The water-energy-climate nexus
Implications for the energy sector

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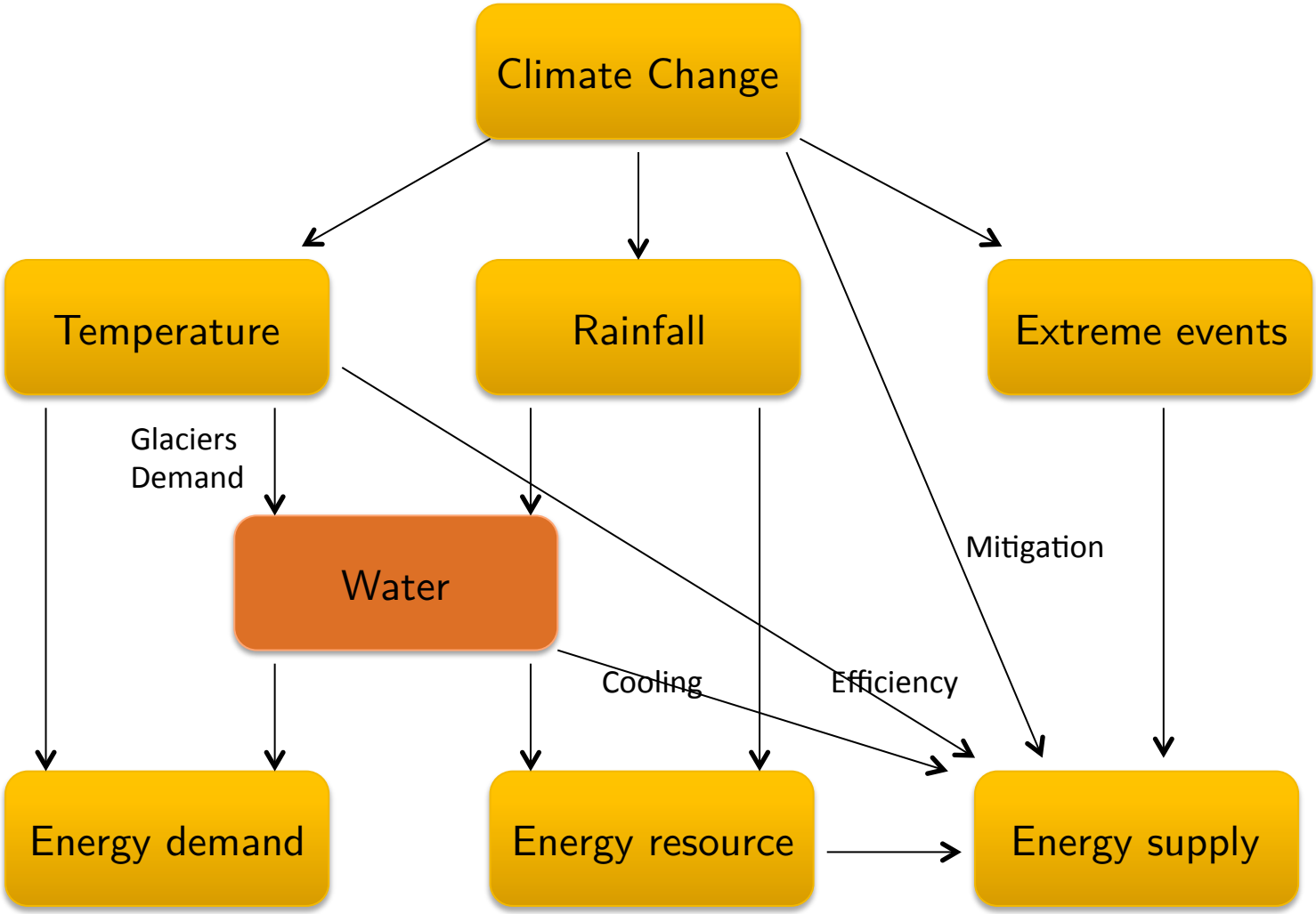
Joint research with Zarrar Khan, partly funded by Fundación Canal

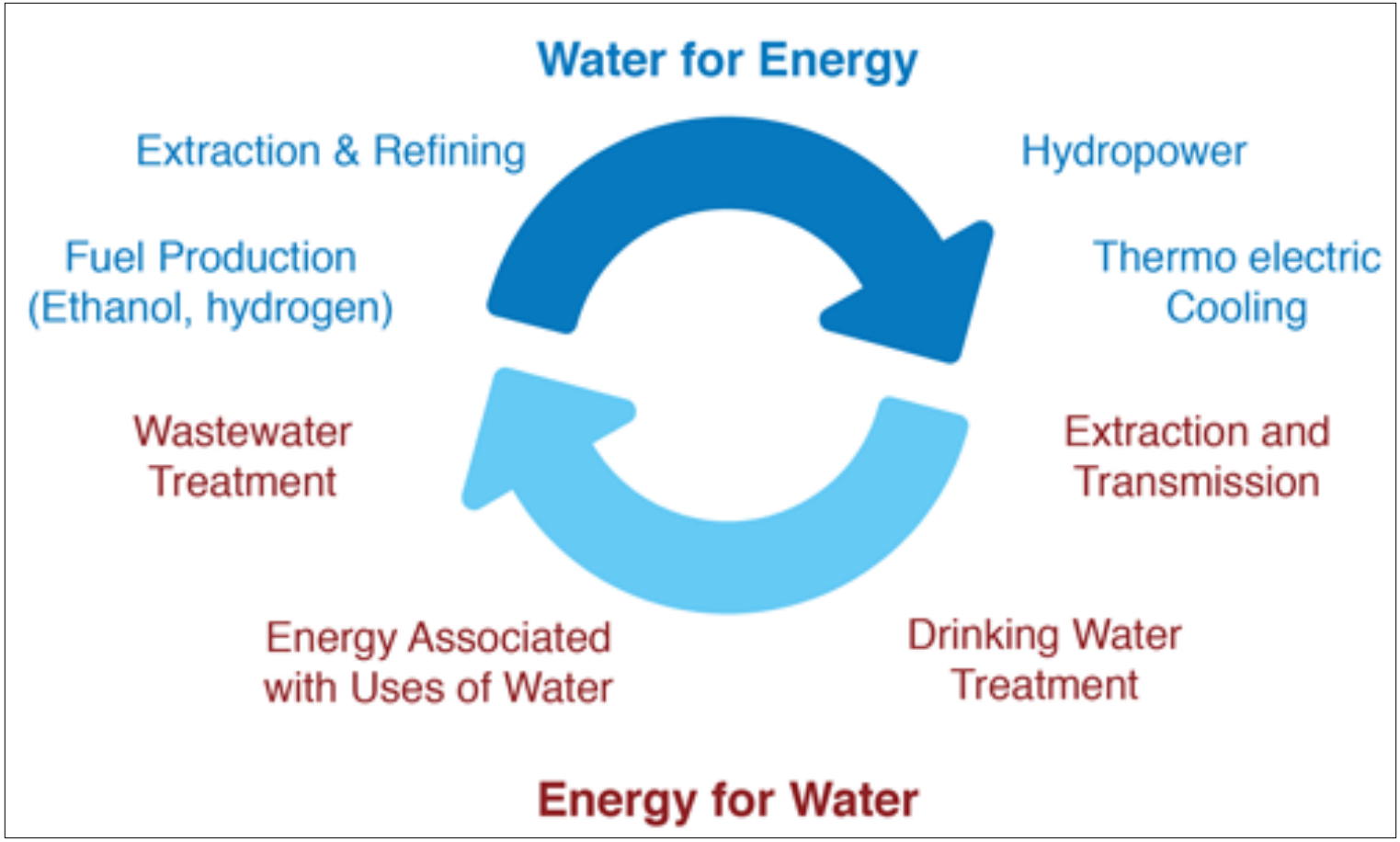
Economics for Energy Workshop

Madrid, January 19th 2015

Adaptation to climate change in energy



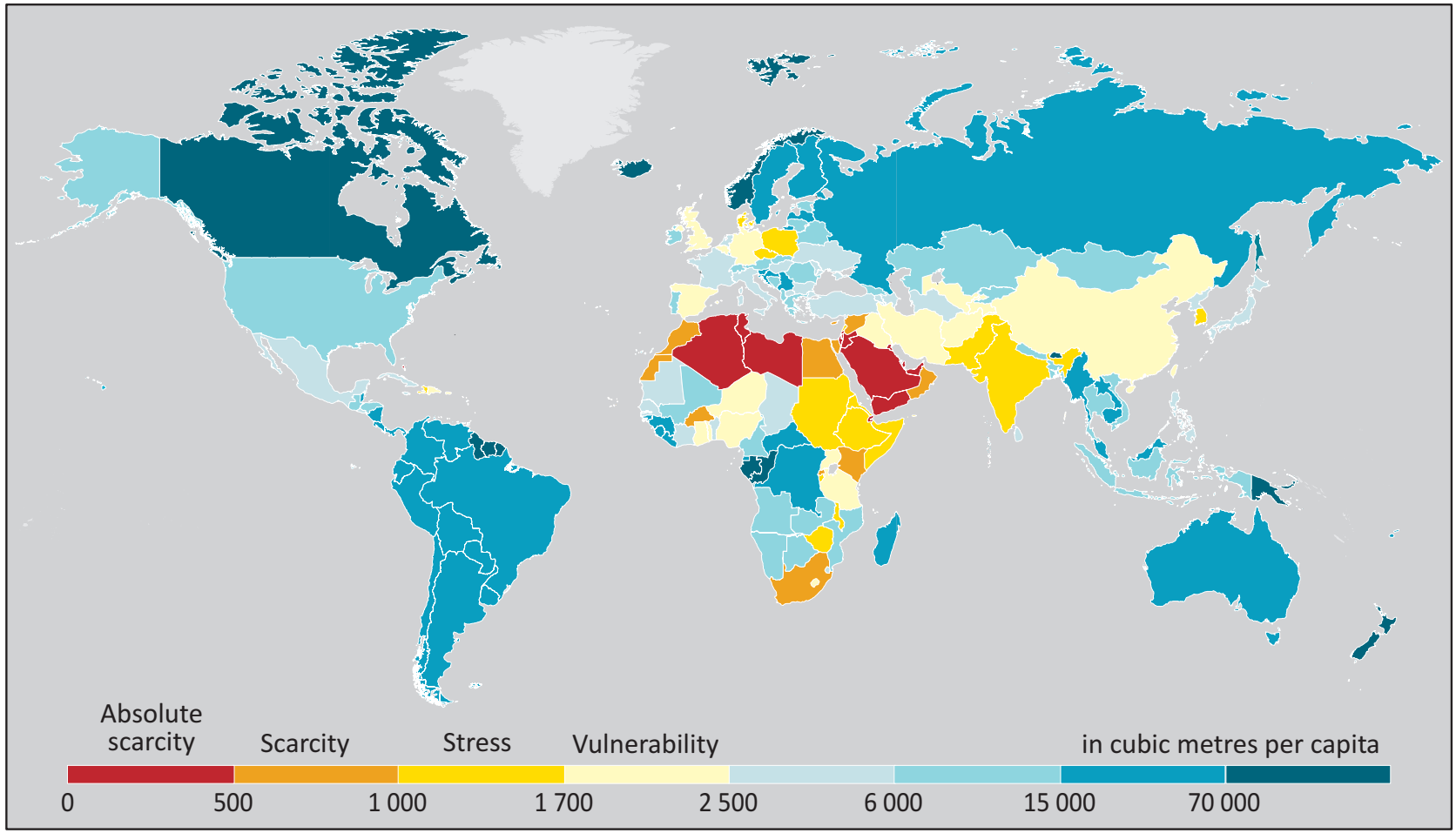
The water-energy nexus



Source: Water, Energy and Climate Change: A Contribution from the Business Community. World Business Council for Sustainable Development. 2009
http://voxglobal.com/2011/03/the-energy-water-nexus-an-emerging-risk/

How relevant is the problem?

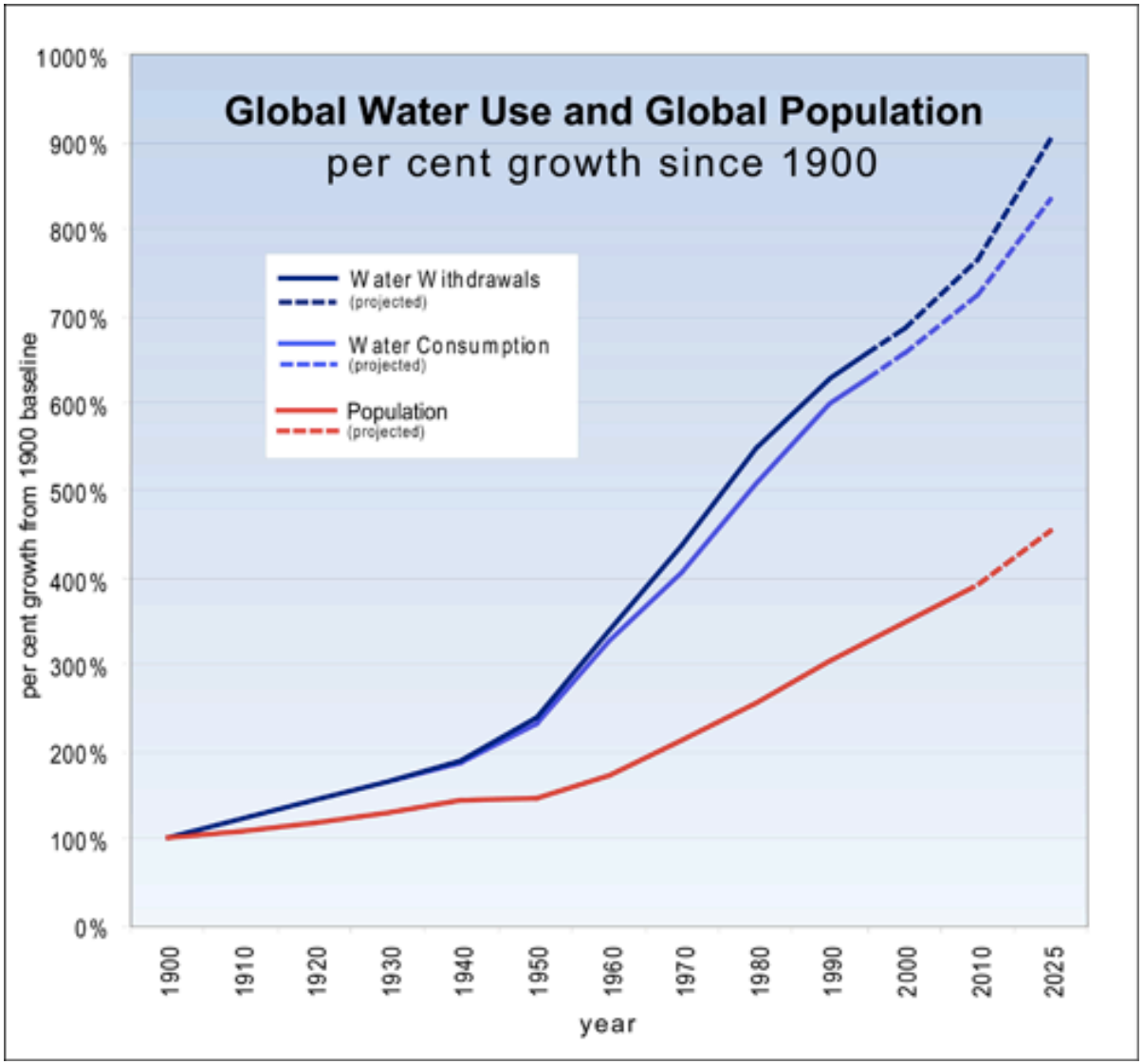
Figure 17.2 ▷ **Renewable water resources per capita in 2010**



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 is increasing



UNEP, 2012

Changes in hydro

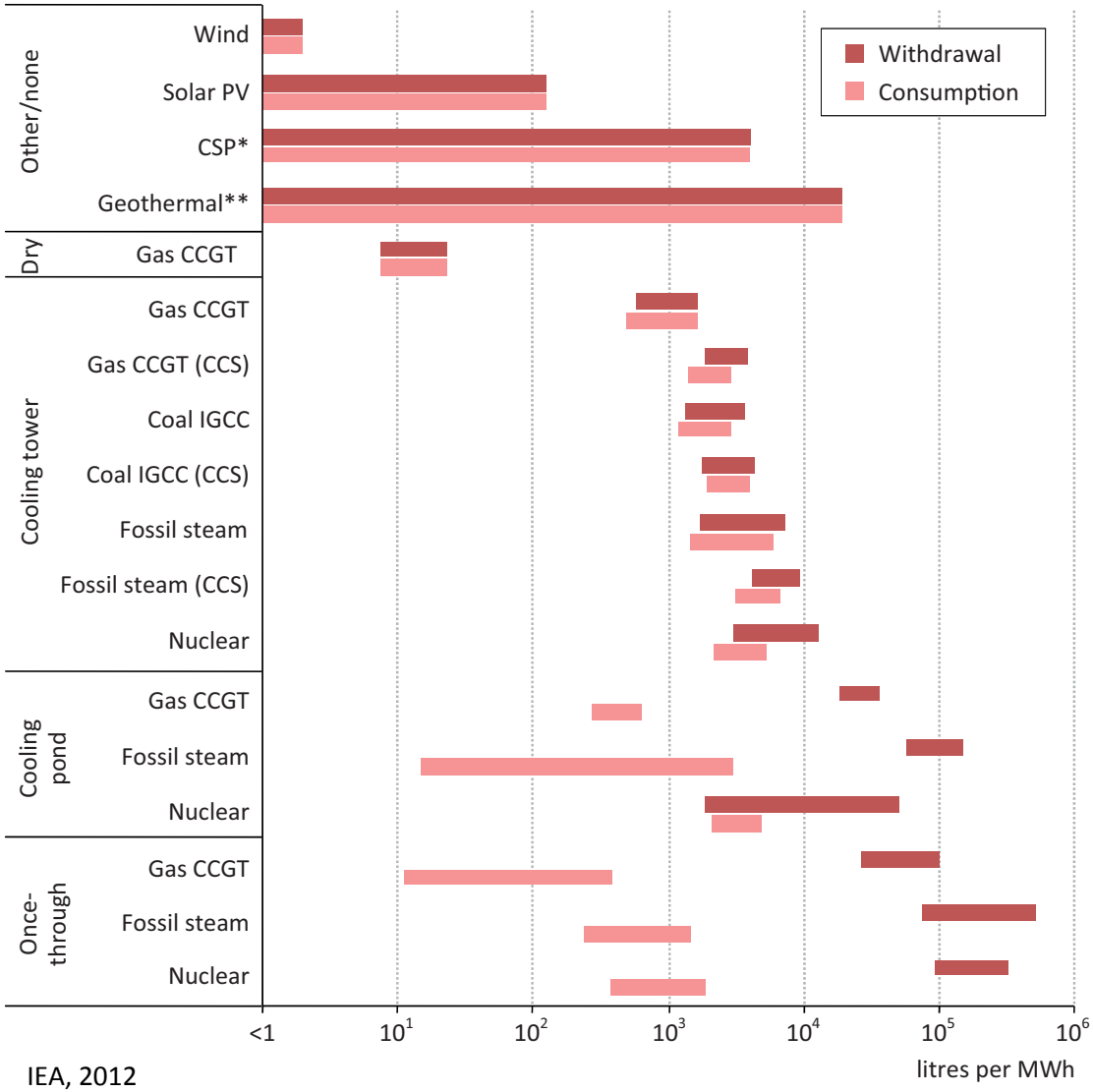
Box 3.1. Projected Changes in Hydropower Generation

Modeling by the Norwegian University of Science and Technology examined climate impacts on river flows and hydropower generation to 2050. Systems at highest risk had both a high dependence on hydropower generation for electricity and a declining trend in runoff. South Africa is quoted as one example with a potential reduction of 70 GWh per year in generation by 2050. Afghanistan, Tajikistan, Venezuela, and parts of Brazil face similar challenges.

Source: Hamududu and Killingtveit, 2010.

Technology choices are relevant

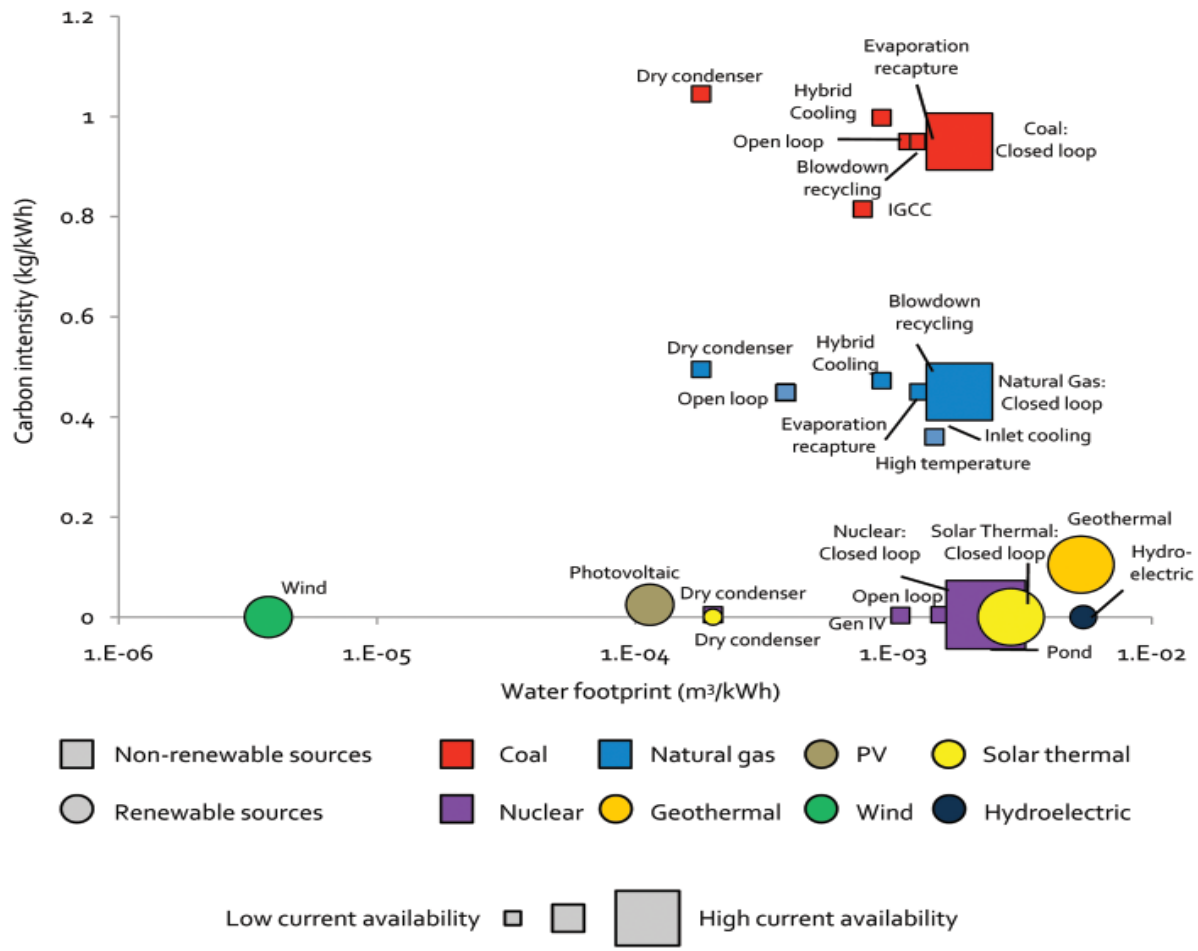
Figure 17.4 ▷ **Water use for electricity generation by cooling technology**



IEA, 2012

Water and CO_2

Figure 3.4. Effect of Emerging Technologies on Carbon and Water Intensity of Electricity Sources



Source: Lux Research, 2009.

Previous studies

- Have looked at different regions
- But typically in a single direction:
  - From energy to water
- Point out to the need to model simultaneously water and energy

The need for joint planning & modeling

- Need to account for tradeoffs
  - Shadow values for water or energy
- And the reaction of the system
  - Unidirectional simulations overestimate effects
  - Changes in operation and investment may mitigate risks
- At the right geographical disaggregation
  - Interconnected power/energy systems
  - Not so interconnected water systems

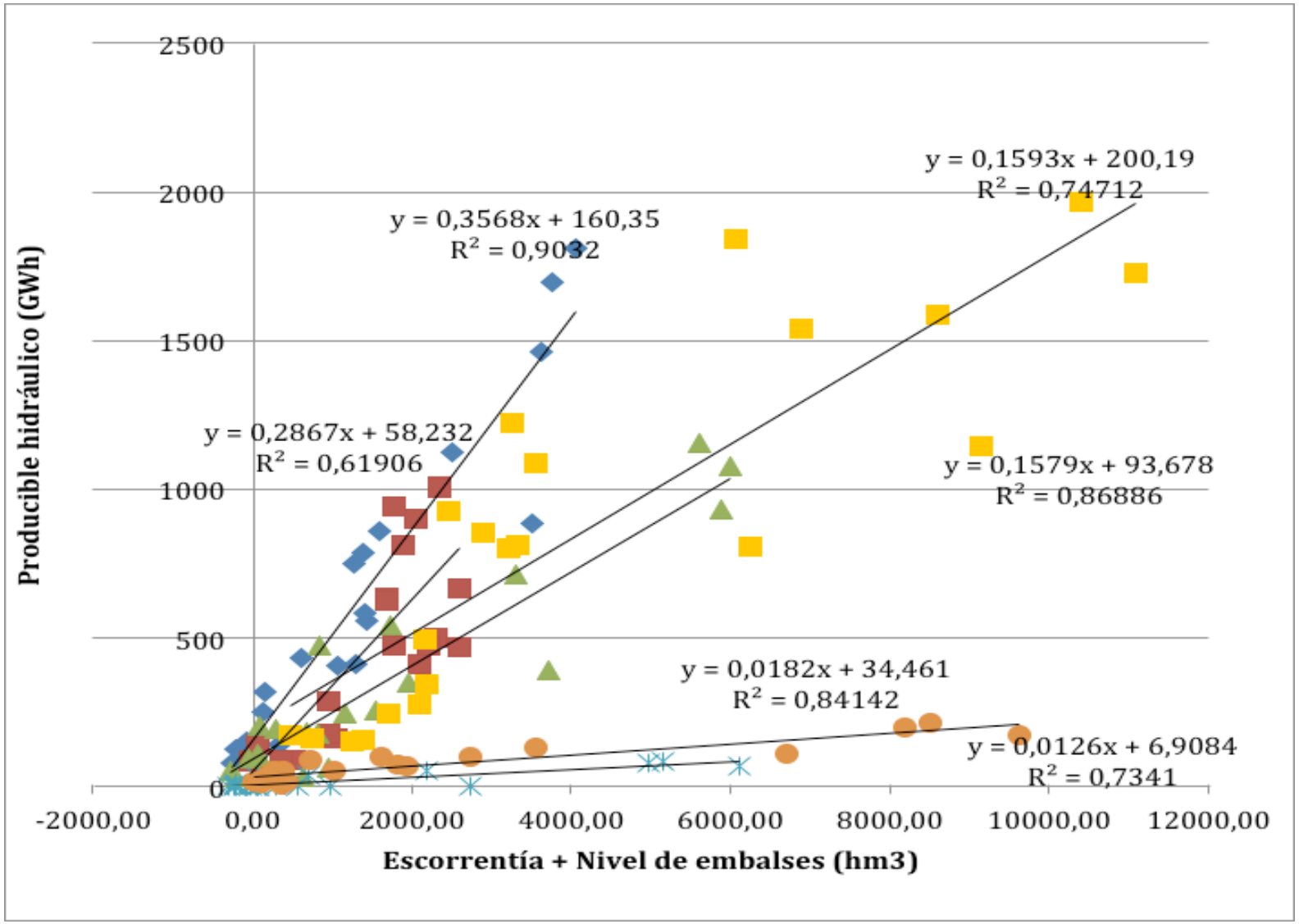
Our study for Spain

Water basins
Galicia Costa
Miño - Sil
Cantábrico
Cuencas Internas del País Vasco
Duero
Tajo
Guadiana
Cuencas Atlánticas de Andalucía
Guadalquivir
Cuencas Mediterráneas de Andalucía
Segura
Júcar
Ebro
Cuencas Internas de Cataluña

Water modeling

- Water consumption and withdrawal for each energy technology (including water-efficient technologies)
- Energy production is geographically referenced
- Water availability per water basin
- Relationship between runoff and hydro production

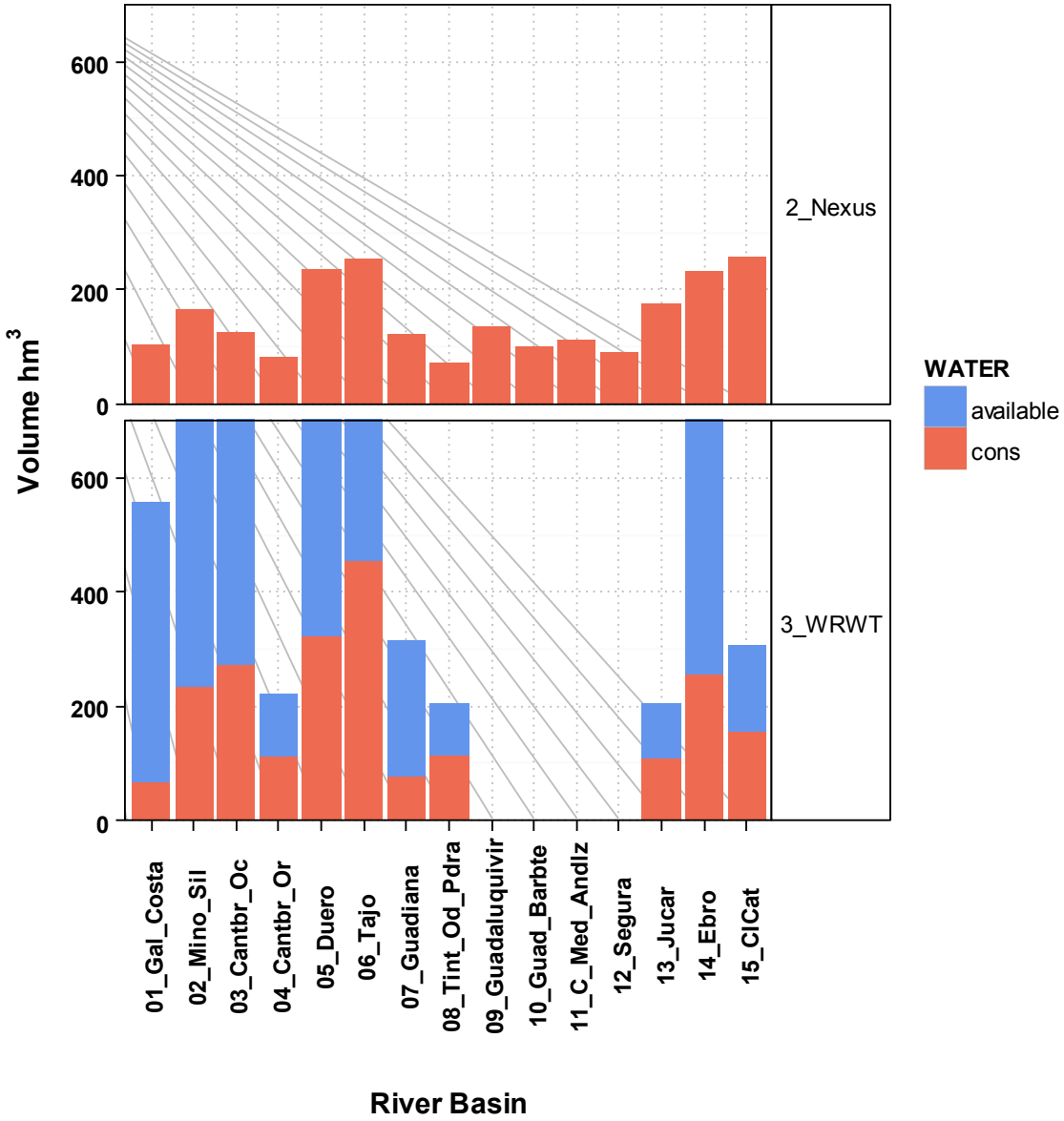
Runoff and Hydro



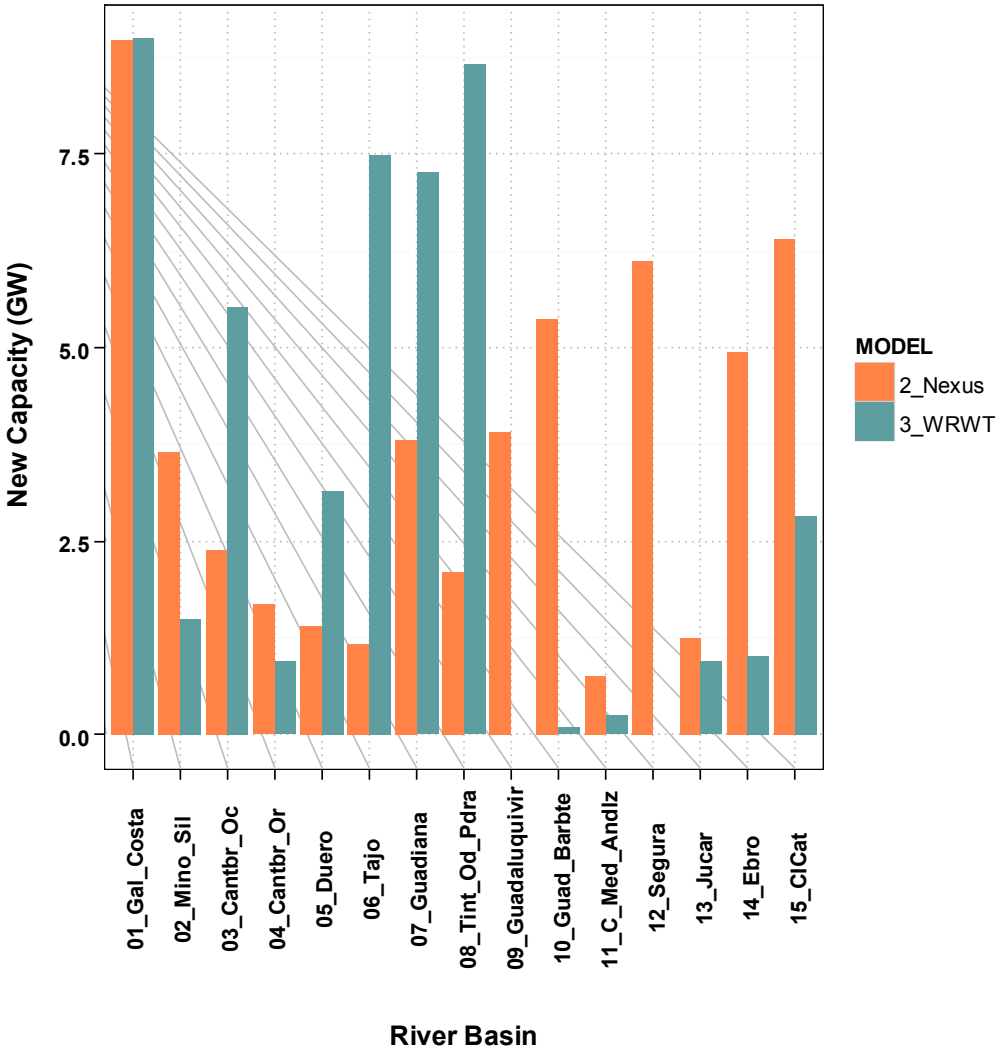
Climate change scenarios

River Basin	Variation in Runoff (%) (2041-2070)		Variation in Water Available (%) (2041-2070)	
	A2i	A2ii	A2i	A2ii
	CGCM2-FIC	ECHAM4-FIC	CGCM2-FIC	ECHAM4-FIC
Galicia Costa	-4	-31	-14	-37
Miño-Sil	-6	-34	-11	-28
Cantabrico Occidental	-4	-27	-20	-38
Cantabrico Oriental	-2	-24	-11	-34
Duero	-13	-41	-10	-37
Tajo	-16	-48	-13	-50
Guadiana	-23	-58	-19	-58
Tinto, Odiel Y Piedras	-23	-58	-8	-65
Guadalquivir	-18	-55	-7	-55
Guadalete Y Barbate	-18	-55	-12	-56
Cuencas Mediterraneas Andaluzas	-15	-50	-13	-41
Segura	-10	-39	-11	-44
Jucar	-11	-28	-11	-32
Ebro	-6	-26	-14	-27
Distrito Fluvial de Cataluña	-2	-5	-5	-11

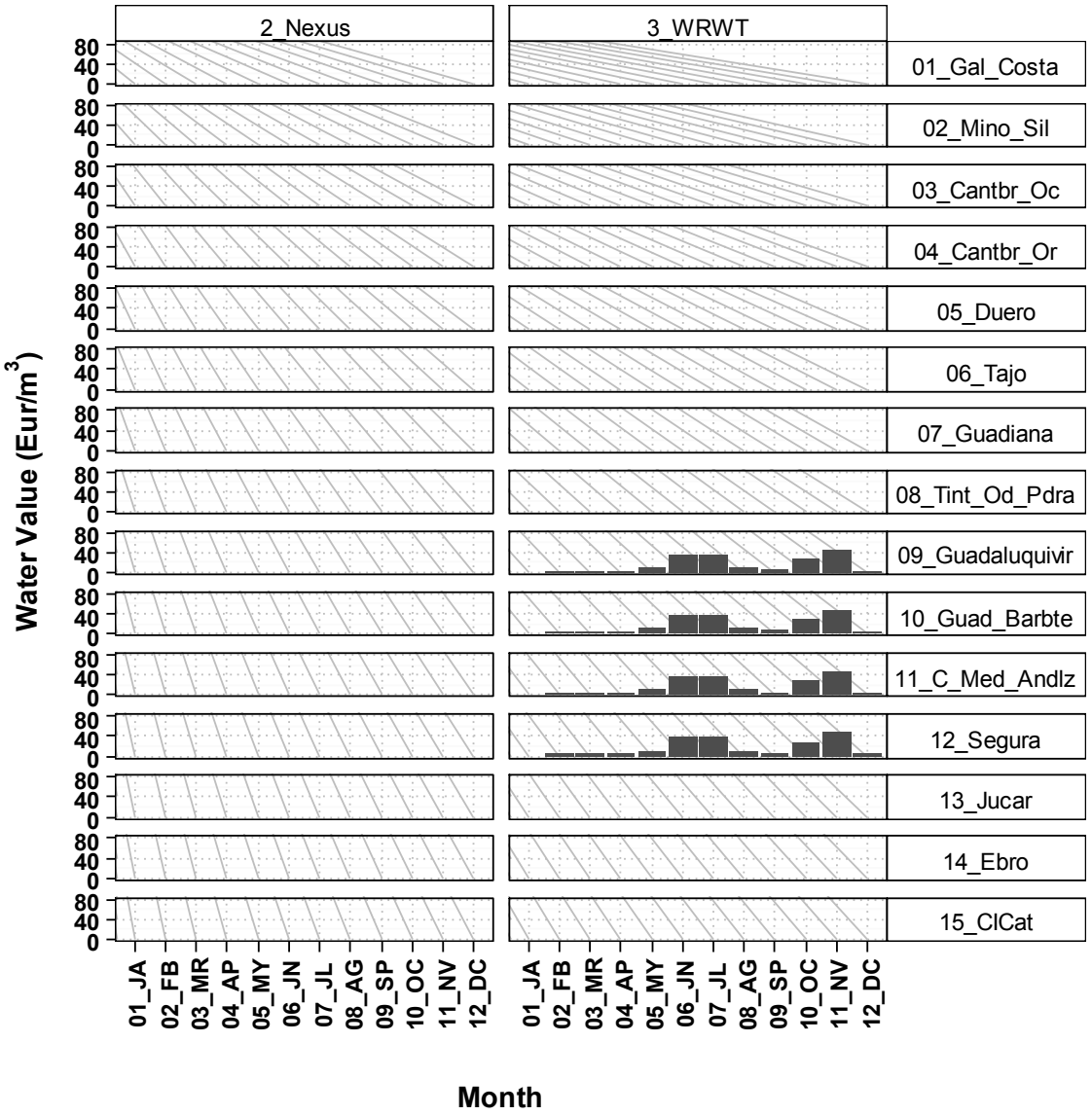
Results: Water availability



Results: Change in investment



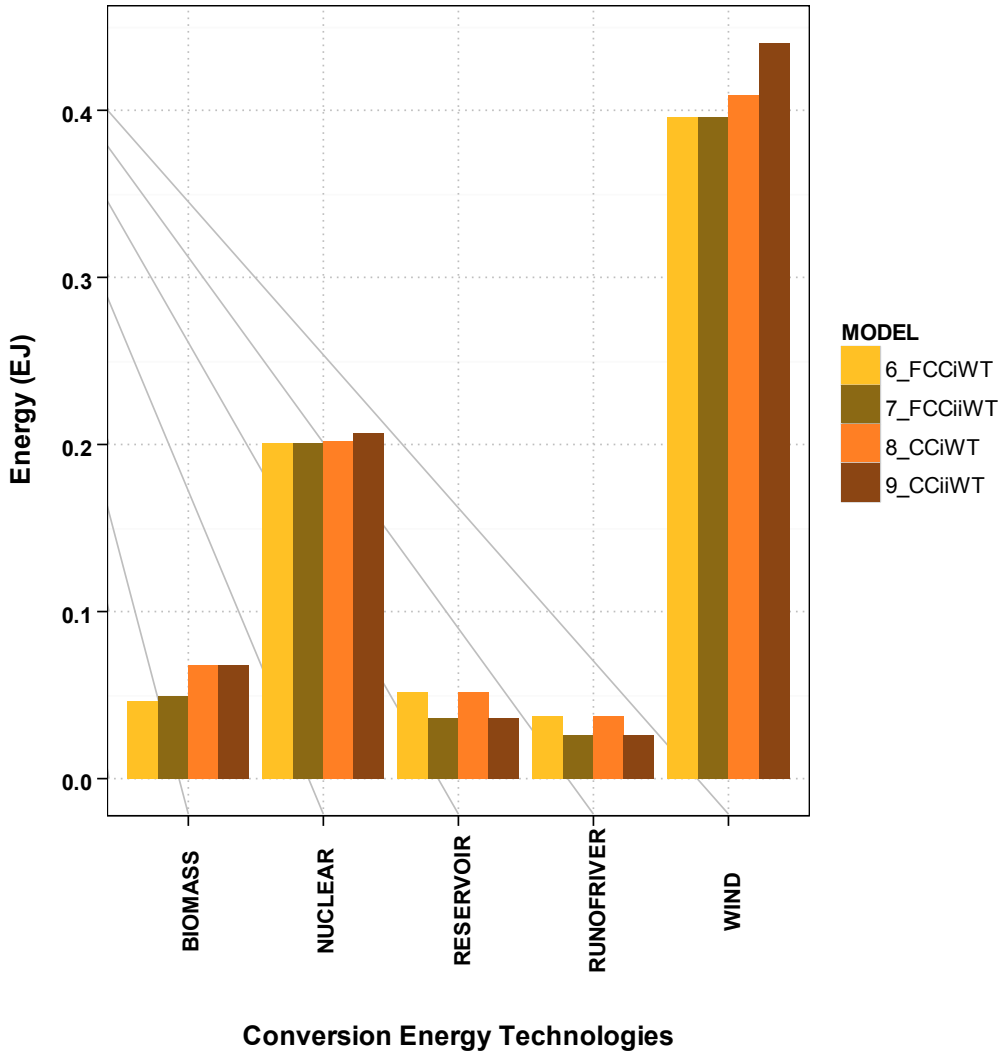
Results: Water values



Results: the cost of climate change

Output	6_FXWT	7_FXCCiWT	8_FXCCiiWT
Total system costs (Giga Eur)	249.6322	249.9059	250.569
Final Energy Activity Cost (GigaEurs)	169.7856	170.1048	170.4908
Total Energy Dependence (%)	75.2736	75.3916	75.741
Primary Energy Import Costs (GigaEurs)	13.0525	13.0544	13.2213

Results: Adaptation to climate change



Summary and conclusions

- Less water means higher costs
  - But only 1%, so does not seem critical
- Less hydro: Less backup, higher cost
- More wind, more efficiency, more water-efficient technologies
- Changes in geographical distribution (networks?)
- Water shadow values: 2-250 €/m3
  - Current prices in Spain lower than 1 €/m3

Thanks for your attention

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