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A Review of Urban Water-Energy Linkages in End-use: a Call for Joint Demand Studies

Simon De Stercke, Dr Ana Mijic, Dr James Keirstead

Department of Civil and Environmental Engineering
Imperial College London

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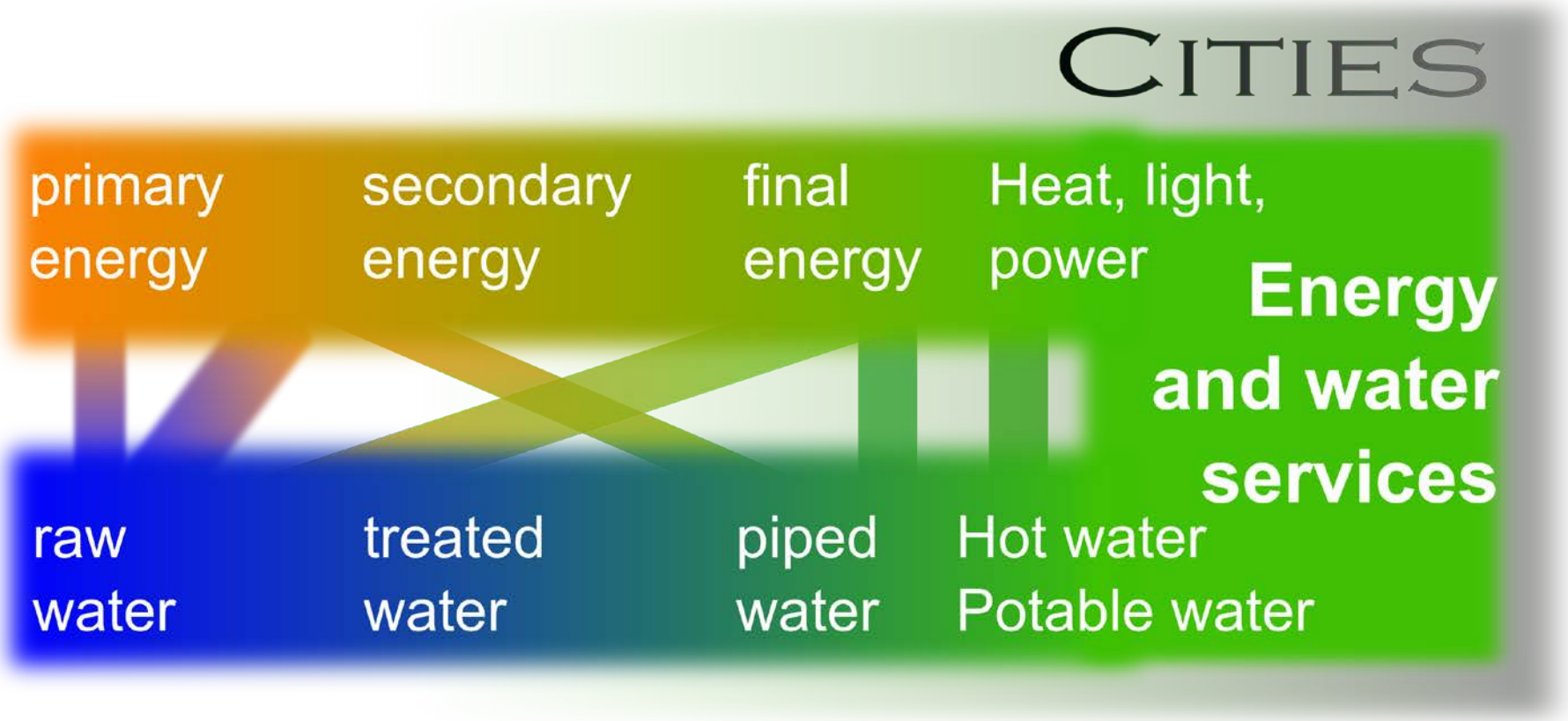
Introduction



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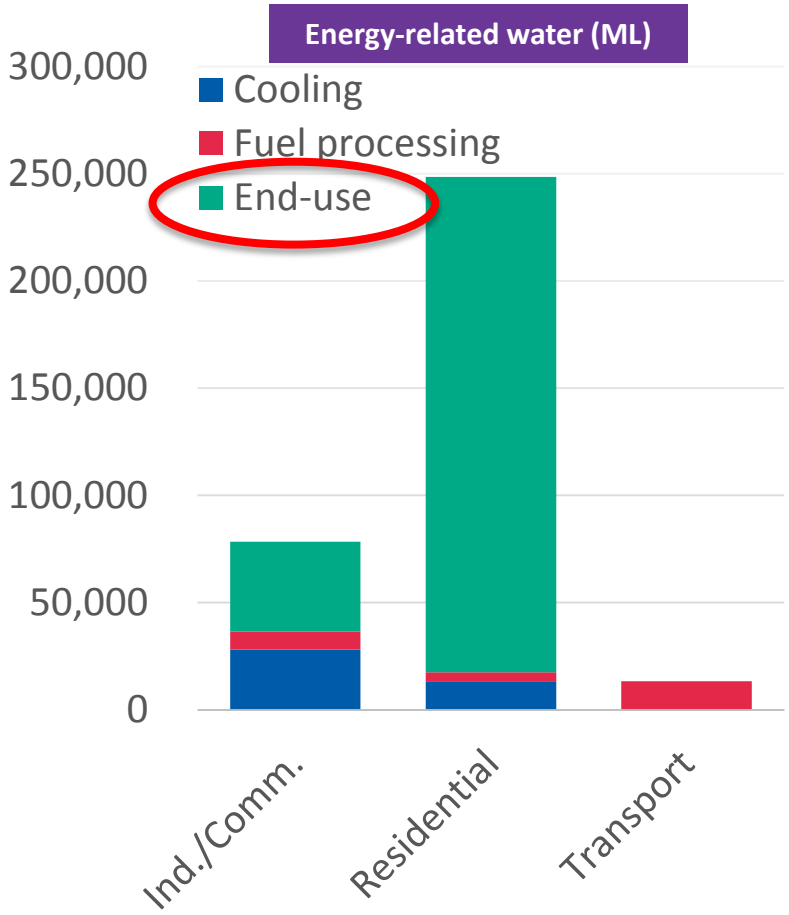
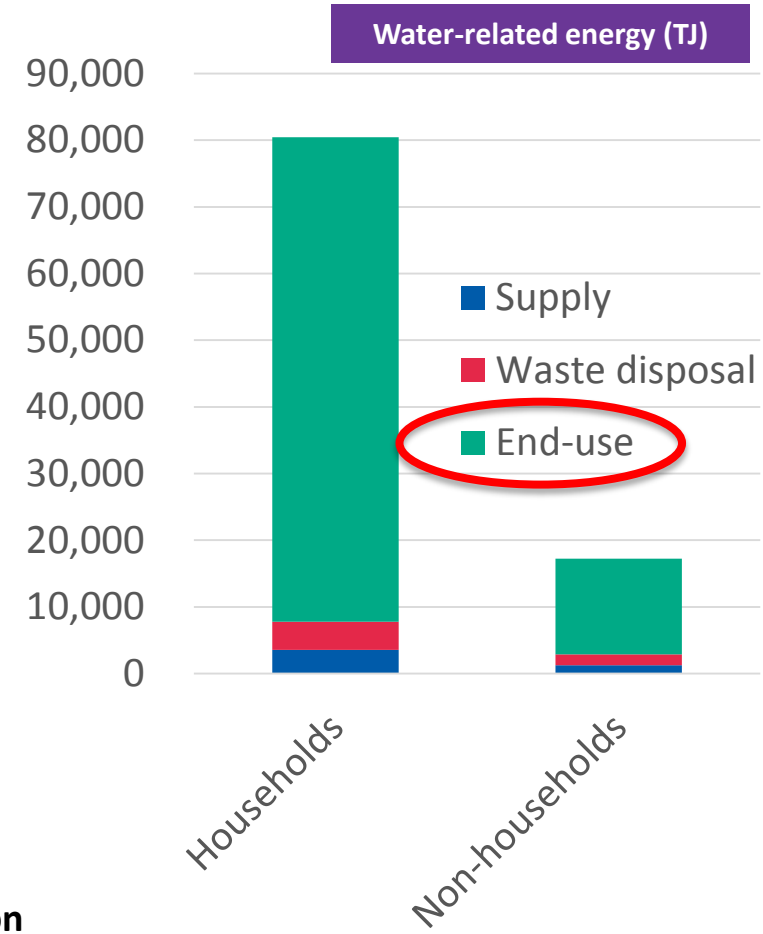
Urban water-energy linkages





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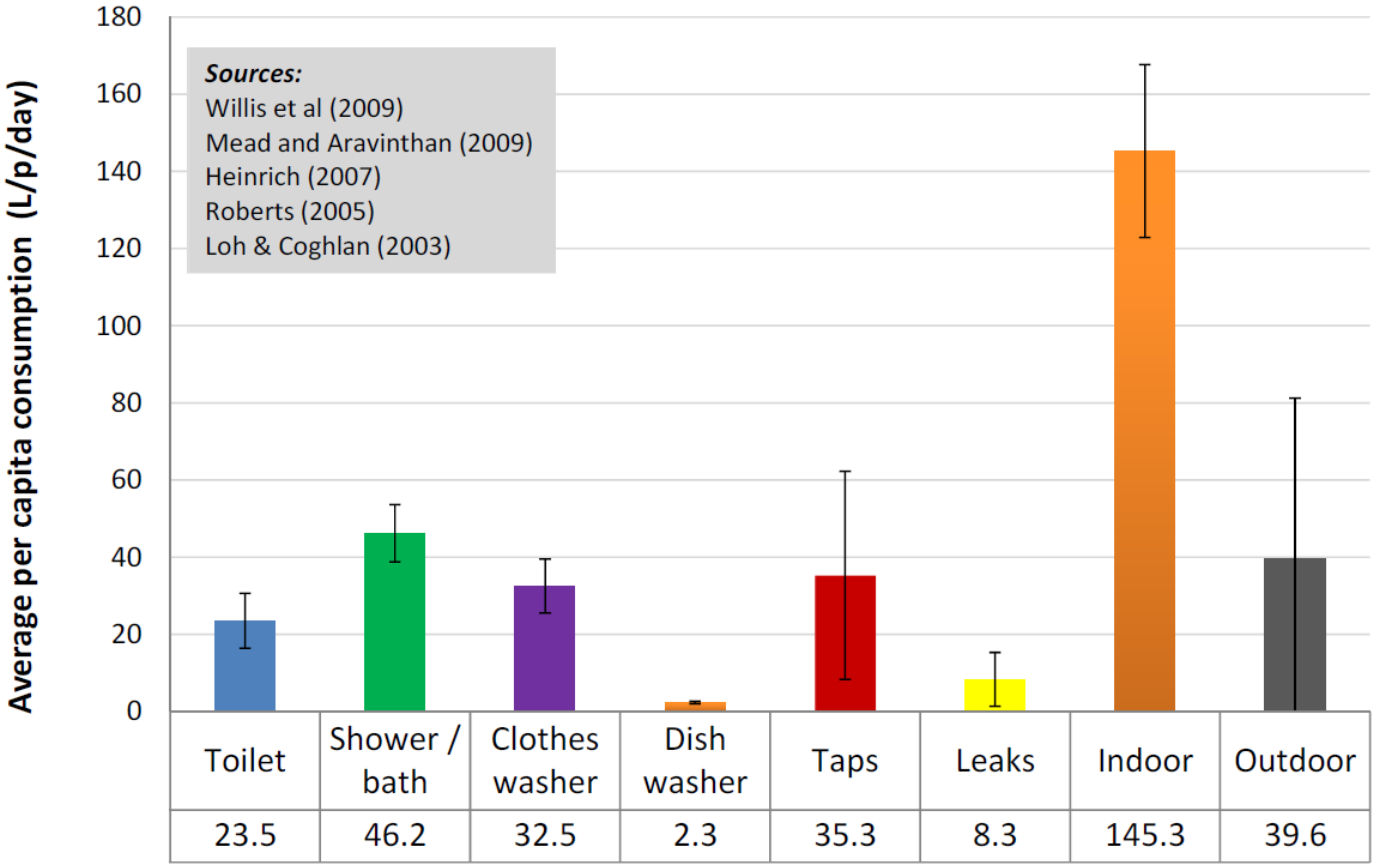
Water-energy services



Source: Beal and Stewart (2011)

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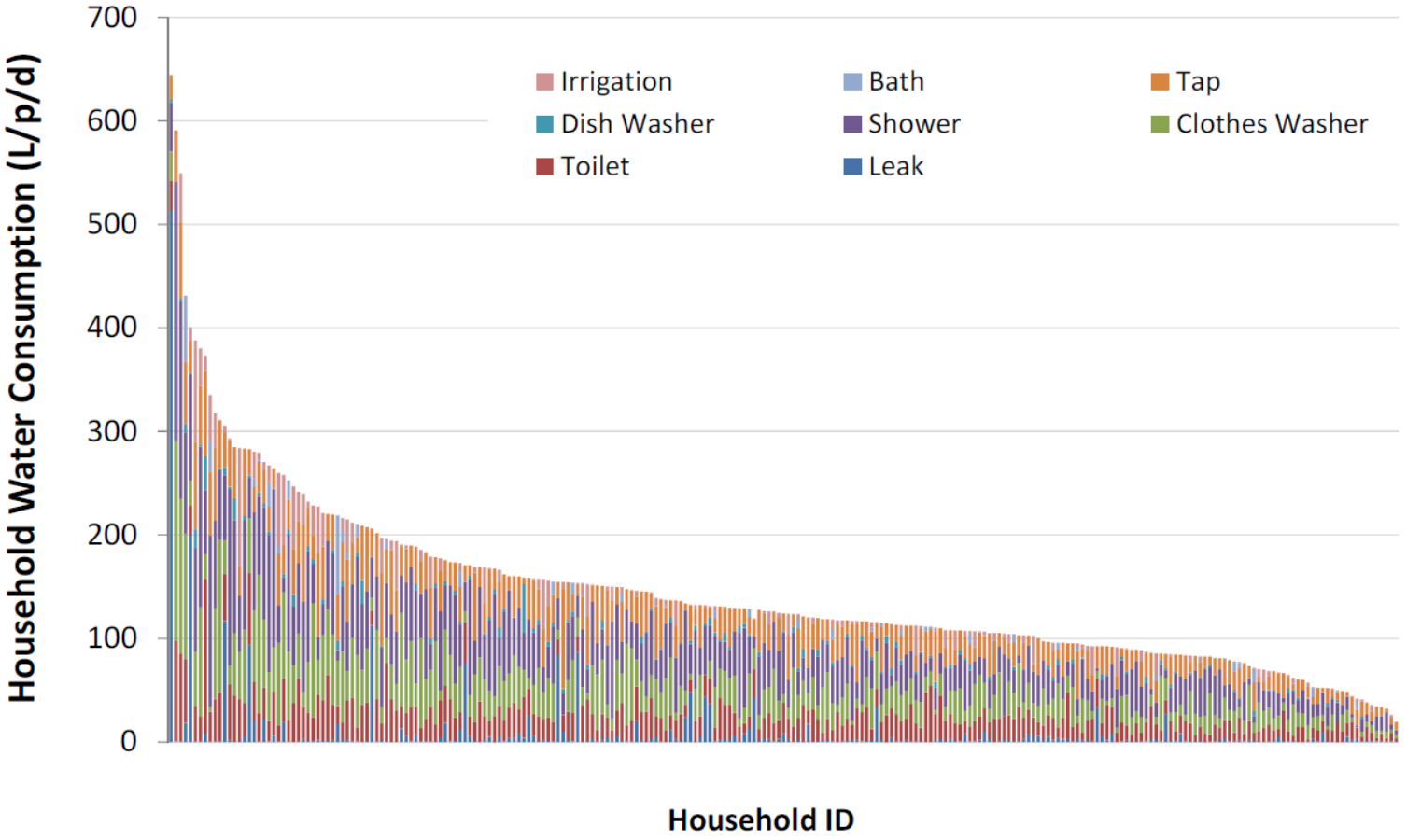
Water-energy services



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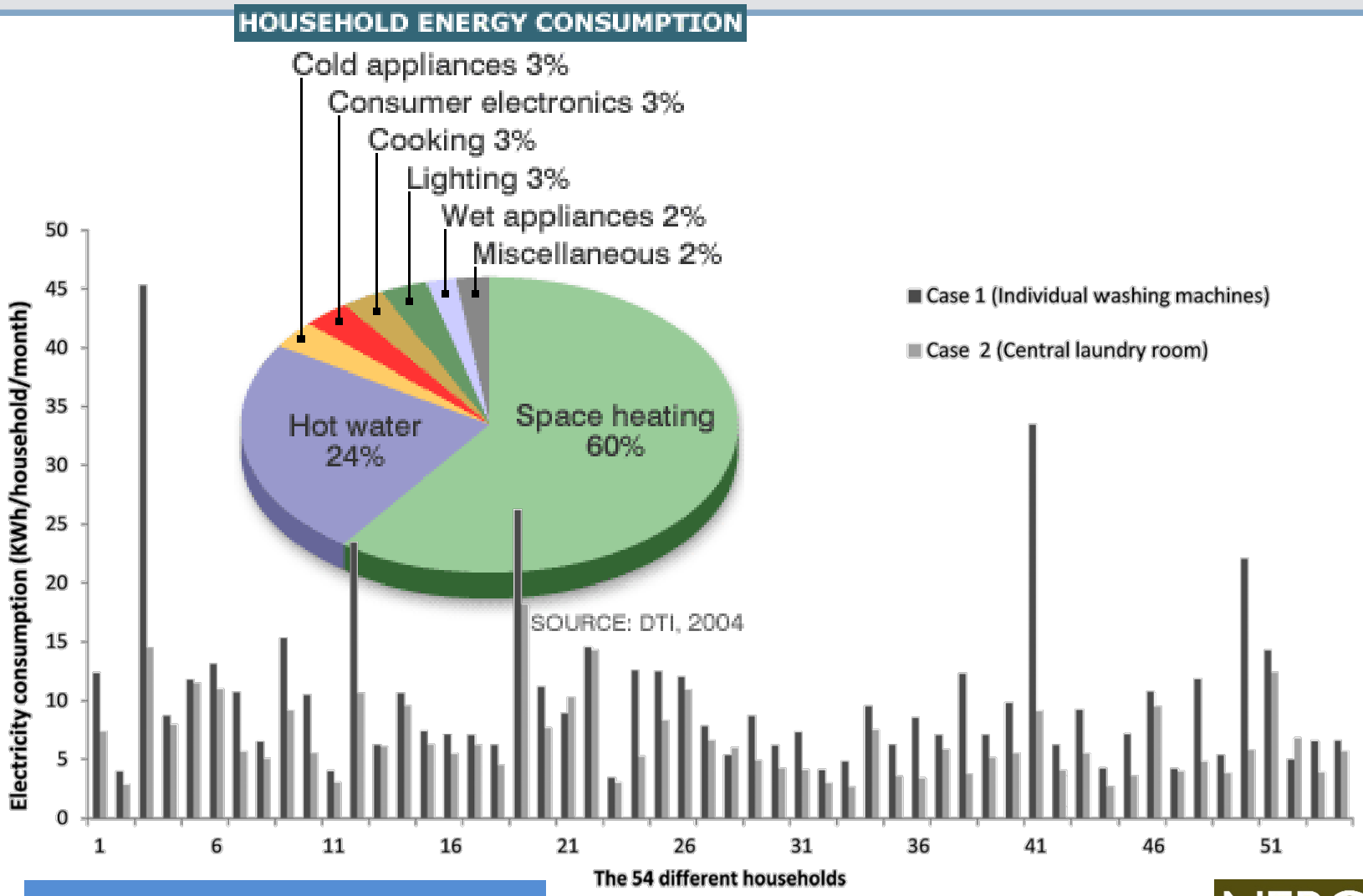
Water-energy services



Washing machine energy use

Source: BBC (2006), Zaraket et al (2015)

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Water-energy services

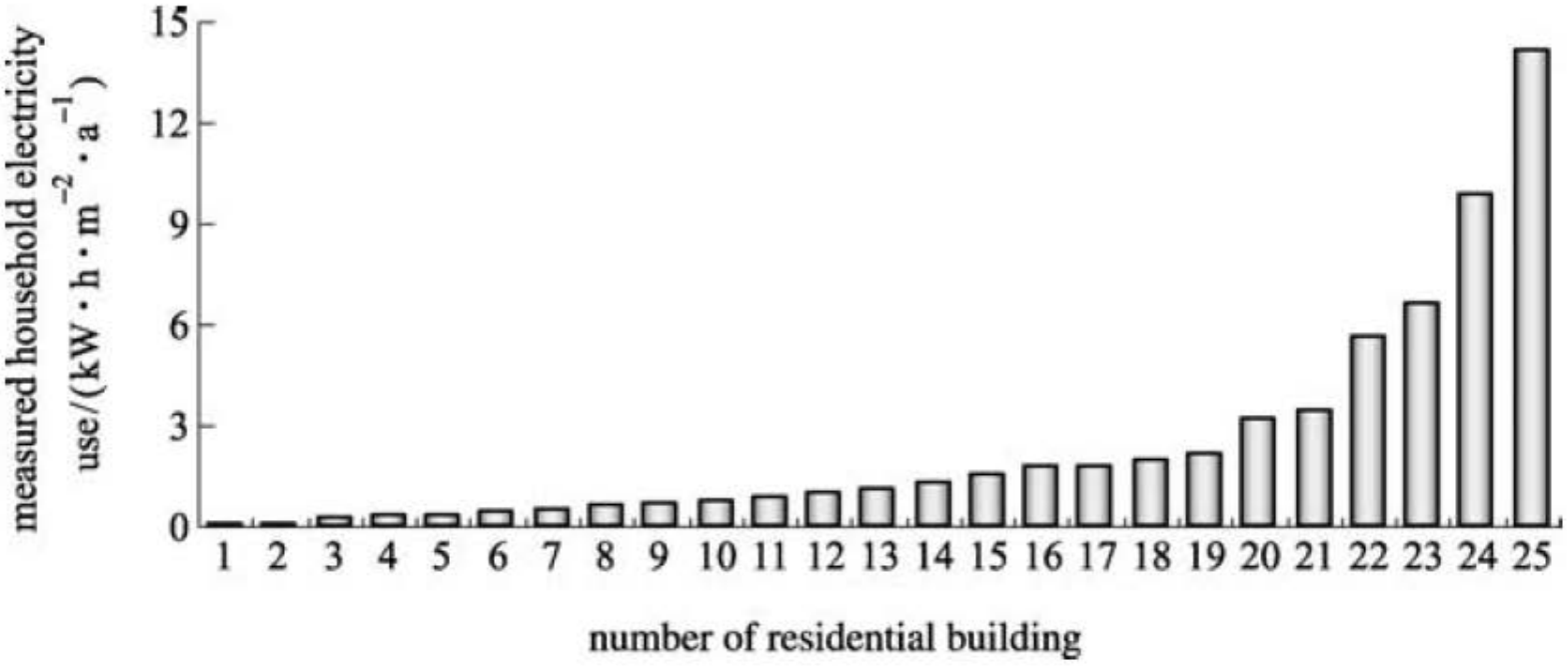

Fig. 18 Measured household electricity use for cooling in a Beijing residential building [32]

Source: Zhang et al (2010)

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Water-energy services

- Large deviations in both water end-use and energy end-use
- Service quantified in terms of water or energy
- No clear picture of full service efficiency

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Energy demand

- Benefits of energy use by service
  - Utilities can target efficiency programs better
  - Increased consumer awareness
  - More accurate models

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Energy demand

- Benefits of energy use by service
  - Utilities can better target efficiency programs
  - Increased consumer awareness
  - More accurate models

- Methods
  - Appliance stock and usage patterns surveys
  - Distributed direct sensing
  - Single-point sensing

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Energy demand (2)

- Single-point sensing
  - Non-intrusive load monitoring (NILM)
  - Developed for electricity
  - Multitude of algorithms, information bearers
  - Classification accuracies >90%
  - Also for gas, e.g. based on acoustic waves

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- Water-related energy
  - 14% to 50% for water heating alone

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Water demand

- Micro-component analysis
  - Water consumption by end-use
  - Increasing importance
  - NILM
    - Flow patterns
    - Pressure waves
    - Vibrations of piping

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Water demand

- Micro-component analysis
  - Water consumption by end-use
  - Increasing importance
  - NILM
    - Flow patterns
    - Pressure waves
    - Vibrations of piping

- Energy-related water
  - About half of the water use in an average UK household

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Water demand (2)

- Energy intensity of water use
  - Well studied
  - Based on estimates: f(Temperatures, flow, specs, config)
  - Uncertainty, variance

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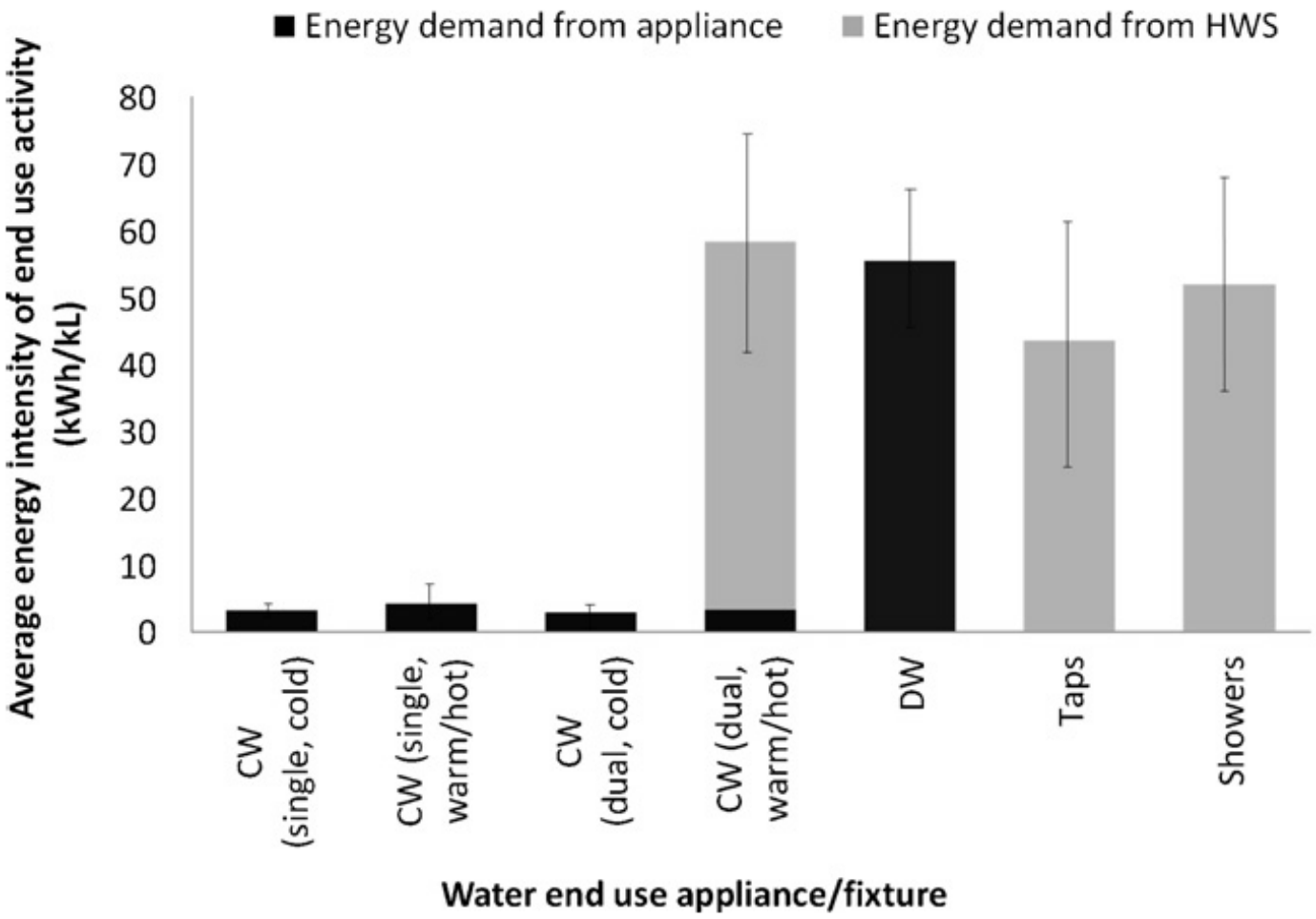
Water demand (3)



Source: Beal et al (2012)

Fig. 4. Average energy intensities for water-related energy in households.

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Combined water and energy demand

- Little empirical data on end-use linkages
- Uncertainty
  - Wrong target estimates
  - Missed potential of cross-conservation
  - Investment risk

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Combined water and energy demand (2)

- Benefits of detailed linked data:
  - for consumers
    - Greater efficiency/conservation incentives
    - Service-based pricing
    - Highlight abnormal operation
  - for utilities
    - Greater DSM benefits
    - Pool costs, pool savings
    - Reduce risk of DSM investments
    - Reduce risk on supply expansion investments

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Conclusions

- Innovative ways for NILM of water, electricity and gas exist and are being developed
- There is a need for simultaneous studies of water and energy end-use to reveal the actual linkages
- Water and energy DSM more cost-effective when utilities collaborate
- Empirical data on end-use water-energy linkages reduce uncertainty/risk for planning and investment in DSM

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