




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

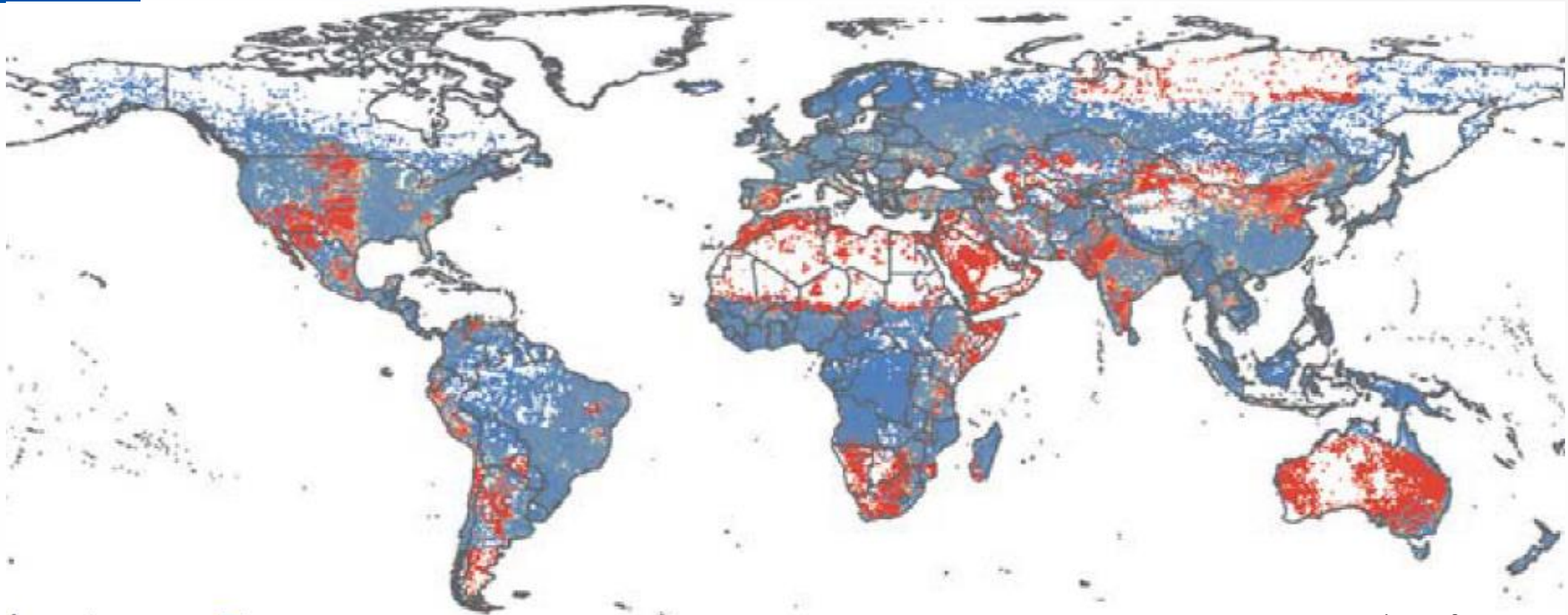
Health and environment

- Reduced emission of air and water pollutants that adversely affect health



Water Desalination

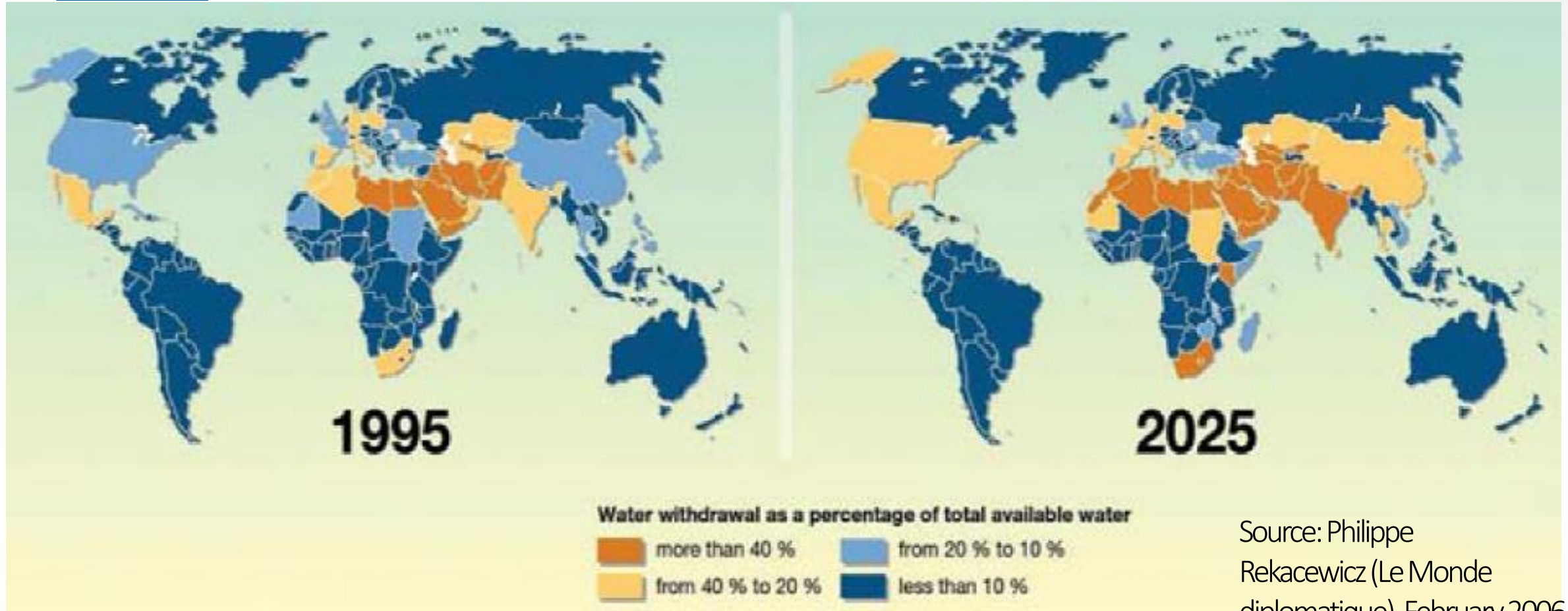
Water availability - 2011



Low stress ■
Medium stress ■
High stress ■
Extreme stress ■
— No data ■

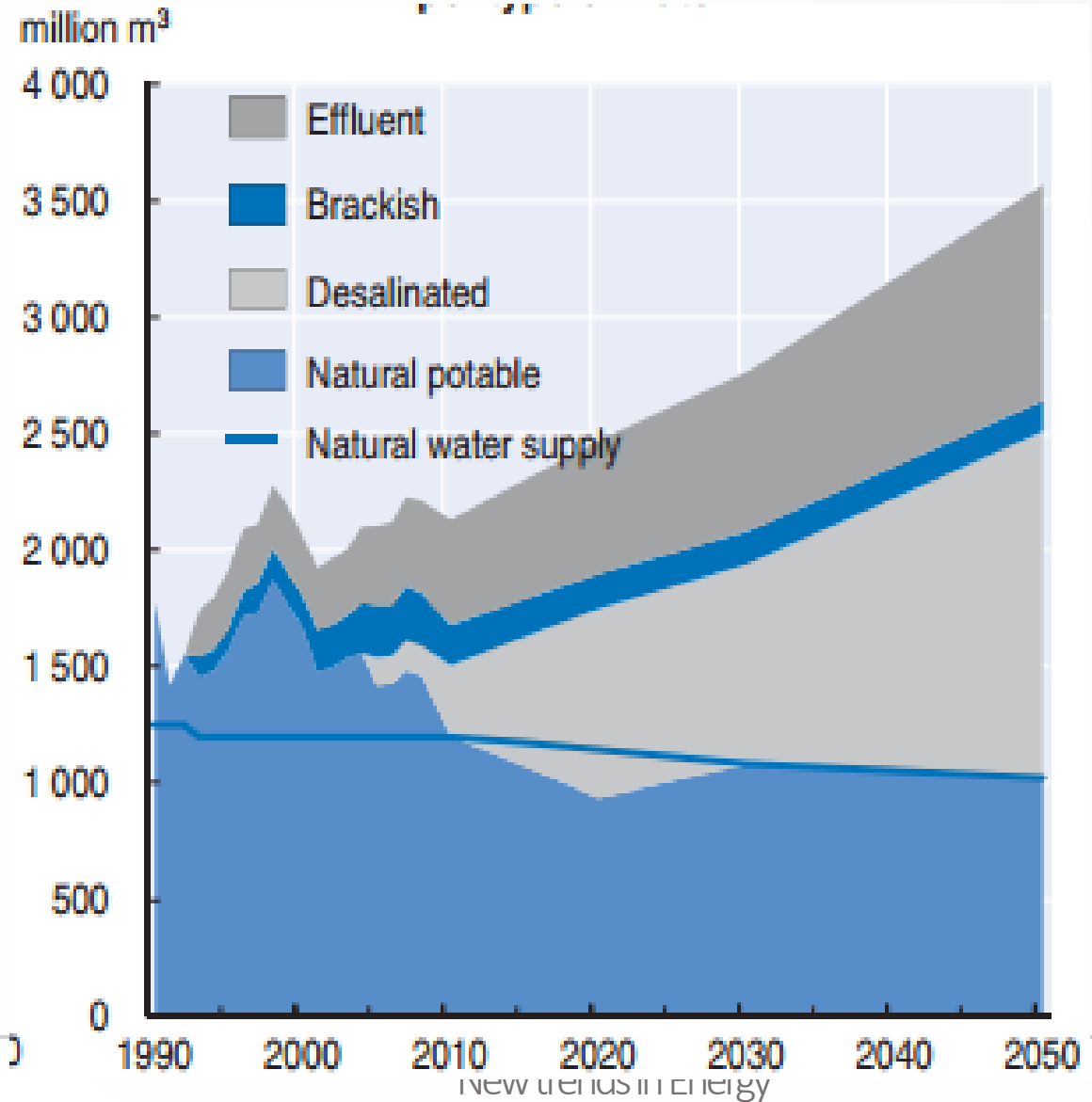
Source: Maplecroft, Water Stress Index 2011

Projections of Global Water Stress



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 m³ per day
 - Serves more than 300 million people

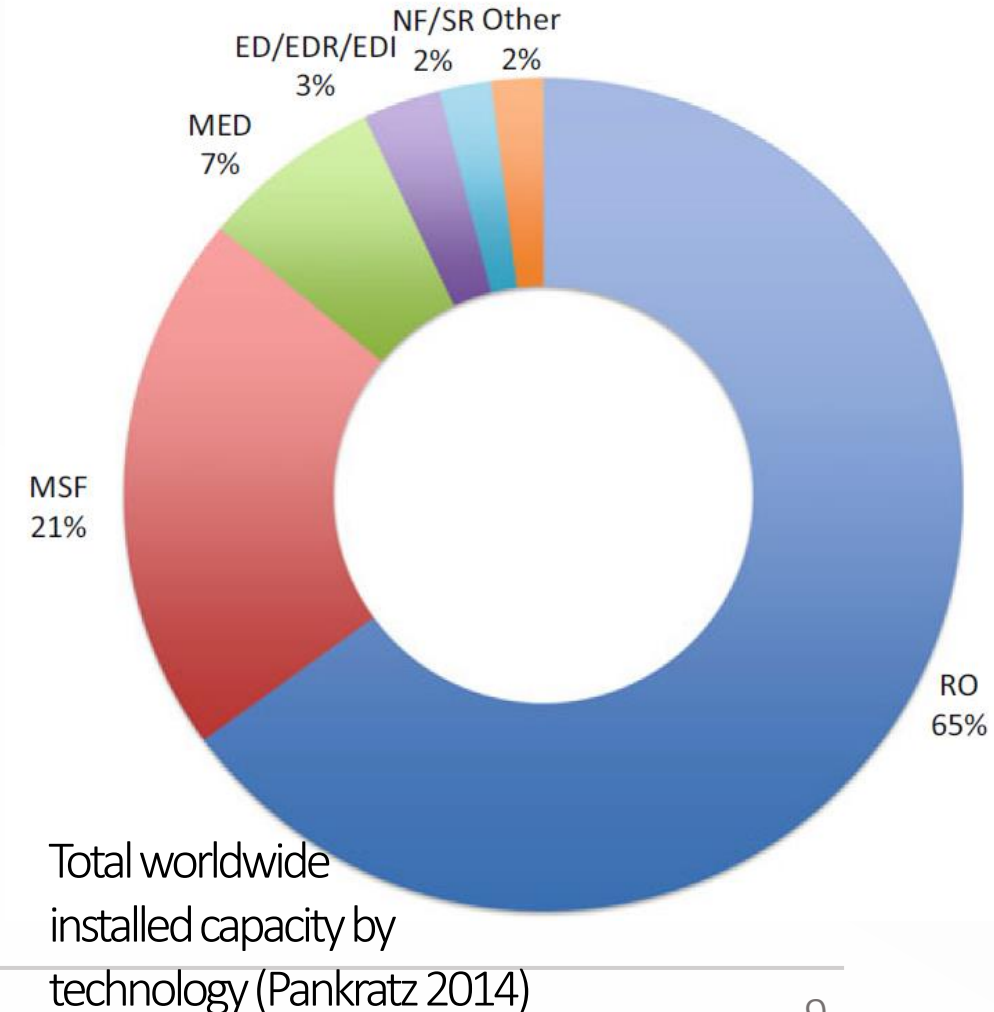
Main desalination technologies

Mechanical

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

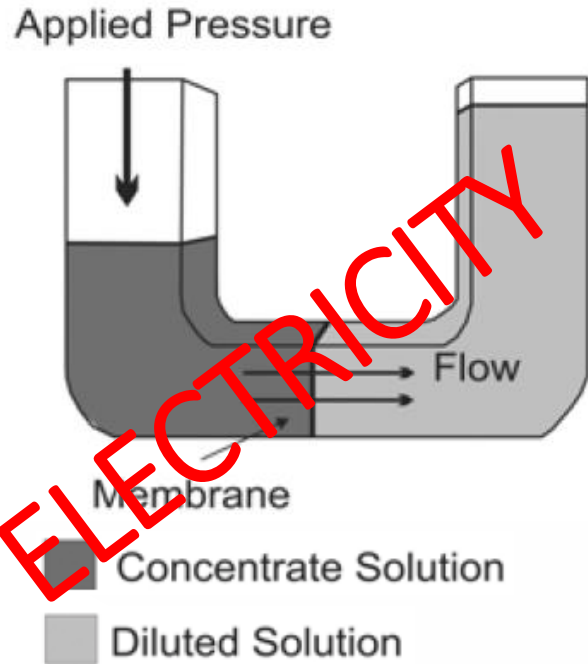
Thermal

- 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.



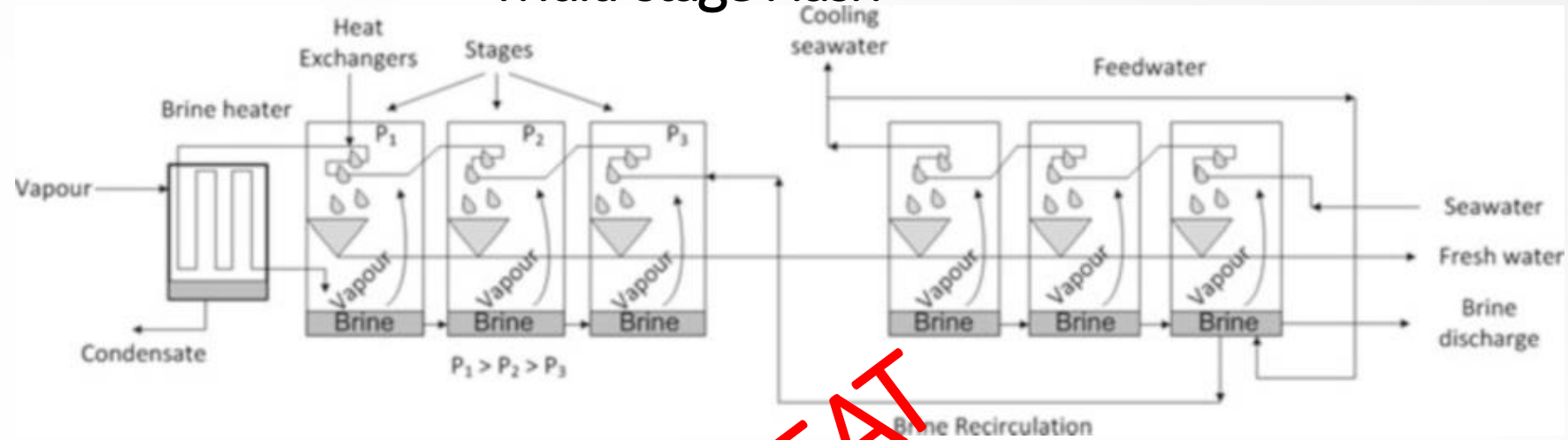
Main desalination technologies

Reverse Osmosis

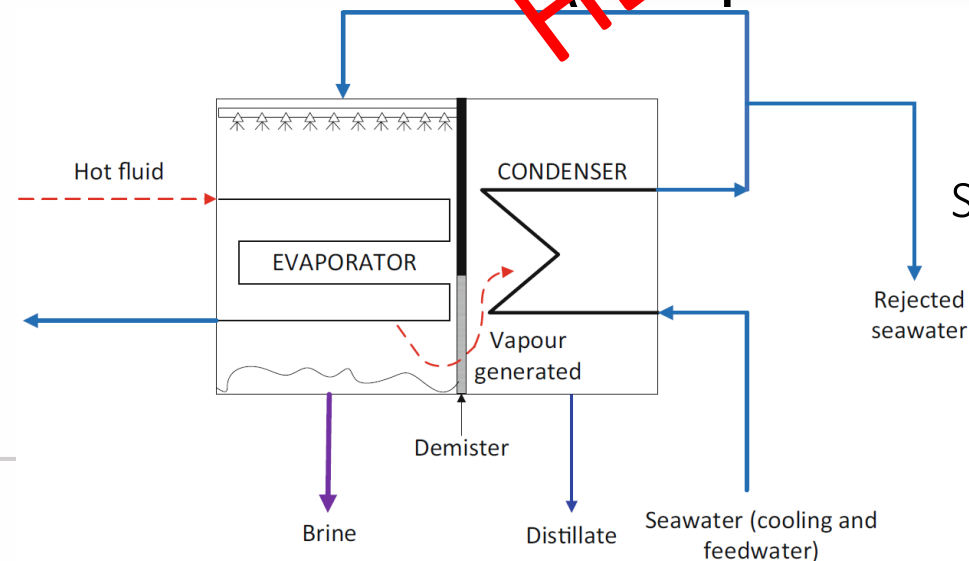


Source: Fritzmann et al, 2007

Multi-stage Flash

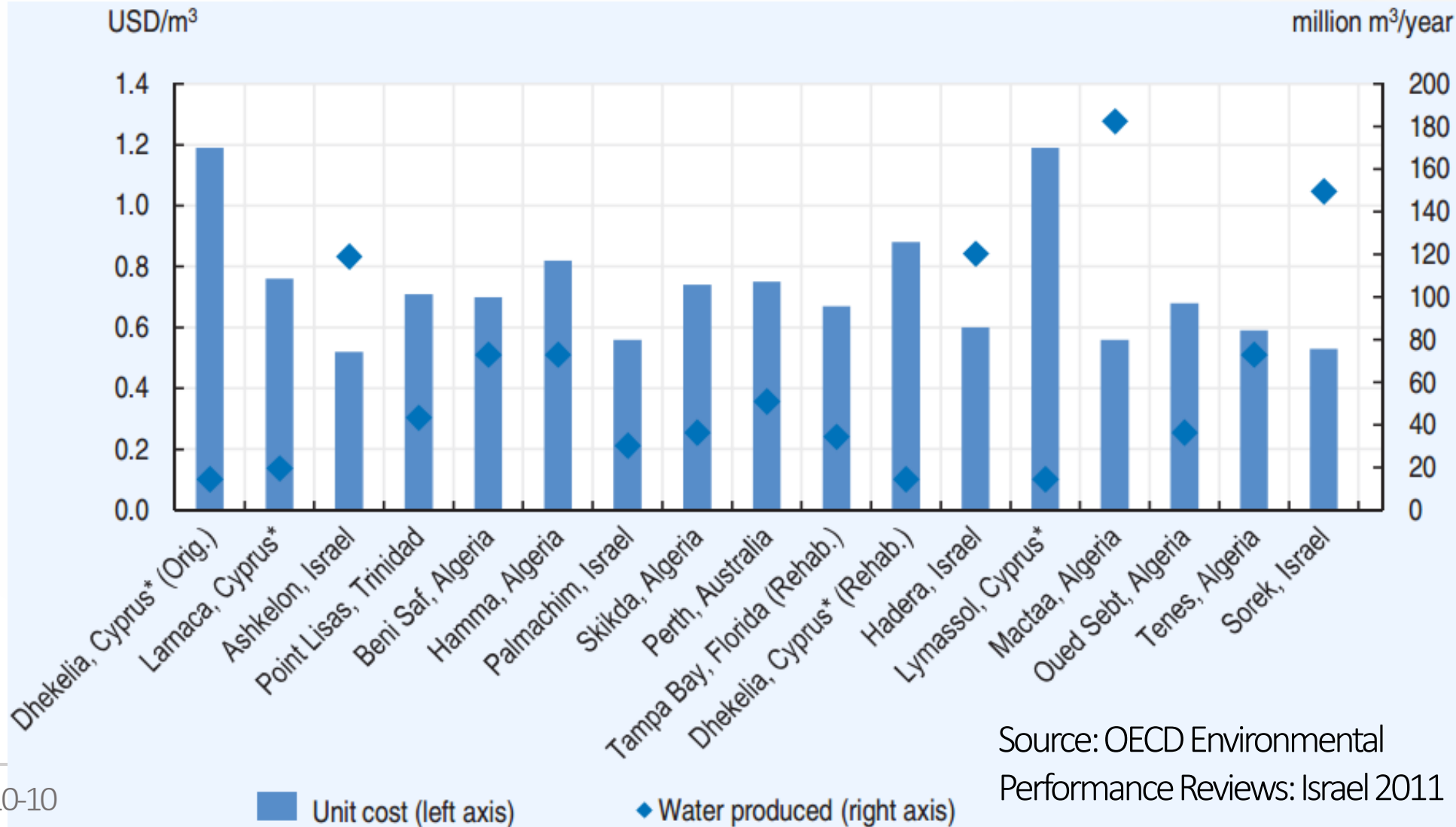


Multi-effect distillation (example of one effect)



Source: Palenzuela et al, 2015

Desalinated seawater – reverse osmosis costs



Source: OECD Environmental Performance Reviews: Israel 2011

Coupling of RE with desalination?

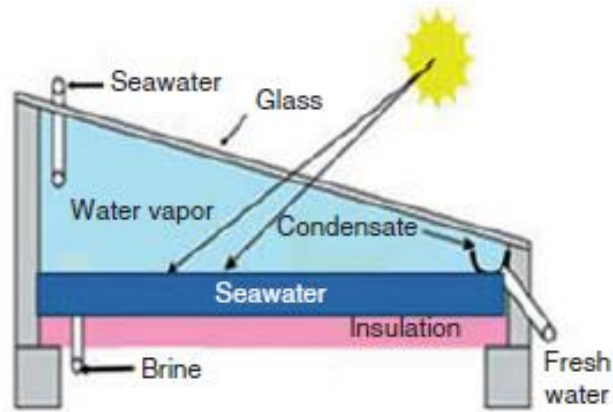
Strong potential for co-benefits

- 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

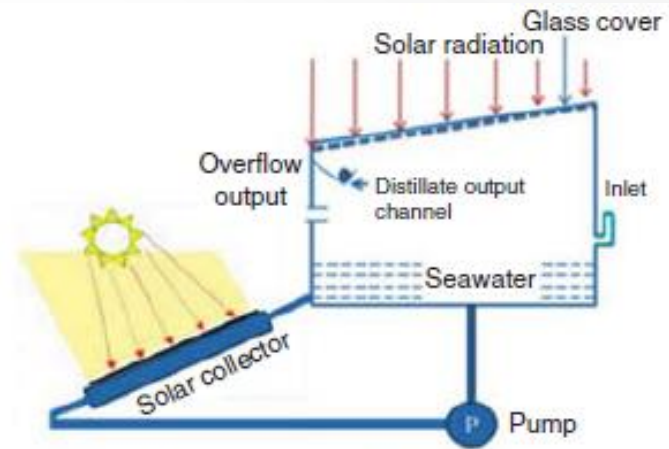


Source: Palenzuela et al, 2015

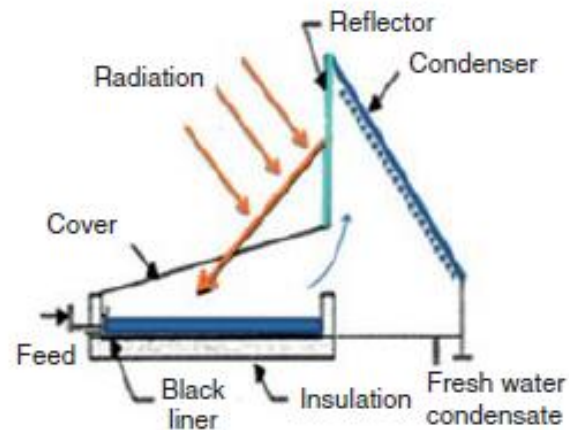
Solar still and Desalination



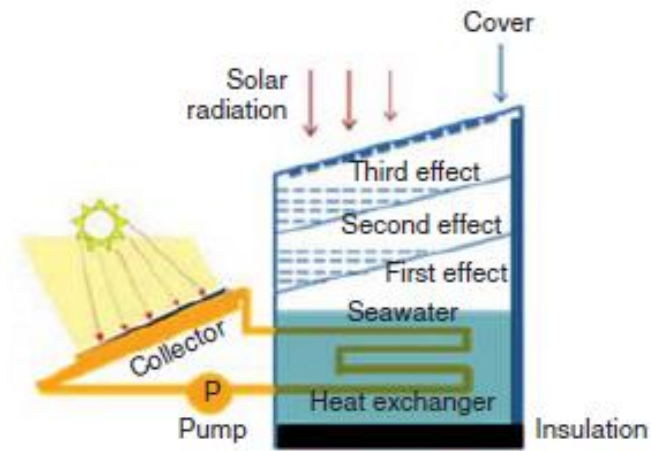
Single-stage solar still



Collector-based solar still



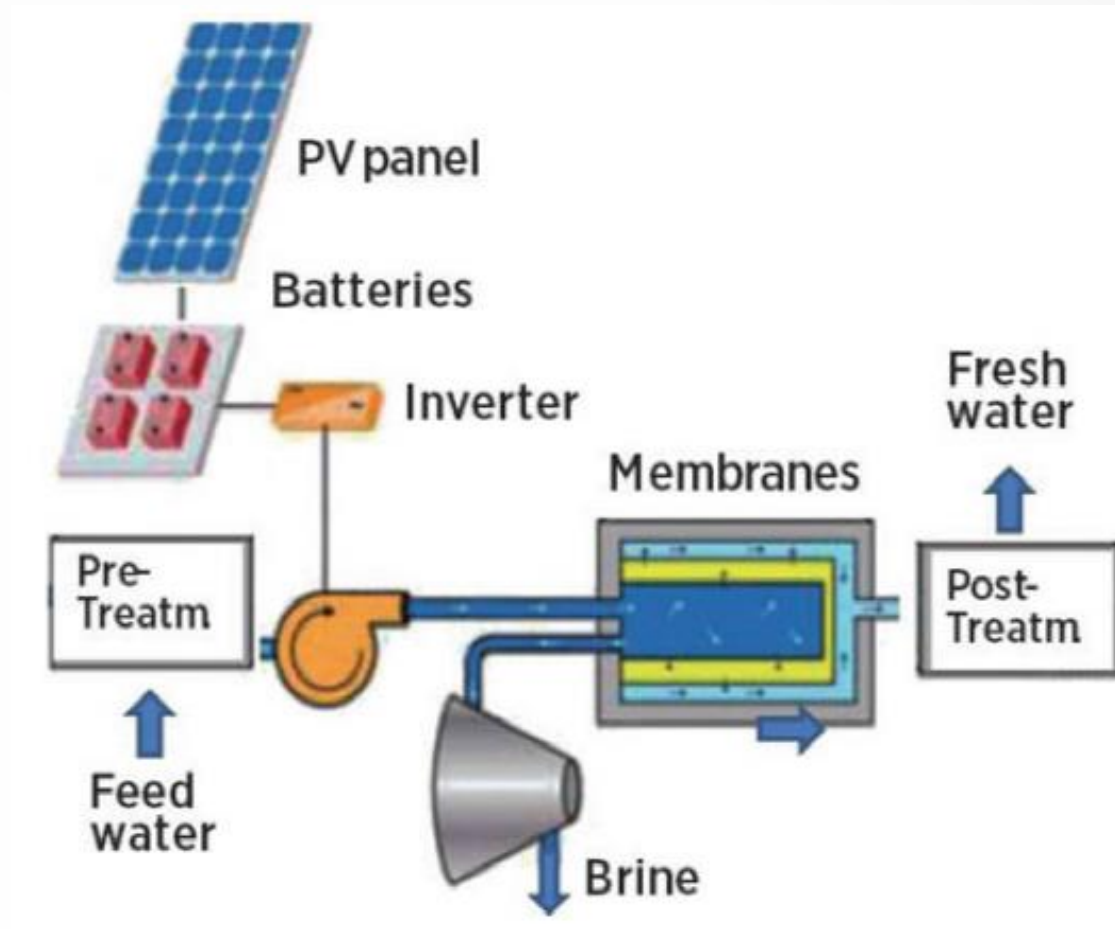
Condenser-based solar still



Multi-stage solar still

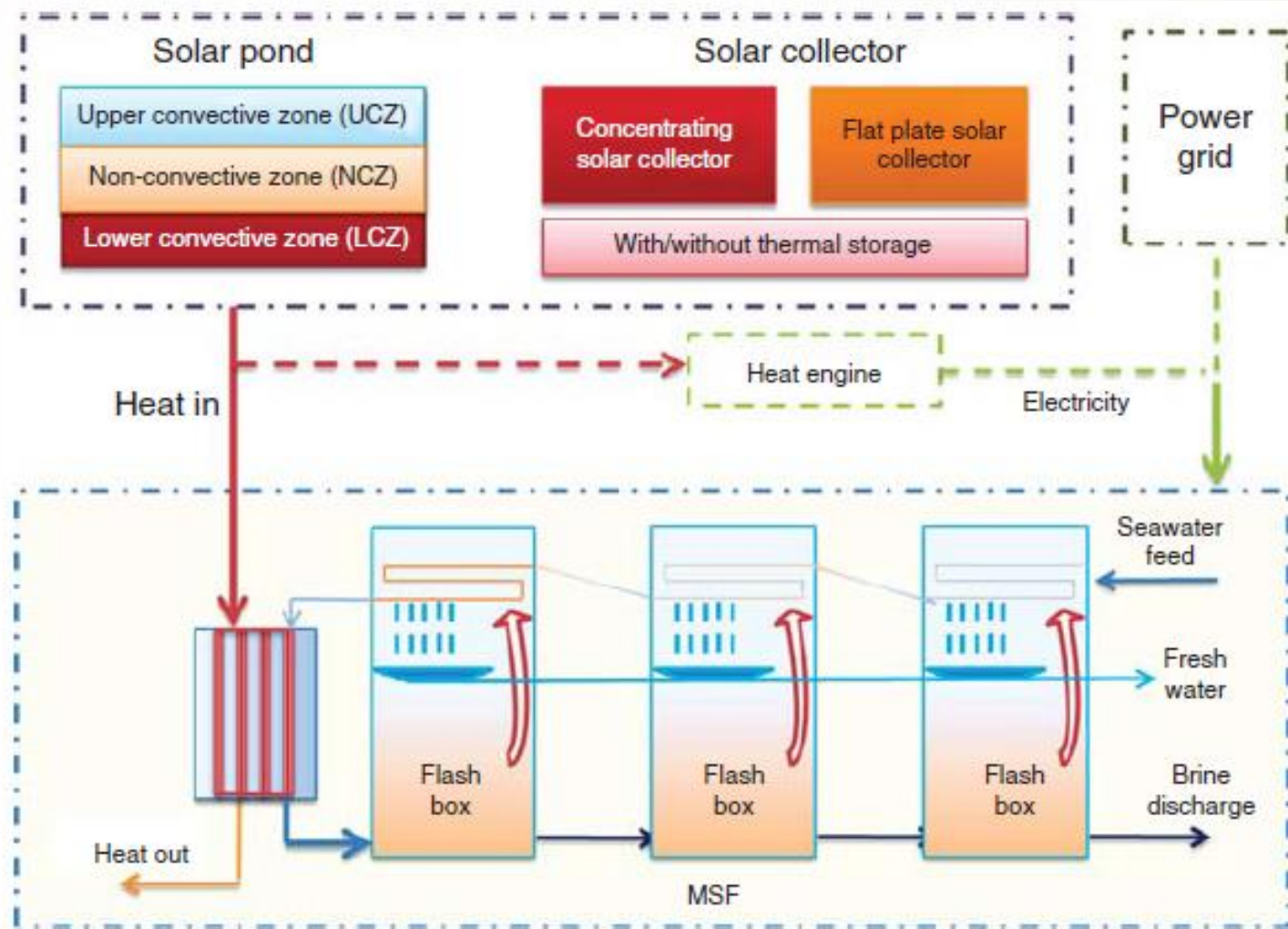
Source: Abutayeh et al, 2014

Solar PV and Reverse Osmosis



Source: Al-Karaghoul 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>



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