Water in Buildings

NRES 285: iCAP Ambassadors

Ashlynn S. Stillwell

2/18/21

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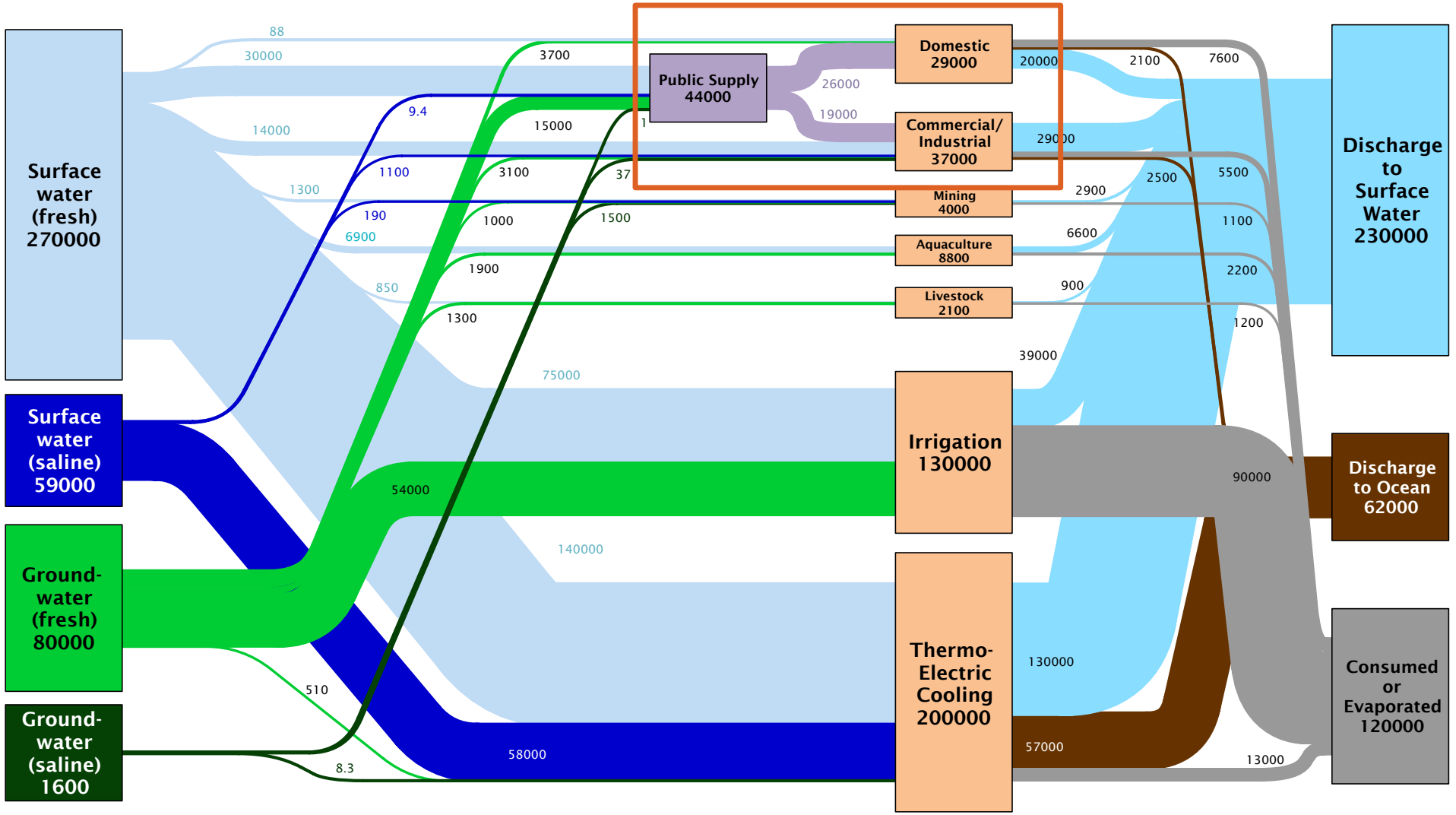
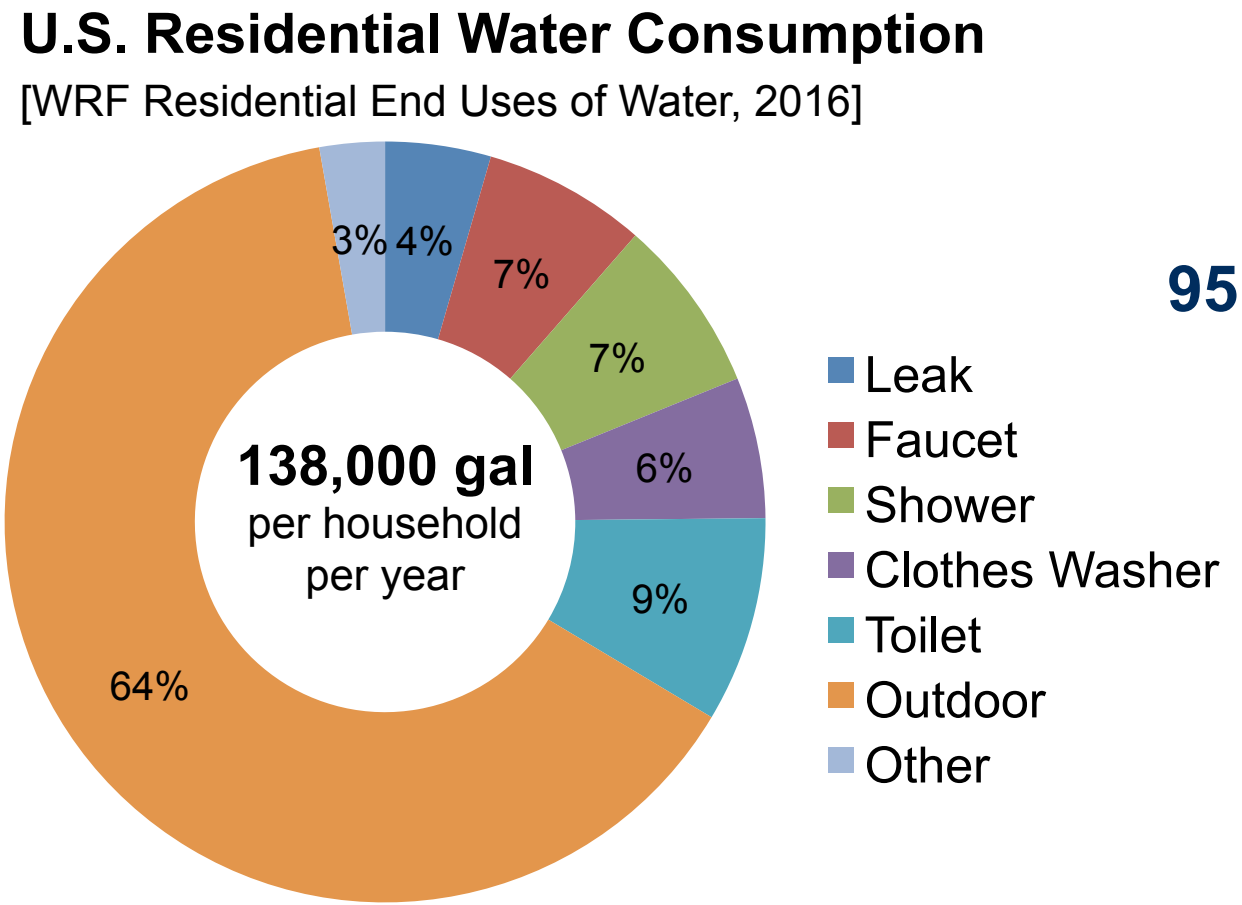
How do we use water in buildings?

Estimated United State Water Flow in 2005: 410000 Million Gallons/Day



Source: LLNL 2011. Data is based on USGS Circular 1344, October 2009. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. All quantities are rounded to 2 significant digits and annual flows of less than 0.05 MGal/day are not included. Totals may not equal sum of flows due to independent rounding. Further detail on how all flows are calculated can be found at http://flowcharts.llnl.gov. LLNL-TR-475772

Most of average American residential water use is outdoors.



95 gal/person/d

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Conservation and efficiency are technically different concepts.

- **Conservation**: using fewer resources, typically requiring behavioral change
  - Water: flushing toilet less often ("If it's yellow, let it mellow…")
  - Energy: adjusting thermostat

- **Efficiency**: performing the same actions with fewer resources, often via appliance or infrastructure upgrade
  - Water: ultra-low flow toilet
  - Energy: high efficiency HVAC

Many appliances and upgrades exist to improve conservation and efficiency in buildings.

- ENERGY STAR
  - Over 30 home appliances, and more for businesses and government
  - New home certification

- WaterSense
  - About 6 appliances for residential or commercial properties
  - New home certification

Energy conservation and efficiency can lead to indoor air quality problems.

- The building envelope is better sealed on energy efficient buildings: less air exchanges

- Poor indoor air quality comes from less leaky buildings
  - Moisture → mold
  - Chemical exposure
  - Radon
  - Pests
  - Combustion gases

EPA's Indoor airPLUS ensures high quality indoor air in energy-efficient buildings

Water conservation and efficiency can increase water age.

- Water conservation and efficiency means drinking water sits in the pipes of the home for longer periods of time: water “age”
- Water quality deteriorates over time due to interactions with the pipe wall and bulk water chemistry
- Studies have shown water age to vary from <1 to 24 days

No analog to Indoor airPLUS to ensure water quality in water-efficient buildings

[EPA, AWWA, 2002]

Water that is too “old” can lead to water quality problems.

- High water age is associated with many water quality problems; some affect public health
  - Disinfection byproduct formation/degradation
  - Microbial growth, particularly *Legionella*
  - Corrosion (copper and lead)
  - Nitrification
  - Taste and odor
- Collective problem with buildings affecting others
- Proposed solutions: flush <1% daily flow at end of plumbing system, disinfectant dosing, fixture retrofit

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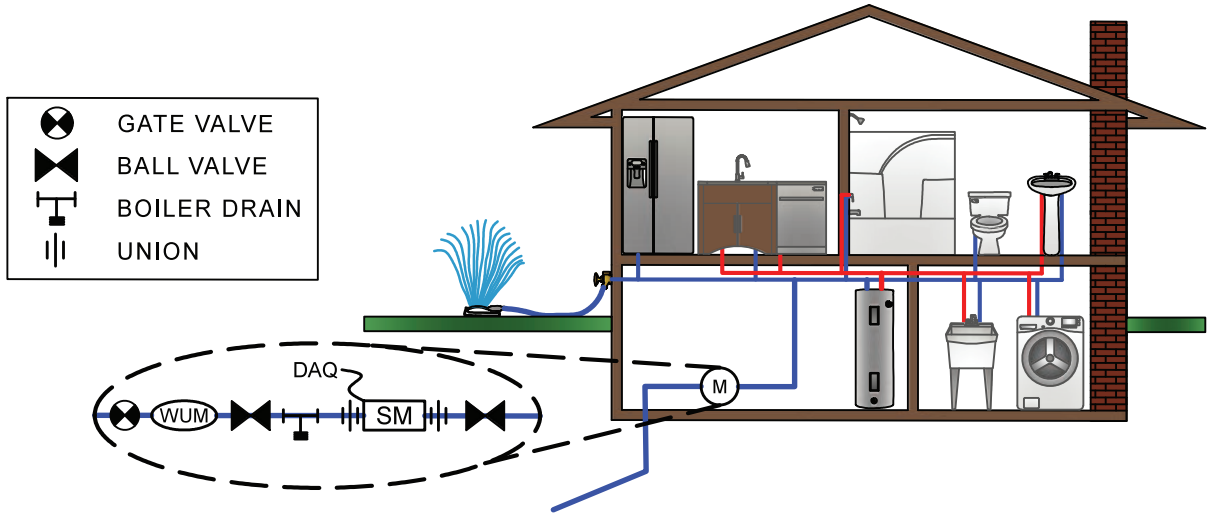
[EPA, AWWA, 2002; Rhoads & Edwards, 2013]

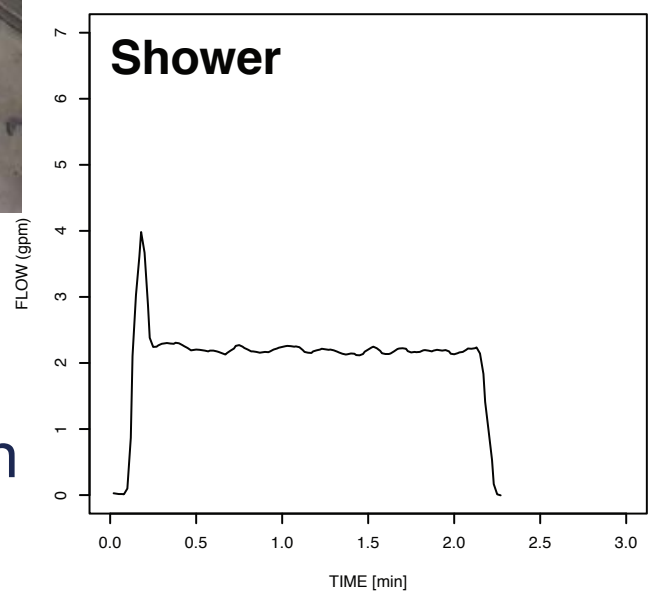
How do *we* use water in *specific* buildings?

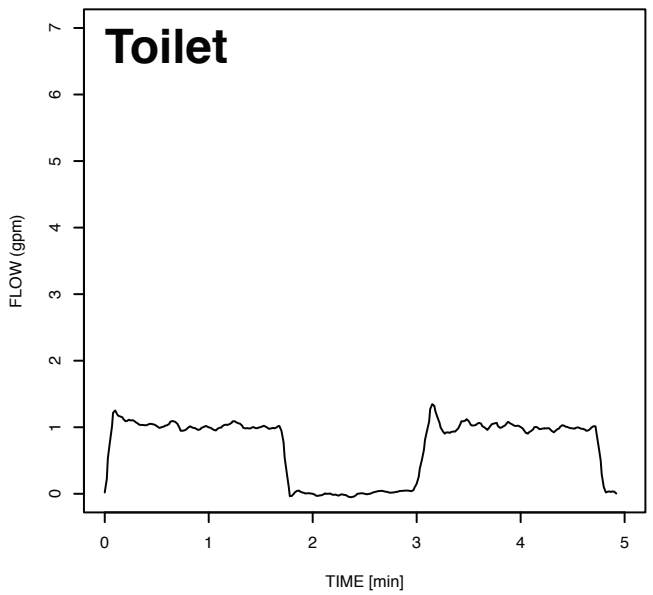
Ongoing research in CEE at Illinois

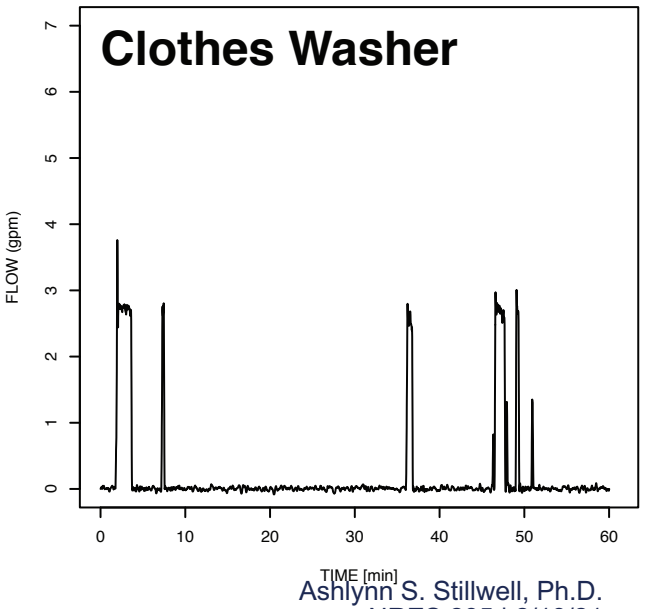
Smart meters give us a better picture of actual use in the residential environment.



2 years of data
(and counting)
1-second resolution

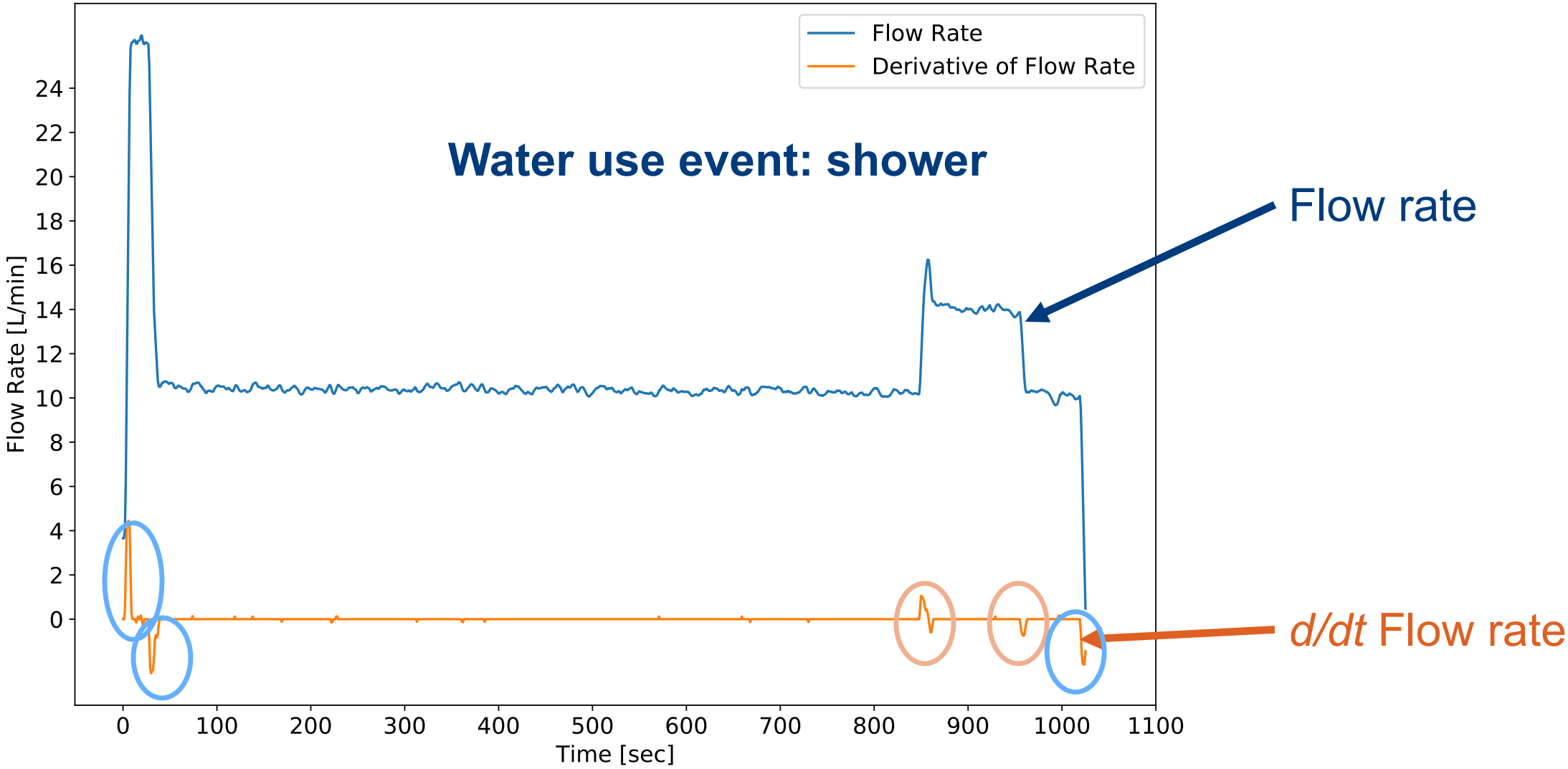






[Bethke et al., *ES:WRT*, 2021]

We can disaggregate water end uses from smart meter data.



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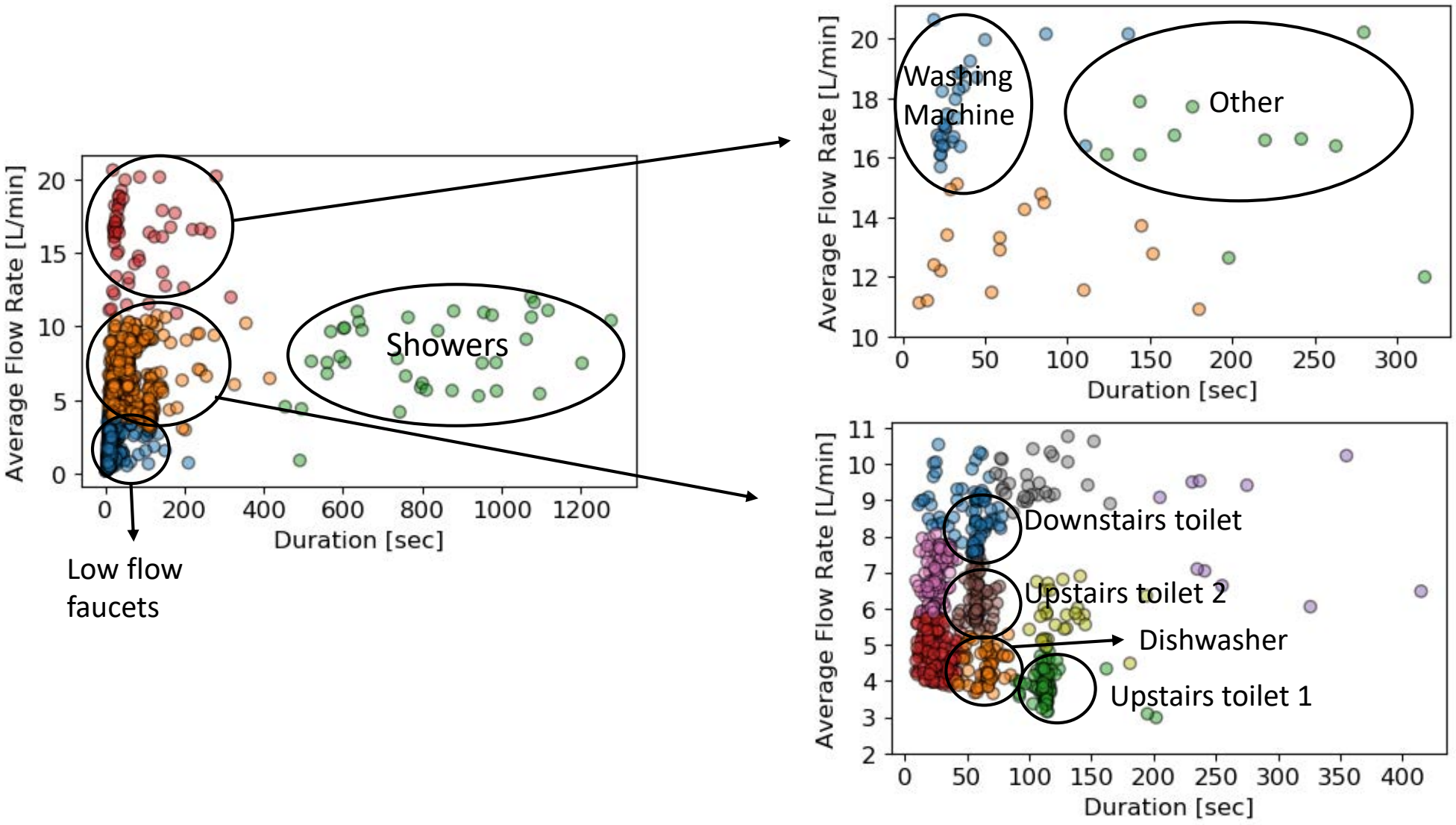
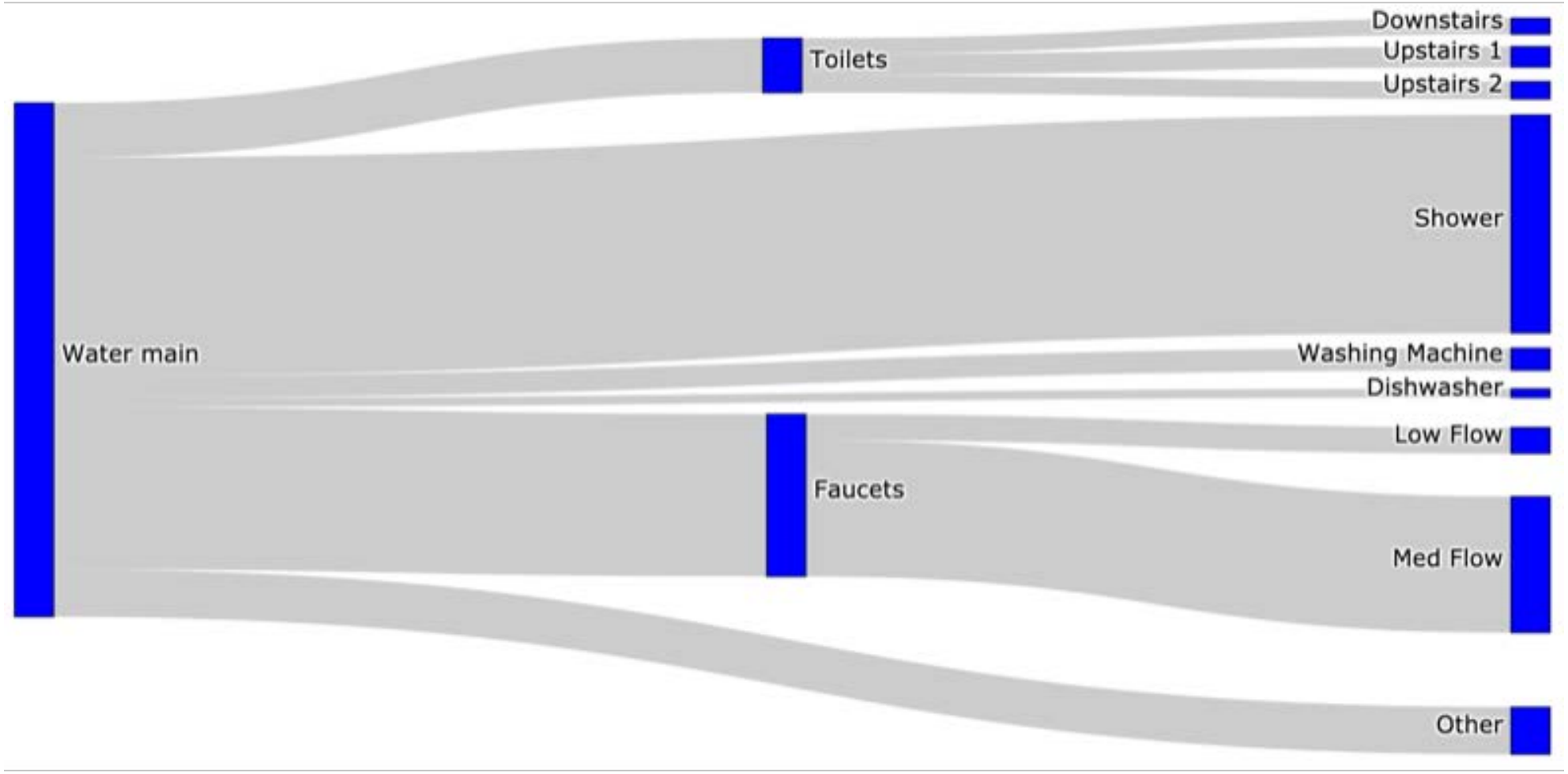


[Bethke et al., *ES:WRT*, 2021]

There are significant conservation and efficiency opportunities in the study home, specifically regarding showers.



[Bethke et al., *ES:WRT*, 2021]

How are energy and water connected at the household level?

- Many energy and water efficiency measures in the residential environment have a negative abatement cost, meaning they **save money over the life of the appliance or fixture**
- Water efficiency can be a cost-effective approach to energy efficiency, and vice versa
- Smart meter data can inform better sustainability investments and resource management, including **customized conservation (behavior) and efficiency (infrastructure) recommendations**

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[Chini et al., *ES&T*, 2016; Bethke et al., *ES:WRT*, 2021]

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