Energy data for the economic modelling of water scarcity

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Research area

- **Water scarcity** one of the looming global threats to economic prosperity – WEF 2015
- Water resources unequally distributed across regions
- About 10% of renewable resources used in economic activities – irrigation 70% of abstractions, power cooling 15% (IEA WEO 2012)
- **Water demand**: How will pressure of the resource base evolve up to 2050? What will be the economy-wide impact of water scarcity?
Analysis

- Withdrawals baseline construction for main user groups
- Modelling sectoral impacts of water scarcity – alternative water allocation methods
Thermal cooling - linking TIAM-UCL data

- Thermal power by fuel and by cooling technology
- Production projection by fuel
- Cooling mix projection
- Withdrawals projections by fuel and by technology

- WaterGAP/EXIOBASE freshwater withdrawals by fuel and cooling technology
- Water intensities ($m^3/MWh$) from Florke et al. (2013)
- TIAM-UCL projections by fuel type for SSP2
- WaterGAP power production by country – mapping to RESCU regions

- Power plant depreciation rate
- Tower cooling adoption rate – new capacity more efficient
- RESCU-Water regional aggregation
Global withdrawals for thermal power cooling – SSP2

• More electricity from tower cooling
• Low impact over withdrawals due to old power plants still operating
Projections in other studies
Water scarcity analysis - RESCU-Water

- Global economic model (CGE) – 20 world regions, 31 productive sectors
- Dynamic-recursive – 2004-2050 simulations based on SSP storylines
- GTAP9-Power database with 11 technologies aggregated into thermal and non-thermal
- Adaptation to water scarcity possible through a switch to non-thermal power production
- Bottom-up representation of crop production – irrigated and rainfed technologies
Water scarcity scenarios

• Regional water use constraints based on sustainability thresholds – India, South Asia, Middle East, Northern Africa

• Four water management options
  – Full allocation (FA) – perfect mobility across the economy
  – Limited mobility (LM) – 5% of resources re-allocable
  – Market fragmentation (MF) – separation between agri and non-agri users
  – Agriculture last (AL) – non-agri users unconstrained
Withdrawals baseline in water scarce regions
Macroeconomic impacts

Change in real GDP

Region

India
South Asia
Middle East
Northern Africa

LM
AL
FA
MF
India – change in output 2050

Change in output

Sector
India - withdrawal changes 2050

India - by volume

India - percentage

Sector

Irrigation  Livestock  Electricity - Thermal  Municipal water  Industrial water

Change in withdrawals

Sector

Irrigation  Livestock  Electricity - Thermal  Municipal water  Industrial water

Change in withdrawals

LM  AL  FA  MF

0%  -10%  -20%  -30%

0  -50  -100  -150  -200  -250
India – crop production changes 2050
Conclusions and next steps

• Baseline subject to many uncertainties e.g. spatial expansion of energy systems
• Significant trade-offs between crop production (food security) and other sectors
• Thermal power production – minor role in withdrawals reduction but highly exposed to water scarcity
• Next steps – co-benefits of low-carbon transitions, potential for retrofitting power plants
Thank you.

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RESCU-Water

- Global dynamic-recursive – 2004-2050 with SSP storylines
- GTAP9-Power database – 20 world regions, 31 productive sectors
- Economy-wide representation of water uses
  - As natural resource for self-abstractors (irrigation, livestock, thermal power cooling, water distribution networks)
  - As commodity for supplied users (industrial and municipal)
- Advanced mechanisms of adaptation to water impairments
  - Crops: irrigated → rainfed growing methods
  - Power production: thermal → non-thermal technologies
  - Input substitution of supplied water
- Alternative water management options
  - Full allocation (FA) – full water mobility
  - Agriculture last (AL) – no-agri users unconstrained
  - Market fragmentation (MF) – separation of agri- and non-agri water users
  - Limited mobility (LM) – only 5% re-allocable / institutional and infrastructure constraints