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Gabès desalination plant

Location:
Gabès

Company:
Groupe Chimique Tunisien (GCT)

Mission:
Construction of a new desalination pant

Cost:
TND 227.5 million

General presentation

The IGPPP (Instance Générale des Partenariats Public-Privé), the PPP Unit, is intending to launch two pilot PPP projects, that are currently at the feasibility study stage. The first project is a desalination plant in Gabès. The second project is a wastewater treatment plant in Tunis.

The Gabès desalination will produce of 50 000 cubic meters per day of desalinated water by means of a reverse osmosis plant. The desalinated water will be used by the Groupe Chimique Tunisien, the State-owned company that's extracting, transforming and exporting Phosphate.

The choice of seawater desalination for industrial water supply in this area is justified because of (i) lack of conventional water resources throughout southern Tunisia, (ii) high cost of water transfer of northern waters to this region in addition that even these waters are today barely covering the demand of drinking water and irrigation in the north of the country.

Tunisia's experience in desalination is quite rich insofar as it began with the desalination of brackish groundwater in 1983 through the implementation of the first desalination plant with a capacity of 3,300 cubic meters per day in the island of Kerkennah. The first seawater desalination plant was commissioned in 2018 in the island of Djerba.

Project rationale

GCT wishes to dispose of a desalinated water production capacity of 50 000 cubic meters per day. The desalinated water must be non-corrosive remineralized water.

The main justification for the project is the preservation of local resource that is currently used by the GCT. The substitution of osmosed water to natural aquifer water is set as a driving force.

The Gabès region, is fed by groundwater of two origins:

- The coastal aquifer of Djeffara: It is a relatively shallow aquifer that is 100 to 500m deep. This is the main aquifer in the governorate of Gabès. It is in contact with the Continental Intercalaire at the threshold of El Hamma, northwest. Flowing water contains 3 to 4 g/l of salts.
- The deep aquifer of the Continental Intercalaire, which extends over the entire South of Tunisia to Algeria has a depth from 1000 to 2000m. The water that springs from the springs and boreholes is hot (60 ° C and above), and it is slightly less salty than the water of the Djeffara aquifer. The salinity is 1.5 to 3.5 g/l. The sheet of the intercalary continental is practically not renewable, the renewal period is from 10,000 to 20,000 years.

Legal and institutional framework

Institutional framework

Tunisia is an international pioneer in the field of rock phosphate and mineral fertilizers. This activity is more than 100 years old for phosphate extraction by the Gafsa Phosphates Company (Compagnie des Phosphates de Gafsa, CPG) and more than 50 years in the field of its valorization in various mineral fertilizers by the Tunisian Chemical Group (Group Chimique Tunisien, GCT). Tunisia is the second country in the world to value a large percentage of its phosphate rock production (85%).

The CPG currently operates seven open pit quarries and one underground mine. Annual production was 8 million tonnes of marketable phosphate before the revolution of 2011; which placed Tunisia in the fifth world rank of phosphate producing countries.

After a long experience of export of raw phosphate, Tunisia has turned towards the transformation and the valorization of this mineral by the establishment of a local industry of production of phosphoric acid and mineral fertilizers within of the GCT. The GCT has four industrial divisions located in Sfax and M'dhilla (TSP plants), Gabès (phosphoric acid (PA) plants, Diammunium phosphate (DAP) plant, and ammonitrate (AN) plant) and Skhira (phosphoric acid plant).

The phosphate sector occupies an important place in the Tunisian economy, both at the level of employment and at the level of the trade balance. Natural phosphate and its derivatives (phosphoric acid, DAP, TSP, DCP, etc.) are currently exported to some fifty countries in five continents.

The GCT is the result of a series of mergers and acquisitions of several companies. The most recent is the unification of the general management of the CPG and the GCT by appointing a single CEO.

This grouping has allowed the phosphate sector to occupy an important place in the Tunisian economy by ensuring the direct employment of more than 4,300 people. Indirect employment has also benefited from the phosphate sector, notably rail and marine transport, subcontracting and a large number of ancillary activities.

Industrial facilities contribute significantly to the promotion and development of the various regions of southern Tunisia.

Legal framework

Concessions

- Law No. 2008-23 of 1 April 2008 on the concession scheme.
- Decree No. 2010-1753 of 19 July 2010, laying down the conditions and procedures for granting concessions.
- Decree No. 2010-3437 of 28 December 2010, setting the criteria for the classification of concessions of national interest.
- Decree No. 2013-4630 of 18 November 2013, establishing a Concession Monitoring Unit within the Presidency of the Government.
- Decree No. 2013-4631 of 18 November 2013, amending and supplementing Decree No. 2010-1753 of 19 July 2010, laying down the conditions and procedures for granting concessions.

PPP contracts

- Law No. 2015-49 of November 27, 2015, on Public Private Partnership Contracts
- Government Decree No. 2016-771 of June 20, 2016, determining the composition and prerogatives of the Public-Private Partnership Strategic Council.
- Government Decree No. 2016-772 of June 20, 2016, setting the conditions and procedures for awarding public-private partnership contracts.
- Government Decree No. 2016-782 of 20 June 2016, laying down the procedures for keeping the register of real rights over constructions, structures and fixed equipment built under a public-private partnership contract.
- Government Decree No. 2016-1104 of 4 July 2016, on the setting of conditions and procedures for determining the consideration paid by the public company to the project company and setting the terms and conditions for the transfer or sale of the project. pledging of claims under public-private partnership contracts.
- Government Decree No. 2016-1185 of October 14, 2016, determining the organization and attributions of the general public-private partnership authority.

In addition, Tunisia has a varied legislative and regulatory arsenal ranging from the development of codes relating to the main natural resources, the multiple coercive measures against the polluting establishments and the obligation of the ESIAs in as a prevention tool.

According to Tunisian legislation, the Code of Town Planning and Territorial Planning (Law No. 2003-78) makes the preparation of EIA mandatory before any planning or equipment program.

The approach of its application is declined by the decree n ° 2005-1991 of July 11th, 2005, relative to the environmental impact studies. This decree constitutes the methodological procedure which allows the examination of the consequences that a planned development project will have on the environment, and ensure that these are duly taken into account in the design, implementation and operation of the project.

Project scope

The desalination plant includes:

- *A seawater intake offshore tower* with a seawater pipeline
- *A seawater pumping station* including an inlet seawater basin, several channels of coarse filtration, pumping bays, and chemicals injection lines
- *Lifting pumps* with filters and a floatation unit

The Filtrated water is pumped to several reverse osmosis “packs” installed in parallel and consisting of high pressure pumps, energy recovery devices, booster pumps, racks of reverse osmosis membranes, and their Clean-In- Place system (CIP).

The desalinated water is remineralized by receiving an injection of carbon dioxide, lime water to add required salts. Lime water is prepared in a side branch of the installation where water and lime are mixed.

Final water quality control check is done before water is sent to a storage tanks before usage.

Filtration backwash system includes backwash water storage tank, and an air blower which generates dirty effluent during backwash sequences of filters. Similarly, high speed flotation generates sludge and foam.

Effluents are treated on a wastewater settling tank before rejection to sea. Sludges are dehydrated with centrifuges before being evacuated as dry sludges.

Effluent are pumped back to a balancing tank close to sea water inlet before being rejected to sea by gravity offshore.

Completed technical studies

Onshore site

The site where the installations are foreseen already is identified and is located north of Ghanouch harbour. The approximate size is 70 hectares, divided in two main plots: One plot along the coast with an area of 15 ha and second one of 55 hectares contiguous to the first one.

Offshore site

Offshore water depth has been investigated and offshore coastal artificial rocks have been identified. There is a boat mooring area which should not be disturbed by seawater intake or discharge pipes. Water intake and discharge have been studied, especially regarding marine sediments, tidal currents and sediment carry-over currents. The results of these investigations are positive for marine installations which are envisaged (no strong current, no sedimentation area , sediments dispersion to North East in winter or South East in summer).

The studies have also shown that the area is widely contaminated by a small settled layer of phosphogypsum and that benthic life is nearly nil. This means that marine works would not deteriorate seawater quality, and that marine works methodology should not put in suspension sediments.

It should be noted also that a complete environmental report should establish the base line of the area and remind the limit values of discharge parameters.

Design parameters

Water analysis: Analysis of seawater performed in november 2010 show a good stability of analysis on all the sampling points tested along a potential pumping line. Water depth, temperature, pH and salinity are quite steady.

As far as detailed analysis is concerned it can be noted that suspended solids are low (2 mg/l), turbidity is also low (0,5 NTU), overall salinity (41-42 g/l) is rather high.

It can be noted that Boron is not analyzed and should be quantified if desalinated water may happen to become potable water, the content may have a small impact on pre-treatment of Reverse Osmosis scheme. The following points are to be noted:

- Traces of oil and grease are common around harbours, and it should be checked if there is an increase with time for this parameter, since November 2010.
- SDI index analysis on seawater would be useful to assess sea water quality specifically in view of reverse osmosis treatment.
- No data are available about algal blooms or gelly fish blooming, these parameters have also an impact on reverse osmosis pre-treatment scheme.
- A more continuous survey regarding suspended solids is necessary to ensure that there is not a new impact linked to a potential increase of large boats movements.

Overall, the analysis shows that the water quality is adequate to feed a desalination plant based on a reverse osmosis process. However, a systematic survey should be implemented over a continuous period of time so that solid and updated data can be used as a basis of design.

Sea water intake

The position of seawater intake has been proposed, considering temperatures, suspended solids, turbidity. It also considers the impact of harbor activity, the impact of sediment from the rejection of the activities of the GCT plants. Seawater intake should be at ten meters water depth, at 1.4 km from the coast, north of the Ghannouch harbour's dyke.

Treated water quality

The water will be for industrial usage as well as for potable water distribution. Therefore, a stringent desalination followed by remineralization which is suitable for potable water grade must be envisaged.

Sea water intake pipeline

Several configurations have been anticipated, leaving open a wide range of solutions. In this type of installation, which are dedicated to operating 24/24, and with a limited storage time for treated water, a common solution is to have 2 pipes to cover design flow rate at a safe velocity and making it possible to have 70% of the capacity of the plant which can be kept for temporary maintenance. At this stage it seems that two pipes of DN 1600 appears as suitable. As part of this choice, a sea water intake pipeline protection can be added by installing a sodium hypochlorite line up to seawater intake to perform sodium hypochlorite shock dosing and thus limit maintenance on the pipe.

Water volumes to be handled

The following table summarizes the water volumes to be handled by the desalination plant:

Flowrates /	Units	Volumes
Treated water outlet	m3/h	**2,084**
Sea water inlet	m3/h	**4,900**
Total pumped water	m3/d	**117,000**

Coarse filtration / pumping station

Equipment should be standard equipment of small size. The reason is to adjust production to initial flow variations. This is particularly valid for coarse screens and band filters. Two channels should be used which will lead to fewer equipment and hence less electrical equipment, less power cables and less instrumentation. However, a more compact civil work for seawater intake would be required.

Similarly, 4 heavy duty seawater pumps would be required. Flexibility for treatment line could be obtained by means of recycling excess of pumped water to the pumping pit.

Regarding chlorination, two injection points are required, one offshore at pipes station inlet, and one onshore, to protect coarse filtrations and pumping station.

High-speed flotation

Unless complementary surveys confirm that there is no algal bloom or other peaks of suspended solids, a high-speed floatation installation needs to be provisioned. This equipment should be installed upstream of the filters. This installation can be by passed when not required during periods where seawater is clear, but it may be used several weeks per year.

Reverse Osmosis

This is the key part of the plant and should be carefully optimized. The number of stages, number of passes per stage, type of membranes, number of membranes per pressure vessels, operating pressure, recycle rates have to be optimized. Energy recovery device is also a key choice, which makes it possible to use brine reject pressure as driving force to feed the reverse osmosis membrane.

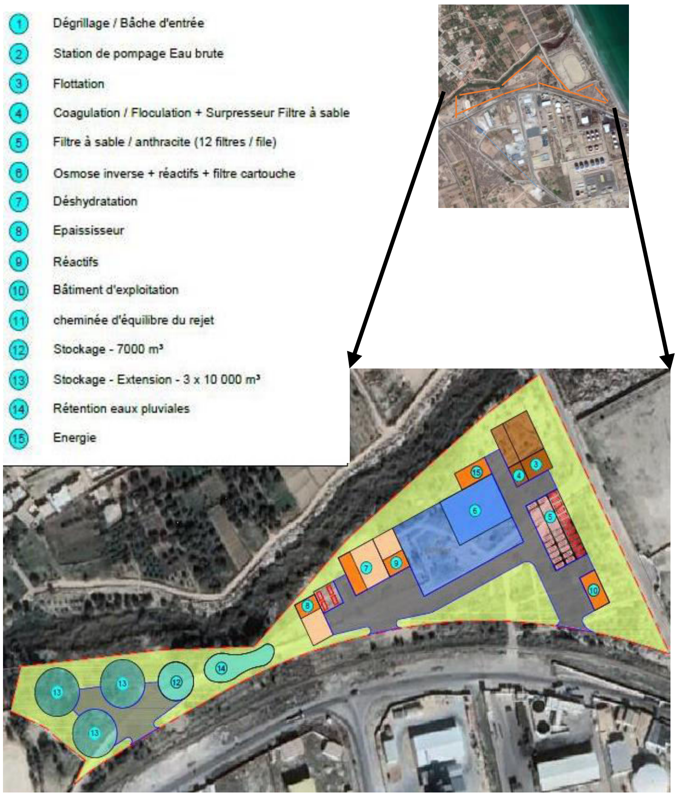
A particular attention should be paid to Bore elimination which may request specific pH conditioning upstream membranes, to meet latest WHO recommendations.

Plot Plan

A preliminary plot plan has been prepared taking into account the characteristics of the equipment discussed here above.

Seawater pumping station are installed on the along the shore. The rest of the plant can be installed in the second plot, beside the GCT plant. Floatation unit are regrouped with the process unit, if placed upstream filters, this part could also be installed close to the pumping station.

Based on current design the estimated constructed area on the ground represent about 26000 m² within 70000 m² which is available. It represents a ratio of 0,37 for a limit of 0,4 in the case where site become an industrial area. This means that flexibility is limited and overall plot plan has to be considered during plant detail design where consideration should be paid to optimization of size and numbers of installed items.



Reject of effluent

A study has been done concerning the diffusion of rejected effluent in the sea at the discharge point. The low salinity variation, the regular temperature change with seasons, the small tidal amplitudes have been confirmed. The costal current has already been modelled to study the reject of GCT effluent, using CORMIX model.

The results show that the location of rejected effluent should be 500 meters South -West of the seawater intake to avoid an impact on pumped seawater, at each current velocity. Seawater intake should be higher than discharge diffuser to reduce brine impact.

Prospective implementation schedule

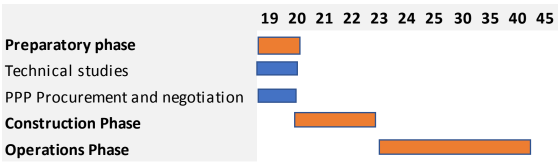
The project comprises three main phases.

Preparatory phase (PPP preparation): 2019-2020

During this period four key activities must be undertaken:

- Update and finalisation of the required studies;
- PPP contract procurement and negotiation

A period of 18 months has been estimated for these activities.



Construction Phase: 2020-2023

The Construction Phase will start after the signing of the PPP contract. It will include the execution studies and the construction phase itself. Depending on the final complexity of the engineering structures, the length of the phase will vary. The duration of the construction phase was estimated at 36 months.

Operations Phase: 2023-2043

After the construction phase is finished, the contract for the plant operation and maintenance will last 20 years.

Challenges (technical, economic, social and others) and Mitigation Measures

Site acquisition and changing site classification

The GCT should finalize the site acquisition and get strong commitments from local and governmental authorities on one hand and with land owner on the other hand that the site shall be unclassified from recreational usage to industrial usage.

Technical studies

Optimization should be performed to compare a solution with reduced large equipment compared to multiple small ones.

Preliminary Cost estimation: CAPEX, OPEX and preliminary Revenue

CAPEX

Costs estimation have been established by benchmarking with local project and expressed in TND, while international reference cost are established in USD, the exchange rate used for the following tables is TND 2,6 for USD 1.

Item	CAPEX in M USD	CAPEX in M TND	Percentage of total CAPEX (in %)
Process Equipment for the plant (without flotation and effluent treatment)	30	78	**60**
Civil works including storage tanks	7.5	19.5	**15**
Power and control	2.5	6.5	**5**
Pumping station and pipes	6	15.6	**12**
Roads and networks	1.5	3.9	**3**
Provision for uncertainties	2.5	6.5	**5**
TOTAL	**50**	**130**	**100**

The table does not include potable grade desalination equipment (necessary), floatation (highly recommended) and effluent treatment. Offshore works are not included. A 15 % should be added on top of the total cost to include complementary treatments. A provision of approx. USD 30 M USD for offshore works should be added to this estimation and results in the following table:

	Total in M USD	Total in M TND
Study estimate	50	130
Additional items	7.5	19.5

Offshore works	30	78
Grand Total	**87.5**	**227.5**

OPEX

An estimation of the OPEX was done based on international benchmarks for operation of Reverse Osmosis plants. Operating expenses are considered in the range of 0.4 to 0.6 USD/cubic meters with following split:

- Fixed cost: Approx. 35 % (employment, amortization, etc.)
- Variable cost: 65 %
  - Power: 45 %
  - Chemicals : 4 %
  - Membranes: 6 %
  - Maintenance: 5 %
  - Various: 5 %

Based on an average cost of 0.5 USD per cubic meter and an exchange rate of 2.6, operating cost would be 1.3 TND/cubic meter. The offtake price of the SONED for desalinated water is 1.42 TND/cubic meter.