Recent Lab Testing of Tankless Units: Evaluating Performance and Reliability

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Presentation Scope

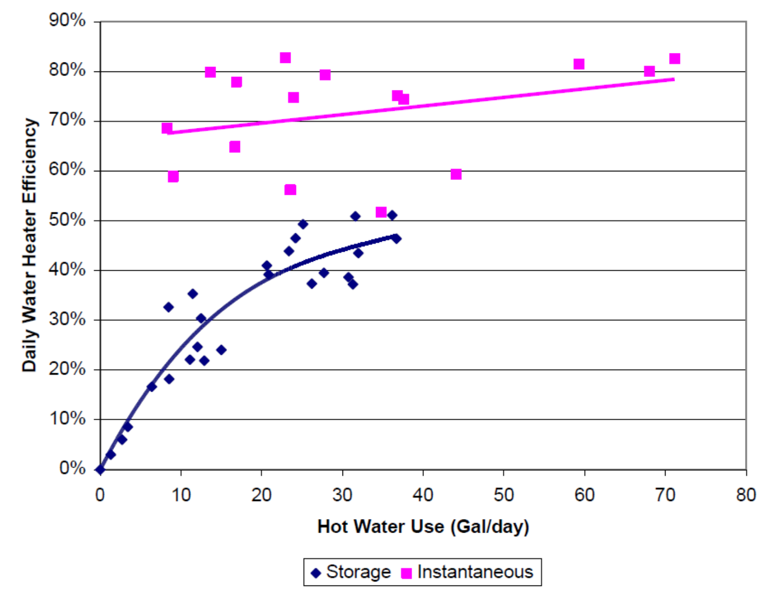
- New project with NEEA
  - No conclusions yet / lots of hypotheses
  - Feedback from audience welcome
- Motivation and background for the project
- Project objectives and approach
- Early results preview and next steps

Opportunity

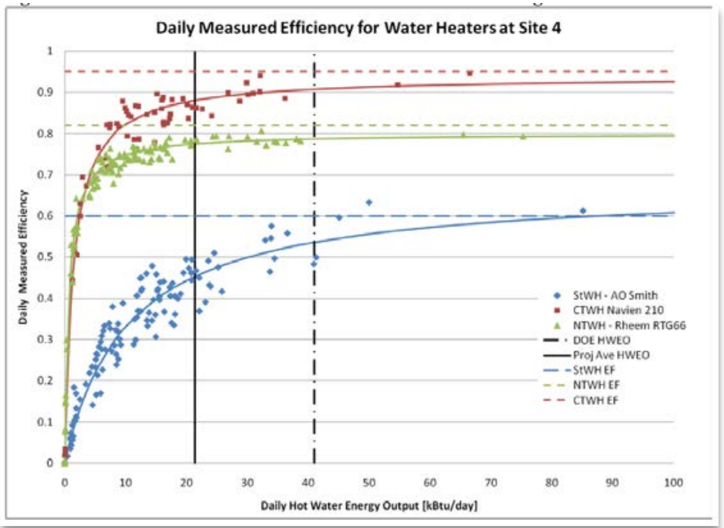
- Water heating in the Pacific Northwest (according to RBSA 2017)
  - Use of gas for water heating up (43→49%)
  - Fraction of tankless increasing, however…
    - 81% non-condensing storage (EF/UEF < 0.7 in most cases)
    - Only 6% condensing tankless (4% non-condensing)
- Story is similar at the national level
- Gas HPWH (UEF > 1) are on their way…
- Tankless (min UEF = 0.81) could provide significant energy savings in the interim

Prior Work and Motivation

- Most recent studies date back 6-10+ years
- Energy savings potential:
  - 20-30% projected energy savings vs NC storage
  - EF rating inadequate for estimating energy savings
  - TWH energy efficiencies 8-10% lower than EF
  - TWH performance depends on hot water draw characteristics



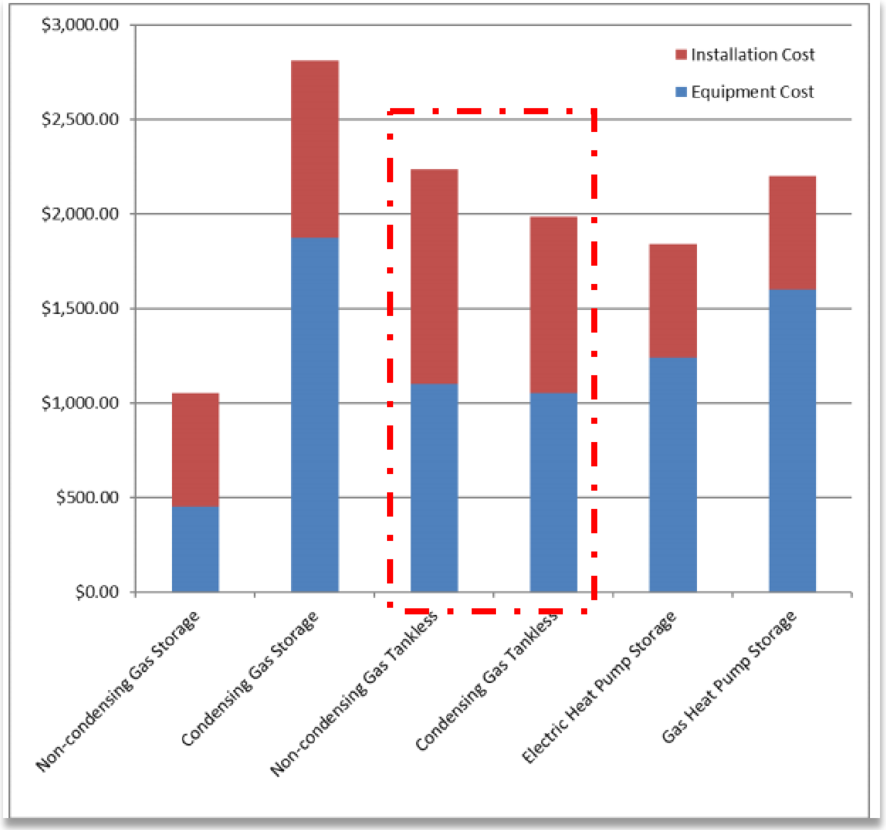
Source: Davis Energy Group – PG&E (2007)



Source: CEE (2010)

Prior Work and Motivation

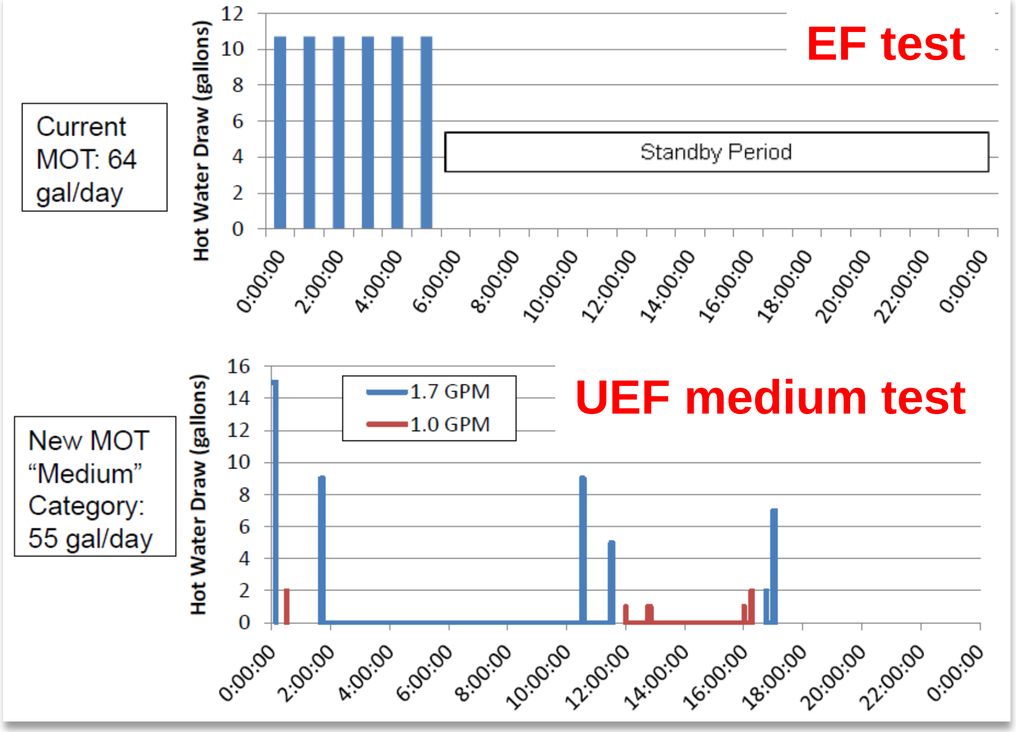
- High installation costs consistently identified as a significant barrier in retrofits
  - Power/direct venting – new penetration ($)
  - Power outlet ($)
  - Gas line upgrades ($$)
- $2000-3000+ installed cost, compared to $1000-1500 for non-condensing storage
- Payback periods of ~20+ years in retrofits



Source: Glanville – ACEE HWF 2018

Product and Market Changes

- In the last 10 years:
  - Roll out of the UEF rating method (~2015) implemented more realistic draw patterns
  - NFPA 54 – National Fuel Gas Code changes (~2012):
    - Can use ½" gas lines up to 40 ft-eq for 200 MBH, with a 3 inWC pressure drop
    - Need 8 inWC gas supply
    - Balance of distribution system must have sufficient capacity

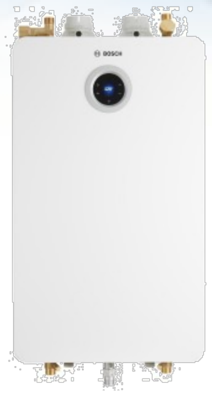


Source: Glanville ACEEE HWF 2015

Product and Market Changes

- New products targeting retrofits:
  - ½" gas line capability
  - Vertical water connections
  - Small diameter PVC venting
  - Improved delivered temperature delay

- Not all OEMs have embraced ½" gas line capability
  - Still recommend a dedicated gas line



Bosch

Rinnai

Navien

Bradford White

Questions and Hypotheses (feedback welcome)

- What are these new ½” capable products?
- What are their operating characteristics and limitations when utilizing ½” gas lines?
- Do the new products have improved energy savings potential?
- Do the new products have reduced installation costs and therefore improved payback periods?
  - If not.., what are the current cost barriers?
  - What is the installer experience with the new products?

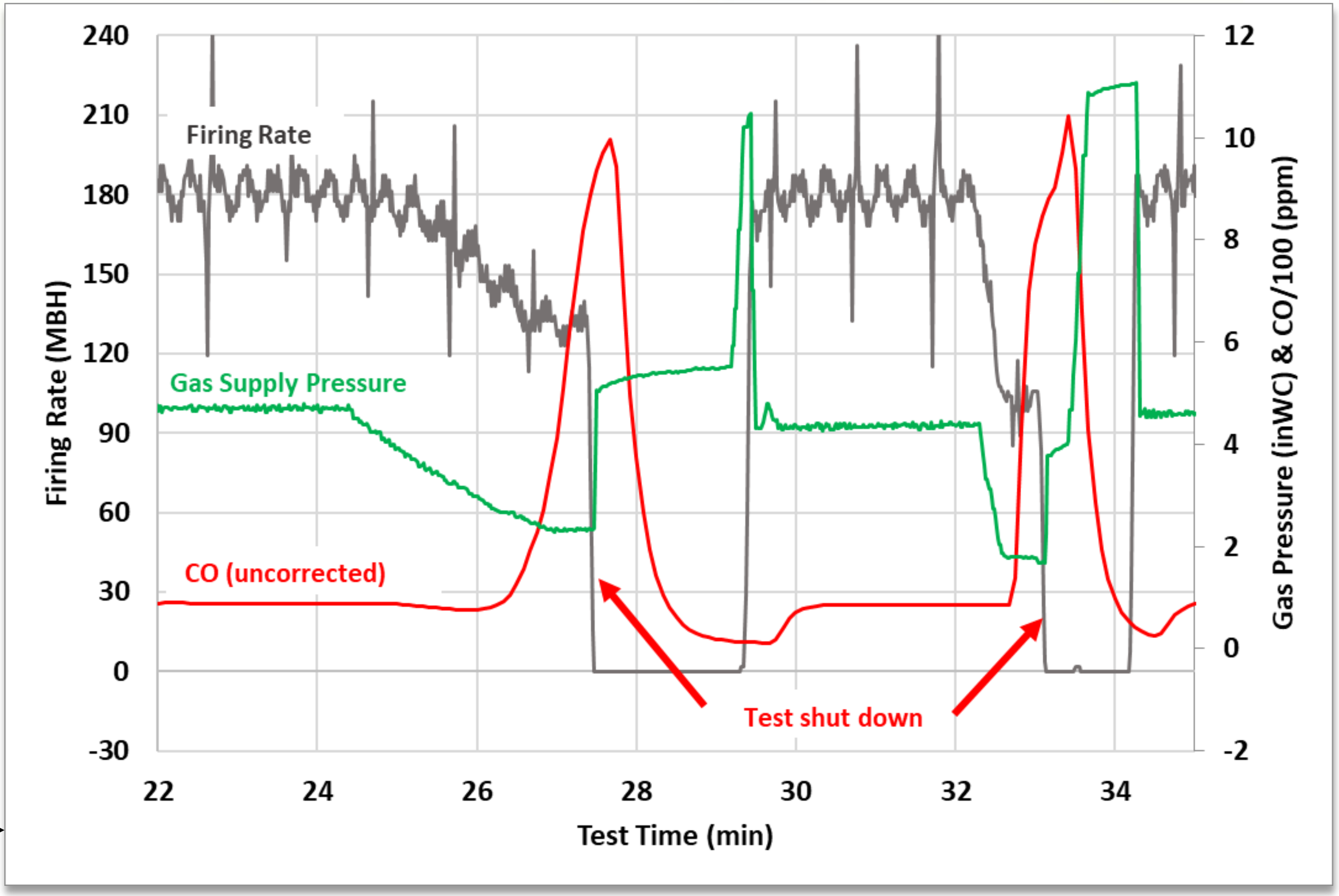
- **Approach:** Laboratory evaluation, survey of installers, techno-economic analysis

Laboratory Evaluation – Operating Characteristics

- **Objective:** Verify rated performance of ½” tankless products, identify any limitations, and map their performance
  - Uniform Energy Factor at minimum required pressure
    - If using ½” gas lines, likely operating near minimum required pressure
    - Stress test a sub-sample of products at adverse pressure conditions

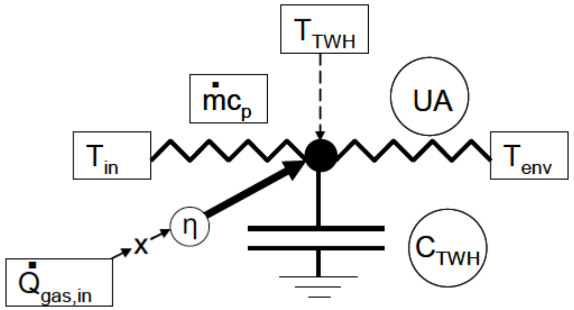
Laboratory Evaluation – Results Preview

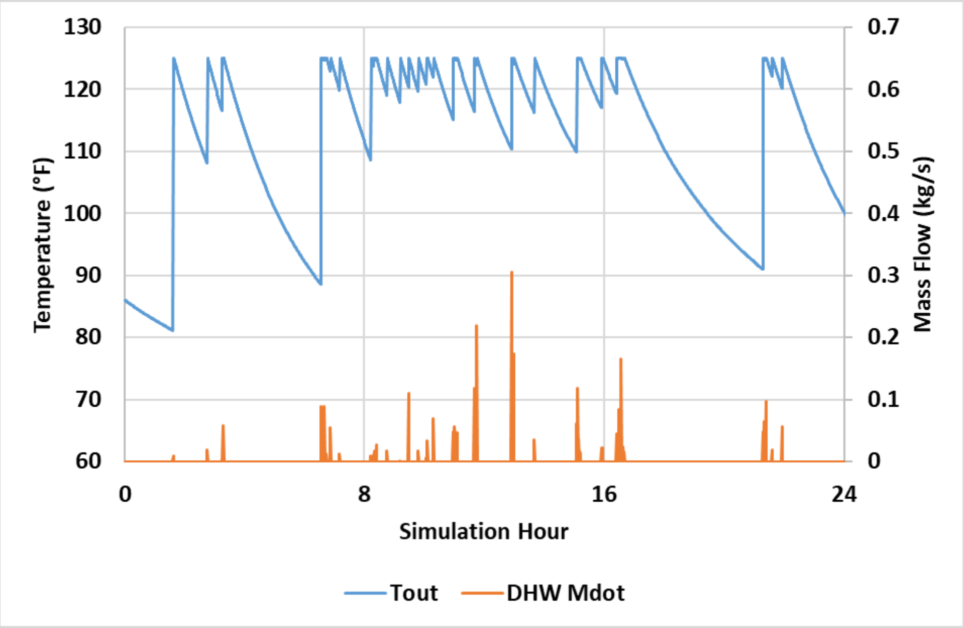
- **Verification**
  - 180 MBH, UEF 0.82, 4.5 max gpm (AHRI) tankless
  - Installed with ~4.5 inWC gas supply at max fire (4 inWC min required)
  - 24-hour UEF test results:
    - UEF = 0.81, 4.4 max gpm
    - Gas supply >5 inWC for the duration of the test
    - <u>No issues if installed properly</u>
- **Stress Test (improper install)**



Laboratory Evaluation – Performance Mapping

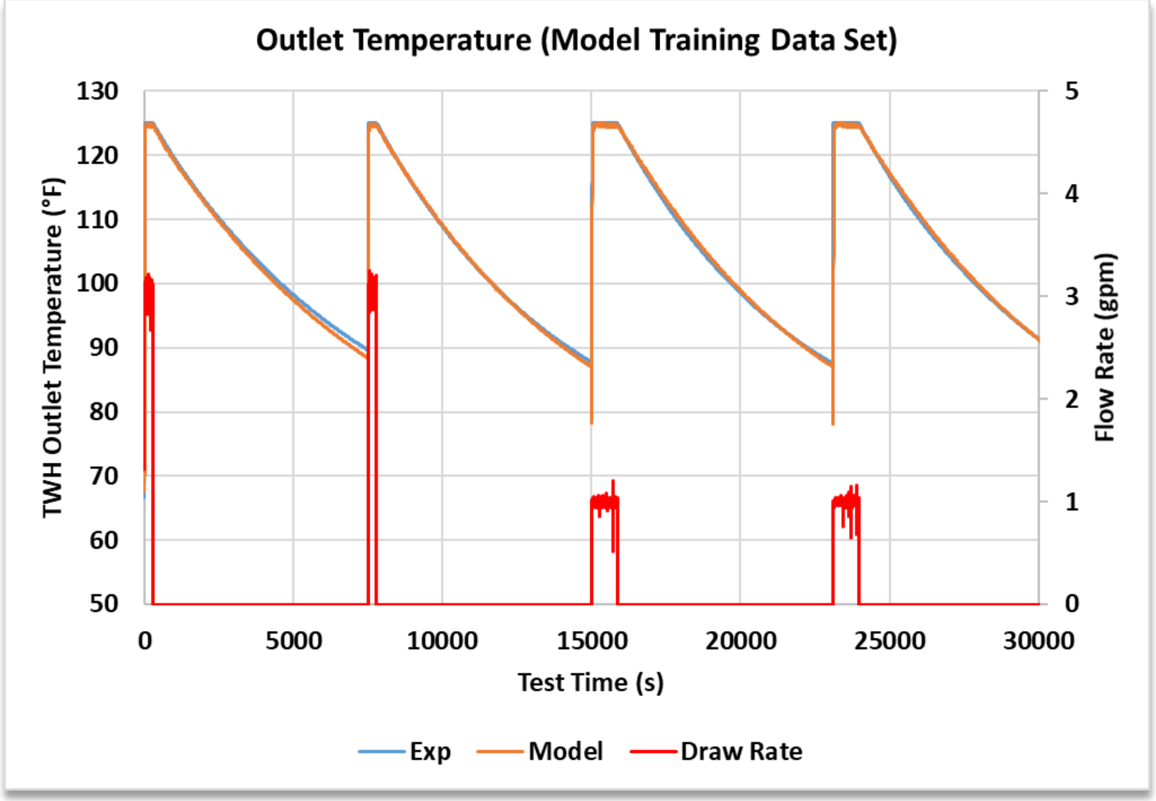
- Performance mapping enabled by lumped heat capacity (LHC) model (Burch et al NREL – 2008)
  - $C * \frac{dT_{\mathrm{TWH}}}{dt} = \eta \dot{Q}_{\mathrm{gas}} - \dot{m}c_p(T_{\mathrm{TWH}} - T_{in}) - UA * (T_{\mathrm{TWH}} - T_{env})$
  - C – thermal capacitance,
  - η – steady state efficiency,
  - UA – standby loss coefficient





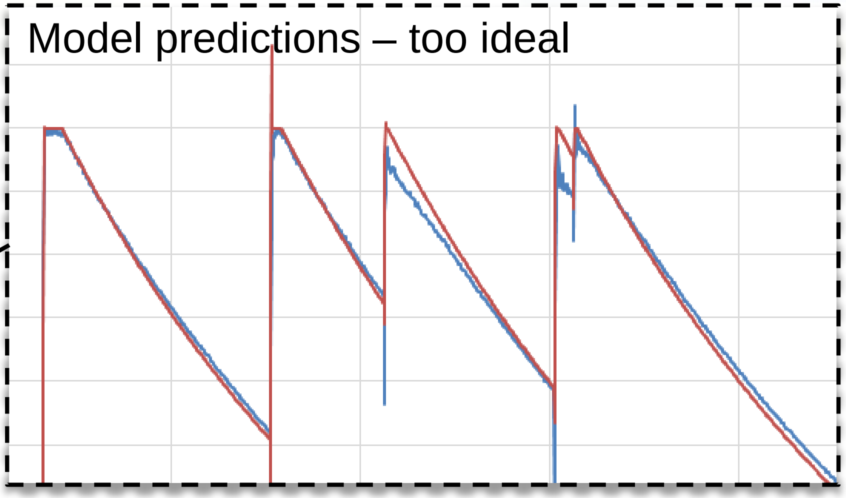
Laboratory Evaluation – Performance Mapping

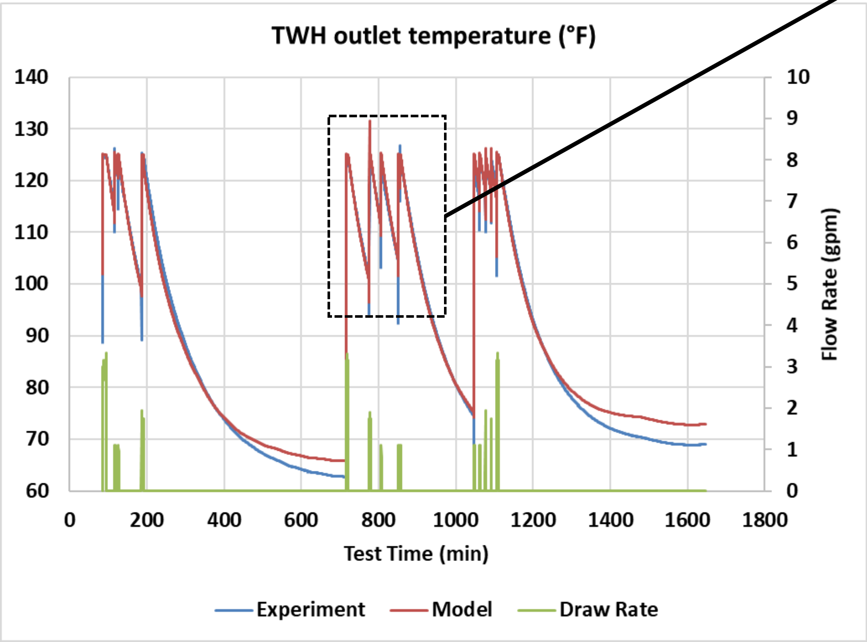
- Simple tests to determine parameters
  - Ramp up, steady fire, environmental decay
- Preliminary results:
  - 180 MBH, UEF 0.82 TWH:
    - C = 3.43 Btu/°F
    - η = 84.4%
    - UA = 2 Btu/hr-°F
    - Needed ~20% over-fire factor when heating up HX
    - Gas consumed within 0.6% of experiments

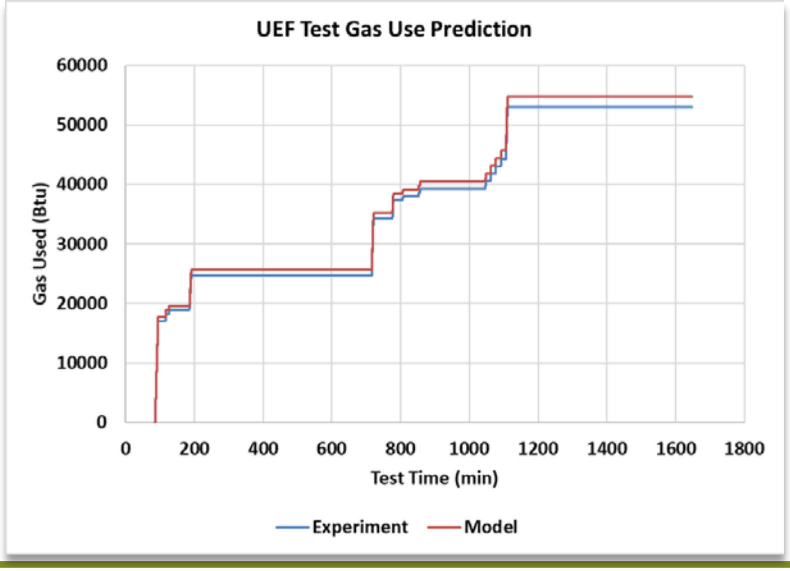


Laboratory Evaluation – Performance Mapping

- Simulating UEF test:
  - Simple model has limitations
  - Predicts gas consumption within 3% (1.5% with optimization)

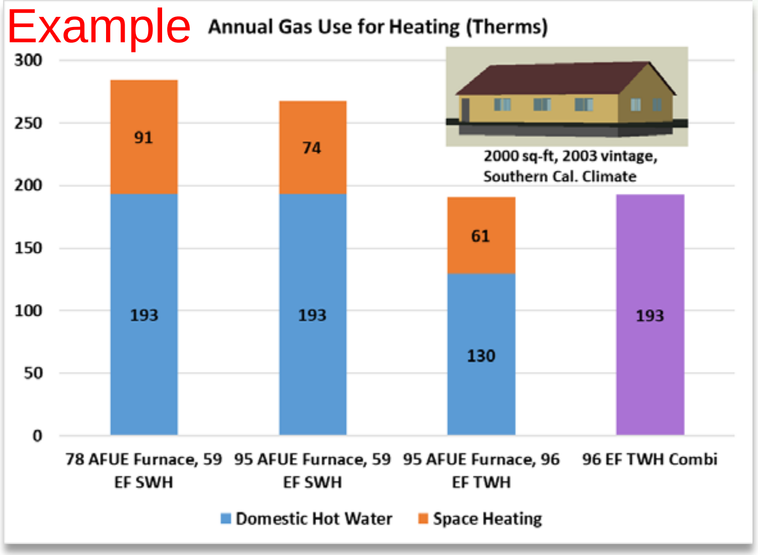


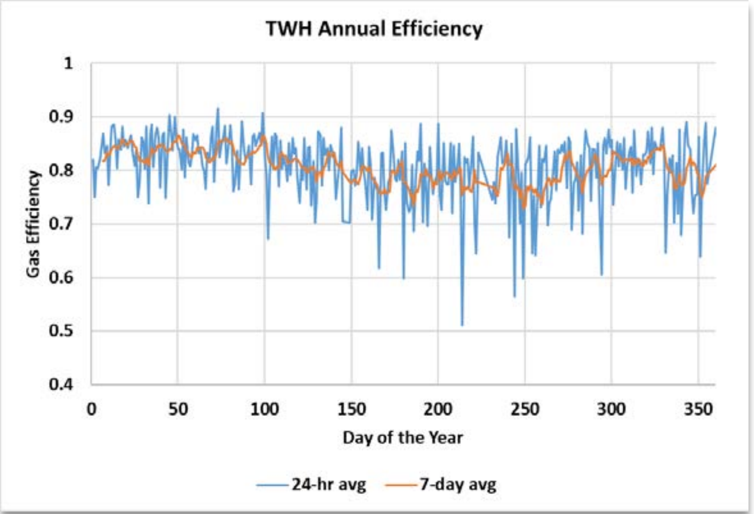




Energy Savings and Market Potential Analysis

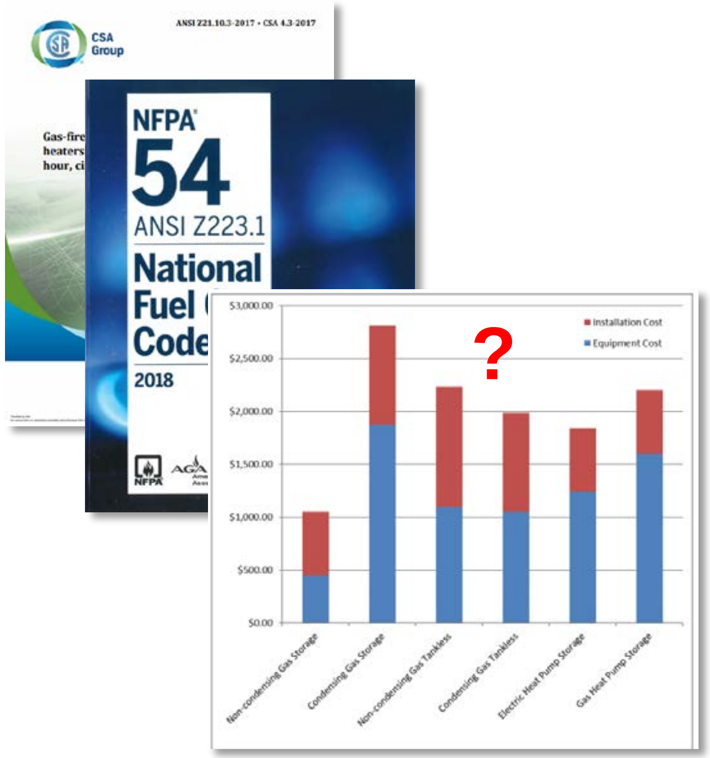
- Integrate LHC with EnergyPlus to:
  - Estimate energy savings for different:
    - Climates (mains temperatures)
    - Usage cases (small and larger homes)
  - Integrated into a combi model (tomorrow's talk)
- LHC first suggested ~10 years ago
  - Few published thermodynamic parameters
  - This study aims to provide more – 4-5 brands, popular models





Energy Savings and Market Potential Analysis

- Balance of the project:
  - Review of national and local codes
  - Survey of plumbers/installers
    - What are still the major barriers?
    - What is their experience with ½” tankless?
    - What are they charging for installations?
  - Updated techno-economic analysis
    - Have paybacks improved?
    - Are the energy savings improved?



Wrap-up

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- Further questions?
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  neea

- GTI Project team:
  - Miroslaw Liszka, Merry Sweeney, Paul Glanville