



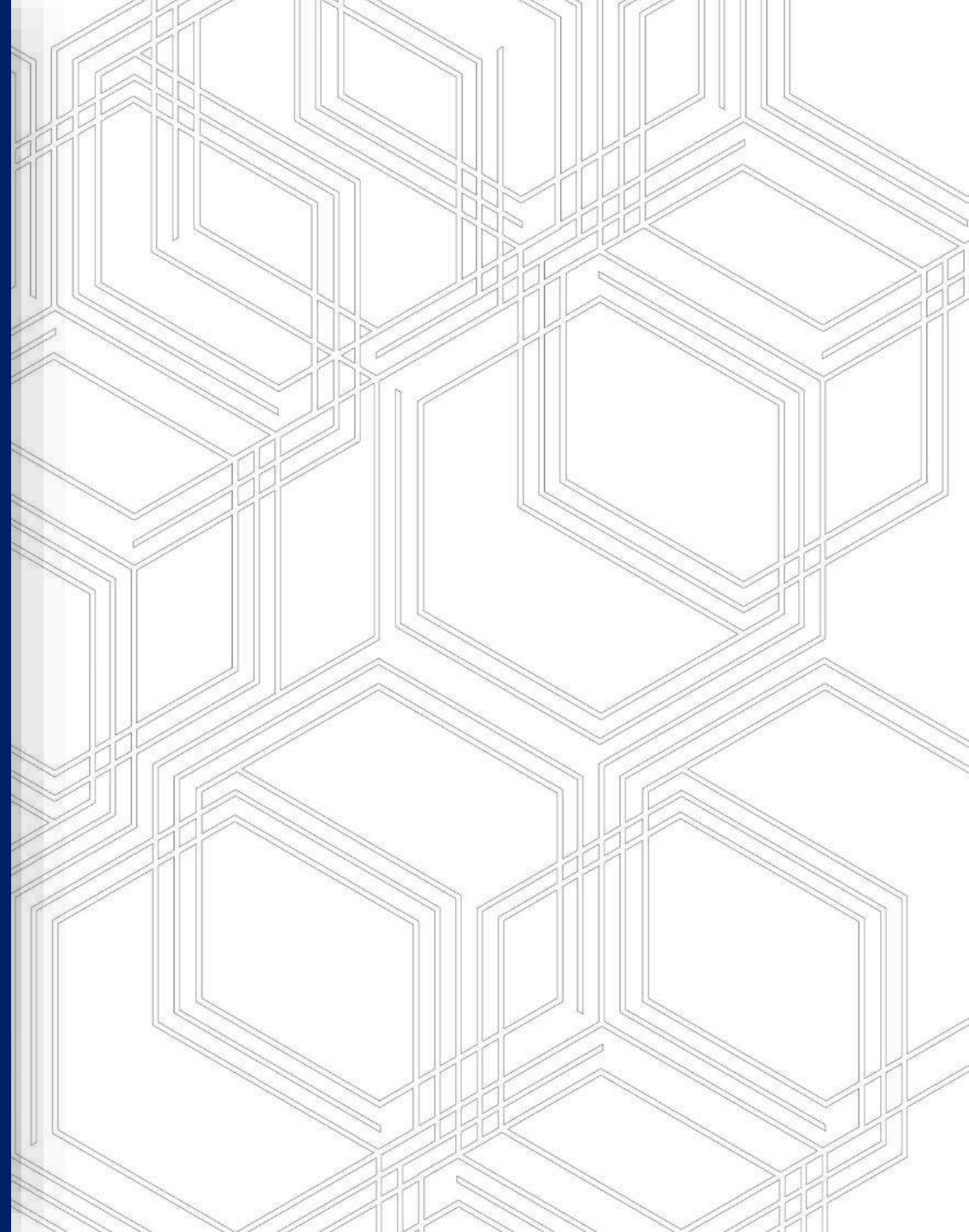
Changing the Paradigm of Window ACs:

Here Come Window Heat Pumps

Technology View

Aaron Tam

Utility Energy Forum
Thursday April 21, 2022



Agenda

- About EPRI
- Field Demonstration of Gradient Window Heat Pump
- Field Demonstration of Innova Heat Pump
- Key Takeaways/Next Steps



Nonprofit

Chartered to serve the public benefit, with guidance from an independent advisory council.



Thought Leadership

Systematically and imaginatively looking ahead to identify issues, technology gaps, and broader needs that can be addressed by the electricity sector.



Independent

Objective, scientific research leading to progress in reliability, efficiency, affordability, health, safety, and the environment.



Scientific and Industry Expertise

Provide expertise in technical disciplines that bring answers and solutions to electricity generation, transmission, distribution, and end use.



Collaborative Value

Bring together our members and diverse scientific and technical sectors to shape and drive research and development in the electricity sector.

120V Inverter Driven Window Heat Pumps

Gradient

- Installation bracket for easy setup
- R-32 refrigerant with water glycol loop
- Reduced noise levels
- Mobile app control and schedule



<https://www.gradientcomfort.com/>

Innova

- Monobloc form factor for easy install
- R-32 refrigerant
- Aesthetically appealing design
- Requires 2 small holes in wall (~6 in)



<https://www.innovaenergie.com/en/products/air-conditioning-without-outdoor-unit/2.0-verticale/>



Field Demonstration of Gradient Heat Pump

Project Overview

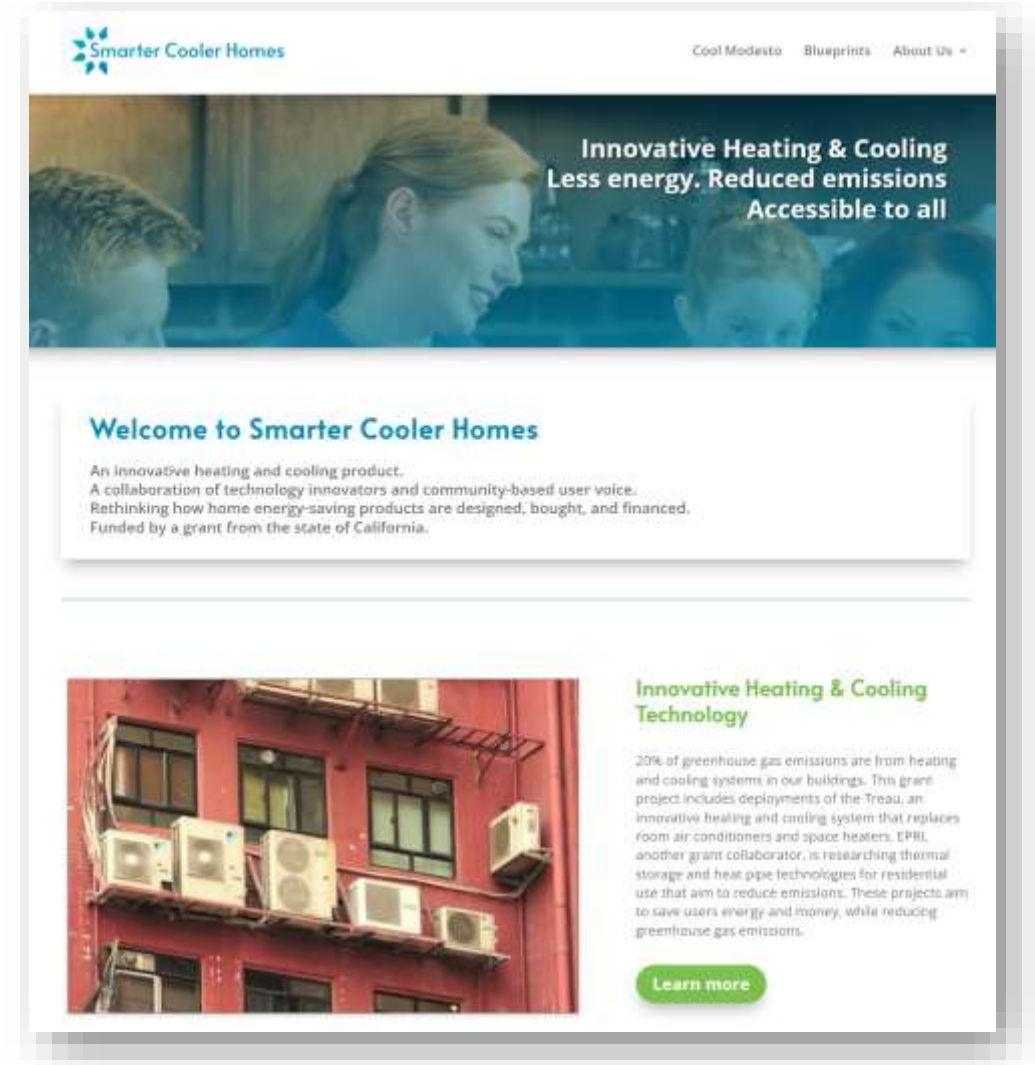
- Innovative Low GHG Residential Space Conditioning Technologies
- CA Strategic Growth Council (Climate Change Research Program # CCR20013)
- Project Partners:
 - Gradient (Technology Provider)
 - GLYNT.AI (Community Engagement Partner)

Objectives

- Demonstrate an easy-install window heat pump with low-GWP refrigerant in low income and disadvantaged communities (Modesto)
- Develop blueprints of customer purchase journey and digital energy engagement

Project Status

- Phase 1 in Modesto
 - Performed six 2-hour residential home visits
 - Tested installation and removal process (vertical and horizontal-sliding windows)
 - Collected homeowner feedback
- Phase 2 in Modesto
 - Install 12 units of beta Gradient units from Spring 2022-Summer 2022
- Developing blueprint on “Credit Building with Utility Payments program”
- Compared national and regional surveys on customer purchase journey for limited income households



Community Outreach - <https://smartercooler.homes/>

Technology Specifications

Dimensions

| Indoor unit | | Outdoor unit | |
|-------------|-------|--------------|-------|
| Height: | 24 in | Height: | 24 in |
| Width: | 24 in | Width: | 24 in |
| Depth: | 8 in | Depth: | 15 in |

Weight

| Indoor unit | Outdoor unit |
|-------------|--------------|
| 50 lbs | 90 lbs |




Noise

High/Medium/Low: 53/49/43 dB



Window compatibility

For single hung or double hung windows only. Check if it fits.

Features

-  Mobile app control
-  Scheduling
-  1-year limited parts & labor warranty

Modes


-  Cooling
-  Heating
-  Fan-Only
-  Boost-mode

Cooling power

9000 BTU/hr

Heating power

8000 BTU/hr

 Contact us for more details

Energy efficiency

10.8 CEER



<https://www.gradientcomfort.com/>

Modesto Phase 1 Highlights

- Evaluated various building designs ranging from mobile homes to traditional houses
 - Potential hazards with old house wiring (improperly grounded outlets)
 - Animal hazards for cables (mice, etc.)
 - Certain building constructions may not be able to handle weight of unit
 - Window heights, frame sizes, sliding mechanisms can differ



Community Outreach

- Will LMI households be able to participate in the upcoming energy transition?
- It depends on the local economics of energy decisions
 - Costs of purchases
 - Savings from purchases
 - Financing available for up-front costs
 - Credit capacity to undertake financing
- Modesto area residents seek information at the utility website during their buying journey



The frontlines of energy equity are in payments and financing



Field Demonstration of Innova Heat Pump

Project Overview

- Developing customer-centric approaches to decarbonization retrofits with Integrated Demand-Side Management
- California Energy Commission (CEC) EPC 15-053
- Project Partners:
 - LINC Housing (Affordable Housing Provider)
 - Itron (M&V)
 - Innova (Technology Provider)

Objectives

- Understand the efficacy of packages of envelope, electrification, and on-site renewable measures on decarbonization in affordable multifamily housing
- Develop an understanding of the impact of measures on various stakeholders including community residents, affordable housing developers, electric & gas utilities, and policy makers

Host Site Information

- Pleasant View at Fresno, CA is a 60-unit master-metered affordable housing community with 1, 2, 3, and 4 BR units
- Each unit had individual swamp cooler and gas furnace











Retrofit Challenges

- Distribution infrastructure upgrades required to electrify space conditioning (w/mini-splits) and water-heating
- 120V window heat pumps were used along with centralized CO2 water heaters



Technology Specifications

| | | | |
|------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
|  |  |  |  |
| <p>"Cooling only" and "heat pump" in the same model</p> | <p>DC Inverter and Dual Power with optimized power and reduced consumption</p> | <p>The installation accessories (mounting template, support bracket, pipes for the holes, external grilles) are contained in the package</p> | <p>Holes in the facade of only 162 mm</p> |
|  |  |  |  |
| <p>Folding external grids</p> | <p>No-Frost system</p> | <p>Almost invisible, inside and outside</p> | <p>WiFi connections for remote control</p> |



| | |
|--------------------|------------------|
| Cooling Capacity | 0.66 Ton |
| Heating Capacity | 8050 BTU/h |
| EER | 11 BTU/Wh |
| COP | 3.28 |
| Dimensions (WxHxD) | 40.5"x21.8"x5.6" |
| Weight | 106 lbs |

Fresno Field Demonstration

- 1 Innova in living room
- 1 Innova in master bedroom (2-4 bed)
- 1 Innova in 2nd bedroom (3-4 bed)
- Living room unit on its own circuit, bedroom units are shared with other loads.



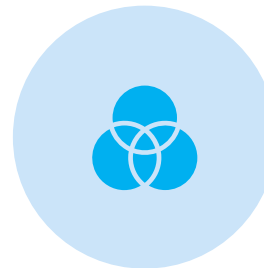
How do Innova Heat Pumps perform relative to swamp coolers and gas wall furnaces?



What is the HVAC load shape as a result of Innova Heat Pumps?

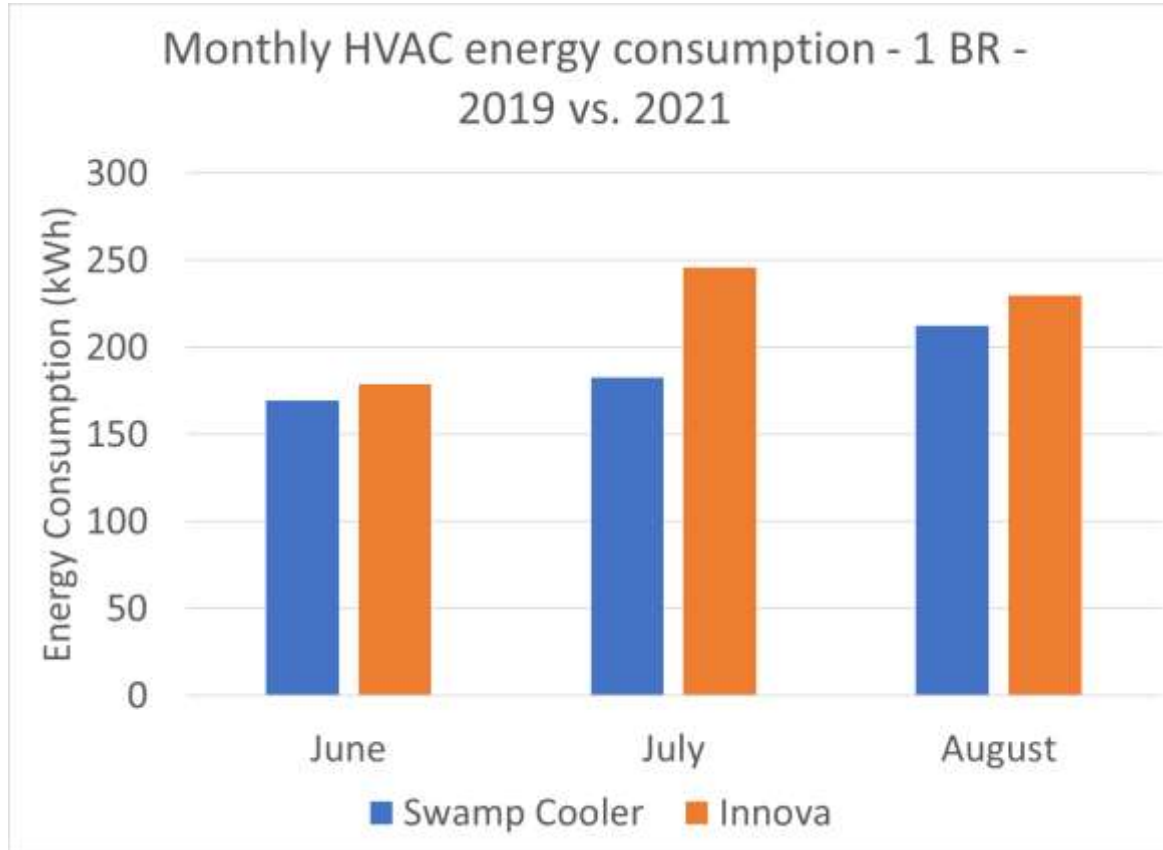


Are multiple Innova heat pumps per living unit a significant concern for the building's electrical capacity?

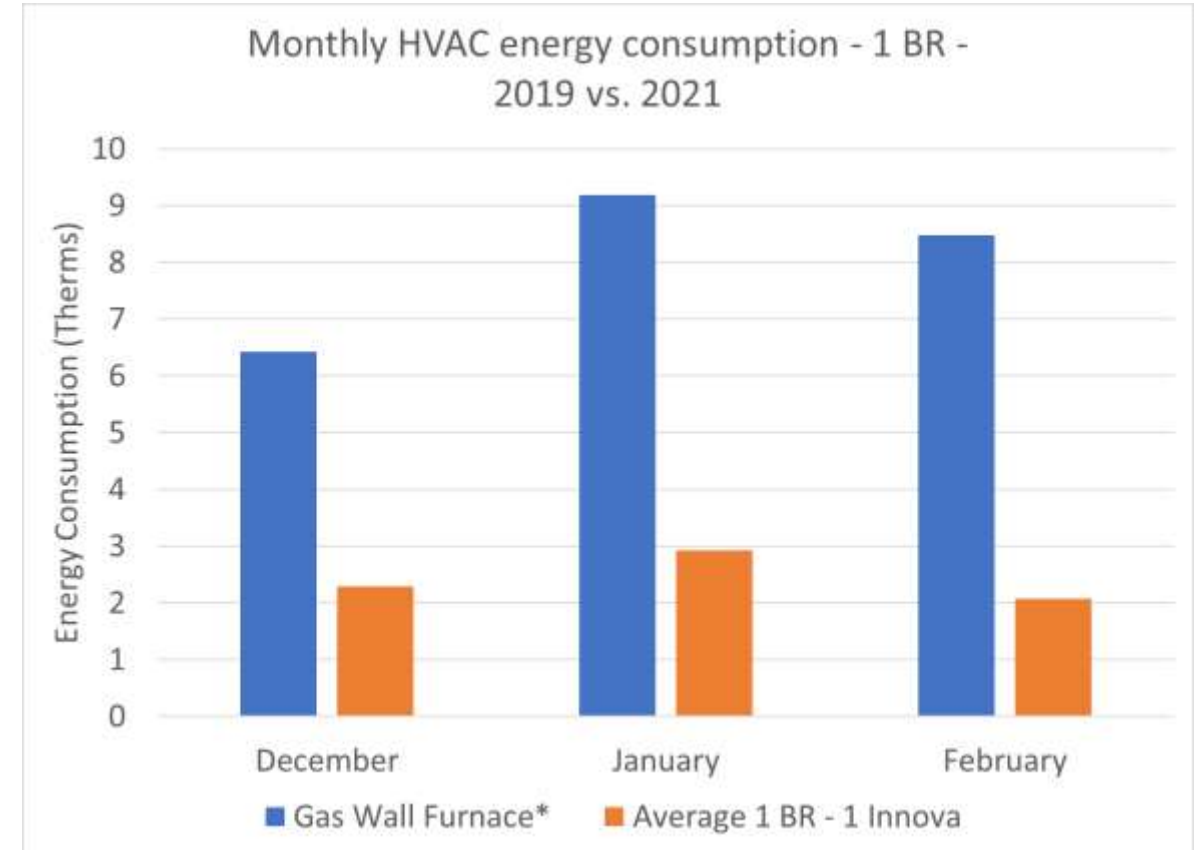


How are Innova units in different rooms used differently?

Energy Performance Comparison to Swamp Cooler – 1 BR

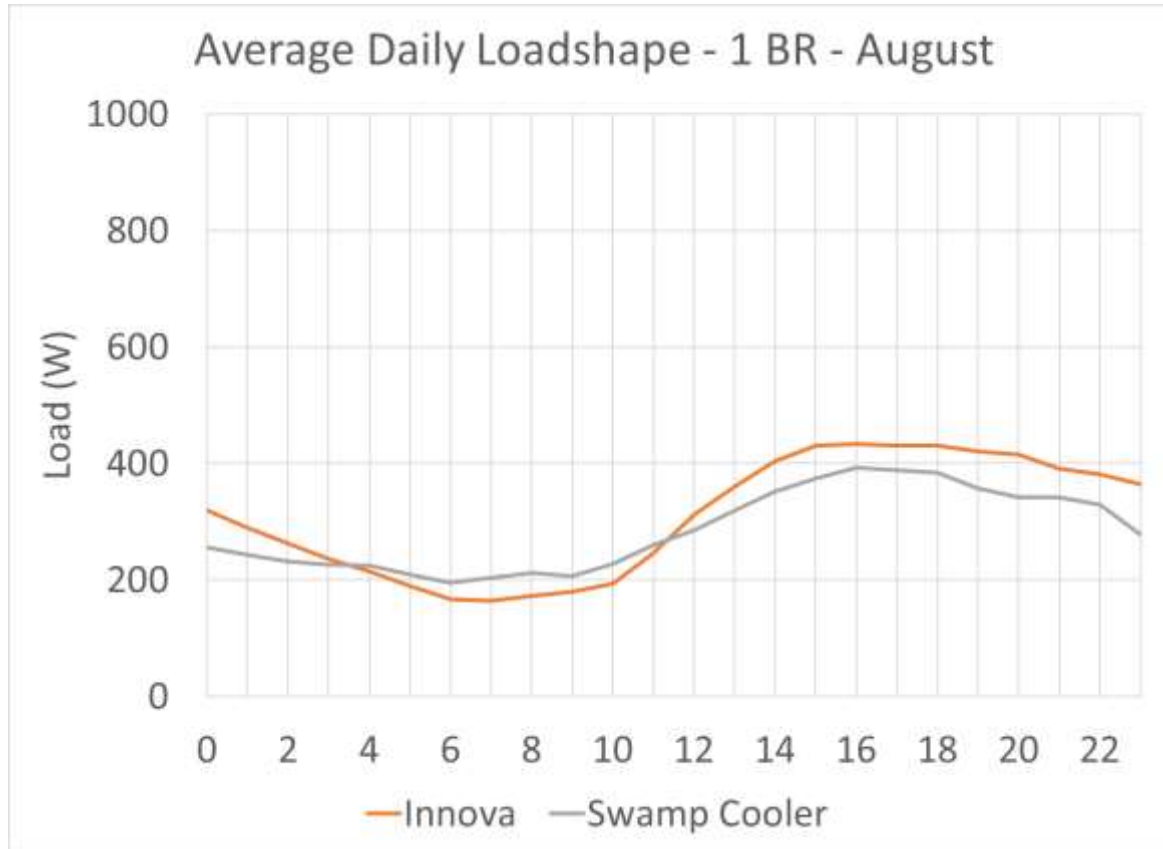


- Innova energy consumption is slightly higher
- Higher energy use is largely driven by increased cooling needs in 2021 compared to 2019
 - Higher degree cooling days and COVID remote work

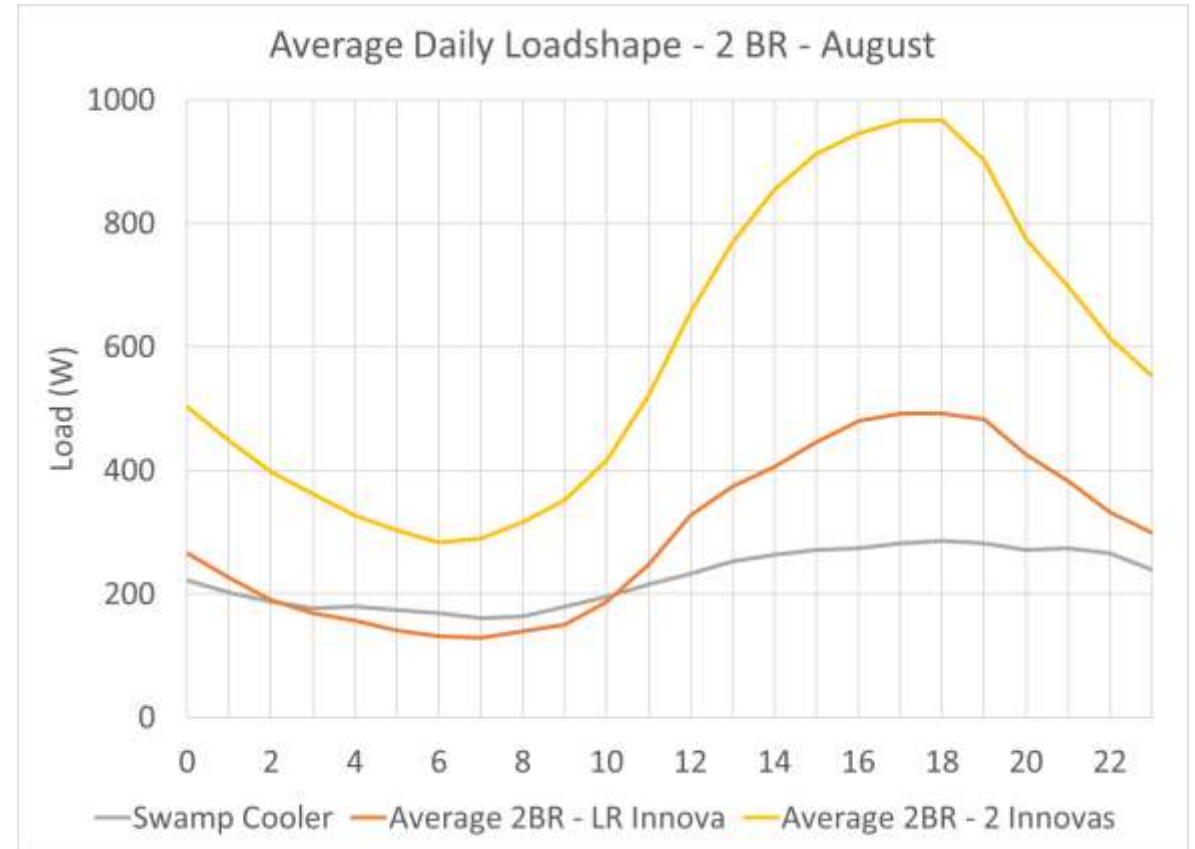


- Innova energy consumption is significantly better than gas wall furnace
- Significantly better performance may be attributed to envelope improvements in the community.

Load Shape Comparison to Swamp Cooler – 1 BR & 2 BR

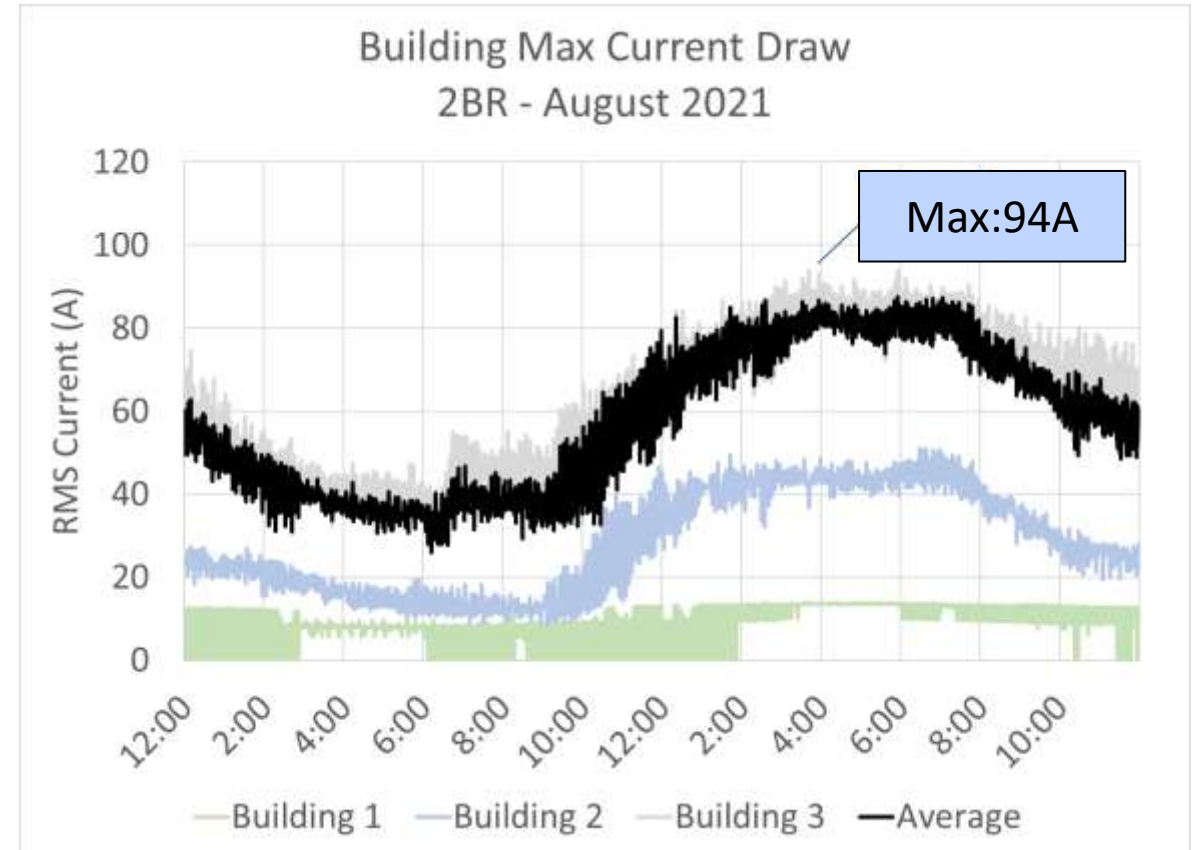
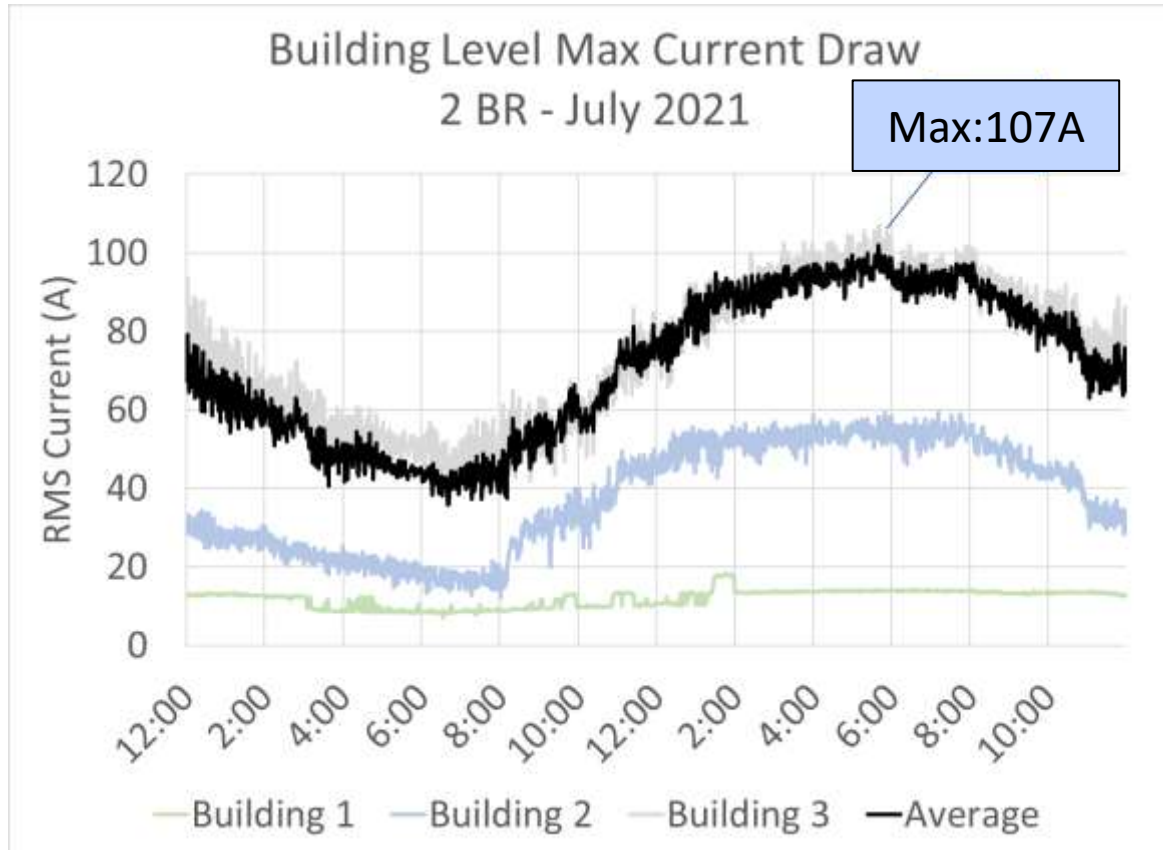


- Living Room Innova performance is similar to swamp cooler
- Inverter-based operation allows lower power during times of lower need



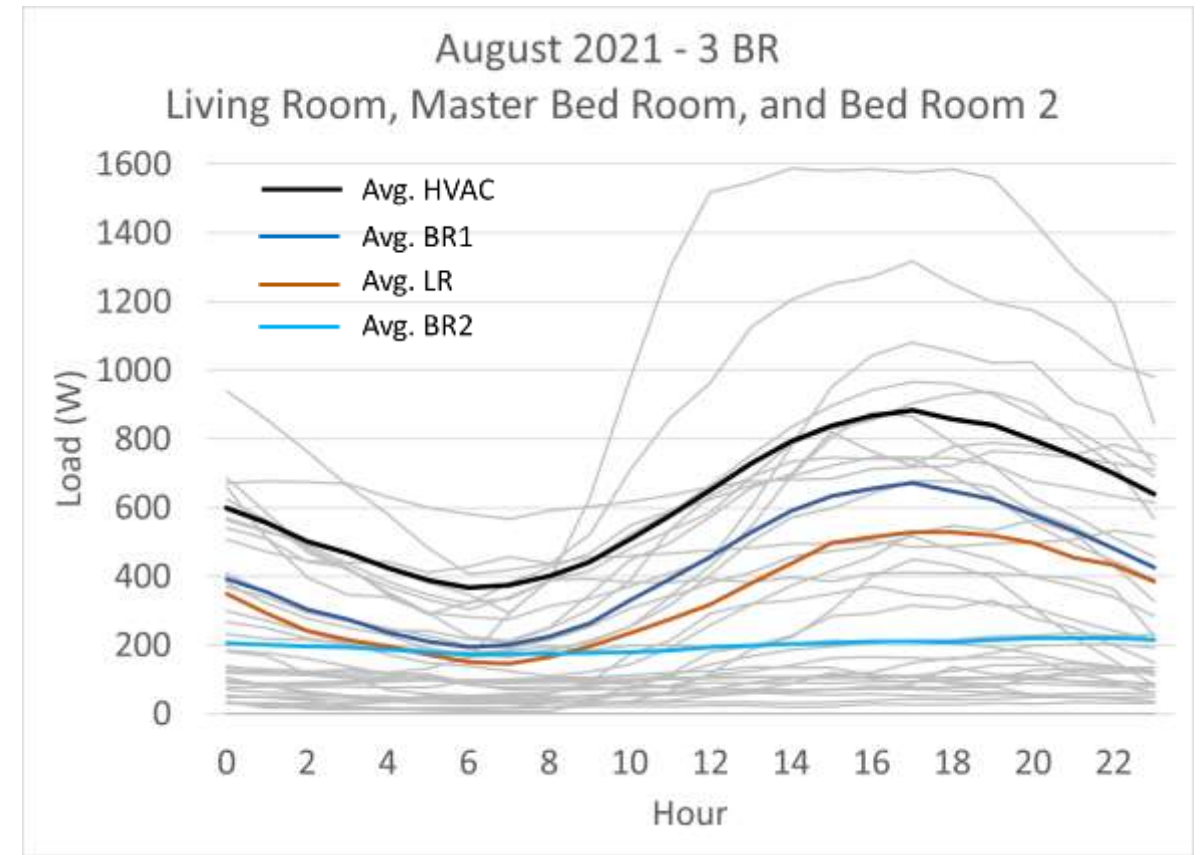
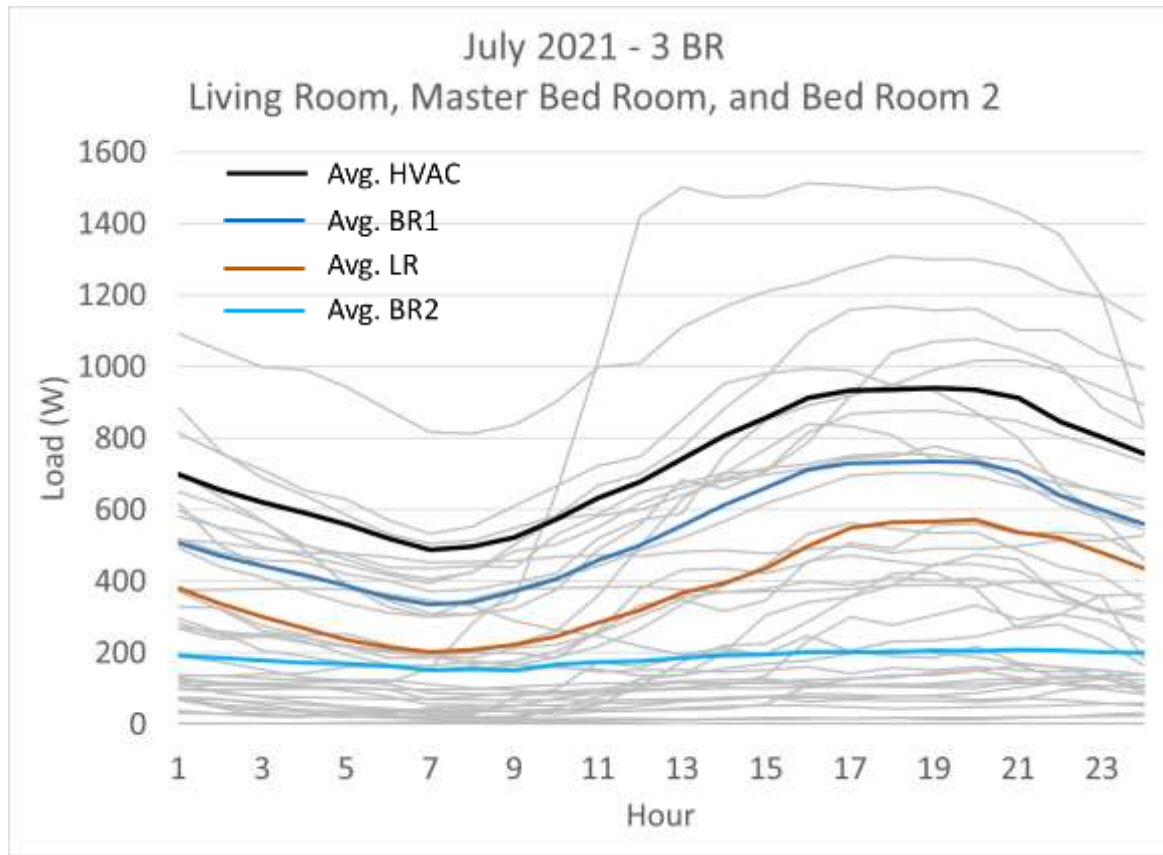
- There is considerably higher HVAC use when 2 units are installed
- Potential for coincident living room and bedroom unit usage

Is coincident use of multiple Innova units a cause for concern?



- Max current draw with multiple Innova units averages out ~ 7.5A per Innova
- At a max of ~ 7.5A per Innova, the use of 2nd unit is not likely to cause CB to trip unless there are other high current loads on the same circuit.

How does use of Innova vary between different rooms?

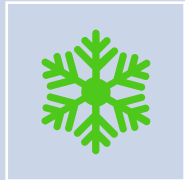


- Significant differences in use of Innova units between different rooms and between different living units
- Living and Bedroom units follow a similar load shape although BR1 consumes more energy – BR1 has largest fenestration area.
- BR2 usage is much lower than BR1 and LR – BR2 is smaller than BR1

Observations and Recommendations



The results indicate the potential for Innova to be a viable solution for retrofits in affordable housing given the significant reduction in winter energy consumption compared to moderate increases in summer.



There were a few cases where high overall usage (arising from low thermostat set points) caused maintenance issues. The product supports a “hoteling” mode that can help prevent extreme set points from causing maintenance issues especially in master-metered facilities



With a peak usage around 700W and an average around 400W, there is about 300W in flexibility potential per unit provided a suitable controls platform is available to aggregate and implement demand side flexibility measures for TOU management and/or demand response.

Next Steps

Gradient

- Field demonstration preparations in Modesto, CA to evaluate performance and gather customer feedback
 - Pre-commercial (Phase 2): 12 units
 - Commercial unit (Phase 3): 100+ units
- Comprehensive evaluation in EPRI Thermal Labs to determine suitability for utility programs



<https://www.gradientcomfort.com/>

Innova

- DOE Connected Communities project in Seattle to study load flexibility potential
 - 250 Innova units in 150 residential units
- Comprehensive evaluation in EPRI Thermal Labs to determine suitability for utility programs



<https://www.innovaenergie.com/en/products/air-conditioning-without-outdoor-unit/2.0-verticale/>

A blue-tinted photograph of four people standing in a row. From left to right: a man with glasses and curly hair in a white lab coat; a man with glasses in a white lab coat; a woman wearing a white hard hat and a dark polo shirt; and a man with glasses and a beard in a light-colored button-down shirt. They are all looking towards the camera with slight smiles.

Together...Shaping the Future of Energy™