Pathways to achieving energy efficiency in urban water management : an Australian perspective

Presenter: Dr Cara Beal
Smart Water Research Centre,
Griffith University, Queensland

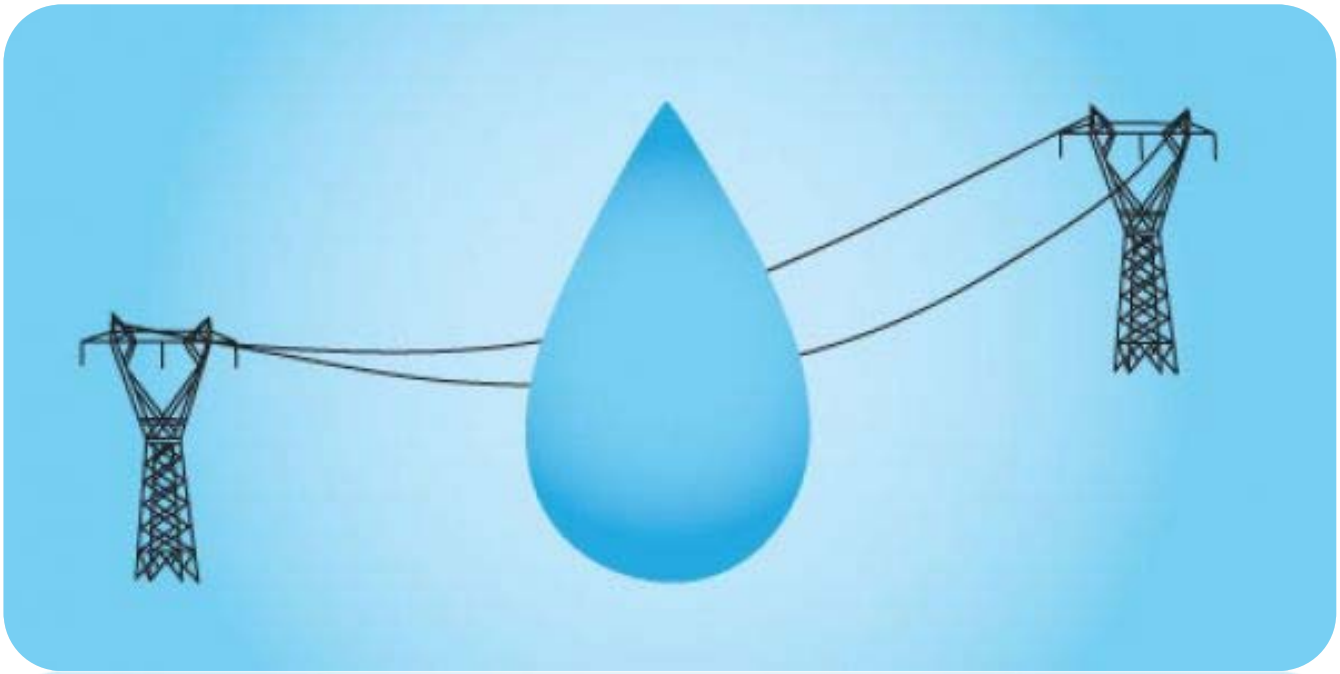
Presentation outline

Water-energy-climate nexus – background and areas of focus

Current research in water-energy nexus at Griffith University

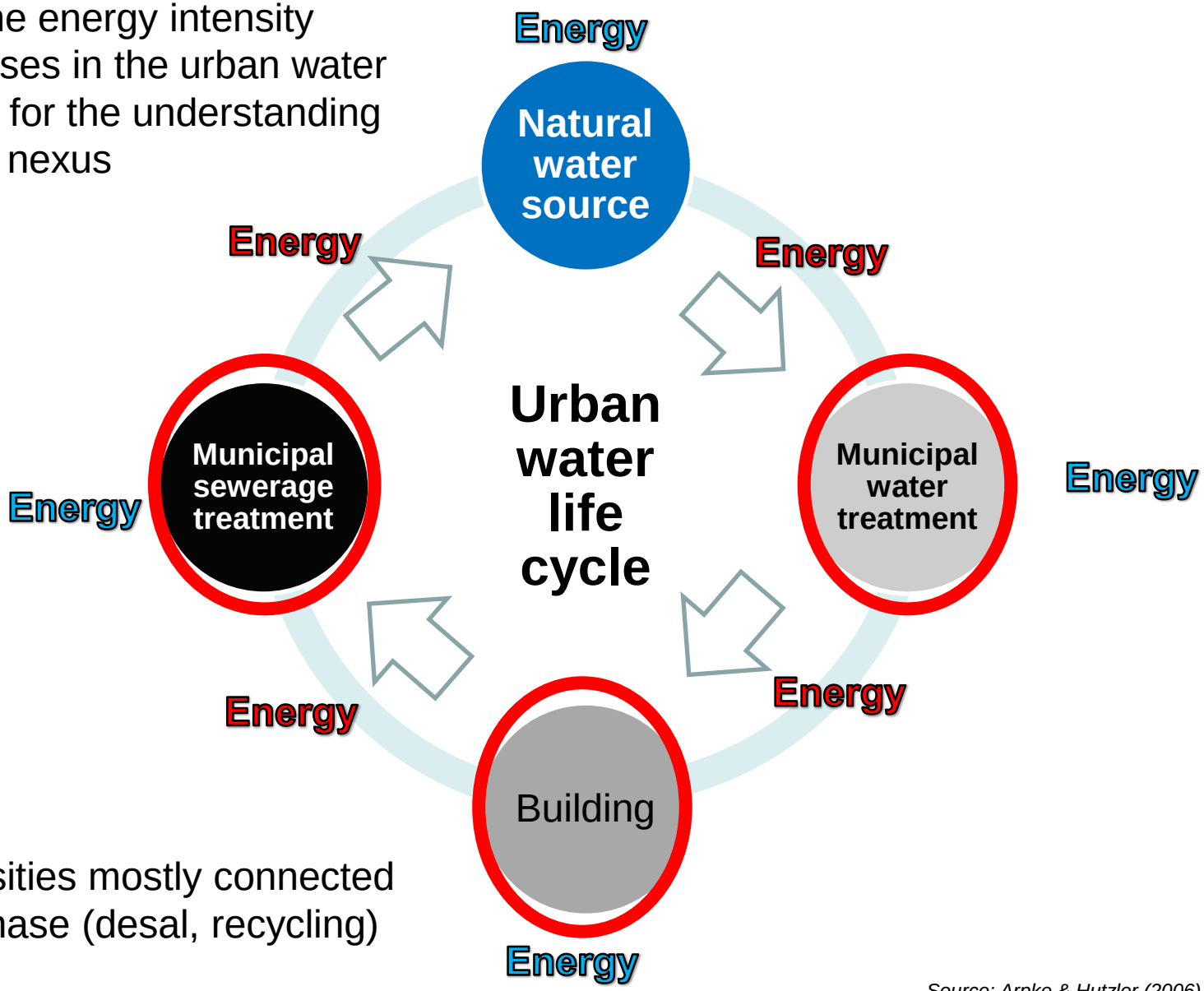
The role of ‘big data’ and informatics in tackling the water-energy nexus

Summary & Conclusions (some key challenges ahead)



Water-energy-climate nexus: Urban water life cycle

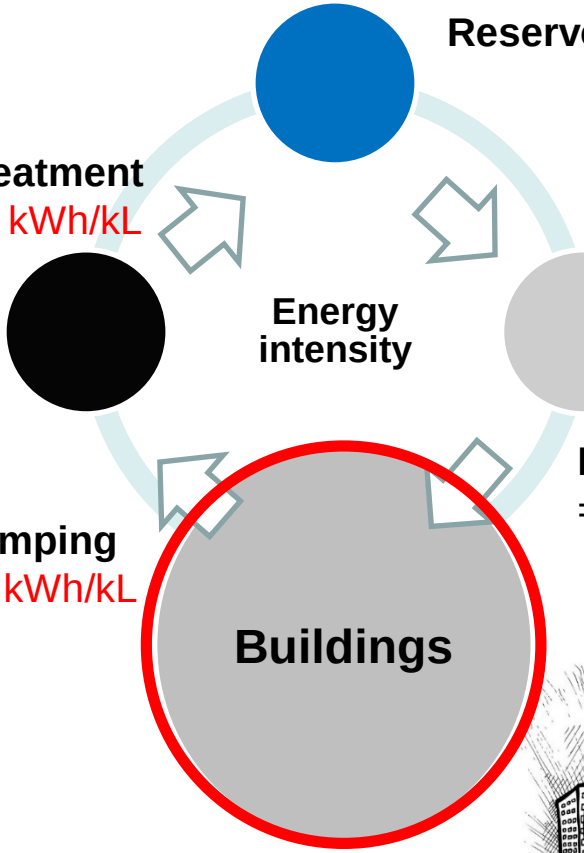
Knowledge about the energy intensity **(kWh/m³)** of processes in the urban water life cycle are critical for the understanding of the water-energy nexus



High energy intensities mostly connected to the operation phase (desal, recycling)

Source: Arpke & Hutzler (2006)

Urban water life cycle:
Energy intensity in supply, distribution and buildings



Reservoirs – very low

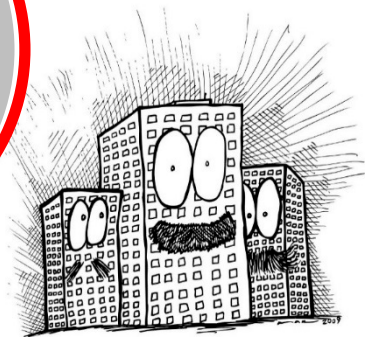
WWTP Treatment
= 0.4 - 0.8 kWh/kL

WTP Treatment
= 0.1 - 0.7 kWh/kL

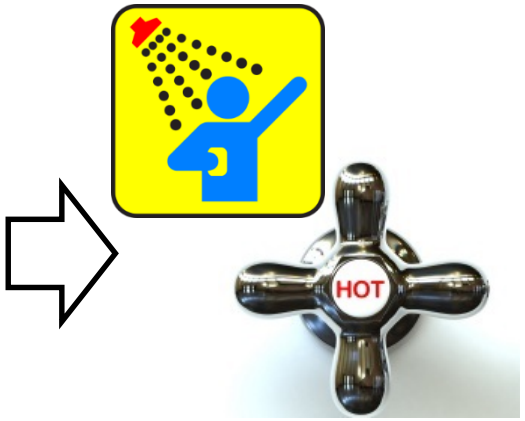
Reverse osmosis for sea water desalination
= 2.0-8.5 kWh/m³

Distribution pumping
= 0.2 - 0.3 kWh/kL

Sewage pumping
= 0.02 - 0.2 kWh/kL



6.6-50.0 kWh/m³



Source: Plappally and Lienhard V (2012)

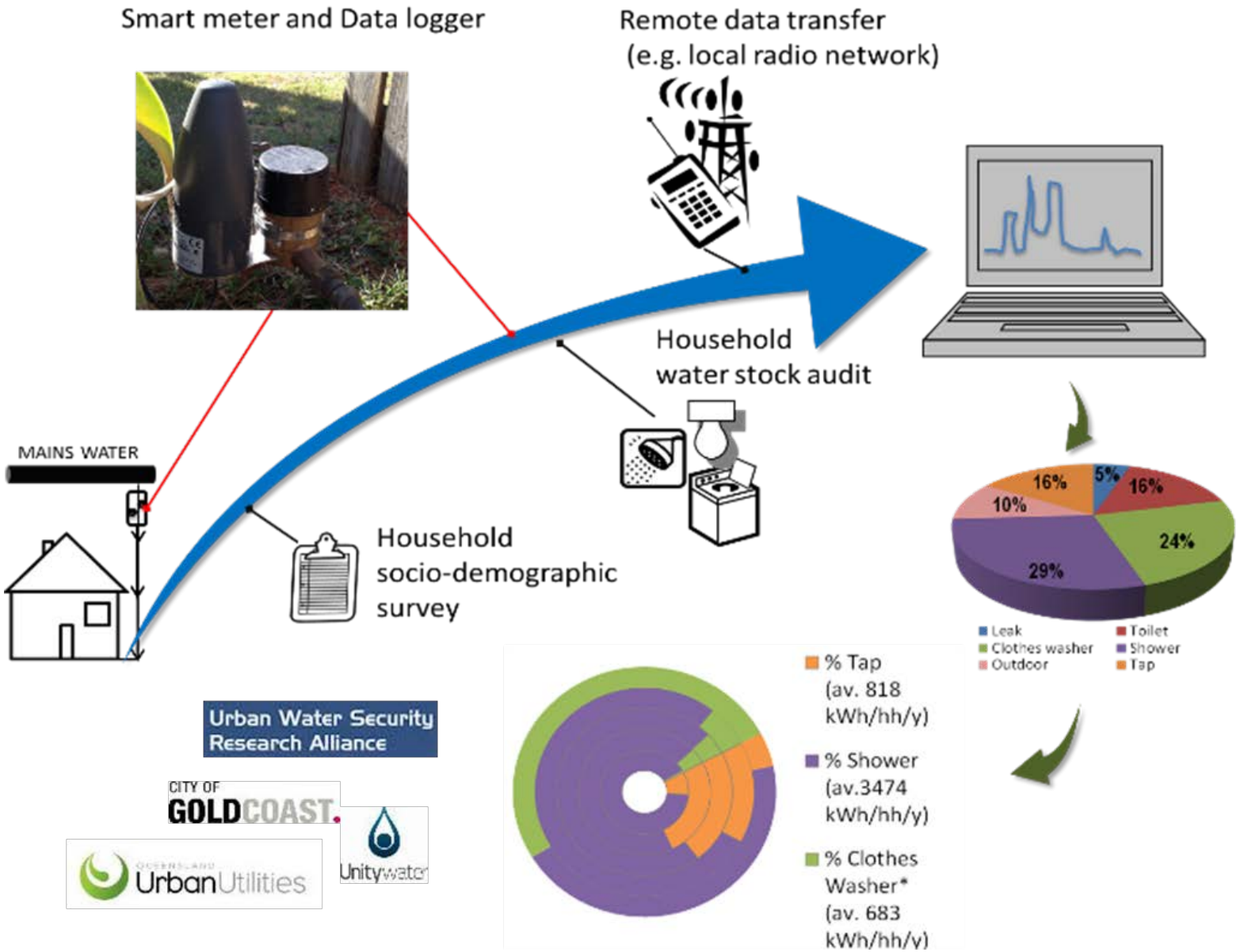
Buildings and water-energy demand

Projects

- **P1** Water-related energy demand of domestic water end-uses
- **P2** Evaluating residential heating systems
- **P3** Rain tank pump energy intensity at an end use level
- **P4** Evidence-based sustainable water and energy supply in regional and remote communities

P1

Water-related energy demand of domestic water end-uses



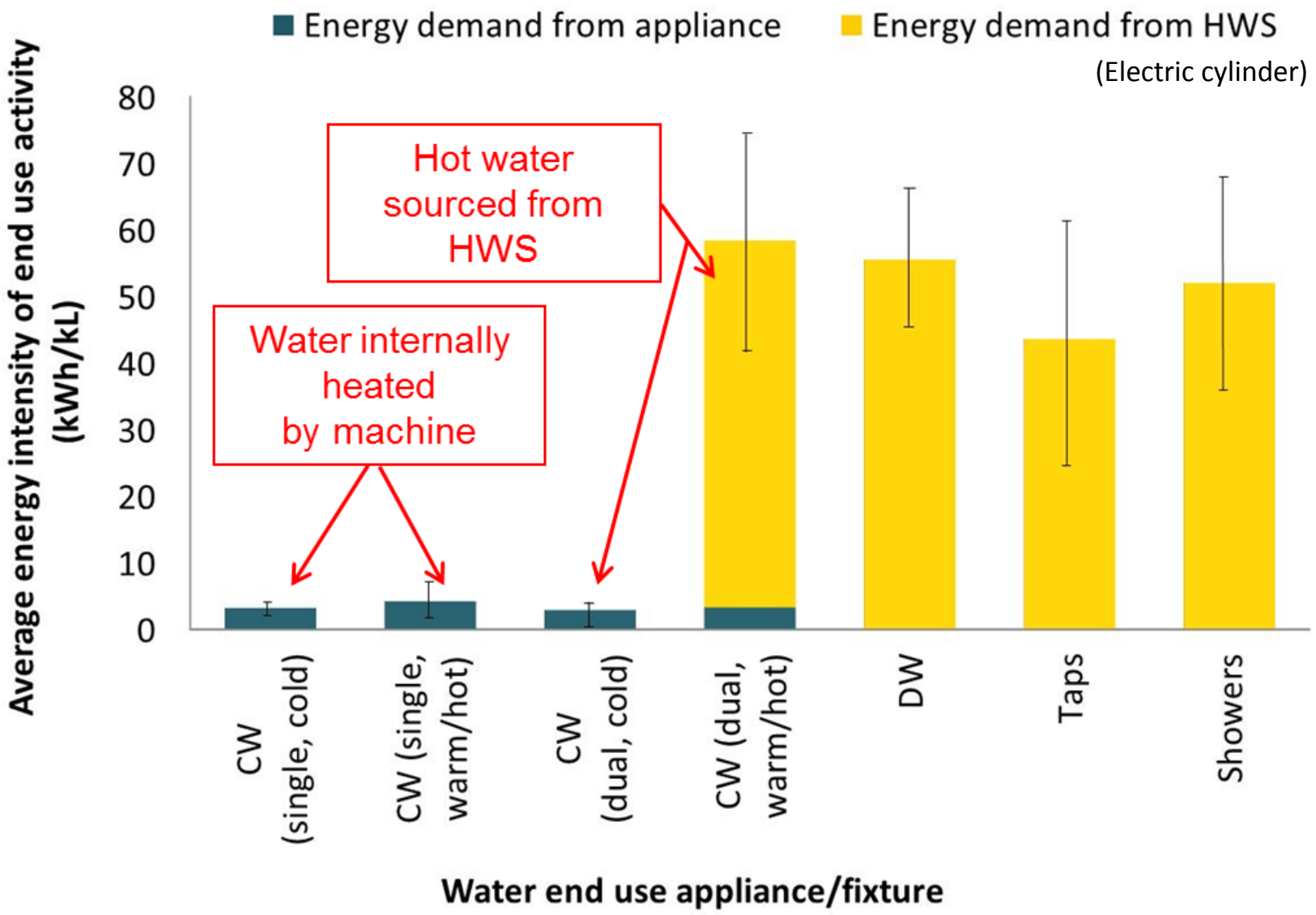
Urban Water Security Research Alliance

CITY OF GOLDCOAST

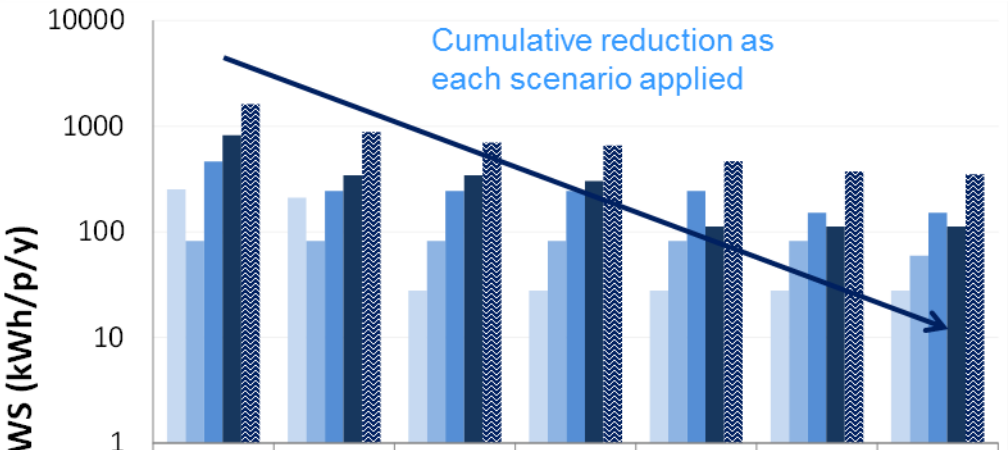
Unitywater

Queensland Urban Utilities

Energy intensity of end-uses



Water-energy end-use assessments



	Base case	Solar HWS	Solar + water efficient CW	Solar + shower ↓ 37°C	Solar + low flow shower head	Solar + tap aerators	Solar + energy efficient DW
CW	251.7	211.0	27.7	27.7	27.7	27.7	27.7
DW	82.0	82.0	82.0	82.0	82.0	82.0	59.4
Taps	464.0	244.0	244.0	244.0	244.0	151.3	151.3
Shower	821.0	345.0	345.0	303.0	112.4	112.4	112.4
Total	1618.7	882.0	698.7	656.7	466.1	373.5	350.9
% total reduction		**46%**	**57%**	**60%**	**72%**	**77%**	**79%**

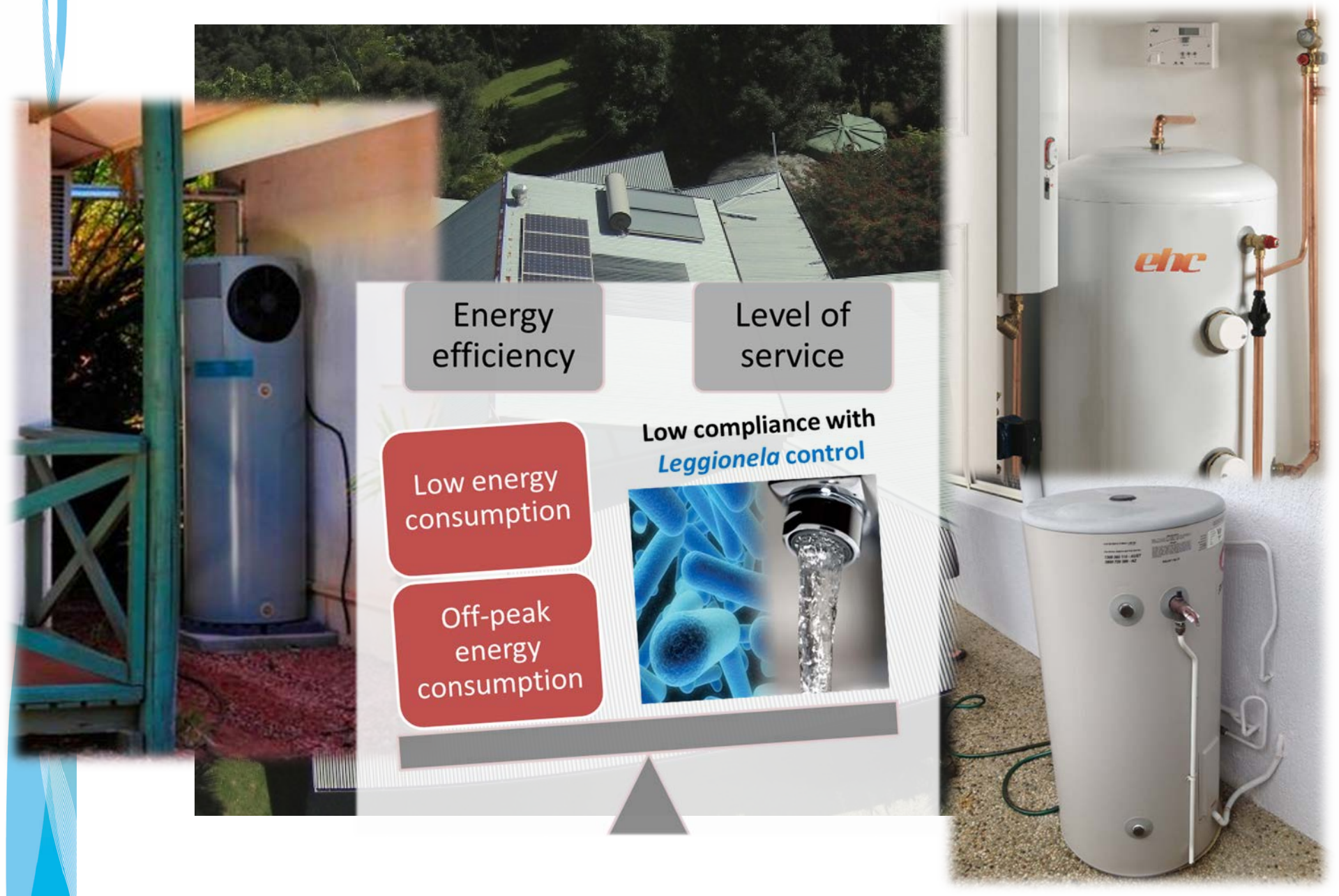
% individual savings (person/year)

Scenario	Water reduction (%)	Energy reduction (%)
Solar HWS (EB)	-	46
Water-efficient shower head ✓	37	63
Water-efficient clothes washer	27	87
Tap aerators	27	38
Shower temp reduced to 37C	-	13
Energy-efficient dish washer	-	28

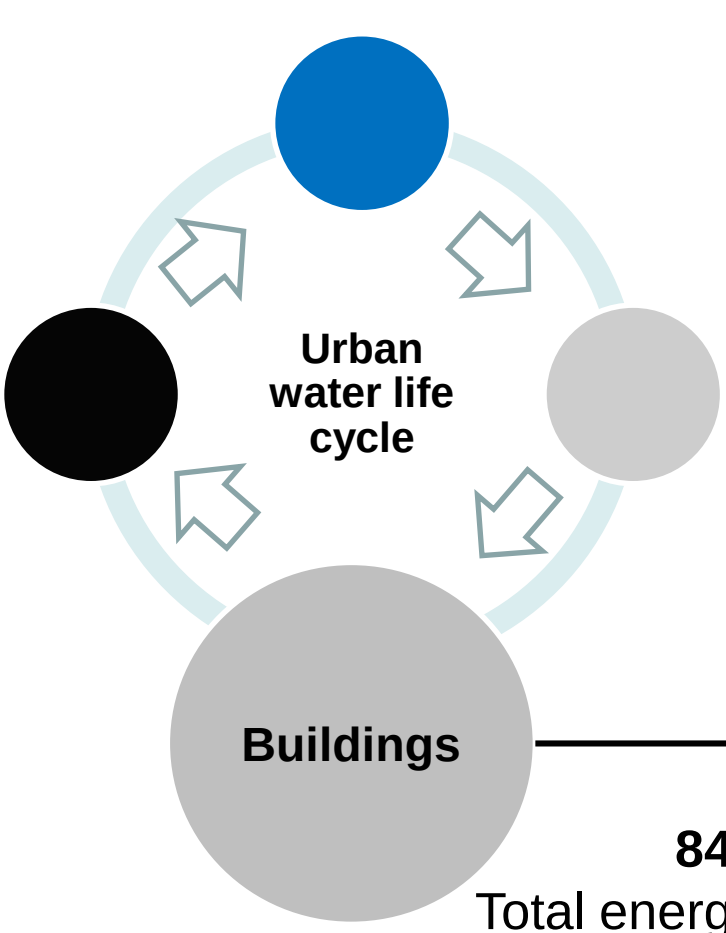
Key conclusions:

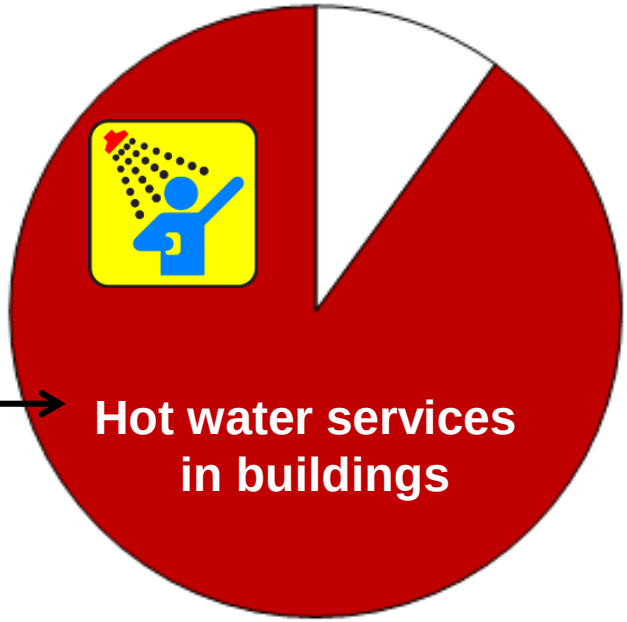
- Need to target user behaviour as well as retrofit technology
- This is tricky as hot water typically discretionary and related to quality of life behaviour/attitude
- Heating system and appliance type is critical to end-use energy demand

P2 Evaluating residential heating systems



Urban water life cycle: Hot water services





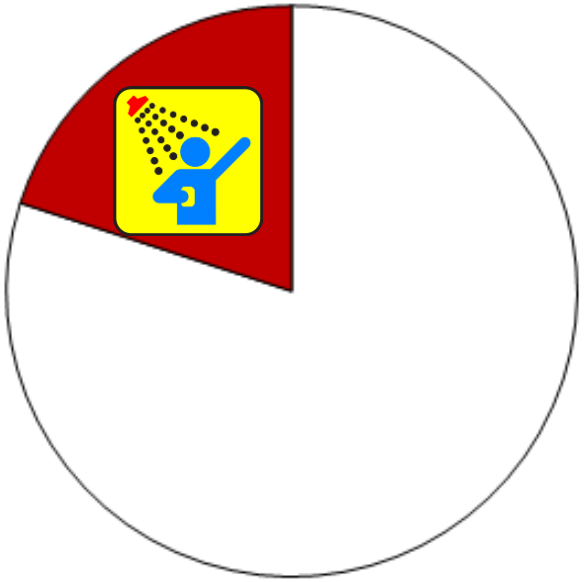
84-97%
Total energy consumption
of the urban water life cycle

Source: Arpke and Hutzler (2006); Cheng (2002); Flower (2009)

Residential sector: Hot water services

Hot water systems are a substantial consumer of electricity

Buildings



14-26%
Total energy consumption
in residential buildings

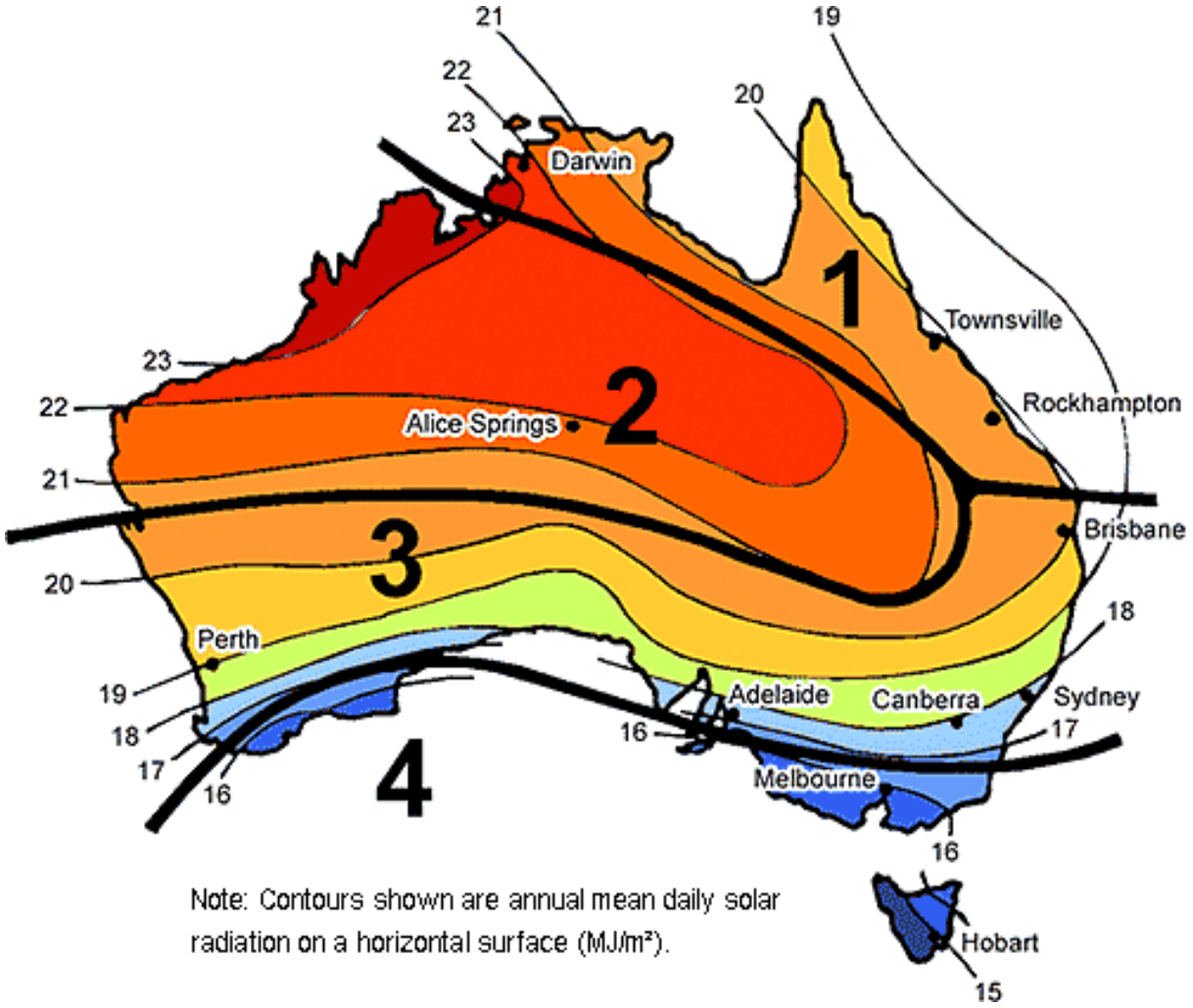
Source: Pérez-Lombard et al. (2008)

Energy efficiency policies: Energy efficient water heaters in Australia

- Small-scale Renewable Energy Scheme (SRES):
  - Provide rebates - small-scale technology certificates (STCs) for new installed solar and air source heat pump systems (ASHP)
  - Based on the estimated displacement or production of energy for electricity grids achieved by systems
  - Performance of systems based on 4 climate zones only in Australia

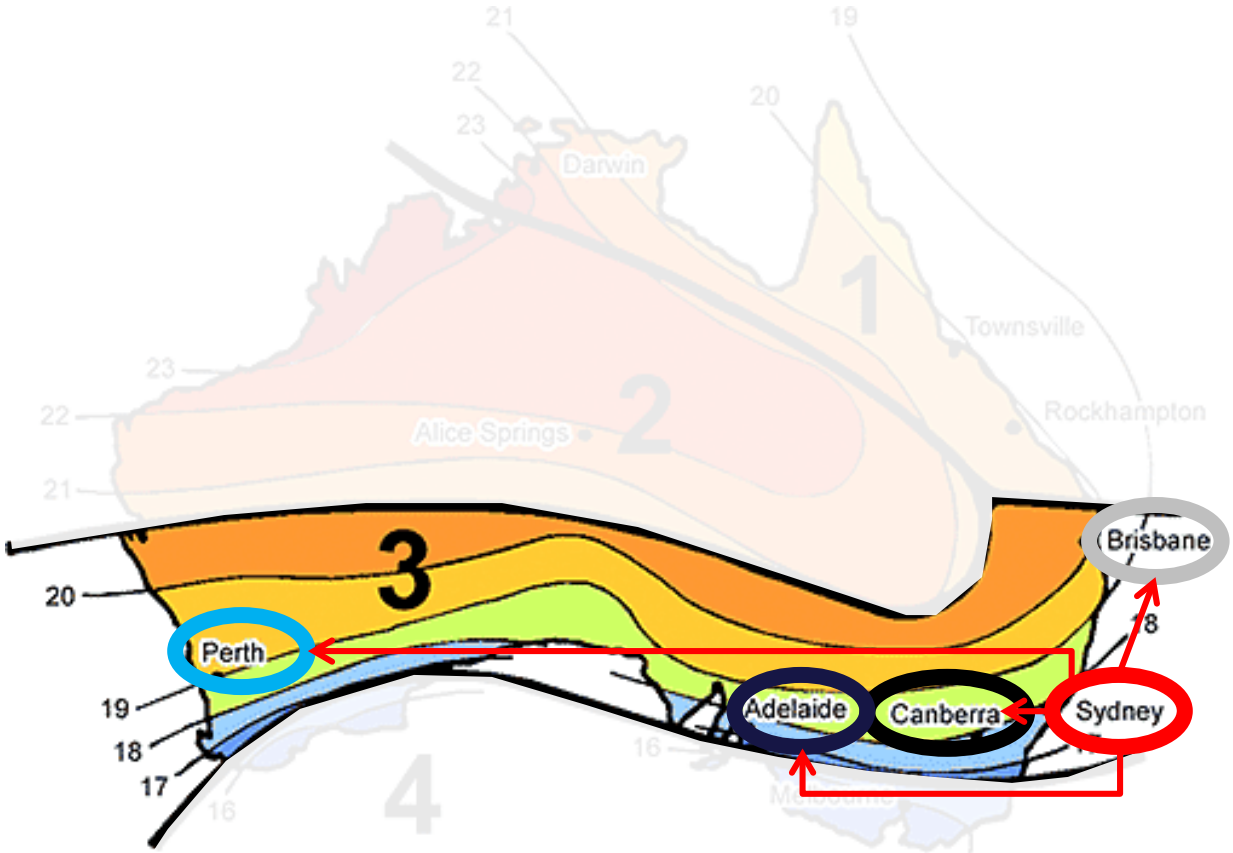
Source: Clean Energy Regulator (2014)

Energy efficiency policies: SRES based on AS4234
Solar water heaters—Domestic and heat pump—Calculation of energy consumption



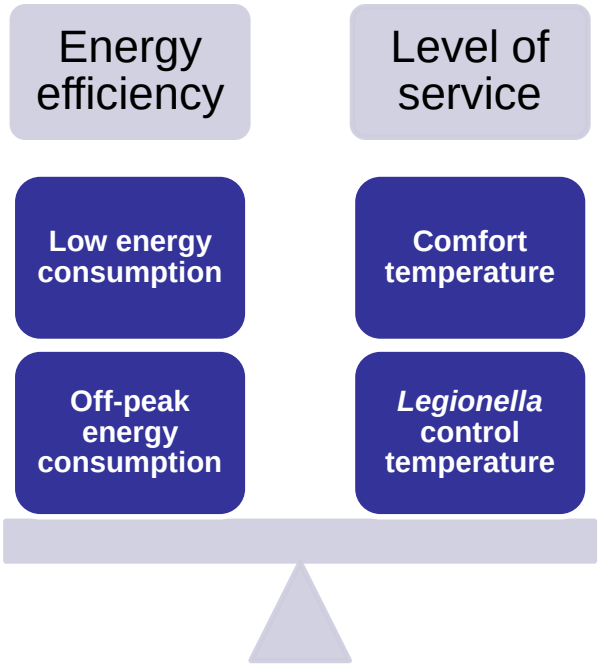
Source: Mills (2004)

Energy efficiency policies: *Current model analyses (AS4234)*



Source: Mills (2004)

Evaluating residential heating systems

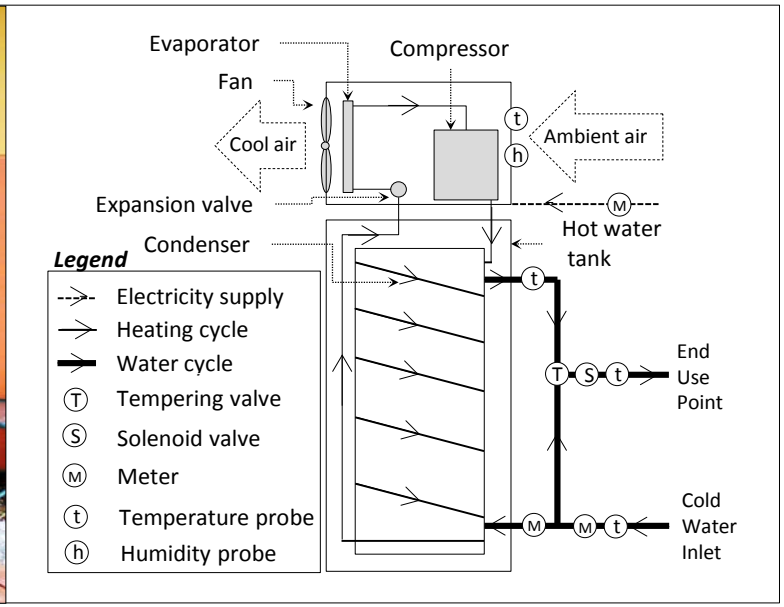


Solar heating Vs Heat pump Vs Electric

- To investigate the performance of residential hot water services under a holistic framework
- Account energy efficiency aspects (i.e. water-energy nexus) and level of service aspects (i.e. compliance levels with minimum temperature thresholds).
- Assist households/developers with selecting ideal residential water heating systems under different site-specific conditions
- Provide governmental departments with a framework to adequately classify and provide rebates for residential water heating systems

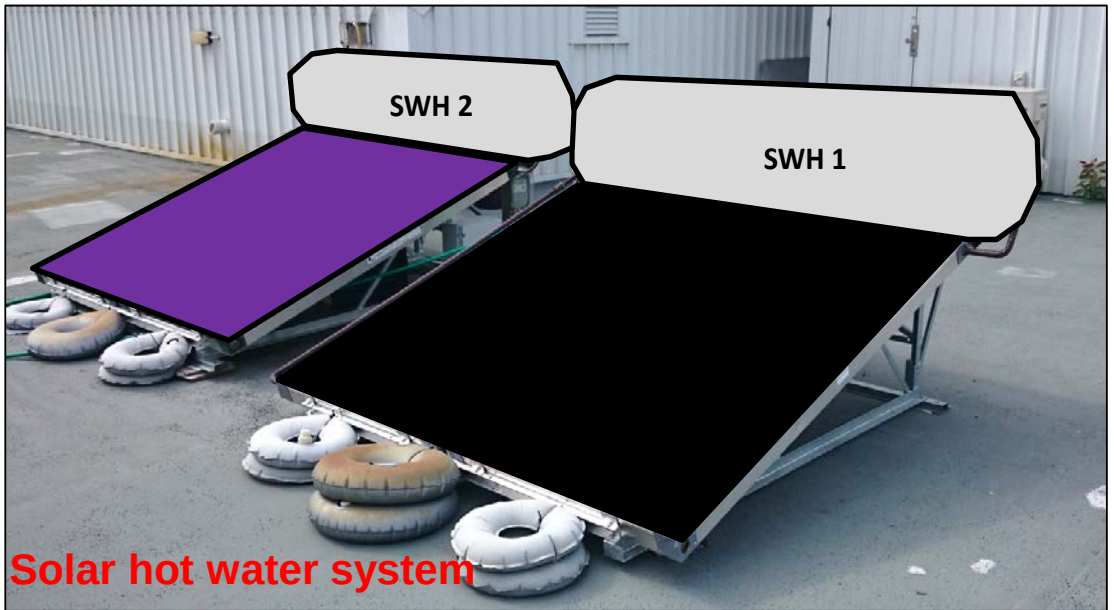
Evaluating residential heating systems cont.

Air sourced heat pump



- lab experiments – empirical data to underpin sensitivity analysis
- heating system performance under various water use patterns, tariff structures, weather conditions, tank sizes and levels of service.

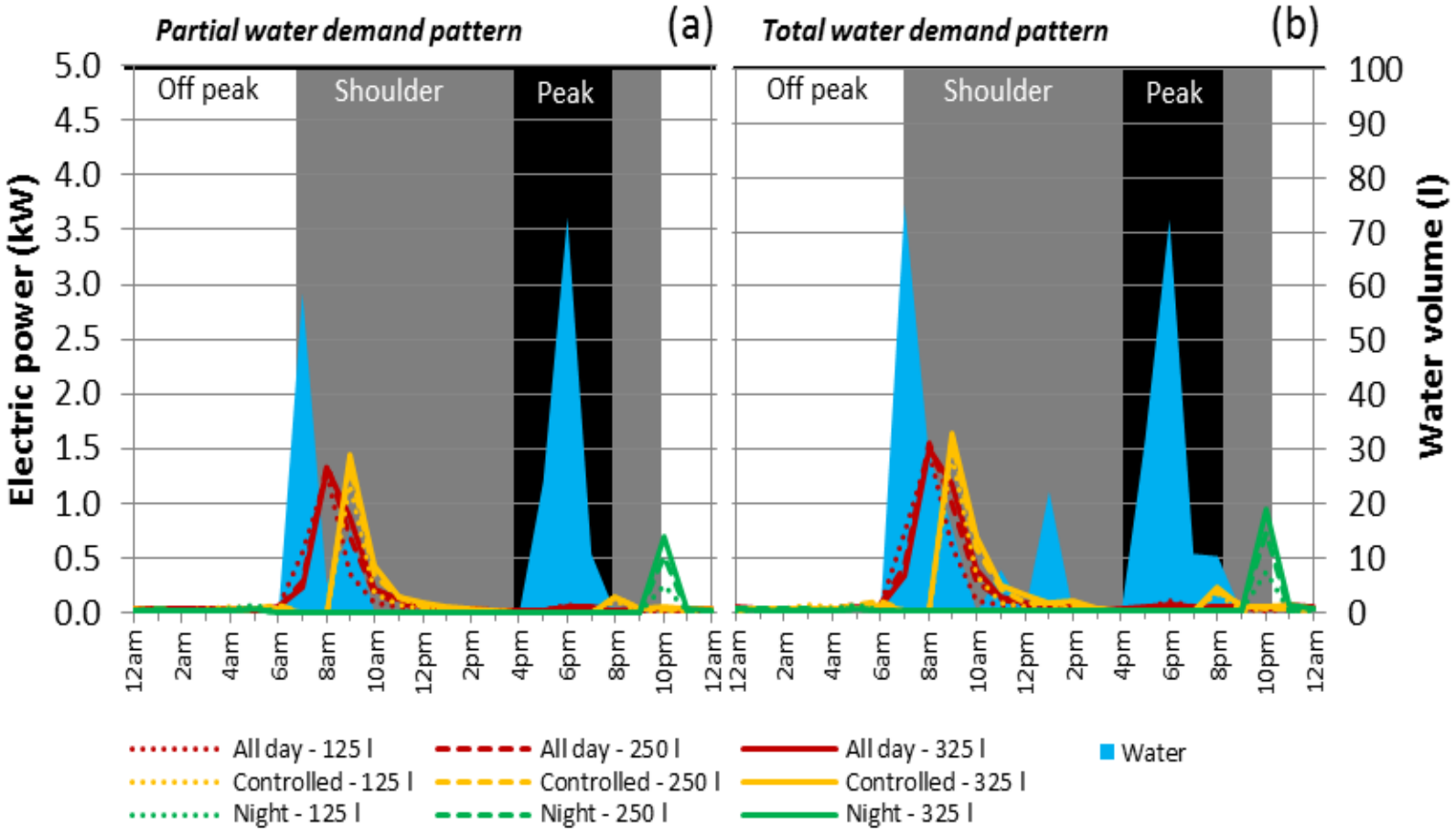
- an energy efficiency evaluation framework based on site-specific conditions, compliance levels and appliance specifications



Solar hot water system

The impact of electricity supply schemes, tank size and washing machines on the performance of residential water heating systems

Solar HWS



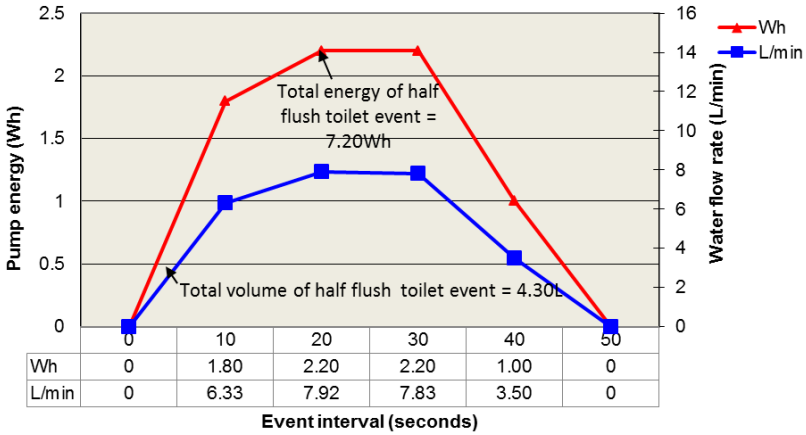
Key conclusions:

- Achieving energy efficiency is not just about the type of hot water system. i.e solar not panacea!
- Guidance / regulations on HWS - individualised to realise optimal water-energy-WQ balance
- Output will be tool for consumers, developers and regulators to help guide system choice/specs

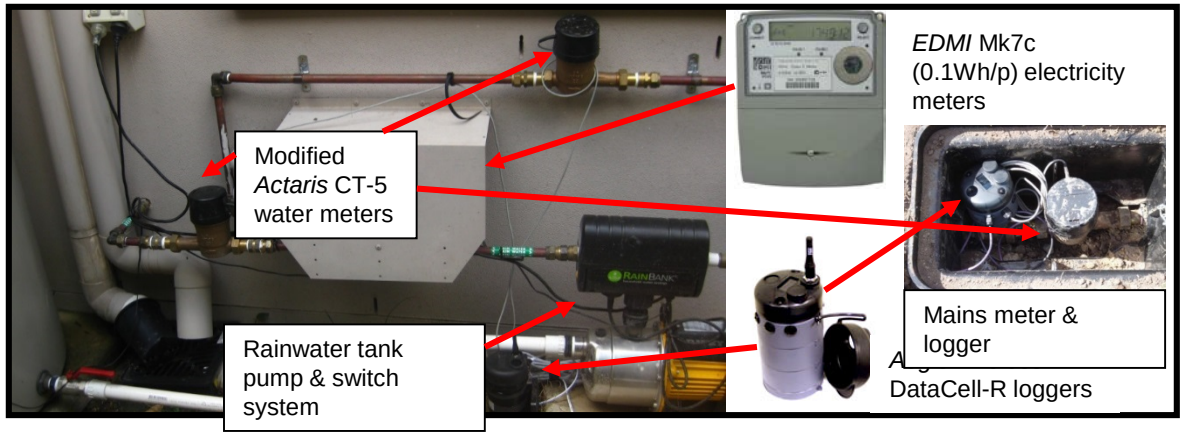
P3 Rain tank pump energy intensity at an end use level

Individual end use event	Event volume (L)	Event energy (Wh)	Event energy intensity (Wh/L)	Event GHG intensity (kg $CO_{2\text{-}e}$/L)*
Long irrigation	450.30	467.20	**1.037**	0.00108
Short irrigation	13.13	13.60	**1.040**	0.00109
Clothes washer (cold water wash)	118.16	128.80	**1.090**	0.00114
Full flush toilet	7.50	11.40	**1.520**	0.00159
Half flush toilet	4.30	7.20	**1.670**	0.00175

e.g. Half flush toilet event water-energy mapping



	0	10	20	30	40	50
Wh	0	1.80	2.20	2.20	1.00	0
L/min	0	6.33	7.92	7.83	3.50	0



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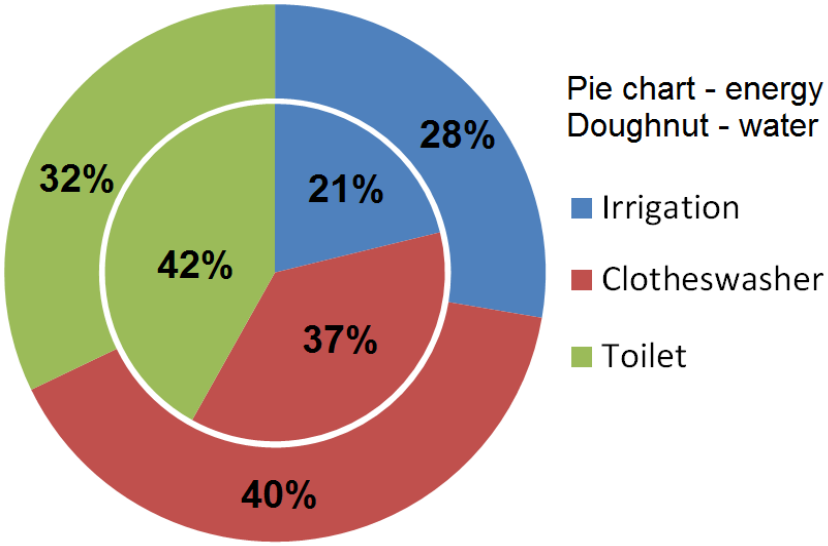
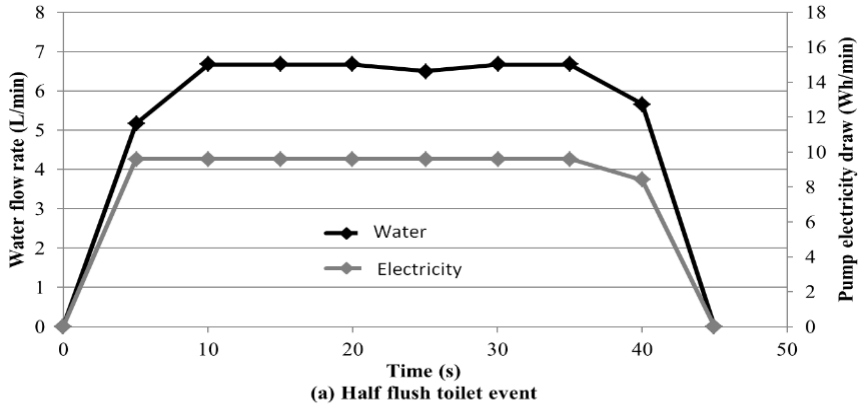
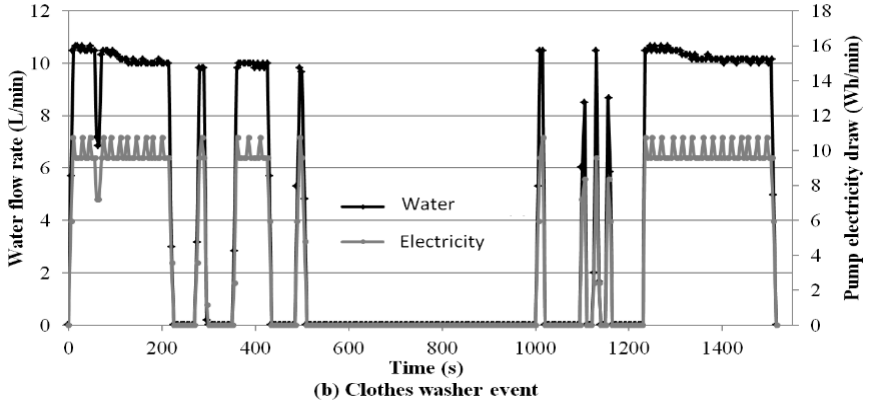
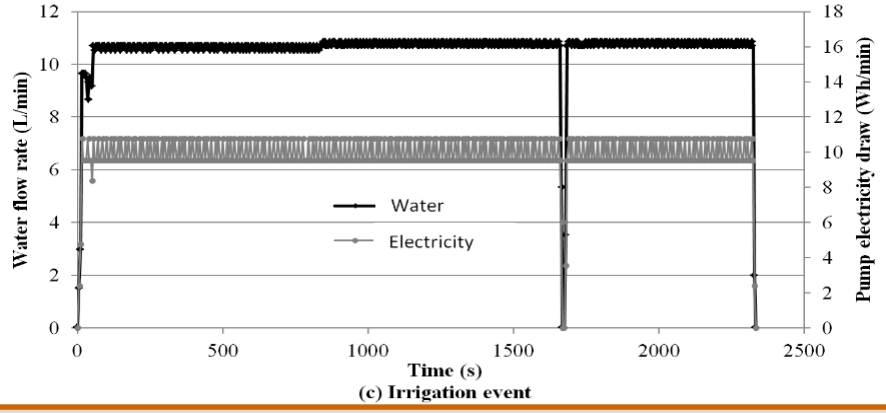
Raintank pumping energy cont.









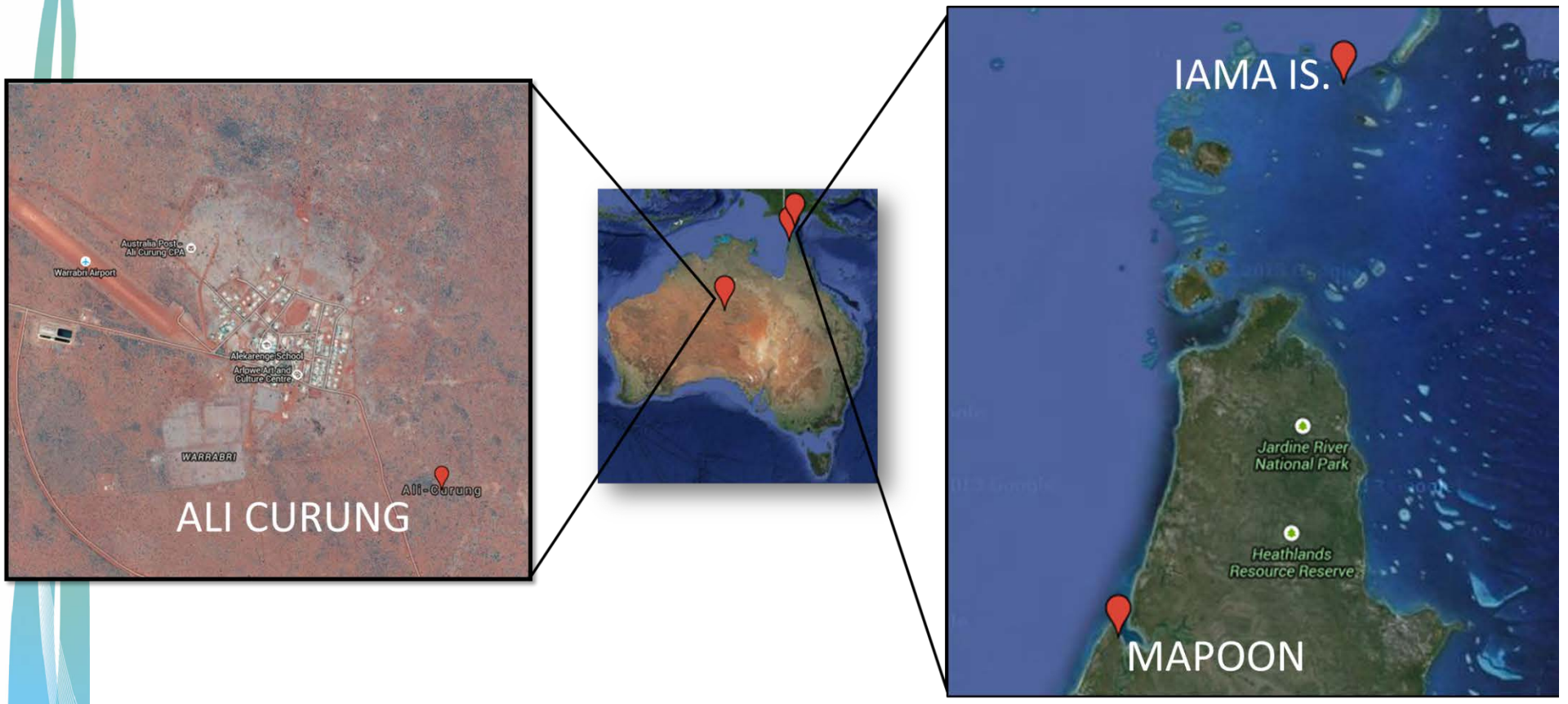
Key conclusions:

- Low flow rate water efficient appliances did not translate to energy efficient pump demand
- Popular fixed speed pump models are inefficient at supplying indoor end-uses
- Longer duration water use events were typically more energy efficient

P4 Evidence-based sustainable water and energy supply in regional and remote communities

Griffith UNIVERSITY | ERGON ENERGY | PowerWater | The University Of Queensland AUSTRALIA | Centre for Appropriate Technology | Torres Strait Island Regional Council | WATER CORPORATION | Queensland Government Department of Energy and Water Supply

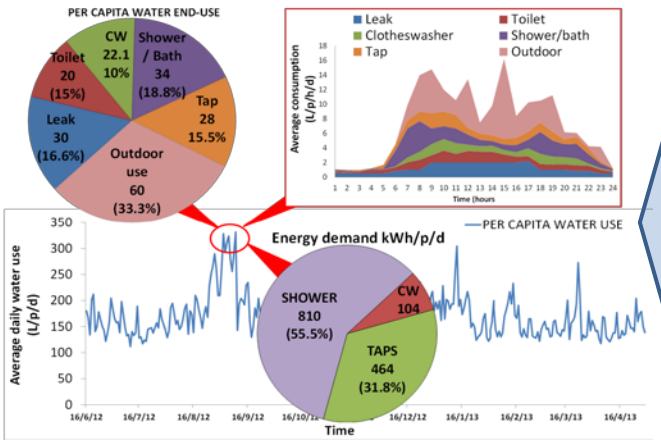
- Focus on high energy water supply systems e.g. desalination, diesel generators for pumping etc.
- Focus on remote (distance from large urban centre) and isolated (can be cut off from regular access) communities



P4

STAGE 1 Objectives

To gather baseline water and energy use data using existing and new information



Existing Data Review

Finalise Engagement Strategy

Recruit sample households

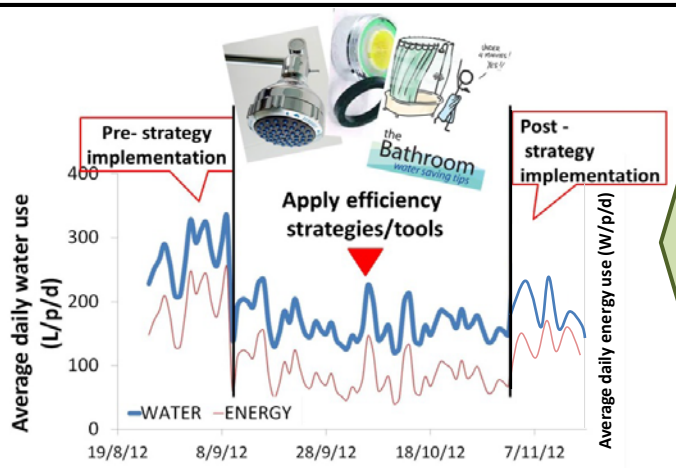
Installation of water and energy smart metering systems

Household Stock & Water Use Survey

Water and Energy Consumption Monitoring

STAGE 2 Objectives

To develop, test and assess appropriate and effective household water and energy efficient strategies



Review and select trial efficiency measures

Efficiency Strategy Testing

Technical | Behavioural

Feedback survey on strategies

Identification and rank of preferred / suitable strategies

STAGE 3 Objectives

To develop a peer-reviewed, nationally applicable handbook for sustainable water and energy efficiency in ATSI communities

Develop Handbook

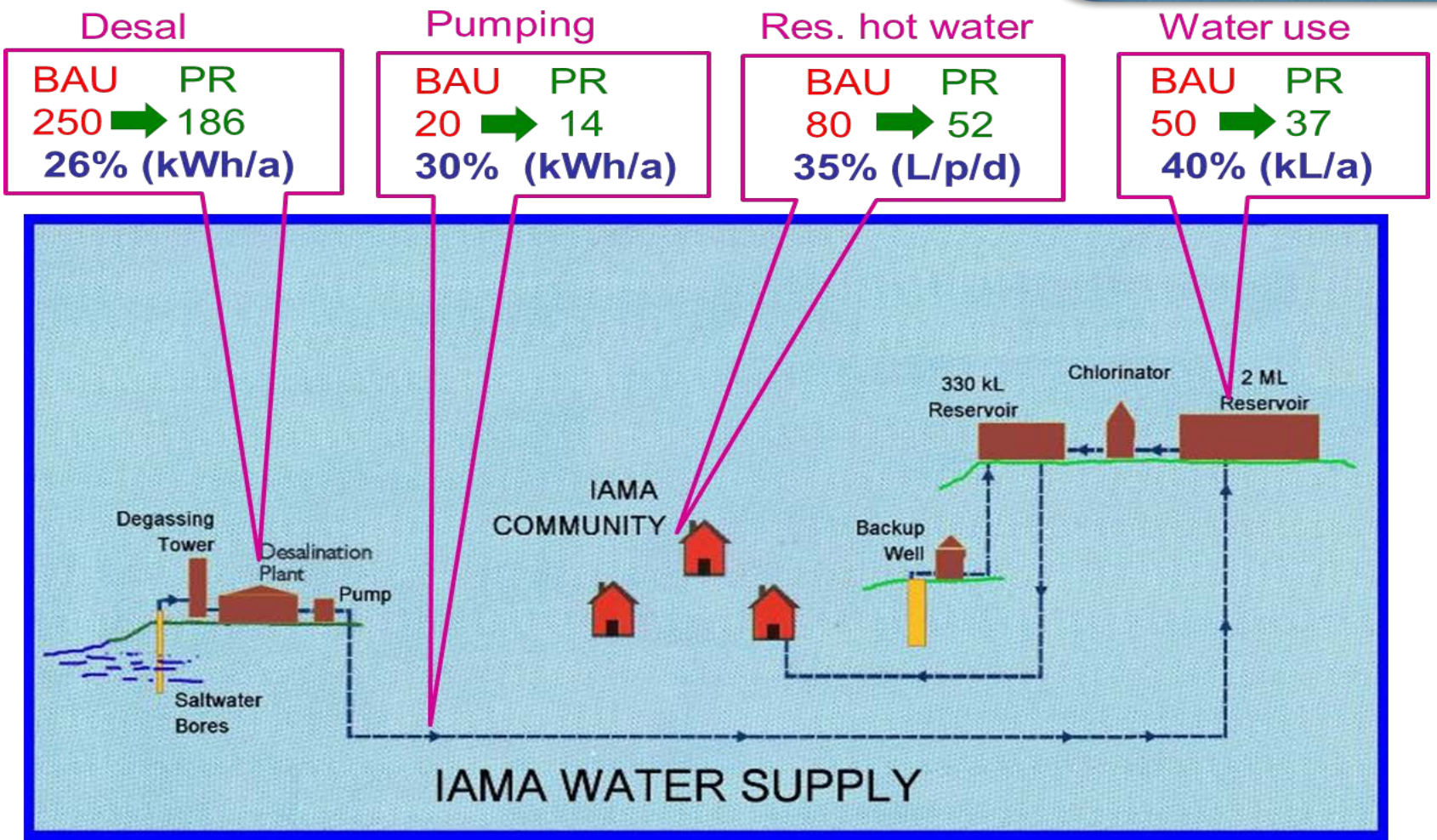
Disseminate Handbook

COMMUNITY AND INDUSTRY PARTNER CONSULTATION

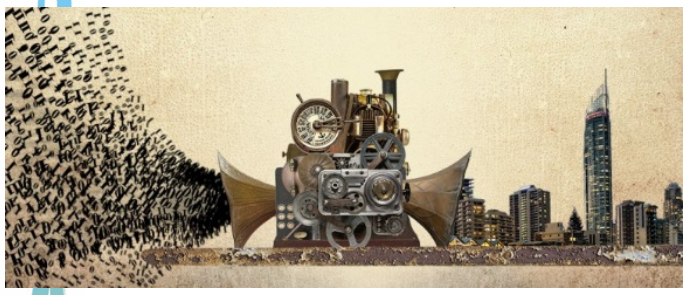
= peer review

Water-energy savings - desktop

Yam Island: Business as usual (BAU) & post retrofitting (PR) efficient technology and concurrent conservation planning /behaviour change programs at an end use level



Role of digital technology



in achieving water-energy balance…

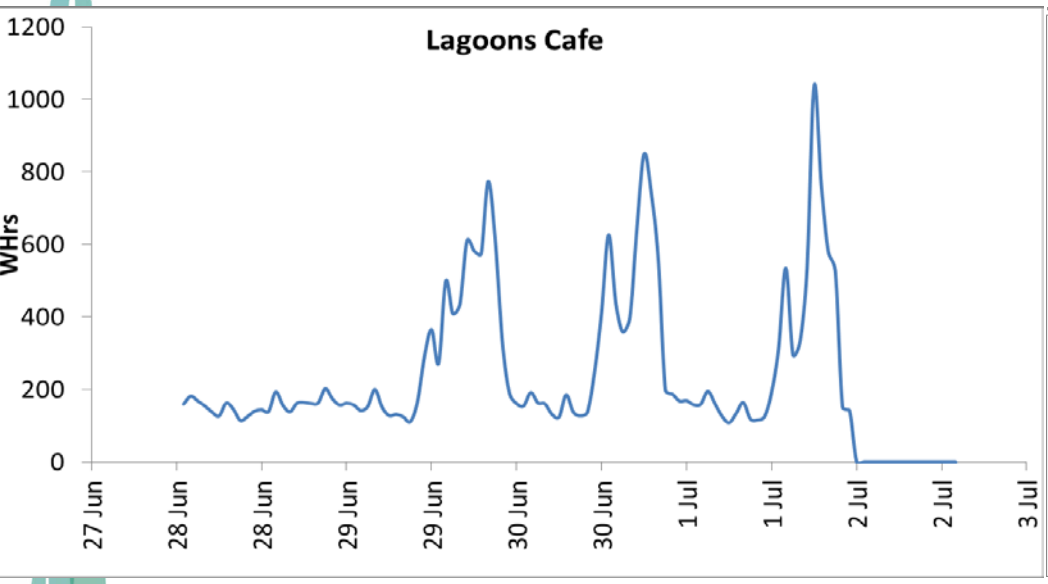
- Beyond the ‘smart meter’ and toward an intelligent whole of network
- Big data and informatics – targeted analysis for water business and customers

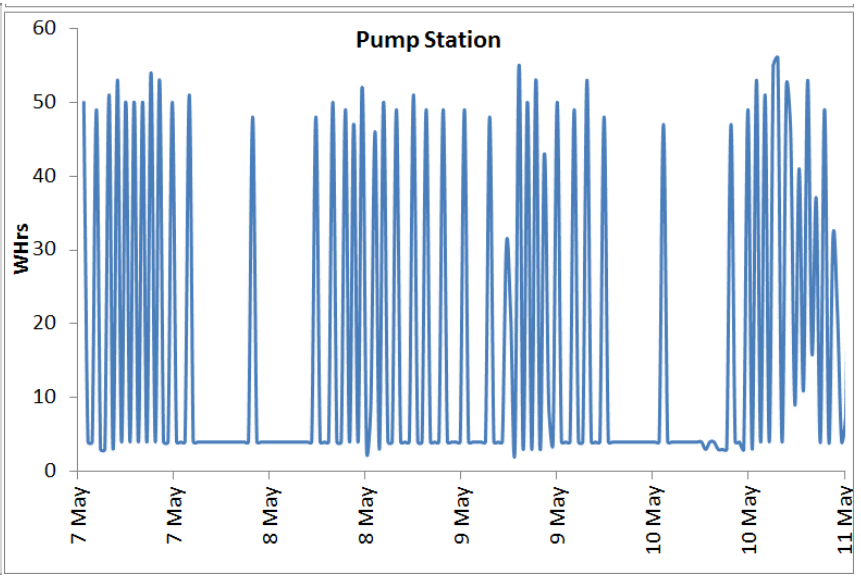
Beneficial outcomes:

- Better targeted water conservation programs and their evaluation
- Leak and pressure monitoring and management – reduce energy
- Understanding drivers of peak water-energy and how to reduce
- Better water distribution network modelling and planning
- Higher customer satisfaction with water business – service focus, better engagement, better customer awareness of water-energy links

Meter, monitor and manage water-related energy

Require intelligent metering, monitoring and analytics for water related energy. Energy is a significant cost component of water supply with great potential to be optimised

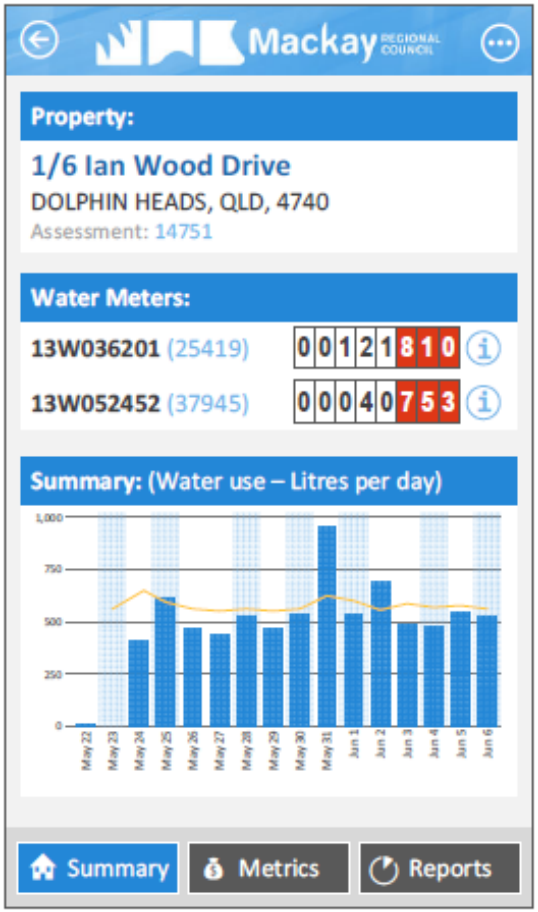


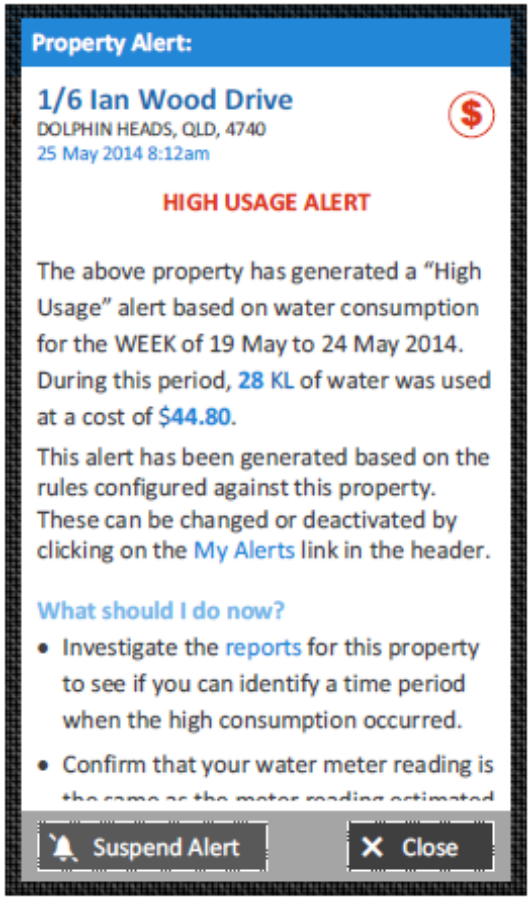


Optimising pump station efficiency – *reduce electricity costs*

Customer water use portals

Smart meters & analytics to enable water businesses to interact with their customers – enhanced customer satisfaction





- Consumption patterns
- Alerts to leaks
- Billing
- Social norms – how to I compare to my neighbour?
- Targeted demand management
- Numerous benefits

Autonomous and intelligent system for enhanced urban water management

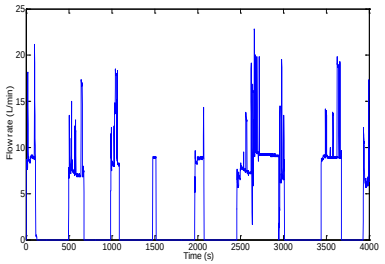
'Big data' from intelligent metering must be supported by good analytics to be useful

Water end use data accessible anywhere

More informative web portals for utilities and customers

Intelligent meter

Meter software can autonomously categorise water consumption



Flow signature patterns

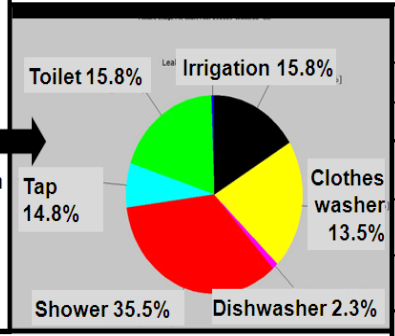
HMM
DTW
ANN
Etc.

WATER BUSINESS X: INTELLIGENT METERING SYSTEM

Welcome: 5 Smith Street, Brisbane, Queensland **Log out**

Please make a selection
My Usage and Budget
Comparative Usage
Rebate Schemes
Water End Use Reports
Reduce Your Consumption
View / Pay Bills
Leak alerts
Contacts

Day - 19 October 2012, Water Consumption End Use Report



Fixture Category	Water Usage (L/hh/d)	Percent (%)
Leak	15.28	2.92
Toilet	83.08	15.87
Clothes washer	70.59	13.49
Shower	186.21	35.58
Dishwasher	12.20	2.33
Tap	77.52	14.81
Irrigation	78.54	15.01
Total	523.42	100

Quick Summary: My Usage

Target Usage Per Day: 480 L/hh/d Yesterdays Usage: 496 L/hh/d
Yesterdays Average Daily Household Consumption: 510 L/hh/d
Last Weeks Average Daily Household Consumption: 472 L/hh/d

Consumption broken into end use categories

Summary

- Heating water in buildings is a substantial component of water-related energy demand and user behaviour change as well as technology to achieve operational efficiency

- Alternative water supplies (e.g. rainwater) and heating systems (e.g. solar hot water systems) may create perverse outcomes if not all factors considered holistically

- Digital water utility transformation can play a critical role in improving the operational water-energy efficiency of urban water systems

- Through smart metering more awareness and engagement with customers, water businesses can improve their water-energy efficiency –

  but this needs to be complimented with internal change management e.g. adopting “smart metering” technology, managing big data to generate appropriate & interesting (=motivating) hydroinformatics to customers

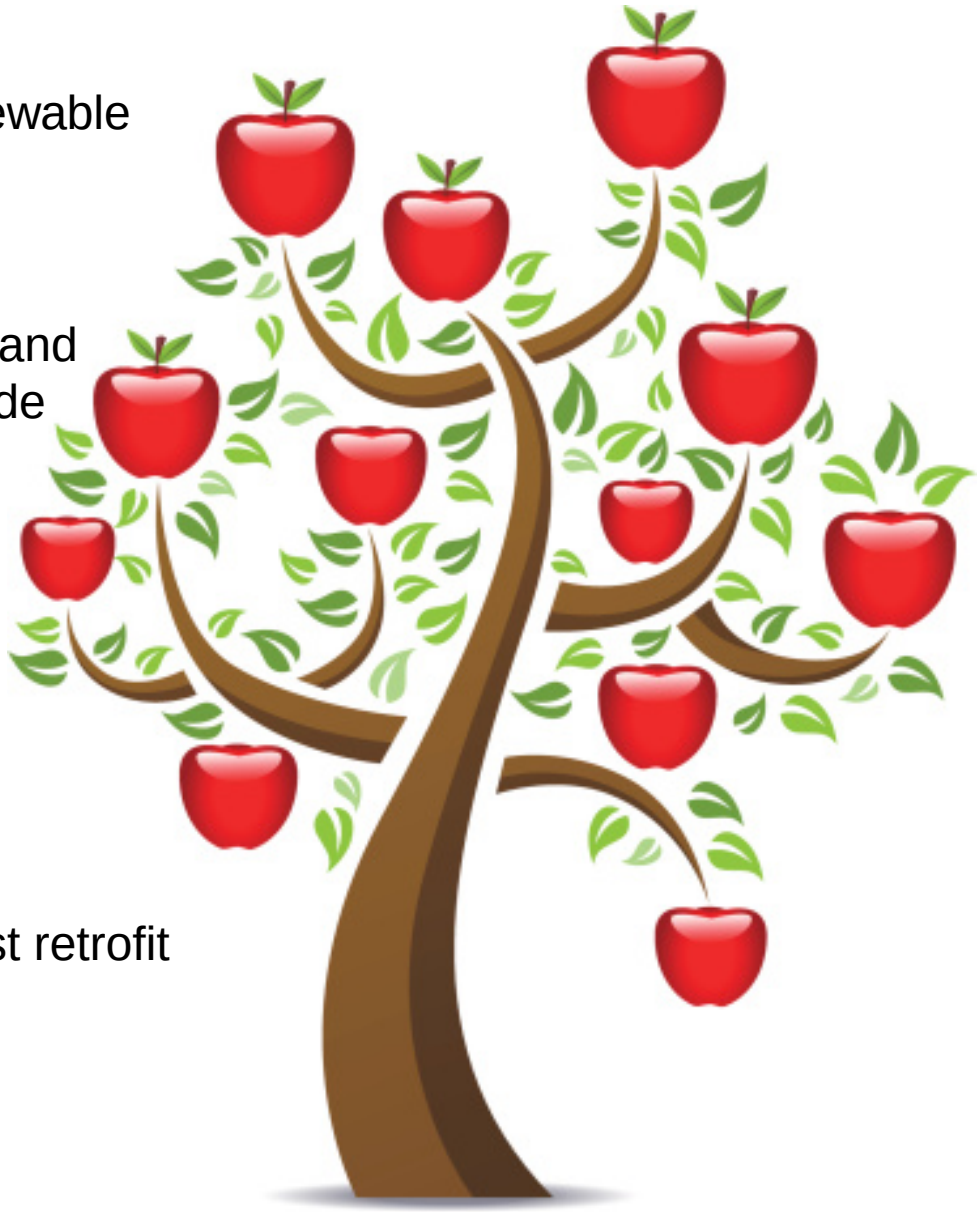
Some challenges ahead for water-energy efficiency

4. Alternative energy sources, renewable energy – changing infrastructure

3. Integrating smart metering, big data and hydroinformatics – utility & customer side

2. The role of behaviour change – not an obvious ROI

1. Beyond “low hanging fruit” – post retrofit



Thank you

c.beal@griffith.edu.au

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