New Trends in Energy

Desalination

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Introductory lecture – Energy commodities and technologies

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Motivation for energy technology research and development
Why innovate?

Energy Efficiency – Cost Efficiency
• The cheapest kWh is a kWh not generated
• Making the best out of the available resources

Energy Security
• Resilient and robust energy system
• Taking advantage of domestic energy sources leads to reduced reliance on fuel imports

Climate Change
• Transition to low-carbon economy

Health and environment
• Reduced emission of air and water pollutants that adversely affect health
Water Desalination
Water availability - 2011

Source: Maplecroft, Water Stress Index 2011
Projections of Global Water Stress

Water withdrawal as a percentage of total available water:
- more than 40%
- from 20% to 10%
- from 40% to 20%
- less than 10%

Source: Philippe Rekacewicz (Le Monde diplomatique), February 2006
Water consumption projection - Israel

Source: OECD Environmental Performance Reviews: Israel 2011
Desalination

Removal of minerals from saline water (i.e. brackish or seawater) to produce freshwater

- Increasing importance in arid/semi-arid countries
- Energy intensive process - hence an expensive option
  - Processes tend to need either input of thermal energy (e.g. multi-effect distillation) or electricity (reverse-osmosis)
- Used in 150 countries (International Desalination Association, 2015)
  - 86.8 million m$^3$ per day
  - Serves more than 300 million people
Main desalination technologies

Mechanical

• Reverse Osmosis – a form of diffusion and occurs when two solutions of different concentrations are separated by means of a semipermeable membrane.

Thermal

• Multi-stage Flash - based on vapour generation from seawater or brine as it enters a chamber (stage) which is at a lower pressure than its saturation pressure, causing flash evaporation.

• Multi-effect Distillation – seawater is sprayed as a thin film and is distilled through a series of distillation steps.
Main desalination technologies

**Multi-stage Flash**

- Source: Fritzmann et al, 2007

**Multi-effect distillation (example of one effect)**

- Source: Palenzuela et al, 2015

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**Reverse Osmosis**

- Applied Pressure
- Membrane
  - Concentrate Solution
  - Diluted Solution

- Source: Fritzmann et al, 2007
Desalinated seawater – reverse osmosis costs

Source: OECD Environmental Performance Reviews: Israel 2011
Coupling of RE with desalination?

Strong potential for co-benefits

• Intermittency in RE generation can be accommodated with varying desalination output in reverse osmosis plants
  • Desalination as a form of storage in electricity systems

• Direct use of solar heat – combined power and water

Source: Palenzuela et al, 2015
Solar still and Desalination

Source: Abutayeh et al, 2014
Solar PV and Reverse Osmosis

Source: Al-Karaghouli and Kazmerski, 2011
CSP and Multi-Stage Flash

Source: Abutayeh et al, 2014
Suggested further reading

• The Future of Seawater Desalination: Energy, Technology, and the Environment
  http://science.sciencemag.org/content/333/6043/712.full

• Desalination using renewable energy sources on the arid islands of South Aegean Sea
  http://www.sciencedirect.com/science/article/pii/S0360544215015248
Changelog and attribution

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