Abstract

The Ashkelon Build, Operate and Transfer Project consists of the financing, design, construction, operation and transfer of a sea-water desalination plant with guaranteed production capacity of up to 100,000,000 m\(^3\)/year. This plant is being built at the Ashkelon site of the Eilat-Ashkelon Pipeline Corporation.

The design of the Plant enables an extension of the production capacity during the operating phase of the Project. The Plant is designed, constructed and operated by a Consortium made up of three international Sponsors, who have created a special purpose company, V.I.D. Desalination Company Ltd. (the "SPC" or "VID") in order to carry out the Project. The companies and their respective initial participation in the SPC’s share capital are: IDE Technologies Ltd. 50%, Veolia Water S.A 25%, Elran Infrastructures Ltd 25%.

The Project is governed by a Build, Operate and Transfer Agreement ("the Agreement") entered into between the Consortium and a government agency, the Water and Desalination Authority ("WDA") of Israel. The Agreement is awarded for a period of 24 years and 11 months from the Effective Date.

Construction is well on its way, and the plant is expected to begin water production in 2005.

The paper will cover, among other things, VID’s experience so far with the implementation of the project, and recommendations for future BOT/BOO Desalination Tenders in Israel in the following fields:

- Prequalification and SPC Structure.
- Financing and Water Price Optimization.
- Technical requirements.
- Statutory (Permits).

1 EXECUTIVE SUMMARY

1.1 Project Description

The Ashkelon Build, Operate and Transfer Project consists of the financing, design, construction, operation and transfer of a sea-water desalination plant with guaranteed production capacity of up to 100,000,000 m\(^3\)/year. This plant will be located at the Ashkelon site of the Eilat-Ashkelon Pipeline Corporation.

The design of the Plant is such that it enables an extension of the production capacity during the operating phase of the Project. In addition, the initial annual production capacity exceeds by - 10 million m\(^3\) the required guaranteed annual production capacity of 100 million m\(^3\) in order to allow for some flexibility in the production levels, should the WDA decide to purchase more desalinated water from VID or allow VID to produce Excess Quantities.

The Plant is designed, constructed and and will be operated by a Consortium made up of three international Sponsors, who have created a special purpose company, V.I.D. Desalination Company Ltd. (the "SPC" or "VID") in order to carry out the Project. The companies and their respective initial participation in the SPC’s share capital are the following:
The Project is governed by a Build, Operate and Transfer Agreement ("the Agreement") entered into between the Consortium and a government agency, the Water and Desalination Authority ("WDA") of Israel. The Agreement has been awarded for a period of 24 years and 11 months from the Effective Date. The production of the Plant will be sold to the WDA, whose obligations (incl. payment obligations) under the Agreement are deemed to be obligations of the State of Israel.

1.2 Technology Used

The Project will use the Membrane Reverse Osmosis technology. This is a modern process technology used to purify water for a wide range of applications, including semiconductors, food processing, biotechnology, pharmaceuticals, power generation, seawater desalting, and municipal drinking water. The reverse osmosis industry today represents a combined world-wide production in excess of 7.7 million m³ per day.

Several innovative technological applications contribute to the low water price offered by the Consortium (52.7 Usc/m³ at the award date):

- Adaptation of SWRO technology for large-scale plants (pressure centers concept)
- Advance Energy Recovery System (low energy consumption)
- Self-Generating Energy Supply System (low electricity cost)

1.3 Overview of the Consortium

The Consortium is be made up of IDE Technologies Ltd. ("IDE"), Veolia Water S.A. (Veolia) and Elran Infrastructures Ltd ("Elran").

IDE Technologies Ltd. is a 50/50 subsidiary of the Delek Group, a leading Israeli group of companies, and Israel Chemicals Ltd, a leading Israeli chemical company whose shares are traded on the Tel Aviv Stock Exchange. IDE is recognised as the world leader in low temperature distillation and has also considerable experience in reverse osmosis. IDE is specialised in the design, research, development and manufacture of sophisticated desalination plants and equipment, including saline water desalination processes, water treatment and purification of industrial streams, heat pumps and ice machines.

Veolia Water S.A. is wholly owned by the Veolia (formerly Vivendi) Group, the world leader in the environmental sector and the second largest communication company in the world. More specifically, Veolia Water is part of Veolia Environment, the world leader in environmental services operating in more than 100 countries. Veolia Water, created by the merger between Générale des Eaux and US Filter in September 1999, is the international brand name of Veolia’s water business.

Elran (formerly Dankner Ellern) Infrastructures Ltd. is a subsidiary of Dor Gas and the Dankner Group, one of Israel's leading privately-owned companies, with diversified interests in energy, chemical, petrochemical and plastic industries, residential and commercial development, cable TV and telecommunications. Dankner Group is traded on the Tel-Aviv Stock Exchange. Dankner is regularly searching for new investment opportunities.

1.4 Project timetable

- April 2003: Notice to Proceed (approval for go ahead of works).
- July-August 2005: Completion of 1st Facility (50mcm/year).
- November-December 2005: Completion of 2nd Facility (100mcm/year)

1.5 Overview of the Contractual Structure

The main contracts are the BOT Agreement, the Engineering Procurement and Construction Contract (“EPC Contract”), the Operation and Maintenance Contract (“O&M Contract”), the Power Purchase Agreement (“PPA”) and the Financial Agreement(s). The general contractual structure of the Project is described below:

Construction of the first 50MCM/y is expected to last 24 months and for the second 50MCM/y, additional 6 months (total 30 months). The Construction is undertaken under an Engineering and Procurement Contract (“EPC Contract”) between the Consortium and the Construction Company made up jointly of OTV (Veolia Group) and IDE Technologies Ltd. The name of the EPC Consortium is OTID.

Operations will be governed by an Operation & Maintenance Agreement (“O&M Agreement”) entered into between the Consortium and the Operating and Maintenance Company made up jointly of Veolia Group, IDE Technologies Ltd, and Elran, the latter being a financial partner.

1.6 Financing Plan

Equity funds 23.5% of the total financing requirements.

Credit facility provided by lenders (syndication between Bank and Institutional Lenders) funds 76.5% of the total financing requirements.

Standby facilities will be provided by shareholders and by Lenders to fund 7-10% of the total financing requirements.
2 – TECHNOLOGY, DESIGN PROCESS AND INFORMATION RELATED TO THE SITE

2.1 Reverse Osmosis

As indicated above, the desalination process selected for this Project is the Seawater Reverse Osmosis (SWRO), which appeared as the best option from a technical and economical points of view, based on the Project’s needs and the Tender Committee's requirements.

The basic concept for the construction of 100 million m3/year plant is to have two plants of 50 million m3/year able to operate separately and independently from each other.

Most subsystems will be double (one for each 50 million m3/year plant), with the exception of the Intake System, the Post-treatment and the Independent Power Plant. Those systems will be unified for the whole 100 million m3/year plant, but are designed with the required redundancy to serve each plant separately.

2.2 Facility Overview, Battery Limits and Systems Design Approach

The System Design Approach has been established after a comprehensive analysis of the different parameters that may have a direct and/or an indirect influence on Plant’s feasibility, reliability and availability. In the following sub-sections, a brief description of the main segments of the Facility and their key features is presented, with particular attention being paid to the critical and relevant parameters that have been considered and finally reflected in the Design Approach.

A Intake System

Three alternatives have been initially considered:

- Open (submerged) Intake Sub-system
- Seawater Wells Sub-system
- IEC’s Seawater Supply Point (Power Station’s cooling water discharge)

Based on experience gained on other desalination projects with similar characteristics, the Open (submerged) Intake alternative has been selected as the most feasible one for this Project. This technical solution is well-known and allows to pump seawater with a better quality than the other alternatives that have been considered. Moreover it offers a better protection from hydrocarbon pollution.

Among design parameters selected, the following should be mentioned:

- safety margins in feed-water flow rate;
- three parallel pipelines, thus increasing both the availability and reliability (ensuring that at least 67% of the plant remains operable, in case of failure or shut-down of one of the pipelines);
- non-turbulent in-flow rates;
- high-density plastic pipelines, which demand low maintenance, have a lower tendency for bio-growth, are simpler to clean and have no hazardous materials for the membrane elements;
- hydrocarbon pollution pre-warning system.

B Intake Pumping Station

Vertical pumps are envisaged, for normal routine operation of the system (“base load”). The key features of this design are:
• Long-term successful experience of this approach widely used in Power Stations intake systems (large flow rates/small water head);
• Higher efficiencies are achieved;
• Lower capital and operating expenditures, directly related to economies of scale - also reflected on the ancillary components (controls, electrical equipment, pipeline manifolds, etc.), improved efficiencies of pump and motors.
• High flexibility in the operational mode, allowing for a quick and easy activation (or de-activation).

C Interconnection and Static Mixers
The design contemplates two parallel lines interconnecting between the Intake Pumping Station and the Pre-Treatment section of the Plant. This approach increases Plant availability and reliability (ensuring that at least 50% of the plant remains operable, in case of failure in one of the pipelines or static mixers).

D Chemicals dosing (at the Pre-Treatment segment of the Plant)
Full redundancy is provided for each dosing station. Each pump is supplied with a device adjusting pumps’ flow rate to Plant’s real-time needs. All the dosing pumps have a long track record in similar applications.

E Gravity Dual Media Filters
The Plant comprises gravity filters, containing gravel, quartz sand and anthracite media. The main features of this approach are:
• High filtration efficiency;
• Low weighted average filtration velocity, approx. 50% of the max. allowed;
• Distribution system which prevents clogging, short-circuits and channelling;
• Low energy consumption;
• Automatic back washing without interrupting Plant operation;
• Overall “spare filtration capacity” (stand by) of 33.3%.

It should be noted that the main principles of the design and operation modes of the Media Filters have been tested and piloted.

The ability of the system to handle higher (storm-induced) turbidities has been also checked.

F Micronic (cartridge) Filters
A battery of filters is planned, grouped in two parallel branches.

The main features of this approach are:
• High filtration efficiency;
• Low weighted average filtration rate;
• Distribution system which prevents clogging, short-circuits and channelling;
• Low energy consumption;
• “Spare filters” (stand by) of 40%.

G High Pressure Pumps/Energy Recovery Devices (ERD)
High-pressure pumps and couples of ERD of the type Double Work Exchanger Energy Recovery (DWEER) are envisaged. The high-pressure and energy recovery components can be operated independently, thus increasing the number of alternative operation modes of the system.
This new “pressure centers concept” is specially designed for large-scale SWRO plants and present the following advantages:

**THREE-CENTER DESIGN CONCEPT:**

The typical concept of equipment arrangement in desalination plants is based on several identical RO trains. Each RO train includes a high-pressure pump, an energy recovery device, and a bank of RO membranes. This concept began its transformation with the appearance of large desalination projects.

The designers of desalination systems tried to reduce water cost by increasing size of high pressure pumps, since larger pumps have higher efficiency at lower specific cost.

The necessity of flow proportionality for each component of RO train calls for the enlargement of membrane bank.

What is beneficial for pumps is detrimental for membranes bank. The relation between pump size and membrane bank size was the first contradiction.

Coupling the pump with the motor and turbine in one aggregate was beneficial up to a certain size. For large capacities, integration of pump and turbine in one machine limited variation in recovery range. Pump combination with two and more Pelton wheels leads to complications in maintenance.

The relation between pump size and number of turbine wheels on the same shaft creates the second contradiction. A further increase of RO train size is detrimental.

This vicious circle is broken in Ashkelon Plant. The high-pressure pump was disconnected from the energy recovery device. Pump capacity has not been equal to RO bank capacity, because the optimal size of the pump is not equal to the optimal size of the RO block. So individual high-pressure pump has to be disconnected from the individual RO bank.

Half of the Ashkelon desalination plant has a capacity of 163,000m$^3$/day. Different sizes of identical RO trains, (between five and forty) were checked during project preparation in all aspects. The concept of several identical RO trains was changed to a Three-Center Design.

The Three-Center Design is a form of installation of high pressure pumps, energy recovery devices and membrane banks. Figure 1, presents the scheme of the Three-Center Design.

Several large high-pressure pumps will form a Pumping Center, which will supply seawater via common feed lines to all RO banks. Forty DWEER units will form an Energy Recovery Center, which will collect pressurized brine from all RO banks, transfer the energy to seawater, and pump it into a common feed line to all RO banks.

The new approach of the Three-Center Design allows size optimization of each system element independently.

The key features of this approach are:

- Plant availability and reliability
- Higher efficiencies are achieved;
- Lower capital and operating expenditures, directly related to economies of scale - also reflected on the ancillary components (controls, electrical equipment, pipeline manifolds, etc.-), improved efficiencies of pumps and motors;
- High flexibility in the operational mode, allowing for a quick and easy activation (or de-activation)
Figure 1. Three Centre Design

**H SWRO Desalination System and Boron Removal**

The design of the Reverse Osmosis system adopted for this Project, comprises multiple RO stages, implementing a process for boron ions removal from the desalinated water each one operating at optimum design point.

The proposed multiple RO-stage desalination and Boron removal system has the following features:

- High removal efficiency and product yield for Boron removal. The system can reach a removal efficiency as required;
- Low specific power consumption;
- Low chemical consumption;
- Lower capital investment required for achieving low Boron and Total Dissolved Solids (TDS) contents in product;
- The boron removal system is flexible and easy adjustable to changes in feed water temperature;
- Lower tendency for membrane fouling;
- Reduced energy consumption is achieved;
- If required, the same configuration can produce larger quantities of permeate. This is achieved by increasing the flow through the membrane elements, still under the limits of manufacturer recommendations.

**I Post-Treatment**

While the final Boron levels are achieved by the multiple stage membrane process, the Post-Treatment envisages mainly the re-hardening of the permeate, bringing the water quality up to the levels required in the Tender Documents. The offered Post-Treatment incorporates limestone treatment (and, optionally, Caustic Soda dosing). This approach, based on several
Pilot Tests and experience gained in similar projects, achieves the lowest capital and operational costs.

**J Auxiliaries**

The “auxiliaries” systems and equipment comprise the cleaning system and the flushing and suck-back system. In the event of power failure, a diesel driven pump for flushing is also provided.

**K Energy Supply**

The Electrical Power for the Project will be provided from two redundant sources:

- by a Self-Generating Energy Supply System that will be built as a part of the Project adjacent to the desalination plant.
- by a 161 KV overhead line from the Israel Electric Company Grid.

This approach contributes to the high reliability of the Project and increases its availability. From an operational point of view, the desalination system will work most of the time on a continuous “base load”, thus avoiding frequent (daily) changes in the operation mode.

The self-generating energy supply system will be fueled by natural gas. Minimal environmental constraints are expected and lower electricity costs will be achieved.

**L Others**

In addition to the above-described key features and benefits, the Plant comprises high quality materials of construction, stand-by and redundant equipment, standardization of equipment and facilities that contribute to higher Plant reliability and expected annual availability. The implementation of instrumentation, controls, alarms, testing procedures, etc., is also part of the Quality Assurance policy to be adopted in order to assure the highest standards of safety and reliability of the Plant.
2.3 Information related to the Site

A Site Description

The desalination plant is located at the Ashkelon Industrial zone, 700 meters north of an existing IEC (Israel Electrical Company) power station, within the EAP (Eilat-Ashkelon Pipeline Corp.) facility.

The feed water to the plant is pumped from the Mediterranean sea. The pumping station is located on the sea shore, 200 meters from the Site. The water quality is typical Mediterranean sea water.

The desalinated water delivery point is at the site battery limit. The brine (concentrated feed water) will be discharged back to the sea diluted with the coolant outfall of the adjacent IEC Power Plant.

The electrical power for the plant will be provided from two independent sources: overhead line from the national grid and self-generating energy supply system (IPP) installed at the site.

B Lease Agreements

The Accountant General leases the Site from EAP in accordance with the provisions of the Lease Agreement.
Under the Agreement, VID is granted the right to utilize the Site or any part thereof concurrently with the issuance of the Notice to Proceed for the term of the Agreement. VID has no other right than the right to use the Site for the Construction, Operation and Maintenance of the desalination plant.

3 - CONTRACTUAL STRUCTURE

3.1 Description of the Contractual Structure

The Project's contractual structure has been designed with a view to allocating the different risks to those parties that are the most qualified to manage and control them.

3.2 Engineering Procurement and Construction Contract (“EPC Contract”)

The Heads of Terms of the EPC Contract include the following:

**A Parties**

The parties to the EPC Contract are (i) VID Desalination Company Limited (as the “Seller”) and (ii) a consortium comprised of the following companies:

- IDE Technologies Ltd (IDE): 50%
- Omnium de Traitement et de Valorisation SA (OTV): 50%

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**B Scope of Work**

The EPC contract is of a turnkey nature. The EPC Contractor is responsible for the development, engineering, design, construction, manufacture, procurement, inspection, supply, transportation and testing of the water desalination plant so as to achieve minimum performance criteria for a fixed lump sum price and in accordance with a final date certain Construction Schedule.

The EPC Contractor shall achieve Construction Completion by the date set forth in the BOT Agreement, within 30 months after the issuance of the Notice to Proceed to allow the Seller to meet its obligations under the BOT Agreement. The minimum performance criteria of the EPC Contractor are in accordance with the BOT Agreement allowing the Seller to meet its obligations under this agreement.

**C Governing Law**

The Law of Israel shall apply to the EPC Contract.

**3.3 Operation and Maintenance Agreement ("O&M Agreement")**

The Heads of the Agreement of the O&M Agreement (OMA) include, but are not limited to, the following.

**A Parties**

The parties are: (i) VID Desalination Company Limited as the “Seller” and (ii) the O&M Company which shall be formed by:
- Veolia Water S.A.: 49.5%
- IDE Technologies Ltd: 40.5%
- Elran Infrastructures Ltd: 10%

Together known as the “O&M Operator” or “A.D.O.M.”.

**B Scope of Work**

The O&M Company’s (A.D.O.M.’s) scope of works will include:
- Operation and maintenance of the water desalination plant except the supply of energy;
- Delivery of guaranteed quality water at the delivery point treated water in accordance with the provisions of the BOT Agreement;
- Pre-operation works including:
  - Review and approve the EPC design and process, the EPC equipment and contracts with equipment suppliers;
  - Participation in the Functional and Completion tests and Commissioning;
  - Provide personnel for training by the EPCC;
  - Write O&M Manual under EPC supervision.

**3.4 Independent Power Purchase Agreement ("IPP Agreement")**

The Heads of Terms of the IPP Agreement include, but are not limited to, the following:

**A Parties**

The parties are: (i) VID Desalination Company Limited, the “Seller” and (ii) the IPP developer which is a SPC named IPP Ashkelon Ltd. (“IPP”)

**B Scope of supply**

IPP Ashkelon undertakes to finance, design, supply, erect, commission, operation and maintain the power plant and to supply all the net output of the power plant, at its own cost. The power plant will be erected on the Site.
4 – WATER PRICE STRUCTURE

4.1 Description of the Water Tariff Structure

The water tariff is composed of Fixed component (to cover capital expenditure, fixed O&M costs and part of the profit) and Variable component (to cover energy costs, variable O&M costs, membranes and chemicals costs and also part of the profit) the indexation of each component is as described below:

Fixed component
Indexed to:
- NIS (min 33%)
- USD
- Euro
- Yen

Variable component
Indexed to:
- oil prices or electricity prices
- CPI (USD and NIS)

Total Price of 52.7 US¢ / m³

To cover:
- energy costs
- variable O&M costs
- membranes & chemical costs
- profit

To cover:
- capital expenditure
- fixed O&M costs
- profit

4.2 Volumes requirements

Desalinated volumes requirements are within a minimum and maximum range defined for Daily, Bi-monthly and Annual quantities as described below:

- The bi-monthly quantities required in the summer months were higher
  - design of plant to facilitate this requirement

- Tolerance band of +/- 8%
  - LDs payable for delivery less than 92% of requirements
  - additional agreement with WDA required for quantities in excess of 108%

- Payment was weighted towards meeting short-term goals:
  - Daily: 50% of capacity payment
  - Bimonthly: 40% of capacity payment
  - Annual: 10% of capacity payment

Volume required (m³ / day)

Jan-Feb Mar-Apr May-Jun Jul-Aug Sep-Oct Nov-Dec
5 – RECOMMENDATIONS FOR FUTURE BOT/BOO DESALINATION TENDERS

In view of VID’s experience so far with the implementation of the Ashkelon 100 MCM/Year project, we would like to make the following recommendations for future BOT/BOO Desalination Tenders in Israel:

5.1 Recommendations with regards to Prequalification and SPC Structure:

- The main partners in the EPC Companies, the O&M Companies and certainly the Technological Partners need to have a minimum of 20%-25% ownership in the SPC. We have learnt in the past BOO Projects, that Groups created by financial partners only, experience difficulty in materializing projects.
- Each SPC Partner should be allowed to rely on backing from its’ Major Shareholders, proportionate to their holdings and not only from Controlling Shareholders.
- Not all companies have a Controlling Shareholder (50% or more). It would be unfortunate to refuse companies (without Controlling Shareholder/s) participation in the SPC. Moreover, the reduction of backing to Controlling Partners does not allow for equal division of the burden among all the major Share Holders.
- It is highly recommended to obtain a Pre ruling from the Commissioner of Restrictive Business Practices that will set down terms allowing for a merger between SPC partners.
- The tender requirements and Project’s scope may necessitate Joint Venture with potential competitors (“merger”) and a prohibition from submission of simultaneous tender proposals. These require the approval of the Commissioner of Restrictive Business Practices. Without a pre-definition of the approval conditions, the Consortium may be faced with the non-approval for merger following the handing in of the submission, or even after being awarded the tender.
- The wording of the Shareholders’ Guarantees required by The State should be amended. These Guarantees need to be worded to ensure that the Equity is invested solely in the SPC. The Guarantees should expire once the Guarantor has provided the full Equity committed to the SPC.

5.2 Recommendations with regards to Financing:

- The Base Interest Rate should be fixed at two alternative dates. Namely, at the Financial Close and/ or at the Completion of the Construction. This will enable Short Term Funding for the Construction Period, as well as for Long Term Funding at better Rating conditions at the end of Construction.
- Foreign Currencies linkage to the Water Price should be allowed including foreign CPI, with division according to Currencies used. This may allow for access to funding from investment by Foreign Banks.
- Institutional Lenders need to be encouraged to be involved at early stages of the Project. Guarantees and LOI’s for funding should be obtained from Institutional Lenders and not only from Banks. Encouraging the involvement of Institutional Lenders greatly reduces the problem of
restrictions by the Bank of Israel concerning Single Borrower and/or Group of Borrowers.

- An Effective Date should be set for 9 months after Contract signature and not closer to the signature of the Project Agreements. The Financial Close of a BOT/BOO Project takes at least 12 months from the date of signature of the Project Agreements. Setting the Effective Date at 9 months after that provides the suitable incentive for the entrepreneurs. Any shorter period is likely to bring about unnecessary losses or a rise in the Water Price.

5.3 **Recommendations with regards to Technical Issues:**

- Offers including Equipment and/or Sub-Systems that have at least two years proven working experience with similar processes, on a scale of at least 50%, if Technological Feasibility has been proven at the full scale Pilot Test, shall be permitted. Technological innovation should be encouraged, for the benefit of The State and for entrepreneurs who are willing to invest in R&D.

- The mixture of brackish water into the Product Water Supply Reservoir should be pre-planned in order to save (where applicable) Post-Treatment costs (land, construction, chemicals, operation).

5.4 **Recommendations with regards to the Statutory Sphere (Permits):**

- Clear requirements for the obtainment of Brine Outflow Permit from the Ministry of Environment should be predetermined. This should include set criteria for Brine Disposal, analysis of sea water, the analysis of product water and pre-determined Brine Dispersion Model.

- Clear criteria for analysis of Sea Water and Product Water should be pre-determined by the Ministry of Health, for the purpose of issuing Permit to supply the Desalinated Product Water.

- When the Project land is located within a site belonging to the State or a Public Entity (for example, within the EAPC Site in Ashkelon or the Israel Electric Company’s “Rabin Lights” Site in Hadera), the State should ensure and pre-arrange adequate freedom of movement for the Constructor within the site. The State should ensure in advance, with all the above mentioned entities, that no interference or delay is caused by the demands of these entities. The entrepreneur should receive financial compensation for damages and additional costs incurred due to changes in construction plans or for works that were imposed on the Consortium due to demands that were made by these above mentioned State owned entities.

- When allocating land for the site, sufficient storage & organization areas should be taken into consideration and planned for as part of the area the government provides to the entrepreneur.
AERIAL VIEW OF THE FACILITY