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EXPERIENCES OF IMPLEMENTING A GRASS ROOT INVESTMENT PROJECT IN AQABA, JORDAN

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1. SUMMARY

After many phases the cooperation between Kemira GrowHow Oy (Kemira) and Arab Potash Company Ltd (APC) finally culminated in the establishment of a joint venture in Aqaba, Jordan in summer 1999. The purpose of the new company, Kemira Arab Potash Company Ltd (Kemapco) was to construct and operate a unit producing 150,000 t/a potassium nitrate (NOP) and 75,000 t/a dicalcium phosphate (DCP). Kemira proprietary know-how was used in the construction of the main production units and the majority of raw materials for the plant are supplied locally.

The project was implemented by keeping project management, procurement and coordination of activities within the company. Kemapco was supported by experienced resources provided by its owners.

The project involved parties from Europe, the Arab countries and the Far East, among others. Different cultures – values/attitudes/behaviour - were clearly reflected in the everyday work.

This paper describes the implementation of the project and the experiences obtained.

2. INTRODUCTION

In 1990, Kemira GrowHow (Kemira) and Arab Potash Company Ltd. (APC) had their first contacts for cooperation concerning potassium fertilizers. However, the 1991-1993 worldwide recession in the chemical industry put an abrupt end to discussions.

APC's strategy was to develop new value-added products based on minerals derived from the Dead Sea. The company had been evaluating projects aimed at value-added potassium fertilizers for a number of years. Kemira, for its part, was evaluating various options for expanding the availability of potassium nitrate. The companies' objectives were a perfect fit.

The companies agreed to execute a feasibility study on a (150,000 tonnes/year) potassium nitrate (NOP) project located in Jordan using the high quality potash produced by APC from Dead Sea minerals and the unique Kemira ion-exchange technology for NOP.

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The Kemira technology produces feed grade dicalcium phosphate (DCP) as a by-product of the phosphate rock intake in the process. The feasibility study encouraged Kemira and APC to proceed with verification of the technology with the local raw materials as well as pre-engineering measures in order to provide a more accurate cost estimate of the investment.

The joint efforts lead to a mutual understanding in April 1998 with the signing of the Memorandum of Understanding. The objective was to set up a 50-50% joint venture for a production company producing NOP based on potash supplied by APC and proprietary technology provided by Kemira. In addition, it was agreed that Kemira would be responsible of the sales of both products using its existing distribution network in the global market.

In June 1999 the decision to establish a 50/50 joint venture and to begin construction of the production units in Aqaba Jordan was taken by the owners. APC and Kemira signed the shareholders agreement including all associated agreements and sealed the new partnership with the registration of the new company, Kemira Arab Potash Company Ltd. (Kemapco).

Owners

The owners, APC and Kemira, both have extensive experience in the business. They know each other well and enjoy a long-standing business relationship.

APC

The Arab Potash Company (APC) is a public shareholding Jordanian company with major shareholders throughout the Arab countries and Canada. It has been granted a concession from the Hashemite Kingdom of Jordan to exploit, manufacture and market the resources of the Dead Sea for a period of 100 years.

APC is one of the world's leading producers of potassium chloride, fertilizer grade and industrial grade potash. APC’s main markets are in Asia and the Mediterranean countries. The company’s sales revenue totalled 200 million USD in 2002.

Kemira GrowHow

Kemira GrowHow is the largest subsidiary of Kemira, a multinational public shareholding company based in Finland. Kemira's business areas include pulp and paper chemicals, water treatment chemicals, paints and coatings, fertilizers and industrial chemicals. Production is located in over thirty countries.

Kemira GrowHow is Europe's second largest producer of fertilizers and phosphates. The main products are related to plant and animal nutrition and include a full range of fertilizers and feed phosphates. Kemira GrowHow fertilizer and phosphate production is based in 12 countries. Turnover in 2002 totalled 1,165 million Euros.

3. CORNERSTONES OF KEMAPCO

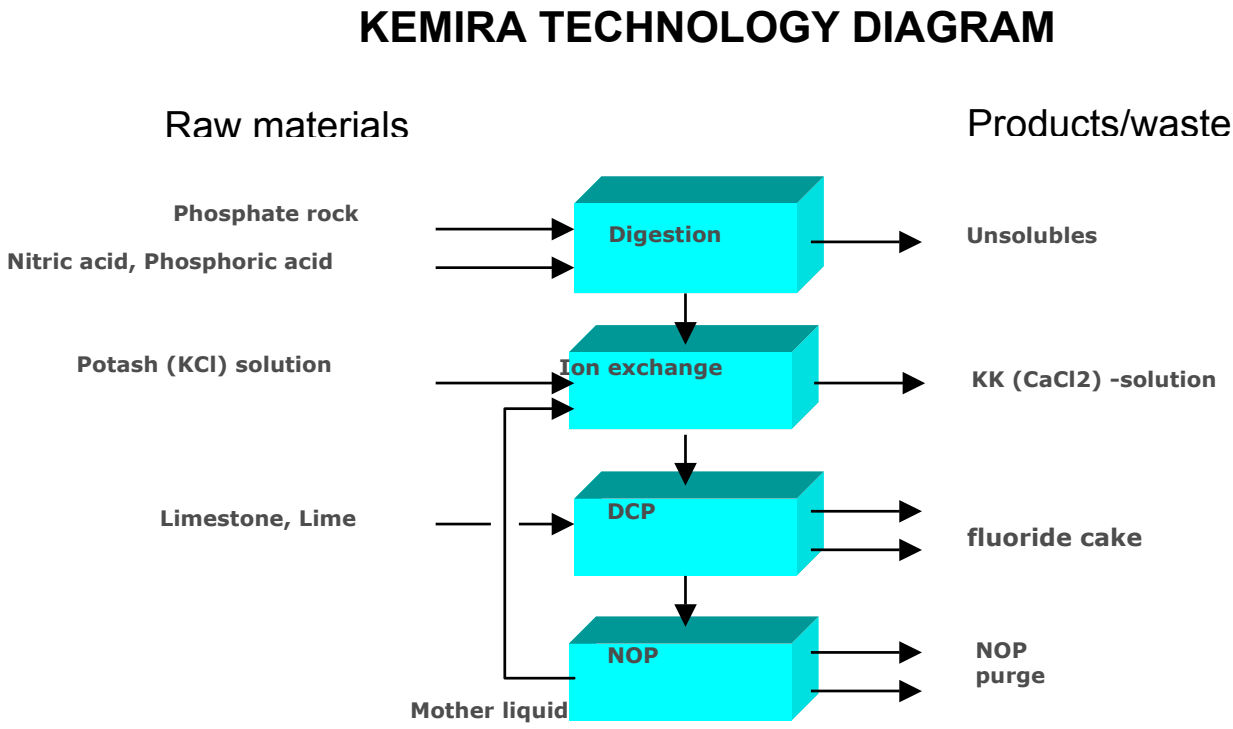
3.1 Technology

Kemira NOP technology is based on conversion of low-cost primary raw materials through an ion exchange process into a solution from which the valuable feed grade DCP and NOP can be crystallized.

The ion exchange process was originally developed in Denmark more than 30 years ago as an alternative means of producing low chloride NPK fertilisers in place of the conventional potassium sulphate (SOP) method.

In the 1980s DCP and NOP extraction was added.

The main process steps are shown in the diagram below:



3.1.1 Digestion

Phosphate rock is digested by nitric acid (62%) as in a mixed acid or nitro phosphate fertilizer process:

$$Ca_5(PO_4)_3F + 10HNO_3 \rightarrow 3H_3PO4 + 5Ca(NO_3)_2 + HF$$

The nitro phosphate slurry is clarified in a thickener to release insoluble components such as silica.

3.1.2 Ion exchange

The purpose of the ion exchange process is to replace the calcium content of the feed solution with potassium. The ion exchange unit is composed of a number of identical

columns filled with a cation resin. Each column is exposed to the operation cycle: regeneration, production and backwash.

In the regeneration stage calcium loaded resin is regenerated to potassium form by a concentrated solution of potassium chloride

$$2KCl + R2\text{-}Ca \rightarrow CaCl_2 + 2R\text{-}K$$

In the production stage the Ca-ions are exchanged with K-ions attached to the resin.

$$Ca(NO_3)_2 + 2R\text{-}K \rightarrow 2KNO_3 + R2\text{-}Ca$$

After the production phase the column is back-washed with water.

Upon leaving the ion unit, the production solution chiefly consists of KNO_3, H_3PO_4, Ca^{2+} and H^+

The by-product of the regeneration stage consists mainly of $CaCl_2$.

3.1.3 DCP

The production solution from the ion exchange unit is defluorinated to meet the requirements of feed grade DCP. Fluorine is precipitated by increasing the pH by means of limestone. The precipitated fluorine compounds are separated by filtration and the purified solution is fed to the DCP crystallizers.

DCP is precipitated by further increasing the pH and crystallized in a crystallizer as a dihydrate. The crystals are separated and dried. The mother liquid which is predominantly a solution of potassium nitrate is fed to the NOP plant.

3.1.4 NOP

The mother liquid from the DCP plant is concentrated in multiple effect evaporators and NOP is crystallized in a vacuum crystallizer. The mother liquid containing some NOP and impurities is recycled back to the ion exchange process for reprocessing.

3.2 Raw materials

Jordan is rich in mineral raw materials. A key reason for Kemira's interest in cooperating with Jordan on NOP manufacture was the ready availability of the necessary raw materials.

The main raw materials are:

- Potassium chloride
- Phosphate rock
- Phosphoric acid
- Lime stone
- Ammonia

Ammonia is the only raw material imported, each of the other main raw materials being supplied locally.

The location of the production plant was selected to be Jordan's deep sea port Aqaba, situated on the Read Sea. All necessary raw materials are readily available at the port

and the site provides an attractive location for the chiefly export-oriented products of Kemapco.

3.3 Marketing

Kemira holds chief responsibility for worldwide marketing of the products, although Kemapco will market the products throughout the neighbouring countries. Kemira has already been involved in the markets with both products for a number of years and has a global marketing network at its disposal for both NOP and DCP sales purposes. NOP will be sold under the Kemira GrowHow brand and DCP under the Bolifor brand.

3.4 Personnel

Jordan readily provides a well educated workforce with good knowledge of the English language. Owners APC and Kemira are also both well positioned to make available their own expertise whenever support is needed. The aim throughout has been to build a multicultural organisation of professional, innovative and motivated individuals.

4. THE SCOPE OF THE PROJECT

4.1 Products

The project contains in practice all activities required to establish a new company and to build all necessary production units to be able to manufacture and supply crystalline potassium nitrate (NOP) 150 000 t/a and crystalline dicalcium phosphate (DCP) 75 000 t/a.

NOP is a fully water soluble NK-fertilizer which is normally used with other fertilizer components. Fully water soluble fertilizers are especially needed in areas where there is a shortage of water and irrigation is the main source of water.

A range of technical uses also exist for NOP in specialized industries.

Specification of NOP

-	total nitrogen	13.5%
-	total potassium oxide (K_2O)	46.0%
-	water insolubles	0.05%
-	moisture	0.04%
-	pH of dilute solution	5.0-7.0
-	white crystalline powder	
-	bulk density, loose	1.0-1.15 t/m^3

DCP is an animal feed ingredient which is used to provide a rich source of phosphorous and calcium.

Specification of DCP

-	total phosphorous (P)	18.0%
-	relative solubility in 2% citric acid	95.0%
-	total calcium (Ca)	24%
-	Ca:P ratio	1.3
-	pH of dilute solution	6-7
-	moisture (free water)	< 2%

Both products are bagged in plastic bags, palletized and hooded.

4.2 Production units

The factory site consists of the following production units (block diagram as Attachment No. 1):

-	Nitric acid plant	350 t/d
-	Boiler and demiwater unit	
-	ION exchange plant	
-	DCP plant	240 t/d, 75,000 t/y
-	NOP plant	480 t/d, 150,000 t/y
-	Bagging plant	
-	Storage facilities	
-	Seawater pumping station	
-	Wastewater evaporation ponds	1.3 million m3

In addition to the production units, the site houses all necessary storage facilities, maintenance facilities, a canteen and administration building.

4.3 Environmental performance

Excellent environmental performance has been the focus from the very beginning of the process design with respect to emissions, raw material efficiency, energy consumption, water consumption, noise and safety.

A full environmental impact assessment study (EIA) has been carried out and implemented in the project. Haz-op studies have also been performed and implemented.

The best available technology has been selected in all process steps and the total environmental performance exceeds current European standards.

4.4 Budget

The total budget for the project was USD 106 million.

4.5 Schedule

Production was planned to commence in September 2002.

5. PROJECT EXECUTION CONCEPT

5.1 Management

The owners of Kemapco, APC and Kemira each have the necessary resources and experience required to implement the projects. Kemira has its specialized company, Kemira Engineering, whose duty is to implement projects within the Kemira group. It was therefore decided to keep the management of the project in Kemapco's own hands, supported by the experienced resources provided by the owners themselves. In practice this meant that the project manager, sub-project managers and the chief discipline engineers all consisted of Kemapco personnel and procurement and contracting, project control and engineering co-ordination were also managed by Kemapco personnel. The majority of managers were seconded by the Kemapco owners.

5.2 Engineering and design

Kemira proprietary know-how was used for the process design. The basic and detail engineering of most units was carried out by Kemira Engineering. The detail engineering of equipment package supplies was co-ordinated by Kemapco.

The basic and detail engineering of outside battery limits of production units as well as civil design was subcontracted to an engineering contractor co-ordinated by Kemapco.

The nitric acid plant was selected to be executed as a turnkey contract due to the limited amount of own resources available. A number of globally well known licensors and contractors are specialised in this field.

Coordination of all engineering was carried out by Kemapco.

5.3 Procurement and contracting

All procurement of equipment and contracting were carried out by Kemapco. The know-how of Kemira and APC in the use of equipment in similar type of production processes was utilized and applied in the context of this project.

The Fidic - Red book contract model was used for all construction contracts, and the Fidic Orange book for turnkey supply of the nitric acid plant. Although less common in Europe, the model is widely used in the Middle East.

5.4 Contract packages

Responsibility for site management was given to the same company which carried out the engineering for the outside battery limits of production units. The company was well experienced in working with Fidic contract models. Kemapco personnel were included in the site management organisation. The site works were split into eight (8) contract packages:

- site preparation
- administration building
- bagging and storage building
- process water feed line
- main plants and area works
- seawater pumping station
- wastewater lines and ponds
- nitric acid plant

Due to the tight schedule this type of split contract model was selected in order to enable commencement of the contract and site works as soon as the engineering of a specific part is ready. Depending on the size and type of work, local and international contractors can be invited to bid. The nitric acid plant was contracted as a turnkey contract.

5.5 Project control

Budget control and reporting was kept totally in the hands of Kemapco. Schedule control and reporting was coordinated by Kemapco based on the information received.

6. EXECUTION OF THE PROJECT

6.1 Basic Engineering

The basic engineering was carried out in three offices. The engineering of production units using Kemira propriety know-how was carried out in Helsinki, Finland by Kemira Engineering. The basic engineering for the outside battery units of the production units was performed in Beirut, Lebanon where the engineering and project consulting company selected for this job has one of its offices. The basic engineering of the production units was relatively straightforward and proceeded smoothly. Some minor variations were made for purposes of economizing.

The requirements of the local authorities caused some delay in the basic engineering of the cooling water and wastewater systems, the environmental regulations in Aqaba being particularly stringent with regards to the Red Sea.

The basic and detail engineering for the nitric acid plant were performed in Paris, France where the licensor and the contractor of nitric acid plant held their offices. Monthly meetings concerning engineering works were coordinated by Kemapco.

6.2 Procurement

The procurement of equipment and contracting were performed via two separate offices. The majority of procurement operations were carried out at the Helsinki office. Most of the equipment was available from Europe and, as the specifications were made in Helsinki, this became the natural choice of location for the procurement staff. Kemapco's Amman office concentrated more on civil contracts and some special purchases.

During the purchasing phase some shortages of resources were faced, in particular, a lack of equipment engineers to draw up the necessary specifications was experienced. This delayed procurement and consequently affected the detail engineering as the information from equipment suppliers was not made available at an early enough stage.

6.3 Detail Engineering

All detail engineering was performed in four (4) separate design offices. In addition to the Helsinki, Beirut and Paris offices, the steel structure detail engineering was carried out in Cairo, Egypt. Some vendors also implemented the detail engineering of their supply packages, which were coordinated by Helsinki office. Communication between the different offices was organised via electronic mail. The design programs were selected in advance and all offices were equipped with 2D design Microstation and AutoCad systems and with the Intergraph PDS program for 3D models.

A few coordination problems were experienced. On a few occasions the latest design version failed to reach the designer in time, forcing work to continue using the old

version. In hindsight, more meetings should have been held to ensure that the right information was made available at right place at right time.

The late purchase of equipment also delayed delivery of the latest information by vendors, thus further delaying detail engineering. As a result, engineering could not be completed on time due to a lack of information on the purchased equipment.

6.4 Construction

The contract packages were planned in such a way as to save time and money. By including a small number of smaller civil contracts local companies were also able to participate. The packages were scheduled to be contracted immediately as soon as the engineering was complete, in this way achieving a more level work load and avoiding high on-site peaks.

Responsibility for site management was given to the same engineering and project consulting company which carried out the engineering for the outside battery limits of the production plants. Specialists from Kemapco, APC and Kemira were included in the site management organisation.

The mobilisation phase of contracts was slow and it was difficult to recover the delay during the project. Bulk procurement, which was within the responsibility of the contractors, also took longer than expected. Most of the deliveries were from abroad and time consuming transportation connected to local customs practices caused some delay.

During the installation period a 3D workstation with the design model was available on-site to help to solve clashings and other problems which normally arise during installation.

Contractors and vendors from several countries worked together on-site. The main contract to erect the ION, DCP and NOP production units and the bagging plant was awarded to a Chinese company. The nitric acid plant was contracted to a French contractor. Most of the civil contractors were from Jordan and other Middle East countries. The equipment suppliers were mainly from Europe.

Co-operation on the site worked well once the various parties learned to work together and according to the Fidic Red Book contract model.

6.5 Commissioning and start-up

The project schedule was planned and contracted to follow the process flow i.e. the upstream part of production was to be made ready first, followed by the downstream units. The same schedule was naturally also applied to the commissioning and start-up of the units. The original sequence was as follows: process water, electricity, cooling water, wastewater line and pond, nitric acid plant, ION exchange unit, DCP unit, NOP unit and finally the bagging plant. The plant was handed over in stages, unit by unit, as planned. This approach was taken in favour of the alternative option, i.e. a single handing over of the entire plant.

During the commissioning and start-up phase, specialists from contractors, vendors, engineering companies, Kemira and Kemapco were present. The commissioning and start-up proceeded according to the planned sequence with the sole exception of the

nitric acid plant, where the commissioning phase took much longer than expected. Use of the wastewater pipeline was also delayed due to damages caused by incorrect piping material supplied.

6.6 Schedule

The original project schedule set production to begin at the beginning of September 2002. This proved a challenging target taking into consideration that the company, Kemira Arab Potash Company Ltd., was established in June 1999 and the project started in September 1999. To build such a plant in 3 years with 4 different process units is exceptionally demanding, even in Europe where most services and supplies are readily available.

Production was started up using imported nitric acid at the beginning of 2003; 6 months later than originally scheduled. The nitric acid plant was finally brought on stream in early summer 2003; 11 months later than originally scheduled.

6.7 Budget

The original budget was USD 106 million which was overrun by USD 4 million, the final expenditure reaching USD 110 million.

7. EXPERIENCES

The experiences here have been summarized from Kemira's point of view, reflecting the position of the European partner in a joint venture outside Europe.

Kemira has extensive experience in executing projects using its own resources to the greatest extent possible, especially when its own technology and production experiences are utilized. For this purpose it has a specialized subsidiary, Kemira Engineering, whose duty is to execute the company’s own investment projects. Over the years Kemira Engineering has gained broad experience in project implementation. The company has chiefly operated in Europe, but also to a minor extent in the Middle East and in the Far East. The main principle has been to keep the management of projects in the company’s own hands and to use own engineering and specialists to the extent which is practical. Own procurement and split contracts have also been used to this end. In line with this concept, the main risk of the project remains squarely with the owner, but key savings are achieved in terms of the budget and the time of execution.

In the case of the Kemapco project in Aqaba, Jordan, the concept proved to be right. However, the project was complex by nature and involved numerous parties in several different locations. The demands on the company’s own resources to manage and coordinate the project were therefore greater than originally expected.

Kemapco was limited in the amount of experienced staff it could make available and the owners, APC and Kemira, also experienced problems providing the extra resources required.

The basic and detail engineering were carried out in 4 offices: Helsinki, Beirut, Cairo and Paris. Some detail engineering was also performed by vendors in charge of supply packages. The coordination of design including accurate up-to-date information was demanding. The project met with various problems, mainly in co-

ordinating the large and complicated steel structures with the equipment, ducting and piping. The level of design was interpreted differently between the parties. The model documents should have been used when contracts were drawn up in order to ensure mutual understanding. Communication via electronic mail was not sufficient and more coordination meetings should have been arranged to avoid misunderstandings. Cultural differences also played a role; it was difficult to admit lack of understanding or lack of experience. It was not always understood that all technical solutions or constructions should serve the purposes of smoothness of production, this aspect having priority over all others.

Procurement was carried out in two offices, in Helsinki and Amman although most of the specifications and bidding documents were prepared in Helsinki. Purchasing was too slow and bureaucratic. The aim was to treat all bidders equally and fairly, a principle shared by all involved, however this target can be reached in a more flexible and less time consuming way than was actually applied in this project. The use of electronic mail in negotiations with vendors also proved to be very slow; a question put forward this week receiving a response the following week, etc. A much better, less time consuming and clearer approach would have been to call a meeting where all open issues could be discussed and settled in one sitting.

Most of the equipment was purchased from Europe, from which they were normally shipped on to Aqaba. This route was slower than expected. Although Kemapco is a so-called "Free Zone" company which enjoys exemptions from import duties, it took long time to receive goods through customs as compared to Europe.

The Fidic conditions of contract for Design-Built and Turnkey, First Edition 1995 was used in contracts including civil works. The main contract to erect the plant was tailored. Responsibility for site and contract management was given to the same engineering and project consulting company which carried out the detail engineering for the outside battery limits of the production plants. Numerous contractors and vendors worked together on-site, including non-Fidic contract models. Management was therefore not easy. The Fidic model of contract clearly stipulates all responsibilities and authorities and leads to a highly bureaucratic and time consuming management system. The employer, Kemapco, had limited powers to influence work on the site. The site organisation also included specialists from Kemapco, Kemira and APC. It was a source of great frustration to the management when the solution to a given problem was straightforward but its implementation required scores of letters to be despatched and weeks of extra time needed to solve each problem.

According to the new version of Fidic the engineer is clearly the consultant and representative of the employer and the client has direct contact with the contractor.

The schedule of the project was too challenging and could not be met in practice. The Ion exchange, DCP- and NOP plant start-up was 6 months delayed and the nitric acid plant 11 months delayed. The schedule was possibly too tight in these circumstances, but it was also recognised during the project that schedule was not always respected.

During the design phase all operations were held under the supervision of the employer, the schedule was followed carefully and any deviations were identified and the relevant recovery measures taken. Later, during the construction phase when the schedule was more in the hands of the constructors, the realistic view of the schedule became somehow lost or diffused, and information was frequently received which after a period proved to be overly optimistic. During the implementation phase we were partly missing a crucial management tool, i.e. a reliable schedule.

In some cases the procurement of bulk materials made by contractors was the problem area. Although at the beginning of the project special attention was paid to the materials procurement capability, Kemapco was in some cases forced to help the contractor by using its own channels to purchase pending materials.

In order to have better maintained the schedule closer cooperation during the detail engineering phase should have been organised. More follow-up meetings for interfaces should have been organised to provide the opportunity to discuss any grey areas in full detail. In this way numerous misunderstandings could have been avoided and existing production experience better applied. In addition, cooperation would have been further facilitated if fewer design offices were used.

During the initial stages all procurement operations should have been orchestrated from a single office in Helsinki, including all resources for equipment purchasing, and subsequently moved to Jordan along with all necessary resources during the contracting phase.

The Chinese main contractor and several of the European suppliers had limited experience of the Fidic contract model used. The model provides a highly bureaucratic means of working, involving numerous inspections and permits. The quality of construction work was excellent but was highly time consuming. However, after the civil construction period a more practical method was developed to save time and maintain the good quality of work. The presence of supervisors with production plant experience also helped to solve many problems on the spot, without having to resort to lengthy discussions.

The original budget for the project, USD 106 million, was exceeded by 4% to finally reach USD 110 million. The main reasons for the overshoot were the special requirements of the authorities concerning the seawater pumping station and wastewater pond, which were actually defined after the project budget had already been agreed and fixed. The extended project period naturally also increased the costs.

Despite the fact that the parties concerned used the same language and terminology, misunderstandings did nevertheless occur during the project. The project involved people from Northern Europe, the Arab countries and China, among others. Cultural differences were evident in the everyday cooperation and the different cultures – values/attitudes/behaviour - reflected in the everyday work. These differences were manifest as different perceptions of time, collectivism, individualism, authority, delegation, planning, verbal communication etc. More attention should have been paid by all parties at the beginning of the project to becoming acquainted with the various cultural differences in order to achieve a better understanding of each other.

The project in Aqaba, Jordan, provided quite a challenge. Many difficulties were faced, especially concerning the schedule. Nevertheless, the plant is now fully completed and despite a few inevitable "teething pains", working smoothly. All parties which contributed and participated in the building of the plant can rightfully be proud of the end result.

Attachment Nr 1

KEMAPCO PLANT BLOCK DIAGRAM