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Could Solar-powered Water Desalination Plants
Be the Answer to Drought WorldWide

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Dr Salameh has presented papers to numerous international energy conferences on the economics and geopolitics of oil and energy and has been frequently invited to lecture on these topics at universities around the world. He has written three books on oil: **"Is a Third Oil Crisis Inevitable?"** (published in London in April 1990), **" Jordan's Energy Prospects & Needs to the Year 2010: The Economic Viability of Extracting Oil from Shale"** (published in London in October 1998) and " **Over a Barrel"** (Published in the UK in June 2004) as well as numerous research papers published in international Oil and Energy Journals. Dr Salameh has undertaken research assignments for the US Department of Energy, the World Bank, the Institute of Energy Economics in Japan, the Indian Government, OPEC, the Canadian Energy Research Institute, Boston University working on the Encyclopedia of Energy and also the Handbook of Energy and the government of Jordan among others. He regularly appears on TV to discuss oil prices and other developments in the global oil market.

Dr Salameh is a member of many International Institutes and Associations including the International Association for Energy Economics (IAEE) in the US, the British Institute of Energy Economics, the International Energy Foundation in Canada, the International Institute for Strategic Studies (IISS) in London, and the Royal Institute of International Affairs (RIIA) in London. He is also an advisor to the Oil Depletion Analysis Centre (ODAC), London.

Could Solar-powered Water Desalination Plants Be the Answer to Drought WorldWide

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By
Dr Mamdouh G Salameh*

Overview

For years, experts and pundits have predicted that conflicts will increase over an ever scarcer and more vulnerable commodity: water. The fear has been that as populations grow and development spreads, vicious battles will erupt between water-rich and water-poor nations, particularly in major river basins where upstream nations control the flow of water to those downstream. To the doomsayers, global warming will only make those battles worse by decreasing rainfall and increasing evaporation in critical areas.

The argument has certain logic and examples abound. Take the case of the Nile. Three days after the fall of Egypt's President Husni Mubarak, the then Ethiopian Prime Minister, Meles Zenawi, announced the start of the construction of a dam on the Nile's main tributary. The Grand Ethiopian Renaissance Dam will be the first Ethiopia has built on the river, despite more than three-quarters of the Nile's flow falling as rain within the highlands. The move is a direct challenge to downstream Egypt's 'hydro-hegemony', which had ensured that it and Sudan enjoy essentially exclusive use of the river, thanks to favourable colonial and post-colonial agreements. **1**

There is a similar dynamic occurring on the Tigris and Euphrates. Turkey is in the process of building a series of 22 dams under the Southeast Anatolia Project to be completed by 2023. About half the dams have already been built while the associated irrigation projects continue to create water shortages in Syria and Iraq. **2**

Then there is the Mekong River in South Asia. China controls the river's headwaters and has worried the downstream states of Cambodia, Laos, Thailand, Burma & Vietnam by planning to build eight giant dams on the upper river, of which two are completed and two are under construction. Once finished, these dams will provide hydropower and irrigation for Yunnan, one of China's poorest regions. But they will also alter the Mekong's flow into the lower-basin states, depriving irrigation water to as many as 60 million people. **3**

There is also the possibility of conflict over the Indus & Ganges-Brahmaputra water systems (shared by India, Pakistan, Nepal & Bangladesh).

However, water wars or conflicts need not happen. The oceans and the seas hold 95% of the world's water, and almost half of the global population lives within 63 miles of the shoreline. This vast source could produce all the water the world

population needs for irrigation and drinking. But we need a cheap and a more cost-effective way of tapping it.
One innovative way is developing a cheap solar-powered water desalination plants. The technology already exists. All it needs is a bit of finesse and cost-cutting to enable its use worldwide, particularly by poorer nations (see Figure 1).

Figure 1
The Mechanics of a Water Desalination Plant
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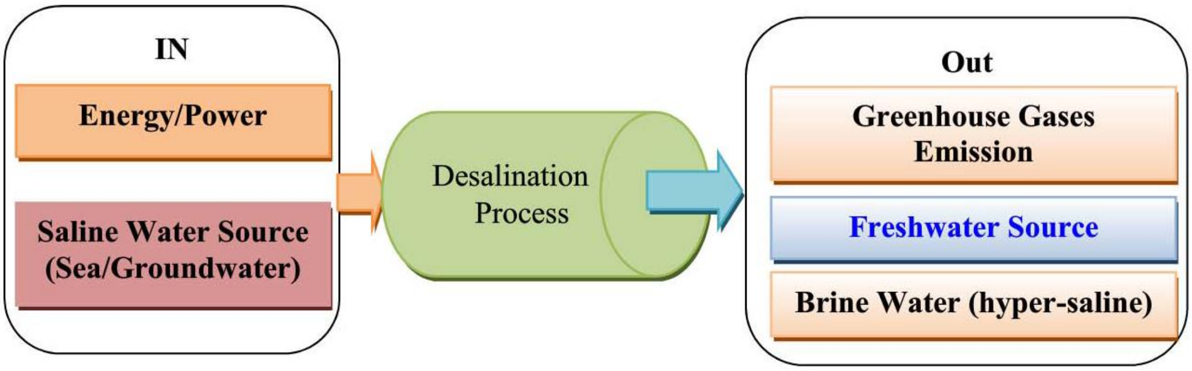

The Economics of Global Warming

Connected to the water issue is the impact of global warming on food production in the developing world. The worst effects are almost certainly going to be on food production in poorer countries, where half or more of the population depends on growing its own food.

For a billion people living in the poorest countries of the world, the loss of half of their food production could be estimated at $365 bn a year. **4** This is less than 0.5% of the world GDP. While this figure doesn't amount to much of a statistic, the loss would have tragic consequences for these people.

Tapping the Seas

Of course, it has been possible to treat sea water on an industrial scale for 40 years. The problem with many of the older plants, though, is that they work by distilling the water and leaving behind the salt residue. This process requires copious amounts of heat energy and is too expensive for all but the richest and thirstiest Middle East nations. Growing shortages have created incentives to develop cheaper technologies. Today's favoured method "reverse osmosis" involves pumping salt water through polymer strips. Microscopic pores let water pass but trap the salt.

Competition, economics of scale and better polymers have halved the cost of producing salt-free water in the last ten years. New plants are beginning to spring up in the most unlikely of places from Florida to Spain, Singapore and China. Forecasters reckon China's capacity could rise fourfold by 2015. Global capacity for desalination is expected to double in the next decade from 5 billion cubic metres per year (bcm/y) to 10 bcm according to Global Water intelligence. Water politics is also driving adoption of the technology.

Cogeneration is one process of using excess heat from electricity generation for another task: in this case the production of drinking water from seawater or brackish groundwater in an integrated, or "dual-purpose", facility where a power plant provides the energy for desalination. Cogeneration takes various forms, and theoretically any form of energy production could be used. However, the majority of current and planned cogeneration desalination plants use either fossil fuels or nuclear power as their source of energy. The advantage of dual-purpose facilities is they can be more efficient in energy consumption, thus making desalination a more viable option for drinking water.

Nuclear reactors can be used to produce large amounts of potable water. The process is already in use in a number of places around the world from India to Japan and Russia and also in nuclear submarines. Eight nuclear reactors coupled to desalination plants are operating in Japan alone. Nuclear desalination plants could be a source of large amounts of potable water transported by pipeline hundreds of miles inland. But it is solar-powered water desalination plants that could prove to be the cheapest and the most practical way of producing water in terms of the environment and energy use.

Economics of Water Desalination Technology

Costs of desalinating sea water (infrastructure, energy and maintenance) are generally higher than the alternatives (fresh water from rivers or groundwater, water recycling and water conservation), but alternatives are not always available. Achievable costs in 2013 range from $2-4/kgal) (see Table 1).

Table 1
Average Water Consumption & Cost of Supply by Sea Water Desalination

Area	Consumption USgal/person/day	Consumption litre/person/day	Desalinated Water Cost US$/person/day
USA	100	380	0.29
Europe	50	190	0.14
Africa	15	60	0.05
UN recommended minimum	13	50	0.04

Factors that determine the costs for desalination include capacity and type of facility, location, feed water, labor, energy, financing, and concentrate disposal. Nuclear-powered desalination might be economical on a large scale.

While noting costs are falling, and generally positive about the technology for affluent areas in proximity to oceans, a 2004 study argued, "Desalinated water may be a solution for some water-stress regions, but not for places that are poor, deep in the interior of a continent, or at high elevation. Unfortunately, that includes some of the places with biggest water problems.", and, "Indeed, one needs to lift the water by 6,600 feet, or transport it over more than 990 miles to get transport costs equal to the desalination costs. Thus, it may be more economical to transport fresh water from somewhere else than to desalinate it.

Desalinated water is also expensive in places that are both somewhat far from the sea and somewhat high such as Riyadh, the capital of Saudi Arabia. After being desalinated at Jubail on the Arab Gulf coast of Saudi Arabia, water is pumped 200 miles inland through a pipeline to Riyadh. For coastal cities, desalination is increasingly viewed as an untapped and unlimited water source.

Still, increased water conservation and efficiency remain the most cost-effective priorities in areas of the world where there is a large potential to improve the efficiency of water use practices. Wastewater reclamation for irrigation and industrial use provides multiple benefits over desalination. Urban runoff and storm water capture also provide benefits in treating, restoring and recharging groundwater.

Energy & the Water Issue: The Case of the Arab Gulf Nations

Connected to the water issue is energy. A “hot spot” of intense desalination activity has always been the Arabian Gulf, but other regional centres of activity are emerging and becoming more prominent, such as the Mediterranean Sea and the Red Sea, or the coastal waters of California, China and Australia.

The growth gap between supply and demand for water in the Gulf Cooperation Council (GCC) countries can be attributed to limited available surface water, high population growth and urbanization development, deficient institutional arrangements, poor management practices and water depletion and deterioration of quality, especially in shallow groundwater aquifers.

Experience in the Gulf States demonstrates that desalination technology has developed to a level where it can serve a reliable source of water at a price comparable to water from conventional sources. Desalination remains in GCC countries the most feasible alternative to augment or meet future water supply requirements. **5**

At present there are 199 desalination plants in the GCC countries and there are plans to add 38 in the future (see Table 2). Most of the desalination plants are combined with power plants for power generation.

Capacity in the GCC countries increased from 3 billion cubic metres per year (bcm/y) in 2000 to about 5 bcm/y in 2012 and is projected to reach 9 bcm/y in 2030. **6**

Table 2
Existing & Future Planned Desalination Plants in GCC Countries

	UAE	Saudi Arabia	Kuwait	Qatar	Oman	Bahrain	Total
Existing	47	97	6	8	35	6	199
Planned	8	11	2	2	14	1	38
Capacity (mcm)	1776	1721	702	391	168	246	5004

Source: Courtesy of International Journal of the Environment & Sustainability (IJES), Vol. 1 No.3.

The main producers in the Gulf region are UAE (35%) of the worldwide seawater desalination capacity), Saudi Arabia (34% of which 14% can be attributed to the Gulf region and 20% to the Red Sea), Kuwait (14%), Qatar (8%), Bahrain (5%) and Oman (4%). **7**

The Saline Water Conversion Corporation of Saudi Arabia (SWCC) provides 50% of the municipal water in the Kingdom, operates a number of desalination plants and has opened at the end of 2013 a Japanese-South Korean-built desalination plant capable of producing a billion litres of water per day, at a total cost of $1.892 bn. The SWCC operates 32 plants in the Kingdom including the Shoaiba plant costing $1.06 bn and producing 450 million liters per day.

Recently in UAE, 30 small-scale solar-powered desalination plants were constructed using photovoltaic solar energy for powering a Reverse Osmosis (RO) system for the desalination of brackish and saline groundwater abstracted from the shallow aquifer system. The design capacity of each unit is 5 m3/hr. **8**

Saudi Arabia also built the world's largest solar-powered desalination plant in the city of Al-Khafji with a capacity of 30,000 m3/day. The plant which became operational in 2013, uses a concentrated solar photovoltaic (PV) technology and new water filtration technology. **9**

Providing fresh water to the Arab Gulf millions is a very high priority in their desert environment. Most of the desalination plants are powered by oil.

The Drive Towards Solar Desalination & Power Generation in the Arab Gulf Countries

In addition to their vulnerability to the volatility of the oil price, the greatest threat to the oil-dependent economies of the Arab Gulf oil producers comes from the steeply-rising domestic oil consumption for power generation and water desalination and a lack of diversification. A precursor of this consumption is the wasteful subsidies amounting to an estimated $150 bn a year. **10**

The Arab Gulf countries are projected to consume 6.38 million barrels a day (mbd), or 33% of their oil production in 2015, a big chunk of which will be used to generate electricity and power water desalination plants.

This means that the Arab Gulf countries will have to cut their domestic oil consumption drastically or replace oil by nuclear power and solar energy in electricity generation and water desalination. Failing to do either would result in their relegation to minor crude oil exporters by 2030 or ceasing to remain oil exporters altogether by 2032 (see Table 3).

Table 3
Combined Current & Projected Production, Consumption & Export of Crude Oil Exports in the Arabian Gulf Countries, 2010-2035 (mbd)

Year	Production	Consumption	Net Exports / Imports
2010	16.65	4.59	12.06
2011	18.70	4.77	13.93
2012	18.92	5.35	13.57
2013	19.07	5.99	13.08
2015	19.51	6.38	13.13
2020	20.90	9.64	11.26
2025	19.83	13.19	6.64
2030	**18.55**	**17.06**	**1.49**
2031	18.44	17.91	0.53
2032	**18.33**	**18.81**	**- 0.48**
2035	17.79	21.78	- 3.99

Sources: US Energy Information Administration (EIA), Oil Outlook 2013 / OPEC Annual Statistical Bulletin 2014 / BP Statistical Review of World Energy, June 2014 / Author’s projections.

Moving into renewable energy for the Arab Gulf countries is a necessity not a luxury. The Arab Gulf region has some of the world’s best solar resources. However, the governments in the region have historically valued oil and gas at cost and have provided their populations with subsidized electricity and water, two factors which have impeded the development of renewable energy. A Bloomberg New Energy Finance Study dated 7 January 2011 showed that falling costs of photovoltaic (PV) technology mean that solar power is already a viable option for power generation and water desalination in the region where it can replace oil for power generation and water desalination as long as oil is valued at the international selling price. **11**

The drive towards using solar power and nuclear power for electricity generation and water desalination should be pursued earnestly in the Arab Gulf countries.

Conclusions

Water wars or conflicts need not happen. The oceans and the seas provide the biggest sources of water for the world. This vast source could produce all the water the world population needs for irrigation and drinking thus banishing droughts for ever.

One innovative way is developing and using cheap solar-powered water desalination plants. This has many environmental, economic and strategic advantages.

Environmentally, it will lead to a significant global reduction of carbon emissions. Economically, it will enable Saudi Arabia and other Arab Gulf oil producers to reduce their domestic consumption of oil and natural gas for power generation and water desalination and thus provide the global oil market with more plentiful supplies of crude oil. It will also listen the possibility of future conflicts over diminishing oil reserves.

Strategically, it will enhance global food production and greatly reduce the impact of climate change on the poor countries of the world. The cost of developing such technology could be a fraction of the $365 bn lost every year in food production in the poorest countries in the world with tragic consequences for them.

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Footnotes

1 Mark Zeitoun, **Trouble Downstream**, the World Today, August/September 2013, p, 37.
2 Ibid., p. 37
3 Michel Klare, **Wars for Water**, Newsweek, April 16/April 23, 2007, p.78.
4 In September 12, 2012, I submitted a proposal to the Innovation Fund FY2012 at the World Bank suggesting that the World Bank spearheads global research efforts to develop a cheap solar-powered water desalination technology to be used worldwide particularly in countries which suffer regularly from drought.
5 Mohamed A. Dawoud & Mohamed M. Sl Mulla, **Environmental Impacts of Seawater Desalination: Arabia Gulf Case Study**" , International Journal of Environment & Sustainability, ISSN 1927-9566, vol. 1 No.3, p. 22, 2112.
6 Ibid.,p. 23.
7 Ibid.,p. 23
8 Ibid., p. 34
9 Mamdouh G Salameh, **"Economic & Financial Crisis Management in the Light of Dwindling Oil Prices**" (a lecture given at the invitation of the National Defence College in Muscat, Oman on 21st of April, 2015).
10 Ibid.,
11 Logan Goldie-scot, "**Sun Sets on Oil for Gulf Power Generation"** (a Bloomberg New Energy Finance Study, January 7, 2011), p. 1.