Renewable Energy for Water Desalination

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Insights for Policymakers

Global demand for water continues to increase whilst freshwater sources are becoming more scarce due to increasing demand for natural resources and the impacts of climate change, particularly in semi-arid and costal/island areas. Desalination of seawater and brackish water can be used to augment the increasing demand for fresh water supplies. However, desalination is a very energy intensive process, often using energy supply from fossil fuel sources which are vulnerable to volatile global market prices as well as logistical supply problems in remote and island communities and are therefore not sustainable.

Until now, the majority of desalination plants have been located in regions with high availability and low costs of energy. Current information on desalination shows that only 1% of total desalinated water is based on energy from renewable sources. Renewables are becoming increasingly mainstream and technology prices continue to decline, thus making renewable energy a viable option. With increasing demand for desalinated water in energy-importing countries such as India, China and small islands, there is a large market potential for renewable energy-powered desalination systems worldwide.

There are two broad categories of desalination technologies. Thermal desalination uses heat to vaporise fresh water, while membrane desalination (reverse osmosis) uses high pressure from electrically-powered pumps to separate fresh water from seawater or brackish water using a membrane. Policy makers need to consider these different technology choices for desalination and base their decisions on locally available renewable energy sources. For example, solar energy – in particular heat from concentrated solar power (CSP) for thermal desalination and electricity from solar photovoltaic and CSP for membrane desalination – is a key solution in arid regions (e.g. the MENA region) with extensive solar energy potentials, whilst wind energy is of interest for membrane desalination projects in coastal and islands communities.

While desalination is still costly, declining renewable energy technology deployment costs are expected to bring this cost down in the coming years. This is of particular interest to remote regions and islands with small populations and poor infrastructure for freshwater and electricity transmission and distribution.

Mapping water needs and renewable energy sources is a strategic tool for planning new desalination systems. Renewable energy-powered desalination could be a key enabler for continued growth, especially in those countries that rely on desalinated water for sustaining local communities and productive uses such as irrigation. As such, renewable energy generation should be seen as a valuable economic investment that reduces external, social, environmental and operational costs. Policy makers may therefore wish to take the evolving market opportunities and long term impacts of technology options into consideration when planning their capacity, infrastructure and sustainable water supply needs.

Highlights

- **Process and Technology Status –** This brief focuses primarily on water desalination based on the use of renewable energy, i.e. *renewable desalination*. Global water withdrawals amount to around 4,000 billion m^3 per year and in some regions – especially the Middle East and Northern Africa (MENA) – desalination has become the most important source of water for drinking and agriculture. Today's global desalinated water production amounts to about 65.2 million m^3 per day (24 billion m^3 per year), equivalent to 0.6% of global water supply. The MENA region accounts for about 38% of the global desalination capacity, with Saudi Arabia being the largest desalinating country. Major desalination technology options are based on thermal processes using both heat and electricity, and membrane technologies using electricity only. The dominant technology is Reverse Osmosis (RO), which accounts for 60% of the global capacity, followed by Multi Stage Flash (MSF), with a 26.8% share. The larger desalination plants can reach a capacity of up to 800,000 m^3 per day or more. Renewable energy can play an important role in desalination. Renewable technologies that are suited to desalination include solar thermal, solar photovoltaics (PV), wind, and geothermal energy. Solar technologies based on solar heat concentration, notably concentrating solar power (CSP), produce a large amount of heat that is suited to thermal desalination. Photovoltaic and wind electricity is often combined with membrane desalination units (reverse osmosis, electrodialysis). As electricity storage is still a challenge, combining power generation and water desalination can also be a cost-effective option for electricity storage when generation exceeds demand.

- **Performance and Costs –** Desalination requires a considerable amount of energy. Seawater desalination via MSF consumes typically 80.6 kWh of heat energy (290 MJ thermal energy per kg) plus 2.5 to 3.5 kWh of electricity per m^3 of water, while large scale RO requires only about 3.5 to 5.0 kWh of electricity per m^3. Currently, the global production of about 65.2 million m^3/d of desalinated water involves the use of at least 75.2 TWh per year, which equals about 0.4% of the global electricity consumption. The cost of desalination has been decreasing over the last years down to USD 0.5/m^3, while market prices for desalinated water are typically between USD 1/m^3 and USD 2/m^3. Therefore, desalination is currently affordable for middle-income regions, not yet for the poorest countries. The economics of *renewable desalination* depends on the cost of renewable energy as the cost of desalination is largely determined by the energy costs. In general, the cost of *renewable desalination* is still higher if compared to the cost of conventional desalination based on fossil fuels as the energy input. However, the costs of renewable technologies are quickly decreasing and *renewable desalination* can already compete with conventional systems in remote regions where the cost of energy transmission and distribution is higher than the cost of distributed generation.

- **Potential and Barriers –** Desalination demand is projected to expand rapidly. The global demand is projected to grow by 9% per year between 2010 and 2016, with a cumulative investment of about USD 88 billion. In the MENA region, water demand is expected to increase from 9 billion m^3 in 2010 up to 13.3 billion m^3 in 2030 while groundwater resources are projected to decrease. As a consequence, desalination capacity in the MENA region is expected to grow quickly from 21 million m^3/d in 2007 to nearly 110 million m^3/d by 2030, of which 70% is in Saudi Arabia, the United Arab Emirates, Kuwait, Algeria and Libya. As desalination requires a considerable amount of energy, water production in MENA countries will contribute significantly to increase the energy use. The total electricity demand for desalination in the MENA region is expected to rise to some 122 TWh by 2030, thus tripling compared with the 2007 level. Desalination demand is also expected to grow in Asia and the Caribbean region. China and India are high potential markets for desalination due to growing population and economies, and water shortage. The need for desalination grows much faster than the economy as a whole, and the associated energy need is projected to increase accordingly.

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