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The Water-Energy Nexus Perspective in Theory and Practice

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Presentation outline

Some preliminary, cautionary remarks, then:

1. A global overview of the energy-water nexus
2. An Australian case study
3. The solution: ‘seeing the wood for the trees’

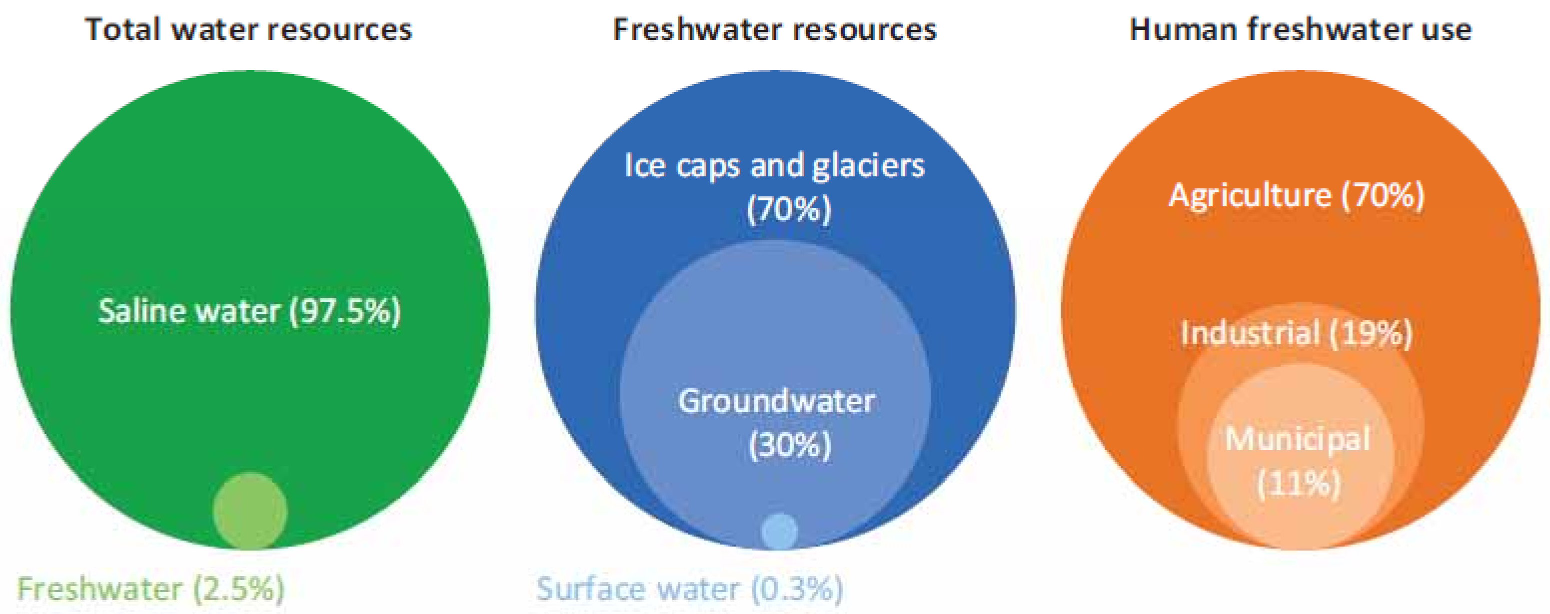
Some preliminary, cautionary remarks

- Aggregate statistics are meaningless in the water sector
- Limitations abound in ‘nexus’ framing... but ‘systems thinking’ has to start somewhere
- Framing water as a commodity has its advantages
- ‘Water resource management’ is not new; managing trade-offs is not new
- Assessing trade-offs is a *social*, *value-laden* decision
- Managing the nexus happens predominantly within nation states (so the solution is mostly there too)

Part 1

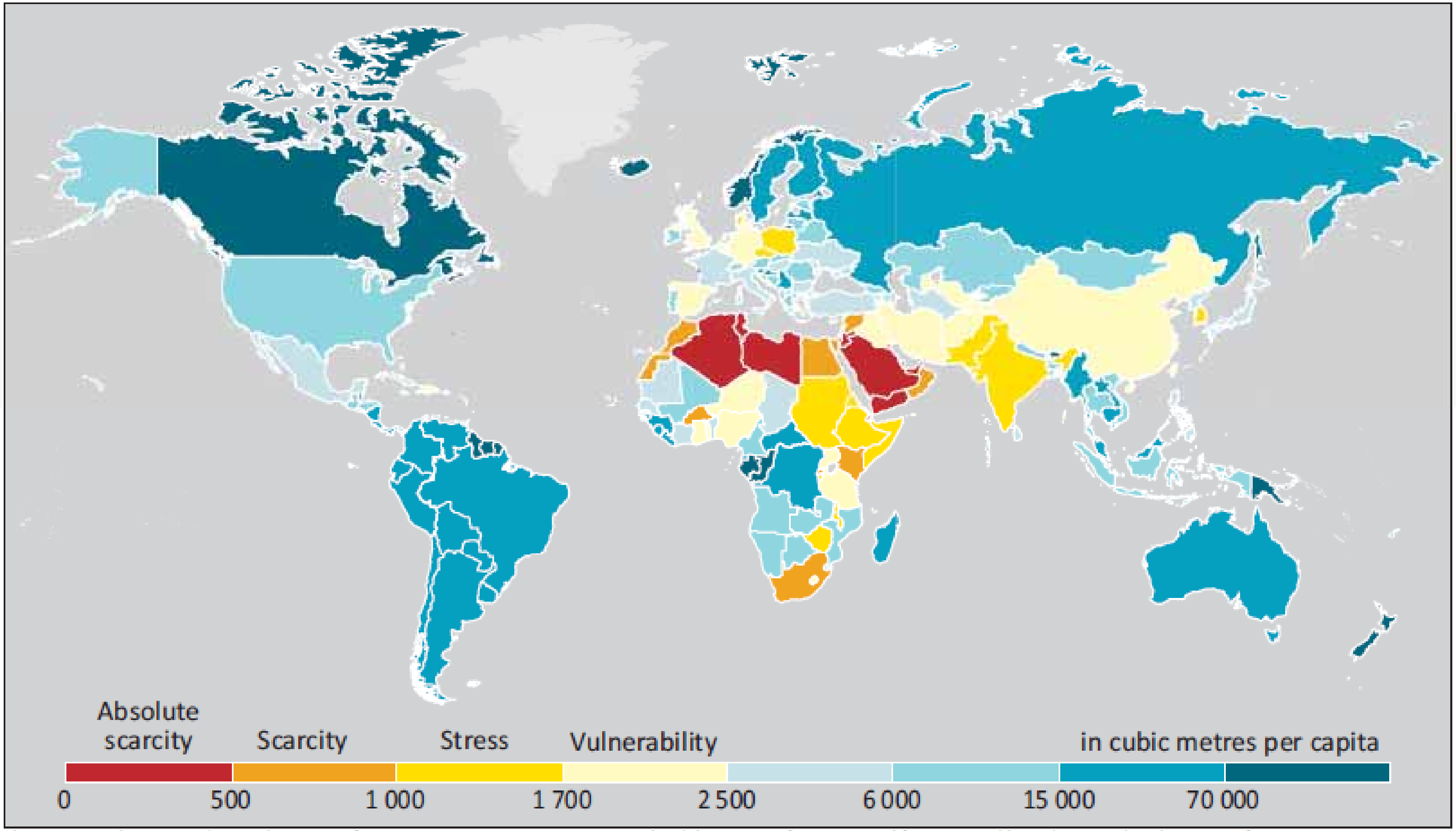
A GLOBAL OVERVIEW OF THE NEXUS: THE AGGREGATE NUMBERS

Water: supply and demand



Sources: Shiklomanov (1993); UN FAO Aquastat database.

Renewable water resources per capita 2020



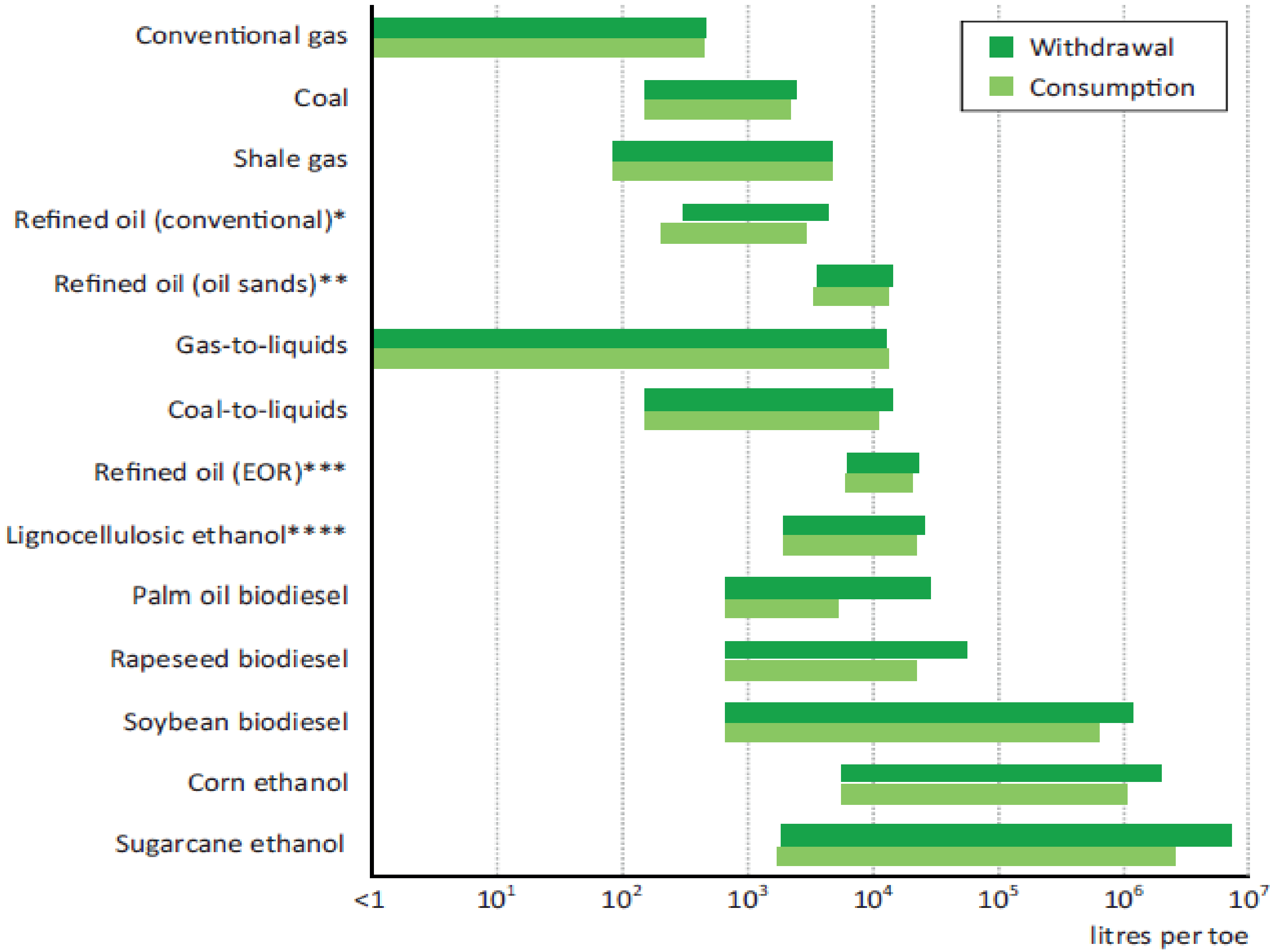
This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Source: UN FAO Aquastat database.

Water use in the energy sector: impacts across supply chain

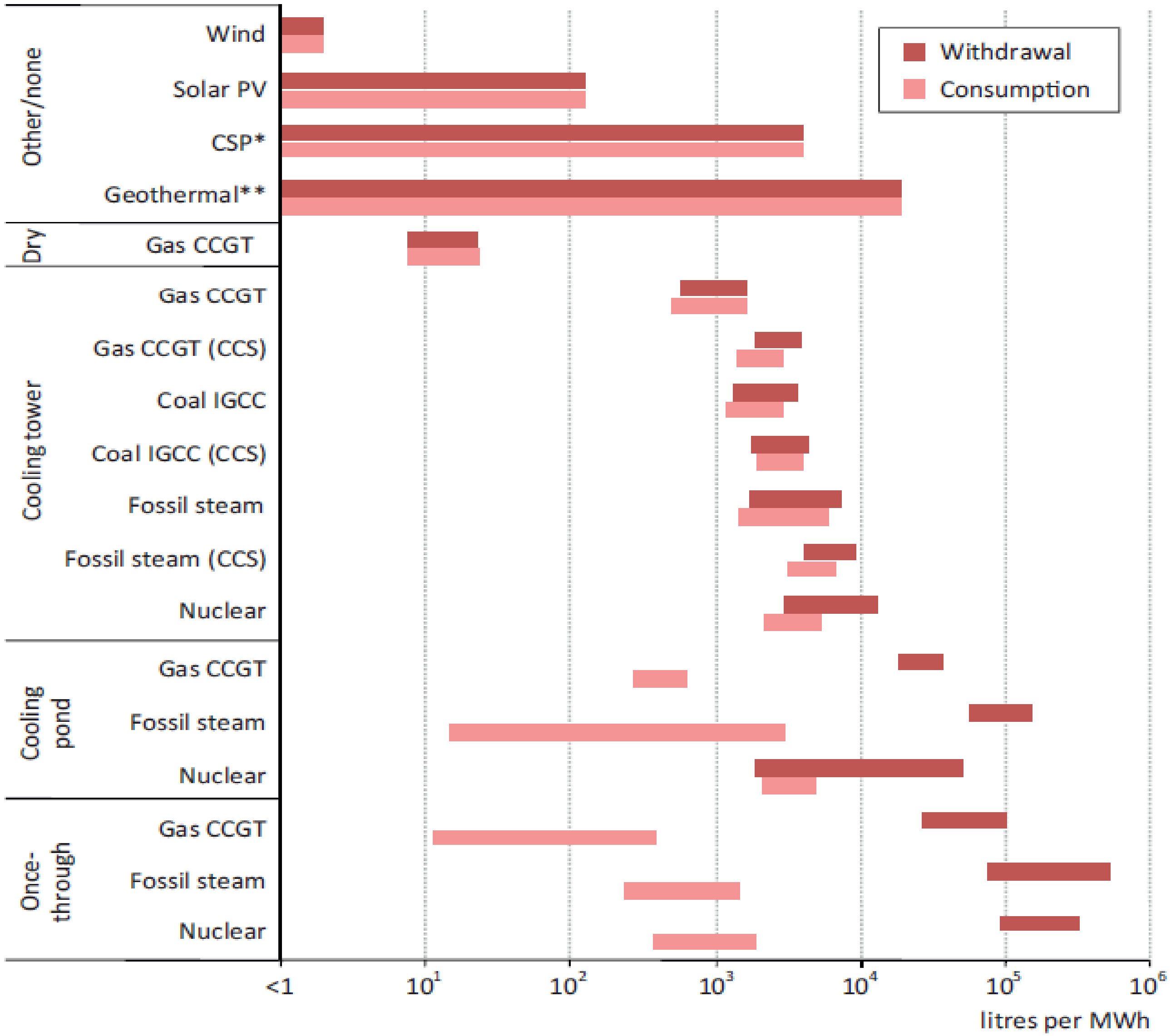
ELECTRIC POWER / ENERGY		Raw material production	Suppliers	Direct operations
Value chain segment		Extraction and refining of oil, natural gas and coal	Suppliers of power generation equipment	Power generation; Power distribution; Maintenance
Withdrawal	*Intensity*	High	Low	High
	Description	Water used for steam and water flooding of reservoirs, steam for oil extraction, cooling and steam generation for refining processes,	Cooling water or steam generation in manufacturing facilities	Water use for cooling, steam generation, flue gas treatment; Hydropower generation requires reliable water flow
Discharge	*Intensity*	High	Low	High
	Description	Wastewater containing metals and hydrocarbons	Wastewater containing heavy metals and other potentially toxic chemicals	Significant thermal discharge impacts on local ecosystems

Water withdrawal and consumption by energy source (WEO 2012)



* The minimum is for primary recovery; the maximum is for secondary recovery. ** The minimum is for in-situ production; the maximum is for surface mining. *** Includes CO_2 injection, steam injection and alkaline injection and in-situ combustion. **** Excludes water use for crop residues allocated to food production.

Water use for electricity consumption by cooling technology



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Power-plant cooling trade-offs

Cooling system	Advantages	Disadvantages
Once-through	Low water consumption. Mature technology. Lower capital cost.	High water withdrawals. Impact on ecosystem. Exposure to thermal discharge limits.
Wet tower	Significantly lower water withdrawal than once-through. Mature technology.	Higher water consumption than once-through. Lower power plant efficiency. Higher capital cost than once-through
Dry	Zero or minimal water withdrawal and consumption.	Higher capital cost relative to once-through and wet tower. Lower plant efficiency, particularly when ambient temperatures are high. Large land area requirements.
Hybrid	Lower capital cost than dry cooling. Reduced water consumption compared with wet tower. No efficiency penalty on hot days. Operational flexibility.	Higher capital cost than wet tower. Limited technology experience.

Source: Mielke, *et al.* (2010).

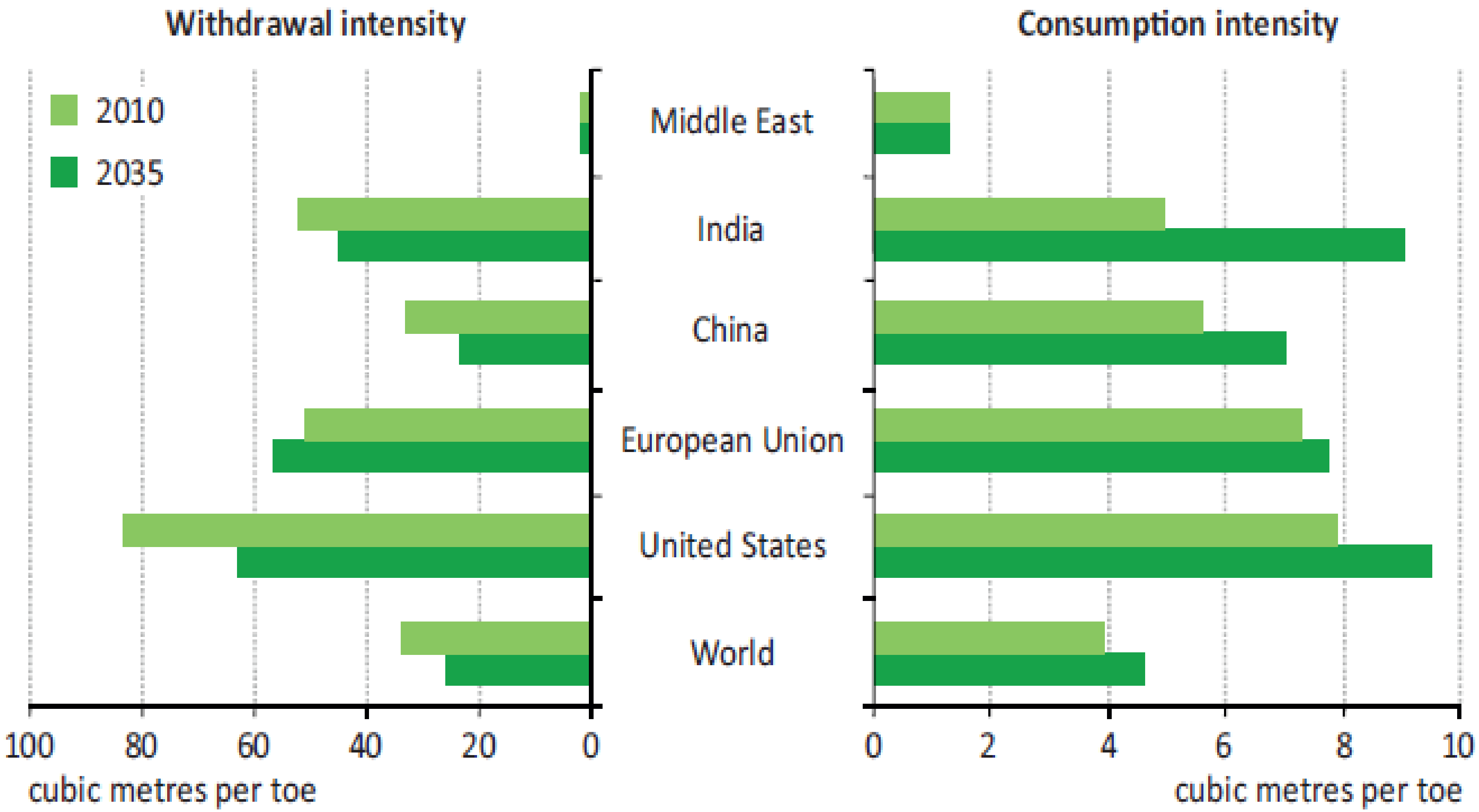
Examples of water impacts on energy production

Location (Year)	Description
	Power generation
India (2012)	A delayed monsoon raised electricity demand (for pumping groundwater for irrigation) and reduced hydro generation, contributing to blackouts lasting two days and affecting over 600 million people.
China (2011)	Drought limited hydro generation along the Yangtze river, contributing to higher coal demand (and prices) and forcing some provinces to implement strict energy efficiency measures and electricity rationing.
Vietnam, Philippines (2010)	The El Niño weather phenomenon caused a drought that lasted several months, reducing hydro generation and causing electricity shortages.
Southeast United States (2007)	During a drought, the Tennessee Valley Authority curtailed hydro generation to conserve water and reduced output from nuclear and fossil fuel-based plants.
Midwest United States (2006)	A heat wave forced nuclear plants to reduce their output because of the high water temperature of the Mississippi River.
France (2003)	An extended heat wave forced EdF to curtail nuclear power output equivalent to the loss of 4-5 reactors, costing an estimated €300 million to import electricity.

Examples of water impacts on energy production

Location (Year)	Description
	Primary energy production
China (2008)	Dozens of planned coal-to-liquids (CTL) projects were abandoned, due in part to concerns they would place heavy burdens on scare water resources.
Australia, Bulgaria, Canada, France, United States	Public concern about the potential environmental impacts of unconventional gas production (including on water) has prompted additional regulation and, in some jurisdictions, temporary moratoria or bans on hydraulic fracturing.

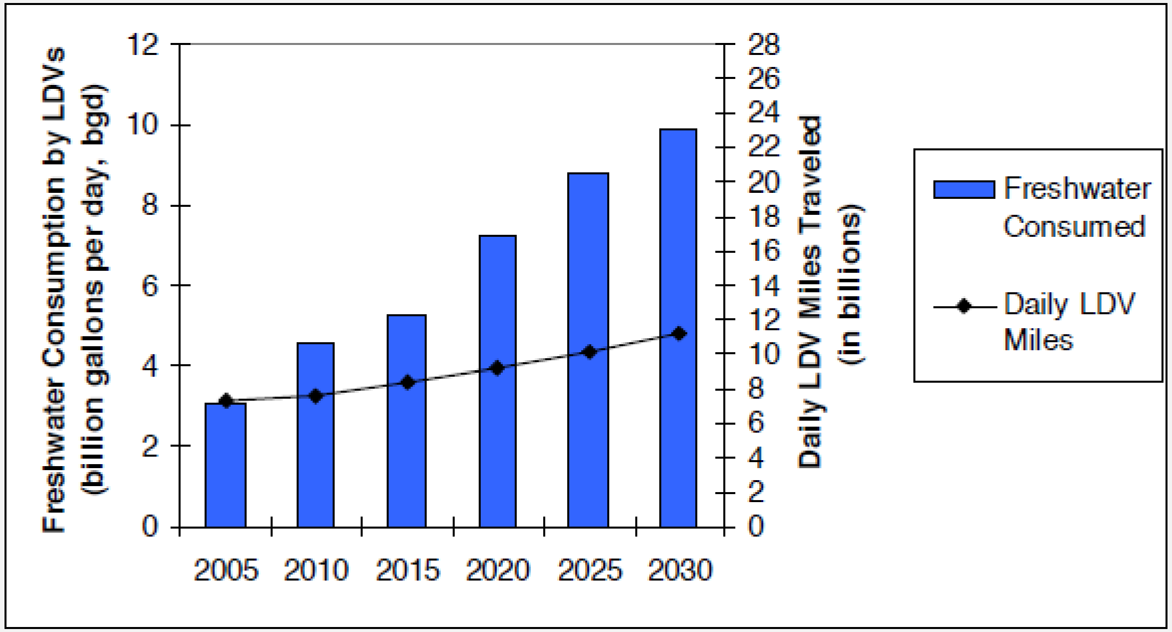
Water intensity of energy production in selected regions (WEO 2012: 517)



So, what do we know?

- Water is used in the production of energy
- Consumption and withdrawal rates vary according to the technology deployed
- Some regions are particularly vulnerable
- Vulnerability will increase in the future: energy demand, climate variability and change and population growth
- Policies in both sectors can either make things worse, or make things better....

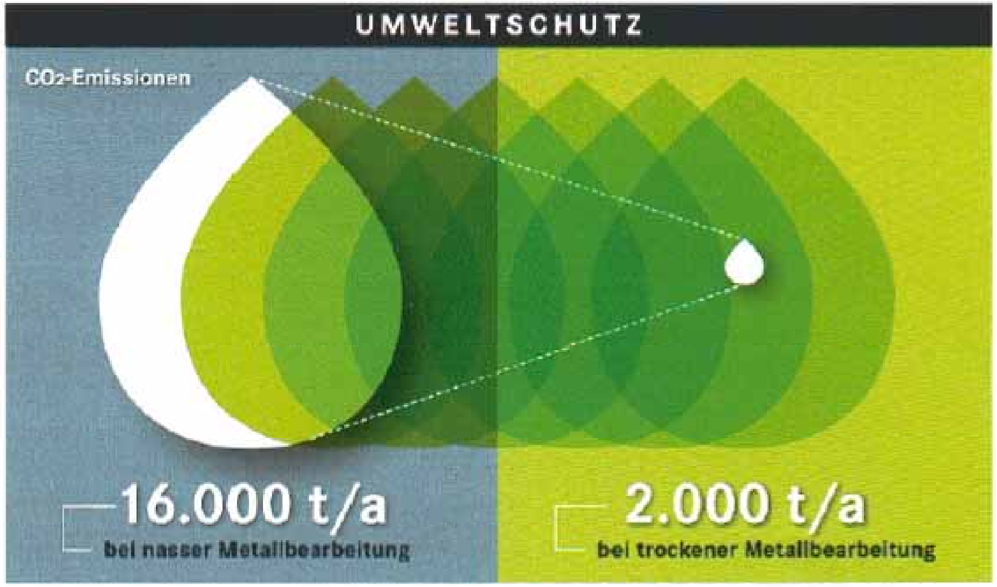
Transportation fuels



Sources: C. W. King,, M. E. Webber, and I. J. Duncan, "The Water Needs for LDV Transportation in the United States," *Energy Policy*, vol. 38 (2010), pp. 1157-1167; EIA, *Annual Energy Outlook 2008*, Table 7, Transportation Sector Key Indicators and Delivered Energy Consumption, Line 15. The King 2010 article used 2008 EIA data.

- An increase in miles driven and the increasing water intensity of fuels, as a result of biofuels (from irrigation feedstock), overwhelms the water gains from improving vehicle fuel efficiency. Water intensity of those vehicles will increase from 40 gallons/100 miles, to over 90 gallons/100miles. (University of Texas, Austin)

The Daimler Example



14.000 Tonnen CO2 können allein bei der Produktion der neuen Dieselmotoren eingespart werden.

- Daimler: high proportion of energy consumption in the production of Diesel engines lay in the metal processing work required in the production of wheel-carrier assemblies
- By altering the process of metalwork from one which required lubricants (oils) and coolants (water), to dry metal processing, the company was able to reduce its CO2 emissions by 80% in that part of the product cycle
- It also reduced its water consumption by 900 tons per year *but that was an added bonus rather than an intentional objective*

Part 2

AN AUSTRALIAN STUDY

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Rationale for the study

- ‘Clean Energy Future Policy’:
  - 5% by 2020; 80% by 2050 reduction GHGs
  - Carbon tax followed by ETS
  - Carbon Farming Initiative
- Frameworks that focus on the mitigation of greenhouse gas emissions rarely consider the impact on other policy areas, such as the governance of water resources.
- Greenhouse gas mitigation is also strongly tied to climate change adaptation: +ve and -ve

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Aim and method

- Aim: to assess the implications for water resources of all carbon mitigation options in the *Climate Works Low Carbon Growth Plan for Australia*
- A quantitative assessment of proposed carbon mitigation measures involving experts from multiple sectors and disciplines
- Based on current, peer-reviewed literature

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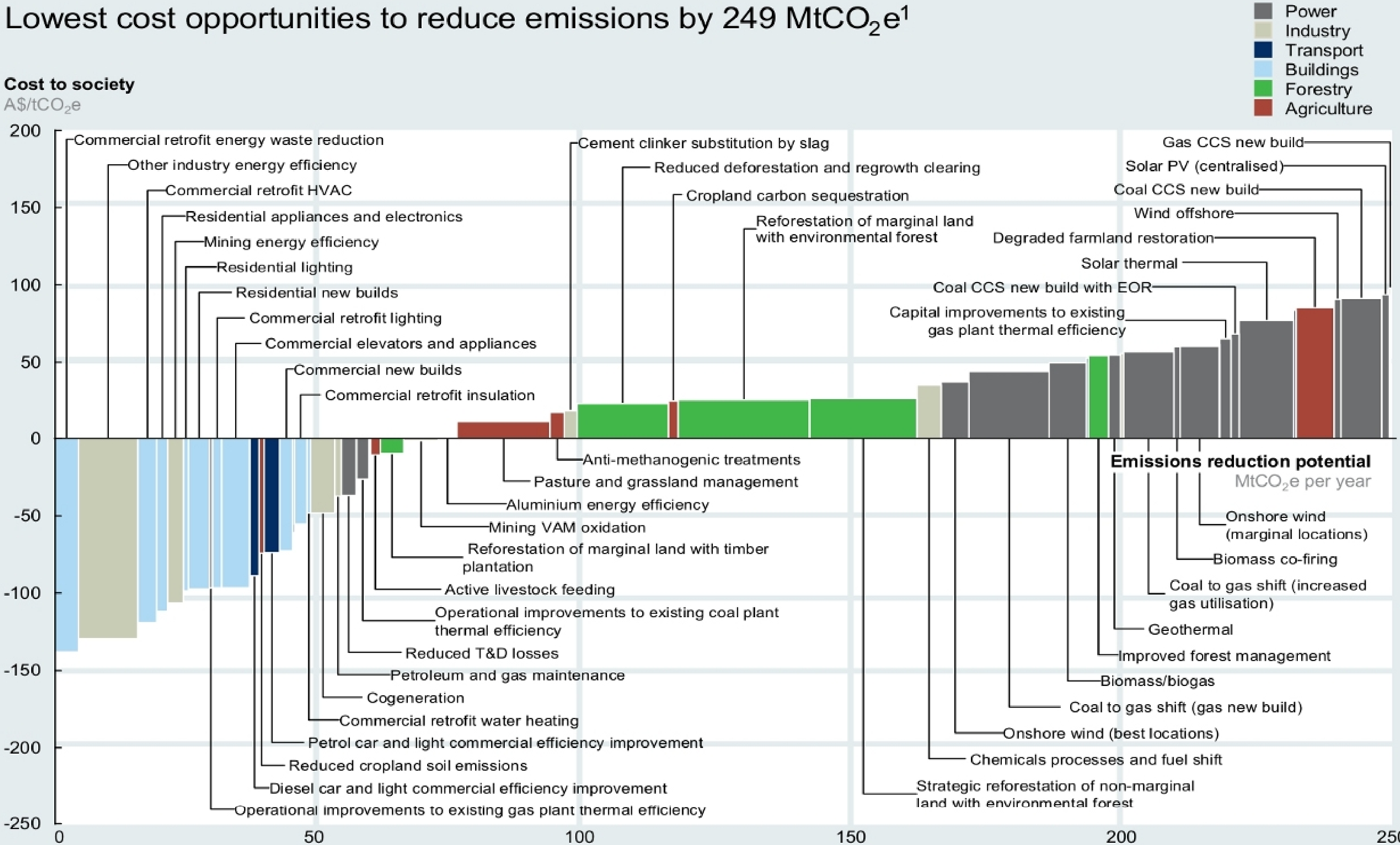
Lowest cost opportunities to reduce emissions by 249 $MtCO_2e$[1]



1 Includes only opportunities required to reach emission reduction target of 249 Mtpa (25% reduction on 2000 emissions); excludes opportunities involving a significant lifestyle element or consumption decision, changes in business/activity mix, and opportunities with a high degree of speculation or technological uncertainty

SOURCE: ClimateWorks team analysis (refer to bibliography)

The nexus in Australia

The analysis dealt with greenhouse gas mitigation measures in each of six sectors:

(1) Energy

(2) Industry

(3) Forestry

(4) Agriculture

(5) Buildings; and

(6) Transport

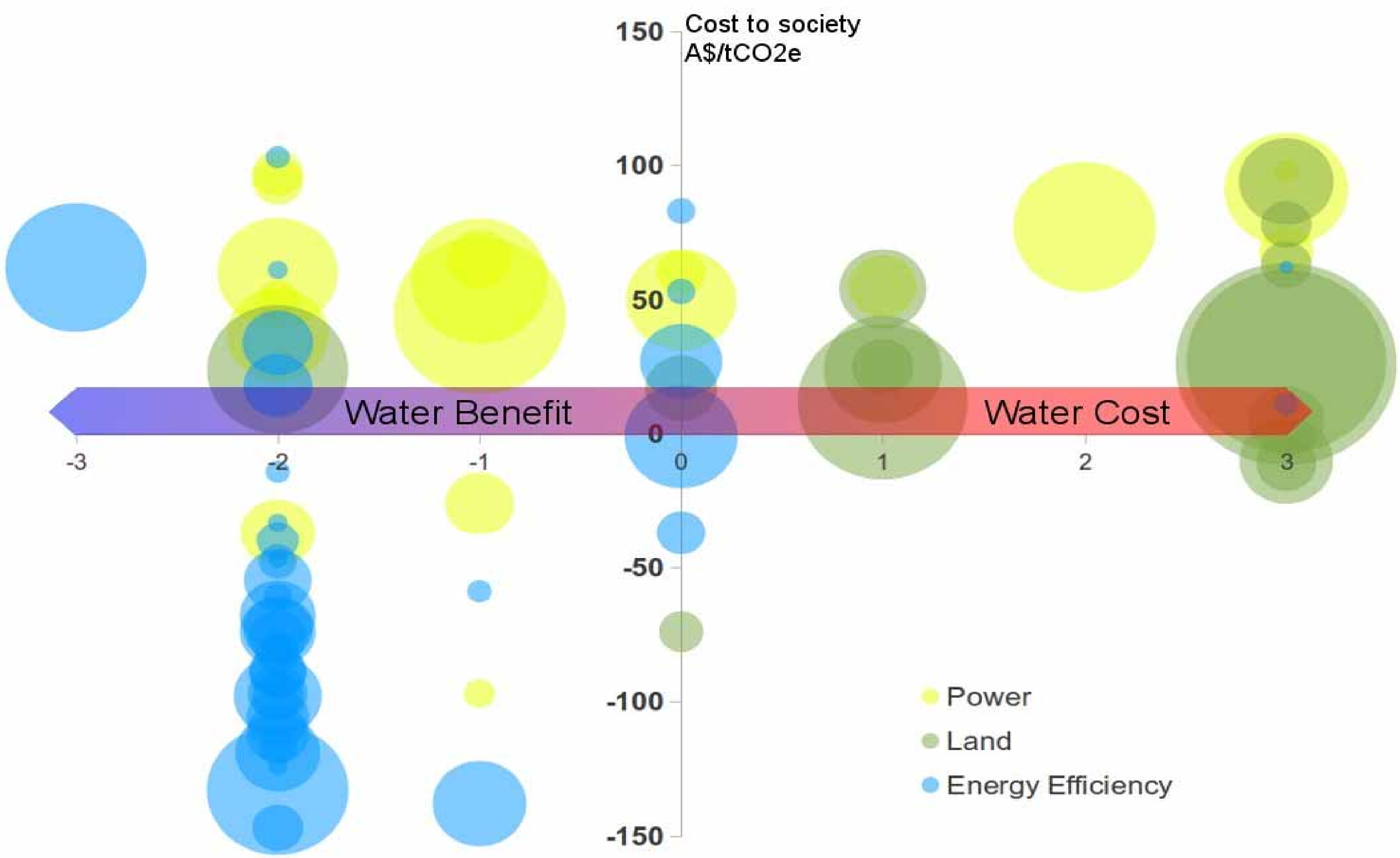
Critical analysis across three key themes:

i. technical perspective (trade-offs or synergies)

ii. economic perspective (incentives or disincentives)

iii. governance perspective (barriers and ‘enablers’).

Figure 1 The water consequences of carbon mitigation - cost of mitigation (y-axis), size of mitigation opportunity (bubble size) and qualitative assessment of water impact (x-axis).



Summary of findings: the numbers

- Of 74 mitigation measures assessed, 64 are estimated to have a water benefit or are water neutral
- They account for approximately 145 GL of water savings in 2020 associated with 178 $MtCO_2e$ (~70 per cent) of a possible 249 $MtCO_2e$ of the total mitigation volume possible in the abatement cost curve.

Summary of findings: the numbers

- Of 10 remaining measures, 7 collectively have a water cost of 41 GL in 2020 associated with 23 MtCO2e (~10 per cent) of the total mitigation volume
- 3 reforestation measures have a potential estimated water cost of 6,000 GL in 2020 associated with 49 $MtCO_2e$ (~20 per cent) of the total mitigation volume.

Summary of policy implications

- Cost-effectiveness of several energy efficiency and renewable power mitigation measures *can be improved by accounting for water savings*
- The benefits of these savings may not directly accrue to the entity that adopts the mitigation measure.
- Some mitigation measures can have smaller water footprint through considered choice of technology and location, in particular solar thermal power.
- Some mitigation measures (reforestation), may need to be reconsidered, either in the scale of plantings, their location, or the carbon price required to make them cost effective.

Results from the power sector

- A total of 17 mitigation measures in the power sector were deemed to incur an acceptable cost to society in the carbon abatement cost curve.
- Water savings typically result from measures that reduce the demand for electricity from centralised, water-cooled, non-renewable thermal power plants i.e. *thermal power offsetting*

Power sector contd.

- 12 of these mitigation measures would potentially result in a moderate water benefit (1-<5 GL/MtCO_2e)
- improvements in thermal efficiency of power generation facilities, or from a shift from coal to gas.
- Operational improvements would slightly reduce the water-cooling demand for the same level of power generation.

Land sector

- Afforestation (or reforestation) of cleared land provides large carbon mitigation potential
- + benefits to biodiversity, reduce erosion, flooding, and transport of sediment, nutrients and salt
- Three mitigation options might have high water impact:
  - Strategic reforestation of non-marginal land with env. Forests
  - Reforestation of marginal land with timber plantation
  - Reforestation of marginal land with environmental forest

Part 4:

THE POLICY CHALLENGE

It's all about integration (as ever)

- country jurisdictions (tech, policy, trade, info)
- disciplines/professions, and research-policy communities
- sub-national jurisdictions & sectors (not just E&W)
  -- mitigation and adaptation
  -- infrastructure provision
  -- technologies within and across E&W
  -- plans/policy regimes/instruments
  -- developments/firms (planning & development)
  -- communities (different aspirations)
  -- households (eg hot water)
  -- multiple individual motivations

What role for government?

1. Inter-governmental agreements
2. Intra-governmental arrangements
3. Regulation by prescription
4. Planning and strategic decision-making
5. Market based instruments
6. Funding function
7. Information and analysis function

Planning and strategic decision-making

- Processes to manage trade-offs
  - Planning provisions – location, impact, allocation rights etc.
  - Strategic decision-making – Long term land use decisions
  - Strategic Environmental Assessment
  - Environmental Impact Assessment
- Explicit need to incorporate ‘nexus’ into planning
- BUT knowledge, capacity and compliance is problematic

Market based instruments

Pricing is critical.

Governance arrangements, including economic incentives, give little inducement for water efficiency in the energy sector, particularly with electricity supply:

- **Ability to trade water**: On-selling water savings is not possible under many water allocation regimes
- **Economic gains from efficiency**: Limited or negative incentive when additional energy costs outweigh the value of water savings
- **Timing and location of demand**: Peak energy demand in hottest, driest times or climes when water is most scarce

Market based instruments

Government policies and corporate incentives may directly conflict with water efficiency

- **Regulatory burden**: a panoply of government regulations already exist in the energy sector and fulfilling the regulatory obligations supersedes voluntary action on other fronts (such as water efficiency)
- **Competing policy priorities**: water quality, emissions mitigation and energy security priorities
- **BUT Business risk**: if water insecurity can cause business disruption then efficiency may be perceived as a solution

Inter- and Intra-governmental

- Articulating clear policy objectives
  - Climate policy = water policy = energy policy = biodiversity policy etc.
- High level of co-operation required. Numerous mechanisms to do this.
  - Council of Australian Governments (COAG) reform process
- Use ‘policy windows’ to insert triggers, thresholds or standards

Information and analysis

- The nexus is context specific – data must be too
- Know the audience:
  - National, state, regional, local governments
  - Business, particularly primary industries, water utilities etc.
- Combine with regulation: data can be extracted by force!

Funding function

- *Conditional* funding potential for:
  - Carbon Farming Initiative
  - Climate adaptation plans
  - Statutory water plans
- Targeted research and development
- Subsidise cleaner technologies
- Combine with other mechanisms – has worked before (see National Water Initiative)

Conclusions

- Aggregate statistics are meaningless; Forecasting is not much better
- Framing water as a commodity is essential: PRICING SIGNALS must reflect scarcity value
- POLICY OBJECTIVES must align
- KEY role for governments across all 7 mechanisms
- Many of the laws and institutions we developed for sustainable development are adequate, or require minor amendments
- *Managing* the risk is the goal; eliminating it is impossible
- Assessing trade-offs is a *social*, *value*-*laden* decision

Further info…

- Special issue *Ecology and Society* 2011-12
- Special issue *Environmental Research Letters* 2012-13
- Chapter 17, World Energy Outlook 2012
- Hussey, Pittock and Dovers CUP book, mid-2013
- Webber Group: University of Texas at Austin