Towards Improved Understanding, Concepts, Policies and Models of Energy Demand - Joint IIASA-RITE International Workshop, 11-13 November 2019, Laxenburg, Austria

International Institute for Applied Systems Analysis
IIASA www.iiasa.ac.at

Modelling the dynamics of the water-energy nexuses of London and Mumbai from an end-use perspective

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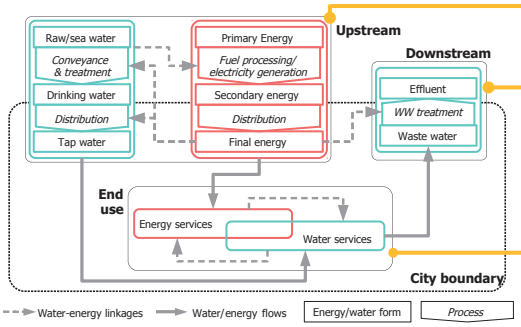
RITE Research Institute of Innovative Technology for the Earth

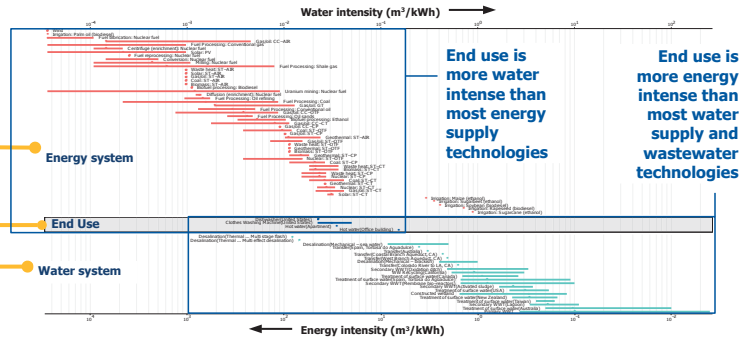
1. Introduction: the Urban water-energy nexus



Research questions:

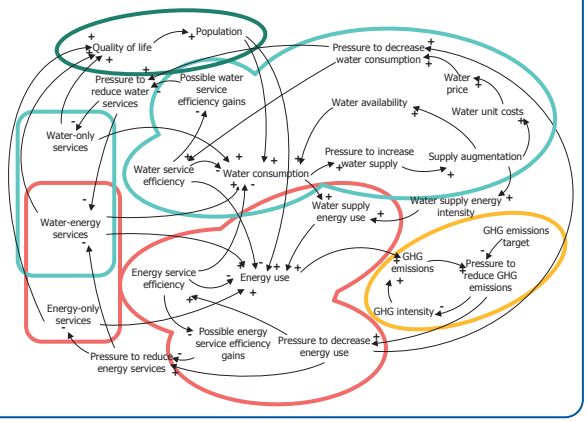
1) How do cities feature in the water-energy nexus? What linkages are relevant *in* cities, and what linkages are relevant *for* cities?
2) What are the nature and the magnitude of water-energy linkages in cities?
3) How do these linkages affect the dynamics of urban water and energy use?
4) How can cities become fully and globally sustainable in terms of water and energy and support a still-growing world population?

Box 1. Characteristic intensities of the water-energy nexus

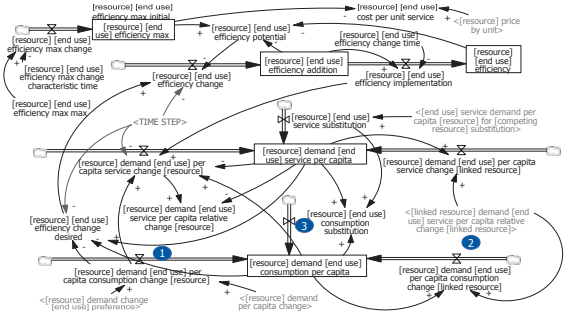


The dual axes are both logarithmic and one is the inverse of the other. The circles indicate central estimates and the lines denote ranges. The top panel lists water intensities of technologies in the upstream component of the energy system, from Spang et al. (2014). The middle panel shows energy intensities of end uses involving water and energy. The bottom panel contains energy intensities of technologies in the upstream and downstream components of the water system. Data in both bottom panels from Plappally & Lienhard V (2012). Abbreviations: ST = steam turbine; CC = combined cycle; GT = gas turbine; PV = photovoltaic, CT = cooling tower (recirculating); OTF = once-through freshwater; CP = cooling pond; AIR = dry cooling, WW = wastewater, WWT = WW treatment.

2. Dynamics: causal loop diagram (London)



3. Dynamics: stock-and-flow diagram, core end-use structure



[resource] demand [end use] consumption per capita is the actual volume (of water) or energy used per person per day for the particular end use, e.g. litres of water for hot water uses such as showering

can change through (1) price-induced change in consumption; (2) linked-resource-induced change in consumption; (3) change in resource consumption through substitution

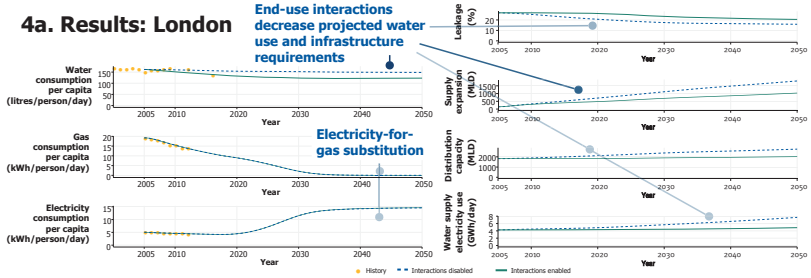
[resource] demand [end use] service per capita is expressed in the same units as the consumption per capita, and its initial value is identical to the initial value of consumption. However, if the service efficiency increases, the service per capita will be greater than the consumption. The service demand indicates the equivalent amount of consumption in a reference year (which is chosen as the initial year of the simulation).

[resource] [end use] efficiency is the efficiency with which consumption of the resource translates into actual service i.e. equivalent reference-year consumption.

[resource] [end use] efficiency max is the maximum obtainable service efficiency for the resource in question. It is a stock to allow for changes over time e.g. as a consequence of technological progress.

[resource] [end use] efficiency addition is the net change in efficiency which is required (or available, if the required change is not possible due to the maximal efficiency limit) to maintain the service level per capita in response to a resource-induced change in consumption.

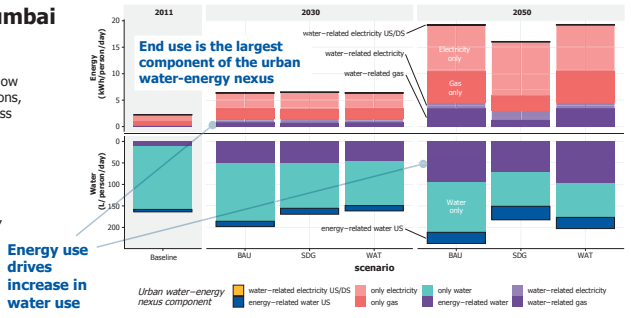
4a. Results: London



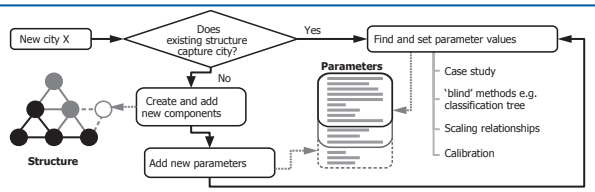
4b. Results: Mumbai

Three scenarios:

- ***BAU:*** business-as-usual, slow elimination of slum conditions, slow environmental progress
- ***SDG:*** achievement of Sustainable Development Goals; slum conditions eliminated, water quality
- ***WAT:*** water as a policy priority; continuous supply, efficiency, full sewerage coverage, high degree of wastewater treatment



5. Expansion of model to other cities: scale, climate, geography



ACKNOWLEDGEMENTS

This work was supported by the Natural Environment Research Council through their Science and Solutions for a Changing Planet (SSCP) Doctoral Training Partnership (DTP) at the Grantham Institute at Imperial College London, and through the CHANSE project; by the British Council through their Newton-Bhabha PhD Placements Programme; and by the Department of Civil and Environmental Engineering at Imperial College London.

REFERENCES

De Stercke, S., Mijic, A., Buytaert, W., Chaturvedi, V., 2018. Modelling the dynamic interactions between London's water and energy systems from an end-use perspective. Applied Energy 230, 615–626.
De Stercke, S., Mijic, A., Buytaert, W., Chaturvedi, V. (submitted for review). Nexus-based long term water and energy use in Mumbai.
De Stercke, S., Mijic, A., Keirstead, J., 2016. A Review of Urban Water-energy Linkages in End-use: A Call for Joint Demand Studies. British Journal of Environment and Climate Change 6, 192–200.
Spang, E.S., Moomaw, W.R., Gallagher, K.S., Kirshen, P.H., Marks, D.H., 2014. The water consumption of energy production: an international comparison. Environ. Res. Lett. 9, 105002.
Plappally, A.K., Lienhard V, J.H., 2012. Energy requirements for water production, treatment, end use, reclamation, and disposal. Renewable and Sustainable Energy Reviews 16, 4818–4848.

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