ECN
Your energy. Our passion.

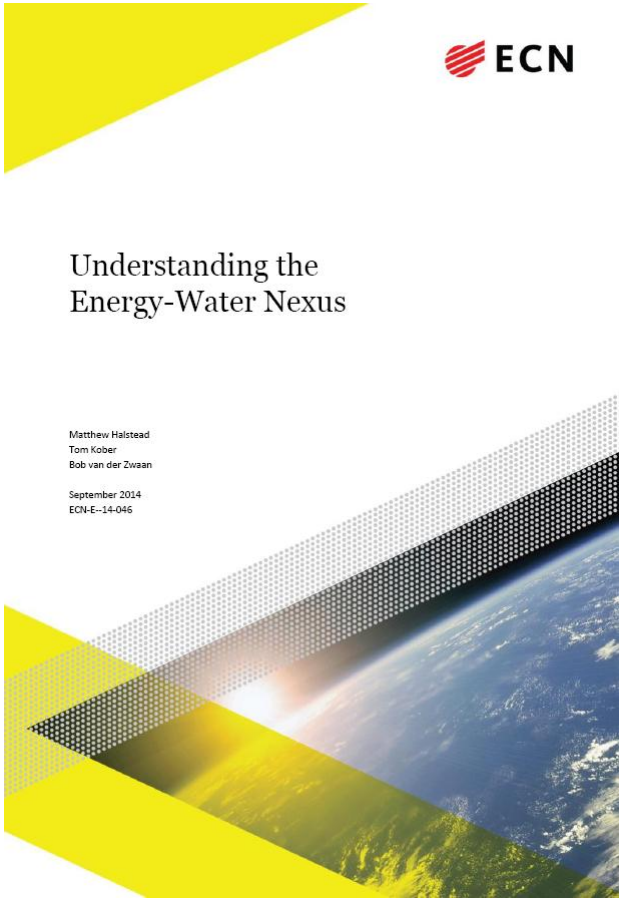
Exploring the Energy-Water Nexus: An analysis with TIAM-ECN for the Middle East

Tom Kober, Bob van der Zwaan, Matthew Halstead

ESTAP Semi-annual workshop
Abu Dhabi
1 June 2015

www.ecn.nl

ECN report available



Halstead, M., T. Kober, B. van der Zwaan, *Understanding the Energy-Water Nexus*, ECN Report no. ECN-E-14-046, Sept. 2014, Petten, The Netherlands.

http://www.ecn.nl/publications/ECN-E--14-046

Preamble

- **Energy, water and food resource systems are fundamentally interrelated.**
- We need energy to produce essentially all forms of food and to treat and move water.
- We need water to cultivate food crops and to generate essentially any form of energy.
- We need food to support the world's growing population that both generates and relies on energy and water services.
- Land availability also constitutes an important element in each of these three resources, e.g. for crop production for food or energy purposes.
- This intricate and variable relationship is since recently referred to as the "Energy-Water-Food Nexus".

Definitional issues

- ‘Energy-Water Nexus’ is a notion that is not clearly delimited, that is, different authors or analysts employ different system boundaries.
- This is e.g. evidenced by the fact that some people expand the concept to ‘Energy-Water-Food Nexus’ or ‘Energy-Water-Food-Climate Nexus’.
- Moreover, ‘The Nexus’ is poorly defined, and interpretations abound on the type of concerns and challenges (plus opportunities) it covers.
- Also amongst policy makers a wide variety of meanings of ‘The Nexus’ exists, some of which are operational, but others are clearly not.

For example

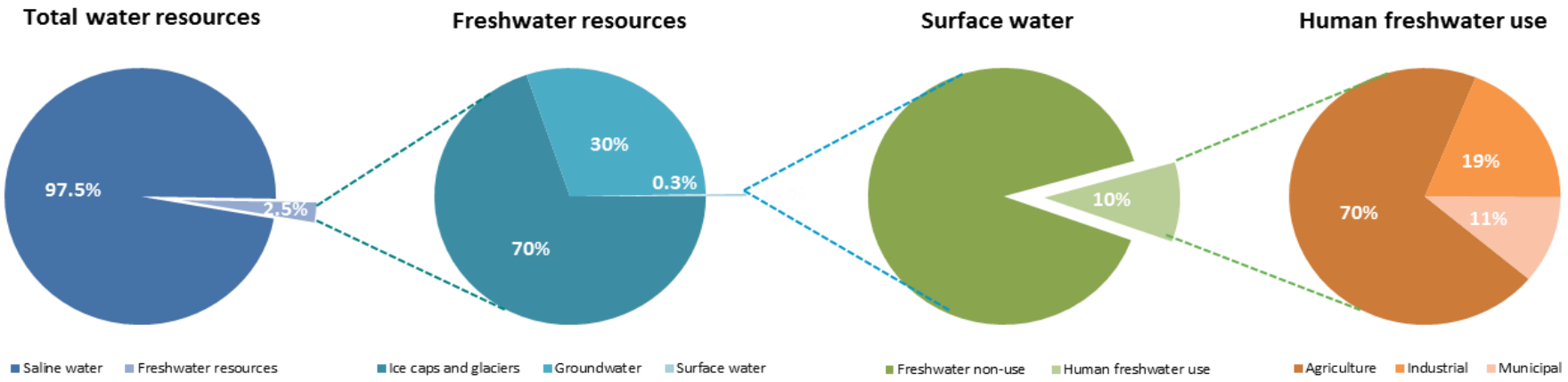
Quite generally, for some analysts it would refer to:

- Mutual linkages between energy and (fresh) water production.
- Interdependence of biomass (land-use) for energy resp. food supply.
- Effects of climate change on power plants and crop yield.

More specifically, for others it would mean:

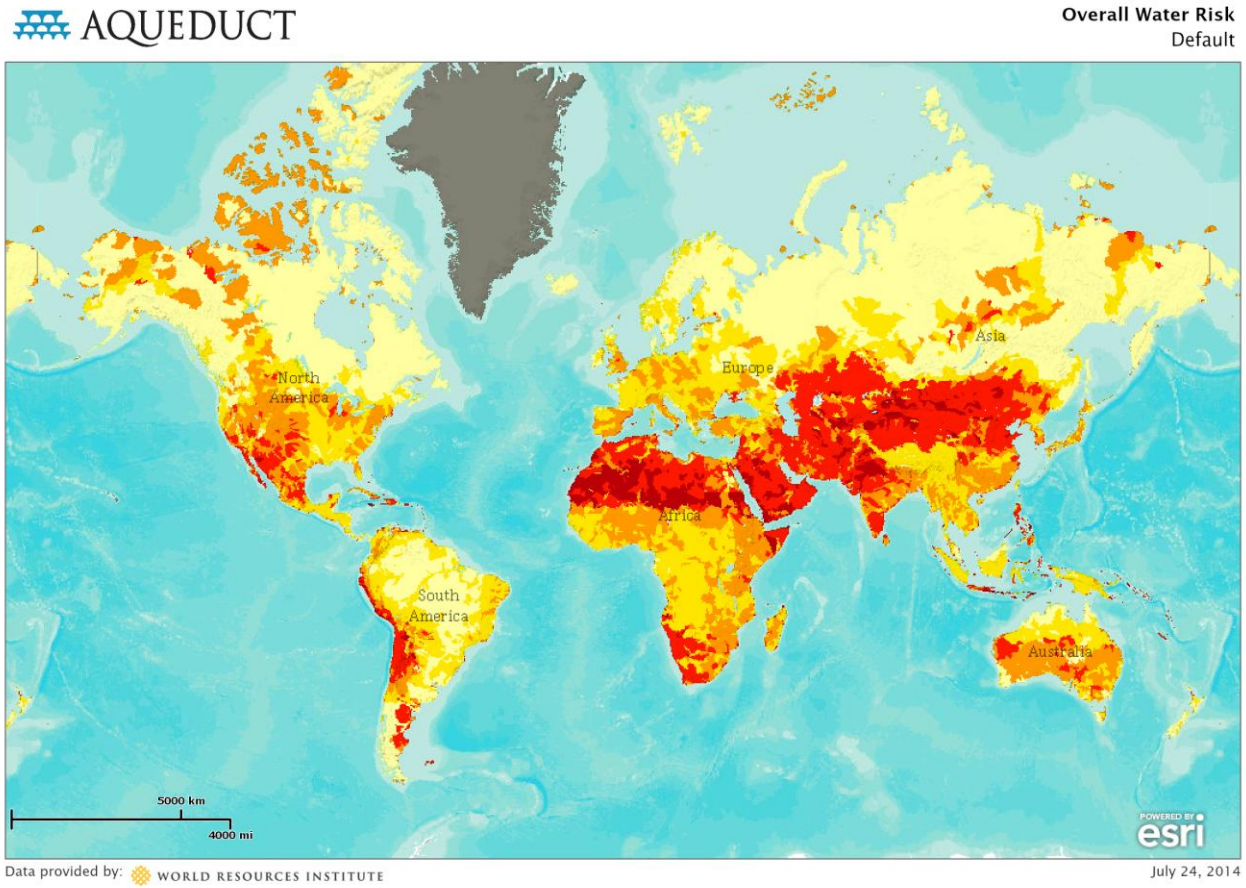
- Hydropower is subject to water availability and variability.
- Wind turbines can be built on dikes and dams.
- Some biofuel options require lots of water (rain or irrigation).
- Industry is generally a water-intensive sector.

Fresh water is the issue

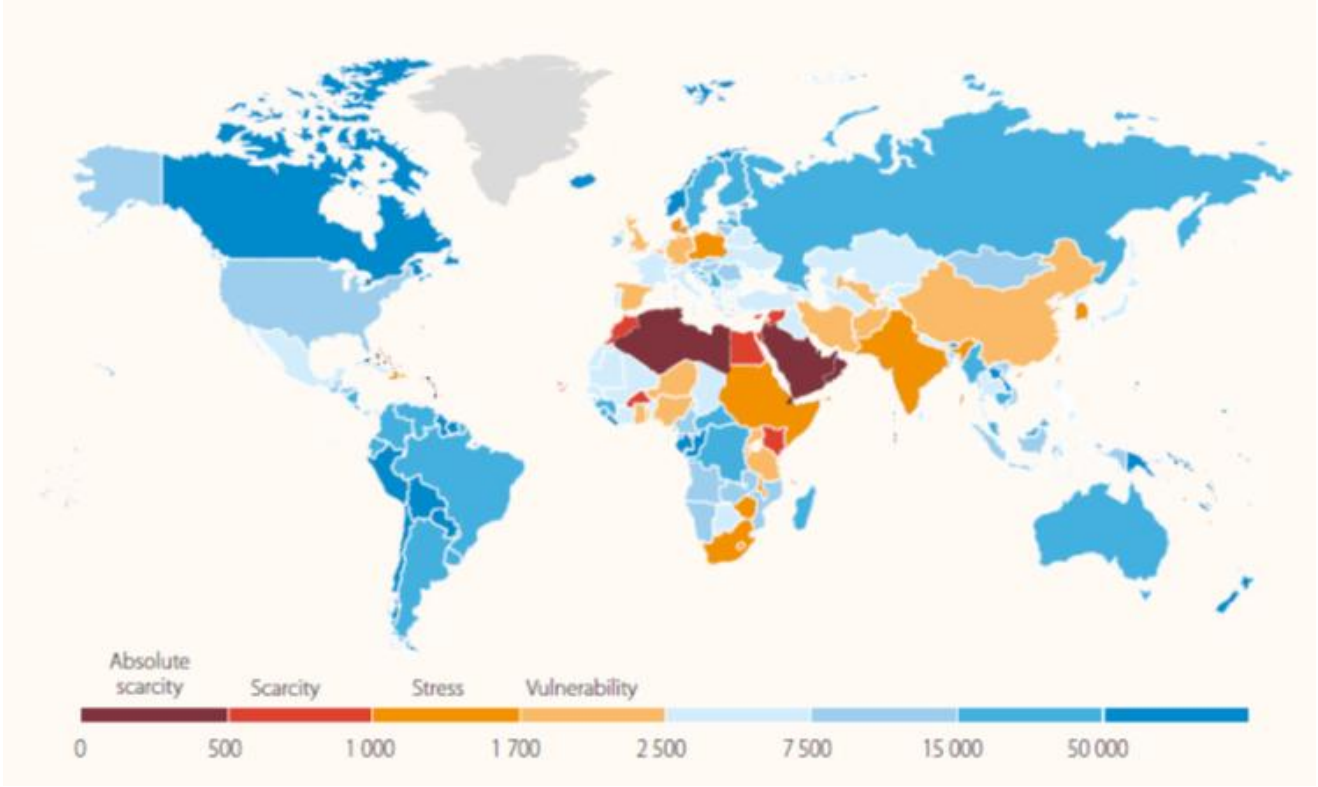


Data sources: Shiklomanov, 1993; UN FAO Aquastat Database; Graedel et al., 2014.

Water risks: drought and flooding



Water stress



Source: UN WWDR, 2014; UN FAO Aquastat database.

Renewable water resources per year per capita (m^3, 2010).

Our goal and achievements

- We have made an overview of the existing literature and expertise in this domain, which encompasses many different aspects.
- We have indicated where the current shortcomings and gaps are in the knowledge about this subject.
- We have analyzed the water requirements for a broad range of energy technologies, particularly those relevant for ECN.
- We performed a regional inspection contrasting several scenarios for energy-water needs in the Middle East against local water availability.

Our main focus

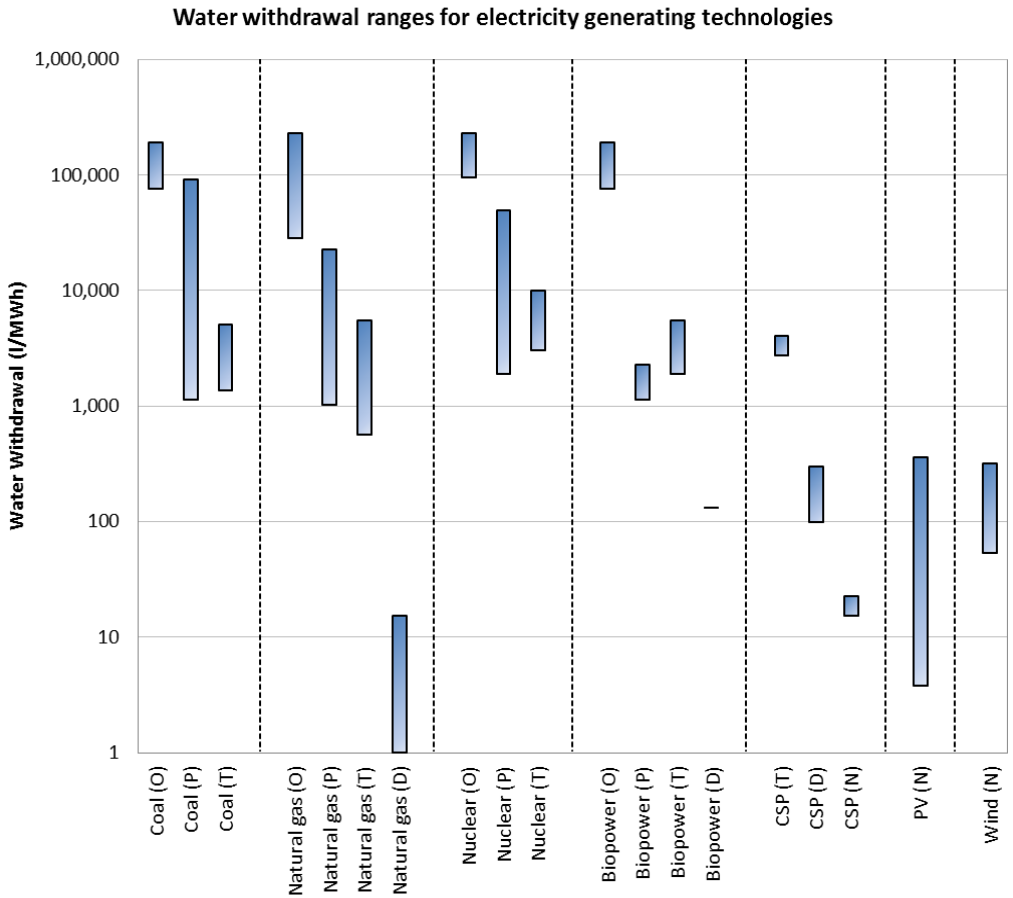
- Focus on the water needs for energy supply, i.e. the **power sector.**

- We thus do not (cannot) go into much detail for a range of other issues.
- These include the environmental impacts from energy on water.

An important distinction needs to be made:

- Water use / requirements: **withdrawal** versus **consumption**.
- **Water withdrawal**: volume of water removed from a source.
- **Water consumption**: volume of water removed from a source but not returned to it (e.g. due to evaporation).
- **Water discharge**: the difference between these two: volume of water withdrawn that is returned to the source (but typically degraded).

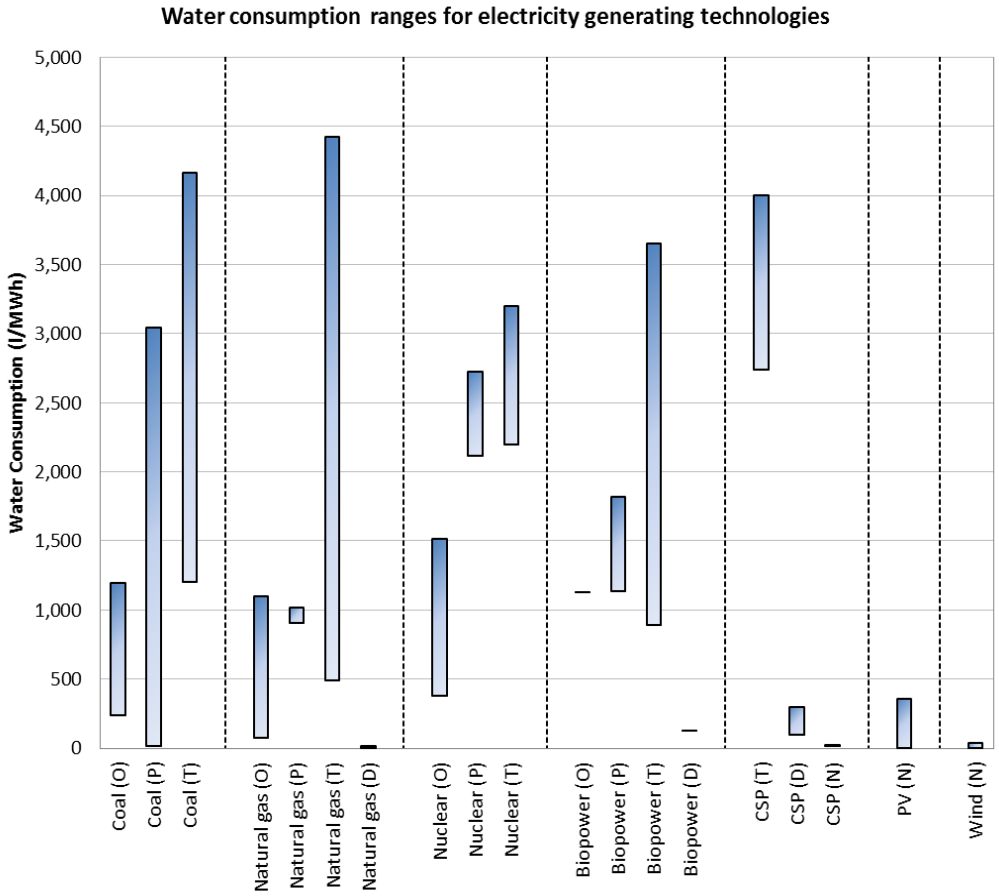
Energy technology: water withdrawal



Data source: our literature review.

Not only large differences in **water withdrawal** levels exist between different types of electricity generation technologies, but especially between different cooling options.

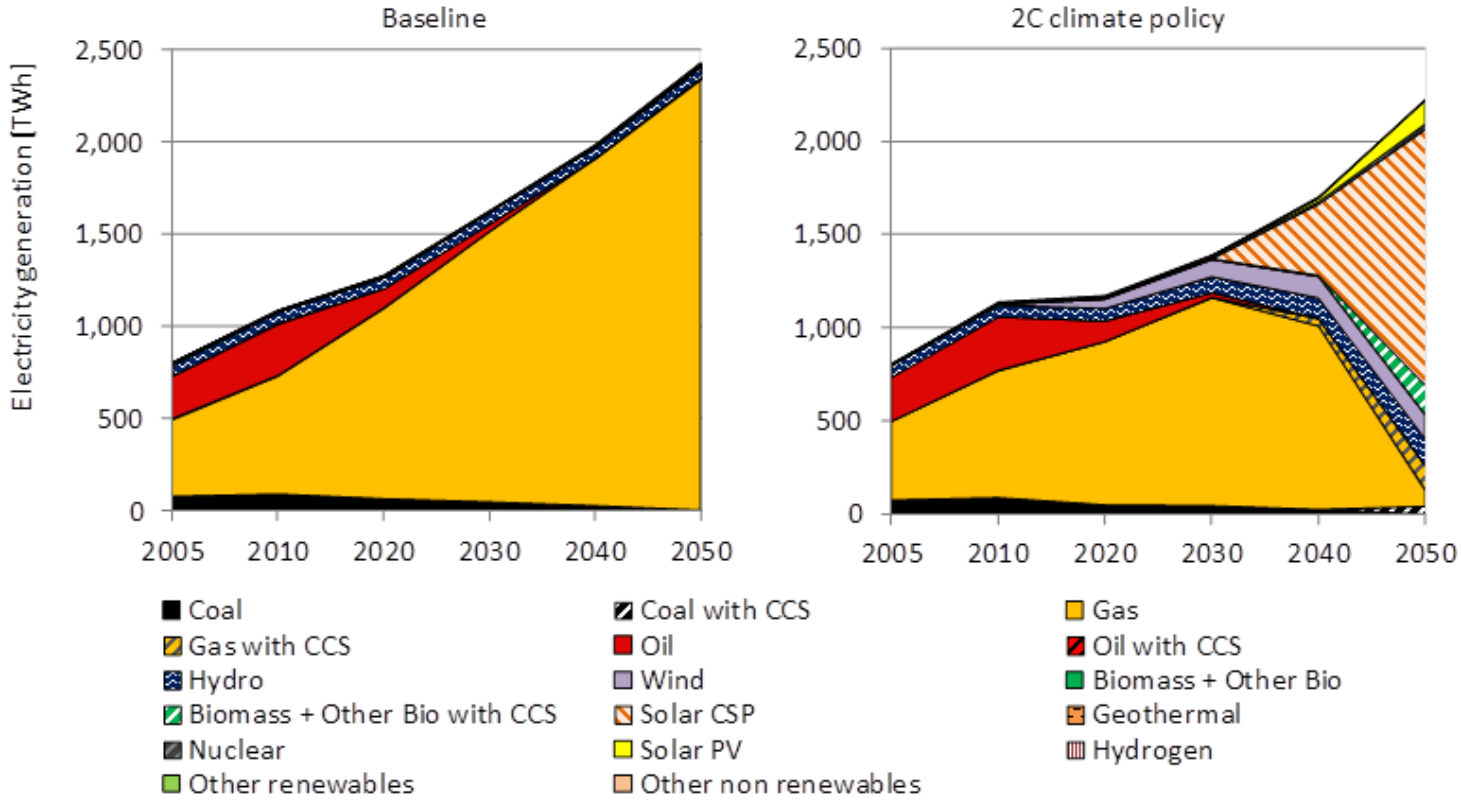
Energy technology: water consumption



Data source: our literature review.

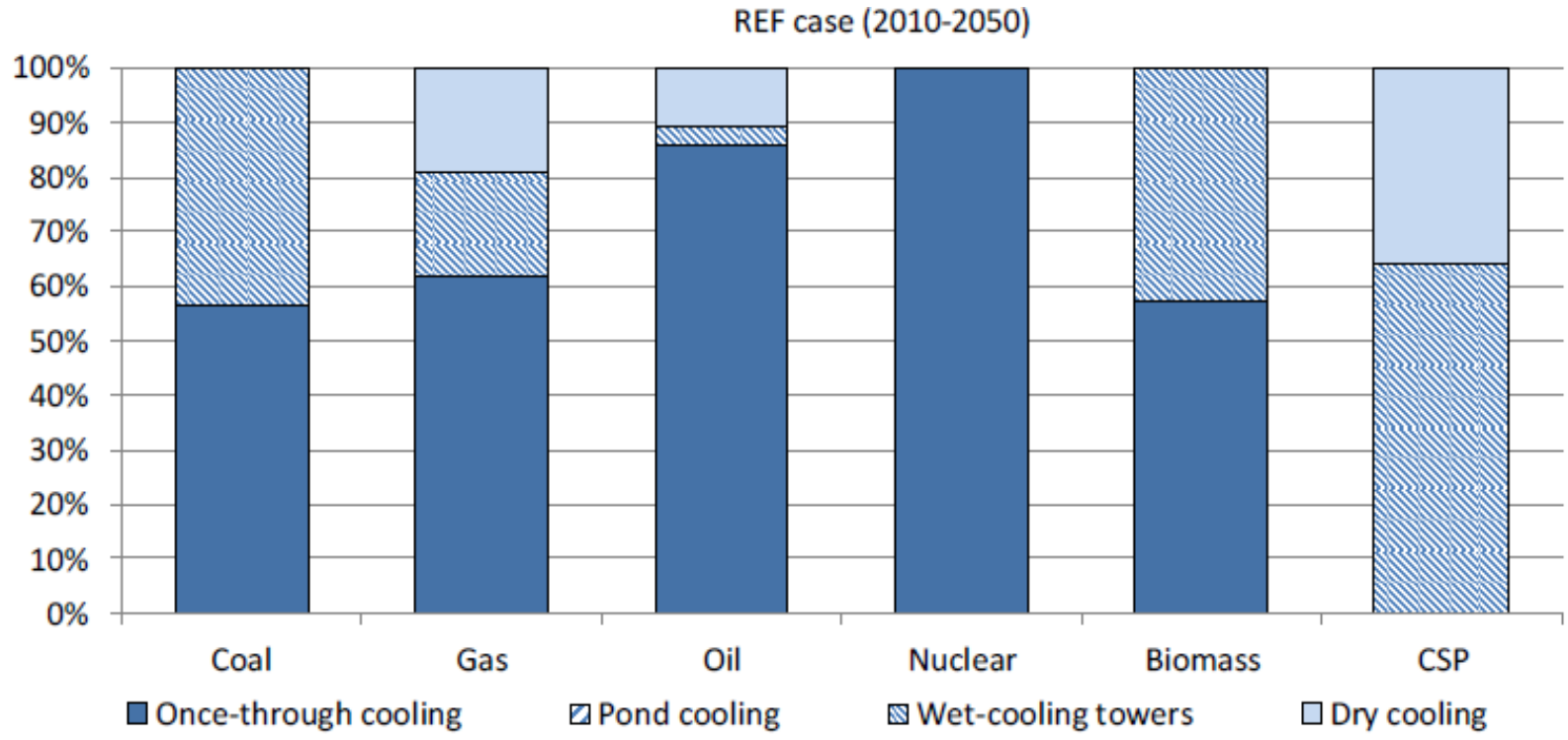
Not only large differences in **water consumption** levels exist between different types of electricity generation technologies, but especially between different cooling options.

Application: power supply Middle East



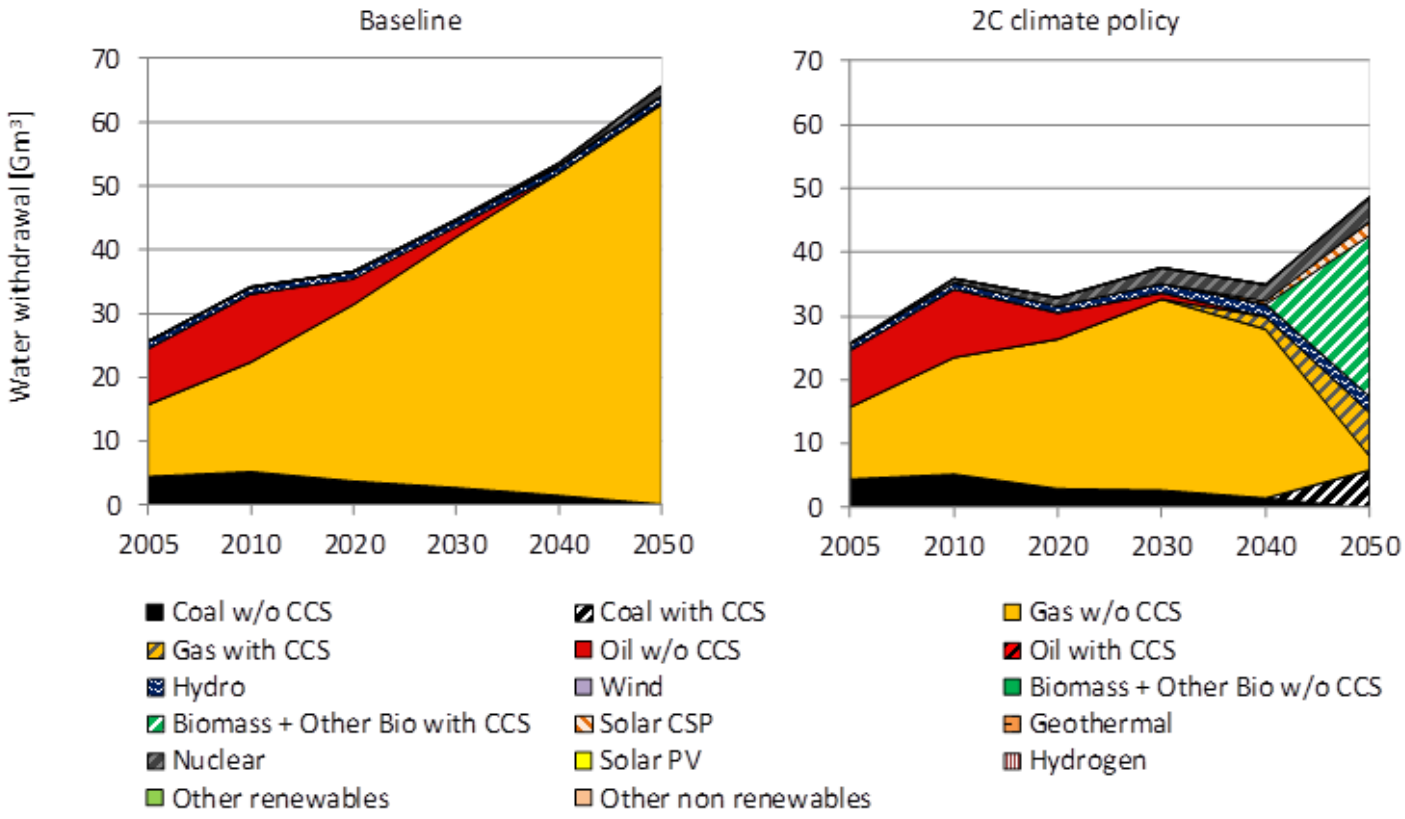
What are the water withdrawal and consumption implications of these possible scenarios, if the same cooling techniques are used for future deployment?

Assumptions on cooling technologies



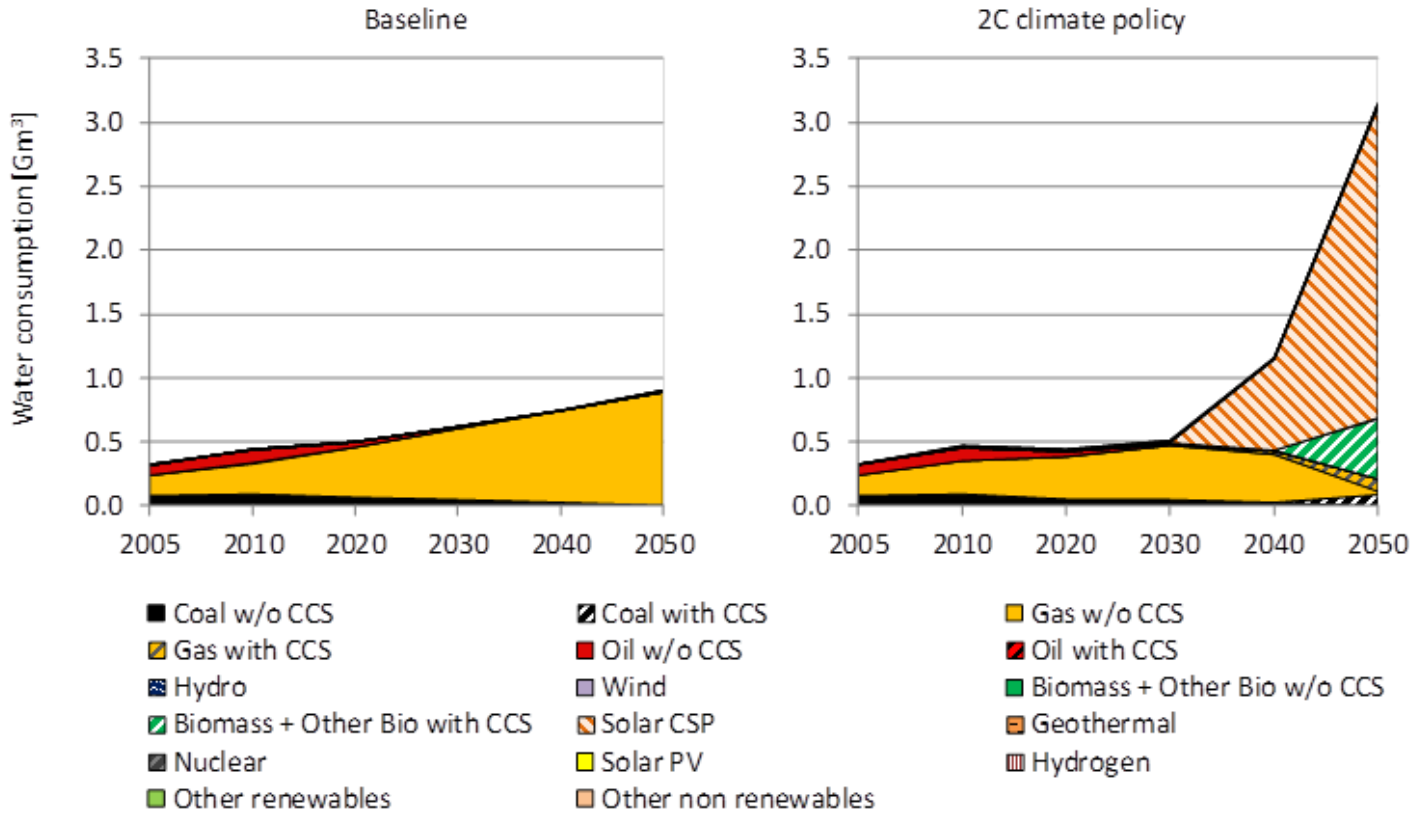
NB: shares refer to technology with the Rankine cycle.

Middle East: water withdrawal



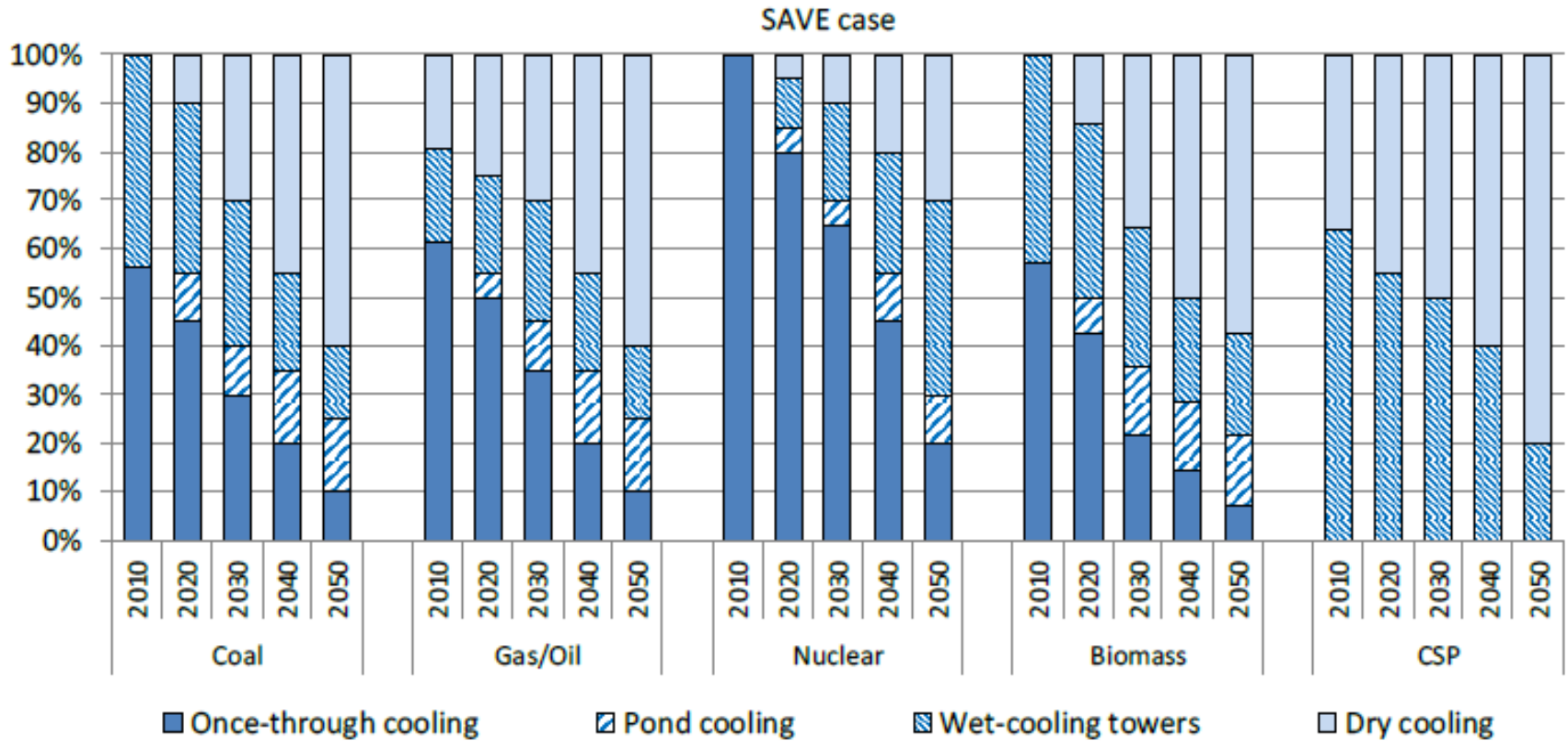
By 2050 various CCS options (and nuclear power) become major water **withdrawers**.

Middle East: water consumption



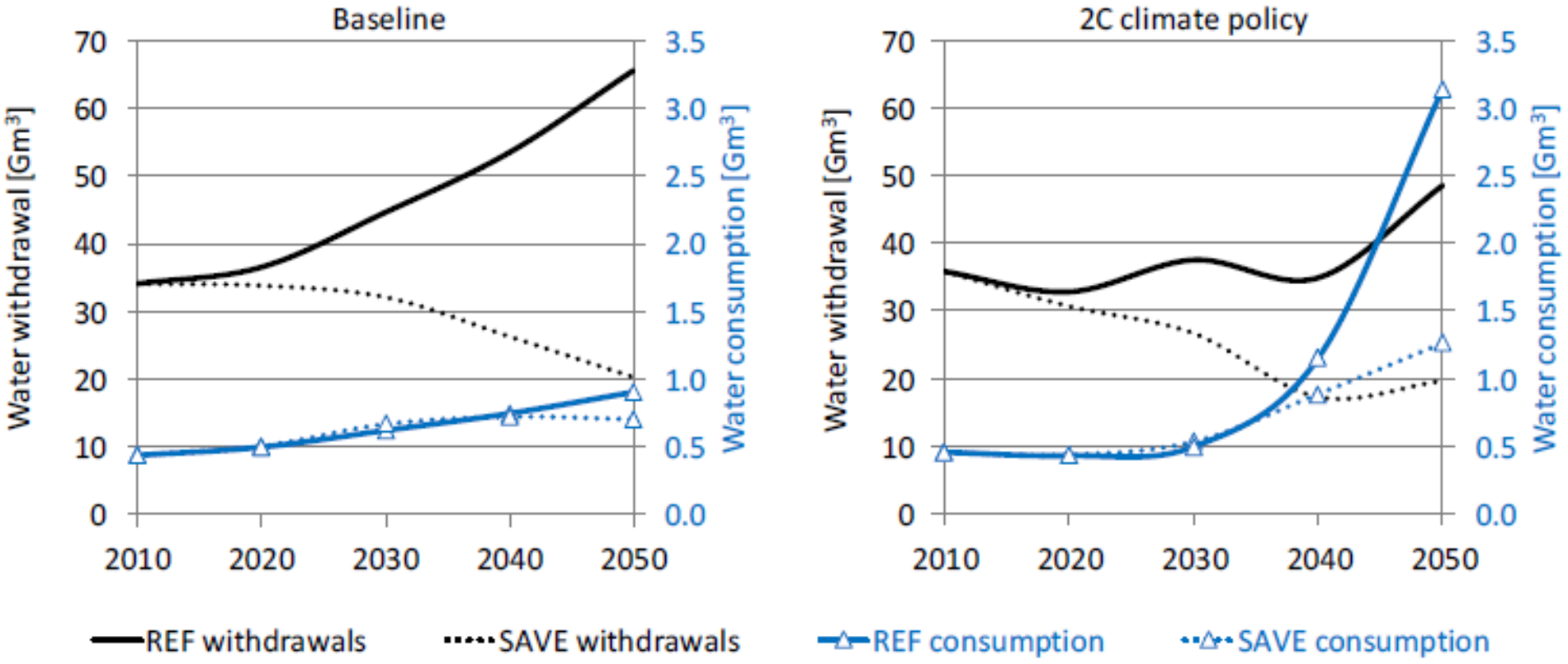
By 2050 CSP technology and various CCS options become major water **consumers**.

Switch in cooling technologies



Suppose once-through and recirculating cooling techniques in the REF case are partly and gradually replaced by dry and hybrid cooling options, as in the SAVE case.

Large water implications

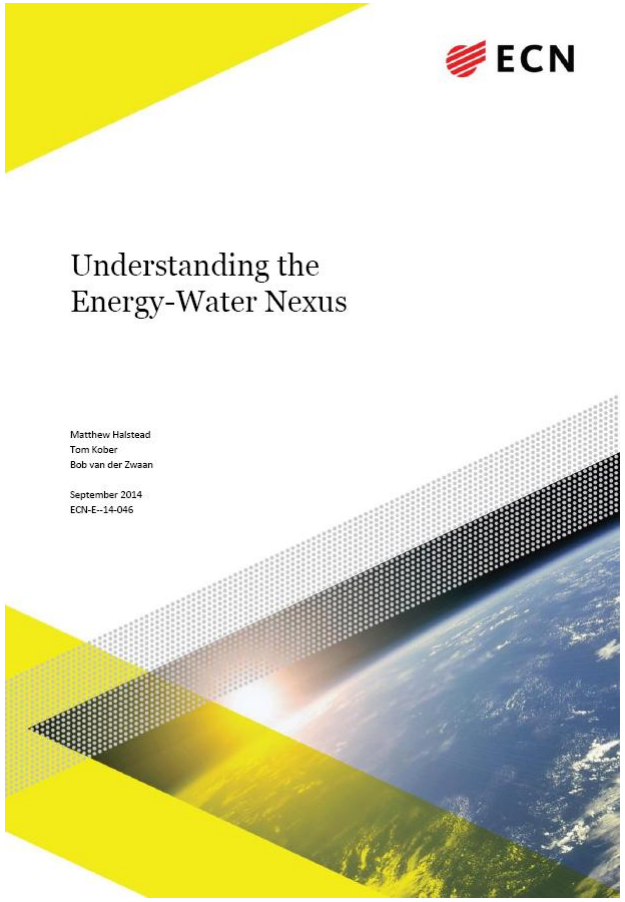


In the long run (but not necessarily in the short run) both water withdrawal and consumption may be reduced significantly: this comes at a price, but may be economic.

Findings and recommendations

- **Type of cooling** at least as determinant for the water needs of power production options as the type of energy technology.
- **Large uncertainties** and many gaps in the literature regarding water use of different energy technologies.
- **Scenario analysis** can provide insight in the water implications for regions or countries of different energy technology deployment paths.
- **Water as important as energy supply** in some regions; therefore joint analysis / optimization / policies necessary.
- **Integrated Assessment Models** useful to assess availability and costs of water.
- **Enhancement of ETSAP-tools** to support analysis around the Water-Energy-Food-Nexus.

Thank you!



Tom Kober, Dr.-Ing.
Policy Studies | Global Sustainability

T: +31 88 515 4105 | F: +31 224 56 83 38
Radarweg 60, 1043 NT Amsterdam, The Netherlands
kober@ecn.nl

http://www.ecn.nl/publications/ECN-E--14-046