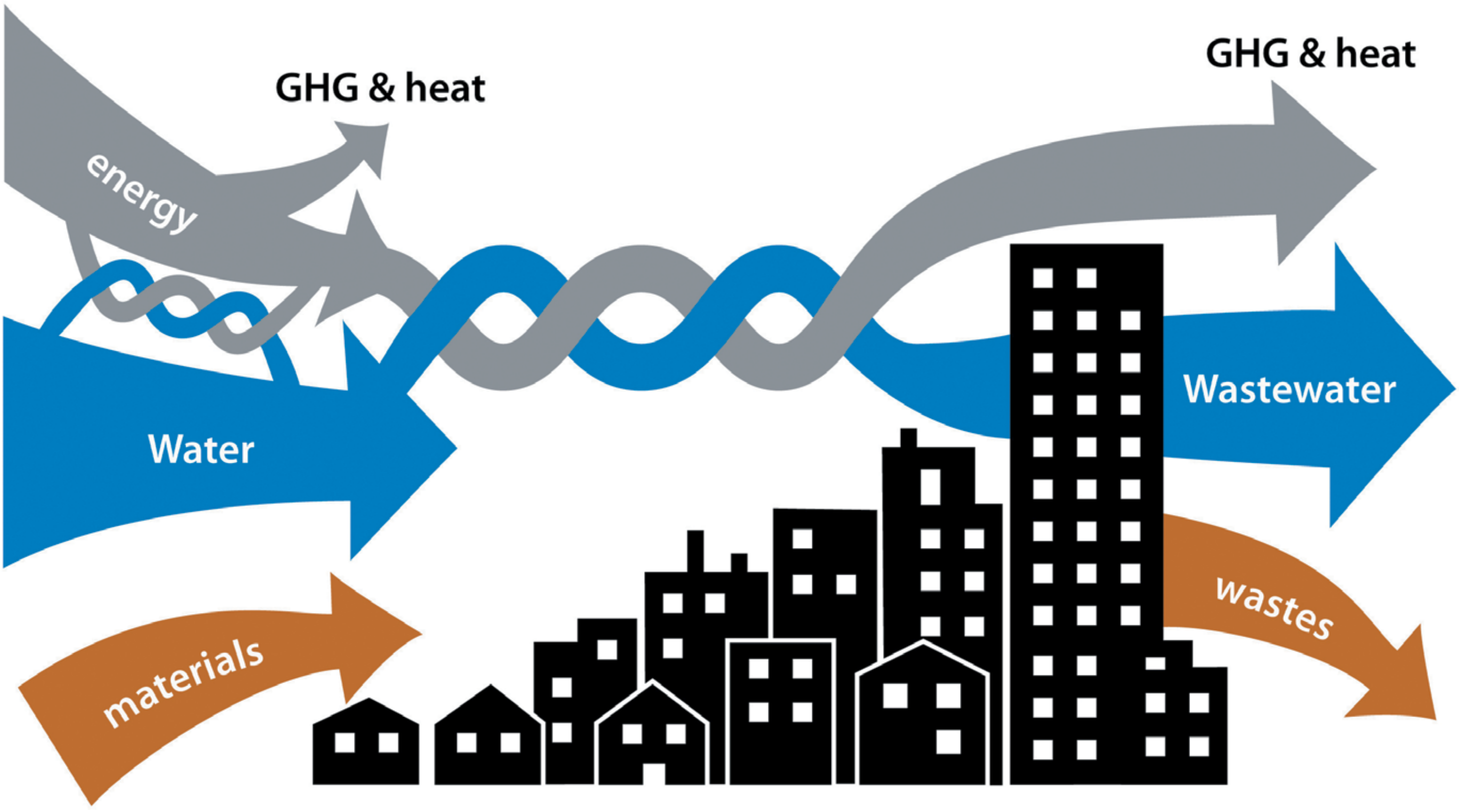
# Water-energy-carbon links in households and cities: a new paradigm






This project is a collaboration between The University of Queensland, the Smart Water Fund, Melbourne's water utilities and relevant Victorian Government agencies. It tackles the major challenge, and major opportunity, of water-related energy use in the residential sector. The research is co-funded by the Australian Research Council under the industry-linkage scheme.

# a: The Challenge

## The Water-Energy Challenge for Australia

The growing energy demand associated with water and wastewater service provision in Australian cities is a large challenge: by 2030, energy consumption is expected to grow to 200-250% of 2007 levels. If the water sector is to adopt the Australian government target to reduce greenhouse gas (GHG) emissions to 80% below 2000 levels by 2050, then we must cut the equivalent of over 90% of the projected 2030 energy consumption levels, or reduce the GHG intensity of the energy by a similar amount, or pay for offsets.

The bill for energy, for urban water, is anticipated to rise even faster, growing to approximately 300-500% of 2007 levels by 2030. This now represents a significant business risk to both the water sector and to communities relying on energy-intensive water services.

## Managing Water-Related Energy – A Solution (the need for the project)

Water-related energy use in Australian cities is significant, accounting for some 13% of Australia's electricity use and 18% of Australia's natural gas use. Overall, urban water management influences 8% of Australia's greenhouse gas emissions [1]. There is a large indirect or 'hidden" fraction of water-related energy effect in the urban environment. The direct energy used by water utilities, while significant, is only a small fraction of the total urban water-related energy consumption, and residential water use is responsible for a significant part of urban water-related energy consumption and greenhouse gas emissions.

Saving water, sometimes in small amounts, can have a surprisingly large impact on energy consumption, for not only the consumer but for water and wastewater treatment and transportation as well. Water conservation can be a cost-efficient way to reduce energy consumption. Lack of understanding of interconnections between water-energy and carbon can also lead to problem-shifting (between water-energy and carbon) rather solving water, energy and carbon problems simultaneously. Analysis of water-energy links is not currently undertaken because the connections are complex, data-intensive and change rapidly (eg: as technologies/appliances/behaviour patterns change).

## The project objectives are:

1. Understand water and energy connections in individual households.
2. Characterise "household types". This will develop an understanding of different households and build a dataset of relevance to city-scale simulation.
3. Understand city-scale water-related energy use and greenhouse gas emissions by using detailed household data and other city-scale information.
4. Identify opportunities to reduce water-related energy. This will quantify the water and greenhouse gas reduction potential of a range of options including technological, behavioural and policy changes.

# b: The Project

## Key activities, methodology and timing

**For Objective 1**, individual households will be characterised and validated in detail for existing water and energy flows. Household survey and characterisation, use of high resolution water and energy metering data and application of a detailed Material Flow Analysis Model [2] will be used in order to understand the mix of technologies and occupant behaviours and resultant water and energy flows. This will help validate the existing model, and establish a first range of performance for the households studied. The existing model has been built through a collaboration between The University of Queensland and The Swiss Federal Institute of Aquatic Science and Technology (Eawag). This work will be complete by the end of 2013.

**For Objective 2**, robust city-scale simulation of water and related flows of energy requires the development of a system to classify (describe) different household types regarding their water use, and related energy consumption. Data from Objective 1 above will be used together with data regarding household (a) plumbing configurations (b) water heating arrangements, (c) energy sources, and (d) associated greenhouse gas emission emissions intensities, (e) water-using technologies and fittings (f) physical environments and (h) occupant behaviours. Data regarding parameters such as (a) shower water use and temperature, (b) clothes washer use (c) temperature of cold water and (d) clothes washer plumbing (eg: to hot or cold water) will be particularly important. Consequently, supported by ETH Zurich Bits to Energy Laboratory, we would seek to deploy a number of Amphiro meters in selected households in order to accurately quantify water and energy use (eg: within showers). This work will be completed by late 2014.

**For Objective 3**, the project will use the household types information, to simulate a selected representative area of Melbourne. City-scale information such as demographics, and household type numbers, will be compiled to augment the household-specific data. Water, electricity and natural gas usage records will be compiled to enable validation with modelled results.

**In Objective 4**, the validated model will be used to explore implications for electricity and natural gas use based on a number of household and city-scale scenario options developed. We will convene workshops with industry and stakeholders. Objectives 3 and 4 will be complete by mid 2015.

## What is the long-term aim of the work?

Managing urban water-energy-carbon links is key to achieving the vision of sustainable cities. It is central to enabling a new paradigm: namely a future where water and energy utilities work together to conserve water and energy. A future which uses the significant potential of water to cost-effectively influence energy consumption including peak electricity demand.

This project will elucidate, quantify and model water-carbon-energy links within households. It will establish how households collectively influence cities. It will lead to detailed knowledge of the influence of policy, technology and behaviour on water and related energy and carbon flows. This will inform the water and carbon efficient design, monitoring and management of buildings and cities of the future.

This project will let us know, for the first time, if our options are systematically influencing the overall energy and water balance (the metabolism) of the city, or simply moving problems around. Ultimately, this method is likely to lead towards city-based targets for water-related energy. Flowing from that will be a need for innovative business and governance models to support achieving the targets.

The work helps position Melbourne as a "resilient" city. The Prime Minister's Science Engineering and Innovation Council (PMSEIC) [3][15] recently identified that "Resilient pathways will simultaneously reduce greenhouse gas emissions, lower overall water demand, maintain overall environmental quality and allow living standards to continue to improve".

1. Kenway, S. J.; Lant, P.; Priestley, A., Quantifying the links between water and energy in cities. Journal of Water and Climate Change 2011, 2, (4), 247-259.
2. Kenway, S. J.; Scheidegger, R.; Bader, H. P.; Larsen, T. A.; Lant, P., Water-related energy in households: a model designed to understand the current state and simulate possible measures. Energy and Buildings 2013, 58, 378-389.
3. PMSEIC Challenges at Energy-Water-Carbon Intersections; Prime Minister's Science, Engineering and Innovation Council: Canberra, 2010.

# C: Anticipated Outcomes

The work will help with an understanding of how changes in technology uptake or behaviour will influence water use, energy use, carbon emissions and costs in households. For example, the research will evaluate a range of scenarios to consider changes, such as:

- increased uptake of high-efficiency appliances and fixtures (eg: new clothes-washing machine and dishwasher models) and the introduction of emerging technologies, such as recirculating showers
- changes to plumbing configurations (eg: hot and cold water intake to appliances from hot water systems)
- changes to incentives, information availability and anticipated costs, which shift end-use patterns
- combinations of technological, behavioural and cost changes.

Scenarios will be discussed with interested stakeholder groups and at two participatory workshops throughout the project.

The work is expected to inform policy decision making, and has implications for utility assets and industry productivity (eg: cost of service delivery). Outcomes will improve the clarity of the business case for utilities to manage water to achieve energy, GHG and cost impacts. It is anticipated that outcomes of this project will encourage dialogue leading to relationships and partnerships between the water and energy sector providers.

## Anticipated outcomes from this project are:

- Understanding of the interconnection of water and energy in individual households, groups of households and at city-scale.
- Identification of variables that have the greatest impact on water and energy use.
- Evaluation of technical, behavioural and preliminary policy scenarios for water-energy at household and at city scale.
- Information relevant to finding least-cost solutions for communities.
- Informed future analysis of the water-energy-carbon linkages in the industrial sector is a possible extension of this project with further considerable scope to influence urban water and energy use.
- High quality research publications.

## Project Team

This project is a collaborative partnership between The University of Queensland (Dr Steven Kenway, Prof Paul Lant, Prof Brian Head, Dr Thomas Taimre, Amanda Binks, Julijana Bors, Dr Adam Grant), The Melbourne Water Sector (via the Smart Water Fund), Victorian Government and three Melbourne Utilities (Yarra Valley Water, City West Water and South East Water), along with the relevant Victorian Government agencies.

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For more information regarding the current status on this project, please CLICK HERE.