

The Revised Method of Test for Residential Water Heating and Its Impact on Incentive Programs

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ACEEE Hot Water Forum

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Overview

- >How Water Heaters are Rated Today
- >Changes in the MOT
- >Test Plan
- >Test Results
- >Market Implications

How Water Heaters are Rated Today

Known Drawbacks of the Current Method of Test/ASHRAE 118.2:

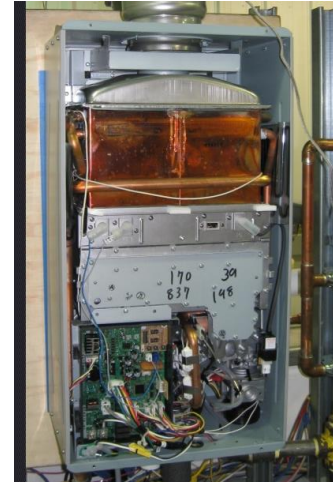
- Daily hot water draw volumes vary significantly and, on average are lower – recent meta-analysis of 10 U.S. studies shows average is 50.6 gal/day.
- Too few hot water draws favor low storage volumes, same analysis shows median daily draw count is 62 draws/day versus six in the current MOT.
- Thermostat setting of 135°F is too high, majority of units shipped have out-of-box setting of $\leq 125^{\circ}\text{F}$.
- Limited coverage of MOT leaves out many products known to be used in residential applications.

Changes in the MOT

Legislation puts changes on fast track:

The new Federal MOT includes major changes to a procedure largely unchanged for over 25 years:

- Categorized by output capacity into one of four groups: Very Small, Low, Medium, or High Usage, each with unique draw pattern.
- The four draw patterns applied are distributed, more realistic, unlike the current MOT.
- Products are included that were not previously given an “Energy Factor (EF)”, thus were exempt from Energy Star, including hybrid and light commercial products.



Impact: Categorization

- Current MOT rates all products with 64 gal/day draw pattern
- New MOT (below) has criteria for 4 categories

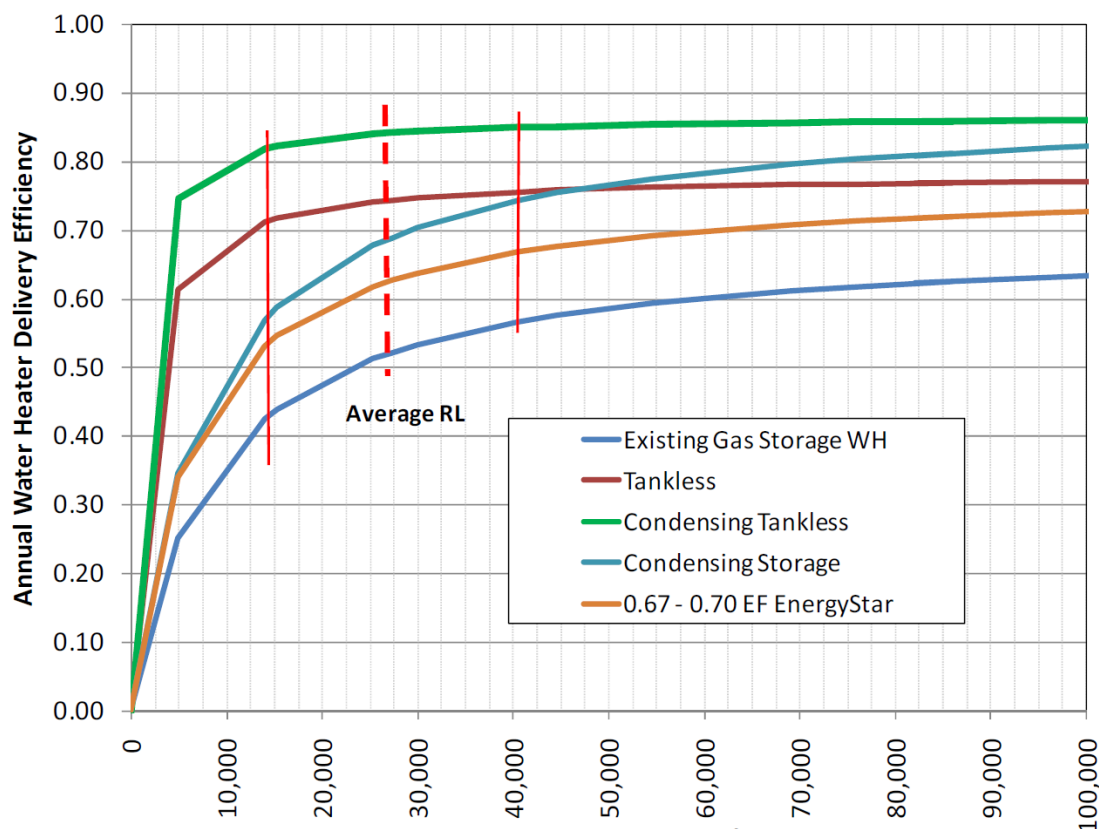
Water Heater Type	Draw Pattern Name	Daily Hot Water Draw (Gal.)	First Hour Rating/Max. GPM	Definition	
				Volume	Input
Storage	Very Small Usage	10	$0 \leq \text{FHR} < 18$	2 < Gal. < 120	< 75,000 Btu/hr or < 12 kW
	Low Usage	38	$18 \leq \text{FHR} < 51$		
	Medium Usage	55	$51 \leq \text{FHR} < 75$		
	High Usage	84	$75 \leq \text{FHR}$		
Tankless	Very Small Usage	10	$0 \leq \text{GPM} < 1.7$	Gal. < 2	< 200,000 Btu/hr or < 12 kW
	Low Usage	38	$1.7 \leq \text{GPM} < 2.8$		
	Medium Usage	55	$2.8 \leq \text{GPM} < 4.0$		
	High Usage	84	$4.0 \leq \text{GPM}$		

Impact: Categorization

Delivered Efficiency, is strong function of daily hot water draw -> Lower capacity WHs will have lower rated EFs.

Previously uncategorized products will go from Thermal Efficiency (TE) to EF, recent data show that a 95% TE condensing storage WH receives a 0.78 EF with the current MOT

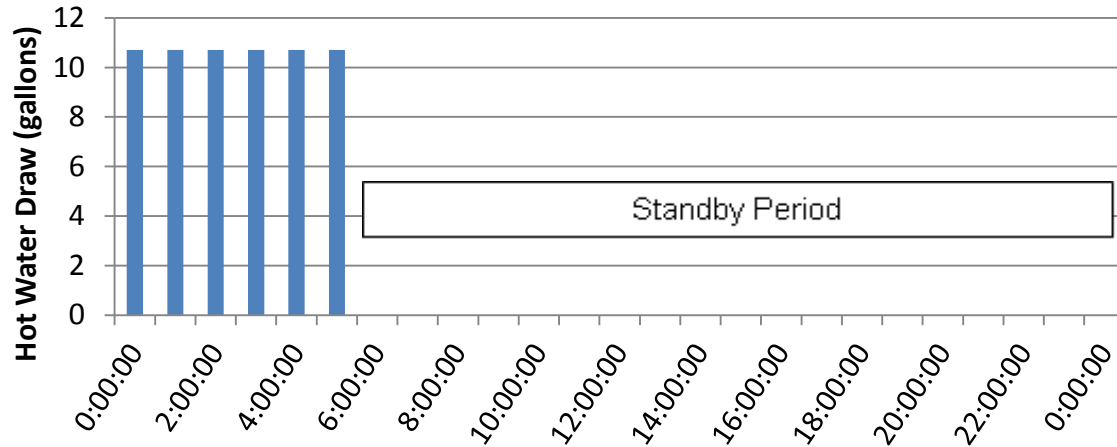
Delivered Efficiency versus Daily Heat Output (Btus)



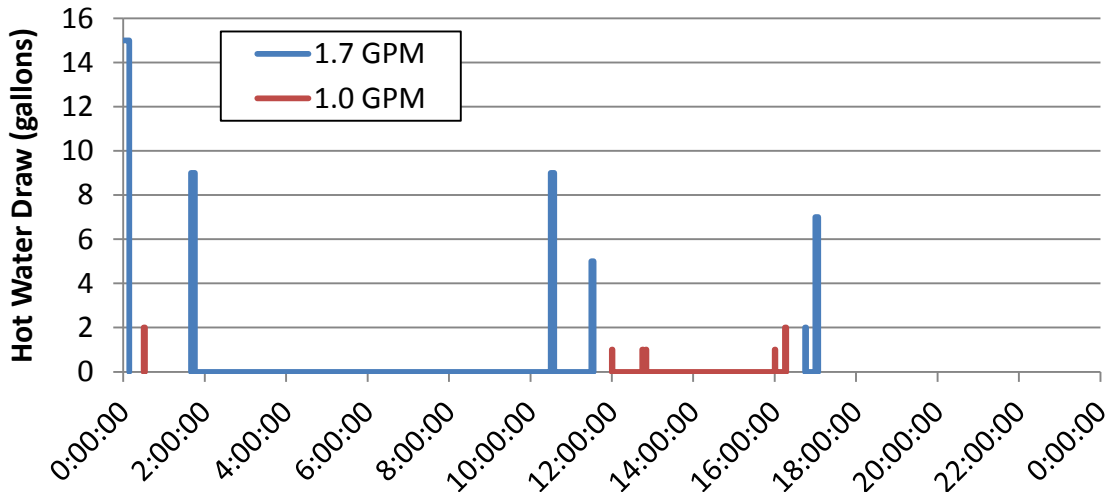
Kosar, D. et al. "Residential Water Heating Program - Facilitating the Market Transformation to Higher Efficiency Gas-Fired Water Heating - Final Project Report". CEC Contract CEC-500-2013-060. (2013).

Impact: Draw Patterns

Current
MOT: 64
gal/day



New MOT
"Medium"
Category:
55 gal/day



Current MOT Draw Pattern, for all WHs, is known to over-estimate the efficiency of no/low-storage equipment.

Distributed draw patterns in the new MOT may result in rated changes of value between EF/UEF

Other Impacts

- Reduction of thermostat setting to 125°F
- Broadening scope, to include:
 - Storage equipment with 2-20 gallons, covering a previously existing gap for these “hybrids”.
 - “Residential-duty commercial” products, essentially products not covered currently but: use single phase power, do not produce water > 180°F, and do not require ASME Boiler/Pressure Vessel certification.

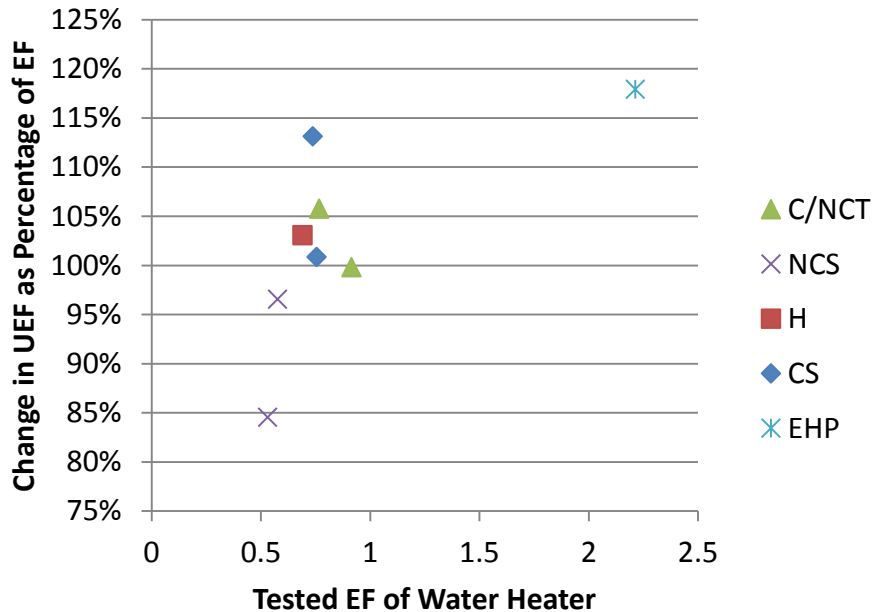
Test Plan

- Seven representative WHs tested to current and new MOT.
- Quantify difference in results for EF/UEF (and other parameters) and their impact on projected energy savings.

Water Heater Type	Rated FHR/Max. GPM*	Revised SUT Daily Volume
Non-condensing Storage (NCS)	75 gal. > FHR > 51 gal.	Medium (Derate for Low Usage Too)
Condensing Storage – Residential (CS-L)	> 75 gal.	High
Condensing Storage – Res. Duty Commercial (CS-H)	> 75 gal.	High
Non-condensing Tankless (NCT)	> 4.0 gpm	High
Condensing Tankless (CT)	> 4.0 gpm	High
Hybrid (H)	> 75 gal.	High
Electric Heat Pump Storage (EHP)	75 gal. > FHR > 51 gal.	Medium

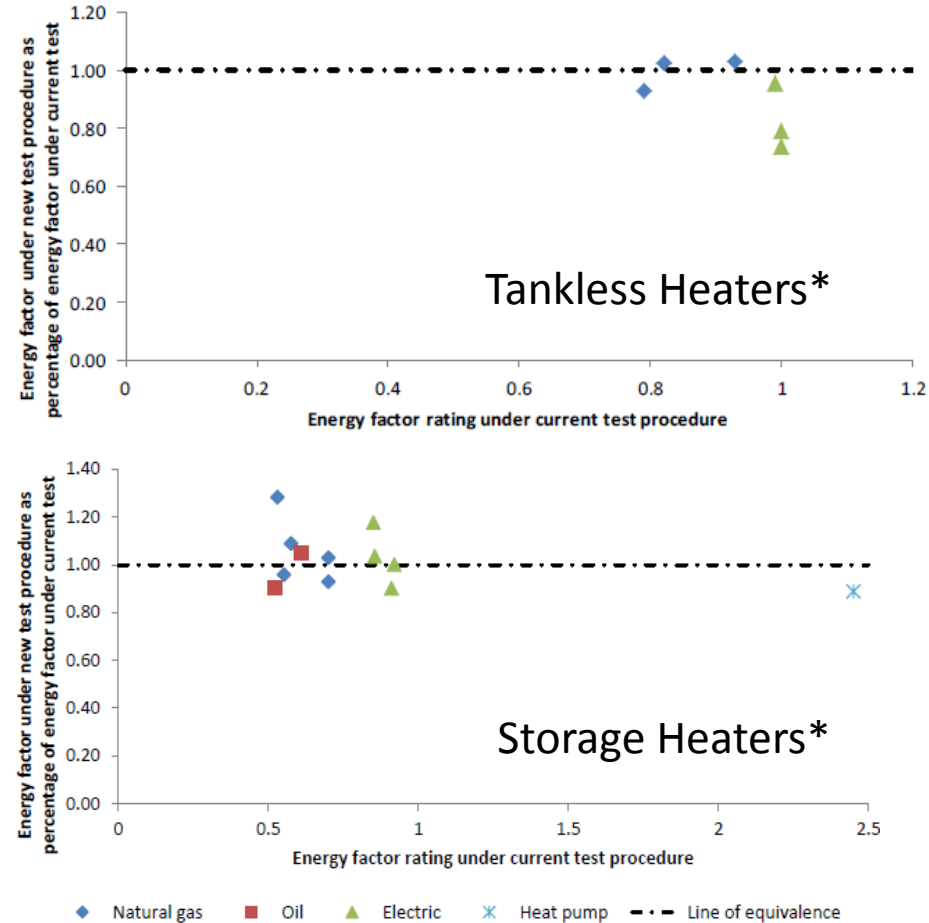
* Note FHRs/Max. GPM determined at new reduced thermostat setting

Test Results



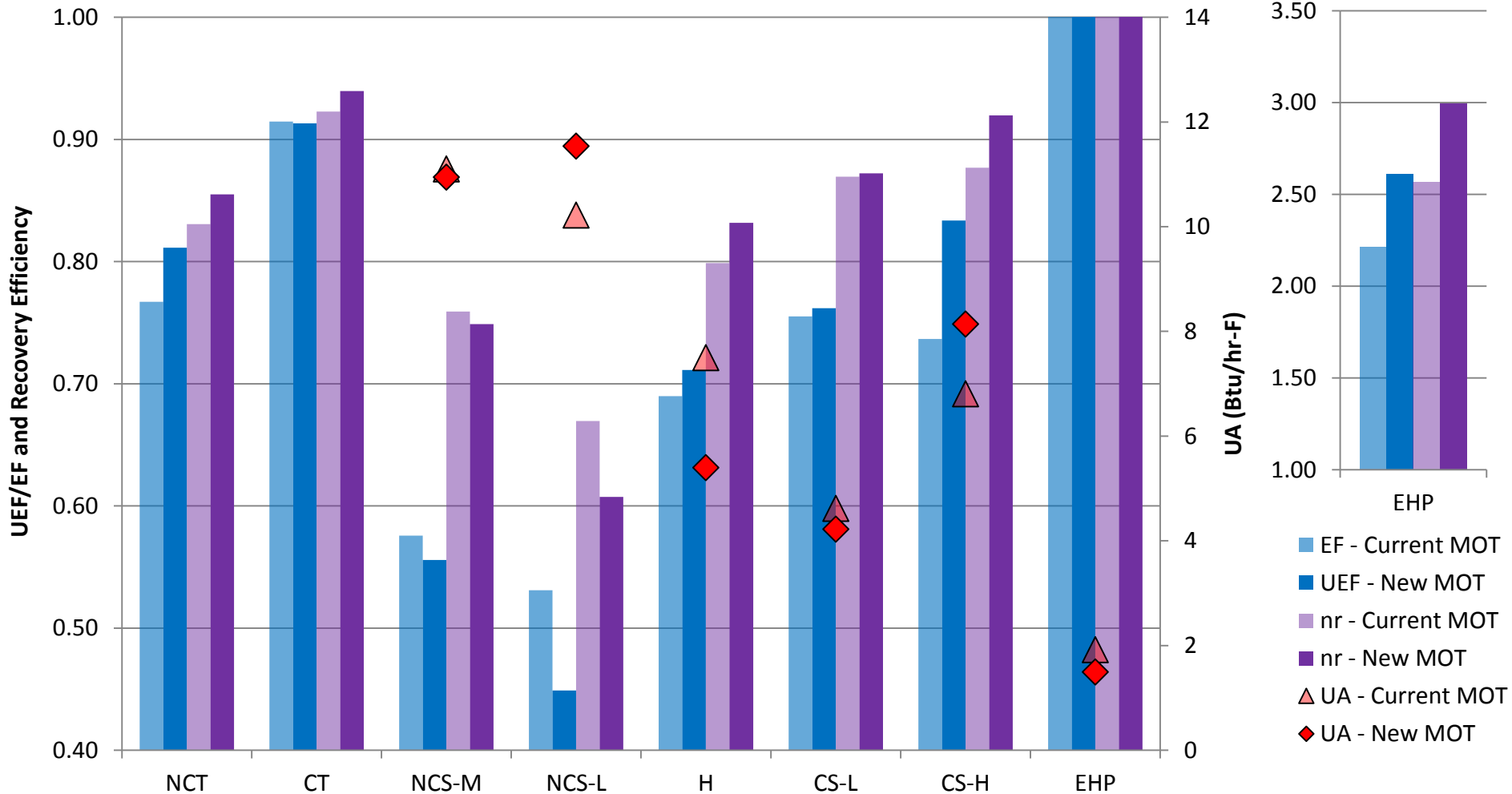
Data show range of +/-20% change in UEF/EF, on par with what US DOE published previously.

- Impact of daily volume draw
- Standby recovery bias



*Water Heater Test Procedure Rulemaking: Development Testing Preliminary Report – Energy Conservation Program for Consumer Products and Certain Industrial Equipment: Residential and Light Commercial Water Heaters , US DOE (2013)

Test Results



Test Results

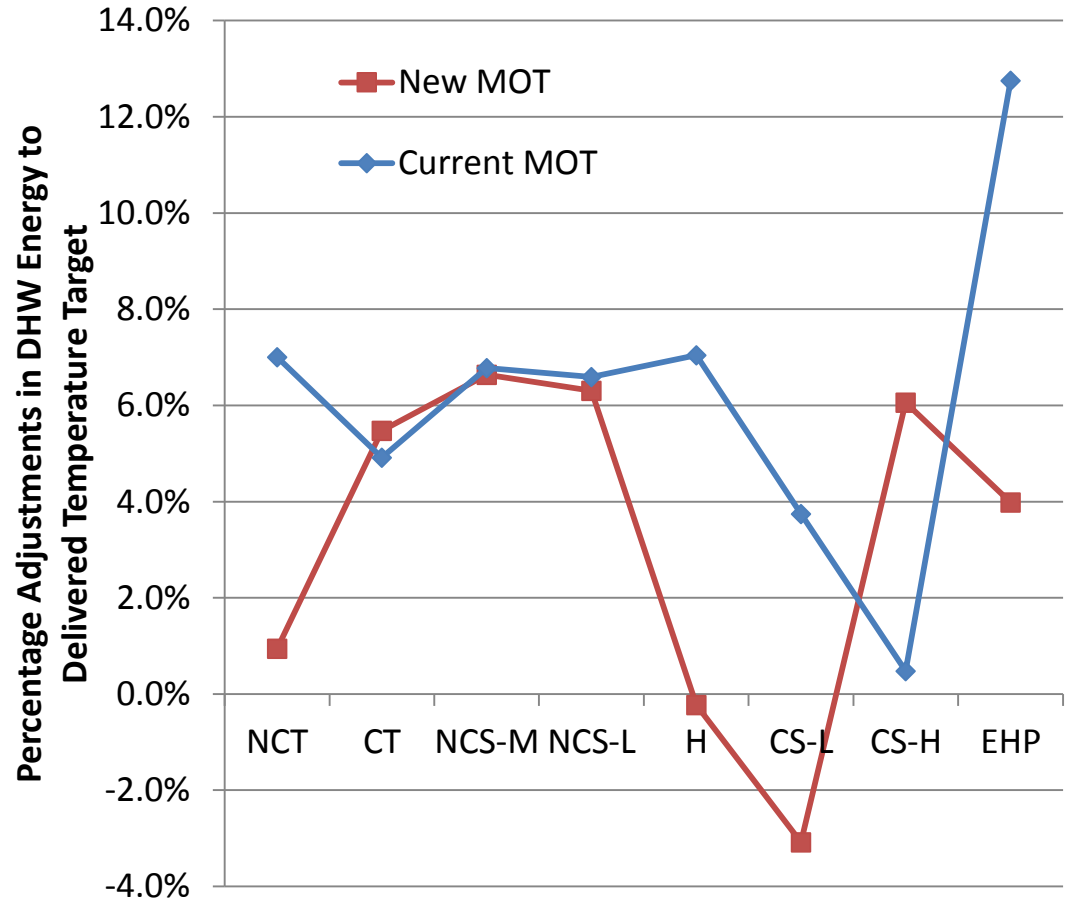
Why is UEF > EF except for NCS?

- Higher daily draw volumes increase impact of SS efficiency versus standby losses
- First draw volume of 15/27 gallons larger and, for Low/Medium Usage patterns, at 1.7 gpm, yielding higher recovery efficiency.
- Recovery efficiency also higher for units with slower recoveries (heat pumps), which can fully recover prior to end of hot water draws.
- Outlet temperature variation can bias UEF/EF.
- Both units not currently rated with “EF” experienced a standby recovery, biasing EFs lower

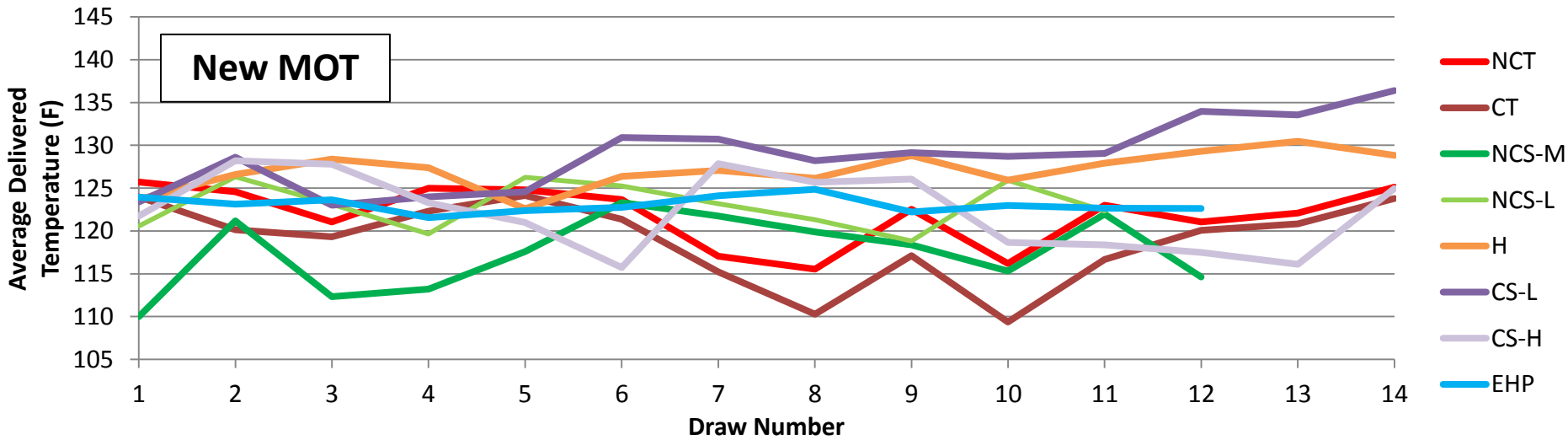
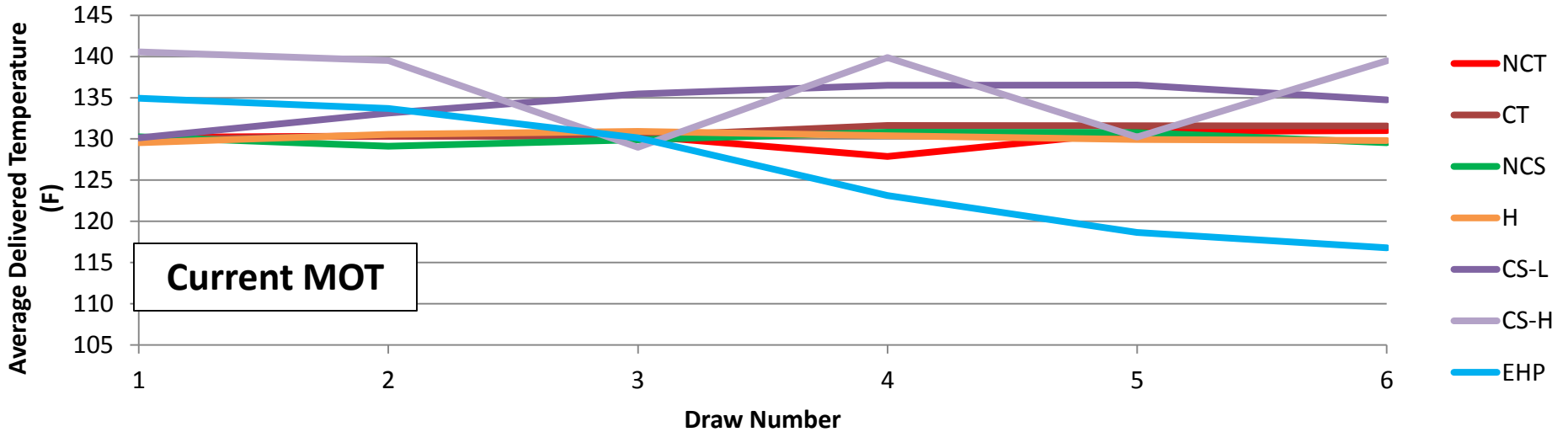


Test Results – Delivered Temperature

- Both MOTs adjust DHW output energy for delivered temperatures off-target.
- Like other adjustments (e.g. ambient conditions), the smaller it is (total and for each draw event), the more repeatable and accurate the results.

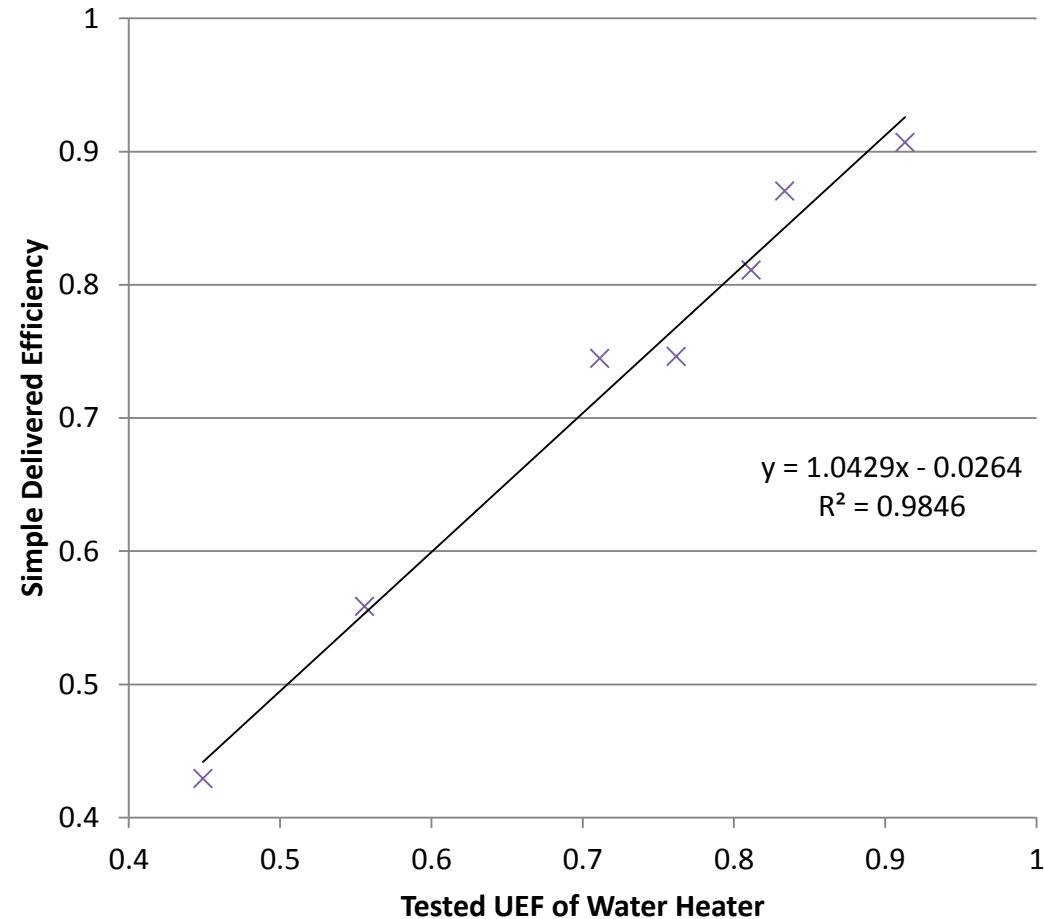


Test Results – Delivered Temperature



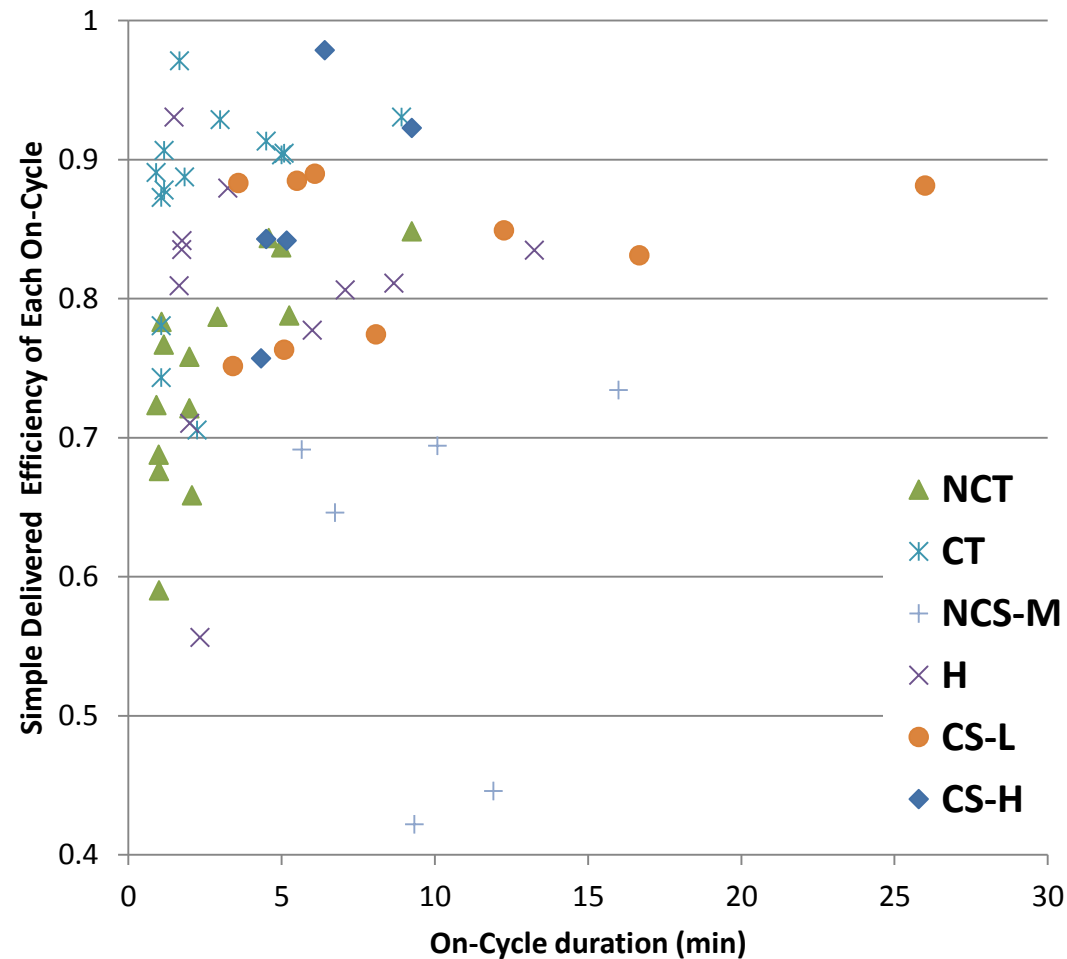
Test Results – Draw Pattern

- Overall test UEF and simple delivered efficiency show high degree of linearity.
- Despite range of delivered efficiencies for each on-cycle event.

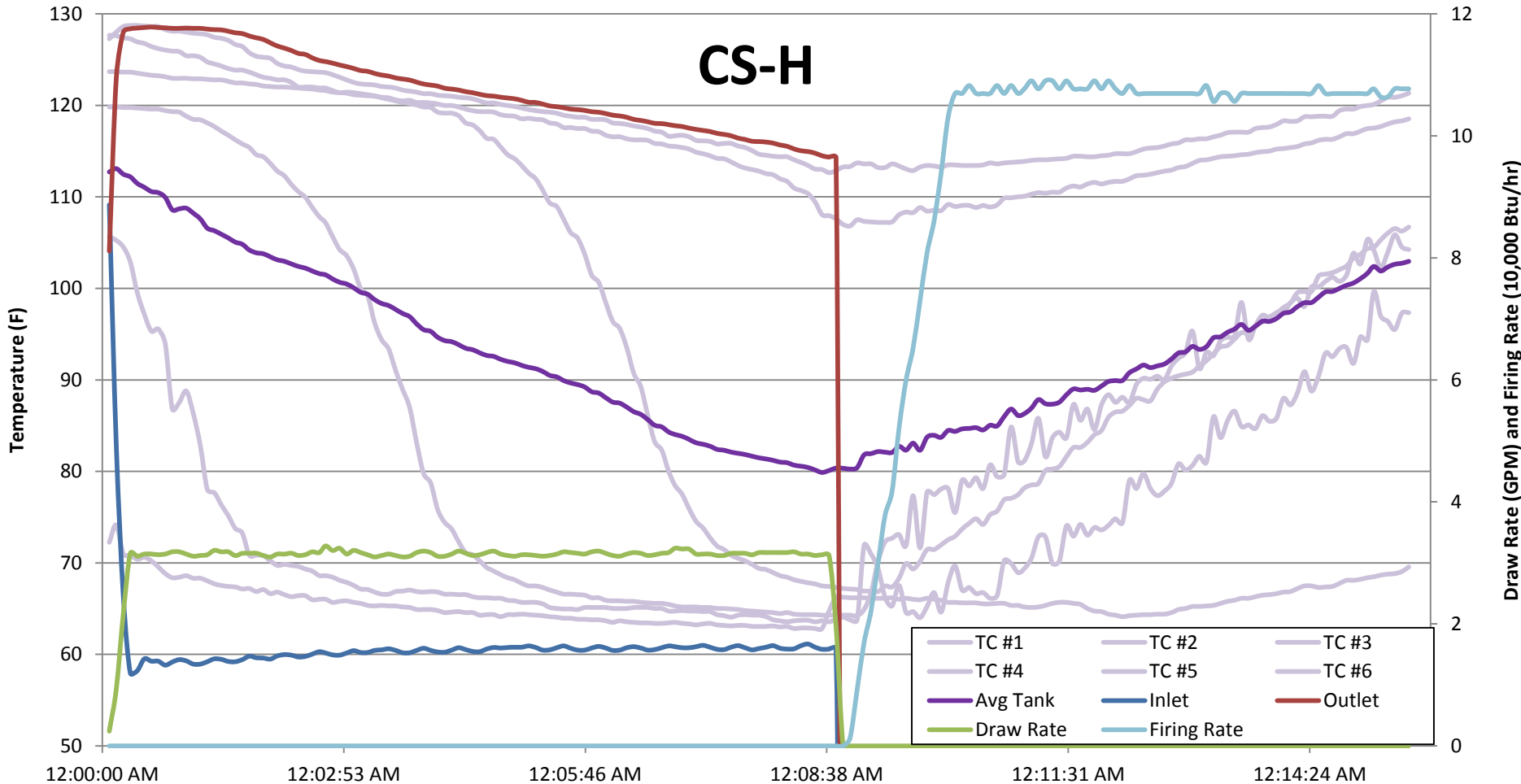


Test Results – Draw Pattern

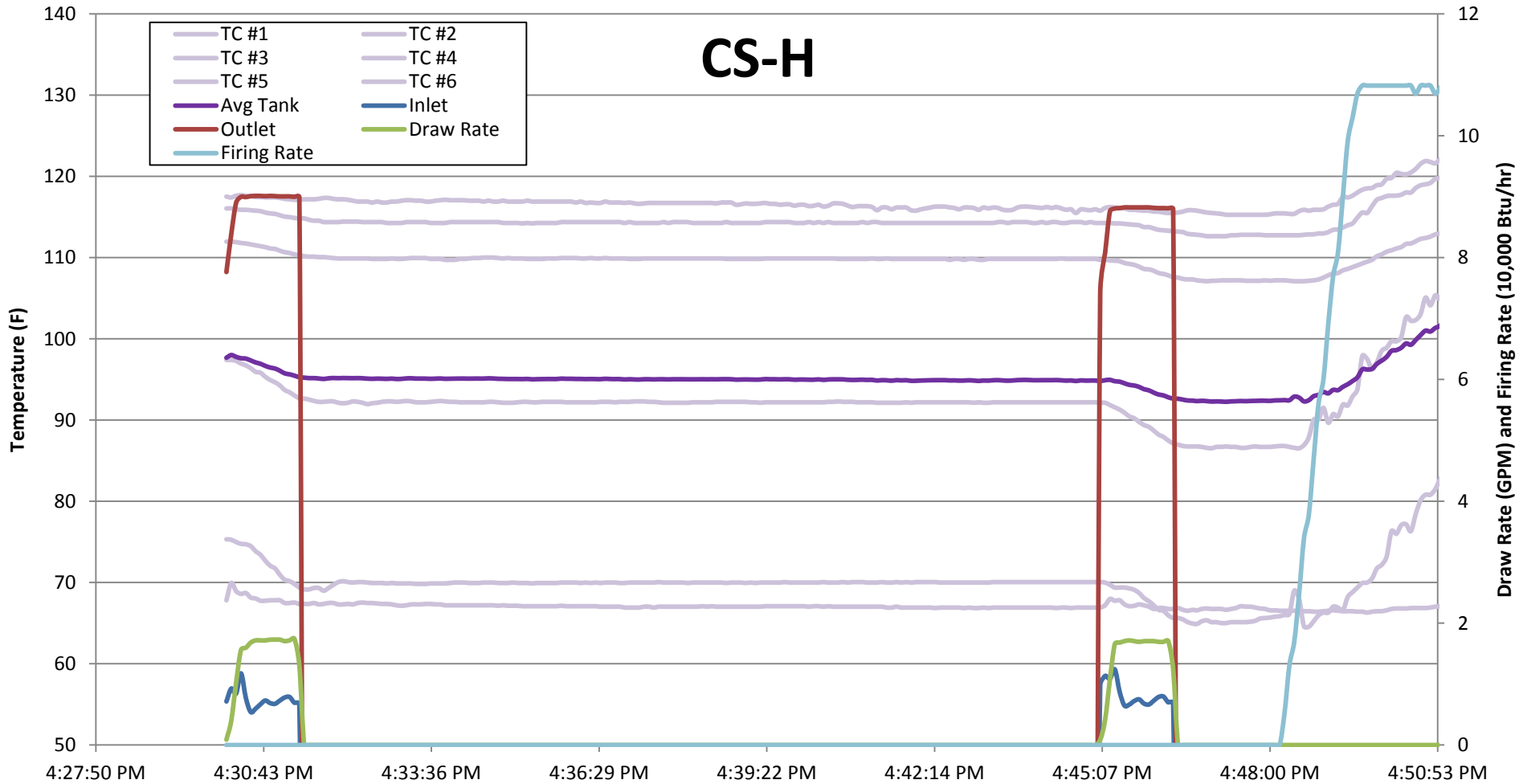
- The range of delivered efficiencies for each on-cycle event is high (without adjustments for change in stored energy).
- Impact of using an assumed constant recovery efficiency
 - Impacts Higher UEF systems. Same magnitude error in quantifying recovery heat, disproportionately affects UEF of EHP vs. NCS by order of magnitude.



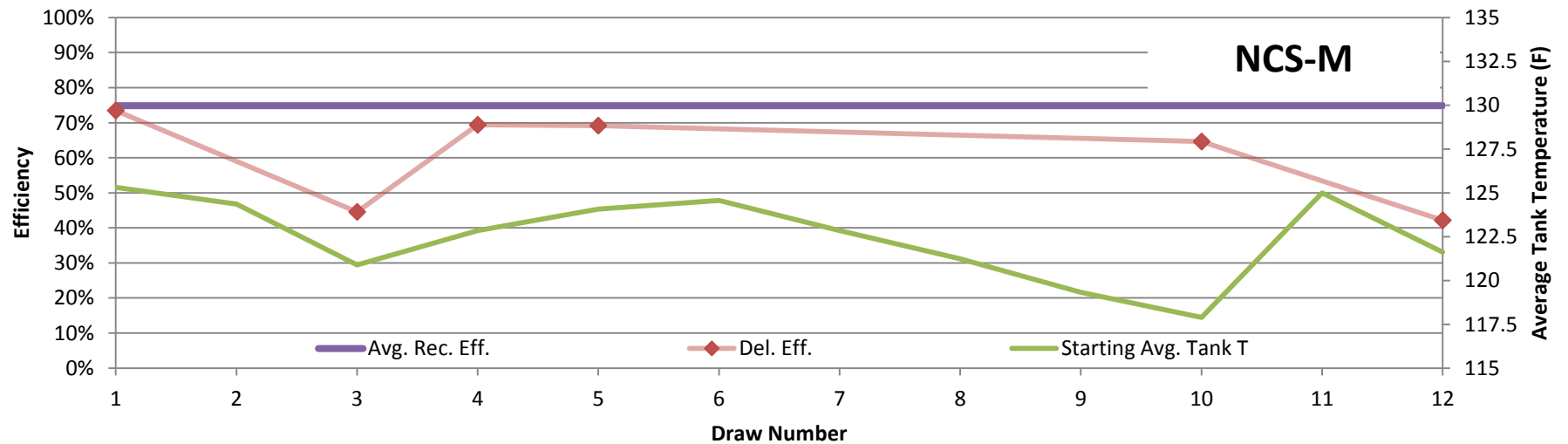
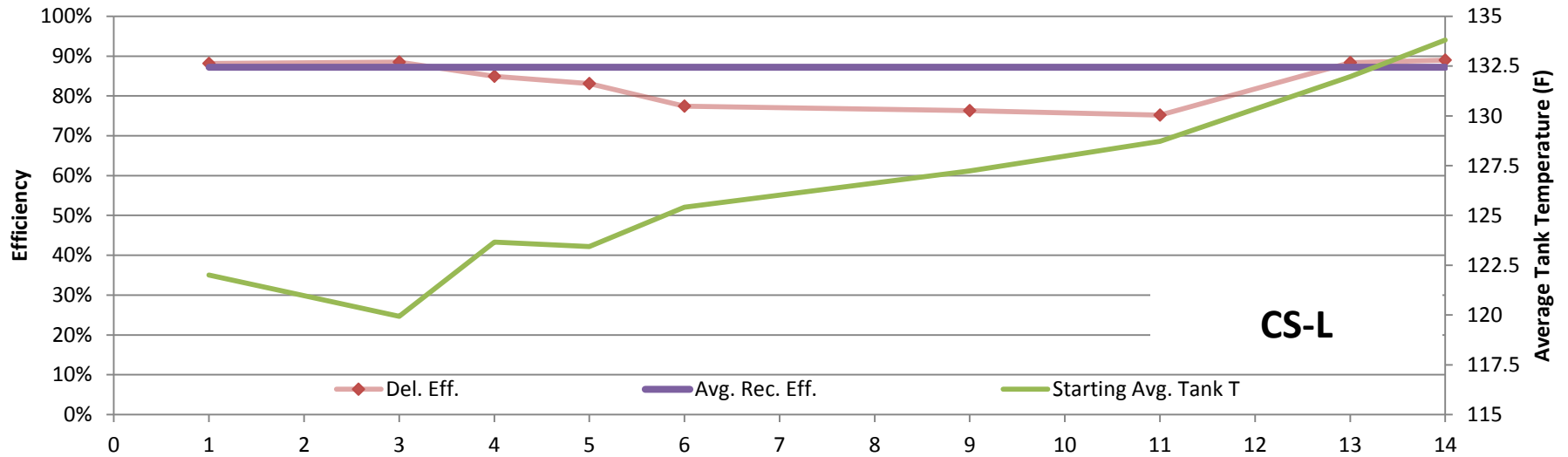
Test Results – Draw Pattern (Long)



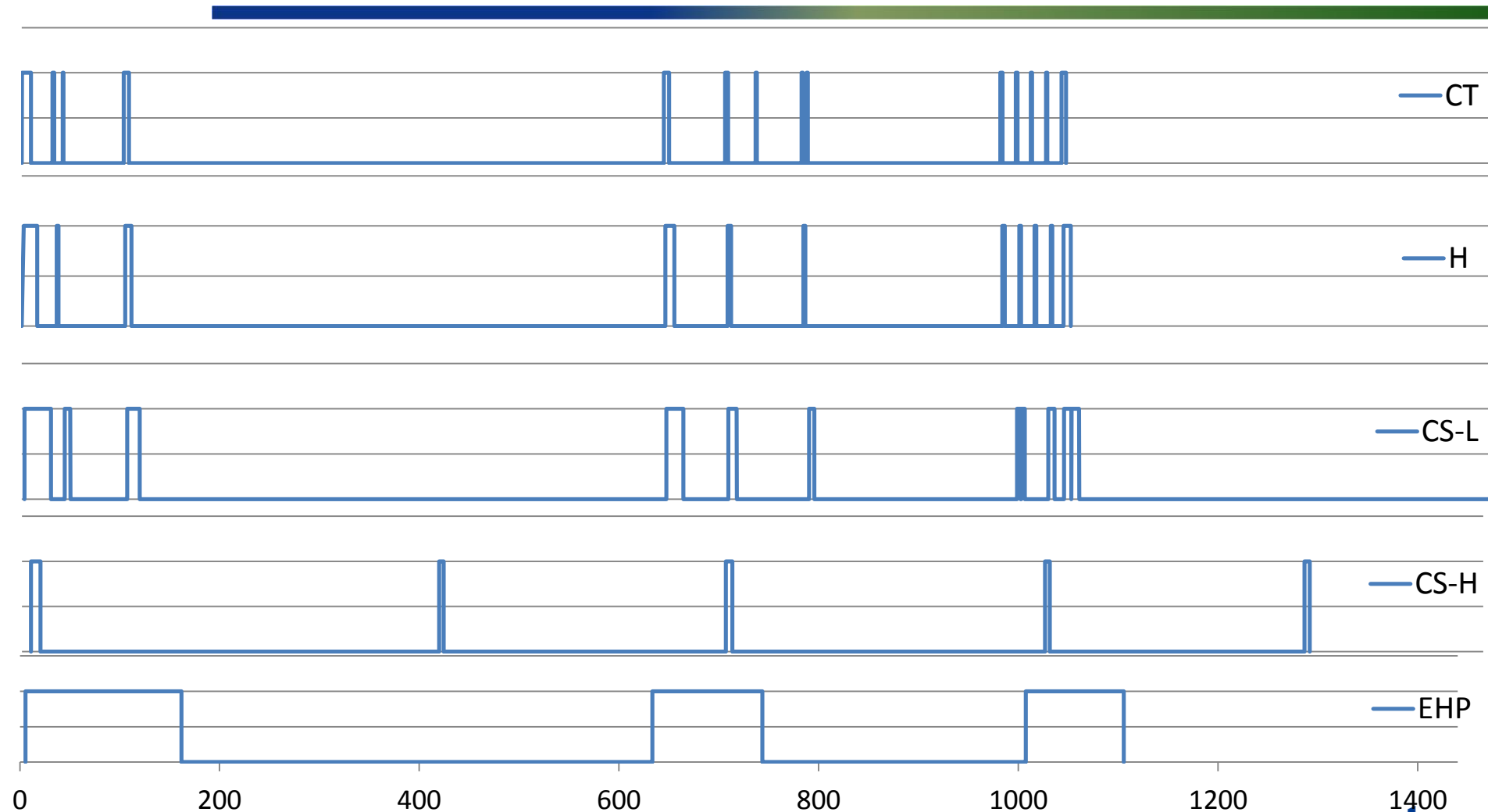
Test Results – Draw Pattern (Short)



Test Results – Draw Pattern



Test Results – Draw Pattern



Market Implications

- For these data, where $UEF < EF$ for baseline (NCS) but $EF < UEF$ for all others, water heaters now may have shorter paybacks.
- Depending on local conditions, incentives for higher efficiency residential water heaters may make more sense where they may not currently.
- **Further Challenge for Utilities:** But what is baseline? Is it category specific or universal?

Assuming High Usage draw patterns using measured EF/UEF values, all product types show improved economics with 2013 avg. utility prices.

Reduction in Payback Period with New MOT

Water Heater Type	NY	CA	FL
CS-L	42%	43.2%	38%
CS-H	17%	17.6%	16%
NCT	25%	25.4%	24%
CT	9%	9.4%	9%
H	33%	34.6%	28%

Conclusions – Things to Look For

- **Repeatability** – How do the distributed draw patterns impact repeatability of the test? How well are the short hot water draws characterized?
 - Does the same test within the tolerances, ± 0.1 gal/draw (1 gpm/1 gal. draw), $\pm 2^\circ\text{F}$ inlet, etc. yield the same on-cycle pattern?
- **What's the baseline?** – With pending conversions for existing products, do consumers compare mid to mid usage products, high to high?
 - Most common min. EF will be categorized as “mid”, most mid/high efficiency will be categorized as “high”, how to compare?



Questions & Answers



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