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# SOLAR VS NUCLEAR: WHICH IS CHEAPER FOR WATER DESALINATION?

**Rami W. Bitar**
Graduate Student at the Energy Studies Program at the American University of Beirut

**Ali Ahmad, Ph.D.**
Director of the Energy Policy and Security in the Middle East Program, Issam Fares Institute for Public Policy and International Affairs

***Summary***
*In response to the need to move away from fossil fuel, countries across the region have been proposing ambitious plans to invest in nuclear and solar power to deal with the increasing demand for electricity and desalinated water. This Policy Brief summarizes a comparative cost analysis of nuclear and solar desalination for the Middle East. Of all the coupled desalination technologies and power options studied, we found that the most cost effective combination is the solar photovoltaic (PV) panels coupled with reverse osmosis (RO) technology. However, requirements for high production capacity, lower levels of salinity and the existence of off-peak heat source could justify the coupling between nuclear power and thermal desalination technologies.*

## MAIN FINDINGS

- **Solar photovoltaic energy source coupled with reverse osmosis desalination technology was found to be the most cost-effective option;**
- **Multiple Effect Desalination and Multi-Stage Flashing technologies are more economic when coupled with nuclear power rather than concentrated solar power;**
- **Declining costs of solar photovoltaic technologies promises further cost reductions for both generating electricity and desalinating water when coupled with reverse osmosis systems.**

The Middle East is witnessing a remarkable increase in water consumption due to population growth and subsidized tariffs. Freshwater resources are in fact scarce within the region and therefor the demand for desalinated water has been rising, particularly in the Gulf Cooperation Council (GCC) states. According to the World Resource Institute, the Middle East will be facing extremely high water stress levels in 2040; by that time, all the GCC states are expected to rank among the top ten water stressed countries in the world.

The reason behind studying nuclear vis-à-vis solar desalination is that countries across the Middle East are proposing ambitious plans to enhance their energy security and shift away from fossil fuel by adding large capacities of nuclear and renewable energy sources in the coming decades. However, different countries in the Middle East have different economic profiles and some, such as Jordan or Egypt, might not be able to sustain large investments in energy infrastructure projects and thus might have to choose one technology over another. Even resource-rich countries like the GCC states are susceptible to strained budgets due to declining oil revenues. These countries might also find themselves in a position that requires prioritizing their energy investments rather than embarking on an “all-in” diversification plan.

## *Cost analysis of nuclear vs solar desalination*

The comparative economics of nuclear and solar desalination plants depend on a wide variety of parameters. It is necessary to analyze the resulting electricity and water desalination costs in relation to these parameters. When it comes to nuclear power plants, capital cost is the most important contributor to their total levelized cost of electricity. Similarly, solar photovoltaic and concentrated solar power technologies have high capital costs yet their cost projections show great cost reduction potential.

Unlike nuclear power, solar technologies are characterized by zero fuel costs and low operation and management (O&M) costs. Furthermore, compared to nuclear technology, solar power is underdeveloped and immature. This is promising, as the projected capital costs of PV panels in 2030 are roughly half of current values but O&M costs are about the same.

Another factor that influences the levelized cost is the discount rate. Countries in the Middle East are expected to have discount rates within the 5-10% range. Resource-rich countries such as the GCC states are likely to benefit from low discount rates while other less capable countries, with deteriorating economies such as Egypt or Jordan, are likely to deal with high discount rates closer to the 10% mark, if not higher.

In total, we studied ten combinations that are based on four energy sources and three desalination technologies. Nuclear power coupled with reverse osmosis, Multi-Stage Flashing (MSF), and Multiple Effect Desalination (MED); solar PV was coupled only with RO, concentrated solar power (CSP) was coupled with RO, MSF and MED. Figure 1 shows the water desalination cost ($/m$^3$) of the different combinations of energy sources and distillation technologies.

As expected, energy cost is the major contributor to water desalination cost, especially when thermal processes are involved. Out of all the distillation technologies, MSF costs the most, followed by MED and RO. Other costs related to O&M comprise a small percentage of total water distillation costs. Nevertheless, O&M costs of RO systems is the highest in all technologies due to the fact that RO processes are more sensitive to fouling than MED and MSF.

Solar PV systems, combined with RO, is the most economical option with a water desalination cost of $0.85/m$^3$. Compared to a nuclear powered RO desalination plant whose cost is at $0.91/m$^3$, a solar PV desalination plant produces potable water at a cheaper rate.  Moreover, it seems that the coupling between nuclear and thermal desalination processes results in higher water desalination costs. Nevertheless, these options still offer the advantage of larger desalination capacities.

**“Nuclear proves to be more economical than CSP when coupled with MED technology .”**

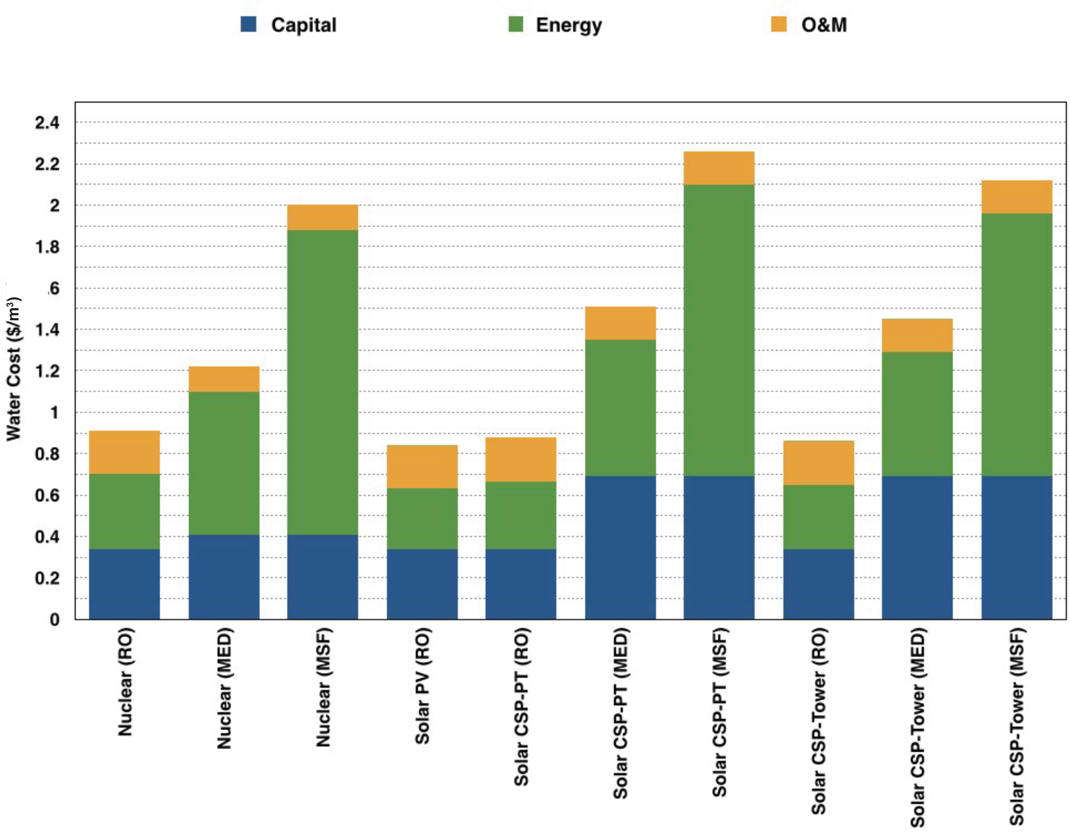


*Figure 1*

*Water desalination cost of different coupling combinations*

For MSF desalination, nuclear and CSP energy sources are not economically competitive due to high capital costs for both energy and desalination technologies. It should be noted that CSP systems costs incorporate costs of thermal storage capacity up to six hours. This leads to capital costs of $6,300/kWe and $5,700/kWe for CSP parabolic trough and CSP tower, respectively. MSF coupled with nuclear on the other hand has a lower capital cost of $0.41 /m$^3$ and also lower O&M cost of $0.12 /m$^3$. Nuclear, however, does have a higher energy cost of $1.47 /m$^3$ resulting in a total desalination cost of $2.00/m$^3$.

Nuclear proves to be more economical than CSP when coupled with MED technology. MED coupled with nuclear also has the same capital and O&M costs of an MSF plant of $0.41 /m$^3$ and $0.12 /m$^3$. Since MED is less energy intensive than MSF, the energy cost is now only $0.68 /m$^3$ making nuclear the most economical of all three options with a water cost of $1.22 /m$^3$.

Figure 2 shows the water desalination cost range in $/m$^3$ of the different desalination and energy technologies. Each combination is represented by a bandwidth that shows the lowest and the highest potential water desalination costs generated using that particular technology. The lower value is based on low interest rates and capital costs and short construction periods, whereas the higher value is based on more conservative figures where the interest rates are high and construction periods are long. More importantly, the figure shows that the cheapest technology for producing potable water is reverse osmosis running on solar PV panels. In fact, the maximum cost of using solar PV panels is still below the average cost of nuclear-powered RO.

***"The cheapest technology for producing potable water is reverse osmosis running on solar PV panels."***

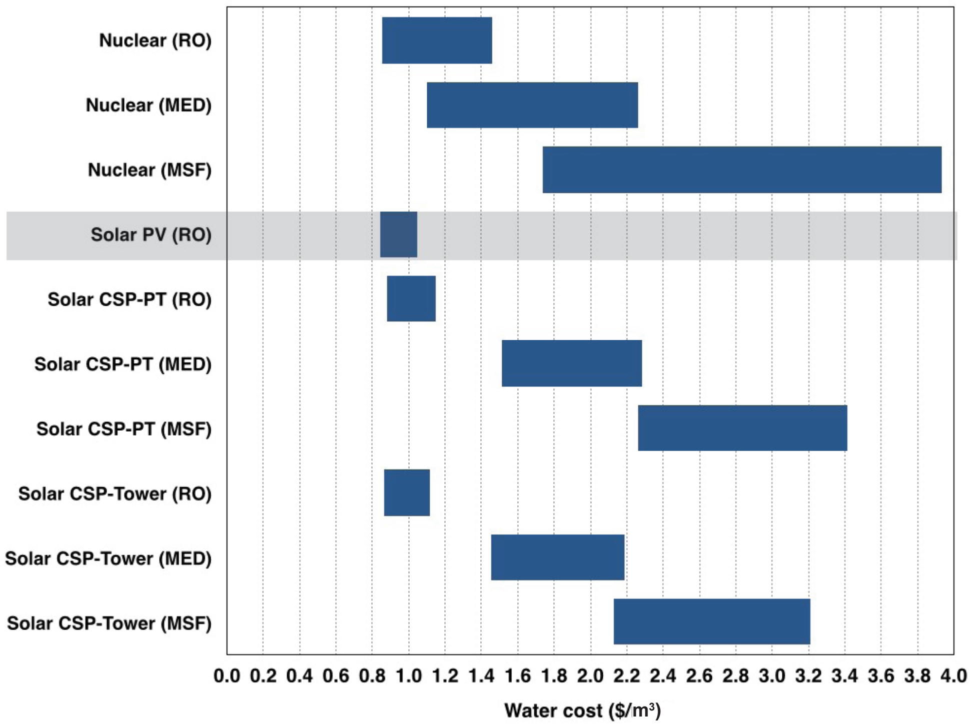


*Figure 2*

*Desalination cost range of different energy sources coupled with different desalination technologies*

## Conclusion

The aim of this Policy Brief is to provide reliable data for policy-makers in the Middle East on the comparative economics of solar and nuclear desalination. Ten combinations were studied and were based on four energy sources and three desalination technologies. Of all the desalination technologies and power options studied, solar PV panels coupled with reverse osmosis technology were found to be the most economical combination. Water cost for a plant running on reverse osmosis coupled with solar PV panels is $0.85/m$^3$, while a nuclear power plant coupled with the same technology would have a water cost of $0.91/m$^3$.

MED and MSF, on the other hand, proved to be more economical when coupled with nuclear power rather than solar CSP. An MED plant coupled with nuclear power has a water cost of $1.22/m$^3$, while when coupled with a solar CSP tower and CSP parabolic trough, the cost rises to $1.45/m$^3$ and $1.52/m$^3$, respectively.

As for MSF, a plant running on nuclear power has a water cost of $2.00/m$^3$. The cost rises when the same plant is coupled with CSP tower ($2.13/m$^3$) and CSP Parabolic ($2.26 /m$^3$).

Manufacturing costs of PV panels will drop even further as solar technology develops, bringing down capital costs and consequently potential LCOE and water desalination costs of solar powered plants. In conclusion, integrating solar power with desalination technology could prove more cost effective than nuclear-powered desalination plants.

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## The Energy Policy and Security Program

The Energy Policy and Security Program at the Issam Fares Institute for Public Policy and International Affairs was launched in 2016 as a Middle East-based, interdisciplinary, platform to examine, inform and impact energy and security policies, regionally and globally. The Program closely monitors the challenges and opportunities of the shift towards alternative energy sources with focus on nuclear power and the Middle East. The Program has been established with a seed grant support from the John D. and Catherine T. MacArthur Foundation to investigate the prospects of nuclear power in the Middle East and its potential to promote regional cooperation as a way to address the security concerns associated with the spread of nuclear power.

## AUB POLICY INSTITUTE

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AUB Policy Institute (Issam Fares Institute for Public Policy and International Affairs)
American University of Beirut
P.O.Box 11-0236
Riad El-Solh / Beirut 1107 2020
Lebanon

Issam Fares Institute Building
AUB
961-1-350000 ext. 4150
+961-1-737627
ifi@aub.edu.lb
www.aub.edu.lb/ifi
aub.ifi
@ifi_aub