# Global energy consumption for water use

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## Background

- Energy and water are inextricably inter-connected.
- Global water withdrawal has increased rapidly.
- Energy for water (EFW) simultaneously increased.
- No explicit EFW data in current energy inventories.
- Global quantitative assessment of EFW is missing.

## Objectives

- Benchmark energy intensities (EI) for different water use processes and water sources.
- Estimate EFW at sectoral- and process-level at 14 regions across the globe over the historical period of 1975 to 2010.

## Methodology

- Construct a country-level historical water database.
- Evaluate energy intensities values and range.
- Estimate conversion ratios from primary energy to electricity.
- Estimate EFW at the country scale for 1975-2010.

## Results

*1. Estimates of energy intensity (EI)*

- Mean and the variance of EI for surface water "source and conveyance" (SC) are especially high.
- Industrial wastewater treatment has higher EI values due to smaller flow rates and higher loadings of contamination.
- Water distribution also requires relatively high EI.

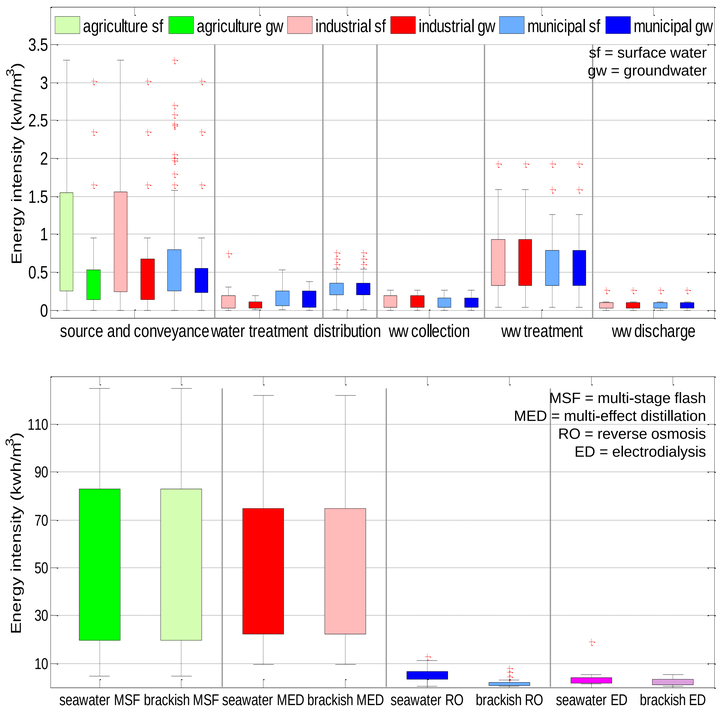


Figure 1: Range of energy intensity (EI, kwh/m$^3$): (a) by water use processes and water sources and end-use sectors; and (b) by desalination technologies and water sources.

*2. EFW changes across sectors, sources, processes & regions*

- Municipal, agricultural, industrial water sectors account for 44% (4.3EJ), 27% (2.6EJ), and 29% (2.9EJ), respectively.
- The most energy-intensive process is SC (4EJ, 41% of the total EFW), followed by wastewater treatment.
- Energy for desalination went from 0.9% to 8.4% (1980-2010)
- India, the Middle East and China surpassed the USA from 2003 onwards and became the three largest EFW consumers

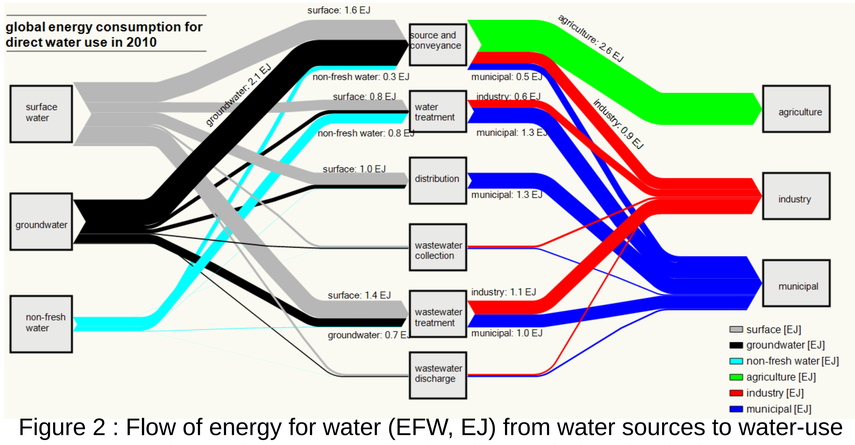


Figure 2 : Flow of energy for water (EFW, EJ) from water sources to water-use processes and to end-use sectors in 2010 (first global evaluation).

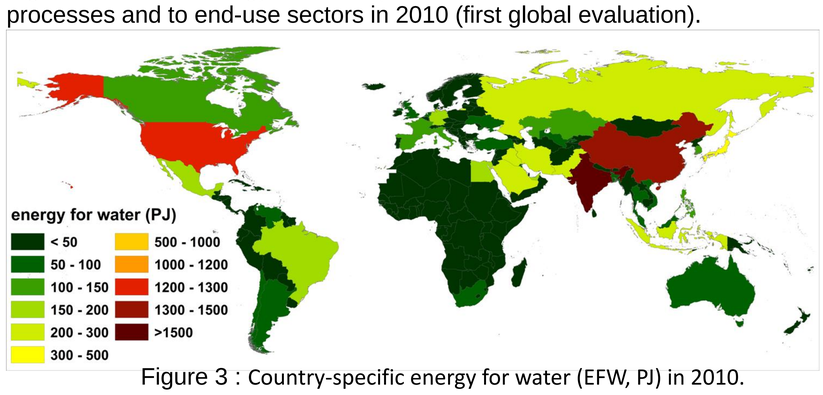


Figure 3 : Country-specific energy for water (EFW, PJ) in 2010.

*3. EFW ranges and percentage of EFW in total primary energy supply (TPES)*

- Globally, EFW accounts for 1–3% of the global TPES.
- EFW of regions such as the Middle East and India account for 5.0% – 6.5% of the regional TPES.
- Negative trend in the fraction of TPES allocated to EFW, except India and Africa.

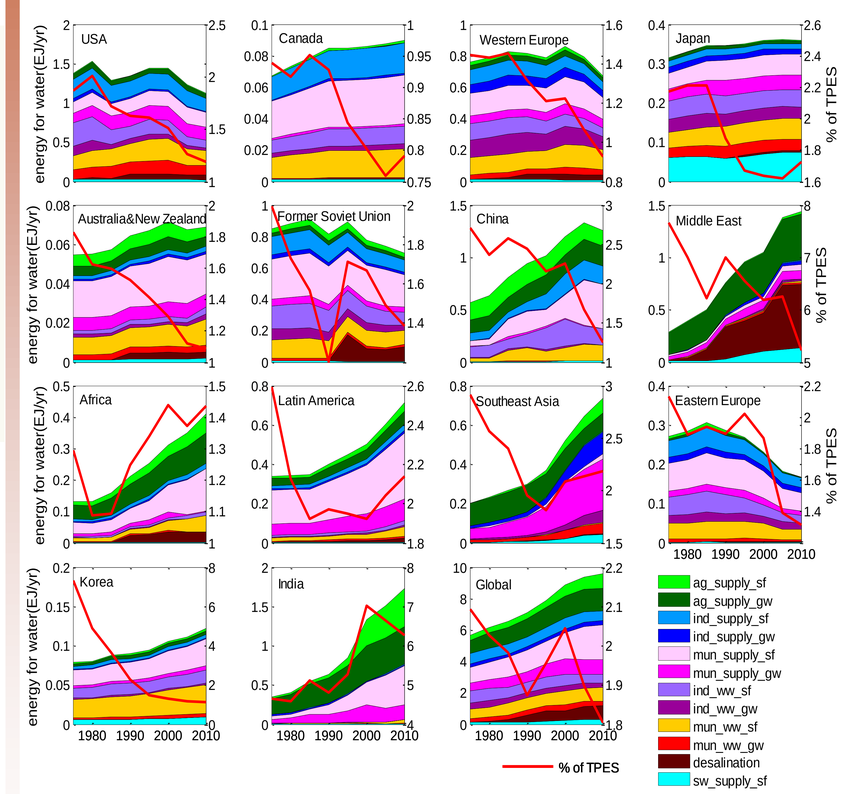


Figure 4 : Region-specific changes of energy for water (EFW, EJ) by water-use processes and water sources and end-use sectors.

## Ongoing and future work

- Incorporate EFW into Global Change Assessment Model.
- Investigate the EFW induced greenhouse gas emissions.
- Examine the impacts of climate change on irrigation and subsequently on EFW.
- Uncover effects of EFW on the fate of future desalination.

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**References:**


- Liu, Y, MI Hejazi, S Kim, P Kyle, E Davies, D Miralles, R Teuling, Y He, D Niyogi (In review). Global energy consumption for water use. *Environmental Science & Technology*.