Research Paper

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The Costs of Municipal Water Supply in Bahrain

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CHATHAM HOUSE
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The Valuing Vital Resources Series

The Valuing Vital Resources initiative encourages incentives for the sustainable use of energy, water and food through furthering understanding of the economic and societal costs of their interlinked modes of use and production. It involves a series of dialogues, materials and country focused reports to gather and make available international experience in cost-assessments, price reform and related policies. The idea is to provide tools and expert networks that can support countries which currently administer resource prices and are in the process of, or considering price reforms.

This Research Paper

This paper was commissioned as part of the Valuing Vital Resources research series focused on the Arab Gulf region. Meeting water consumption in Bahrain, Kuwait, Iraq, Oman, Qatar, Saudi Arabia and the United Arab Emirates will be a major challenge during and beyond the next decade owing to depleting groundwater (and in Iraq's case, rivers) and rapidly rising urban and industrial demand. Desalination of sea and brackish water now accounts for the majority of non-agricultural water use in the Gulf Cooperation Council (GCC) countries, with gas or oil, or both, being key inputs. While authorities in the region often explain that water supplies are 'subsidized', the current and longer-term costs of meeting demand with desalinated water are not widely understood. This assessment of the costs of water supply in Bahrain aims to inform policy-makers and consumers about the trade-offs involved in the current system of pricing and consumption. It should be of great interest to other GCC countries, which have similar systems, and other countries intending to scale up desalinated water supplies.

Summary

- The costs of municipal water supply in Bahrain, 88 per cent of which comes from desalination plants, is much higher than the price that households and businesses pay for it.
- Official direct government subsidies for the municipal water sector stood at BD123 million (US$326m) in the financial year 2012/13, having risen by 173 per cent since 2006 as water demand and the costs of domestically produced natural gas increased. Even water consumption of over $100m^3$/month – a category into which 31 per cent of subscribers fall – receives a subsidy of more than 70 per cent.
- This does not account for wastewater collection, treatment and reuse, all of which are provided free of charge.
- On current plans and projections, Bahrain will be able to increase desalination capacity to meet municipal water demand to 2030, but this will entail heavy financial, economic and environmental burdens.
- Between 2013 and 2030, this would result in cumulative costs of US$11 billion and consume 15.9 billion m^3 of Bahrain's gas – driving competition for limited gas resources between industrial and municipal sectors – as well as emitting 78 million tonnes of carbon dioxide (CO_2).
- Additional desalination costs to society not analysed in this paper include the impacts of gaseous emissions on local health and of brine discharges on seawater quality and marine ecosystems.
- Revising the municipal water tariff structure would help conserve water, enhance cost recovery and contribute to achieving social equity among water consumers. Implementing a tariff for servicing of wastewater and provision for reuse would have similar benefits, as well as encouraging efficient water use in irrigation.

The price of water in Bahrain

In the Kingdom of Bahrain, a block-rate water tariff in the municipal sector was introduced in 1986[1] and modified in 1992. In the last quarter of 2013, the government planned to reduce subsidies gradually for non-domestic (commercial and industrial customers) municipal water users by restructuring the tariff. From October 2013, the tariff for non-domestic consumers using more than 1,000m^3/month rose to US$1.33 (0.500 BD)/m^3, to be increased annually by US$0.265 (0.100 BD)/m^3, reaching US$1.86 (0.700 BD)/m^3 – the cost price – in 2016. There are currently no plans to raise domestic prices. Table 1 shows the tariff as of late 2014.

Table 1: Municipal water supply tariff structure, 2013/14

Price in US$/m^3 (BD/m^3)	Consumption per month (m^3)	Block	Sector
0.07 (0.025)	<60	1	Domestic
0.21 (0.080)	61–100	2	
0.53 (0.200)	>100	3	
0.80 (0.300)	1–450	1	Non-domestic
1.06 (0.400)	450–1,000	2	
1.59 (0.600)*	>1,000	3	

*As of October 2014.
Source: Electricity and Water Authority (EWA), Government of Bahrain.
Note: BD = Bahraini dinar (=2.65 US$).

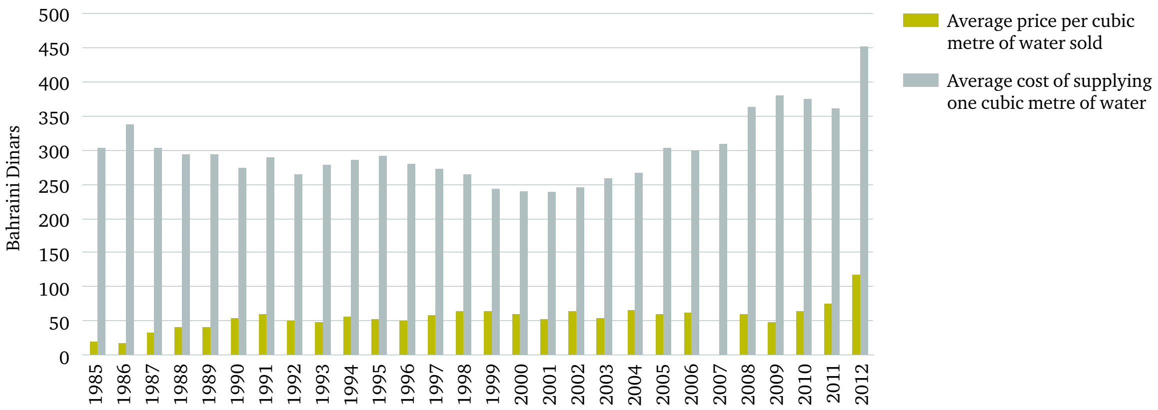
The costs of supplying water

Figure 1 shows the cost per cubic metre of the water supplied, including 'non-revenue water',[2] according to the Electricity and Water Authority (EWA) in Bahrain, for the period 1985–2012. This includes the costs of production, conveyance and distribution of both desalinated water (88 per cent) and groundwater (12 per cent) to fulfil municipal demand. The cost averages US$0.78 (BD0.295) versus an average sales price to the municipal consumer of US$0.15 (BD0.055) for the same period. The increase in 2008 and 2009 was primarily due to the increase in the cost of energy. The cost of natural gas gradually increased – from US$1.20/million British thermal units (mmBtu) gross (US$1.33/mmBtu net) to US$1.5/mmBtu gross in August 2011, to US$2.25/mmBtu gross from January 2012.

The relatively large increase in the cost of water supply in 2012 is due to the dispatch issues normally associated with new independent power and water project (IPWP) plants operating at a lower load factor, as well as an increase in the price of energy. However, from 2013 onwards the cost of water supply is expected to follow the previous levels, averaging about US$0.93 (BD0.350)/m^3, assuming an energy (natural gas) cost of US$2.25/mmBtu gross (US$2.5/mmBtu net).

[1] Ministerial Order No. 3, 1985 Concerning the Establishment of Municipal Desalinated Water, Ministry of Electricity and Water, Government of Bahrain.
[2] Water that is lost before it reaches the customer or unaccounted for by bill payments.

Figure 1: Average price and supply cost of a cubic metre of water in the municipal sector, 1985–2012



Sources: 1985–2007: Al-Masri, 2011; 2008–12: Dr Khalid Burashid, Deputy CEO, Bahrain Electricity and Water Authority, personal communication with author.
Note: 2007 sale prices were not given in the source; 2012 figures are estimates.

The total *financial* cost of water supplied is higher. These costs are calculated by dividing the total expenses (fixed and variable) by the total quantity of water produced and are usually given in US$/$m^3$ or BD/m^3. Fixed costs include capital amortization, insurance, fixed operation and maintenance costs such as salaries, wages, equipment maintenance, etc. The variable costs consist of energy, chemicals or other consumables and costs of membrane replacement (in the case of reverse osmosis (RO) desalination plants). The full financial costs for 2012/13 range from US$1.92 to US$1.86/m^3 (and average US$1.89/$m^3$).[3]

Subsidies for municipal water supply

It is clear that the domestic tariff is very low relative to the total cost of municipal water supply. Even though the non-domestic tariff is moving towards full cost, these customers represent only 10 per cent of the total municipal water consumption. This means the EWA has low cost recovery. On the basis of full financial costs, bill payments cover only about 20 per cent of the costs of supplying municipal water, the remainder being compensated by government funding.

Table 2 illustrates the monetary values of the subsidies for the municipal sector. In 2006, the government of Bahrain subsidized the municipal water supply by about US$120 million (45 million BD).[4] This figure has been increasing every year owing to the increase in municipal water demand, reaching about US$326 million (123 million BD) in 2012–13.

Table 2: Number of domestic and non-domestic subscribers and annual subsidies, Q4, 2013

Annual subsidies (BD million)	Number of subscribers	Sector
100	197,956	Domestic
22.9	22,326	Non-domestic
122.9	220,282	Total

Source: Government of Bahrain.

[3] Personal communication, Khalid Burashid, Deputy CEO, Electricity and Water Authority, April 2014.
[4] Al Masri, N. A.(2011),'Identification of Current and Future Water Issues in the Kingdom of Bahrain', unpublished report, Water Research Project, EWA and Bahrain Center for Studies and Research (BCSR), Kingdom of Bahrain (in Arabic).

Yet analysis of the domestic (household) tariff structure indicates that even in the case of high consumption (i.e. the third block, consuming more than 100m^3 per month – see Table 1), the pricing of water, which is set at US$0.53 (0.200BD)/m^3, is not even near the current range of the true cost of water supply (US$1.92–1.86/m^3), revealing a subsidization of more than 70 per cent. In other words, the government not only subsidizes consumers who conserve water – i.e. in the first block (0–60m^3/month), and to some extent the second block (61–100m^3/month) – but also heavily subsidizes consumers in the third block who are using water in a wasteful manner.

Moreover, the EWA data indicate that the average proportion of municipal water consumers falling within the first block is about 56 per cent (ranging from 53.8 to 58.9 per cent) of the total municipal water consumption (Figure 2); for the second block it is about 13 per cent (ranging from 10.9 to 14.6 per cent). About 31 per cent of all consumers are in the third block (ranging from 26.5 to 35.3 per cent).

While over half of consumption falls within the first block and could be considered as representing basic human needs at the household level, requiring a highly subsidized price to make water accessible to everyone, the relatively high consumption rate in the third block indicates that the tariff does not present a strong enough incentive for the high-income households to use water carefully. In fact, high water consumption is subsidized more than modest consumption. Revising the current tariff structure, particularly for the third block, would therefore not only help in conserving water and increase the percentage of costs recovered, but it would also contribute to achieving social equity among water consumers.

Figure 2: Proportions of municipal water consumption per tariff block

Source: EWA.

The costs of wastewater treatment and reuse

The amounts of generated and collected wastewater are driven by urban water consumption. In 2013 the total volume of collected and treated domestic wastewater was about 122 million m^3/yr (Mm^3). Out of this about 36 Mm^3 was treated to a tertiary level and reused for irrigating farms and landscaping. The remainder was treated only to a secondary level and then discharged to the sea in Tubli Bay. The latest preliminary estimated figures (2013) for the wastewater sub-cycles (i.e. collection, treatment and reuse[5]) are US$0.4 (0.150 BD)/m^3, US$0.53 (0.200 BD/m^3) and US$0.13–0.27 (0.05–0.100 BD)/m^3), respectively;[6] i.e., a total of about US$1.1 (0.400 BD)/m^3).

Currently, there are no existing tariffs for wastewater collection and treatment, nor for reuse, all of which are provided free of charge. Hence the wastewater sector depends entirely on government budget allocation. Such financial conditions have driven the sector to partner with the private sector (build-own-operate-transfer (BOOT) scheme) to build a new wastewater treatment plant (Muharraq STP), while most of the sector's other programmes are awaiting funds, expected to be obtained through loans from regional funding agencies. Implementing a tariff for the wastewater collection and treatment service, even if indirectly, would enhance the financial capabilities of the sector and improve its performance. The absence of an explicit tariff (even if only a 'symbolic' or 'shadow' tariff) deprives the management of the municipal water sector of an incentive mechanism for water conservation. Moreover, a symbolic wastewater reuse tariff, whereby farmers would pay a nominal cost but the full cost would be made transparent, would have two benefits. Not only would it contribute to cost recovery in this sector, but it could also encourage efficient water use in irrigation as government agencies would be motivated to invest or create the right investment incentives.

The wider costs of water supply to Bahrain

While Bahrain has been able to meet the rising municipal water demand through expanding the capacity of desalination plants, this is imposing increasing costs on the country, in terms of financing, asset depletion and environmental impact.

Energy input

The primary fuel used for desalination is indigenously produced natural gas, which is more efficient, less costly and less environmentally harmful than oil. However, the total volume of energy used to produce desalinated water in Bahrain has been increasing progressively in the past 10 years, showing an increase of about 48 per cent during the period 2000–10. The author estimates that in 2010 it accounted for about 30 per cent of total national energy use (see Table 3).

Table 3: Installed capacities and primary energy use for desalination

Item	2000	2005	2010	2012
Actual desalination capacity (MCM/yr)	41.5 (SPWS)	41.5	41.5	41.5
	28.2 (RAJ)	28.2	28.2	28.2
	6.6 (ADUR)	6.6	6.6	6.6
	50 (HIDD)	50	150	150
	–	11.6 (Alba)	11.6	11.6
	Total = 86.3	Total = 137.9	Total = 237.9	Total = 237.9
Estimated primary energy used (mtoe)[a]	2.37 bn kWh	2.65 bn kWh	3.45 bn kWh	3.45 bn kWh
National primary energy used (%)[b]	44.2	33.4	29.7	

Note: Alba total installed capacity is 11.6 MCM; the government is buying desalinated water ranging between 6–11 MCM from Alba;
a = in kWh, calculated according to capacities: MSF = 24 kWh/m^3, MED = 8 kWh/m^3, RO = 5 kWh/m^3;
b = national energy consumption for Bahrain obtained from Open Data for Bahrain government website (www.knoema.com);
2000 = 5.36 bn kWh, 2005 = 7.92 bn kWh, 2010 = 11.61 bn kWh, 2012 data are not available.

[5] The costs are estimated at the Directorate for Sanitary Planning & Engineering, Ministry of Works, based on actual spending by the ministry for each stage of these three sub-cycles: collection, tertiary treatment and delivery to the farmers.
[6] Personal communication, Khalifa Al-Mansour, Assistant Undersecretary, Sanitary Planning & Engineering, Ministry of Works, 23 March 2014.

The *opportunity cost* and *in situ* value of gas used to meet municipal water demand needs careful attention. This is especially crucial for Bahrain given its limited gas reserves and the fact that its future natural gas requirements will have to be imported.[7] This will have repercussions not only for the desalination sector but also for the industrial sector, which relies on such fuel. Under Bahrain's operational conditions, with MED and MSF desalination technologies, every cubic metre of desalinated water requires on average 8,640 kilojoules (equivalent to 24 kWh of electricity). Discounting losses in the energy conversion process, which could be as much as 40 per cent, this is equivalent to 2.064 kg of oil equivalent (kg oe), or about 2.71m^3 of natural gas.[8]

On current projections, Bahrain will not import liquefied natural gas before 2030. However, on the basis of current trends in the expansion of energy-intensive industries, and their competition for the same source of energy, depletion of natural gas reserves is likely to occur more rapidly than anticipated. Once imports begin, this would necessarily raise the water cost.

Emissions

In terms of greenhouse gas emissions, for every cubic metre produced by desalination, a range of 10–20 kg of carbon dioxide (CO_2) for cogeneration multi-stage flash (MSF) technology, 11.2–19.6 kg CO_2 for cogeneration multi-stage effect desalination (MED), and a value of 3.6 kg CO_2 for seawater reverse osmosis (SWRO) is emitted.[9] A weighted average figure of 13.13 kg/m^3 CO_2 can be used to estimate the CO_2 emissions based on the current desalination technology mix in Bahrain (MED 45 per cent, MSF 37 per cent and RO 18 per cent). Other desalination plant emissions relevant to local air pollution include carbon monoxide and dioxide (CO and CO_2), nitric oxide (NO), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2). These are not quantified here.

The cost of increasing desalination capacity

Moreover, it is estimated that the capital expenditure for desalination plants has been increasing; from US$1,320 per m^3/day of capacity during the period 1995–2000 to about US$1,540 per m^3/d in 2000–05, and to US$1,760 per m^3/d in 2005–10.[10]

Table 4: Specific capital expenditure in US$/($m^3$/d) for desalination plants

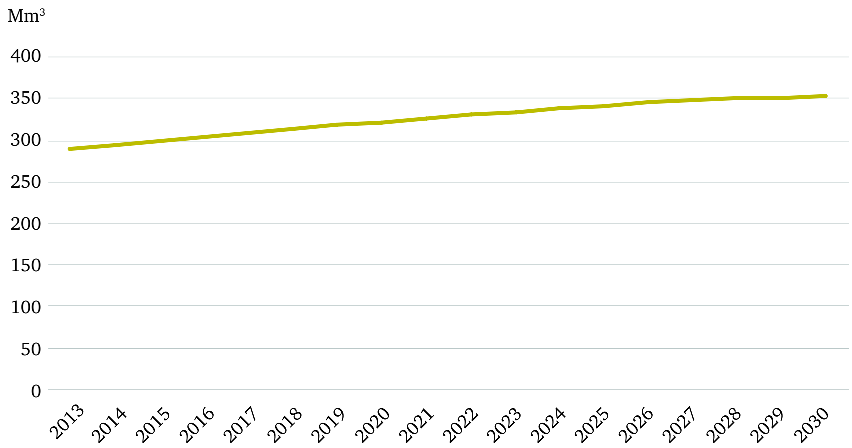
Plant type	1995–2000	2000–2005	2005–2010
MSF	1,320	No plant constructed	No plant constructed
MED-TVC	No plant constructed	1,540	No plant constructed
SWRO	No plant constructed	No plant constructed	1,760

[7] For a more detailed discussion on the cost and pricing considerations for domestically produced natural gas, see Lahn, G. and Stevens, P., *Finding the 'Right' Price for Exhaustible Resources: The Case of Gas in the Gulf*, Chatham House Programme Report, 2014. Available at: http://www.chathamhouse.org/publication/finding-%E2%80%98right%E2%80%99-price-exhaustible-resources-case-gas-gulf.
[8] 1 kWh = 0.086 kg oe = 0.113m^3 natural gas.
[9] MSF and MED are thermal desalination technologies which use heat for evaporation. These are often teamed with electricity generation in 'cogeneration' plants producing both electricity and water. SWRO uses membranes to filter the water and is powered by electricity. CO_2 calculations from Sommariva, C. (2010),'Efficiency improvements in power desalination for better environmental impact', notes of a workshop, Jeddah.
[10] This reflects the costs of desalination technologies deployed over these periods; the first was dominated by MSF, the second by MED and the third by SWRO.

However, it should be noted that all desalination plants built during these periods were independent power and water projects (IPWPs) from which the government purchases water at various rates.[11]

The author has been involved in creating a dynamic mathematical model representing Bahrain's water resources system using the WEAP21 (Water Evaluation And Planning) model.[12] Using this, the current and future municipal water supply in Bahrain are calculated on the basis of the government's population projections, and current per capita consumption in different areas of Bahrain is assumed with climate change impacts taken into consideration (Figure 4). Using the above-mentioned cost indicators enables calculation of future costs of the municipal water supply – financial (at current prices), economic (indicated by natural gas asset consumption) and environmental (indicated by CO_2 emissions). Table 5 illustrates these cost indicators for the period 2013–30.

Figure 4: Estimated future municipal water supply in Bahrain



Source: Projected municipal water demand for Bahrain using the WEAP model.

The total desalination capacity in Bahrain will reach about 318 million m^3/yr by the end of 2014. If official population projections play out and the current percentage share between desalinated water and groundwater in the municipal water supply mix remains the same, this desalination capacity would be able to satisfy municipal water demand until 2030. However, this will entail high costs for Bahrain. Using the three cost indicators mentioned above (financial cost, gas consumption and CO_2 emissions), it would cost about US$11 billion, consume about 15.9 billion m^3 of its natural gas reserves[13] and emit about 78 million tonnes of CO_2.

There are other important externalities and costs associated with rising municipal water consumption which are not factored into the estimates in Table 5. These are chiefly the cost of treating water and the impact of brine discharge, as explained below.

[11] In 2006 the government sold its desalination plant (al-Hidd) to the private sector as part of a privatization drive to lower the cost. Since then all desalination plants have been built as an IPWP and the actual figures for costs are not available. The water authority is buying the water produced by these plants at a certain price and electricity at a negotiable price.

[12] Al Zubari, W.K., El Sadek, A.A., Al Aradi, M.J. and Al Mahal, H.A. (forthcoming 2015), *Assessment of Climate Change Impacts on Water Resources in the Kingdom of Bahrain: Vulnerability and Adaptation*. UNDP and AGU. For detailed information on WEAP21 visit: http://weap21.org.

[13] Bahrain's proven natural gas reserves are estimated at 920 billion cubic metres, and average annual growth in the consumption of natural gas is about 4%. Natural gas production comes from two main sources: natural gas itself, representing about 80%, and associated gas, accounting for 20%. All natural gas is consumed locally, with 33% used for electricity generation, 27% for aluminium production, 18% reinjected back to oil fields, 8% used for petrochemical production, and the remaining 14% used for assorted industrial applications. See Environment High Council (2012), Bahrain Second National Communication to the UNFCCC, Environment High Council (formerly the Public Commission for the Protection of Marine Resources, Environment and Wildlife), Kingdom of Bahrain.

Table 5: Estimated future municipal water demand and associated costs

Year	Municipal water consumption (million m^3)	Financial cost (million US$)	CO_2 emissions (million tons)	Gas consumption (million m^3)
2013	289.5	547.2	3.8	784.5
2014	294.6	556.8	3.9	798.4
2015	299.5	566.1	3.9	811.6
2016	304.3	575.1	4.0	824.7
2017	308.8	583.6	4.1	836.8
2018	313.3	592.1	4.1	849.0
2019	317.6	600.3	4.2	860.7
2020	321.8	608.2	4.2	872.1
2021	325.9	616.0	4.3	883.2
2022	329.9	623.5	4.3	894.0
2023	333.8	630.9	4.4	904.6
2024	337.7	638.3	4.4	915.2
2025	341.5	645.4	4.5	925.5
2026	345.2	652.4	4.5	935.5
2027	347.5	656.8	4.6	941.7
2028	349.6	660.7	4.6	947.4
2029	351.7	664.7	4.6	953.1
2030	353.8	668.7	4.6	958.8
Total	5,866	11,086.7	78	15,897

Source: Author's calculations based on the declared EWA cost of 1.89US$/m^3 (which includes groundwater use).

The treatment of wastewater

These costs are manifest in the financial and energy costs of the wastewater treatment process, in addition to the environmental costs when hydraulic loading occurs (i.e. when the received generated wastewater exceeds the treatment plants' capacity). This has an impact on treatment efficiency and increases carryover volumes to the coastal and marine environment.

Harm to marine ecology

The current total discharge of brine (high salinity reject water) to the coastal and marine environment is about 848 Mm^3/year, resulting from the production of about 237 Mm^3/y of desalinated water in total.[14] The average ratio of this reject water to water produced is about 3.6 (see Appendix for the basis of these calculations). About 93 per cent of the total brine discharged from MSF and MED desalination plants has elevated temperatures (about 40°C). Based on the projected desalination capacity increase, by the year 2015 this discharge will have increased to about 1,050 Mm^3/y. Such volumes of discharge to the coastal and marine environment surrounding the Bahraini islands poses a threat to marine life and ecology.[15]

[14] This is calculated on the basis of the desalination technology mix used in Bahrain, each type of plant having a different ratio of reject water to water production: in government brackish water RO plant = 1.4; in private sector seawater RO plant = 2.5; in government MSF plant = 9–12.7, in private sector MSF plants = 2, and in private MED plants = 2.5.
[15] Al Mahal, H. A. (2013), 'Assessment of the Sustainability of the Municipal Wastewater Management Systems in the Kingdom of Bahrain', Master's thesis, College of Graduate Studies, Water Resources Management Programme, Arabian Gulf University, Bahrain.

The need for more detailed studies

In the above calculations, there is a high uncertainty in the projected population (the main driver for municipal water demands followed by consumption patterns). The population projections are based on a study carried out by the Ministry of Works, which estimates the population will have risen to about 1.5 million by 2030. This figure is considered an underestimate, or a lower bound, since in 2012 the population had already reached 1.23 million.

For this reason, it is recommended that a detailed population study be undertaken to update the projections with averaged upper- and lower-bound estimates. There are a number of other variable parameters of the water management system, leading to great uncertainty when using deterministic modelling. Therefore, a stochastic modelling approach (allowing for the probability of different outcomes over time) is recommended in any future modelling exercise.

CO_2 emissions are plotted as a general indicator of environmental externalities, but these are not indicative of the full environmental costs of desalination, which are country-specific and require in-depth assessment and evaluation. An economic study monetizing the impacts of desalination plants on the surrounding environment and health impacts is recommended.

Conclusion

This paper has attempted to quantify the costs to Bahrain of current and future municipal water demand. Given that this demand will be met through the expansion of desalination plants, the current cost to the government are likely to rise dramatically over the next 25 years.

Significant costs include the required energy (natural gas) for desalinated water production as well as the financial and energy/electricity cost of every stage in the operation of the water cycle system (i.e. production, transmission, distribution, wastewater collection, treatment and reuse). There are further societal costs: brine discharge by desalination plants adversely affects the surrounding coastal and marine environment, and the gaseous emissions and particulate matter from the combustion of gas can have a harmful impact on public health, as well as contributing to climate change.

The paper recommends that the current domestic tariff structure be revised, particularly for the third consumption block, in order to conserve water, increase cost recovery and help achieve social equity among water consumers. Moreover, even if farm users receive a subsidized rate, a cost-reflective waste-water tariff would encourage efficient water use in irrigation and contribute to cost recovery in this sector.

The uncertainties in population and other demand and supply projections suggest that more detailed studies should be undertaken, adopting a stochastic modelling approach to planning for Bahrain's water sector. This could form the basis of a fuller economic study monetizing the impacts of desalination plants on the surrounding environment and public health.

Appendix: Bahrain desalination plants and performance data

Table A1: Reject water and recovery by desalination plant technology

Item	RO	MSF	MED-TVC
Rejected brine:			
• Maximum total dissolved solids (TDS) (mg/L)	42,245 (RAJBRO) 76,300 (DSWRO)	60,000–64,000 (SMSF) 65,000 (HMSF)	65,000 (HMED)
• Volume of saline water (m^3 per day of brine/m^3 of fresh water)	1.44 2.53	9–12.7 2	2.5
• Temperature (°C)	33 28	35–38 40	40
Overall Plant Recovery (%)	70% 42%	80% –	–
Typical Product Water TDS (mg/L)	350 (300–800) 150	20–75 25	35

Table A2: Daily production capacity of desalination plants in Bahrain

No.	Plant	Commissioning date	Technology used	No. of units	Capacity 1,000 m^3/d	Raw water	Ownership/ management	Ratio of brine discharge	Brine volume
1	Sitra (SPWS)	1975	Multi-stage flash (MSF)	6	113.6	Seawater	Governmental	11x produced	456 Mm^3/y
2	RasAbuJarjur (RAJ)	1984	Reverse Osmosis	10	77.3	Brackish groundwater	Governmental	1.4x produced	39.5 Mm^3/y
3	Al Dur (ADUR)	1990	Reverse Osmosis	8	18.2	Seawater	Governmental	2.5x produced	16.6 Mm^3/y
4	Al-Hidd (HIDD)	1999	Multi-stage Flash (MSF) and Multi-Effect Distillation (MED)	14 (4 MSF and 10 MED)	409.1	Seawater	Privatized (entire production purchased)	2x produced 2.5x produced	336 Mm^3/y
5	Alba	2002	Multi-Effect Distillation (MED)	4	31.8	Seawater	Private (production purchased)		
6	Al-DUR RO	2012	Reverse Osmosis	–	(220.0)	Seawater	Private (production purchased)	2.5x produced	201 Mm^3/y
Total desalination capacity					650 (870)*				

Source: Electricity and Water Authority data; * = capacity by 2014.
Note: Al Dur SWRO, owned by EWA, no longer exists as a production facility; it is currently mothballed pending an EWA decision to refurbish or upgrade it, or place it with a new plant.

About the author

Dr Waleed Al-Zubari is Professor of Water Resources Management at the Arabian Gulf University (AGU) in Bahrain. He is also Coordinator of the Water Resources Management Program, and Coordinator of the UNU Water Learning Center for the Arab Region. He is active in the Water Science and Technology Association (WSTA), a regional water NGO in the Gulf Cooperation Council (GCC) countries, and serves as a consultant for many international and regional organizations, including UNESCO, UNEP, UNDP, ESCWA and FAO. In 2002, he received the award of Best Researcher in the Arab World in the field of Water Resources from the Arab League Educational, Cultural, and Scientific Organization (ALECSO). In March 2008, he published his first book on *Water Issues and Challenges in the GCC* (in Arabic), which received the Yousif Bin Ahmad Kanoo Prize for best Bahraini book in early 2012. Dr Al-Zubari obtained his MSc degree from Ohio University in 1987, in the field of groundwater mathematical modelling, and his PhD degree in 1990 in the same field from Colorado State University.

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