ACEEE
American Council for an Energy-Efficient Economy

HOT WATER FORUM 2015

Monday, February 23
Session 3C

Understanding Behavioral Waste In The Shower & It's Impact On Water & Energy Efficiency

presented by: evolve TECHNOLOGIES

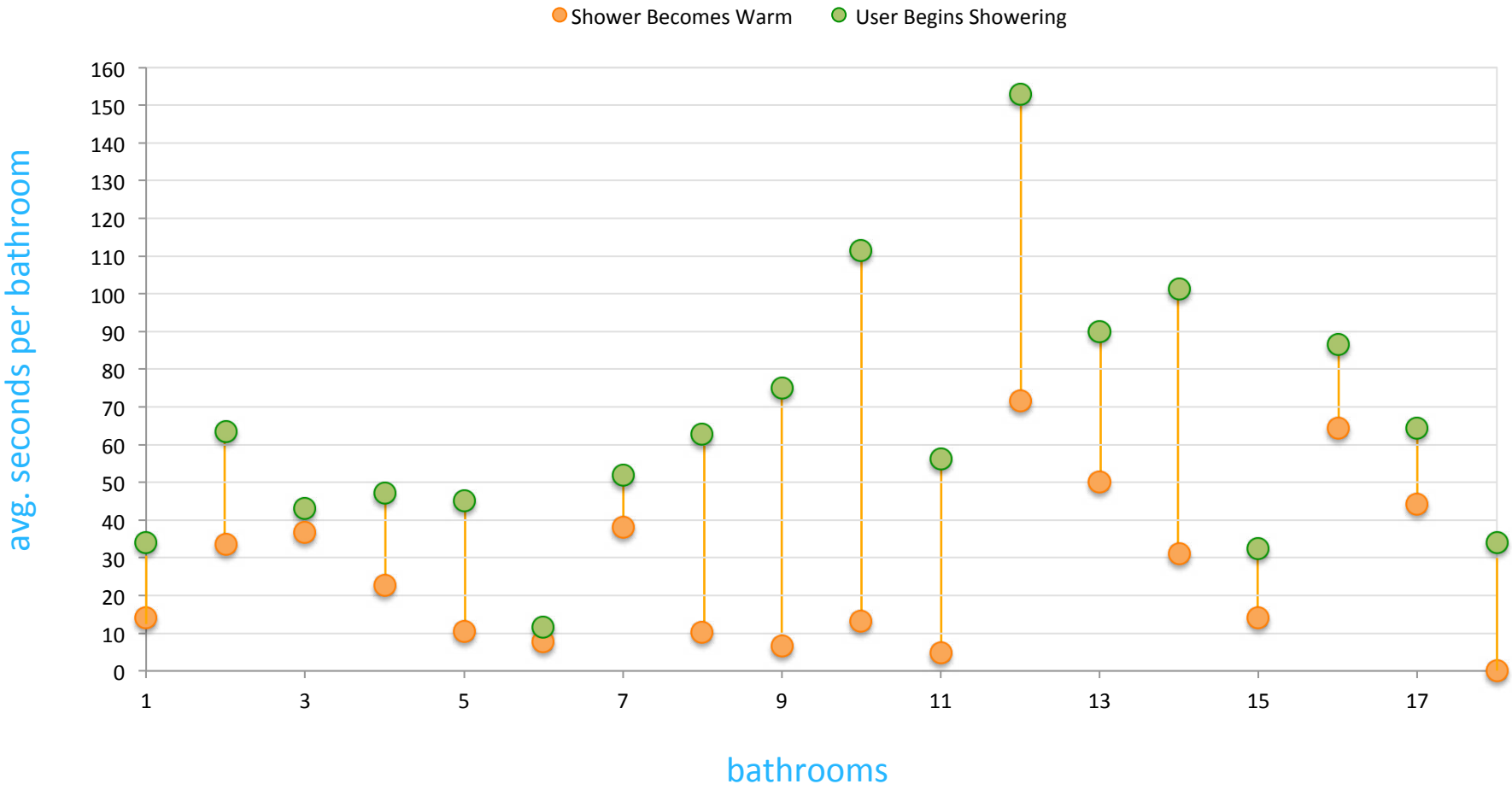
Houston,

We Have A Problem.

- Apollo 13 Space Mission

Fast Hot Water Delivery Does Not Appear To Produce Behavior Change

50% of bathrooms average less than a 10 second wait for hot water,
but exhibited above average behavioral waste @ 43 seconds.



SOURCE: 2014 Disaggregating Residential Shower Warm-Up Waste – An Understanding and Quantification of Behavioral Waste Based On Data From Lawrence Berkeley National Lab

Changing Behavior Is Hard – Really Hard

Consider how
hard it is to change yourself
and you'll understand what
little chance
you have in trying to
change others.

- Benjamin Franklin

Most People Do Stuff While Waiting For Shower– Behavioral Waste

Behavioral waste occurs when bathers use their time comfortably and efficiently while waiting for hot water to reach the shower. Activities include brushing teeth, using the washroom, picking out clothes, drinking coffee …

71%

do other stuff

while waiting for hot water to reach the shower

SOURCE: 2005 Shower Behavior Survey- 153 respondents

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52%

do more than 1 thing

as part of their warm-up routine

SOURCE: 2005 Shower Behavior Survey- 153 respondents

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do more than 1 thing

as part of their warm-up routine

60%

routine dictates return

not presence of hot water

SOURCE: 2005 Shower Behavior Survey- 153 respondents

2004 LBNL Total Waste For Shower Warm-Up – 95 Sec.

Lawrence Berkeley National Lab [Lutz (2004)] used the REUWS data for total volume and duration of water draws, along with the peak and mode flow rates during draws, to develop an equation for calculating wasted hot water during shower events. 26,000 events met the criteria - "Estimating Energy and Water Losses in Residential Hot Water Distribution Systems"

SHOWER WARM-UP WASTE

WATER THAT GOS DOWN THE DRAIN BEFORE THE USER BEGINS SHOWERING

BATHING USE

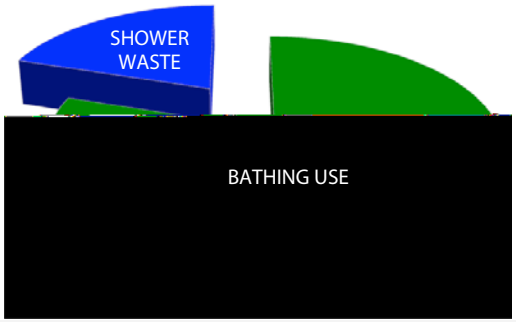
WATER THAT IS ACTUALLY USED FOR SHOWERING

$$A = PEAK \times \frac{(VOLUME - MODE \times DURATION)}{PEAK - MODE}$$

PEAK is the maximum flow rate recorded during the event,
VOLUME is the total amount of water used by the event,
MODE is the most commonly recorded flow rate during the event, and
DURATION is the time duration of the event.

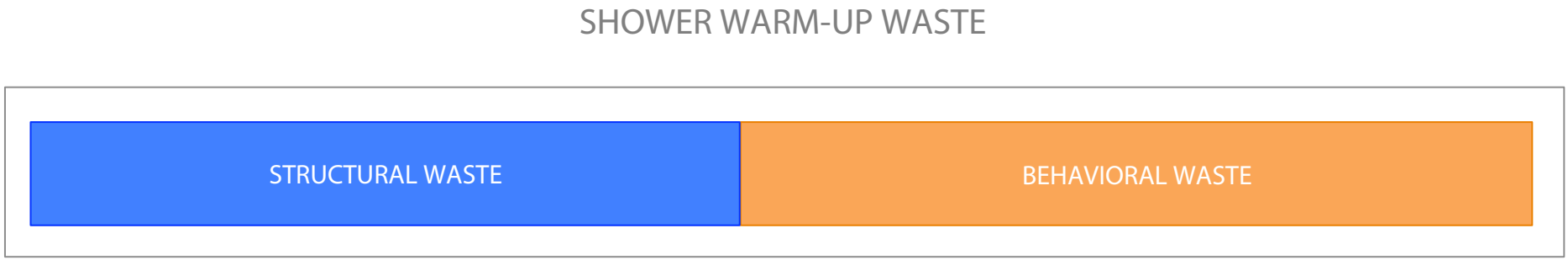
95 sec

(3.48 gallons wasted / 2.2 gpm flow rate) x 60 seconds



2011 LBNL Recognizes Shower Warm-Up Waste Has 2 Components

In a 2011 paper "Water and Energy Wasted During Residential Shower Events" Lawrence Berkeley National Lab (Lutz) recognizes that shower warm-up waste actually consists of two distinct components; structural waste and behavioral waste.



"In the case of showers, waiting for cooled-off hot water to clear from the pipe that connects the water heater to the shower represents structural waste."

"Water that is hot enough, but runs down the drain before the user makes use of the shower, represents behavioral waste."

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SHOWER WARM-UP WASTE

STRUCTURAL WASTE	BEHAVIORAL WASTE

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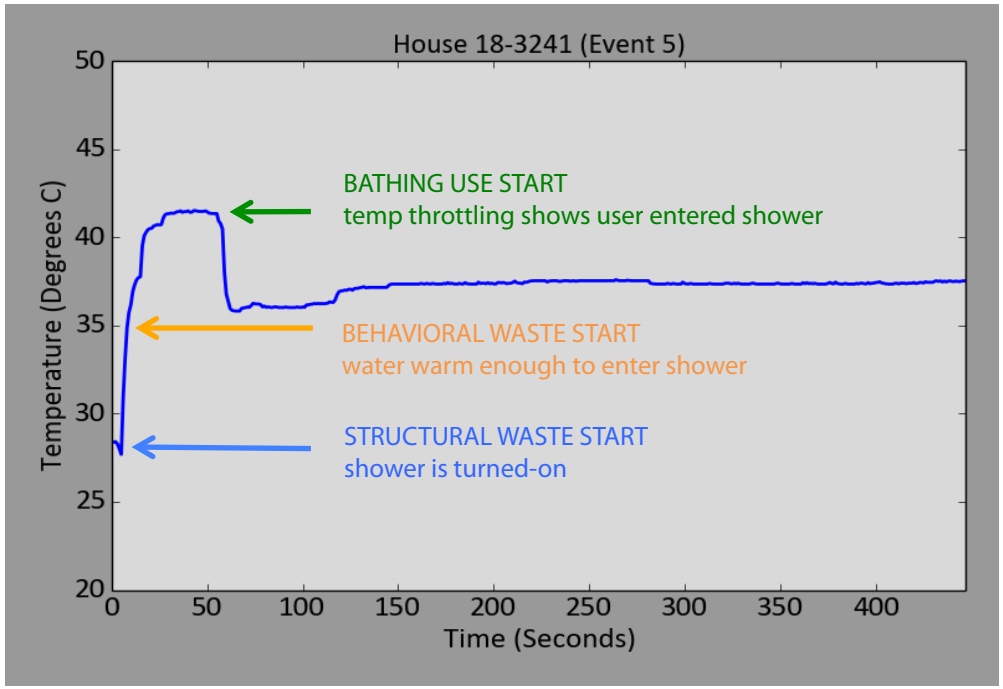
Quantifying Components – The Lutz (LBNL) Shower Curve

Identified and described by LBNL (Lutz 2011) – "Water & Energy Wasted During Residential Shower Events". Signature collected via time, temp and flow sensors placed at showerhead.

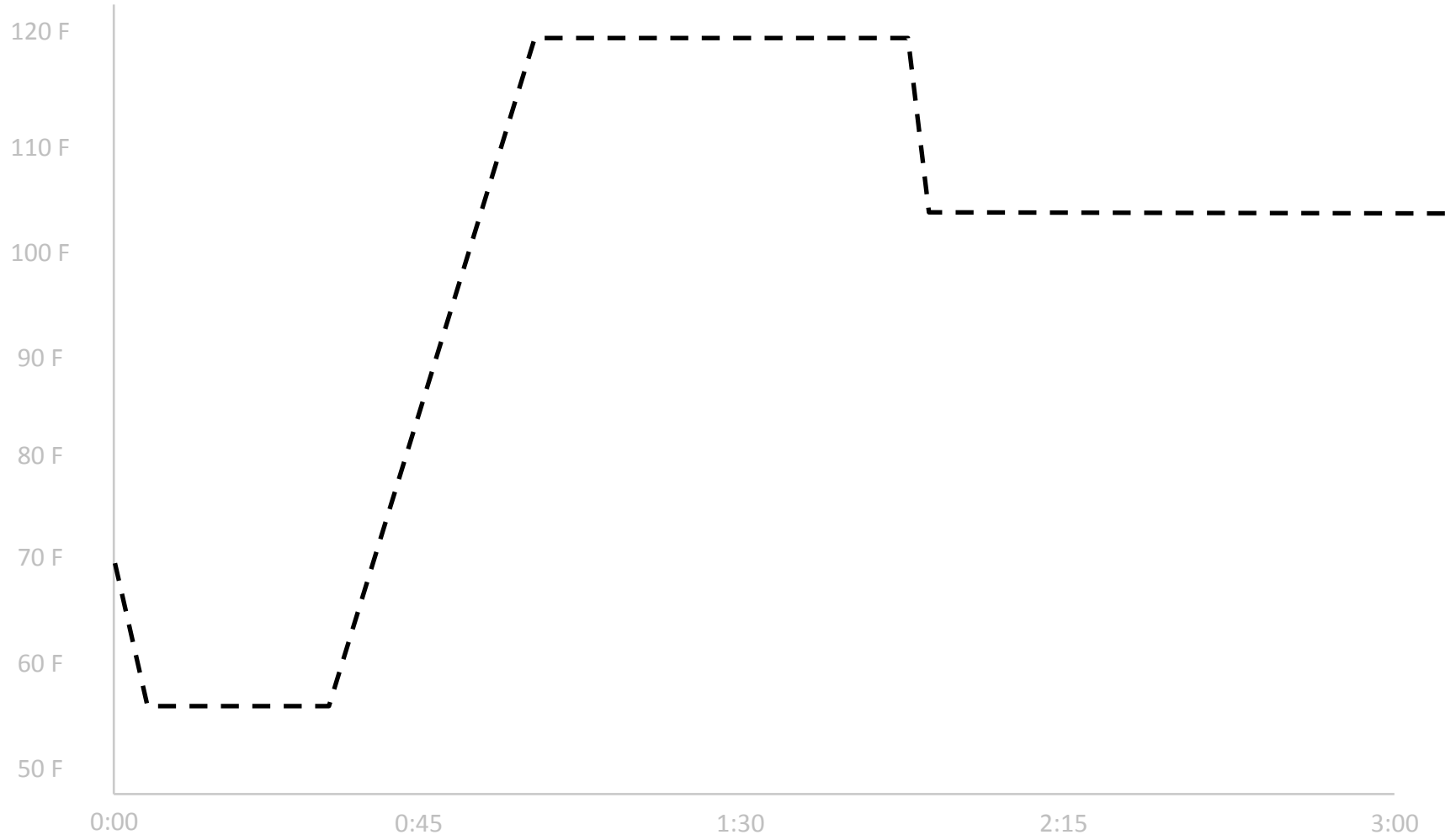
SHOWER WARM-UP WASTE

STRUCTURAL WASTE	BEHAVIORAL WASTE	BATHING USE



LBNL system captures time, temp and flow at shower and transmits data wirelessly to server database

The Lutz (LBNL) Shower Curve



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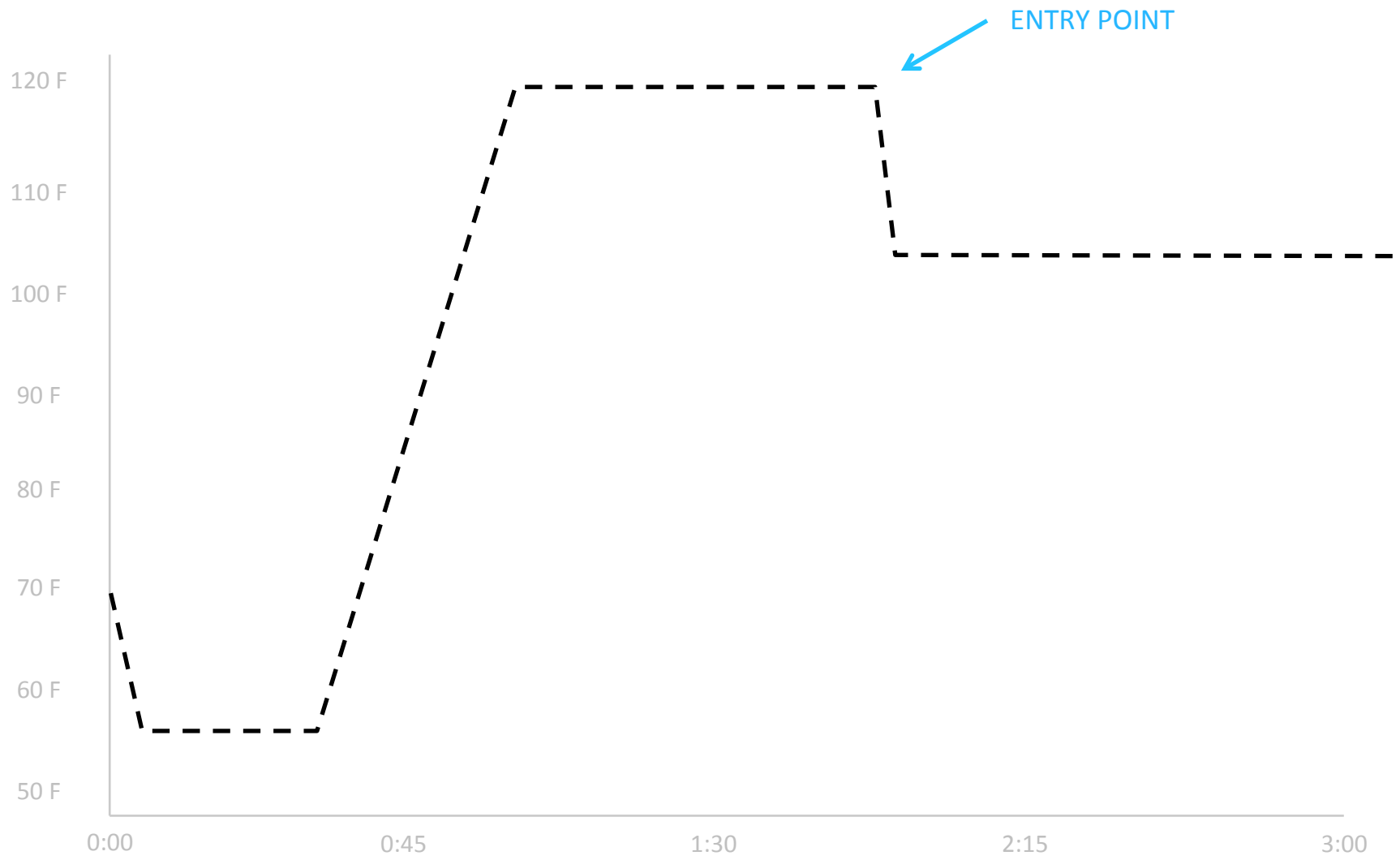

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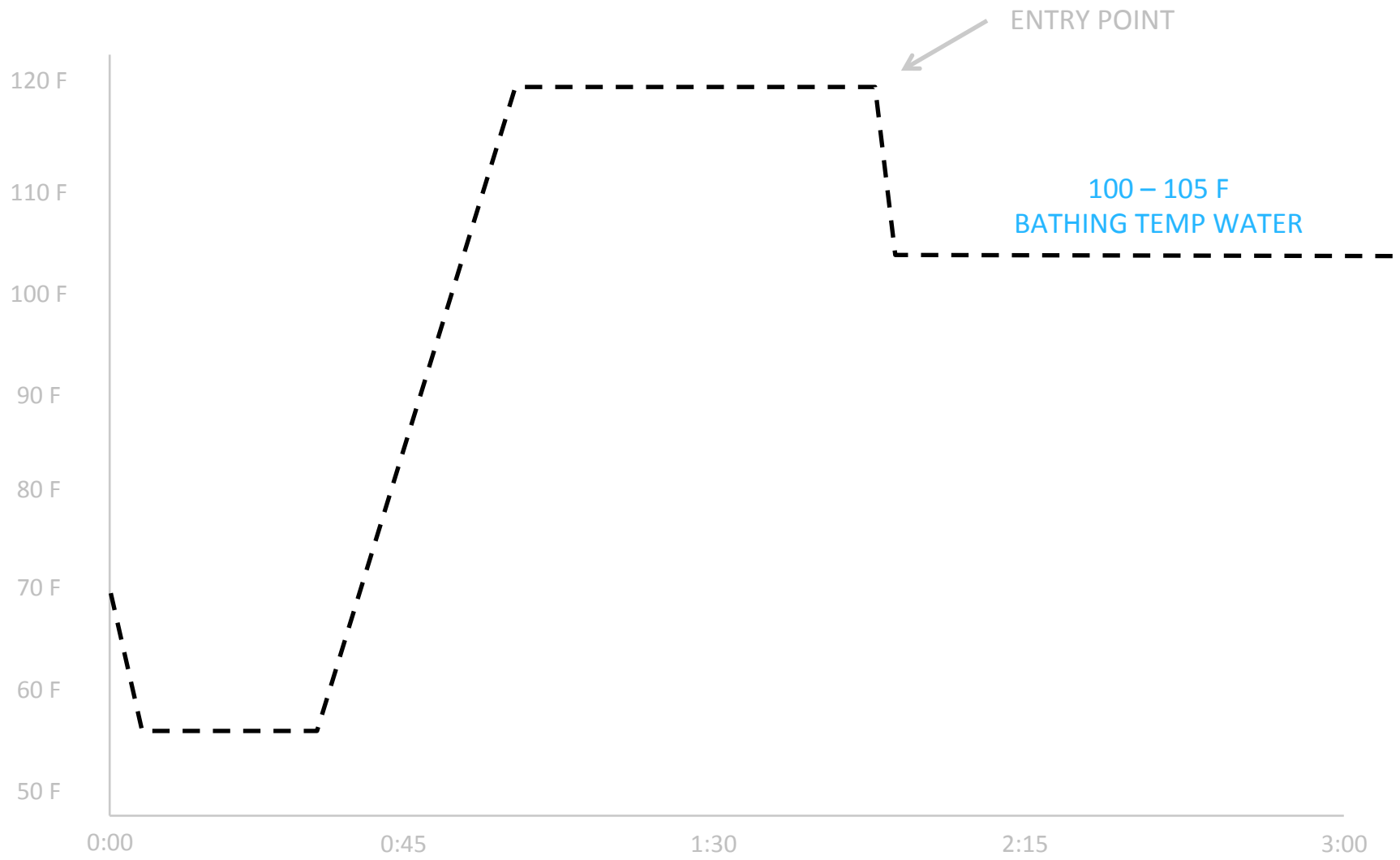

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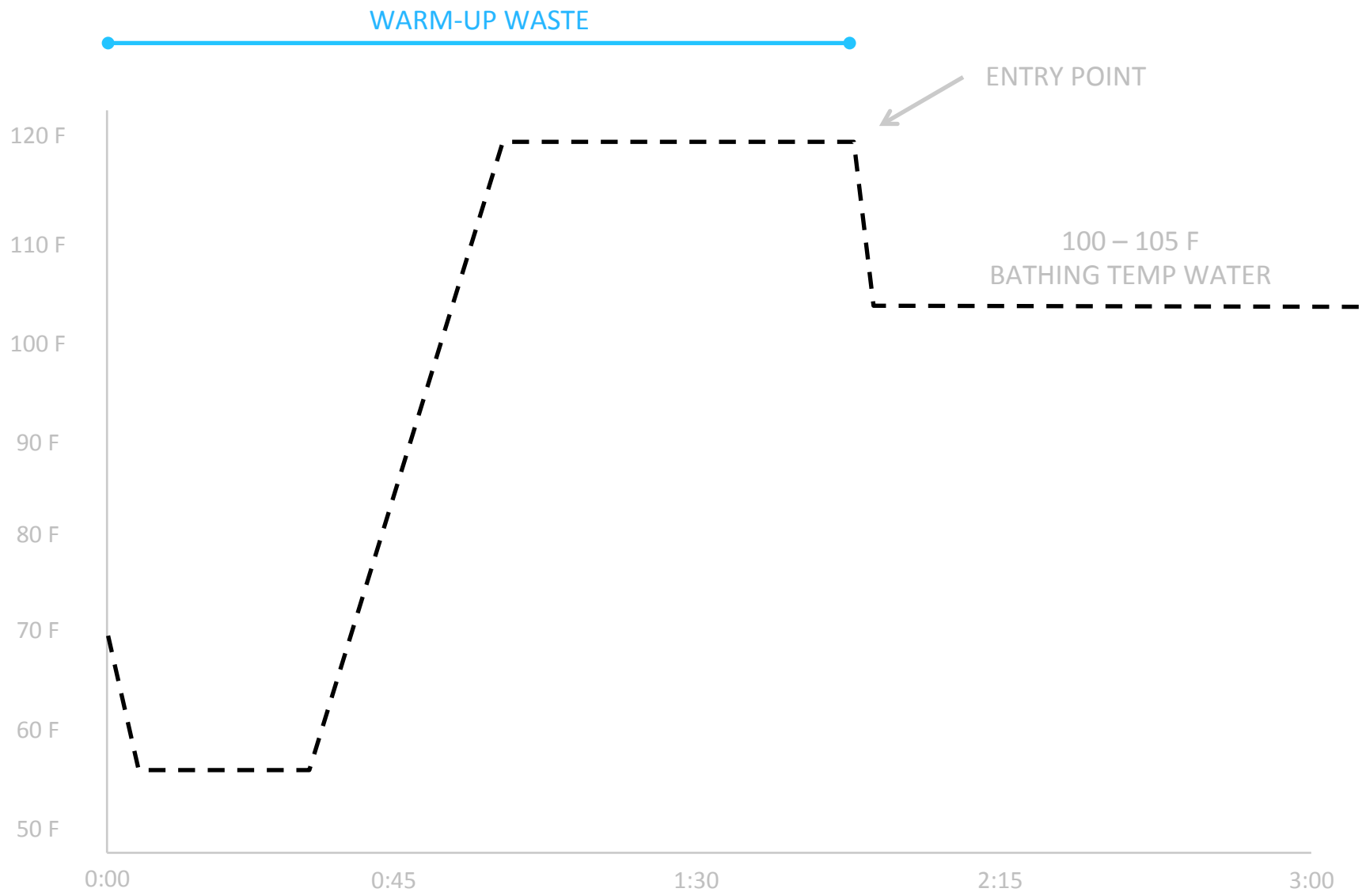

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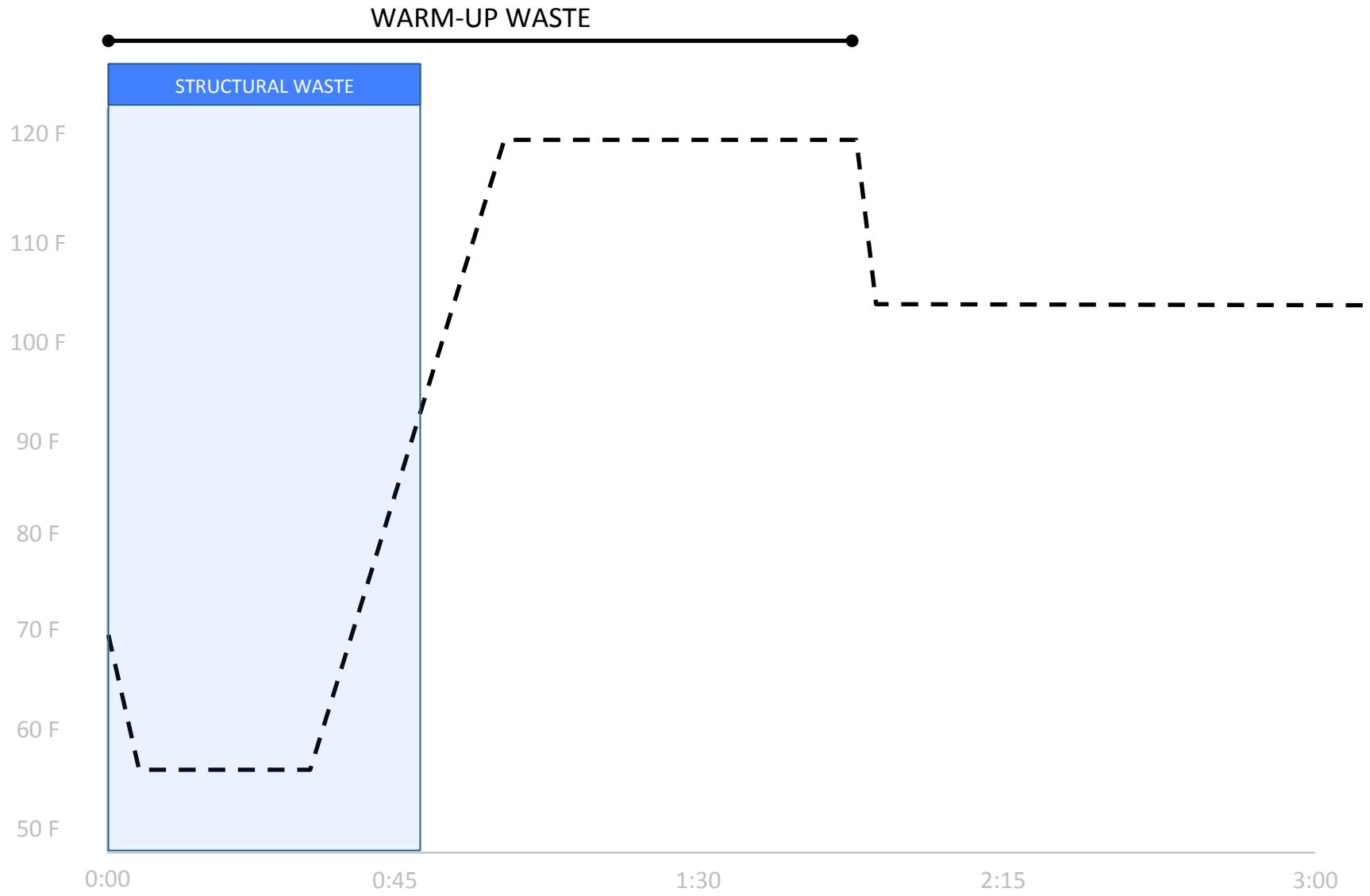

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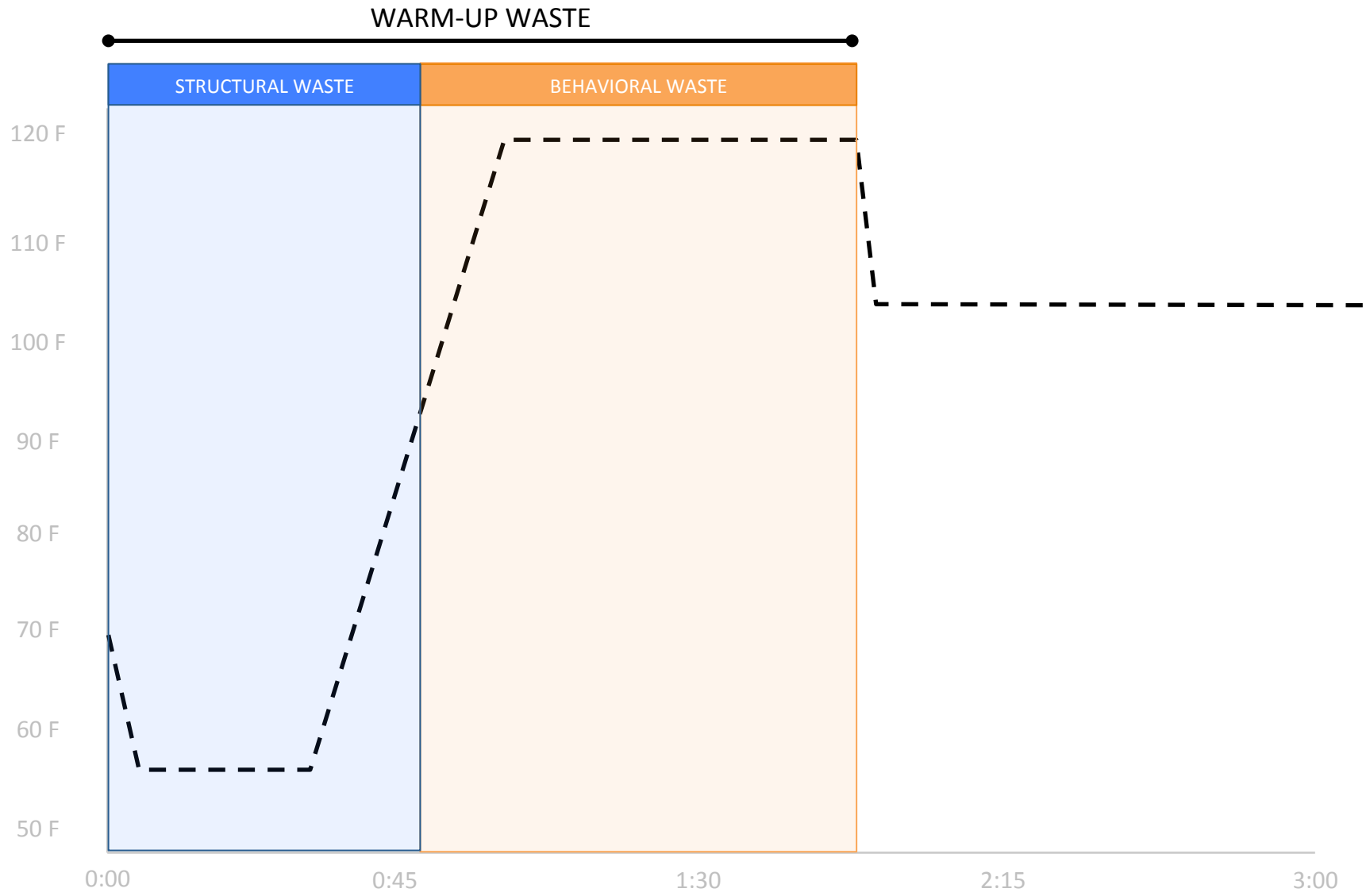

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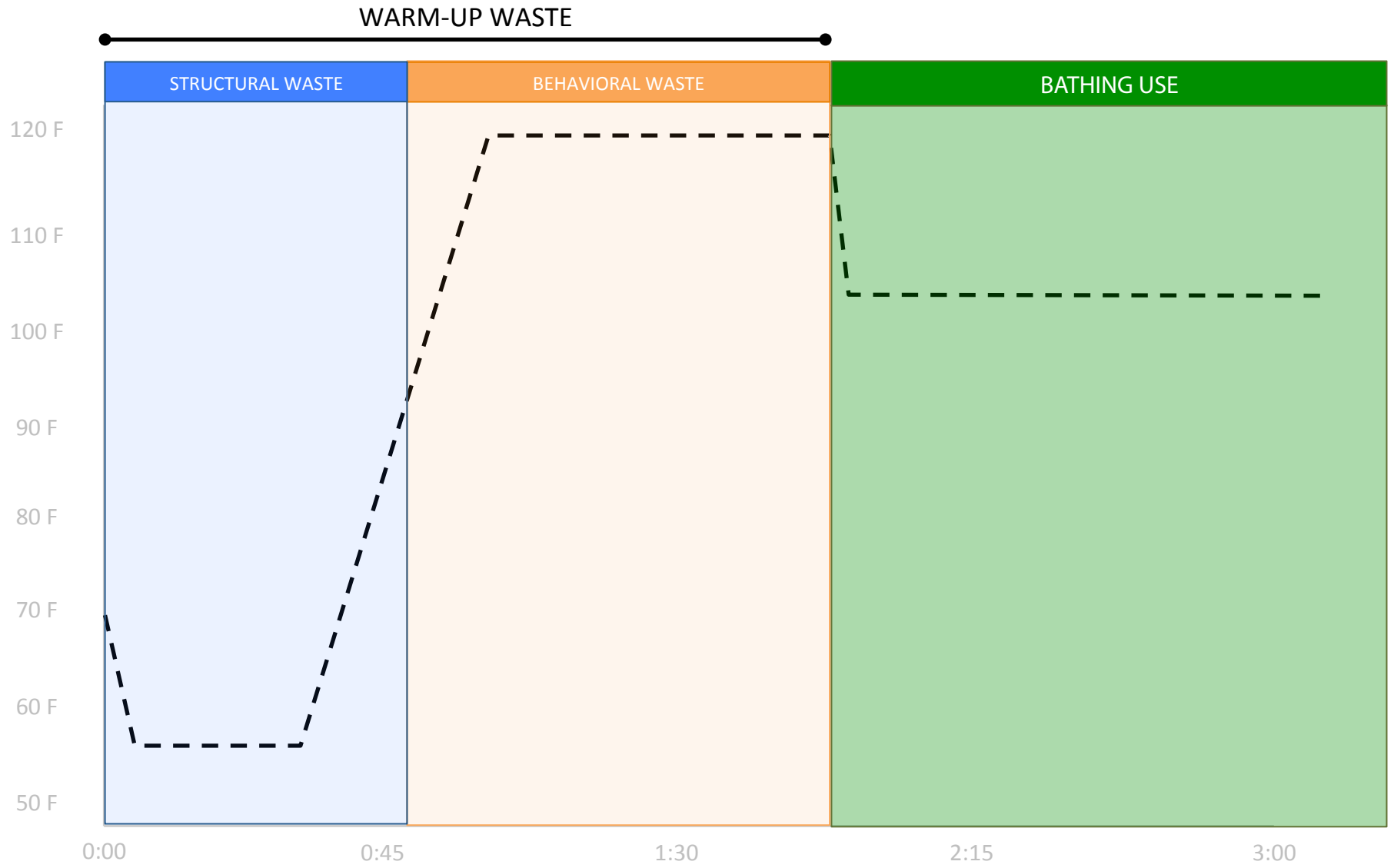


2013 LBNL Field Study – Domestic Hot Water Use

Lawrence Berkeley National Lab (Jim Lutz) conducted a field study of domestic hot water usage in N. California homes. Evolve Technologies identified the following data points regarding shower usage in homes with usable data for the period Dec 1-31, 2013.

11

HOMES

- 27% 1001 to 1500 Square Ft
- 27% 1501 to 2000 Square Ft
- 36% 2001 to 3000 Square Ft
- 9% more than 3000 Square Ft

good mix of different home sizes

44%

DEDICATED SHOWERS

(est. based on master bath count)

56%

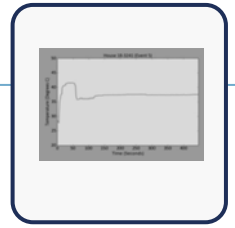
TUB/SHOWER COMBOS

(est. based on secondary bath count)

18

BATHROOMS

data is includes dedicated showers and tub/shower combos as well as cold start and clustered events



283

"GOOD" SIGNATURES

- 528 total events
- 54% identifiable signatures

significant number of individual shower events

SOURCE: 2014 Disaggregating Residential Shower Warm-Up Waste – An Understanding and Quantification of Behavioral Waste Based On Data From Lawrence Berkeley National Lab

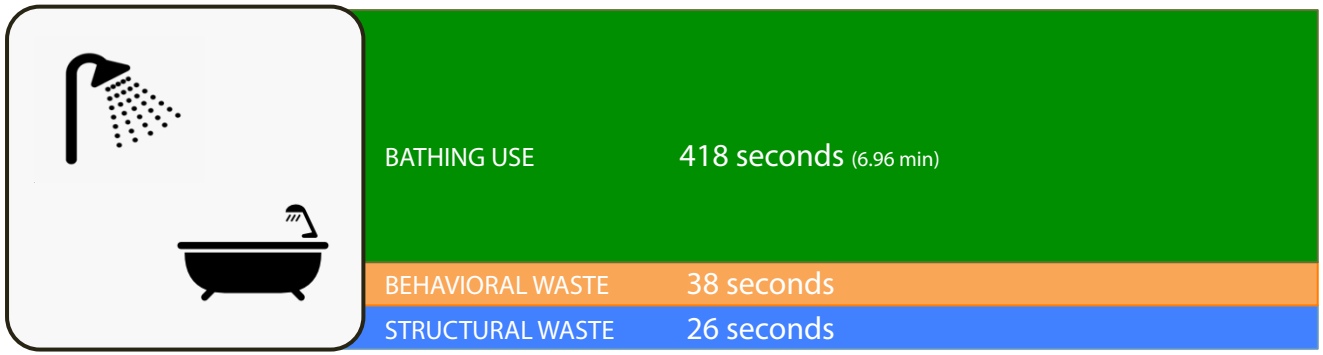
The Dataset Is Small, But Looks A Lot Like REUWS – It's Pretty Good

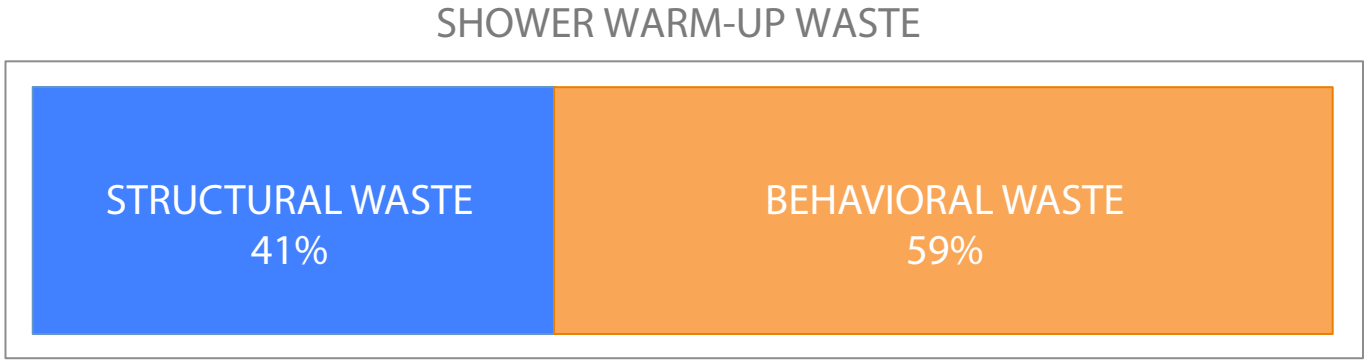
In addition to capturing a representative cross section of home sizes and bathroom types, the Dec 2013 LBNL data also aligns with REUWS (residential end use of water survey) statistics for showers.

	LBNL 2013	REUWS 2 2014	REUWS 1 1999
Houses Logged	11	762	1187
Total Number of Recorded Showers	283	17,066	50,286
Average Shower Volume	14.2 gallons	15.8 gallons (+/- .5 gal)	16.7 gallons (+/- .3 gal)
Average Shower Duration	8 minutes	7.8 minutes (+/- .02 min)	7.8 min (+/- .14 min)
Aver Flow Rate For Showers	1.8 gpm	2.1 gpm (+/- .04 gpm)	2.2 gpm (+/- .04 gpm)

2013 LBNL Field Study Analysis – Behavioral Waste Is Largest Component

Raw LBNL data was analyzed for the period: December 1-31, 2013. Individual bathrooms were evenly weighted.





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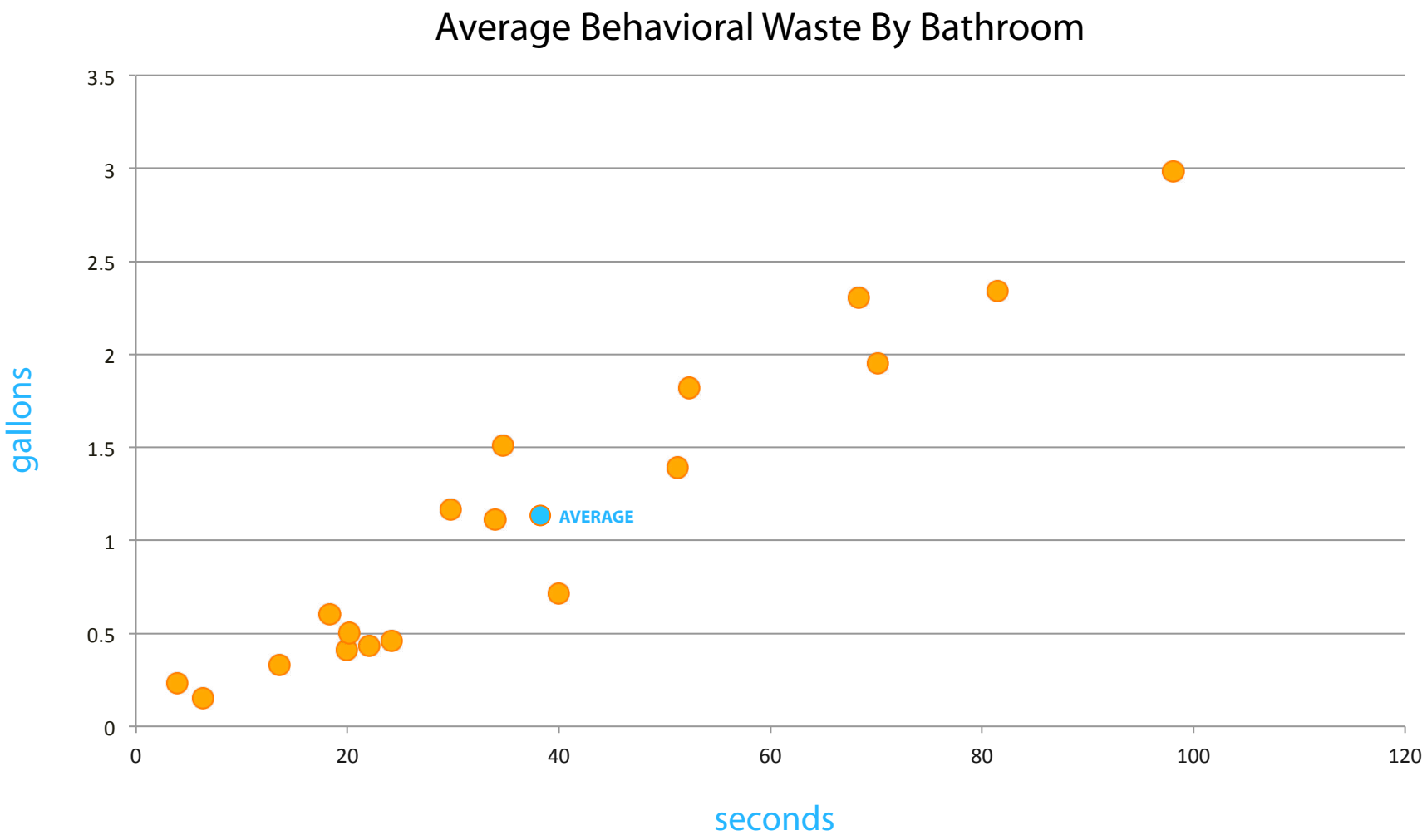
Some Waste A Little – Others Waste A Lot



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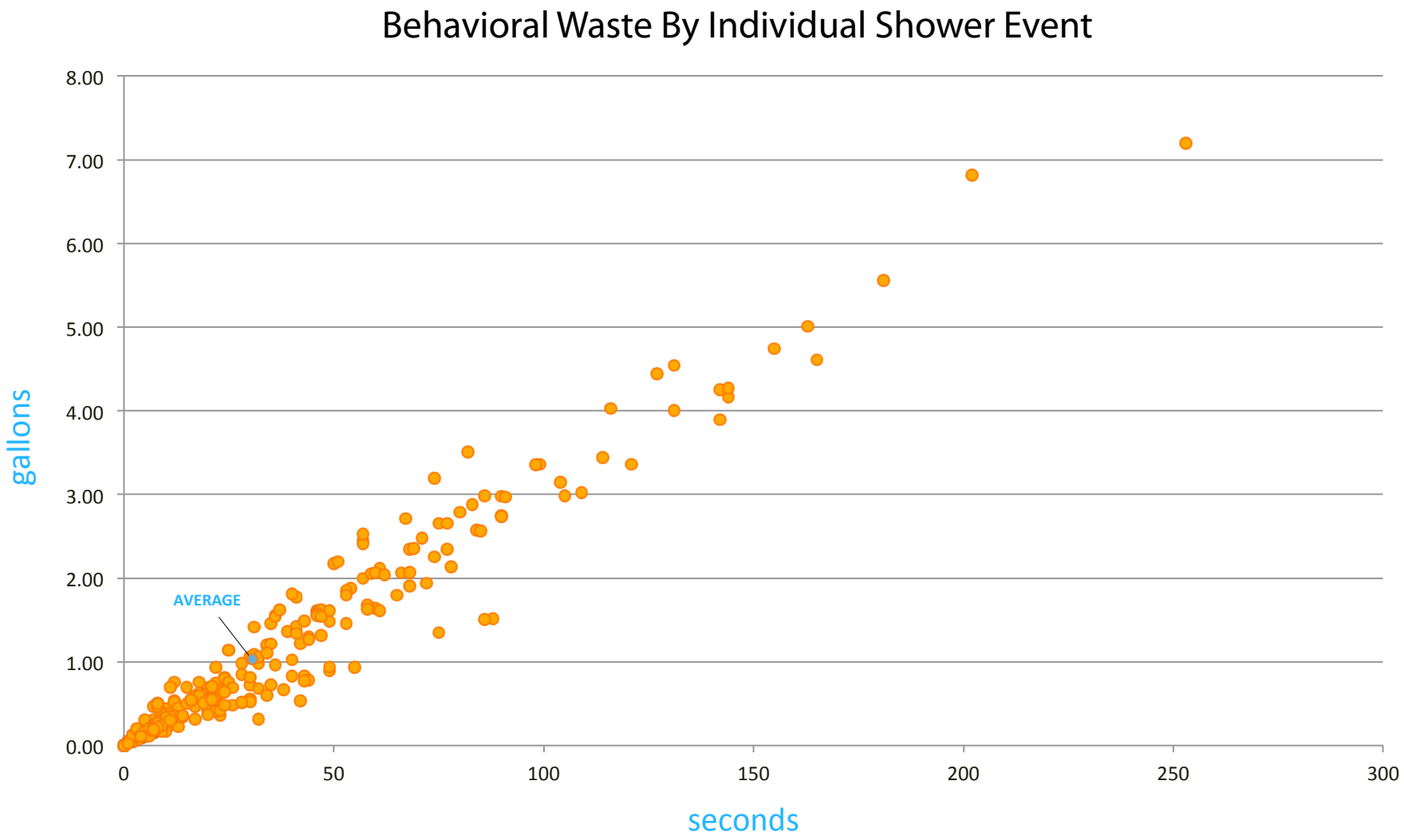

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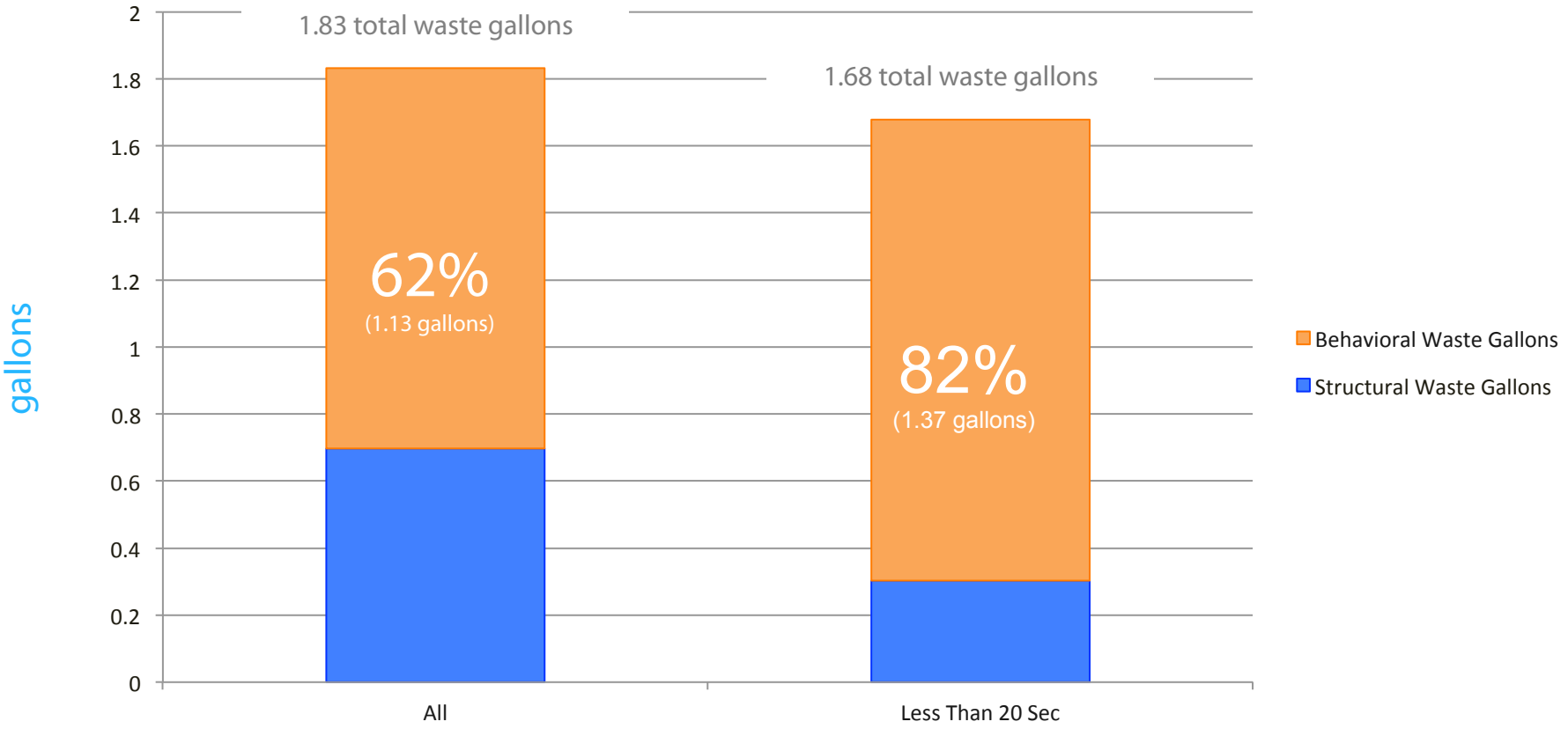
Fast Hot Water Delivery Shifts Waste To Behavioral – Behavior Is Persistent

Fast hot water delivery increases average behavioral waste volume by 32%,
while only reducing total average shower warm-up waste by 9%



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Cal Behavioral Waste Estimate Based On LBNL Body of Work

Estimate range is inclusive of cold starts and clustered events.
Estimate range is based on LBNL work from 2004 – 2013.
Estimate is likely conservative as data was collected in one of the "greenest" regions of the country (SF Bay area).

38 seconds

Field Study

BEHAVIORAL WASTE RANGE

47 seconds average

56 seconds

95 sec of total waste from Lutz x
59% Behavioral Waste from field study

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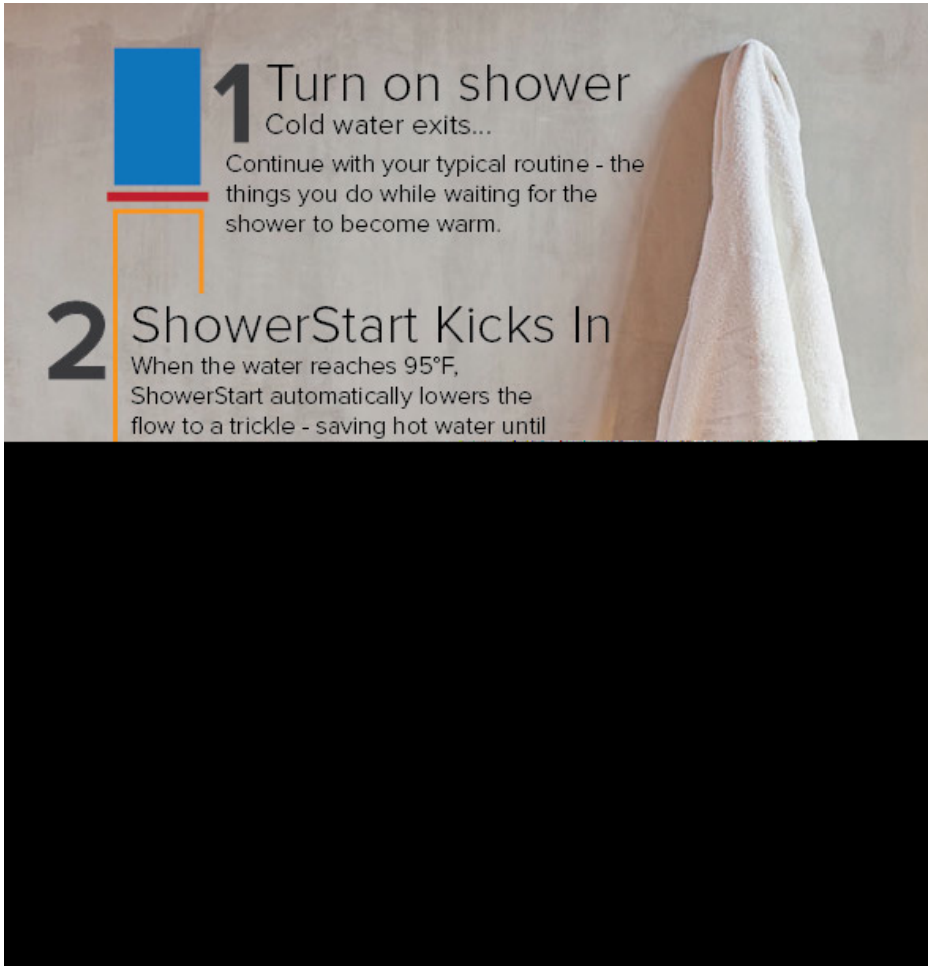
Behavioral Waste Matrix Based On LBNL Body of Work – 2 to 5 gallons

Calculations for Behavioral Waste based on showerhead flow rate, time spent away from the shower and an incremental adjustment for tub spout warm ups. "Greener" regions of the country will likely skew towards towards the lower end of the scale, while other regions will likely fall in the middle to higher end.

		BEHAVIORAL WASTE			
		45 seconds	60 seconds	75 seconds	90 seconds
FLOW RATE	2.5 gpm	2.5 gal	3.3 gal	4.1 gal	4.9 gal
	2.25 gpm	2.3 gal	3.0 gal	3.8 gal	4.6 gal
	2.0 gpm	2.1 gal	2.8 gal	3.5 gal	4.2 gal
	1.75 gpm	1.9 gal	2.5 gal	3.2 gal	3.8 gal
	1.5 gpm	1.7 gal	2.3 gal	2.9 gal	3.4 gal

Thermostatic Shut-Off Valve (TSV) Eliminates Behavioral Waste Without Behavior Change



Keep Your Routine, Save Your Hot Water

2-12 Therms*
Saved Per Year

A small thermostatic shut-off valve (TSV) is all that's needed to save the resources most bathers don't even realize they're wasting.

Better still, conservation occurs without changing shower flow, feel or even your morning routine.

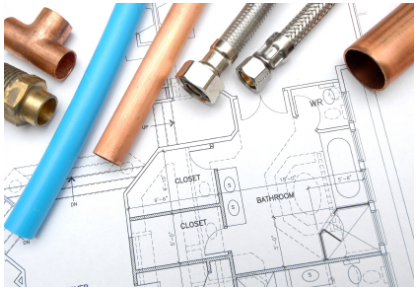
* Current savings range based on deemed savings calculations by U.S. IOUs using the TSV in their EE and Weatherization programs.

Implications For Our Industry

Behavior is persistent and a Thermostatic Shut-Off Valve is necessary to guarantee the assumed effectiveness and deemed savings associated with Structured Plumbing Designs and Hot Water Recirculation Loops/Systems.

thermostatic
shut-off valve

GUARANTEE



structured plumbing designs (efficient)

recirculation loops

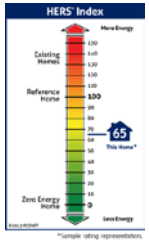
Without a TSV these systems may actually increase water and energy consumption.

Technology Adoption & Behavioral Waste Consideration

- + 750K units installed in single family and multifamily homes via the largest IOU EE & weatherization programs in the country.

- Inclusion in Build It GREEN's updated Green Point energy and water calculator.

- Inclusion in RESNET's updated HERS scoring method for energy efficiency.



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