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WORLDWIDE OIL PRIZE, DESALINATION AND POPULATION GROWTH CORRELATION STUDY

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Abstract

In this paper, the investment in new desalination capacity, expressed as daily production capacity, was studied as a function of oil production and population increase for a large group of countries for the last 25 years. These countries were selected for their large desalination production and Sweden presented as reference. Oil production correlated well with investments in new desalination capacity. On a yearly basis, the correlation was about 78 %, but taking into account the time needed from investment decision to inauguration of new desalination plants, the correlation increased. The world oil production two years prior inauguration correlated to 88 % with new world desalination capacity during the entire study time.

The total population for the studied countries was compared to the world population. In 1950, about 69 % of world population lived in the chosen countries, decreasing to 63 % in the year 2008 and according to population prognosis continues to decrease to 56 % in the year 2050 with occupied area of about 52 %. The total desalination capacities of these countries are slightly increased from 88 to 92 % in 1996 and 2008 respectively, and decreased to 90 % at 2050.

Increased desalination capacity means increased energy demand. To a large extent, the energy costs are site specific as are the costs of labour and capital, but the reported water price was about 2.5 US \$/m^3 desalinated water until the 1980s, decreasing to roughly US \$1.5/m^3 in the early 1990s and to about \$0.50/m^3 in the late 2003.

Key words – Seawater Desalination and Capacity; Oil Production; Population; Recovery Ratio; Brine Discharge; Salinity

1. Introduction

1.1. General

The main objectives of this study was to find the relationships between desalination plant projects, amount of water resources and population for the oil production and price. Three major questions will be considered for the study countries and globally in this work: Which are the driving forces for the investments in desalination plant projects? What is the percentage of fresh water produced by desalination over renewable water resources? Where is the most growth in population, desalination and oil production?

This paper has been written for evaluation three major parameters (population, oil production and renewable water resources) as driving forces for desalination projects. The oil productions have good correlation to increasing fresh water from desalination. There have been found good relation between growth in population and oil production countries e.g. Saudi Arabia, United Arab Emirates, Kuwait and Qatar.

Desalination is an important method for producing potable water in the world. Usually a country is considered to risk water shortage if renewable water resources are below 1000 m^3/capita/yr (Al-Gobaisi, 1997). Desalination is a quickly growing technology, not the least visual through the large number of regional and international organizations established during the last 30 years (the International Desalination Association (IDA), the Australian Desalination Association, the European Desalination Association (EDS), the Southeast Asian Desalination Association, the American Desalination

Association, and the Middle East Desalinisation Research Center (MEDRC) (Cooley, et al, 2006)). Desalination has been a freshwater supply opportunity for a long time, especially at remote locations and, especially, on naval ships at sea site. A British patent was granted for such a device in 1852 (Simon, 1998). The island of Curaçao in the Netherlands Antilles has had desalination plants in operation since 1928. A major seawater desalination plant was built in 1938 in what is now Saudi Arabia and an early version of a modern distillation plant was built in Kuwait in the early 1960s (Cooley, et al., 2006).

Desalination is an important source of fresh water in parts of the arid Middle East (e.g. Saudi Arabia, United Arab Emirates, Oman, Qatar and Kuwait etc.), along the shores of the Persian Gulf/Arabian Gulf, Red Sea, Mediterranean Sea, in North Africa, on the Caribbean islands, and other locations where the amount of renewable fresh water is insufficient for the population. Thus, in order to meet the demand where traditional water-supply options or transfers from elsewhere are considered as uneconomical, desalination capacity must increase. The concept of desalination refers to a wide range of processes designed to remove salts from waters of different salinities as collected from different areas see Table 1. All major water sources can be utilized as raw water supply for desalination, except the Dead Sea. Salinity affects the efficiency and the economy of the desalination plants: the more saline raw water sources, the costlier is the production.

1.2. Desalination and energy

The amount of water in the hydrosphere is approximately estimated to be about 1,400 Mkm^3, 95.5 % of which is saltwater present in oceans and seas, and the rest 4.5 %, is fresh water (Ruiz et al., 2007). Desalination plants production percentage as function of their raw water sources are shown in Table 2. The difference found in the two references is due to different years of finding this percentage in which 2008–09 is the most recent and accurate values. The installed capacity by technology is as follows: reverse osmosis (RO) 60 %, multi-stage flash evaporation (MSF) 28 %, multi-effect distillation (MED) 9 %, and electrodialysis (ED) 4 % (GWI Desalination data IDA 2008–09).

The specific energy need for desalination of seawater reverse osmosis (SWRO) has decreased with the development of energy reuse systems. At present, 1 cubic meter of desalinated water consumes 3.7 kWh of energy, mainly electricity (Gary, 2006). Although the investment and operational costs of desalination plants depend on where they are located, total production costs decreased from roughly \$2.5/m^3 in the late 1970s to \$1.5/m^3 in the early 1990s to around \$0.50/m^3 2003 (Pankratz, 2004). The total primary energy supply for desalination by source was in 2002 as follows: Oil 35.8 %, coal 23.0 %, gas 20.9 %, combustible, renewable and waste 10.8 %, nuclear 6.8 %, hydro 2.2 %, geothermal/solar/wind 0.5 % (IEA, 2005). Desalination relies heavily on fossil fuels.

The world average renewable hydrological resources (not considering desalted and reused waters) are about 42,750km^3/yr, or 1 % the total volume of superficial waters (fresh or salt). Only six countries host 50 % of the renewable water resources (i.e. Brazil, Canada, Russia, United States, China and India). Five great rivers discharge 27 % of these renewable resources to the sea (Amazon, Ganghes-Brahmaputra, Congo, Yellow and Orinoco) (Ruiz et al., 2007 and Valero et al., 2001).

2. Desalination types comparisons

2.1. Desalination and technologies used

There is no single best method for desalination. Feasibility studies should always be executed according to local conditions such as site-specifications, raw water salt con-

Table 1. *Salt concentrations of different world water sources (OTV, 1999; Gleick, 1993; and Magazine, 2005).*

Water source or type	Concentration (g/l, ppt)
Brackish waters	0.5 to 3
North Sea (near estuaries)	21
Gulf of Mexico and coastal waters	23 to 33
Atlantic Ocean	35
Pacific Ocean	38
Persian Gulf/Arabian Gulf	45
Mediterranean Sea	38.6
Red Sea	41
Dead Sea	~300

Table 2. *Distribution of global desalination capacity by source water.*

Water source	Worldwide installed capacity, %	
	Wangnick/GWI (2005)	GWI Desalination data IDA (2008–09)
Seawater	56	62
Brackish	24	19
River	9	8
Waste water	6	5
Pure	5	5
Brine	<1	

Table 3. *Comparison of reverse osmosis (RO) versus thermal multi-stage flash (MSF) in seawater desalination (MEDRC 2002; Lattemann and Höpner).*

Properties	Reverse Osmosis (RO)	Multi-Stage Flash (MSF)
Raw water salinity	Up to 65–85 g/L.	About 50 g/L.
Temperature	Approximately ambient seawater temperature.	+5 to 15°C above ambient.
Plume density	Negatively buoyant brine discharge.	Positively, neutrally or negatively buoyant depending on the process of brine mixing.
Chlorine	If chlorine is used to control biofouling, these are typically neutralized before the water enters the membranes to prevent membrane damage.	Approx. 10–25 % of source water feed dosage, if not neutralized.
Cleaning chemicals	Alkaline (pH 11–12) or acidic (pH 2–3) solutions with additives such as: detergents (e.g. dodecylsulfate), oxidants (e.g. sodium perborate), biocides (e.g. formaldehyde).	Acidic (pH 2) solution containing corrosion inhibitors such as benzotriazole derivates.

centration, economics, the quality of water needed, and local engineering experience and skills (Cooley et al., 2006). There are three types of desalination methods used throughout the world for a wide range of purposes, but mainly for potable water production for domestic and municipal use.

a. *Membrane Systems*: Reverse osmosis (RO) or Electrodialysis and Electrodialysis Reversal (ED) (Heberer et al., 2001; Sedlak and Pinkston 2001 and NAS, 2004).
b. *Thermal Processes* (TP): Multi-Stage Flash Distillation (MSF) Multiple-Effect Distillation (MED), and Vapor Compression (VC) (Birkett, 1999 and Wangnick/GWI, 2005).
c. *Other Desalination Processes*: Different types of water can be desalinated through many other processes including small-scale ion-exchange resins, freezing, and membrane distillation (MD) (Wangnick/GWI, 2005).

At the beginning of the 1970s, the number of installed reverse osmosis plants grew; these systems have some advantages and some disadvantages compared to thermal systems. Thermal desalination systems produce water quality of less than 25 parts per million (ppm) as total dissolved solids (TDS) compared to membrane systems of less than 500 ppm, TDS (USBR, 2003). Some of the advantages and disadvantages are presented in Table 3 as a difference between reverse osmosis (RO) and multi-stage flash (MSF).

2.2. Input/Output scheme

There are generally three different types of water flows in a desalination plant: freshwater production Q_F, brine discharge Q_{Brine}, and seawater intake Q_{Intake}, see Figure 1, in which a reverse osmosis system is used for seawater desalination plant. Pre and post treatment processes are also described including some process. S_{Intake} and Q_{Intake} are salinity and volume flux flow of seawater intake, S_{Brine} and Q_{Brine} are salinity and volume flux flow of brine discharge and S_F and Q_F are salinity and volume flux flow of fresh water produced by the desalination plant. From this, $S_{Brine} = S_{Intake}/(1\text{-}r)$ and $Q_{Brine} = (1\text{-}r)Q_{Intake}$, where r is the recovery ratio, the freshwater yield, typically in the order of 35 to 45 % of the intake. Further on, $S_F \approx 0$ and $Q_F = rQ_{Intake}$.

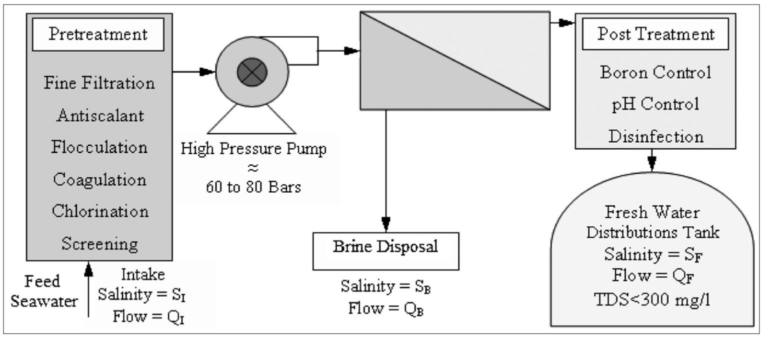

Fig. 1. *Reveres osmosis seawater desalination plant typical scheme showing input/output and different stages of treatment.*

During the last ten years of desalination development, the recovery ratio r has increased significantly in reverse osmosis plants. For example from Al Shaaer et al., 2007, if seawater intake salinity, S_{Intake} is equal to 41.7 ppt, and the brine directly front of output pipeline is equal to 74 ppt, then as $S_{Brine} = S_{Intake}/(1\text{-}r)$, the recovery ratio r = 44 %.

3. Methodology and data collection

In this study, 36 countries were identified hosting respectively about 88, 92 and 90 % of all desalination capacity of the world total capacity at years 1996, 2008 and predicted 2050 see Table 4. Sweden is also included in this study for comparison. The largest desalination

Table 4. *Comparison between world and major desalination capacities producers for 1996, 2008 and predicted values 2050 and population in three years.*

Country/area	Desalination capacity (Q_F) in 1000 m^3/day			Population in 10^6		
	Observed		Predicted	Observed		Predicted
	1996	2008	2050	1950	2008	2050
World	**20000**	**47709**	**192211**	**2555.9**	**6677.6**	**9392.8**
Algeria	190.8	1055.9	3044.1	8.89	33.77	44.16
Australia	82.1	587.1	1577.4	8.27	20.60	24.18
Bahrain	283.0	825.2	3022.0	0.115	0.718	0.973
Chile	83.5	260.8	926.7	6.091	16.454	19.387
China	42.0	1092.5	2402.6	562.6	1330.0	1424.2
Egypt	102.1	491.1	1479.6	21.20	81.71	127.56
France	29.1	230.3	603.7	42.52	64.06	69.77
Germany	96.0	356.7	1179.8	68.37	82.37	73.61
India	115.5	771.3	2108.8	369.9	1148.0	1807.9
Indonesia	103.2	242.8	985.2	82.98	237.51	313.02
Iran	423.4	547.8	3138.2	16.36	65.88	81.49
Iraq	324.5	476.6	2519.3	5.163	28.221	56.361
Israel	90.4	630.1	1703.6	1.286	7.112	10.828
Italy	483.7	824.3	3984.7	47.11	58.15	50.39
Japan	637.9	1487.6	6061.8	83.81	127.29	93.67
Kazakhstan	167.4	254.6	1317.3	6.693	15.341	15.100
Korea (South)	266.0	995.8	3283.9	20.85	49.23	45.22
Kuwait	1284.3	2308.7	10822.1	0.145	2.597	6.375
Libya	638.4	940.0	4961.1	0.961	6.17	10.82
Malta	145.0	248.4	1197.3	0.312	0.404	0.396
Mexico	105.1	336.4	1182.9	28.49	110.0	147.9
Netherlands	110.4	251.3	1036.9	10.11	16.65	17.33
Oman	180.6	582.7	2041.7	0.489	3.312	8.359
Qatar	560.8	1026.3	4761.9	0.025	0.929	1.239
Russia	116.1	244.2	1049.9	101.94	140.70	109.19
Saudi Arabia	5006.2	7750.8	39669.3	3.860	28.161	49.707
Singapore	133.7	512.1	1674.0	1.022	4.608	4.635
South Africa	79.5	104.2	592.0	13.596	43.786	33.003
Spain	492.8	3420.7	9258.7	28.063	40.491	35.564
Sweden	1.30	3.812	13.93	7.014	9.045	9.085
Taiwan	101.2	638.3	1771.9	7.981	22.921	20.161
Tunisia	47.4	98.8	426.7	3.517	10.384	12.512
Turkmenistan	43.7	165.8	543.9	1.204	5.180	7.592
UAE	2134.2	6094.7	22532.6	0.072	4.621	8.019
UK	101.4	442.2	1378.0	50.127	60.944	63.977
USA	2799.0	7525.1	28608.4	152.27	303.82	420.08
Sub Total	17602	43825	172862	1763	4181	5224
Percentage, %	88	92	90	69	63	56

Data based on: (U.S. Census Bureau; World Bank 2004; http://www.worldwater.org/data.html; Ghabayen et al., 2004; IDA, 2006; IDA, year book 2006–07 and 2007–08; Wiseman, 2006 and Lattemann and T. Höpner, 2008).

capacity is found in Saudi Arabia, with a daily capacity of about 5, 7.75 and 39.7 million cubic meters in 1996, 2008 and predicted 2050 respectively.

Desalination capacity were compared for world and major producing countries, until the beginning of the years 1996 and 2008 and prediction for the year 2050, including population and land area. The prediction for desalination capacity has been obtained by extrapolating the trendline of world desalination data from 1960 to 2008 as the best fit. The trendline was developed by some trials until matching with second degree polynomial and that was used for prediction of year 2050 desalination production globally and each country. Daily oil production and average cost per barrel were used from 1983 to 2008; it was 30.5 dollars per barrel in 1983, the yearly average was 30.6 and in 2008, the oil prize reached a maximum of 134 and an average of 109.6 US dollars per barrel (online from: Energy Information Administration).

From Table 4 it is clear that the population growth in the selected 36 countries will be slower than in the rest of the world. In 1950, about 69 % of the world population lived in the selected countries. In 2008, the share had decreased to 63 % and in the year 2050, it is estimated to be 56 % of world population. With respect to land area, the 36 selected countries represent slightly more than half of the global total land area (52 %).

The population used in this study is the data of 1950, 2008 and 2050 prognosis were obtained from U.S. Census Bureau, International: Data Base. The population increase over the 100 year period is about 7 billions people, which is very high relative to desalination and oil production in the whole world. The US Census Bureau growth rate has been used. The population growth rate is calculated using the formula:

$R(t) = \ln [P(t+1) / P(t)]$ where t = year; R(t) = growth rate from midyear t to midyear t+1; P(t) = population at midyear t and ln = natural log (U.S. Census Bureau, 2008).

Figure 2 is the logarithmic graph and alphabetic order, that shows the world major desalination countries producers to the left side for 1996, 2008 and predicted values for year 2050 and to the right side the amount per capita per year as found to be in 2050. Fresh water produced by seawater desalination is quite close to the world water standard as cubic meters per capita per year. It has been found in year 2050 with the same development the result in Saudi Arabia, United Arab Emirates, Kuwait, Qatar and Bahrain will be 189.3, 666.7, 402.8, 911.7 and 736.5 m^3/capita/yr respectively.

4. Results and discussions

The arid Middle East is also the main oil field of the world country producers as they are also the most important desalination producers in the chosen countries. In Table 5, the world desalination capacity is presented with oil production and cumulative oil cost for the years 1983–2008. Oil data available from 1983 until 2008 are compared with the same period of desalination and population in the world and study countries. Capital intensive desalination projects need financing. Freshwater supply is fundamental for the welfare of people, together with wastewater treatment, safe food production and industrial works. Also, water supply needs to follow population growth. Countries with proportionally higher population growth ratios may face larger challenges to tackle water scarcity and increasing oil cost.

The daily oil production and its cost, daily desalination capacity and population increases could be analyzed and compared for the last 25 years. The correlation between daily oil production and its cost and the desalination capacity was clear, see Figure 3. World daily desalination capacity as a function of daily costs for oil correlated to about 78 % if the same year of oil production and cost correlated with desalination capacity (Y0) and even better when the desalination capacity was superim-

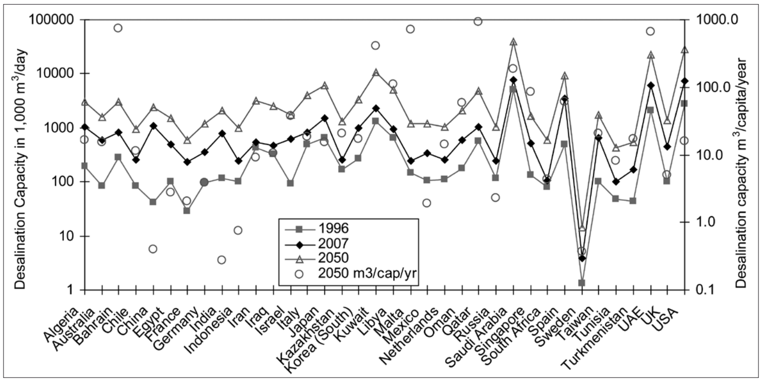

Fig. 2. *Major desalination countries producers and amount per capita per year for 1996, 2008 and prediction for the year 2050.*

Table 5. *World desalination capacity, oil cost and production and yearly population increases from the years 1983 to 2008 (online from: Energy Information Administration).*

Year	Population (millions)	Cumulative population increments (millions)	Yearly oil average cost (US $/barrel)	Oil daily production (million barrels/day)	Cumulative oil cost (millions US $/day)	Cumulative desalination capacity (MCM/day)
1983	4690.9	82	30.6	3.33	102	1.4
1984	4771.1	162	29.4	3.43	203	2.4
1985	4852.6	243	27.9	3.20	292	3.5
1986	4936.0	327	15.0	4.18	355	4.5
1987	5022.0	413	19.1	4.67	444	5.2
1988	5108.5	499	16.0	5.11	526	6.5
1989	5194.9	586	19.6	5.84	640	7.2
1990	5282.4	673	24.5	5.90	785	8.1
1991	5365.7	757	21.5	5.78	909	8.7
1992	5448.7	840	20.7	6.08	1035	9.7
1993	5530.0	921	18.5	6.79	1160	10.6
1994	5610.1	1001	17.2	7.06	1281	11.5
1995	5691.0	1082	18.4	7.23	1414	12.6
1996	5771.4	1162	22.0	7.51	1580	14.1
1997	5850.8	1242	20.6	8.23	1749	15.7
1998	5929.7	1321	14.4	8.71	1875	17.3
1999	6007.5	1398	19.2	8.73	2043	18.4
2000	6084.9	1476	30.2	9.07	2317	20.0
2001	6162.3	1553	25.9	9.33	2558	21.8
2002	6238.8	1630	26.1	9.14	2797	25.0
2003	6315.2	1706	31.0	9.66	3097	27.1
2004	6392.4	1783	41.4	10.09	3514	30.6
2005	6470.3	1861	56.6	10.13	4087	33.2
2006	6548.7	1940	66.2	10.12	4757	36.4
2007	6627.5	2018	72.3	10.03	5482	41.0
2008	6707.0	2098	109.6			45.8

posed 1 year after the year of oil production and cost (Y1: 86 %) and slightly better when superimposed 2 years (Y2: 88 %). In other words, one important driving force for investments in building a new desalination plant projects seems to be incomes from oil. This correlation could help us to make prognosis for new projects related to the fresh water supply in the oil producing countries, as for example Saudi Arabia and Qatar.

In Figure 4, the increase in world population is correlated with the daily oil production and cost for the last 25 years (data from Table 5). The correlation is equal to 81 % between population and oil cost namely. The

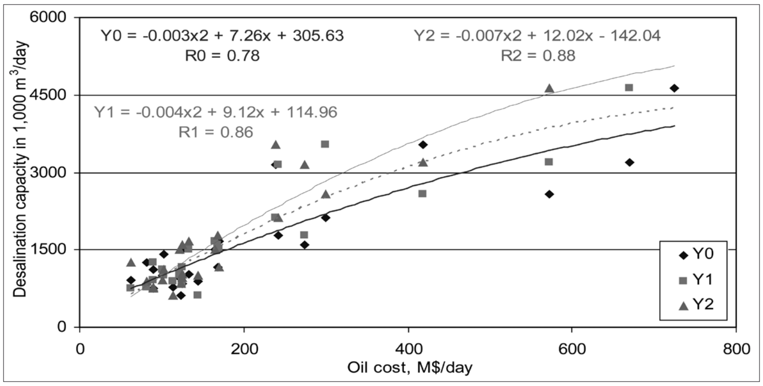

Fig. 3. *World daily desalination capacity versus world daily oil costs.*

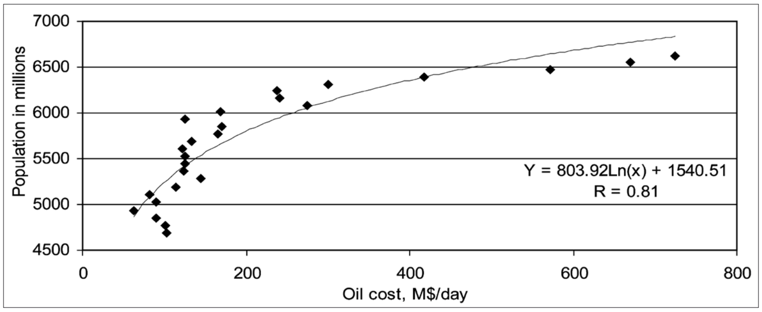

Fig. 4. *World population versus world daily oil costs.*

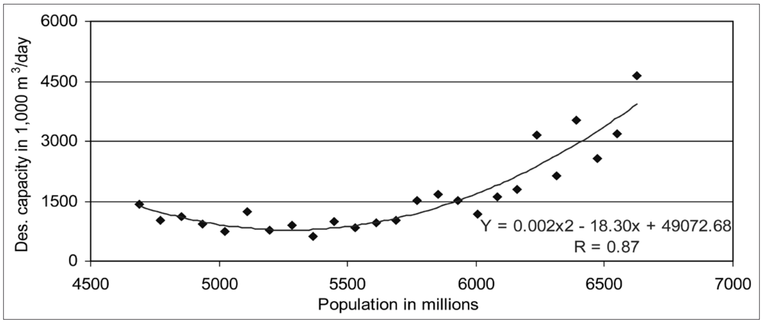

Fig. 5. *World daily desalination capacity versus world population.*

annual variation in population growth rate is limited. Another important driving force for investments in desalination seems to be the population increase; it is found to correlate with 87 % as shown in Figure 5. As seen in Figure 6 the three main parameters world cumulative daily desalination capacity, cumulative daily oil cost and cumulative population increments in the last 25 years are compared from year 1983 to 2007.

The total annual renewable freshwater supply, population growth rate and the country desalination capacity over country total annual renewable freshwater of the major producer countries are presented in Table 6. The 36 countries account an average of 90 % of the world total desalination production capacity and about 34.6 % of the world total annual renewable fresh water. These countries are distributed into two groups depending on population growth rate (PGR) in which the first group, countries from 1 to 21, has (PGR > 1.0) and the second group, countries from 22 to 36, has (PGR < 1.0).

The two groups are shown in Figure 7 as the result of the total country desalination capacity over total renewable freshwater and population growth rate. The year and source of the annual renewable water resources available in this study is taken and recalculated from (Source: http://www.worldwater.org/data.html) where the last update was in 2006. The 36 countries account

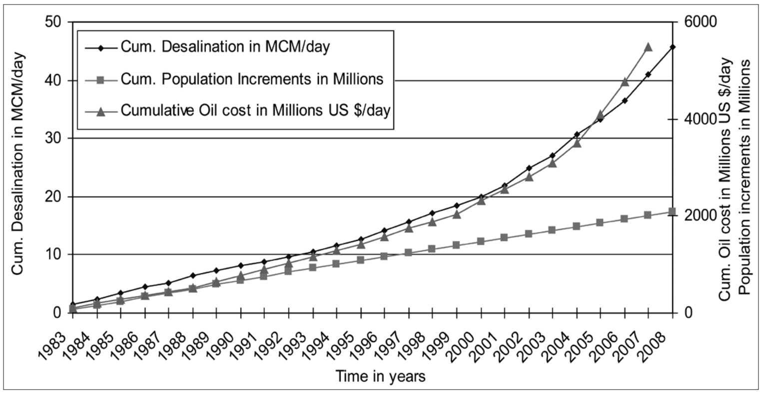

Fig. 6. *World cumulative daily desalination capacity, cumulative oil daily cost and cumulative population increments from year 1983 to 2008.*

Table 6. *Total annual renewable freshwater supply and population growth rate (PGR) in the major desalination producer countries (Update: 2006, Source: http://www.worldwater.org/data.html)*

Country	Annual renewable water resources (km^3/yr)	Year	Source	Desalination over renewable water Ratio	100 years PGR 1950–2050
Group 1					
UAE	0.15	1997	f	10.0	4.72
Qatar	0.05	1997	f	5.46	3.90
Kuwait	0.02	1997	f	32.8	3.78
Oman	0.99	1997	f	0.14	2.84
Saudi Arabia	2.40	1997	f	0.97	2.56
Libya	0.60	1997	c,f	0.48	2.42
Iraq	96.4	1997	f	0.002	2.39
Bahrain	0.12	1997	f	1.74	2.14
Israel	1.70	2001	l,m	0.08	2.13
Egypt	86.8	1997	f	0.001	1.79
Mexico	457.2	2000	j	0.0002	1.65
Iran	137.5	1997	f	0.001	1.61
Algeria	14.3	1997	c,f	0.02	1.60
India	1907.8	1999	h	0.0001	1.59
Singapore	0.60	1975	d	0.20	1.51
Indonesia	2838.0	1999	h	0.00002	1.33
Turkmenistan	60.9	1997	m	0.001	1.27
Tunisia	4.6	2003	m	0.006	1.24
China	2829.6	1999	h	0.0001	1.16
Australia	398.0	1995	i	0.0003	1.07
USA	3069.0	1985	n	0.001	1.01
Group 2					
Chile	922.0	2000	j	0.0001	0.93
Taiwan	67.0	2000	r	0.002	0.93
South Africa	50.0	1990	c	0.001	0.89
Kazakhstan	109.6	1997	g	0.001	0.81
Korea (South)	70.0	1999	h	0.003	0.77
Netherlands	89.7	2005	s	0.001	0.54
France	189.0	2005	s	0.0003	0.50
Sweden	179.0	2005	s	0.00001	0.26
UK	160.6	2005	s	0.001	0.24
Malta	0.07	2005	s	1.03	0.24
Spain	111.1	2005	s	0.006	0.24
Japan	430.0	1999	h	0.001	0.11
Germany	188.0	2005	s	0.0004	0.07
Russia	4498.0	1997	e,g	0.00001	0.07
Italy	175.0	2005	s	0.001	0.07

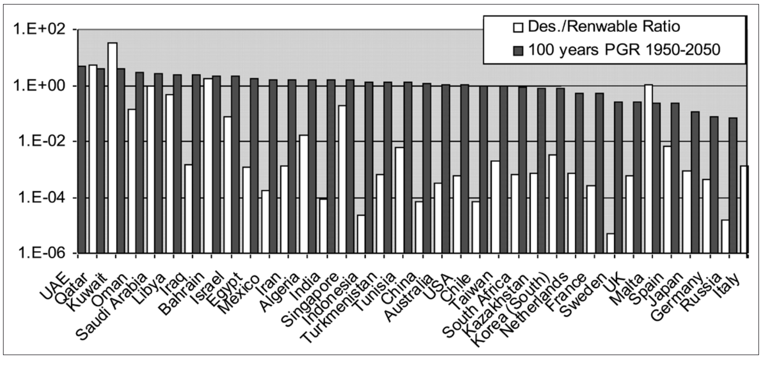

Fig. 7. *Results of total country desalination capacity over renewable freshwater supply and population growth rate.*

90.7 % of the world desalination capacity until mid of year 2008 as found in the calculation. Further on, the countries of the first group have in total 72 % of the world desalination capacities (i.e. 79 % of the 90.7 %), and the countries of the second group account for 18.7 % of the total world desalination capacities (or 21 % of the 90.7 %).

Looking at the shares of renewable freshwater supply is more revealing. In total, the two groups counted for 34.6 % of the world total annual renewable fresh water, but this value is distributed so that the countries of the first group has a share of 21.5 % of the world total annual renewable fresh water (which make 62 % out of 34.6 %), while the countries of the second group has a share of 13 % of the world total annual renewable fresh water (or 38 % out of 34.6 %).

Some countries have been found in the first group (Tunisia, Qatar, Kuwait and Bahrain) have to increase their desalination projects to cove the shortage of production and renewable fresh water. This water supply is challenged by the high population growth rate (greater than 1.0) an low amount of renewable fresh water. Some countries in the second group have at present severe problems with fresh water supply due to shortage of renewable water resources (Spain, Italy and South Korea). Investment in desalination seems also to correlate both with high population growths and the obvious lack of renewable water resources.

5. Conclusion

Desalination offers both advantages and disadvantages in terms of energy, environmental impact and population growth needs. The potential benefits of seawater desalination are great since the water supply can be independent of precipitation, but the economic and environmental costs remain high without national and international rules and regulations. In the non-oil countries, desalination is an attractive alternative for freshwater supply if the renewable water resource is very scarce. In oil-producing countries in arid area (e.g. some countries of group one), desalination is at present necessary for water supply and will be even more important with growing population. High revenues from oil export trigger the investment in new desalination plants with a time-lag of 2 years. Oil and desalination comes in pairs. Still, desalination requires high energy input and produces not only freshwater, but also brines with high salt concentrations. These are often discharged directly into the sea. On a local level, continuously discharged brine will result in salinity increases. Such increases in salinity concentration will exacerbate the critical problem of seawater intrusion into coastal groundwater aquifers.

As (Cooley et al., 2006) summarised: Is desalination the ultimate solution to our water scarcity problems? (No!) Is it likely to be a piece of our water production and management scheme? (The answer now is yes)

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