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The Water-Energy Nexus from a renewable energy perspective

LE TEMPS DES SOLUTIONS

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Energy and Water Nexus

- ***Renewable energy can be used to produce and process water***
  - Pumping and water distribution
  - Desalination
  - Drinking water preparation
  - Waste water treatment
- ***Water can be used to produce renewable energy***
  - Irrigation for bioenergy crops
  - Hydropower for electricity production
  - Pumped hydro for electricity storage
  - Cooling water for thermal power plant incl CSP
- ***Water can be stored easily, electricity not: water as solution for RE intermittency?***
- ***In parts of the world energy and water are scarce***
- ***Solutions for one scarce resource should not increase scarcity for another resource***

Electricity use for water processing: examples

- *No accurate statistics*
- *3% of total US electricity use for water and waste water treatment (LBNL, 2011)*
- *22% of Indian electricity use for water pumping (>35% in some states)*
- *Water desalination: approx 0.4% of global electricity use*
  - Much higher share where desalination is applied
  - In MENA region, 10 % of the national primary energy is used for desalination (World Bank, 2012)
  - Thermal desalination dominates in regions with high salinity such as Persian gulf
  - Use of renewable energy resources for desalination can lead to significant fossil energy and cost savings
  - More technology information on IRENA Technology factsheet

ETSAP ENERGY TECHNOLOGY SYSTEM ANALYSIS PROGRAMME

IRENA International Renewable Energy Agency

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Water Desalination by Renewable Energy

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 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 26.6% share. The larger desalination plants can reach a capacity of up to 800,000 m^3 per day or larger. 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 the demand.

■ PERFORMANCE AND COSTS – Desalination requires a considerable amount of energy. Seawater desalination via MSF consumes typically 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 up 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 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 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% 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 2007 level. Desalination need 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 economy, 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.

TECHNOLOGIES AND PERFORMANCE

The global water demand is continuously increasing due to population growth and economic development. Global water withdrawals exceeds 4,000 billion m^3 per year (Rosegrant et al, 2002) and about 25% of the world population encounters fresh water scarcity (UN OCHA, 2010). In response to the increasing demand, desalination has become the most important sources of water for drinking and agriculture in some world regions, especially Middle East and North Africa (MENA), and some of Caribbean islands, where water is particularly scarce. According to the Worldwide Desalting Plant Inventory of the International Desalination Association (IDA), there are about 15,000 desalination plants worldwide, with a global capacity of 71.7 million m^3/d, of which 65.2 million m^3/d in operation (Figure 1). About 60% of feed water used in these plants is seawater (IDA, 2011). Over the past years, the deployment of desalination plants has been led by countries of the MENA region where approximately 2,800 desalination plants produce 27 million m^3/d fresh water (about 38% of the global capacity) from seawater (Fichtner, 2011). Major desalination technologies consist of thermal processes using either thermal power and electricity as the energy input, and membrane-based processes using only electricity (Table 1). The

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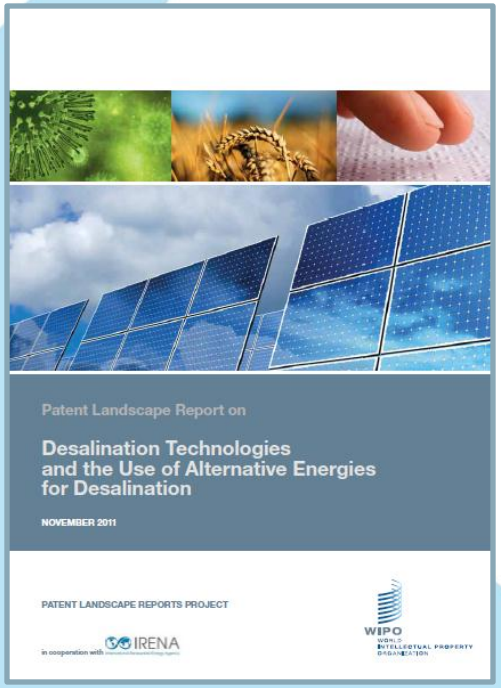
*Technology factsheet developed with IEA ETSAP **http://iea-etsap.org/web/E-TechDS/Technology.asp**

Example: Energy-Water Nexus in the Pacific

- ***Small islands in the Pacific have very limited land and water resources, which has implications for energy production and use. Managing these natural resource constraints optimally must be done in an integrated way.***
- ***Nauru:***
- 190 kWp solar PV system which will power 100 m^3/d RO desalination plant
- 1.3% of the current energy demand
- ***Tuvalu:***
- 100m^3/d RO desalination plant for Funafuti, as well as two 10m^3/d RO mobile plants
- 65.52kWp solar PV system will also be installed directly to the power grid on the island of Funafuti.
- ***Assessment of islands with nexus issues (e.g., Tarawa (Kiribati), Funafuti (Tuvalu), Majuro(Marshall Islands)) to develop a strategy on optimizing the use of limited resources***

Example: Patents analysis desalination with renewables

- ***So far the use of renewable energy for desalination is low. R&D and technology learning can help to improve the RE technology to become competitive.***
- ***Patents provide insights regarding the innovation speed and direction.***
- ***4,551 patent families related to desalination of water***
  - more than 20% represent desalination with renewable energy
  - for 80% of these renewable energy technologies, the integration occurs with solar thermal energy
- ***Historically, Japan has been the leading location but some German and US companies have seen increased patenting activity in the last 5 years and South Korea and China have become important locations for patent filings.***



*Patent landscape report developed in collaboration with World Intellectual Property Organization (WIPO), available at **http://www.wipo.int/patentscope/en/programs/patent_landscapes/reports/desalination.html**

IRENA involvement

- ***IRENA DG is nexus ambassador***
- ***Nexus analysis Pacific Island countries***
  - Endorsed by Pacific leaders summit 13 January
  - Build on nexus analysis Mauritius
- ***Islands high level summit, Malta, 9-10 May***
  - Preparatory meeting for Rio+20
- ***Desalination with renewables: factsheet and policy brief (with IEA ETSAP)***
- ***Patents analysis desalination with renewables***

International Renewable Energy Agency

Organisation dedicated to promote widespread adoption and sustainable use of RE:

Signatories: 148 states and the EU

Members: 88 States and the EU

Three programme areas:

- ***Knowledge Management and Technology Cooperation:*** Establishes a knowledge base; encouraging regional collaboration; setting up platforms for industry stakeholders; and encouraging north-south and south-south technology cooperation.
- ***Policy Advisory Service and Capacity Building:*** encourages an enabling environment for renewables. IRENA is developing an understanding of the enabling conditions so investments can be leveraged in a sustainable way.
- ***Innovation and Technology Centre:*** to accelerate the uptake of renewable energy technology. IRENA is creating a framework for technology support, work on cost reduction potentials and the wider use of standards.

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