Implementing Solar Energy in Desalination Plants in Libya

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Abstract

Libya's 100% dependence on oil is not only unsustainable environmentally and economically, but it also contributes to pollution. Just as well, most of Libya's potable water comes from "fossil water". Scientists estimate that within 50 years, there will be no oil or freshwater left. Because of Libya's high solar potential, the project focuses on introducing solar power to future desalination projects within the country.

Methodology

We collected data on existing solar desalination plants, existing desalination plants in Libya, membrane vs. thermal, and varying types of solar panels in order to compare the most promising types of desalination methods, the most effective types of solar panels, and understand what was out in the world for solar desalination plants right now.

Solution

Our recommendation is an eight-unit multi-effect evaporation desalination plant run by parabolic trough panels. The plant would be able to generate 250,000 m3 of water a day. For that amount of water to be desalinated, the plant would need approximately 3,500 MW; 1,280 parabolic trough panels would satisfy this. We also created an easy to understand comparison of what we believe are the top two in each category as well as cost comparisons because Libya's needs and resources may be different in the future, so the right combination may need to be reevaluated.

Desalination Cost Comparison

	Unit cost ($/m^3)	Capital Cost ($)	Unit Capital Cost ($/m^3/d)	Annual Energy Cost ($/yr.)
Reverse Osmosis 37,850 m^3/d	1.09	49,700,000	1,313.10	4,300,000
Multiple Effect Evaporation 37,850 m^3/d	1.08	70,400,000	1,860	1,000,000

Solar Types Cost Comparison

	Solar Field Installation ($/m^2)	Energy Storage ($/kWh-t)	Operation and Maintenance ($/kWh-yr.)
Parabolic Trough Collector	245 – 295	50 – 80	60 – 70
Evacuated Tube Collector	330 – 550	N/A	36 – 60

Reverse Osmosis

Advantages	Disadvantages
Minimized corrosion risk	Membranes require maintenance
No need for external thermal energy	Requires the seawater to be pretreated
Automation is feasible	
Low energy consumption	

Evacuated Tube Collectors

Advantages	Disadvantages
Minimized heat loss	Take up a lot of space
Can operate in higher temperatures	

Multiple Effect Evaporation

Advantages	Disadvantages
Low electrical consumption	High corrosion risk
Can operate at low temperature (70^{o}C)	If there is no heat-recycling system, operation costs rise
No pretreatment required	
Highly reliable and simple to operate	
Reduced footprint	

Parabolic Trough Collectors

Advantages	Disadvantages
Have higher thermodynamic efficiency	Require a sun tracking system
Reflective surfaces are cheap	Reflective surfaces require maintenance
Economically viable	

Acknowledgements

The team would like to thank Tatiana Huet De Bacellar, Christina Noyes, Adrian Creed, David Spanagel, Rebecca Ziino and Jim Monaco for their great help in preparing this project.

References

- Flat Plate Solar Collectors For Solar Hot Water & Heating Systems. (2013, January 21). Retrieved April 17, 2015, from http://www.siliconsolar.com/flat-plate-solar-collectors.html
- Evacuated Tube Solar Collectors-Heat Pipes vs. U Pipes-Solar Hot Water & Heating Manufacturer. (n.d.). Retrieved April 15, 2015, from http://www.sunmaxxsolar.com/heat-pipe-vs-u-pipe-solar-collectors.php
- European Desalination Society and Center for Research and Technology Hellas (CERTH), Sani Resort 22-25 April 2007, Halkidiki, Greece (22-25 ed., Vol. 220). (2008). Elsevier.
- Goodland, R. (2013). 2. Conservation of water, irrigation, desalination. In Libya: The urgent transition to environmental sustainability. Tripoli.
- Kalogirou, S. (2004). Solar thermal collectors and applications. Progress in Energy and Combustion Science, 30, 231-295.
- Planning and Installing Solar Thermal Systems (p. 158). (2005). New York, New York: Earthscan.

References Continued

- Seawater Desalination Costs. (2011, September 1). Retrieved April 4, 2015, from https://www.watereuse.org/sites/default/files/u8/WateReuse_Desal_Cost_White_Paper.pdf
- Next-Generation Solar Parabolic Trough Technology. (2011, November 1). Retrieved April 9, 2015, from http://www.skyfuel.com/downloads/brochure/SkyTroughBrochure.pdf
- Desalination Technologies. (n.d.). Retrieved April 25, 2015, from http://www.wabag.com/wp-content/uploads/2012/04/WABAG_Desalination_englisch-20081.pdf
- MED Technology. (n.d.). Retrieved April 24, 2015, from http://www.entropie.com/en/services/desalination/MED/
- Mineral and Energy Resources of the Sea. (n.d.). Retrieved April 25, 2015, from http://www.soest.hawaii.edu/oceanography/courses/OCN330/Fall2011/11_Desalination.pdf