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Presented by

Demonstration of Unitary HPWH Load Shifting in an Affordable Multifamily Clustered Configuration

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136 page report in 8 minutes… GO!

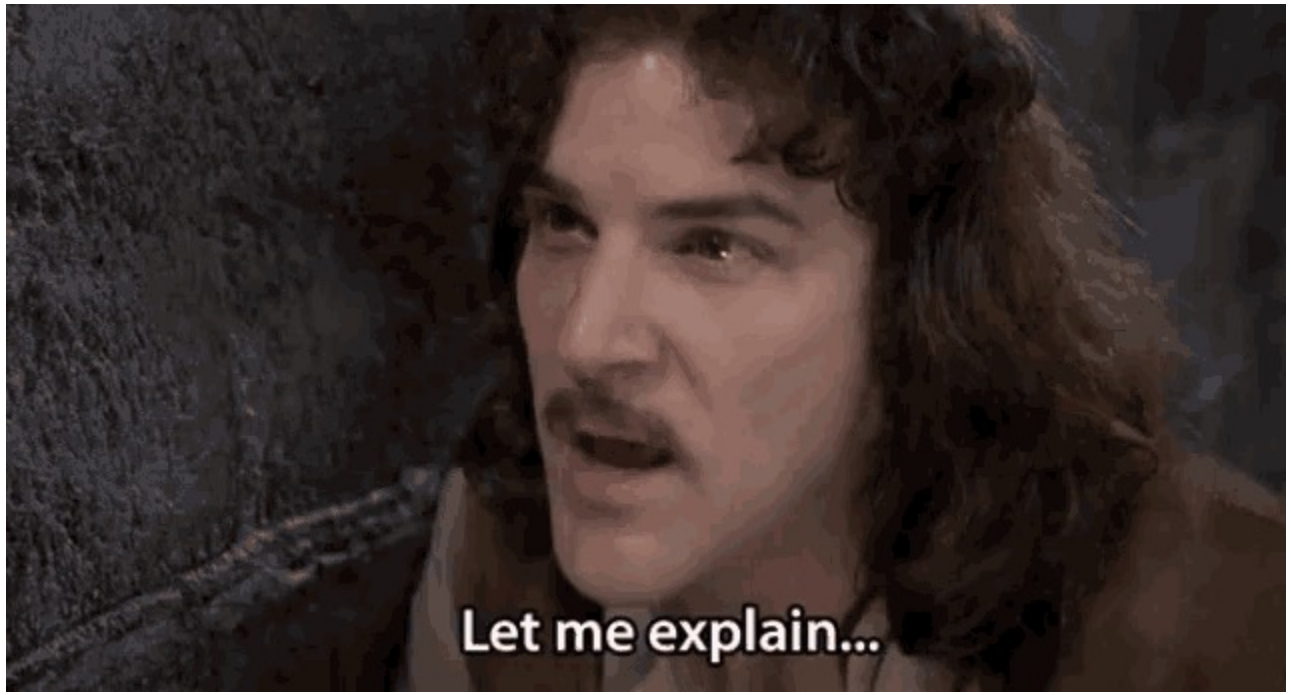

Image Credit: “The Princess Bride”, 20th Century Fox. (1987)

Acknowledgements

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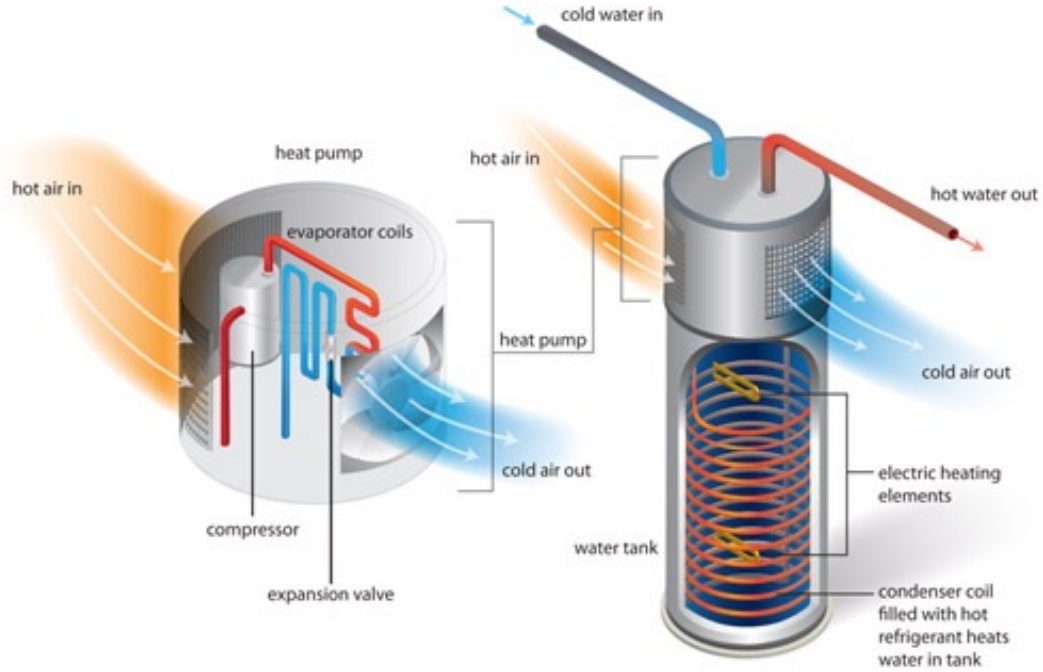
Multifamily HPWH Load Shifting Project

Objectives:

- Demonstrate HPWH load shifting in a central multifamily application.
  - Gather detailed, high-resolution field data at 10 HPWHs over 18-month period.
  - Compare load shifting operation to fixed setpoint.
    - Maximize use of mid-day PV.
    - Minimize on-peak electricity consumption.
    - Minimize resistance heat use for load up period.
- Develop and validate detailed simulation model
  - Publicly available upon project completion.
  - Evaluate annual performance of different control strategies.
  - Estimate annual energy cost, on-peak kWh, and GHG emissions.



Unitary HPWH Schematic
Image Source: EnergyStar

Test Site: Creekside Affordable ZNE Project

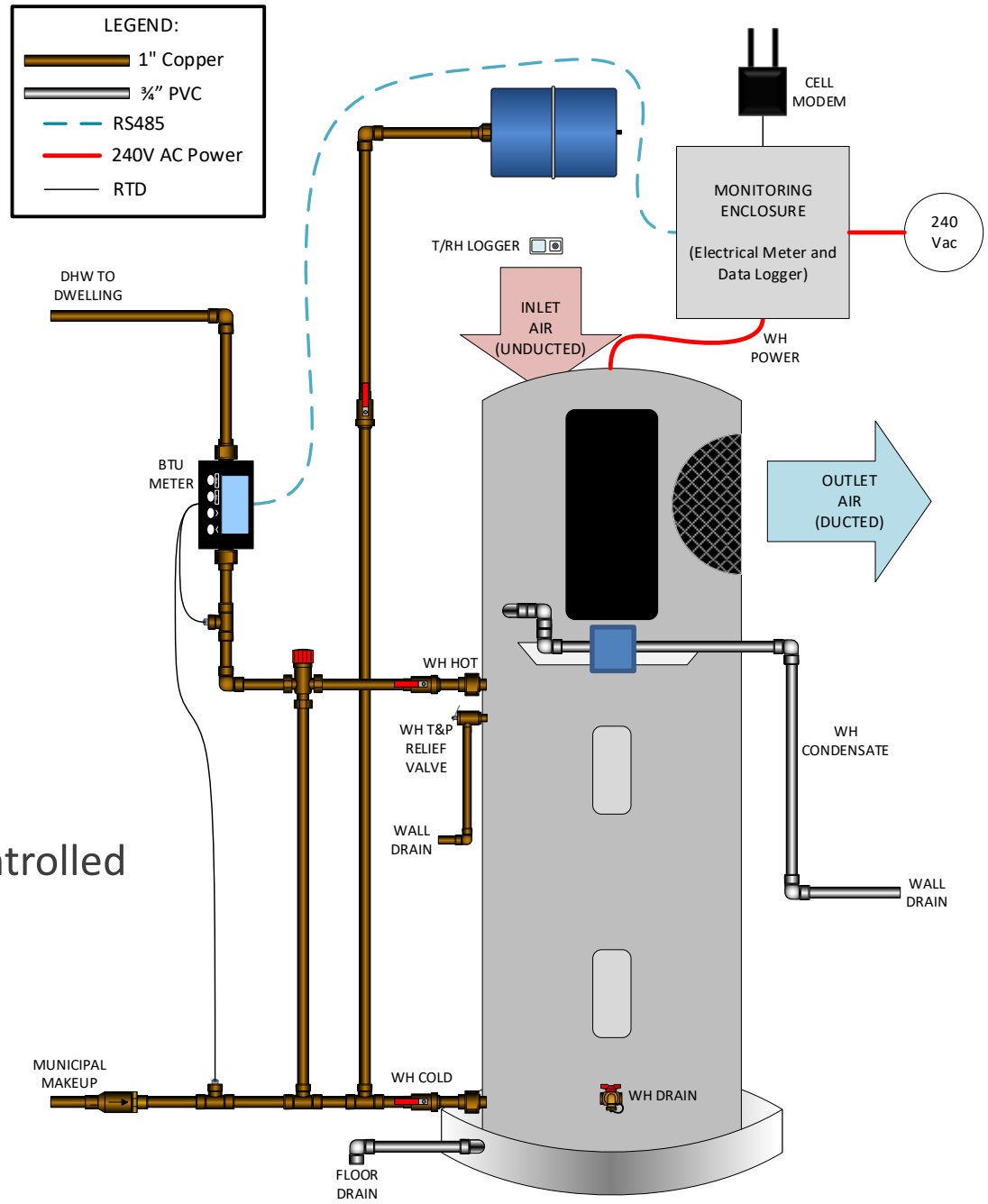
- Creekside is a 90-unit workforce and special needs ZNE housing project in Davis, CA.
- 40% of the units prioritized for disabled individuals and/or homeless.
- HUD Program provides rent subsidies to almost a quarter of the tenants.

"Clustered" HPWH System Design

- Single unitary HPWH serves 4 apartment units.
  - 72-gallon storage (80 nominal)
  - 3.7 UEF
  - 4.2 kBtu HP compressor
  - 4.5 kW electric resistance backup
- Installed in small closet that opens to the building exterior.
- **Advantages:**
  - Reduced first costs.
  - 10% plumbing cost savings over central gas.
  - 12% plumbing cost savings over individual HPWHs.
  - Reduced maintenance and replacement costs.
- **Disadvantages:**
  - Increased chance of hot water runouts.
  - Equipment failure affects more tenants.
  - Likely lower efficiency due to coincident hot water loads.

Monitoring Approach

- 15-second interval data (unless otherwise noted)
- Electrical Consumption:
  - True-RMS Revenue Grade Energy Meter
- Hot Water Use:
  - EN1434 and C900.1 Class 1 Ultrasonic Flow Meter
  - Matched pair of 1 kOhm platinum RTDs
  - BTU calculator with < 0.09% computation error
- Cabinet Ambient Conditions:
  - Wireless T/RH Logger (±0.38°F, ±2%RH)
- Weather Conditions:
  - 1-minute interval data from nearby weather station controlled by Frontier.
- HPWH Operation and Control:
  - Manufacturer Cloud API (logged on status change)

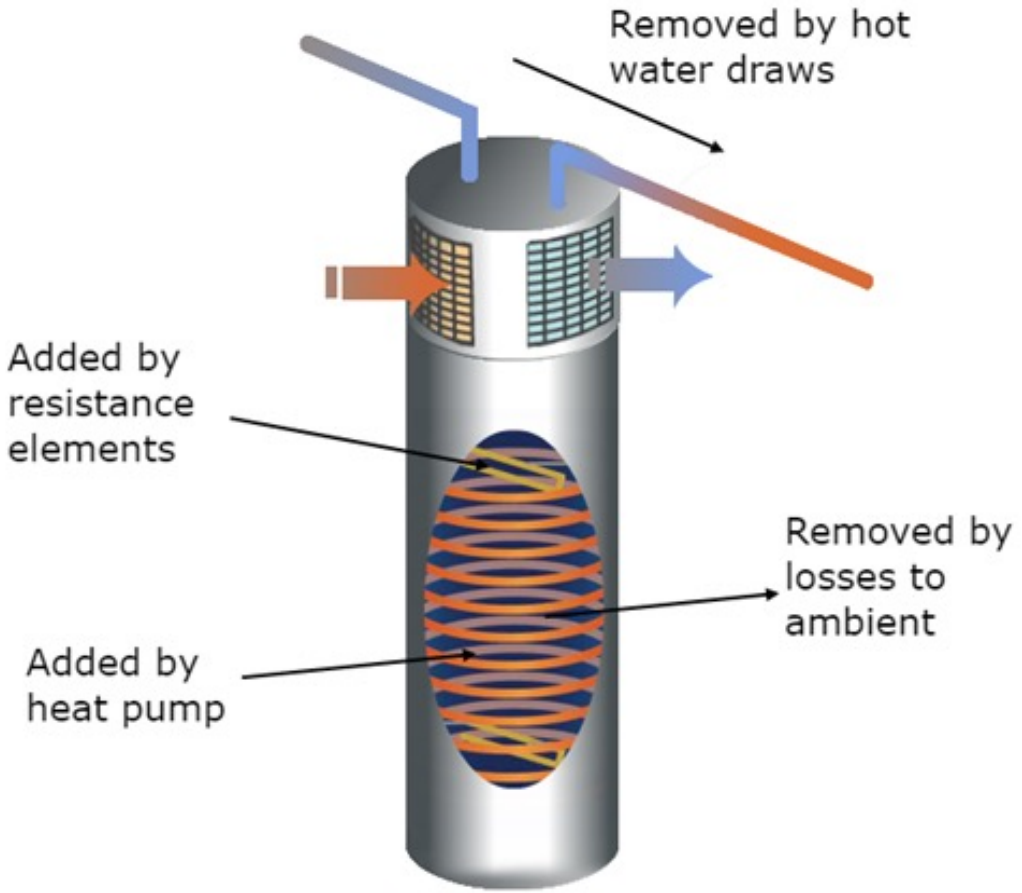


Small Closet Airflow Issues

- Ducting helps address recycled air problem, improving efficiency.
- Small closet performance is important for retrofits and multi-family.
- More to learn more about ducted vs non-ducted performance in Ben Larson/NEEA lab work.
- Ducted fix saves ~14% energy use.

Flexible HPWH Performance Predictor (Flexi-HPWH)

- Features
  - Multiple node tank
  - Water flow through tank
  - Jacket losses
  - Manufacturer control logic
  - Energy added by heating elements
  - COP performance map
  - Easily edited configuration file

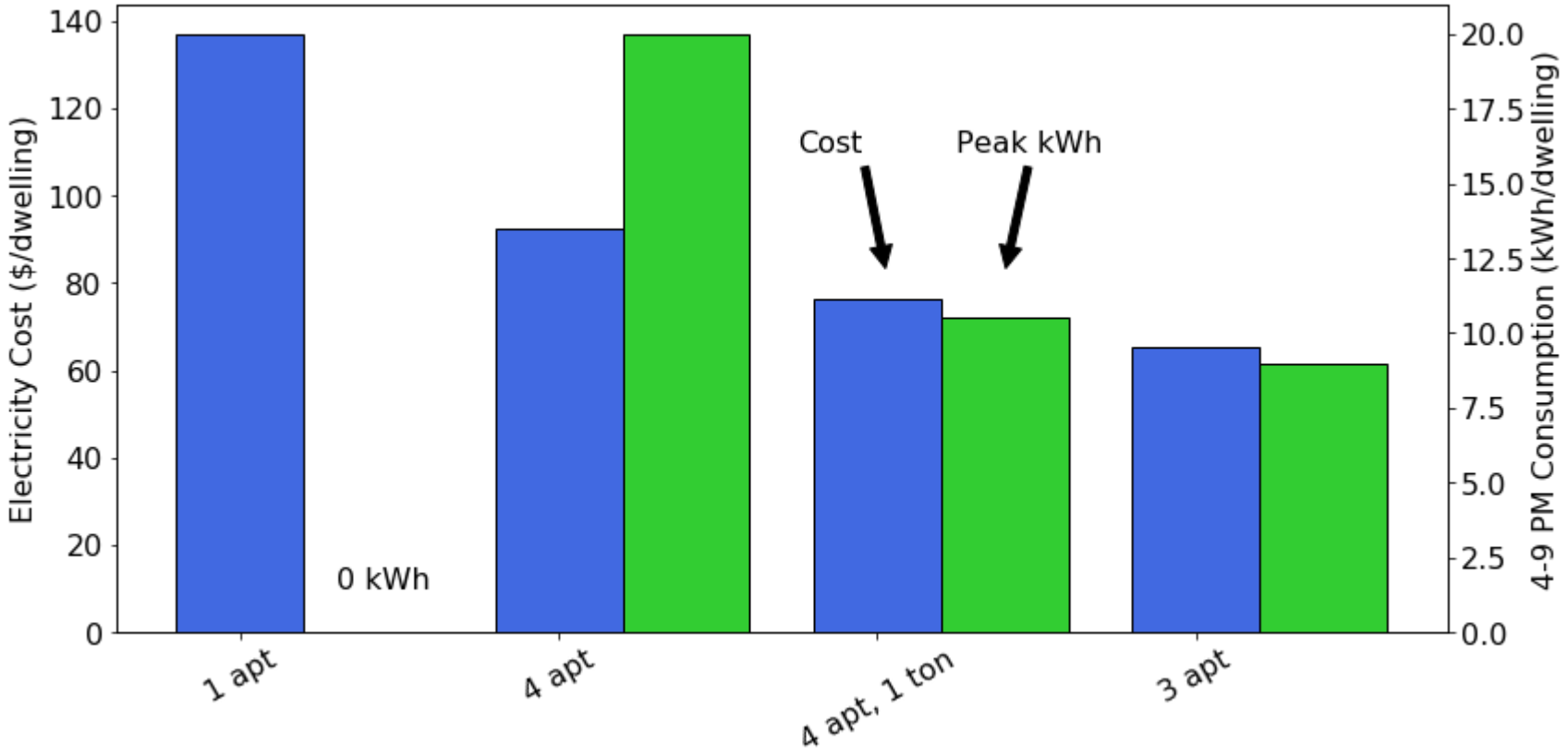


Simulation Goals and Parameters

- Extrapolate monitored findings
  - Annual impacts of fixed set point and load-shifting strategies
    - Peak kWh consumption, electricity cost, carbon emissions
  - Different dwellings/HPWH or HPWH design
    - 4 apt, 4 apt with a 1 ton heat pump, 3 apt, 1 apt
- 3 monitored input data sets
  - Presented simulation results use Medium profile
  - Monitored Davis, CA air and water temperatures
  - Use shared configuration unless specified

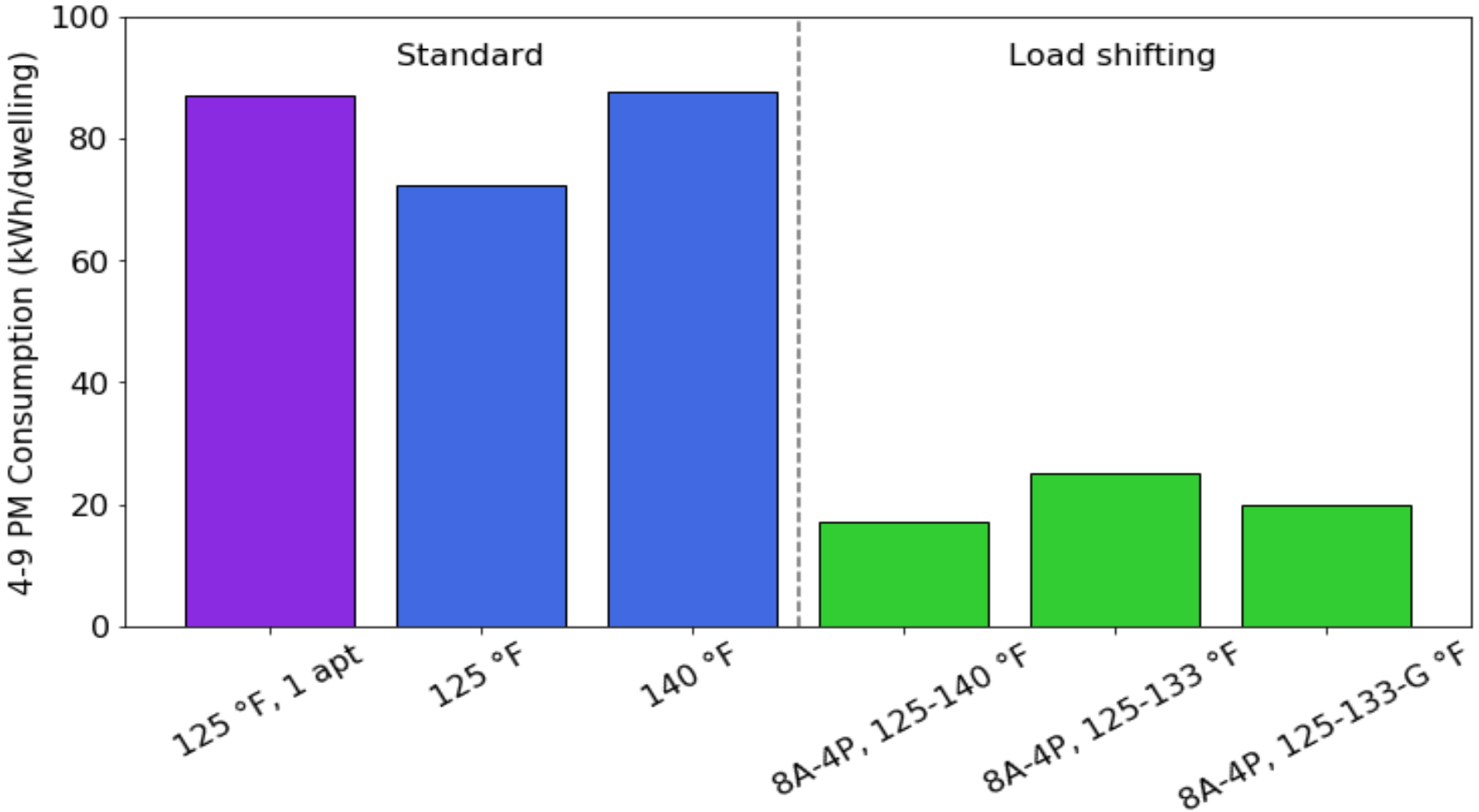
	Low	Medium	High
Daily Average Consumption (gal)	67.4	92.0	119.7
Daily Consumption Standard Deviation (gal)	30.0	44.6	53.6

Simulation Results – Design Changes



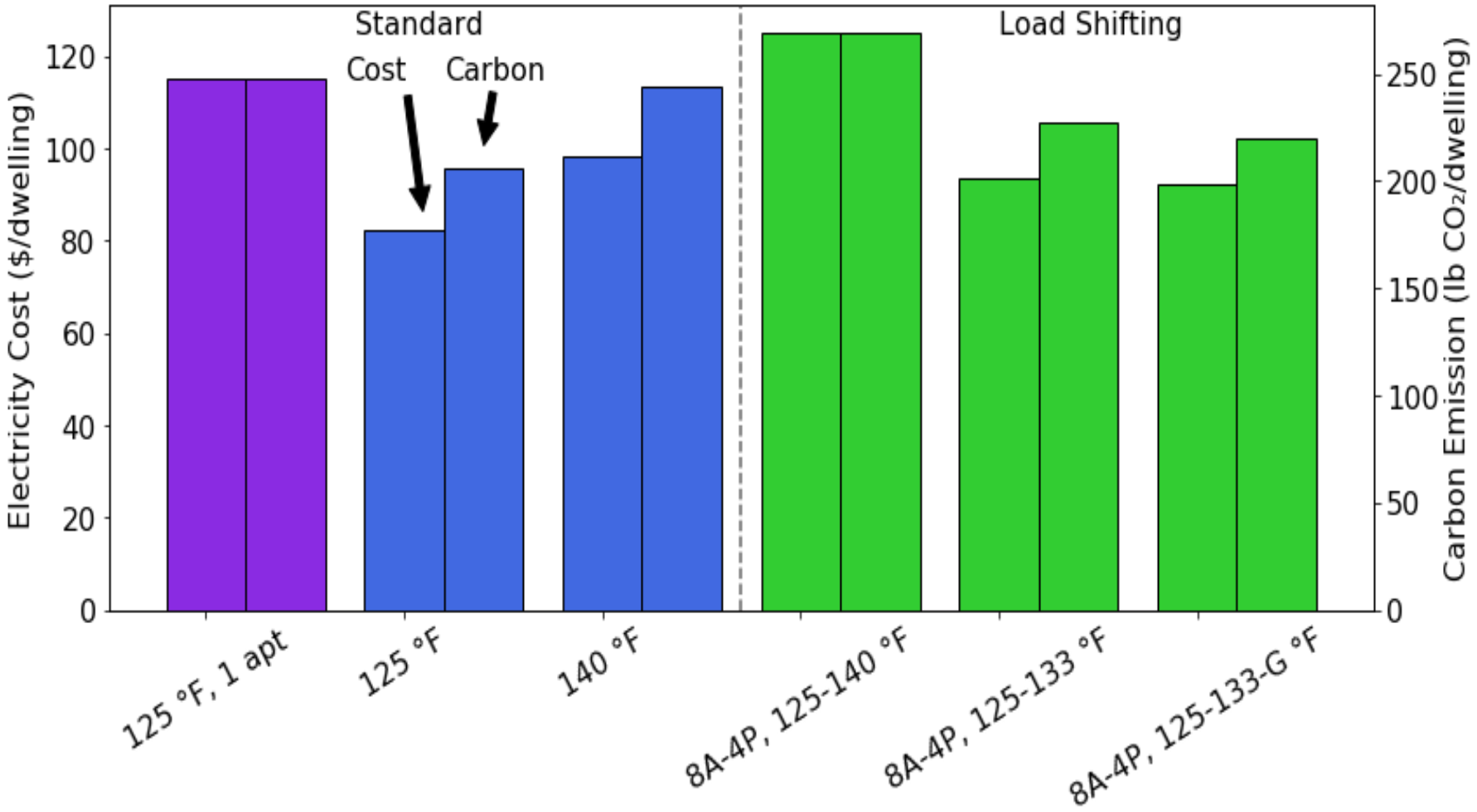
- 8A-4P load-up period
- 1 apt
  - High jacket losses
  - Excellent load shifting
- 4 apt
  - Lower jacket losses
  - Worse load shifting
- 1 ton
  - Less resistance
  - More load shifted
- 3 apt
  - Reduced load
  - Less resistance

Simulation Results – Peak Period Consumption



- 17% savings from sharing
- Load shifting
  - 8A-4P load up period
  - 125-X °F set temperatures
  - G: Gradual set temperature increase
  - 65-81% reduction
  - Gradual increase performs better

Simulation Results – Cost and CO_2



- PG&E TOU-C rates
- CAISO carbon intensity multipliers for monitored period

- Cost and carbon emissions are...worse

Shared v Individual Comparison

- Comparing 80-gal shared to 50-gal individual
- Pros
  - $1,850 savings per apartment
  - 10-32% operating cost savings
  - 16-36% CO_2 emission savings
- Cons
  - More runouts – 9.4% in highly loaded unit!

Questions?

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Flexi-HPWH Model Project on GitHub:

https://github.com/PeterGrant/Flexi-HPWH

Creekside Final Report:

https://www.etcc-ca.com/reports/evaluation-unitary-heat-pump-water-heaters-load-shifting-controls-shared-multi-family