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Summary

Water Resources. The bulk of the potential conventional water resources of Tunisia lie in the northern region of the country and amount to 4,600 MCM/yr of which 54% has a salinity less than 1.5 g/l. These comprise 2,700 MCM from surface water and 1,900 MCM from ground water. Potential per capita supply is 450 m3/yr. Given the concentration of the natural resource is in the north, the southern part of the country is the area where water is in short supply. This is exacerbated by the growth in tourism in the southern region.

Energy. Tunisia is currently self-sufficient in (conventional) energy, provided from petroleum (72%), natural gas - principally from Algeria (26%), coke (1.6%) and hydo-power (0.3%). In terms of renewable energy, wind and solar are the main focus and have potential application with desalination in rural areas.

Institutions. The Ministere de l'Agriculture, de l'Environnement et des Ressources Hydrauliques (Ministry of Agriculture, Environment and Water Resources) is by law in charge of the management of the water resources as well as drinking water supply and sanitation in Tunisia.
The Societe Nationale d'Exploitation et de Distribution des Eaux (Sonede) is responsible for domestic and industrial water supply in all urban areas of Tunisia. It is a so-called Etablissement Public a Caractere Industriel et Commercial (EPIC), a public entity with an industrial and commercial character. It operates within the Ministry as an industrial organisation.
The national company STEG is in charge of electricity and gas distribution in the whole country. The National Agency of Renewable Energies is active in most fields of renewable energy

Water Supply Sector Performance. Coverage, cost recovery, unaccounted-for water
The population is mainly served through the networks of Sonede. An estimated 75 % of the population is connected. A further 1.22 million people are served by local organisations (Associations d'interets collectifs). In this way about 88 % of the population of Tunisia is connected to the water supply system. The rest takes its water from rainfall collectors, shallow wells and other means.
The potable water demand is estimated at 290 MCM per year in 1996, of which Sonede distributes 256 million m3. Of this amount 134 million m3 comes from surface water sources, 156 million m3 from ground water sources and 7 million m3 from desalination plants. Only the cities of Kerkenah and Gabes are supplied by these desalination plants.

Current status of desalination. Because of the lack of adequate good quality water resources in the southern part of Tunisia it has resorted to building desalination plants using brackish water.
In Tunisia there are some 48 desalination plants with a total capacity of 130,000 m^3/day of potable water. Most of them are run by industries for their own water supply. The majority of the plants are operating with brackish water as the feed source. Except for a few these plants are located along the coast. The small number operating on seawater are mainly VC plants where the product water is being used as boiler feed water make –up in power generation plants. Of the 48 plants, 22 use the electro-dialysis (EDR) process to treat the brackish water. Only four plants are owned and operated by Sonede. They are all brackish water plants and are located in coastal areas in the southern part of Tunisia which is particularly short of potable water and where there has been huge growth in tourism. The plants are located in Kerkennah, Gabes, Zarzis and Djerba. The latter two locations are major destinations for international tourists.

Future plans for desalination. Sonede are currently considering building a large seawater desalination plant at Djerba to cope with the increasing (touristic) demand. The output of the plant will be about 25,000 m^3/day. Although the process and the contractual option still needs to be decided upon it is hoped that the plant will be operational by 2006.
Sonede is also looking at 13 sites in southern Tunisia (inland?) where it is considering installing

equipment to improve the quality of the water. The feed water in these cases is brackish water. This will involve building water treatment plants at these sites and in the further development of the pipe network.

Private sector participation. The private sector operates a number of small plants for industrial self-supply. So far it has not participated in financing or operating desalinaiton plants supplying water to the network, although a new plant in Djerba (see above) is likely to be implemented with private sector participation in its design, operation and possibly financing. A recent amendment to the Water Law has allowed PSP in non-conventional water supply, including desalination.

Environment. Proper implementation of EIA guidelines under a more basic environmental law would also be of great use; in Tunisia. According to decree no. 91-362, dated 13 March 1991, an EIA study is required for public and private projects likely to have effects on the environment. The legislation is there, but level of enforcement should be investigated. In the Water Strategy Tunisia is planning, however, a number of mechanisms for monitoring progress for water savings are built in, such as periodic assessments for major consumers, assessments of water provision equipment, development of bodies specialising in water saving assessment and expertise, and plans for development of economic incentives for water saving.

Capacity Building. Regarding the involvement of the private sector in the development ofdesalination , there is a need to invest in education of Sonede staff with regard to BOT tendering, contracting and monitoring skills.

1 Country Profile

Tunisia, a Maghreb country in the centre of the Mediterranean on the North Eastern coast of Africa, has a land area of 162,155 km^2 and 1,300 km of shoreline. It is a generally low-lying country, two-thirds being plains. The country is divided into three main regions. The North is the richest and most populated with fertile soils and heavy rainfall; where the coastal plains and valleys of the Maritime Atlas mountains are characterised by farmland, vineyards and forests of cork oak, pine and juniper. Central Tunisia is a region of high and low steppes extending to the Sahel coast, dominated by steppe vegetation of wild grasses and shrubs, and with a dry, hot climate. Southern Tunisia, bounded on the North by the chotts (salt lakes), is a mix of large desert reaches and lush palm groves fed by rare springs, where the people crowd into oases and sometimes venture out in search of pasturage.
Tunisia is in the south of the temperate zone and, influenced by the Mediterranean, has a usually mild and clement climate which becomes progressively hotter and drier towards the south. In the north temperatures average 10.6 °C in January and 26.1 °C in July, with a rainy season between October and May. Annual rainfall is about 610 mm but varies greatly between regions and from year to year: Ain Draham in the north has an average rainfall of 1500 mm, whereas in the far south it is less than 150 mm. It rarely snows except on some mountain peaks.

Tunisia has a population of 9.8 million (2002) growing by 1.1% per annum, with nearly two thirds of the people living in the quarter of the country's land lying on the Mediterranean coast between Bizerte and Jerba. Continued migration from the rural areas plus the natural increase of the inhabitants of towns and cities has resulted in over 60% of the population being urban, with six cities having a population in excess of 100,000 : Sfax (231,000), Ariana (153,000), Ettadhamen (150,000), Sousse (125,000), Kairouan (103,000), and the capital city of Tunis (675,000) where the population of the wider metropolitan area now exceeds 1.8 million. Present day Tunisians, because of their history, are a mix of many civilisations, principally from around the Mediterranean, with the Berbers constituting the ethnic base. Arabic is the official language with French widely spoken. Islam is the state religion with freedom in religious practice enshrined in the national constitution.

The agricultural sector in Tunisia is highly developed, with five million hectares under cultivation of which 300,000 (5%) are currently irrigated. The principal crops are olive oil, citrus fruits, cereals and dates; and the main livestock reared are goats and sheep (7.6 million) and cattle (630,000). The offshore fishing industry is also locally important for many coastal communities.
Tunisia has evolved an important manufacturing base since independence, with the traditional sectors such as textiles, shoes, leather, food processing, engineering and chemicals being reinforced through the recent growth of newer industries such as electronics, automotive components and manufacturing services. Over a third of manufacturing is concentrated around Tunis, with the remainder spread between the coastal, north western and southern regions. Of the nation's 2000 manufacturing plants, half are either joint-ventures with, or owned by, foreign companies, and this external investment and the associated technology transfer has played a major role in Tunisia's economic growth.

Around 20% of Tunisia's area is currently arable land, with the fertile plains of the north producing wheat, barley, tomatoes, vegetables, melons and grapes; the Cap Bon peninsula specialising in oranges; the semi-arid central regions producing olives; and with dates being predominantly grown in the oases of the Sahara region. Annual agricultural yields fluctuate through frequent droughts and the absence of substantial water resources for irrigation, which currently is available over an area of approximately 300,000 ha. Just under a fifth of land is made up of meadows, pastures and grazing, though the livestock economy is also subjected to climate induced fluctuations. Overgrazing, resulting in desertification, can be a problem in some areas of the country.

Tunisia is not as well-endowed with oil as its neighbours Algeria and Libya, but it has substantial

on-shore and off-shore deposits; and annual oil production reached nearly 40 million barrels by the late 1980s, together with over 350 million cubic metres of natural gas.
Tunisia is also a major world producer of phosphates (6 million metric tonnes per annum), lead, zinc, iron ore and salt.

Table 1.1 Statistical profile

Topic	
Geographical region	North Africa
Area (km2)	163,610 km2
Climate	temperate in north with mild rainy winters and hot dry summers, desert in south
Natural resources	petroleum, phosphate, iron ore, lead, zinc, salt
Land use: arable land	19 %
permanent crops	13 %
other	68%
Irrigated lands	3,800 km2
Environment - current issues	toxic and hazardous waste disposal, water pollution from waste disposal, limited natural fresh water resources, desertification
Population	9,8 million (2002)
Population growth	1.12 % (2002)
Languages spoken	Arabic, French
Capital city	Tunis
Inhabitants	675,000
Other cities, inhabitants	Sfax (231,000), Ariana (153,000), Ettadhamen (150,000), Sousse (125,000), Kairouan (103,000)
Economy	diverse economy, agriculture, tourism, mining, energy, manufacturing
GDP	USD 64.5 billion (2001)
GDP per capita	USD 6,600 (2001)
GDP composition	agriculture - 13 5 industry - 33 % services - 54 %
Industries	petroleum, mining, tourism, textiles, footwear, agribusiness, beverages
Agriculture	citrus, olives, olive oil, dairy products, tomatoes, beef, dates, almonds
Administrative divisions	23 governorates

Source: CIA - The World Factbook 2002 and 2003

2 Water Resources and Water Balance

2.1 Rainfall

Rainfall in Tunisia is irregular, varying by both by region and by season, with 75% of the annual precipitation coming in the cold season. The Majerda is the only real perennial river flowing from Northern Algeria into the Gulf of Tunis, with intermittent streams being predominant elsewhere, although there are some artesian springs in the south together with access to fossil water aquifers shared with Libya. Total annual internal renewable resources are estimated to be around 3,750 MCM with net annual renewable resources of 4,350 MCM. Renewable water resources per capita have fallen, principally through population growth, from 1,036 m3 in 1960 to 532m3 by 1990, and if present trends continue Tunisia's annual water balance is expected to become negative by 2030.

All water resources are under the jurisdiction of the Ministry of Agriculture, and until recently a significant proportion of the Ministry's budget was allocated for water resources development. There is a master plan for developing water resources in each of Tunisia's three regions to provide irrigation, hydropower and public water supplies through investment in dams, reservoirs and a substantial programme of drilling both shallow and deep wells. Currently around 80% of total water use is by agriculture, with 13% for domestic use and 7% for industry; and there is a policy priority to improve both the efficiency of water use and its quality throughout the country. Whilst virtually all the urban population has access to safe drinking water, only a third of rural communities have similar provision; and sanitation services in both urban and rural areas require investment to bring up to modern standards. Research is being expanded on water use and wastewater treatment; and a number of AVICENNE projects address these aspects of Tunisia's most precious natural resource

2.2 Water resources

The "Strategie du Secteur de l'Eau en Tunisie a long terme (2030) - EAU XXI" that was published in 1998 by the Ministry of Agriculture gives a clear overview of the water balance of the country. The report includes the water balance of 1996 and provides projections for 2010, 2020 and 2030. The most important figures regarding water resources and water demand have been compiled here.

The surface water and the ground water resources as they were evaluated in 1996 are shown in the following tables. There is a clear variation in the supply of water regionally.

MCM per year

	North	Centre	South	Total
Surface water	2190	320	190	2700
Phreatic ground water	395	222	102	719
Deep ground water	216	306	728	1250
Total				

The table shows that the contribution to the total surface water is 81 % in the North of the country but only 8 % in the South.

There is also a great variation in the water resources from year to year. The surface water resources vary from 780 MCM per year up to 11,000 MCM per year.

On average 2100 MCM per year is available for use by means of reservoirs and lakes in the hills and through weirs. In fact 1340 MCM per year of the surface water was abstracted by means of the reservoirs and 65 MCM per year from the weirs.

Of the available deep ground water it is estimated that 600 MCM per year is replenished annually. The rest is non-renewable water.

It is stated that 72 % of the surface water has a salinity less than 1.5 g/l. (82 % for the North, 48 % for the Centre and 8 % for the South.)
The situation regarding phreatic ground water is that only 8 % has a salinty less than 1.5 g/l. For the deep aquifers this is 20 %.

There are 18 large reservoirs in the country, 11 in the North, 3 in the Centre and 4 in the South. Some statistics regarding reservoirs are presented in the following table.

million m3

Location	**Number of reservoirs**	**Capacity**	**Average Inflow**	**Average Outflow**
Total North	11	1248	1152	320
Total Centre	3	312	167	54
Total Cap Bon	4	52	23	8
Total	18	1612	1342	382

Treated sewage water is also being reused in Tunisia. This is mostly done in the coastal zones where more than half of the populations live. About 120 MCM of waste water per year is being treated and reused. Moreover about 60 MCM per year of surface water is being used for artificial recharge of the ground water aquifers in order to replenish the over exploited aquifers.

A small quantity of water in produced in desalination plants.

2.3 Water Demand

The main economic sectors that are distinguished for the purpose of establishing the water demand are: population, irrigation, industry and tourism. The irrigation is by far the biggest user. The total volume of water used by the various economic sectors in 1996 was 2517 MCM per year.
A volume of 2115 MCM per year or 84 % of the total water demand is used for irrigation. This quantity of water supplies 335,000 ha with water. The irrigation water is taken from all available sources: surface water (mainly from the large reservoirs and the artificial lakes), shallow wells, deep wells and treated sewage water.

The population is mainly served through the networks of Sonede. An estimated 75 % of the population is connected. A further 1.22 million people are served by local organisations (AIC, Associations d'interets collectifs). In this way about 88 % of the population of Tunisia is connected to the water supply system. The rest takes its water from rainfall collectors, shallow wells and other means.
The potable water demand is estimated at 290 MCM per year in 1996, of which Sonede distributes 256 million m3. Of this amount 134 million m3 comes from surface water sources, 156 million m3 from ground water sources and 7 million m3 from desalination plants. Only the cities of Kerkenah and Gabes are supplied by these desalination plants.

The water demand of the industry amounts to 93 MCM per year. Of this volume 34 MCM is delivered by Sonede and 59 MCM comes from own sources managed by the industries themselves. 18 MCM comes from surface water and 75 million m3 from ground water.

Finally the tourist sector has seen a tremendous increase over the recent years. In 1990 there were about 100,000 hotel beds, in 1996 this number had increased to about 150,000. In 1996 the total water demand for this sector was 19 MCM per year, 10 million m3 from surface water and 9 million m3 from ground water.

2.4 Water balance

As can be derived from the information given above the water balance for 1996 for Tunisia as a whole is still favourable. Against a total of exploitable volumes of 2,647 MCM per yeqar there is a demand of 2,517 MCM per year. The fact that the surplus is only 130 million m3 is due to the fact that the two preceding years were extremely dry. However a strong warning should go out from this that Tunisia must take the necessary action to safeguard its supply lines.

These actions are the basis for the drawing up of a strategy for the supply of water to all sectors of the economy in the medium and long term. Special attention should be given to the agriculture being the largest user of water. A few percent of water savings in this sector can free up large quantities of water for the other sectors.

2.5 Medium term strategy

The Ministry has drawn up five major objectives for the satisfaction of the water demand in the medium term. They are as follows:

- All Tunisians should be supplied with drinking water;
- Irrigated areas should be extended, but the water use should be rationalised;
- The needs for the industry, the tourism and the ecological demands should be met;
- The protection against flooding and the effects of the droughts should be guaranteed;
- The resources should be exploited in a durable and equitable way and they should be protected against pollution.

In order to mobilise the remaining resources a number of reservoirs have been planned. 21 large reservoirs will be completed by 2005. About 200 small reservoirs have been planned in the hills and about 1000 small lakes.
It is expected that water demand for irrigation will reach 2100 MCM per year. By that time all irrigable areas will be exploited.

The development of non-conventional water resources, treated waste water and desalinated water, will become more important. Desalination of brackish water will satisfy the demands of Gabes, Djerba and Zarzis.

3 Water Resources Management

3.1 Ministry of Agriculture, Environment and Water Resources

The Ministere de l'Agricult ure, de l'Environnement et des Ressources Hydrauliques (Ministry of Agriculture, Environment and Water Resources) is by law nr. 2001-419 of 13 February 2001 in charge of the management of the water resources in Tunisia.
The Ministry comprises the followin g four Directorates General and their sections, each with their own responsibilities:

A. The Direction Générale des Ressources en Eau (DGRE) (Directorate General of Water Resources); Its tasks and responsibilities are:

- management of an observation network for rainfall, surface water and groundwater
- carrying out studies to evaluate the water resources in the country and optimise their exploitation
- promote research and experiments for different aspects of water resources including water quality to enhance the rural development;
- assure the enforcement of the respective legislation for the public hydraulic domain, especially as regards protection against pollution.

The DGRE has three directorates: the Direction des Eaux de Surface, the Direction des Eaux Souterraines and the Direction des Eaux Non-Conventionelles et de Recharge Artificielle, respectively the Directorates for Surface Water, Groundwater and Non-conventional water sources and Artificial Recharge.

B. The Direction Générale des Barrages et des Grands Travaux Hydrauliques (DG/BGTH) (Directorate General of Dams and Great Hydrauliques Works) Its tasks and responsibilities are:

- hydraulic studies;
- masterplans for the use of water
- studies of large hydraulic infrastructural works
- study, execution and management of works to protect against inundations of the agricultural zones;
- exploitation and management of the dams and reservoirs.

The DG/BGTH has four directorates: Direction des Etudes de Mobilisation des Eaux, Direction des Grands Ouvrages Hydrauliques, Direction des Grands Barrages, Direction de l'Éxploitation des Barrages, respectively the Directorates of Studies, Large Hydraulic Works, Large Dams and Exploitation of the Dams.

C. The Direction Generale de l'Amengemant et la Conservation des Terres Agriocoles (DG/ACTA) (Direstorate General for the Agricultural Lands). Its tasks and responsibilities are:

- drafting plans for the preservation of the natural resources of soils, vegetation, water and agricultural lands;
- studies of soil and water;
- coordinate the activities of all parties involved in soil and water;
- carrying out studies to fight erosion;
- carrying out studies for the improvements of watersheds;
- carrying projects for water and soils conservation;

The DG/ACTA has four directorates: Direction de l'Amenagements et de la Valaorisation des ouvrages, Direction des Etudes, Direction des Ressources en Sol, Direction de l'Espace Rural, respectively the Directorates of Works, of Studies, of Soils and of the Rural Environment.

D. The Direction Générale du Genie Rurale et de l'Exploitation des Eaux (DG/GREE) (Directorate General of Rural Development and Agricultural Infrastructure). Its tasks and responsibilities are:

- study and execution of the infrastructure of irrigation schemes
- management of the use of water in the irrigation schemes
- coordinate programmes for the provision of drinking water in urban and rural areas;
- coordinate the programmes for rural infrastructure and mechanisation in the agricultural sector.

The DG/GREE has three directorates: Direction de l'Irrigation et de l'Exploitation des Eaux Agricoles, Direction de l'Economie de l'Eau and the Direction de l'Eau Potable et de l'Equipement Rural, respectively the Directorates of Irrigation, Water Savings and Drinking Water.

3.2 Sonede

The Societe Nationale d'Exploitation et de Distribution des Eaux (Sonede) is a so-called Etablissement Public a Caractere Industriel et Commercial (EPIC), a public entity with an industrial and commercial character. It operates within the Ministry as an industrial organisation.

The Sonede is responsible for the production and distribution of the domestic and industrial water in Tunisia. Its tasks and responsibilities are defined in the law no. 68-33 by which the Sonede was established in 1968.

The objective of Sonede is according to Article 2 of the law: It is the purpose of Sonede to provide potable water in the whole of the country. To carry out this task Sonede has a monopoly, which it can partially leave to other parties. Sonede is charged with exploitation, maintenance, and upkeep of intake structures of water, transport, treatment and distribution to the end-users.

Furthermore the Sonede is charged with the analysis of the water demand and to realisation of new intake structures that can satisfy the increased demand. For this purpose the State will reserve when necessary the resources in the country the quantities of water that are necessary to satisfy the demands of the population of Tunisia.

Sonede has 1.6 million subscribers (2001) all of whom are metered. The company distributes 1 MCM per day of water of which some 50,500 m^3 are produced by desalination.

It addition Sonede should distribute potable water to industrial users and other users.

The Sonede is also charged with the exploitation of the water infrastructure.

There are a number of Directorates within the Sonede. They are grouped in the Functional Directorates and the Operation Directorates.

The Functional Directorates are:

- Direction Comptable et Financiere
- Direction des Affaires Juridique et Foncieres
- Direction des Ressources Humaines
- Direction de l'Informatique
- Direction du Developpement et de la Planification and the
- Direction Organisationelle

The Operational Directorates are:

- Direction des Etudes
- Direction de l'Exploitation
- Direction des Travaux Neufs and the
- Direction de la Production.

The main tasks of the Production Directorate are:

- Managing in an efficient manner the infrastructure and improve the technical methods with respect to production, treatment and transport of water;
- Checking the biological, bacteriological and chemical components in the water from the point of abstracting the water until the distribution to the water user;
- Maintain a statistical database of the data regarding production, treatment and transport of the

water;
- Make annual and monthly estimates of the purchase and provision of water for the various water users, while taking care of rational repartition and at least cost;
- Make sure that the budget for materials needed for the production and the maintenance of the infrastructure is adhered to.

3.3 Other institutions

Also under this Ministry is the Organisation Nationale de l'Assainissment (ONAS). This agency deals with the collection and treatment of sewage.

Within this Ministry one can find also the Agence Nationale de Protection de l'Environnement (ANPE) and the Centre International des Technologies de l'Environnement (CITET).

Briefly stated it is the task of the ANPE to protect the environment. In order to do that it takes therefore preventive actions, such as the control of waste disposal and of installations that treat liquid and solid wastes, and it checks whether the applicable laws are being adhered to.

The activities of the CITET are mainly
- Training at national and international level concerning urban waste disposal, solid waste disposal, control of industrial pollution, proper management of the urban environment, carrying out of environmental impact assessments, fight against the desertification, etc.
- Research and development regarding waste water treatment facilities for small villages, air quality
- Transfer of technologies, desalination of sea water and brackish water, physical and chemical treatment of industrial effluent.

There are many agencies that have a certain responsibility regarding water. The Sonede is the main agency charged with the collection, treatment, and distribution of water to the population, but other agencies deal with the overall planning of the water resources in the country. Pollution control and care for the environment is in the hands of even other agencies. This rather complex array of agencies calls upon a good common policies for water management.

4 Desalination

4.1 Water Resources

The bulk of the potential conventional water resources of Tunisia lie in the northern region of the country and amount to 4,600 MCM/yr of which 54% has a salinity less than 1.5 g/l. These comprise 2,700 MCM from surface water and 1,900 MCM from ground water. Surface water quality varies but 74% has salinity less than 1.5g/l. Potential per capita supply is 450 m3/yr. Given the concentration of the natural resource is in the north, the southern part of the country is the area where water is in short supply. This is exacerbated by the growth in tourism in the southern region. Virtually all of the desalination experience is consequently in the southern part of Tunisia.

4.2 Desalination Experience

Table 4.1 lists all of the desalination plants installed in Tunisia since 1970. This accounts for some 48 plants with a total capacity of 130,000m^3/day of potable water. As can be seen from the list the majority of the plants are operating with brackish water as the feed source. The small number operating on seawater are mainly VC plants where the product water is being used as boiler feed water make –up in power generation plants. Of the 48 plants, 22 use the Electro-dialysis (EDR) process to treat the brackish water. The product water is then used in industrial processes. With the exception of the four large plants owned and operated by Societe Nationale d"Exploitation et de Distribution des Eaux (Sonede), the average size of the plants is 682 m^3/day.

Table 4.1 Desalination Plants in Tunisia

Process	Capacity m3/day	Total Capacity %	no of plants	Average Capacity m3/day	Feed-water
EDR	15607	19.4	22	709	Brackish
VC	4820	6.0	8	603	Seawater
MSF or ME	697	.8	3	232	Seawater
RO not Sonede	8865	11.1	11	806	Brackish
RO Sonede	50500	62.7	4	12625	Brackish
Total	80489	100	48		

A more detailed breakdown concerning each particular plant is given in Appendix A.

The four plants owned and operated by Sonede are located in the southern part of Tunisia which is particularly short of potable water and where there has been huge growth in tourism.
Sonede has responsibility for the production and distribution of potable water to the people of Tunisia. Because of the lack of adequate good quality water resources in the south part of Tunisia it has resorted to building desalination plants. In southern Tunisia there are sources of brackish water and Sonede has chosen the desalination of these resources as the cheaper option rather than desalinate seawater. Sonede produces 374 MCM/year of which only 84 10 MCM or approximately 1% is from the desalination plants.
The drinking water sector uses 59% of the desalted water production. The following table shows the breakdown of usage.

Table 4.2 Distribution of Desalination Capacity by Usage

Application	Drinking Water	Tourism	Industry	Others	Total
Capacity m^3/day	49800	2000	25500	7700	85000
Rate %	59	2.3	29.9	8.8	100

Four brackish water desalination plants have been constructed since 1982. Details are as follows:

Table 4.3 Desalination Plants operated by Sonede

Location	Size m^3/day	no of Units	Date in service
Kerkennah Island	3300	4	1984
Gabes	25000	3	1995
Zarzis	15000	3	1999
Jerba	15000	3	2000

4.3 Kerkannah Island

The desalination plant on Kerkannah Island consists of 4 units each of 825 m^3/day capacity. Membranes are spiral wound cellulose acetate (CA). The plant operates as a two-stage process with 75% recovery. Operating pressure to the first stage is 300 metres. The plant configuration is similar to the Gabes Plant (See Figure 4.1)
The feed water for the plant is pumped from an aquifer of 500 metre depth and has a salt concentration of 3.6 g/l TDS at a temperature of 31°C and has an iron concentration exceeding 0.7 mg/l. Since 2001, AC membranes had been changed with PA membranes contributing to a reduction of energy consumption to about 40%.

Pre-treatment

Iron is removed in an oxidation basin by blowing air through the feed water. This is subsequently chlorinated to kill bacteria. The feed is then filtered through sand filters to remove iron hydroxide together with any suspended material. Final filtration is through 5 micron cartridge filters to protect the membranes. Scale control involves the addition of Hexametaphosphate (HMPS) at a rate of 4 mg/l. H_2SO_4 is injected to maintain a pH of 5.6. The HMPS had been charged with organic antiscalant which is now Argo scientific AF220UL and chlorination is stopped.

Post Treatment

The product water is passed through a degasser to remove CO_2 and the pH corrected by soda addition to reduce corrosion in tanks and pipes. It is then blended with filtered feed-water to obtain a drinking water with salinity ranging between 1.2 and 1.5 g/l.

Process Development

In 2001, one of the 4 lines was converted to polyamide membranes (PA). Table 4.4 shows the comparison of the plant with polyamide versus cellulose acetate.

Table 4.4 Comparison between membranes

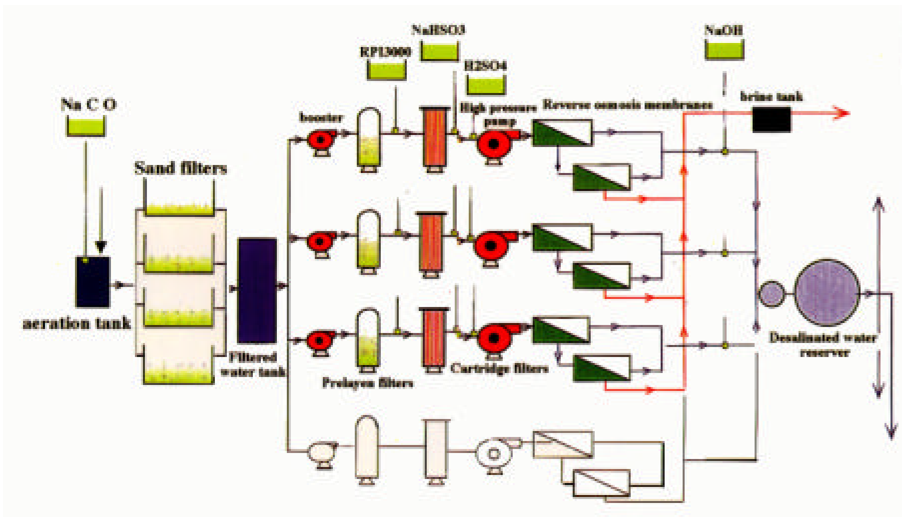
Indicator	CA membrane	Polyamide membrane
Feed pressure	300 metres	160 metres
Recovery rate	75%	75%
Product salinity	400 mg/l	80 mg/l
pH	5.6	6.0
Plant capacity	3600 m3/day	4700 m3/day
Energy (kWh/m3)	2.0	1.1

Following the success of this work a further line was converted to use PA membranes.
Initial investment in the plant was USD 665 per m3 at today's rate. Long run marginal cost of production is USD 0.465 per m3 and this is expected to fall further to USD 0.43 per m3.

4.4 Gabes

The decision to proceed with the construction of the desalination plant in Gabes was made after examining various conveyance projects bringing in water from other regions. Brackish water desalination appeared the best option. The plant has a capacity of 22,500 m3/day and consists of 3 units of 7,500 m^3/day. There is provision for an extension of 7500 m3/day by adding an extra unit. The membranes are spiral wound polyamide. The plant operates as a two-stage process with a design recovery rate of 75%. A schematic diagram of the process is shown in Figure 4.1.

Figure 4.1 Gabes Desalination Plant



Pre-treatment

The feed water is from a number of local aquifers and has a salinity of 3.2 g/l with a high sulphate concentration and hardness exceeding 400 mg/l of calcium. The water is passed through an oxidation basin where air is pumped through it to oxidise the iron and magnesium present to hydroxide. Originally it was chlorinated to kill bacteria. This is then passed through multi-media filters to remove most of the suspended matter. Final filtration is by a pre-coat filter using diatomaceous earth which is effective down to 1micron. This is followed by 5 micron cartridge filters. Scale control chemical is added and pH is maintained at 7.1 by addition of sulphuric acid.
Following the commissioning of this plant, considerable problems were encountered with bio-fouling of the membranes and eutrophocation of the oxidation basin. 6 chemicals were used originally. These have been reduced to 3.

Bio-fouling

Because of the deterioration of the plant performance which necessitated frequent expensive plant cleaning, a membrane autopsy was carried out. This showed a significant level of bio-fouling on the membrane surface. It was subsequently found that bacteria which escaped from chlorine action exhibited a high level of activity. It was found that chlorination produced organic material for the bacteria to feed on. Suspension of chlorination eliminated the problem.

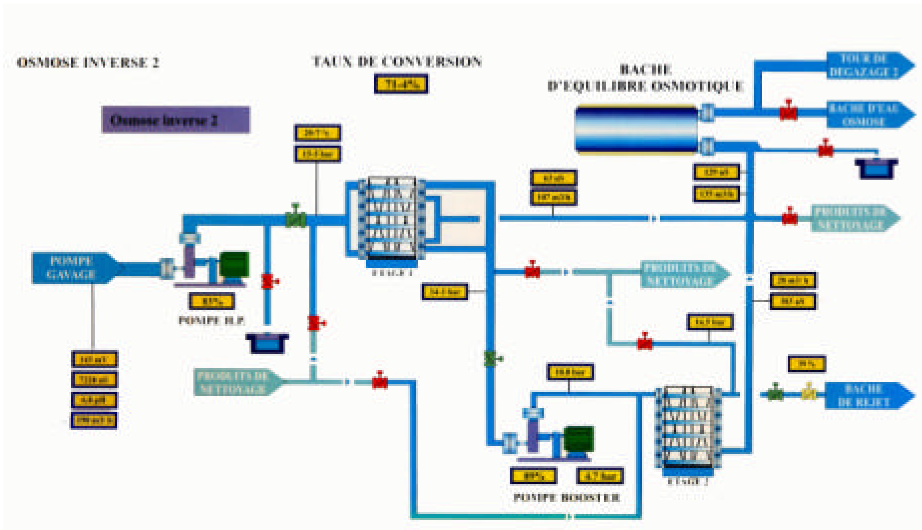
Eutrophication

This problem appeared after the resolution of the bio-fouling problem. Discontinuous chlorination resulted in algal proliferation in the oxidation basin and the sand filters. This generated huge loads for the filtration system which was unable to cope and required frequent backwashing. Neither the oxidation basin nor the sand filters were covered. The solution was to cover these and prevent photosynthesis. This was successful.

4.5 Zarzis

The desalination plant at Zarzis has a capacity of 12,000 m^3/day and was commissioned in 1999. It comprises 3 units of 4000 m^3/day. It is similar to Gabes and Kerkannah in that it is a two-stage plant using spiral wound polyamide membranes. A major difference is the inclusion of a speed controlled booster pump between the first and second stages and speed control on the first stage high pressure pump. The first stage is operated at a pressure of 140 metres and the second stage at 50 metres. This is a more efficient method of operation and reduces the power consumption of the process by 12 % compared to the other two plants. The recovery rate is 75%.

Figure 4.2 Zarzis DesalinationPlant



The feed water is again from an aquifer. The water salinity is 6 g/l at a temperature of 30°C. Pre-treatment consists of aeration, decarbonation and decantation followed by sand filtration and micro-filtration. Scale control chemical is added and pH modified to inhibit scale deposition.

4.6 Djerba

Djerba Island is a rapidly developing island at the southern end of Tunisia. Tourism and agriculture are important. The island has a population of 120,000 people. A desalination plant of 15,000 m^3/day was brought into operation in 1997. The plant is similar in concept to Zarzis although the water is of a different quality. The feed water is drawn from an aquifer which contains high concentrations of sulphides (10 – 30 mg/l depending on the well) and chlorides and has a high hardness.

Pre-treatment

The feed water contains H_2S which on exposure to air in the oxidation basin forms a suspension of colloidal sulphur which is very difficult to remove by filtration and which irreversibly blocks the membranes. Two classes of processes for sulphur removal were investigated by Sonede: Aerobic processes and anaerobic processes.

Aerobic Processes

Three methods were examined. The first two were inconclusive. The third was tested on one of the lines for a period of three months

- H2S removal by degasification at the plant entry
- Precipitation of sulphides by sulphate salts and decantation
- Oxidation of sulphur derivatives and decantation from the product water

Anaerobic Process

This was tested on one of the lines for two months. The feed-water system is enclosed to prevent oxidation and the pH adjusted to favour the formation of H_2S which can cross the membrane and will be present in the product and the reject brine. The H_2S is easily stripped out of the product water by air.

4.7 Sonede Experiences

Membranes

Sonede has experimented with both CA and PA membranes. It is clear form the work done that the PA membrane has many advantages when dealing with brackish water.

Pre-treatment

Sonede has now gained considerable experience in the pre-treatment of various qualities of brackish water. In all cases it has managed to reduce the chemicals involved to between two to three chemicals, which results in important savings in chemical costs. This is in line with experience gained by other users where it has been found that the recommendations of the companies supplying chemicals or the membrane supplier have been overly conservative.

Energy Consumption

The average energy consumption on all four plants operated by Sonede is 1.2 kWh/m^3. The adoption of the inter-stage booster pump at Djerba and Zarzis has made a significant improvement in energy consumption bearing in mind the feed water at these plants is twice that of the other two.

Capital Cost

The average investment cost of all four plants operated by Sonede is € 650 per m^3.

Operational Costs

The operational cost of seawater desalination plants is shown in Table 4.5. The total cost of brackish waster desalination is estimated at € 0.15 per m^3.

Table 4.5 Water cost breakdown

Indicator	Wages	Energy	Chemicals	Other	Capital recovery	Total
€/m3	0.14	0.06	0.03	0.11	0.29	0.50
%	2.8	12.1	5	22.9	57.2	100

Indicator	Amortisation	Equipment replacement	Maintenance	Energy	Chemicals	Labour	Total
DT/m3	0.023	0.12	0.03	0.08	0.04	0.015	0.515

5 Energy

5.1 Conventional Energy

Tunisia is currently self-sufficient in energy, with a total consumption of 5016 KTEP in 1993 being provided from petroleum (72%), natural gas - principally from Algeria (26%), coke (1.6%) and hydo-power (0.3%).

5.2 Renewable Energy

The principle body responsible for renewable energy development in Tunisia is the National Agency of Renewable Energies (ANER). The Agency was established in 1985 under the aegis of the Ministry of the Environment and Land Use Planning. ANER has a number of programmes focussing on different aspects of energy conservation, renewable energy and the dissemination of information on the environment. The Agency works closely with the Institute National Recherche Scientifique et Technique (INRST) and Sonede.

5.3 National Agency of Renewable Energies

The National Agency of Renewable Energies is active in most fields of Renewable Energy but wind and solar are the main focus and have potential application with desalination in rural areas. The Agency has responsibility for developing government strategy for energy conservation and renewable energy and for collecting data on the renewable resource. The various renewable energy options investigated are discussed below.

Wind energy

The Agency feels that Tunisia has a useful wind resource, which they plan to develop. The Agency in conjunction with STEG (Tunisian Electricity & Gas Company) has supported the creation of a 10 MW wind farm at Sidi Daoud 30 km south of Tunis. This comprises some 30 – 330kW turbines supplied by a Spanish manufacturer. The wind farm is connected to the electricity grid. Wind data for the country are available. Most of the data is for 7-8 metre hub height which is felt to be inadequate. Currently the Agency is embarking on a program of data collection involving the installation of anemometers at 40-metre height.
The Agency foresees the application of wind turbine driven desalination plants for remote applications.

Solar energy

Solar energy is seen as a major resource.

Photovoltaic energy

In 1999, the Agency sponsored a program involving the electrification of 10,000 homes using photovoltaic energy (PV) together with 200 rural schools, several border posts and community clinics. Further programmes are planned. Some work on water pumping is underway. PV is also being used for the powering remote tele-coms stations.

Thermal energy

The Agency is also encouraging the adoption of solar water heaters for domestic housing. It has been responsible for the installation of 90,000 squares of solar heaters, as well as setting up 3 solar heater producing companies and at a regional level, over 100 small enterprises to install and maintain this equipment. They are also sponsoring a programme of energy conservation.

Biomass

ANER has set up a pilot unit for the production of biogas from chicken manure.

Action program

ANER has an action program for the years 2002-2010 with ambitious targets.

- Wind 200 megawatts
- Thermal Solar: 300,000 square metres
- PV : Lighting 6000 rural homes. Developing other applications such as water pumping etc
- Rationalisation of energy consumption across many sectors.

5.4 Institute National de Recherche Scientifique et Technique

The Institute National de Recherche Scientifique et Technique (INRST) is located at Hammam-Lif some 15 km south of Tunis on a remote coastal site and consists of a number of government funded scientific institutions. It is planned to give each of these institutions a degree of autonomy as freestanding bodies. There are also ambitious plans underway to develop the site as a techno-park with a business incubator and space for high-tech private sector companies.

In particular the Laboratoire des Applications Solaires is involved in the application of renewable energy to desalination. The Laboratory has experience with PV and thermal and participates in EC programmes for renewable energy. The facility is relatively Spartan with regards equipment but should be seen as a nucleation point for further work in this area.

6 Water Sector Capacity and Capabilities

Desalination related capacities and capabilities are strongly clustered around the national water company Sonede. As regards understanding and developing desalination technologies, there are a number of universities and institutions with whom Sonede has worked and is working for example in the field of financial and economic feasibility, and technical feasibility studies aimed at developing pilot projects and demonstration projects. Research activities are carried out by a number of universities and institutes, including:

- Secrétariat d'Etat à la Recherche Scientifique et la Technologie,
- l'Institut Nationale de la Recherche Scientifique et de la Technologie,
- le Centre Nationale des Sciences et Techniques Nucléaires,
- la Société Tunisienne d'Electrécité et du Gaz,
- l'Agence Nationale des Energies Renouvelables

In terms of formal education, it is quite remarkable that the Ecole Nationale d'Ingénieurs de Tunis intends to develop a degree in desalination. Such a degree is currently non-existent in the region.

Regarding the involvement of the private sector in the development of public infrastructure, there is a need to invest in education of Sonede staff with regard to BOT tendering, contracting and monitoring skills. In this respect, much could be learned from international best practices, but also from Tunisia's experience in the field of BOT contracting in the electricity sector and wastewater sector.

6.1 Private Sector Participation in the water sector

Whereas Tunisia has been privatizing state companies under a large privatization programme since 1987, water supply and sanitation services are still provided in full by the Government. In a study carried out in 1999 by a consortium of Study and IdeaConsult it was suggested that a number of activities could be contracted out under service-contract arrangements.

In order to promote private sector involvement in the development of non-conventional water sources, a amendment of the Water Code (national water law) was adopted. Law no. 116 allows private parties to produce and distribute water, either for themselves, or for third parties, as long as the intended use of the water is for industrial or tourism purposes, and as long as the source of water is non-conventional, e.g. desalination. A financial incentive programme is linked to this regulation to promote the development of non-conventional water for the industry and tourism sector.

In a World Bank funded study carried out in 2002, concerning Private Sector Participation in Infrastructure it was concluded that the productivity of Sonede was rather low. One of the reasons for this is indeed the lack of sub-contracting. Sonede still carries out many activities that are directly or indirectly related to water supply itself, thus including a wide range of activities that are not 'core business' activities. In the study it was once again recommended that as a first important step non-core business should be contracted out. Recently Sonede is starting to subcontract certain activities, particularly those for large works (100% contracted out), network extensions (90%), and new connections (55%).

There are plans for further development of subcontracting at Sonede. Two important arguments for this is:

- Due to market pressure the private sector will be able to deliver services at more competitive cost;
- A number of activities that can be subcontracted have significant fluctuations in terms of workload. The risk of having staff on the pay roll who have no work to do can be transferred to

the private sector.

The recommendations of Study and IdeaConsult are now being implemented through a phased approach. Activities that are to be subcontracted in the future are according to Sonede (presentation in Amman, 2002):

- Short term: Maintenance, transportation, fleet maintenance and maintenance of fixed assets, hydraulic and topographical studies
- Medium term: Fixing leaks and broken pipes, especially mains, bad debt collection activities
- Long term: Billing and collection, water sanitary controls, network supervision

The trend towards outsourcing a number of activities will require staff redeployment, training of staff who are dealing with the private sector subcontractors. A remarkable task envisaged by Sonede is assistance to the private sector. This may be necessary since in some regions there is a lack of competent private parties to undertake work against the professional standards of Sonede.

From a social perspective, with regard to staff redeployment, Sonede will support staff that wishes to make the switch to the private sector and will promote the recruitment of (former) Sonede staff by the private sector. Also, they envisage supporting staff that want to start their own company to provide services to Sonede.

Taking into account, however, that the ambitions plans for improvement and extension of the water supply services into more rural areas will require significant investments, thought should be given to private sector investments in the water sector as well. On the one hand the company is ready for private sector involvement, since fair water tariffs are in place, and the 'external' performance of the company (service levels and state of infrastructure) is about the best in the region. However, private sector involvement will lead to a drive towards highly efficient use of human resources. Given the high number of employees per connection (10, World Bank presentation Amman, 2000) this may be a painful process.

6.2 Private Sector Participation in desalination

The sea water desalination plant that is planned in Jerba island (15,000 m3/day) will actually be the first privately financed water project. It is envisaged that the project be implemented under a BOT arrangement. The project is in an advanced stage of planning. The European Commission is supporting the process by commissioning a technical and financial study for this project in preparation of the future BOT tender.

Another project for which private sector involvement is sought is the development of 10 medium sized brackish water treatment plants, requiring an estimated investment of some USD 20 million.

7 Environmental Issues

7.1 Introduction

With 1300 km of shoreline, Tunisia hosts four million tourists a year, making this sector its largest foreign exchange earner. A clean environment will be essential to continue to expand this sector. Increasing water needs and the danger of periodic drought leave Tunisia vulnerable to water shortage. Growing demand has already led to saline intrusion into some groundwater sources. Conservation, treatment, wastewater reuse in agriculture, and desalination are remedial options the government is pursuing. Within the Tunisian government, Sonede (the National Water Authority within the Ministry of Agriculture) is responsible for water stockage and delivery while ONAS (the National Sewage Agency within the Ministry of Environment) handles sewage, wastewater treatment, and prevention of watershed pollution.

The Government of Tunisia's ambitious Ninth Economic Plan, running from 1997 to the year 2001, stipulates a growth rate of 6% a year. Inflation is planned not to exceed 4.1% and the budget deficit to be maintained at 2.4% of GDP. Investment rates are slated to rise from 24.3% to 27.6 % of GDP. Significantly, this Plan projects annual spending on environmental projects to comprise 4% of the budget, or about $350 million a year. The Tunisian Government is undertaking a wide range of structural reforms to move toward a more market-based economy. These steps include liberalization and privatization, which multilateral institutions have suggested need to be accomplished in a more rapid manner.

On the treatment side, ONAS plans to construct 22 wastewater plants by the year 2006. The largest of these is Tunis-West valued at approximately $45 million. ONAS is expected to need foreign technology to furnish laboratories, provide cleaning and purification equipment and to furnish wastewater treatment facilities. Treated wastewater is likely to be a major future source for irrigation water, giving preference to water treatment techniques that generate water suitable for agriculture. Pretreatment of industrial pollutants and tertiary wastewater treatment also provide potential markets.

On the supply side, the Ninth Economic Plan foresees construction of 10 desalination plants and four large dams. Bids have already been called for the first two desalination plants, in Djerba and Zarzis. The need to augment urban and rural water supply to meet growing demands also provides a potential market for piping and equipment and expansion of networks, although the civil engineering works will remain largely dominated by Tunisian companies (Ibid).

7.2 Environmental Impacts

The below impacts are described in general terms in the Main Report; these impacts are also valid for the situation in Tunisia. More specific impacts for the situation in Tunisia are presented in the following sections.

7.2.1 Construction Stage

In Tunisia, several desalination plants are planned; however, desalination has already been occurring for approximately ten years in this country. General construction impacts should be expected. Impacts on tourism and the landscape from a visual perspective should be examined carefully before proceeding.

7.2.2 Operational Stage

Energy Use and Air Quality
The emissions of pollutants (contributing to air pollution) and CO_2 (contributing to global warming) that result from the extra power production would add to the country's total emissions. Tunisia accepted the Kyoto Protocol in 2003, but has not as yet ratified or signed it (UNFCCC, 2003). ANER does little by way of renewable energy. Renewable energy (solar energy and wind) could be used in desalination plants of a capacity of 50 to 100 m^3 per day. These plants could serve small villages.

Marine Environment
At present, Tunisian desalination plants are for brackish water; however, in the case of Gabes, for example, the water is discharged to the sea. The below impacts are valid for sea discharges, and must be taken into account if future desalination plants have seawater as their feedw ater.

In Tunisia, it is notable that the existing plant at Gabes (a groundwater desalination plant) eliminates its wastes through approximately 10 km of pipelines into the sea; however, discharge from the pipe occurs in the dune area of the coast and not in an area where the brine would mix well into the sea. This action could have impact on surrounding groundwater quality, as well as organisms and the fragile habitat of the dune area. However, it is noted that an environmental study was carried out on this activity, which indicated that "no negative impacts were seen on groundwater or sea" (Agriculture Ministry/National Potable Water Authority, ca. 2001).

In Tunisia, one of the endangered species is the mother-of-pearl *Pinna nobilis*, a shellfish living in the *Posidonia oceanica* fields in the littoral zone. *Posidonia* "herbaria" provide important benthic habitat for many different organisms; this plant is threatened by changes in saline levels and contaminants. Changes in brine concentrations may disturb this protected creature. Biocenoses are also threatened along the Mediterranean and Atlantic coasts; these could also possibly be impacted by desalination brine discharge (State of the Environment, 2001). There is also a reef of *Neogoniolithon notarisii*, which, as with many reef organisms and habitats, is highly sensitive to changes in water conditions.

7.3 Recommendations for Mitigation

7.3.1 Institutional and Management Mitigation

Proper enforcement of any existing environmental or water laws or regulations
Proper implementation of an EIA law or EIA as guidelines under a more basic environmental law would also be of great use; in Tunisia, according to decree no. 91-362, dated 13 March 1991, an EIA study is required for public and private projects likely to have effects on the environment. The legislation is there, but level of enforcement, which is generally not high in the Middle East, should be investigated. In the Water Strategy Tunisia is planning, however, a number of mechanisms for monitoring progress for water savings are built in, such as periodic assessments for major consumers, assessments of water provision equipment, development of bodies specialising in water saving assessment and expertise, and plans for development of economic incentives for water saving.

Effective water resources management planning with environmental aspects
Tunisia is developing a Strategy for Potable Water which is aimed at the period present-2030, aimed at "curbing demand and consumption, achieving a 30% water savings effort, and providing 7% of water needs from non-conventional resources (desalination and wastewater reuse)". On paper it appears as a sound strategy; again, the policy must be implemented in a concise and transparent manner.

Properly developed environmental institutions; ensuring that environmental responsibilities

are not divided over too many institutions; clear mission statements regarding environment for involved institutions

In Tunisia, it appears that the proper institutions are in place for the proper implementation of a water resources strategy and successful, sustainable desalination. Sonede's mandate is to "operate the water production and distribution system all over the country", including both potable and non-potable sources. Additionally, it is responsible for the study and implementation of water catchment, canalisation and supply installations and technical and financial management of the supply system. Sonede is represented by four regional directions and 30 districts. As well, the Ministry of Environment and Land Use Planning is in place; it also has a mandate involving mainland waters and their protection. If these organisations can work together effectively, it would be possible to achieve some of the goals in the above-mentioned Water Strategy.

Further awareness-raising for water conservation

According to brochures from Sonede, in the Cabinet Meeting of June 2001, a number of measures were taken into national water policy. These measures included the development of an awareness raising and training strategy with three main tenets: i) intensifying programs aimed at raising the awareness of the public as to water savings, through various media; ii) celebrating a National Water Savings Day; and iii) intensifying and diversifying training and re-training programmes for water-saving equipment. Therefore, it appears that Tunisia has the awareness raising component of its strategy well in hand.

7.3.2 Physical Mitigation

<u>For the purpose of water conservation</u>

Avoidance of problems associated with saltwater intrusion

If seawater desalination is to begin in Tunisia, aquifer recharge management for sustainable yield must take place, as coastal areas suffer badly already from saltwater intrusion.

Improved wastewater treatment for the existing situation

Wastewater from domestic and other sources is already significant; it is not treated properly in Tunisia. Proper capacity for treatment should be installed immediately and reuse should be undertaken to the extent possible.

<u>For the purpose of desalination plant mitigation</u>

Construction

Site pipeline routes should be chosen to minimize impacts to sensitive areas (there are more than 1,000,000 ha of land protected in Tunisia – wetlands, national parks and reserves - thus far).

Operational

Energy Use and Air Quality

Thus far in Tunisia in the existing desalination plants, little or no energy recovery is being attempted (see above). Steps in this direction may aid in minimising energy usage.

Water Balance Issues

The water balance of the given area should be well-known, so that the exact effects of the increased water in the basin can be calculated with a reasonable error margin. It appears that Tunisia has a good idea of its water balance (SoER, 2001).

8 Future Developments

8.1 Seawater Desalination

Sonede are currently considering building a large seawater desalination plant at Djerba to cope with the increasing water demand, mainly from the tourism sector. This will be the first large-scale seawater desalination plant for municipal water supply. The output of the plant will be 25,000 m^3/day. Consultants have been invited to carry out a feasibility study for the construction of the plant. Their report will include recommendations with regards to the process to be used.

The government wants to involve the private sector in setting up and running of the plant. It is planned that the project will be operational by 2007.

8.2 Water Quality Improvement

Sonede are currently looking at 13 sites in southern Tunisia where it is considering installing equipment to improve the quality of the water. This will involve building water treatment plants at these sites and in the further development of the pipe network. This work is still at the planning stage and no contracts have been placed.

Figure 8.1 Location of Water Quality Improvement Projects

9 References

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Appendix A List of existing desalination plants

List of existing desalination plants

Tunisia											
Location	Total Capacity m3/d	Units	Process	Equipment	Feature	Customer	Water Qual	User	Con.Year	Plant Supplier	Membrane Supplier
Gabes	850	1	ED	FM	EDR	Cement Factory	BRACK	INDU	1975	IONICS US	IONICS US
El Borma	250	1	ED	FM	EDR	SITEP	BRACK	INDU	1976	IONICS US	IONICS US
Enfida	850	1	ED	FM	EDR	Cement Factory	BRACK	INDU	1980	IONICS US	IONICS US
Enfida	850	1	ED	FM	EDR	Cement Factory	BRACK	INDU	1980	IONICS US	IONICS US
El Borma	250	1	ED	FM	EDR	SITEP	BRACK	INDU	1981	IONICS US	IONICS US
Djebel Oust	600	1	ED	FM	EDR	Cement Factory	BRACK	INDU	1984	IONICS US	IONICS US
Sfax	2500	1	OTHER	OTHER	*Unknown	UTAIM	BRACK	IRR	1989	AQUASOLAR DE	*Unknown
	600	1	ED	FM	EDR		BRACK	INDU	1990	IONICS US	IONICS US
	600	1	ED	FM	EDR	SGBIA	BRACK	INDU	1990	IONICS US	IONICS US
Bouargoub	600	1	ED	FM	EDR	SEABG	BRACK	INDU	1990	IONICS US	IONICS US
Mahdia	600	1	ED	FM	EDR	SFBT	BRACK	INDU	1990	IONICS US	IONICS US
Sfax	600	1	ED	FM	EDR	SFBT	BRACK	INDU	1990	IONICS US	IONICS US
Tunis	600	1	ED	FM	EDR	SFBT	BRACK	INDU	1990	IONICS US	IONICS US
Tunis	600	1	ED	FM	EDR	STGB	BRACK	INDU	1990	IONICS US	IONICS US
	1800	2	ED	FM	EDR		BRACK	INDU	1991	IONICS US	IONICS US
	600	1	ED	FM	EDR		BRACK	INDU	1991	IONICS US	IONICS US
	600	1	ED	FM	EDR		BRACK	INDU	1991	IONICS US	IONICS US
	240	1	ED	FM	EDR		BRACK	POWER	1993	IONICS US	IONICS US
	600	1	ED	FM	EDR		BRACK	INDU	1994	IONICS US	*Unknown
	600	1	ED	FM	EDR		BRACK	INDU	1995	IONICS US	*Unknown
	272	1	EDI	FM	*Unknown		*Unknown	POWER	2000	IONICS US	IONICS US
	545	1	EDI	FM	*Unknown		SEA	POWER	2000	IONICS US	IONICS US
Total	15607	23									
Gabes	336	1	MSF	FLASH	*Unknown	MAGREBINE	SEA	INDU	1970	CGA FR	*Unknown
Rhennouch	240	2	ME	ST	*Unknown		BRACK	INDU	1970	SIDEM FR	*Unknown
La Skirra	121	1	OTHER	FLASH	HST	TRAPSA	SEA	INDU	1971	WEIR TECHNA GB	*Unknown
Total	697	4									

Tunisia											
Location	Total Capacity m3/d	Units	Process	Equipment	Feature	Customer	Water Qual	User	Con.Year	Plant Supplier	Membrane Supplier
Gabes	720	2	VC	HTE	*Unknown		SEA	INDU	1972	SIDEM FR	*Unknown
Gabes	960	2	VC	HTE	*Unknown		SEA	POWER	1978	SIDEM FR	*Unknown
Gabes	1020	2	VC	HTE	*Unknown	MAGREBINE	SEA	INDU	1979	CGA FR	*Unknown
Gabes	480	2	VC	HTE	*Unknown	SAEPA	SEA	POWER	1982	SIDEM FR	*Unknown
MDilla	360	1	VC	HTE	*Unknown	ICG	SEA	POWER	1982	SIDEM FR	*Unknown
La Skhirra	200	2	VC	HTE	*Unknown	TRAPSA	SEA	INDU	1983	SIDEM FR	*Unknown
Gabes	480	1	VC	HTE	TVC		SEA	INDU	1985	SIDEM FR	*Unknown
	600	1	VC	HTE	TVC		SEA	INDU	1997	WEIR TECHNA GB	*Unknown
Total	4820	13									
Nefta	181	1	RO	MTU	*Unknown	SAHARA PALACE	BRACK	TOUR	1976	CONTI WATER US	*Unknown
Tunis	432	2	RO	MTU	*Unknown	STEG	BRACK	POWER	1976	CULLIGAN IT	*Unknown
Tunis	200	1	RO	HFM	*Unknown	KAWASAKI	BRACK	INDU	1979	SASAKURA JP	DUPONT US
Tunis	3480	4	RO	SWM	*Unknown		BRACK	MUNI	1982	KRUPP DE	KOCH FLUID S US
Kerkennah Isl.	4000	4	RO	SWM	*Unknown	SONEDE	BRA CK	INDU	1982	SULZER CH	*Unknown
Ben Bechir	1104	1	RO	SWM	*Unknown	C.S.T.	BRACK	MUNI	1985	SNAM PROGETT IT	TORAY JP
	410	1	RO	SWM	ER	BRITISH GAS	SEA	POWER	1993	METITO GROUP AE	*Unknown
Jerba	1248	1	RO	SWM	*Unknown	SITI	BRACK	IRR	1993	OSMO SISTEM IT	DOW FILMTEC US
Koutine	360	1	RO	SWM	*Unknown	SINALCO	BRACK	MUNI	1993	OSMO SISTEM IT	DOW FILMTEC US
Sfax	100	1	RO	SWM	ER	BRITISH GAS	SEA	POWER	1993	METITO GROUP AE	*Unknown
Gabes	22500	3	RO	SWM	HST	SONEDE	BRACK	MUNI	1993	CHRIST CH	TORAY JP
Jerba	12000	3	RO	SWM	*Unknown	SONEDE	BRACK	INDU	1997	CADAGUA ES	HYDRANAUTICS US
Zarzis	12000	3	RO	SWM	*Unknown	SONEDE	BRACK	INDU	1997	CADAGUA ES	HYDRANAUTICS US
	600	1	RO	SWM	*Unknown	SWISS INN	SEA	TOUR	1998	UNIHA AT	*Unknown
	750	2	RO	SWM	*Unknown		SEA	POWER	1999	IONICS US	HYDRANAUTICS US
Total	59365	29									

Source: 2002 IDA Worldwide Desalting Plants Inventory No. 17, Wangnick Consulting GMBH and IDA