rehabilitation

Pre-feasibility Study

Study Report

February 2005

Engineering and Consulting Firms Association, Japan
Japan Development Institute
Pacific Consultants International
Overview of Plant Power (MAEC)

Nuclear Power Plant

Desalination Plant

Desalination Plant

Power Plant of MAEC in Aktau City

Water and Heating Pipelines
At Ministry of Energy and Mineral Resources

Deputy Akim of Mangystau Region (3rd from Left) and General Director of MAEC (2nd from Left)

At Ministry of Energy and Mineral Resources

Deputy Akim of Mangystau Region (2nd from Right) and Head of Regional management for economy, industry and commerce (the Right)

Housing in Aktau City

Rusted Pipelines

Aktau International Port
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<th>Full Name</th>
<th>Explanation &amp; Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Aktal LLP</td>
<td>Chemical Complex “Aktal LLP” - Nitrogen-fertilizing and chemical hydrometallurgical factory</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>BTX</td>
<td>Benzene, toluene and xylem</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>GDS</td>
<td>Gas Distribution Station</td>
<td></td>
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<tr>
<td></td>
<td>GKL</td>
<td>Aktau City Power Distribution Public Corporation</td>
<td></td>
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<tr>
<td></td>
<td>GKP</td>
<td>State-owned Communal Enterprise</td>
<td></td>
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<tr>
<td></td>
<td>GKP &quot;TSV&amp;C&quot;</td>
<td>Aktau City Water Supply Public Corporation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GHG</td>
<td>Greenhouse Gas</td>
<td></td>
</tr>
<tr>
<td></td>
<td>G</td>
<td>Giga</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>MAEK</td>
<td>Mangystau Atomic Energy Plant</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MAEK-KazAtomProm</td>
<td>The MAEK Joined KazAtomProm in 2003. A 100 % subsidiary owned by the national company of “KazAtomProm.” Employees: 3,950 people</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MPK</td>
<td>Mangystauskaya Promyshliennaya Company</td>
<td></td>
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<tr>
<td></td>
<td>MTES</td>
<td>Mangystau Thermo-electric Power Station</td>
<td></td>
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<tr>
<td></td>
<td>MSF</td>
<td>Multi-stage Flashing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MEF</td>
<td>Multi-effect Can</td>
<td></td>
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<tr>
<td>M</td>
<td>M</td>
<td>Mega</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>KazMunaiGaz</td>
<td>Kazakhstan national oil &amp; gas company</td>
<td></td>
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<tr>
<td></td>
<td>Kazmortransflot</td>
<td>A subsidiary of KazMunaiGaz in charge of transportation and logistics</td>
<td></td>
</tr>
<tr>
<td></td>
<td>KazAtomProm</td>
<td>A national atomic energy company</td>
<td></td>
</tr>
<tr>
<td>k</td>
<td>K</td>
<td>Kiro</td>
<td></td>
</tr>
<tr>
<td>O</td>
<td>Oblast</td>
<td>State (or Province) in Russia</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>PKSK</td>
<td>Consumer Cooperate of Apartment Owners</td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>Abbreviation, etc.</td>
<td>Full Name</td>
<td>Explanation &amp; Remarks</td>
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</tr>
<tr>
<td>R</td>
<td>RO</td>
<td>Reverse Osmosis</td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>TSV&amp;C</td>
<td>Heating &amp; Water</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TDS</td>
<td>Total Dissolved Solids</td>
<td></td>
</tr>
</tbody>
</table>
Preface: Introduction


During the previous study in 2003, JDI has received a request for rehabilitation of Akutau Electric Power and Desalination Plant and has been waiting an opportunity to assist the Mangystau Regional Government for the rehabilitation of Akutau Electric Power and Desalination Plant. In the summer of 2004, Engineering Consulting Firms Association (ECFA) was requesting proposals for feasibility study and JDI decided to use this opportunity to obtain necessary funding of the feasibility study. Fortunately our proposal for Mangystau Power & Desalination Plant rehabilitation was approved in October 2004.

Therefore, JDI dispatched a study mission from January 15 to 27 to Kazakhstan and carried out a pre-Feasibility Study. The study mission member is as follows:
1. Team Leader & Development Economist: Shoichi Kobayashi Ph.D.
2. Utility Specials: Mr. Tsukidate Yoshikazu
3. Regional Planner & Financial Analysis: Mr. Sumiyuki Otsuki

The study team visited Mangystau and able to meet the Deputy Governor, Mr. Turysbekov and with his assistance our study team visited the MAEK Power & Desalination Plant complex and various agencies in Aktau. Thanks to the kind corporation and assistance of the Deputy Governor and other officials, we were able to carry out our field study successfully. Then, the study team visited Astana and met several federal ministries: Ministry of Energy, Ministry of Environment & Natural Resources, Ministry of Finance and Ministry of Foreign Affair of Kazakhstan.

Discussions with the central government were very meaningful for clearing energy and public utilities development issues and overseas borrowing policy issues. Based on our short study, we are proposing as an immediate action to rehabilitate 10,000 tons a day desalination plant and main water pipelines with the investment cost of $40 million. The rehabilitation of these
two items is urgent and needed absolutely for survival of people of Mangystau region. The project is needed so badly since no alternative to obtain water in the region but sufficient investment funds are not available at a reasonable interest rate. Therefore, we are proposing use of Japan Bank for International Corporation (JBIC) special loan which is one of lowest interest loan in the world for supporting projects which are public goods but low returns. We are hoping that this Pre-Feasibility Study will assist the concerned agencies to take further actions for implementation of this urgent and important project soon.

Finally, we would like to express our sincere thank for Deputy Governor, Mr. Turysebekov and Mr. Kusherov Adilbek, Head of Regional Management for Economy, Industry and Commerce, Mangystau Regional Government for assisting our study team.

Shoichi Kobayashi, Ph.D.
Team Leader of Study & Chairman of Japan Development Institute (JDI)
Summary and Recommendation

1. Objective of Study
   ● Objective of this study is to investigate the economic trend of Mangystau Region and try to identify the major infrastructure problems faced by Mangystau Region responding an original request made in 2003.
   ● Then the study team with the assistance from Mangystau Authority and experts identify major problems and investigated them to solve the problems.
   ● During the short study period, the study team identified that water supply for the Region is the most serious problem faced and an immediate action is needed. Therefore, this study team focused on the rehabilitation of 40 years old desalination plant and water supply pipelines.

2. Political & Economic Trend and Future Prospect of Kazakhstan
   ● Kazakhstan became an independent country in 1991 unexpectedly due to the collapse of the Soviet Union. Due to sudden changes and breaking up of the former Soviet economic system, Kazakhstan economy suffered serious declines of GDP to nearly a half during the period from 1990 to 1998 and increasing unemployment reaching to over 20% of the workforce.
   ● However, Kazakhstan economy started to recover from 1999 due to increasing the global demand for energy and mineral resources which are main products of Kazakhstan. Due to discovery of large oil & gas fields in the Caspian Sea region, Kazakhstan became one of largest oil & gas reserve countries. The oil reserve of Kazakhstan by 2003 is 30 billion tons which is the second largest oil reserve next to Saudi Arabia. Besides the oil & gas reserve, Kazakhstan is endowed with abundant reserves of coal, cobalt, chrome, copper and uranium. Considering the future demand of these strategic natural resources, future of Kazakhstan economy is promising
   ● Kazakhstan is enjoying about 9% GDP growth since 2000 and this level of high economic growth is likely to continue for some time in the future because of the above mentioned progress of the energy and other strategic natural resources. Also stable political system is supporting the high economic growth of the future.

3. Mangystau Regional Economic Trend & Prospect
   ● Mangystau Region is located at the Southwest corner of Kazakhstan faced with the Caspian Sea to the West. The population of Mangystau region is only 2.2% of the national population (338,000 people Oct. 2003) with 6% of land area and the main industry is oil & gas
production (1.8 million tons in 2003). The industry of rural area is mainly cattle raising.

- The per-capita regional income of Mangystau Region is growing fast from 1999 and now per-capita income is the second highest ($20,683 PPP) in the nation due to abundant oil & gas production.
- From 2008, the large scale Caspian Sea Offshore oil production is expected to start and other oil & gas field is continue to increase production in the future. Plus Mangystau region has an important gate way port of Aktau with (about 10,000 tons/y cargo handling in 2003) and two additional ports at Bautino and Kuryk are under implementation for supporting the offshore oil & gas production. Therefore, Mangystau Region is expected to become Mini-Huston of the Central Asia along with Aterau.

4. Problems Faced by Mangystau

- One of the major problems of the Mangystau Region is limited employment opportunity in none oil sector. The unemployment rate is still over 10% average and the rural area is 16%.
- Another serious problems are deteriorating infrastructure especially water supply system. Mangystau region is dry and limited rainfall and nearly all of drinking and industrial water must obtain from the Caspian Sea by using desalination plants which is already 40 years old and deteriorating badly.

5. Electric Power and Water Supply Sector in Mangystau

- The electric power and water supply of Mangystau region is supplied by the Mangystau Atomic Energy Combine (MAEK). MAEK was established in 1962 when the foundation of Aktau City was laid. Since then MAEK was a sole supplier of both electric power and water to the Aktau City and surrounding areas.
- MAEK is responsible for supplying electric power, city heating and drinking water for the entire Aktau City and surrounding areas. MAEK established the first neutron reactor power plant in 1964 (350MW). However, since the independence of Kazakhstan in 1991, the most of large scale industries in the Mangystau Region were closed down due to collapse of the Soviet market system. Thus reducing demand for both electric power and water supply. Now MAEK is operating just about a half of the capacity in both power and water supply.
- Due to the collapse of demand for power and water, the financial condition of MAEK deteriorated and not able to sustain the production in the late 1990s. Also the problem of using the Nuclear power plant for the safety reason became serious and Kazakhstan Government agreed to stop the operation of the Nuclear power plant in 1998. Now three gas power plants with capacity of 1300MW and 750,000 tons/day desalination plants are located at MAEK site.
6. **Major Problems of MAEK**

- Demand of electric power and water supply declined to half of the capacity due to collapse of the Mangystau Region economy.
- Because of declined demand of power and water, the revenue of MAEK declined along with declined demands.
- Some of power & water supply plants and equipments became old and deteriorating badly but limited financial resources delay rehabilitation and replacement of deteriorating plants and equipments.
- Among deteriorating plants & equipments, one unit of desalination plants and main water pipelines became too old to use and must be replaced near future. MAEK is now trying to replace these desalination plants and main water pipelines which are expected to cost about $40 million in total.
- Water prices are still kept relatively low compared with the investment cost (only 98 Tenges for Drinking water and about 26 Tenges for industrial water for 1 m $^3$) and available finance in Kazakhstan is too high interest and too short loan period (normally 3-5 years loan period with 10% interest or above).

7. **Proposed Short-Term Project (5-10 years)**

- Rehabilitation of 10,000 tons/day MSF desalination plant ($20 million) and rehabilitation of water supply pipeline ($20 million).
- Conversion of steam-turbine power plant to more energy efficient gas-turbine plants (TEST-1: One unit 87MW)

8. **Long-Term Projects (10-20 years)**

- Rehabilitation of other desalination plants for RO (30,000 to 40,000 tons/day)
- Rehabilitation of steam power plant to gas power plants (TETS-2 & TETS-3:two units: 650 MW each)

9. **Financial & Economic Return**

- Base Case (Water price will increase 10% at each 5 years for three times) of IRR is 3.2% and barely feasible and without water price increase the IRR is 0.5% which is not feasible.
- Rehabilitation of Water supply for Mangystau Region is absolutely needed because no other way to supply water except desalination plants from Caspian Sea water and replacement of the 40 years old desalination plants and pipelines are absolutely needed although the return of investment is low.
10. Conclusion & Recommendation

- Rehabilitation of desalination (10,000 tons/day) and main water pipeline are needed immediately due to deterioration of 40 years old desalination plants and water pipelines. Financial return is relatively low due to the public nature of projects and keeping the water supply prices to be affordable to the people of Mangystau.

- Lower interest and long term grace period is needed due to the investment project is a public nature. Therefore, JBIC Yen loan in preferential terms (0.75% interest) is recommended if both countries agree.

- Although the financial return is low (3.2%: Base Case), economic return is expected high by providing clean and reliable water for people and industries of Mangystau Region which allow the future growth of the Region. Therefore, financing by JBIC preferential loan (0.75%) type is highly recommended.

- In order to implement this urgent and important desalination plant and water supply pipeline, a detail feasibility study is needed immediately after an agreement is made among concerned agencies.
1. **Economic and Political History of Kazakhstan since the Independence**

1.1 Political History

Kazakhstan was closely linked to Russia since the 18th century and became a member of the Union of Soviet Socialist Republic (USSR) in 1936. After the collapse of Soviet Union in 1991, Kazakhstan was forced to become an independent country without much preparation. Mr. Narsultan Nazarbayev who was the first secretary of the communist Party of the Kazakh Soviet Republic Kazakhstan during the Soviet Period became the first President of Kazakhstan in 1991. Since then, the President Nazarbayev reelected in 1998 and his supporting party won the parliamentary election with a large majority in 1999. In May 2004, President Nazarbayev announced that he will stand for re-election in 2006. Considering the current strong political condition of his party and a good economic performance of Kazakhstan economy due to high prices of oil and other natural resources produced in Kazakhstan, Mr. Nazarbayev is likely to be re-elected at the third times for the President which will allow his presidency until 2013 assuring a stable political situation until the early 2010s.

1.2 Economic Trend

Since Kazakhstan became an independent in 1991, Kazakhstan experienced a terrible economic confusion and an economic collapse because Kazakhstan didn’t have time to prepare her independence from the Soviet Union. The GDP declined drastically and continuously until 1998 to a nearly half of the 1990 GDP plus the population of Kazakhstan declined as well due to Russian and German who used to lived in Kazakhstan left to their homeland, and the population declined from 16.7 million in 1991 to 14.9 million in 1999.

Unemployment increased to 20-25% of the work force and per capita income declined to less than $1,000 in 1999. However, Kazakhstan economy finally started to shift to the positive economic growth from 1999. Due to higher prices of oil and other none ferrous metals which were main resources, Kazakhstan GDP started to increase rapidly at nearly double digit since 1999 until now. Also population of Kazakhstan leached a bottom in 2001 at 14.85 million and started to pick up from 2002 helped by the healthy economic growth.
Table 1-1 GDP 1999-2003

<table>
<thead>
<tr>
<th></th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current GDP (US$ bn at current prices)</td>
<td>16.6</td>
<td>18.3</td>
<td>22.1</td>
<td>24.6</td>
<td>29.8</td>
</tr>
<tr>
<td>Real GDP (1994 Prices Tenge bn at current prices)</td>
<td>1044</td>
<td>1147</td>
<td>1301</td>
<td>1429</td>
<td>1560</td>
</tr>
<tr>
<td>GDP Growth Rate (%)</td>
<td>2.7</td>
<td>9.8</td>
<td>13.5</td>
<td>9.8</td>
<td>9.2</td>
</tr>
<tr>
<td>Population (1,000)</td>
<td>14,902</td>
<td>14,866</td>
<td>14,851</td>
<td>14,867</td>
<td>14,951</td>
</tr>
</tbody>
</table>

Source: Economist Intelligence Unit 2004

Turn around of Kazakhstan economy form 1999 was mainly helped by the global demand of energy and natural resources which created a sudden prosperity in the energy and natural resource sector. The Table 1-2 shown below indicates that the high growth of energy sector. For example, oil production increased 71% from 1999 to 2003 from 30 million tons to 51 million tons. Natural gas, coal and electric power productions also increased by 65%, 38% and 34% during the same period respectively indicating a strong economic recovery in the past several years.

Table 1-2 Energy Sector Growth: 1999-2003

<table>
<thead>
<tr>
<th></th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil (Million Tons)</td>
<td>30.0</td>
<td>35.3</td>
<td>39.7</td>
<td>47.2</td>
<td>51.4</td>
</tr>
<tr>
<td>Coal (Billion Tons)</td>
<td>58.4</td>
<td>72.4</td>
<td>73.3</td>
<td>70.5</td>
<td>80.5</td>
</tr>
<tr>
<td>Gas (Billion cu meters)</td>
<td>9.8</td>
<td>11.5</td>
<td>11.6</td>
<td>13.1</td>
<td>16.2</td>
</tr>
<tr>
<td>Electric Power (Billion kwh)</td>
<td>47.5</td>
<td>51.6</td>
<td>55.3</td>
<td>58.5</td>
<td>63.3</td>
</tr>
</tbody>
</table>

Source: Economist Intelligence Unit 2004

1.3 Future Prospect

Kazakhstan is located in the middle of Central Asia with the 5th largest land area in the world but unfortunately Kazakhstan is landlocked surrounded by big powerful countries such as Russia in North, China in South East and 4 Central Asian neighbors in South. Also another important feature of Kazakhstan is having a long shoreline of Caspian Sea which is connecting with Russia, Azerbaijan and Iran by the Caspian Sea. Kazakhstan with limited population of only 15 million and landlocked with vast territory is not suitable for manufacturing under the competitive environment. Kazakhstan’s comparative advantages
are likely to be her natural recourses of oil & gas, coal, iron & steel, none-ferrous metals and vast agricultural land which is capable of producing 25-30 million tons of grains and other agricultural products. The most important strategy for Kazakhstan is how economically export these natural resources to the competitive world market. During the Soviet Union, the most of resource production facilities are developed to feed the Soviet Union market plus their affiliated COMECON market. In many cases, these facilities are not designed to compete in the global market nor designed to export to outside of the Soviet Market.

The most important strategy for Kazakhstan is securing transportation means for exporting abundant natural resources from Kazakhstan to the global market and import necessary products to Kazakhstan economically. The most important resource of oil and gas are fortunately able to export by pipelines which are already developed to the Soviet market and Black Sea ports and a few more strategic pipelines such to China, to Mediterranean Sea and Iran are under consideration or under implementation. Other commodities such as Iron & steel, none ferrous metals, coal and grains must be transported by railways or by trucks. Therefore, development of an efficient land transport system is crucial for the future of Kazakhstan. Especially trading routes to China, Russia, Iran and Black Sea region are of most importance.

Understanding of the importance of the transit routes, Kazakhstan is taking bold steps to develop modern efficient transit routes to the above mentioned countries and regions by investing in roads, railways and ports. Among the important transit routes, the China-Caspian Route at Aktau is the most important route. Kazakhstan Government is starting to improve the China-Caspian Railway route and now planning to build a new railway line with a standard gage and also planed to build two additional ports in Mangystau Region.

Considering these steps taken by Kazakhstan and abundant natural recourses, Kazakhstan is likely to expand her economy in the coming decades with a high GDP growth of 10% range or even more. Kazakhstan’s oil reserve is already past 3 billion tons which is the second largest oil reserve in the world. The famous Caspian Sea Offshore oil production is expected to produce oil from 2008 and the oil production of Kazakhstan is expected to expand from 50million tons in 2003 to 150 million tons by 2015. Other commodities such as chrome, copper, aluminum, iron, steel and uranium are also increasing in production volume due to the higher global demand with higher prices.
Among four regions in Kazakhstan, Mangystau region is located the most promising regions due to having the most important resource (oil & gas) especially the Mangystau is only region which has capability to build ports for supporting trades and also supporting the Caspian Offshore oil production.

2. Outline of Mangystau Region
The Mangystau Region is situated in the southwest of Kazakhstan and takes up 6.1% of the total area of the country. The region’s primal port city, Aktau, dominantly functions as the country’s transshipment base for dry cargo, crude oil and oil productions through the Caspian Sea. The climatic condition is sharp continental and extremely arid. Average temperature in winter drops to 4°C to 9°C below zero and yet in summer it goes up to 25°C to 29°C. Annual precipitation is between 100 mm and 150 mm.

2.1 Existing Socio-Economic Conditions
1) Population Trend
The region has traditionally high birth rate in the Republic of Kazakhstan. In 2003 census was 338.5 thousand persons and increased by 3.1% from 2002. Ethnic structure of the region is multinational. About 80 nationalities and peoples live in the region including Kazakhs, Russians, Ukrainians, Tatars, Germans and others. Yet the majority of Kazakhs forms 74% of the whole population and Russians do 17%. Urban population was 262.7 thousand persons or 79% of the total and rural population was 69.7 thousand persons in 2002. A number of workable citizens amount to 56.8% of the total number.
Table 2-1 Population of Mangistau region (Unit: thousand)

<table>
<thead>
<tr>
<th>Year</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Population</td>
<td>314</td>
<td>315.2</td>
<td>319.2</td>
<td>328.2</td>
<td>338.5</td>
</tr>
</tbody>
</table>

Source: Kazakhstan InfoBase (UNDP Kazakhstan)

Having adopted the policy of return of oralmans (Kazakhs living abroad), migration influxes from neighboring countries such as Iran, Turkmenistan, Uzbekistan, Azerbaijan and Moldova have been increased. During last years there were the resettled to the region more than 700 families of repatriates. Namely, among the people arrived in the region from CIS countries, Kazakhs is the majority of 84.8%, followed by Russians of 9.1% and Azerbaijanians of 1.2%.

2) Economy

According to statistic, in the region there were registered 4,350 enterprises of which 23% is state owned and the other enterprises have private and mixed patterns of ownership including the ones with foreign sharing (about 4%). The regional economy is predominantly based on oil-and-gas industries. The most large-scale enterprises are in oil-and gas sector and production of the mineral resources forms more than 90% of the region’s total output. In the region it is extracted up to 30% of crude oil with respect to the total volume of producible oil in the country. Every year the volume of oil production grows by 1.2-1.5 million tons. The industrial sector’s output of the region takes the third place and income per capita (PPP) stands on the second place from the top in the country.
Table 2-2 Income per capita in USD by PPP (Unit: US dollar)

<table>
<thead>
<tr>
<th>Region</th>
<th>1997</th>
<th>1998</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mangistau</td>
<td>10,325</td>
<td>7,790</td>
<td>10,309</td>
<td>13,783</td>
<td>14,678</td>
<td>20,683</td>
</tr>
<tr>
<td>Akmola</td>
<td>2,831</td>
<td>2,543</td>
<td>3,666</td>
<td>3,399</td>
<td>4,139</td>
<td>4,686</td>
</tr>
<tr>
<td>Aktobe</td>
<td>5,242</td>
<td>5,496</td>
<td>5,136</td>
<td>5,607</td>
<td>6,483</td>
<td>8,196</td>
</tr>
<tr>
<td>Almaty</td>
<td>2,904</td>
<td>2,603</td>
<td>2,424</td>
<td>2,532</td>
<td>3,098</td>
<td>3,471</td>
</tr>
<tr>
<td>Atyrau</td>
<td>11,996</td>
<td>9,553</td>
<td>11,940</td>
<td>19,094</td>
<td>21,638</td>
<td>27,035</td>
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<tr>
<td>East Kazakhstan</td>
<td>4,764</td>
<td>5,102</td>
<td>5,191</td>
<td>5,040</td>
<td>5,497</td>
<td>5,693</td>
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<td>Zhambyl</td>
<td>2,150</td>
<td>1,928</td>
<td>1,814</td>
<td>1,833</td>
<td>2,005</td>
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<td>West Kazakhstan</td>
<td>4,047</td>
<td>3,989</td>
<td>4,800</td>
<td>6,458</td>
<td>7,882</td>
<td>10,162</td>
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<tr>
<td>Karagandy</td>
<td>5,760</td>
<td>5,575</td>
<td>6,256</td>
<td>6,780</td>
<td>7,181</td>
<td>7,461</td>
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<tr>
<td>Kostanai</td>
<td>5,646</td>
<td>5,009</td>
<td>5,088</td>
<td>5,287</td>
<td>5,556</td>
<td>5,562</td>
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<tr>
<td>Kyzylorda</td>
<td>3,265</td>
<td>2,643</td>
<td>2,437</td>
<td>3,097</td>
<td>3,640</td>
<td>5,759</td>
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<tr>
<td>Pavlodar</td>
<td>5,368</td>
<td>10,537</td>
<td>5,651</td>
<td>6,882</td>
<td>8,007</td>
<td>7,988</td>
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<tr>
<td>North Kazakhstan</td>
<td>4,921</td>
<td>3,527</td>
<td>3,783</td>
<td>3,232</td>
<td>4,408</td>
<td>4,377</td>
</tr>
<tr>
<td>South Kazakhstan</td>
<td>2,302</td>
<td>2,071</td>
<td>2,271</td>
<td>2,751</td>
<td>3,262</td>
<td>3,228</td>
</tr>
</tbody>
</table>

Source: Agency on Statistics

The unemployment rate of the region is relatively high in estimated 9.7% in 2003 and the rural status is reported further 16.1%. However the overall trend of unemployment rate has been slightly declining in the past 5 years.
In the year 2003 in the region as a whole the foreign trade turnover amounted 2.2 billion USD including volume of exports to the sum of 1.7 billion USD and the imports of 445.1 million USD. Major part of foreign trade turnover (79.1%) of the region is export. The primary export item is crude oil, whose share is 98% of the total volume in 2003. More than three fourth of all the exploited oil is delivered to distant foreign countries and almost one fourth is supplied to Commonwealth countries. Reportedly the produced oil is directed to consumers in Poland (22.7%), the UAE (22.6%), Italy (19.7%), Ukraine, Germany, Switzerland, Great Britain, the Virgin Islands and other countries. In the meanwhile, major suppliers of import goods are come from the Russian Federation (36.8%), the USA (13.0%), Germany, Great Britain, Romania, Turkey, France and the UAE. Main imported items are metal production such as pipes of large and small diameters, special vehicles, motorcars, equipment, oil products and others.

Table 2-4 Export and Import in Mangistau region (Unit: million USD)

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>Export</td>
<td>715.2</td>
<td>721.5</td>
<td>1,111.60</td>
<td>1,700</td>
</tr>
<tr>
<td>Import</td>
<td>206.5</td>
<td>283.2</td>
<td>245.5</td>
<td>445.1</td>
</tr>
</tbody>
</table>
As the region’s economic investment policy, the diversification of the economy from solely depending on the oil-and-gas industry to the development of non-oil industries is promoted. And already several business projects are planned. Furthermore particularly interesting feature in region's economic activity is the construction work for housing. During only one year there were built over the region 1,220 flats including 770 flats of private property. In 2002 it was accomplished construction of a municipal dwelling house of 60 flats and houses of 126 flats in Aktau. Additionally it was started building of high-middle class houses in the central part of Aktau city. A possible reason behind of the housing construction boom can be related to the new discovery of oil fields in north-east Caspian Sea so that thousands of new employment would be created and additional domestic and foreign oil-related workers have to be accommodated in the city.

2.2 Major Problems and Future Prospect

1) Problems

The deterioration of region’s water supply system is the most serious and urgent resolve-required problem. The region’s water resource is largely confined to the salty water of the Caspian Sea and the Mangyshlak Atomic Energy Combine (MAEC) is supplying the drinking and industrial use water with the combined technology of power generation and desalination plants. Now entire regional cities rely on water supply from the power plant in Aktau and its facilities have been deteriorated in the past 40 years from its installation. With respect to the financial affairs in water sector in the region, inherited a negative legacy of the last communism regime, water rates are oppressed in lower price and water supply business is deemed unprofitable at present state.

2) Prospect

New discoveries of oil fields in the Caspian Sea would create much big demand on building extensive oil and gas pipelines and other oil exploration related infrastructures (seaport, road and airport). At the same time housing business is most likely to be boomed
with the increase of new comers in oil-and-gas sector businesses. Now in the Aktau city there are many place of constructing apartments and it is easy to expect in the near future the city’s population would be dramatically increased. Moreover in accordance with the development and expansion of the seaport transit activities, the linkage of railway network with central and eastern Kazakhstan and even with China would be enhanced and the region is like to be a centre of trade and confluence. In this sense, inadequate quantity and quality of water supply can be a bottleneck for the future development of region’s prospects.

3. On-going and Planned Major Projects

3.1 Oil & Oil Related Development Projects

In the Mangistau region there are discovered 59 oil and gas fields. The estimated volume of oil resources is 3,156.2 million tons and extractable raw materials are 1,440.3 million tons, and in 2002 total volume of the oil extraction reached no less than 12.5 million tons. Gas production in the region has stably been declining annually by 3-5% that is accrued to the depletion of gas reserves at the principal gas field of Uzen, however, oil and gas exploration data within the region show future trends of increase in that new outflow from oil production of additional major deposits are expected.

Regarding to the additional major deposits of oil-and gas fields, according to the Government, Program Kazakhstan Sector of Caspian Sea (KSCS) has been divided into 3 main zones:

1) Zone I – ‘Pricaspian’ which includes such oilfields as – “Kashagan”, “Kairan”, “Aktoty”, etc.
2) Zone II – “Ustyurt – Buzachinskaya including “Kurmangazy”, “Tyub-Karagan”, “Darkhan”, etc.
3) Zone III – “Mangyshlakskaya” with oilfields “Rokushechnoye more”, “Nursultan”, etc.

Namely, the country’s oil production will increase dramatically after the development of oilfields in Zone I and II between 2006 and 2015. Those discoveries of major oil reserves in the Northeast Caspian Sea shelf where probable oil reserves at depths not exceeding 50 meters comes to roughly 500 million tons will surely stress the region’s oil business related infrastructure development to sustain rapid and significant increase of oil production.
Mangiatau region has been planning to implement several oil related projects to support oil business operation in coming years. There are four sites of focus: Bautino, Kuryk, Atyrau and Aktau.

1) Bautino

There are a number of projects identified for the development of Bautino, like construction of sea ships refueling station, Stone shipping wharf and Sea oil operations support base. Those project will be initiated by Teniz Service, which is development company owning the right for developing Caspian seacoast area and the company is currently negotiating its service agreement with AGIP, which is the operating company of Kashagan field. Another agreement is also under consideration with AGIP on construction of a waste recycling plant. Additionally joint operations agreement has already been signed with Halliburton International Inc. on production of bore grouts and cement materials on the sea oil operations support base.

2) Kuryk

Another sea oil operations support base will be built in Kuryk to cover operations in Zone III in the future. It is expected that maximum annual turnover through this base will amount 300 thousand tons. According to the general plan of KSCS infrastructure development an oil terminal will be built in Kuryk with a capacity of 20 million per year. Construction is scheduled for 2007 and will cost US$ 50 million.

3) Atyrau

Atyrau will be a service center for small capacity cargos and transfer of staff employed at sea oil production. The general plan indicative figures are around 25,000 people to be engaged in the region. A sea oil support base will be built in Peshnoye with project value of US$ 80 million in 2007. The major customer of the Base will be AGIP.

4) Aktau

The most promising operations in this region are transshipment of large-scale cargos and staff delivery. In the general plan total assets are expected to increase by KZT 10 billion every year and reach KZT 70 billion (or US$ 500 mil.) by 2010.
Reference. Major Oil and Gas fields in Kazakhstan

The followings are the major oil and gas fields in Kazakhstan territory;

(1) Tengiz field in western Kazakhstan has an estimated 6 billion - 9 billion barrels in recoverable reserves and produced around 250,000 barrels per days in 2001. With liquids output (oil and gas condensate) of 12.75m tonnes, a consortium led by ChevronTexaco (US), Tengizchevroil (TCO) has raised its contribution to national production from 5% in 1993 to 25% in 2003.

(2) The newly discovered Kashagan field has an estimated recoverable reserve at 7 billion - 9 billion barrels. The operation is carried out by Agip on behalf of a consortium comprising ENI, ExxonMobil, Inpex, Phillips Petroleum (US), Shell (UK) and TotalFinaElf (France).

(3) Karachaganak field in northwestern Kazakhstan has estimated reserves of 1.2 billion tonnes of liquid hydrocarbons and 1.3 trillion cubic meters of gas. The consortium comprises BG (UK), ENI ChevronTexxaco and LUKoil.

<table>
<thead>
<tr>
<th>Country</th>
<th>Project</th>
<th>Proven Reserves</th>
<th>2004 Production</th>
<th>Projection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azerbaijan</td>
<td>ACG Mega-Structure (BP et al.)</td>
<td>5.4 Billion Barrels</td>
<td>144,000 bbl/d</td>
<td>2005: 460,000 bbl/d</td>
</tr>
<tr>
<td></td>
<td>Shah Deniz (BP et al.)</td>
<td>2.6 Billion Barrels</td>
<td>14 Trillion Cubic Feet</td>
<td>2006: 236 Bcf</td>
</tr>
<tr>
<td>Kazakhstan</td>
<td>Tengiz (ChevronTexaco et al.)</td>
<td>6.9 Billion Barrels</td>
<td>290,000 bbl/d</td>
<td>2006: 450,000 bbl/d</td>
</tr>
<tr>
<td></td>
<td>Karachaganak (BG, Agip, et al.)</td>
<td>2.4 Billion Barrels</td>
<td>210,000 bbl/d</td>
<td>2008: 240,000 bbl/d</td>
</tr>
<tr>
<td></td>
<td>Kashagan (ENI-Agip, BG, et al.)</td>
<td>7.9 Billion Barrels</td>
<td>not producing</td>
<td>2008: 75,000 bbl/d</td>
</tr>
<tr>
<td>Turkmenistan</td>
<td>Cheleken (Dragon Oil)</td>
<td>0.8 Billion Barrels</td>
<td>10,000 bbl/d</td>
<td>2003: 11,000 bbl/d</td>
</tr>
<tr>
<td></td>
<td>Nokit Dag (Eurime Energy)</td>
<td>0.1 Billion Barrels</td>
<td>10,000 bbl/d</td>
<td>2003: 12,000 bbl/d</td>
</tr>
<tr>
<td>Uzbekistan</td>
<td>Central Ustyurt and Southwest Gissar (Trinity Energy)</td>
<td>Being Developed</td>
<td></td>
<td>2006: 2,600 bbl/d 71 Bcf</td>
</tr>
</tbody>
</table>

Source: The Economist Intelligence Unit and Energy Information Administration, U.S.
3.2 Infrastructure Projects

1) Electric Power

The Mangyshlak Atomic Energy Combine (MAEC) was founded in 1968 as a single energy supply enterprise. Although the enterprise faced serious financial problems after the collapse of USSR, the company has been in a reviving stage since May 2003. An objective of the enterprise is electric, heat and water supply to the region’s industries and population. The plant of MAEC are comprised of a fast neutron nuclear reactor BN-350, which was taken out of service in 2000, a sea-water desalination plant (DPP), HPP-1 (heat power plant), HPP-2, HPS (heating and power station) and CUVS-1, 2, 3. Power station is run by the natural gas and desalination plant is using evaporation technology. Now most of these facilities have been operating for more than 40 years and the equipments are getting old.

Productive capacities of the MAEC are:
- Electric power (Total) - 1342 MW;
  - The heat generation part of the station - 630 MW,
  - The thermoelectric power station (blocks) part has 3 energy blocks of 210 MW each.
- Heat energy - 1843 Gcal per hour;
  - The total steam generation capacity - 2,400 tons per hour.
  - The heat generating part has 13 boilers and 10 turbines.
- Water - 195 thousand cubic meters per day.

In reported year the tariff for electric energy increased by 8.6% owing to increase of cost of natural gas supplied for MAEC by OJSC “Ozenmunaygas” and “TShO LLP”.

MAEC supplies services not only to Aktau but also to Bautino and Kuryk and even outside the region. Currently the extensional works are under consideration with the progress of the development projects in Bautino and Kuryk.

2) Water Supply

As it has been described, MAEC is the main player of water supply operation in the region. In the country in general, the majority of water resources come from surface water (91%) and underground water is only available in 9%. The region’s water resource is predominantly attributed to the water body of Caspian Sea. And the proportion of water supply from decentralized water sources (wells, springs, artesian wells, without transfer
pipelines) is just 1%. In this respect, an installation of fast neutron nuclear reactor in combined with power generation and desalination plant of seawater was seen unique practice but crucial for artificial city of Aktau.

The salinity of Caspian Sea is about 13.5 g per litter (Sea-water is about 35 g per litter), and after the desalination process, the salinity will drop in 5 mg per litter for industrial use and 0.5 - 0.7 mg per litter for drinking water. Seawater is draw by pumps in the capacity of 1,000 cubic meter per sec. and processed in a seawater distillate production plant with the evaporation method. The capacity of water supply from the plants is about 200 thousand cubic meter per day.

As water-related projects identified in the region, extensional works will be implemented in proportion with the development works in Bautino and Kuryk. Besides the desalination plant becomes old and the condition of water supply pipes in Aktau city has been deteriorating. It was detected that some part of city’s dwellings have serious problems to have reddish water from tap and it has been raised its necessity of replacement by the regional authority. The projects of reconstruction and rehabilitation of desalination plant and water supply pipe network in Aktau is badly needed and urgently required.

3) Ports

The international commercial port Aktau, created in 1963 situates at the east coast of the Caspian Sea and serves as one of the largest transport base in Kazakhstan. In 1999 the port was reconstructed with the funds of 54 million USD from EBRD. Unlike Atyrau port, the port is non-freezing and based in the deep-enough water berth, which is no less than 6 m and approaching channel is 9 m. Endowed with good natural conditions and its strategically important location the port functions as the main transport gateway in several corridors, which connect Europe and Asia running through the Caspian Sea, the Black Sea, Volga-Don, and the Belomor-Baltic canal to the Baltic Sea.

The transshipment is the current main operation in the port and different dry cargoes, crude oil, petrochemicals and grain are loaded on board from 12 port terminals of which 3 terminals are dry-cargo, 4 ones are bulk-oil and the others are used for auxiliary purposes. The oil berths can simultaneously handle 3 tankers of 12 thousand tones. The contents of transshipment of export-import freights are metal, grain, minerals, fertilizers, equipment, and building materials. The handling capacities of Aktau port are 8 million tones of oil, 600 thousand tones of grain, up to 1.5 million tones of general and bulk cargo and up to 24
thousand items of containers (T.E.U) per year. And also there are ferry conveyances in the course of Aktau-Astrakhan and Aktau-Turkmenbashi-Iran. Since June 1999 it has been started a ferry conveyance of passengers and cars between the ports Aktau and Baku.

There are another two ports in the region. In Bautino, where a base of Agip CCO is situated, the works are underway on reconstruction of a port terminal for the oil exploration works in Kashagan field, while Kuryk, where an assembly base of construction parts for the development of oil-and-gas fields of the region locates, is an intentional site for installation of a shipyard for repairing and ship-building operations. For the construction of a shipyard in Kuryk the Korean company Samsung and other Singaporean and Russian companies have already shown interest.

### Reference. Seaman Training

It is arranged co-operation with the Russian Federation in the field of sea transport and in the sphere of training of skilled technicians. In the area of education it is in progress an agreement between the Aktau affiliate of the Tynshpaev Academy of Transport and Communication and the Astrakhan State Technical University on co-operation in the realm of training and professional development of specialists in seaman.

#### 4) Road

Mangistau region is covered by 910 km of road network. Namely the highway "Dossor-Kulsary- Beyneu-Say Utes-Shetpe-Zhetybay-Morport- Aktau with the length of 589 km, of which only 285 km have been paved while 299 km have gravel surfacing and the rest 5 km are just earth road. To Turkmenistan, there is a highway "Zhetybay-Zhanaozen-Kenderli-the border of Turkmenistan with the length of 237 km. 187 km have asphalt-concrete covering, 25 km have gravel surfacing and 25 km have lining.

There were assigned extra funds for the special purpose of road reconstruction projection between Kazakhstan and Uzbekistan. Now the road is under the reconstruction. It is also scheduled a large volume of works on maintenance and repair of local motor roads with their own local budget. In 2004 it is also planned to start reconstruction of the highway between Aktau and Atyrau.

#### 5) Railway

Railway functions as the lifeline of the country’s economy and in regional context is no
exception in that most of the commodities are brought in by the railway and the country’s export goods like grains and oil are carried by the railway and transshipped from the Aktau port to other countries. Kazakhstan Temir Zholy (KTZ) is operational company of railway and it has a monopolistic status in the country. KTZ is a government owned natural monopoly, which has been recently subdivided into three separate railway companies. Reportedly, respective companies recently posed additional tariff for railway transport in order to maximize profits based on the flourish of oil sector business and their monopolistic advantages. Even if the charge was reflected from the booming of the oil sectors and the bulk of the cargo was dominantly used for oil transshipment, the additional transport cost is casting dreadful impacts on other non-oil sector business. Eventually this monopolistic condition has been concerned in the government side as well and new railway line for an alternative route through southern region is under planning.

6) Airport
The airport Aktau was opened in 1983. The number of air passengers and airplanes using the airport has been raised in that the passengers increased from 32,000 persons in 1999 to 2.3 times of 75,000 in 2002. There were increased dispatches of air passengers to the following cities: Istanbul, Rotterdam, London and Amsterdam. And also, although there is a small airbase in Bautino, its capacity seems to reach its limit likewise in Aktau airport with the start of future oil field operations in Kashagan, which would create more flight demands from oil-and-gas exploration companies both from and into Aktau, Bautino and other major cities.

In 2002 airport operation company in Aktau, Kazaeroproekt designed a new present-day airport building corresponding to international standards and it was planned in 2003 to start construction of a hotel in the territory of the international airport of Aktau.

3.3 SEZ and other Manufacturing Industry
The Special Economic Zone (SEZ) has begun its operation in January 2003 as a state initiative project based on the Decree of the President of the Republic of Kazakhstan. The zone was created for a term of 4 years up to 2007 in the territory of 227.1 hectares next to the Aktau Port. The primal aim of establishing SEZ is to develop oil exploration projects in the Caspian Sea region. For administration of the SEZ and performance of the duties of the local public management the Akimat of Aktau city constitutes an executive office named as the Administration of SEZ "Morport Aktau" and provides its operational finance from the local budget. In SEZ, now four manufacturing companies of glass fiber, steel pipe
(Ispat Industries), metal fabrication and ship repairing (Keppel Engineering) are operating.

1) SEZ Development Plan
As a future potential of SEZ development, while the term is ending, the region’s strategic position should be considered. Namely the Mangistau region, particularly Aktau port is becoming an accumulation and transit ground of export goods and has still much room for its capacity of expansion according to both market availability and cost/benefit advantages of transit business through the Caspian Sea. Therefore SEZ site can be extended to accommodate Free Trade Zone (FTZ) functions in that manufactured goods especially from China can be gathered in the zone and then exported with no tariff to neighboring countries of Iran, Azerbaijan, Russia or Europe. This FTZ operation would create impetus for inviting service sector businesses of finance, insurance and transport as well. Thus as a future plan the site can be a potential place for marketing where antenna shop can be stationed and buyers from the regional countries can pick the items in the zone.

2) Manufacturing Projects
In the manufacturing sector in general, the industry represented by light industries, food, chemical, engineering and other branches are developed to only some extent. Total production volume of the sector is about 3% of the whole in the region. Although the chemical complex was created in the late 60’s in the region, limited operations are now seen in that a nitrogenous fertilizer plant was put into operation in 1969, but at the present the enterprise stands idle. To the contrary, the enterprises of the oil-and-gas sector related manufacturing industries would have good prospects. The plants producing a broad range of spare parts and tools designed for drilling and capital repairs of oil equipments including tanks for oil gathering and storing, pump and repairing engineering services of power and oil plants are in good state. Therefore it is expected these oil-and-gas related industries, especially the oil exploration supporting industries would come and station in the region in the near future.

3.4 Tourism Prospect
1) Existing Tourism
Aktau city is a regional center, which stretches along the Caspian Sea and utilizes relatively moderate climate of the coast region to attract tourism. Some historical monuments are situated along the Great Silk Road in the region and both flora and fauna are rich in that about 70% of the all kinds of birds in the country and one third of national mammal population are found in the region. Especially swans migrating to the coast of
Aktau city in winter season are famous and sturgeons, which are famous for its unique resources of caviar and sea mammals of Caspian seal capture people’s interest.

At present, there are some hotels, recreation bases (small bars and casinos), and children's play set found along the coastline.

2) Future Prospect

The Mangistau region has been trying to appeal its tourism potentials in several international exhibitions. And also some measures are taken with respect to the development of domestic tourism with issuing introductory video and booklet of the region’s attractions. However, still the number of the visitor to the region is limited and recreation facilities must be improved so that casinos, hotel resorts, esthetic therapies (ex. thalassotherapy based on resources from Caspian Sea) and yacht harbor are recommended to be developed more systematically in proportion to the development of new oil fields and increase of foreign new comers (drill men, oilmen, builders and erector) to be engaged in the oil field development.

4. Electricity and Water Supply System in Aktau City and Mangystau Province

4.1 General

The national development plan of the Government of Kazakhstan has defined the development of oil and natural gas as the strategic issue having priority, and they try to develop of the coastal area of the Caspian Sea as the project of national importance. Aktau Port in Aktau City has become the important loading and unloading places not only of the crude oil but also of grain, steel products, fertilizers, ores, etc. Aktau City, the biggest physical distribution base in Kazakhstan, is also deemed to be the important development region to promote the nourishment of supportive industries for the above industries, and to advance the development such as the arrangement of infrastructures etc.

Consequently the improvement business of MAEK, which is the fundamental infrastructure facilities to supply electric power, industrial water to support the civil life and industrial activities in the region, and to supply drinking water and hot water for people’s daily life, has become the emergent and indispensable factors of the industrial development in the region.
Specifically the decrease in the capacity of desalination facilities owing to the wearing out and the decline in the efficiency of supply of the electric power and heat, are raised as the problems that need to be solved.

And it also has the fundamental problems that many of facilities will approach its life of use after 2005, and judging from the fact that this region is an artificial City isolated from other regions, the necessity of the improvement of facilities to secure the lifeline is becoming remarkably high.

Figure 4-1 shows Schematic Block Flow Diagram of Existing MAEK’s Desalination and Electric Power Plants.
Figure 4-1 Schematic block flow diagram of existing MAEK’s desalination and electric power plants
4.2 Profile and History of MAEK

MAEK (Mangystau Atomic Energy Plants) is called a heart of the Mangystau region because it supplies energy, heat and potable water to the citizens of the region. The history of the energy plant is linked with the history of development of oil and gas reserves in Mangystau. Exploration and commercial development of oil fields in the Bozashchy Peninsula caused a need in construction of energy generation facilities.

Today the Mangystau Energy Complex is passing through its revival stage. Modernization and overhaul of plants and equipment are ongoing, the production capacity is increasing. The Mangystau Energy Complex supplies potable and domestic water, thermal heat and power to the citizens in Aktau and neighboring settlements. Despite all difficulties of the period the enterprise could keep its personnel, specialists of the highest class. 3,950 people work at the complex. Table 4-1 shows the history of MAEK.

<table>
<thead>
<tr>
<th>Year</th>
<th>Events and Activities</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>The first train of power plants arrived in Mangystau.</td>
<td>The first power plant delivered.</td>
</tr>
<tr>
<td>1962</td>
<td>The diesel power station was commissioned, and then the first turbines of 6 MW at the <strong>Power Station No.1</strong> (TES-1) were launched (started operation). The first evaporator installation produced potable water of 150 tons of distilled water per hour (3,600 tons per day). Since that year, power generation started in the region. <strong>For 40 years</strong>, the station generated power and heat for the whole City and region. <strong>Power Station No.1</strong> is the major source of heat and hot water in Aktau.</td>
<td>Power generation and making potable water started.</td>
</tr>
<tr>
<td>1964</td>
<td>The construction of fast neutron reactor, <strong>BN-350</strong> began.</td>
<td></td>
</tr>
<tr>
<td>1967</td>
<td>Construction of desalination installation began for the <strong>Distilled Water Preparation Plant (DPP) complex.</strong> The first block was commissioned in 1969 to 70.</td>
<td></td>
</tr>
<tr>
<td>1973</td>
<td>The nuclear reactor on fast neutrons reactor, <strong>BN-350</strong> (Nominal</td>
<td>A nuclear power plant</td>
</tr>
<tr>
<td>Year</td>
<td>Events and Activities</td>
<td>Remarks</td>
</tr>
<tr>
<td>------</td>
<td>-----------------------</td>
<td>---------</td>
</tr>
<tr>
<td>1979</td>
<td>The Central Power Distribution System was launched which increased reliability of performance of the equipment and connection of new facilities of the regional production complex to the system.</td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>The collapse of the USSR</td>
<td></td>
</tr>
<tr>
<td>1998</td>
<td>By the Kazakhstan government’s resolution, the nuclear reactor was stopped. At present, the nuclear reactor is being liquidated.</td>
<td>The nuclear power plant fully stopped.</td>
</tr>
<tr>
<td>1998</td>
<td>The <strong>Mangystau Thermo-electric Power Station</strong> (MTES) was founded to increase the efficiency of loading of the equipment under different regimes of operation and to save fuel consumption.</td>
<td></td>
</tr>
<tr>
<td>1999</td>
<td><strong>Since that year</strong>, the natural gas-fired/steam turbine -driven <strong>Power Station No.2</strong> (TETS-2) works and supplies heat and electric power to the desalination plants and other industrial enterprises.</td>
<td>The present power plant starts generating electricity.</td>
</tr>
<tr>
<td>2003</td>
<td>The MAEK jointed the national atomic energy company of “KazAtomProm” and then “MAEK-KazAtomProm” has become the owner and operator of the energy complex as a 100 % subsidiary of KazAtomProm.</td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>The funds were allocated to upgrade the station, specifically the steam generating unit BKZ-160 and also for refurbishment of the company facilities and buildings.</td>
<td></td>
</tr>
<tr>
<td>Present</td>
<td>Now the power station (TETS-2) focuses on supply of steam to desalination plant to prepare distilled water and industrial heat and water.</td>
<td>At present, less than a half of the capacity is operated.</td>
</tr>
<tr>
<td></td>
<td>The electric power capacity of the station (TETS-2) is <strong>630 MW</strong>, the total steam generation capacity of <strong>2,400 tons per hour</strong>, having <strong>13</strong> steam generators (boilers) and <strong>10</strong> turbines. The</td>
<td></td>
</tr>
<tr>
<td></td>
<td>started generating electricity.</td>
<td></td>
</tr>
</tbody>
</table>
electric power is supplied to industrial enterprises and the population in Mangystau Province.

The part of MTES generates electricity for all oil fields in Mangystau and Atyrau. There is a power transmission line to supply power to Karajanbas, Kalamkas, Buzachy and Uzen oil fields.

<table>
<thead>
<tr>
<th>Year</th>
<th>Events and Activities</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>electric power is supplied to industrial enterprises and the population in Mangystau Province.</td>
<td>The part of MTES generates electricity for all oil fields in Mangystau and Atyrau. There is a power transmission line to supply power to Karajanbas, Kalamkas, Buzachy and Uzen oil fields.</td>
</tr>
</tbody>
</table>

4.3 Electricity Supply System

1) Electricity supply facilities and capacities

The supply of electricity to Aktau City is made by the 3 power stations of MAEK only. Aktau City was originally an artificially constructed town isolated from others, and so it also is severed from the national grid. The present capacity of power generation facilities is 1,357 MW (TETS-1: 87 MW, TETS-2: 650 MW, TETS-3: 620 MW) in total, which will generate 7,000 to 7,500 GWh of electric power per year. In 1990 electric power consumption was equal to 4,000 GWh, and in 2003 decreased to 2,620 GWh. Figure 4-1 shows a schematic flow diagram for electricity and water supply system in Aktau City and Mangystau Province.

These power generation facilities were put into operation in 1962. Power generation was carried out there before equipped with nuclear power generation facilities and gas-fired generation facilities. Now only natural gas is used for power generation, that is produced inside the Province with its main constituent of methane and ethane (including the accompanying gas), and the annual gas consumption is 1,400 to 1,600 m³.

And at present power transmission is made partially from MAEK to Tengi, Jutibei, Kalamkas oil fields in the Mangystau Province. Figure 4-2 shows power transmission and distribution areas by MAEK.
2) Substation and power distribution network

MAEK which owns and manages power transmission lines up to Aktau City, substations (except some of them), and GKL (Aktau City Power Distribution Public Corporation) is also in charge of managing the terminals of transmission lines up to each apartment house etc.

Power transmission lines from MAEK are 2 systems of 35 KV and 4 system of 110 KV, and substations of 35 KV/6 KV is owned and managed by GKL. There are three 110 KV
substations (two of 110 KV/10 KV and one for 110 KV/6 KV), all of which are owned and managed by MAEK.

In each district of Aktau City there are 10 to 15 distribution substations of 10 KV/0.4 KV or 6 KV/0.4 KV, totaling 176 in the whole Aktau City. In districts which are relatively distant from substations, distribution units are installed to receive cables coming from substations and send out them to each distribution substation. There are 5 distribution units in total in the whole Aktau City.

The number of employees of Power Distribution Public Corporation is 159, out of which 35 are engaged in management business and the others are technical personnel.

The users of power distribution consist of about 60% of ordinary homes, about 30% of business premises such as factories, offices etc. and about 10% of public facilities such as schools, hospitals etc.

3) Forecast of future demand for electric power

The feasibility study conducted in 2001 by Engineering Advancement Association of Japan (ENAA) made a presumption, assuming that the demand for electricity would increase rate continues until 2020.

The Provincial government forecasted that the power generation amount in 2005 will be 31.1% greater than that in 2000 on the basis of the following four reasons;

a) Growth can be expected in the oil related industries.

b) There is an outlook of chemical plants being reopened.

c) There is a plan to supply electric power to Atyrau Province, Aktubinsk Province and Uralsk Province under the policies of the central government.

d) The population is assumed to reach 300,000 in 2015 as had been planned at first around 1990. (This equals to the annual population increase of 5% after 2000.)

According to the forecast, demand of electricity in Mangystau will increase from 4,000 GWh/year in 1990 after decreasing to 2,000 GWh/year in 2001 to more than 5,000 GWh/year in 2020.
4) Detailed power plants and facilities

(1) The power station of MAEK consists of 3 places and each is called TETS-1, TETS-2 and TETS-3.

(a) TETS-1
It is installed in the nearest place to the living residential districts, and in the period of 1962 to 1968, 7 units of boilers and 5 units of steam turbine generators were installed. The facilities are mainly for supplying the heat (hot water) to the region, and the overall facilities capacity is 87 MW for power generation and 440 Gcal/h for heat supply.

(b) TETS-2
It is installed in a place about 5 km to the southeast of the TETS-1 and constructed with a view to ensure stable operation of the adjacent BN-350 and the existing desalination facilities. In the period of 1962 to 1983, 13 units of boilers and 10 units of steam turbine generators were installed, and the total facilities capacity is 650 MW for power generation and 560 Gcal/h for heat supply, and in 1998 the BN-350 reached its life of use to cease its operation, it now supplies the steam to the existing desalination facilities and supplies the heat (steam) and electric power to the region by means of the boilers and steam turbines.

(c) TETS-3
It is located about 1 km to the southeast of the TETS-2, and was constructed to meet the increased demand for electric power accompanying the development of industries in the surrounding areas. In the period of 1982 to 1988, 3 units of boilers and 3 units of steam turbine generators were installed, and the total facilities capacity is 620 MW.

As stated above, in total 26 years 23 units of boilers and 18 units of steam turbine power generators were installed in MAEK for the purpose of ensuring the stable operation of the BNt-350 and the stable supply of water and energy.

(2) Fuel
Main fuels at present are natural gas. Its major production points are the gas fields in the surrounding areas of Uzen City located about 150 km southeast of Aktau City, and it is produced by oil and gas mining corporations of Kazakhstan (Magistaummai Gas and Uzenmnai Gas). The gas is transported to Aktau City from the gas treatment facilities by means of the Uzen-Aktau gas pipeline, and the volume of gas produced in the area is about half of the volume consumed in MAEK.
The gas to MAEK is supplied through the outside facility of Gas Distribution Station, Uzen-MAEK (GDS) and the inside facility of Gas Regulation Point (GRP).

The supply pressure of natural gas is 17 kg/cm² from the pipeline to the GDS (designed pressure is 35 kg/cm²), 12 kg/cm² from the GDS to the GRP, and the present consumption of overall MEAK is about 90,000 to 95,000 Nm³/h in summertime and 150,000 to 180,000 Nm³/h in wintertime.

These are the data collected on August 21, 2000 and the annual average heat generation amount in 1990 to 1999 fluctuated between the values of 32,527 to 36,270 kJ/Nm³.

(3) Cooling water
The water intake facilities are located in two places, the TETS-1 and the TETS-2. Each takes water in from the Caspian Sea using an individual waterway.

The pump station has total 27 units of seawater pumps and dust removing facilities, with the total intake capacity of 543,000 t/h, but the present possible intake amount has come down to 350,000 t/h due to the wearing-out of the facilities. The seawater temperature fluctuates within the range of minimum 1°C and maximum 26°C.

The discharge waterway is installed in each TETS, and the TETS-1 discharges water direct into the Caspian Sea, and the TETS-2 and TETS-3 discharge water to the Caspian Sea through the adjacent Lake Karkol.

(4) Treatment of water supplies to the plant
The raw water is supplied in 10,000 t per day from the desalination system of the existing desalination facilities, and the plant water supply treatment facilities at each TETS carries out the desalination treatment.

(5) Power transmission
The generated electric power of each unit of TETS-1 through TETS-3 is connected to each power transmission system through the outdoor switchgear station adjacent to the boiler-turbine main building, classified into each voltage class. The double bus is laid inside the outdoor switchgear station having the bypass bus. The transmission frequency is 50 Hz. The drawing of power transmission system is included in the attached materials.
The 220 kV system is connected to the northwestern Kazakhstan system in Uzen City, but the circuit breaker is left open at present. As for the TETS-1, #1 to 2 units is connected to the 35 kV system and #3 to 4 units can be connected to the 35 kV and 110 kV systems by switching, and #5 unit is connected to the 110 kV system. And all the units of the TETS-2 and #1 unit of the TETS-3 are connected to the 110 kV system and #2 to 3 units of the TETS-3 are connected to the 220 kV system.

4.4 Water Supply System

1) Water supply system of Aktau City

The water supply of Aktau City comprises 3 systems, drinking water, technical water (water for miscellaneous use) and hot water (for heating and for hot water supply). These water supply systems are related to and managed by the following 3 organizations.

(1) **MAEK:** Manufactures drinking water, technical water and hot water by means of the desalination etc. to supply them to Aktau City, etc.

(2) **GKP “TSV&C”:** Aktau City Water Supply Public Corporation (GKP: State-owned Communal Enterprise, TSV&C: Heating & Water) carries out distribute the drinking water, technical water and hot water as supplied by MAEK to each of the apartment houses in Aktau City.

(3) **PKSK:** Management cooperative of apartment houses etc. (PKSK: Consumer Cooperate of Apartment Owners) carried out the plumbing etc. and maintains it, to be used for distribution to each home the drinking water, technical water and hot water as distributed by TSV&C to each of the apartment houses. The present PKSK has 23 organizations in overall Aktau City. The PKSK does not necessarily match the division of street blocks.

MAEK is located about 15 km to the south of the City area of Aktau, and the water purification plant is about 5 km from the City area, and the pipes for drinking water and technical water are laid in a set of two pipes all through to the end users. MAEK is in charge of the piping up to No.3 pumping plant located in the City area, and TSV&C is in charge of the piping from No.3 pumping plant up to each of the apartment houses etc. PKSK is in charge of the inside of each of the apartment houses.
The fees of drinking water and technical water are the sum of water fees charged by MAEK and water distribution fees charged by TSV&C.

2) Water purification plant and water distribution plant

The water purification plant that is about 5 km from the City area, has 2 systems of purification facilities for treating the drinking water. Their processing capacity is 350,000 t/d plus 400,000 t totaling 750,000 t/d.

The purification facilities are of the 2-stage filtering, sand filtering and activated carbon filtering, and the gravity method is applied to both of them.

In this water purification plant, seawater is desalinated and distilled, blended with underground water of 1/10 in amount, then injected with calcium, carbon dioxide, fluorine and sodium carbonate, its mineral content is adjusted to 200 to 400 mg/l, and in addition the drinking water is chlorinated to comply with the WHO standard.

And adjacent to Aktau City there is a water distribution plant equipped with underground concrete tanks of 2,000 tons for drinking water and of 6,000 tons x 2 units for technical water. In this water distribution plant the drinking water is chlorinated again to make the residual chlorine become 0.8 to 1.2 mg/l.

The pipes for drinking water and technical water are laid in a set of two pipes all through to the end users, but most of them are on the ground and the piping is laid alongside the road everywhere. The drinking water supply line is not enough in some residential districts and its reinforcement is required.

3) Hot water supply system in Aktau City

Hot water in Aktau City is used as the heat source of heating of apartment houses and for hot water supply for kitchens and bathrooms, and is supplied from TETS-1 by way of the 2 trunk lines (owned by MAEK), one of which is the supply line from MAEK and the other is the return line. TSV&C is in charge of the piping from the trunk line to each of the apartment houses and maintain it, and PKSK is in charge of the inside of each of the apartment houses.

The amount of circulation is 5,500 to 6,000 t/h throughout the year, and the amount of heat
is maximum 440 Gcal/h in winter, and 20 to 45 Gcal/h in summer. The temperature of supplied water is maximum 150°C in winter, and about 80°C in summer, in this case the return temperature is about 70°C.

The consumption amount of hot water and the consumption amount of heat are supposed to be calculated by the flow-in and flow-out amount at the user and the water temperature, but as the measuring facilities are expensive, only a limited number of facilities, 25 in total such as schools and office buildings of authorities, are equipped with the facilities. Therefore, the consumption amount of hot water in ordinary homes is actually presumed on the basis of the overall consumption amount and the number of families. No fees are charged on the distribution of hot water.

The pipes of hot water are also laid on the ground in 2 lines, one for the supply line and the other for the return line. Thermal insulation materials are wrapped around to restrain the heat losses, but the thermal insulation materials are badly damaged, and supposedly there must be considerable amount of heat losses.

4) Forecast of future demand for water

Mangystau Province government forecasted the demand for water of the Aktau City from 1999 to 2015 supposing that the population of Aktau City being 160,000 in 1999 to become 300,000 in 2015. According to the forecast, demand of water will increase from 100,000 t/d in 1990 to 120,000 t/d in 2020, decreasing to 40,000 t/d in 2000.

The forecast will be made, considering the following scenario.

The existing petrochemical, fertilizer related plants will reconstruct themselves and in 2015 the electric power consumption of these plants will return to the level of its peak in 1990.

As a base in the hinterland for the development of the continental shelf of the Caspian Sea, and as the supporting industries related to the oil business, the steel and machinery industries based on the electric furnace and the cement industry etc. will be nourished until around 2010.

A manufacturing plant of polyurethane fiber will be invited to be set up at an earlier date, of which steady demand can be expected with relatively small amount of investments, and with this plant forming the core, its upstream processes will be constructed one by one,
and a refinery mainly producing BTX will be completed around 2020.

Aktau Port will be arranged and expanded as the distribution center to connect western Kazakhstan and Russian regions in the north of Kazakhstan with Iran and Turkey. As a result of this the annual increase rates of population, demand for electric power and demand for water will all be expected to reach about 3%.

However, in the calculation of energy-saving effect and CO2 emission reduction effect under this investigation, the forecast value of MAEK that the annual increase rate will be 1% both for electric power and water, shall be adopted as the base line, with a view to ensuring the minimum line of the reduction amount.

4.5 Desalination Plants

As for the desalination facilities, it can roughly be classified into the reverse osmosis (RO) type, the multistage flash type (MSF) and others that include the Multi-effect type (MEF) of the existing facilities, and the RO membrane desalination type and the MSF, which have scale merits in the case of a large capacity plant with a single machine capacity of 5,000 t/d or more, account for 90% of the overall desalination facilities. And in the case of the brackish water of which TDS is 20,000 mg/l or less, a great majority of facilities are of the Reverse Osmosis (RO) Membrane Desalination Method. In this project the raw water is the seawater of the Caspian Sea of about 13,500 mg/l TDS value, and so the Reverse Osmosis (RO) Membrane Desalination Method gives the greatest advantages from the viewpoint of energy-saving with the following reasons.

1) MEF

It is a vaporizing type and fit for the desalination of high purity water, but is energy consuming. As the required energy does not largely depend on the characteristics of raw water (TDS concentration), even in the case of the sea water of the Caspian Sea having the low TSD concentration, the amount of energy similar to the case of the normal sea water is required.

2) MSF

Because it is a vaporizing type, it is energy consuming like the MEF. In the case of the seawater of the Caspian Sea having the low TSD concentration, the energy-saving effect and the reduction effect of atmosphere warming gas emission are small as compared with the Reverse Osmosis (RO) Membrane Desalination Method.
3) **Reverse Osmosis (RO)**

The Reverse Osmosis (RO) Membrane Desalination Method is to utilize the phenomenon that pure water contained in the raw water passes through the Reverse Osmosis Membrane toward the pure water on the opposite side of the membrane when pressure greater than the osmotic pressure is applied to the raw water, and the osmotic pressure changes greatly depending on the characteristics (TSD concentration) of the raw water. Normally the osmotic pressure of the seawater (TSD 35,000 mg/l) is about 25 atm, while that of the seawater of the Caspian Sea is about 10 atm. Hence it can be desalinated with lower pressure as compared with the normal sea water and recovery ratio can also be set at a large figure, giving greater energy-saving effect and reduction effect of atmosphere warming gas emission.

Table 4-2 shows the comparison of consumed energy between the Reverse Osmosis (RO) membrane and the conventional evaporation desalination methods. Although the MSF better energy-saving performance can be expected than the existing MEF, the Reverse Osmosis membrane method still greater energy-saving evaporator be pursued.

Meanwhile in order to attain the purity of 5-25 mg/l as required for the boiler water and the industrial water, the Reverse Osmosis (RO) Membrane Desalination Method requires a combination of the two-stage RO permeation system and the purification facilities, and the vaporizing method has advantages. However, while carrying out the investigation activities this time, we have found out that MAEK is intending to meet the demand for boiler water and industrial water with the existing vaporizing type desalination facilities, and to supply drinking water and hot water with the newly installed facilities, and as a result there shall be no problem in the Reverse Osmosis (RO) Membrane Desalination Method from the viewpoint of quality of the manufactured water as well.

In view of the above, we shall devise the project plan on the basis of a renewal plan to install the Reverse Osmosis (RO) Membrane Desalination Plant with which greater energy-saving effect and reduction of greenhouse gas emission can be expected.
Table 4-2 Evaporation Desalination and RO Membrane Desalination Methods

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Desalination Method</th>
<th>Existing MEF</th>
<th>Multi-stage flash</th>
<th>RO membrane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desalination amount</td>
<td>t/d</td>
<td></td>
<td>50,000</td>
<td>50,000</td>
<td>50,000</td>
</tr>
<tr>
<td>Characteristics of raw water</td>
<td>TDS mg/l</td>
<td></td>
<td>13,500</td>
<td>13,500</td>
<td>13,500</td>
</tr>
<tr>
<td>Characteristics of manufactured water</td>
<td>TDS mg/l</td>
<td></td>
<td>5 to 25</td>
<td>Max 25</td>
<td>Max 150</td>
</tr>
<tr>
<td>Electric power consumption of required utility</td>
<td>KWh</td>
<td></td>
<td>4,167</td>
<td>10,600</td>
<td>7,500</td>
</tr>
<tr>
<td>Electric power energy consumed per ton of manufactured water</td>
<td>KW/t of water</td>
<td></td>
<td>2.0</td>
<td>5.1</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td>1000 kcal/t of water</td>
<td></td>
<td>1.7</td>
<td>4.4</td>
<td>3.1</td>
</tr>
<tr>
<td>Steam consumption Required amount of steam (6 kg/cm²)</td>
<td>t/h</td>
<td></td>
<td>370</td>
<td>250</td>
<td>27.5</td>
</tr>
<tr>
<td></td>
<td>1000 kcal/t of water</td>
<td></td>
<td>229,259</td>
<td>135,500</td>
<td>16,748</td>
</tr>
<tr>
<td>Steam consumed per ton of manufactured water</td>
<td>1000 kcal/t of water</td>
<td></td>
<td>110.0</td>
<td>65.0</td>
<td>8.0</td>
</tr>
<tr>
<td>Energy consumed per ton of manufactured water (Electric power + stem)</td>
<td>1000 kcal/t of water</td>
<td></td>
<td>111.8</td>
<td>69.4</td>
<td>11.8</td>
</tr>
</tbody>
</table>

Source: Feasibility Study on Replacement of Power Plant and Desalination Plant in Aktau City, Mangystau Region, Republic of Kazakhstan, March 2001, Engineering Advancement Association of Japan (ENAA)

5. Proposed Plans and Projects of Water and Power Plants

5.1 Urgent-needed Plants (Start of operation: within 3 - 5 years)

The existing desalination plant is too old (nearly 40 years) to be replaced and/or added to a new one immediately. The existing one is of MEF type which consumes more energy than MSF and RO membrane ones as shown on Table 4-2. The new desalination plants will be of MSF type which can utilize steam and heat from the existing plants and facilities. The capacity will be 400 t/h (Approximately 10,000 t/d) which the MAEK-KazAtomProm is urgently requesting.

The new one will be installed while the existing plants and facilities run and operate for the
time being as much as possible. However, in the near future within 5-10 years, they should be replaced to the energy-saving plants and facilities. That is to say, desalination plants should be finally replaced to RO membrane type ones and electric power generation plants to natural gas turbine-driven ones which are energy-saving and good efficient.

Based on the Mangystau Regional Development Plans including not only water and electricity supply but also other infrastructures, industries, tourism, etc. which should be also prepared, the short-term and long-term plans and projects for water and electrical plants and facilities should be prepared and implemented.

5.2 Short-term Plans and Projects (Within 5 - 10 years)
The short-term (5 - 10 years) and/or long-term (10 - 20 years) plans and projects shall be developed based on the estimated demand of electricity and water in the Mangystau Regional Development Plans which will be prepared as soon as possible.

(1) Conversion from the existing MEF desalination plants (via MSF ones) to RO membrane ones

The large energy-consuming MEF type desalination plans shall be converted to more energy-saving MSF types transitionally and most energy-saving RO membrane types eventually.

(2) Conversion from steam-turbine electric power plants to gas-turbine ones

The existing gas-fired/steam-turbine electric power plants shall be sooner or later converted to natural gas-turbine type ones which is energetically efficient.

5.3 Long-term Plans and Projects (Within 10 - 20 years)

1) Conversion from MSF desalination plants to RO membrane ones

The large energy-consuming MEF type desalination plans shall be converted to more energy-saving MSF types transitionally and most energy-saving RO membrane types eventually.

2) Conversion from steam-turbine electric power plants to gas-turbine ones

The existing gas-fired/steam-turbine electric power plants shall be sooner or later converted to natural gas-turbine type ones which is energetically efficient.

The provisional plans and schedules for water and power plants are shown on Table 5-1.
Table 5-1 Urgent and future plans and projects for water and electric power supply system in Aktau city and Mangystau province
6. Financial and Economic Analysis

6.1 Cost of Desalination Plant

1) Conditions of estate of the required fund

   (1) Exchange rates of currencies
   The exchange rates of currencies used in this study are as follows;
   1 USD = 130 Kazakhstan Tenge (as of January 2005)

2) Construction costs of desalination plant and water supply pipelines
   We have assumed the costs of constructions for desalination plant and water supply pipelines as follows;

   **Table 6-1** Construction costs

<table>
<thead>
<tr>
<th>Amount (in million USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction costs of desalination plant</td>
</tr>
<tr>
<td>Construction cost of water supply pipe lines</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

   * Cost estimation by MAEK

3) Operational costs
   The operational costs are broadly divided into two categories; operation and management (O&M), and interest.

   (1) The O&M per year is assumed in the following equation and calculated as per following table.

   \[
   O&M = (\text{Number of employees} \times \text{USD 3,000}) \times 1 + (0.01 \times \text{investment on desalination plant}) + (0.005 \times \text{investment on water pipelines})
   \]

   **Table 6-2** Annual operating cost

<table>
<thead>
<tr>
<th>Amount (in million USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personnel expenses \times 1</td>
</tr>
<tr>
<td>Maintenance cost \times 2</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

   (2) Interest
   Basic rate of interest is applied from the Yen Credit for ordinary environmental projects in that accumulated value of 2008 to 2037 is 6.075 million USD. (Detail shall be shown below)
4) Planning for required fund
   (1) The loan of this project is scheduled to be set in two occasions. The loan for
desalination plant is totally taken out in the first year and the loan for water supply
pipelines is subdivided in first and second years in equal amount.

   Table 6-3 Planning for loans (Unit: in million USD)

<table>
<thead>
<tr>
<th></th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loan for desalination plant</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>Water Pipelines</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>40</td>
</tr>
</tbody>
</table>

   (2) Interest on the loan is as shown below, applying the interest rate of the Yen Credit for
Middle-Income Countries in preferential terms. We apply this rate to this project
because of its high public nature of supplying water in the region where almost entire
population is relying on their water resource from desalinated Caspian Sea water.
Hereby the degradation of water supply system will directly affect people’s living and
health, therefore from the environmental point of view this project is assumed to be
applicable for this term.

   Table 6-4 Interest conditions

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest rate</td>
<td>0.75% per annual</td>
</tr>
<tr>
<td>Period of reimbursement</td>
<td>20 years</td>
</tr>
<tr>
<td>Grace period (out of the above)</td>
<td>10 years</td>
</tr>
</tbody>
</table>

6.2 Operational Plan

1) Planning for production and sales

   The planning for revenue (production and sales) is assumed as follows;

   (1) Planning for production
      a) Annual hours of operation
         24 hours * 365 days = 8,760 hours
      b) Production amount of desalinated water
         Total capacity of desalination plant is 400 m³ per hour.

   (2) Planning for sales
a) Market
Water is sold to Aktau city and industrial plants in the surrounding industrial areas. In the process of delivery pipeline user fee for water supply is set to be charged at the rate of 62.5 thousand USD per month or 0.75 million per year.

b) Sales price
Although the current end-user sales price of water differs from usage in that drinking water is 98 Tenge per m³ and industrial use is 26 Tenge per m³ (Quality of water is different: higher salinity is allowed for industrial water), the complex unit price is used for the convenience of calculations.

6.3 Financial Analysis
1) Conditions of financial analysis
(1) Schedule of construction
a) Desalination plant
   - Start of construction: Jul. 2006
   - Start of commercial operation: Jan. 2008
   - Period of construction: 18 months
b) Water supply pipelines
   - Start of construction: Jul. 2007
   - Start of commercial operation: Jan. 2008
   - Period of construction: 18 months
(2) Schedule of operation
   - Start from commercial operation: Jan. 2008
(3) Project life
   The project life of this study is set in 30 years. Commercial operation is projected to start from January 2008 until December 2037.

<table>
<thead>
<tr>
<th>Schedule</th>
<th>Desalination Plant</th>
<th>Water supply pipelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Start of construction</td>
<td>July 2006</td>
<td>July 2006</td>
</tr>
<tr>
<td>• Start of commercial operation</td>
<td>January 2008</td>
<td>January 2008</td>
</tr>
<tr>
<td>• Period of construction</td>
<td>18 months</td>
<td>18 months</td>
</tr>
<tr>
<td>Total amount of investment</td>
<td>20 million USD</td>
<td>20 million USD</td>
</tr>
</tbody>
</table>

Table 6-5 Summary of conditions in financial analysis
Interest Period of reimbursement Grace period 0.75% 20 years 0.75% 20 years
Exchange rates 1 USD = 130 Tenge 1 USD = 130 Tenge
Period of operation 8,760 hours 8,760 hours
Production(Revenue) About 10,000 m³ per day • Unit price of water 98 Tenge per m³ • Pipeline user fee 0.75 million USD per year
Operational costs Personnel expense 0.09 million USD per year Maintenance cost 0.2 million USD per year 0.1 million USD per year

2) Evaluation
(1) Methodology
The value of an investment project can be evaluated by converting the whole cash flow of the project to the present value. Thus as an evaluation method, the common method of applying internal rate of return (IRR) is studied.

(2) Results
The ROI calculated under the aforesaid conditions obtains 0.5% as shown below, but the ROI of this value is too low as commercial project at all. Furthermore the interest rate of 0.75% is presumably the minimum rate available in JBIC loan but general terms of 1.5% interest charge would spoil the project finance. Therefore we are studying the alternative way of sustaining this project in that since the sales price of water has been confined to a lower price regardless of producing costly desalinated water, and as a result it lowers the ROI, in this project the price of water is gradually increased at the rate of 10% in every 5 years. We assume the increase would be affordable in the regional socio-economic context from the oil-and-gas sector development as explained in prior chapters. The result of adopting this scheme shows the ROI brings up to 3.2%, which is still not high return for investors but it can be applicable in the base of public project.

Table 6-6 Financial internal rate of return

<table>
<thead>
<tr>
<th>Water price (constant)</th>
<th>Preferential terms interest rate 0.75%</th>
<th>General terms interest rate 1.5%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.5</td>
<td>-0.9</td>
</tr>
</tbody>
</table>
3) Sensitivity analysis of return on investment

To evaluate the project in more comprehensive way, we conducted sensitivity analysis as fluctuating parameters on investment cost, water price and O&M at the rate of 10% from the base case.

<table>
<thead>
<tr>
<th></th>
<th>-10%</th>
<th>Base case</th>
<th>+10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment</td>
<td>4.9%</td>
<td>3.2%</td>
<td>1.6%</td>
</tr>
<tr>
<td>Water price</td>
<td>1.7%</td>
<td>3.2%</td>
<td>4.5%</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>3.3%</td>
<td>3.2%</td>
<td>3.0%</td>
</tr>
</tbody>
</table>

(1) Results

Accordingly, the large extent of influence accrues to the changes of investment cost and water sales price. To the contrary, O&M cost does least impact as its cost is relatively small. However the gap between the highest IRR and lowest is 3.3% in investment cost, and then it can be evaluated that the profitability of this project would expose more direct impact from the changes of investment cost than others. However more noteworthy is that the changes of water price show nearly equivalent range of IRR gap in this project. From here onwards, it is indicated that water price is a critical element for destining this project.

At present the price of water has been confined to lower state but there appears sign of
economic growth in the region from oil-and-gas sector development where the regional population’s income is likely to be grown as well. Thus, we think it is necessary and practical to increase the price of water to the extent where people can afford so that the water supply project becomes sustainable hereafter.

4) Conclusion
The water supply system in Mangystau region has been deteriorated in the past 40 years. Now the productivity and efficiency of installed desalination plant has been declined and the condition of water supply pipelines is also in poor condition where drinking water might harm people’s health. Water is a fundamental element for people’s standard of living and industrial development, and the situation in the region is no exception but even more serious since nearly entire water source is coming from desalinated Caspian Sea water.

This project should have a public nature and classified into an environmental project from above reasons. In this sense, JBIC Yen loan in preferential terms can be applicable. Even applying the long term loan at low interest rate, however the project IRR remains 3.2%. But it is important to remember that this project stand on the premise related to an issue of raising water rates so that this project can be economically sustainable.

Even so this project, having as its object to supply safe and reliable water to the Mangystau region, is to contribute not only to the life of people but to the industrial development of the region. And realization of this project is highly significant from the perspective of improving environmental, economic and social activities which are soon to be enhanced with the start of production from new oil-and-gas fields in Caspian Sea. Aktau city will be the centre of socio-economic activities and the meaning of successful project implementation in water supply sector will surely have greater influence on the further development in other coastal regions.
7. Conclusion & Recommendation

Mangystau Region started to revive due to the rapidly expanding oil & gas sector and the future of Mangystau is bright. However, the deteriorating infrastructure especially the water supply is likely became a major bottleneck for the future progress of the Region. The 40 years old desalination plants and pipelines became too old to properly producing water and supplying water to homes and factories. It is therefore, we are recommending to implement the $40 million project immediately without delay because no choice for Mangystau Region.

Because of lower prices of water and limited capacity to raise the water supply prices, the return of the project is too low to be financed by a commercial loan and only way to

Reference. Water price in the world

The information gathered by the World Water Commission shows that consumers connected to water systems pay widely divergent prices for water around the world. A 1998 survey Prices in OECD countries based on purchasing power parity method using 1998 OECD PPP figures showed consumers in Canada pay the least amount for their water among residents of the industrialized world, with an average price of $0.31 per cubic meter (pcm), while Germans pay the most, $2.16 pcm, about five times as much. If the disposal of wastewater is included, Germans pay about $5.71 pcm. Residents of Jakarta, Indonesia, on the other hand, pay just $0.09 pcm, but few developing country cities have proper wastewater disposal.

Other nations surveyed in 1998, in descending order of price, include Belgium, $1.55 pcm; France, $1.35 pcm; Netherlands, $1.30 pcm; UK, $1.28 pcm; Finland, $0.77 pcm; Italy, $0.70 pcm; Sweden, $0.69 pcm; Ireland, $0.61 pcm; Spain, $0.47 pcm; the United States, $0.40-0.80 pcm; and South Africa, $0.45 pcm.

Some 1996 municipal water system prices in the developing world include: Algeria, $0.27-0.57 pcm; Botswana, $0.28-1.48; India, $0.02-0.92; Madagascar, $0.392; Namibia, $0.22-0.45; Pakistan, $0.06-0.10; Sudan, $0.08-0.10; Taiwan, 0.25-0.42; Tanzania, $0.062-0.24; Tunisia, $0.096-0.53; and Uganda, $0.38-0.59.

implement this type of project is to use a preferential loans which is aiming to assist public oriented project such this project like JBIC preferential special loan (0.75% with 10 year grace period payable by 30 to 40 years). We are recommending seriously considering the implement of the urgent and important desalination and pipeline rehabilitation project.
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