

ET Summit 2019

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Next Generation Residential Space Conditioning System for California

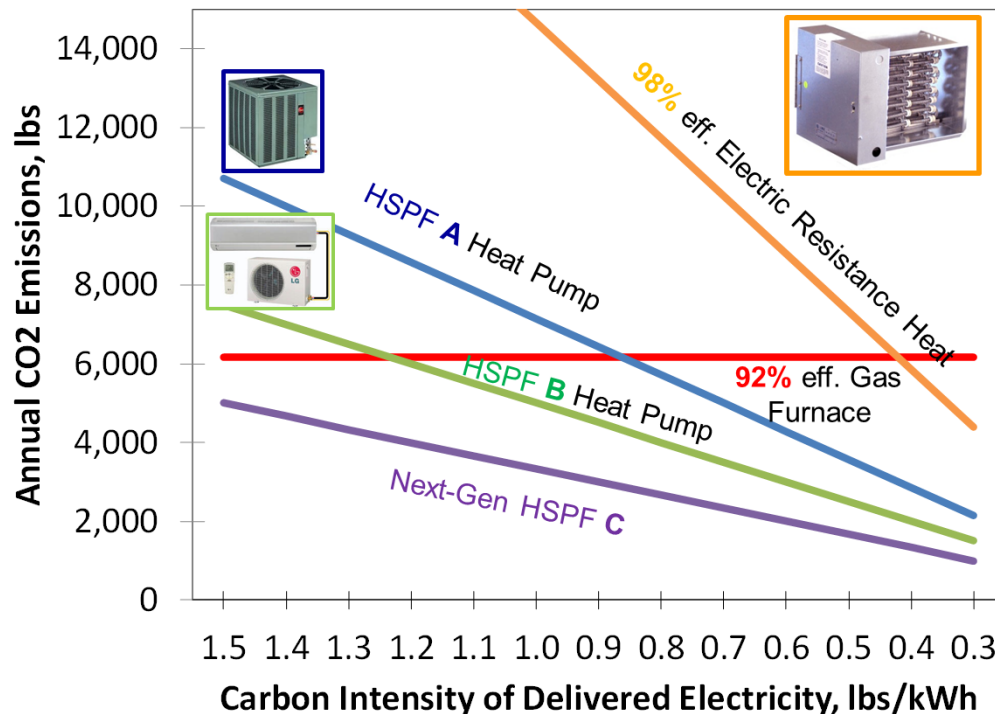
CEC EPIC Project EPC-14-021

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Sr. Technical Executive

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Heating with Heat Pumps – Decarbonization Opportunity

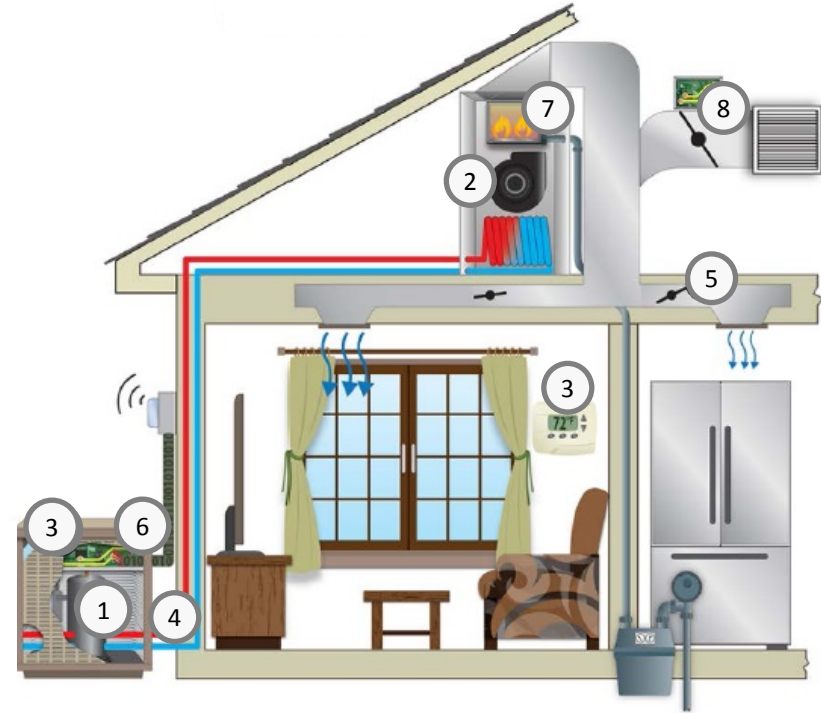


Next Gen HP System – Potential of Meeting Non-Attainment Goals

CEC EPIC Project: Next-Generation Space Conditioner (Variable Capacity Heat Pump System)

multiple energy efficiency features integrated into single system

1. Variable Capacity Compressor
2. Variable Speed Indoor Blower
3. Auto Demand Response
4. Alternative Refrigerant
5. Zonal Control
6. Fault Detection & Diagnostics
7. Dual Fuel (Intelligent Heating)
8. Integrated Ventilation Control



Daikin/Goodman residential heat pump units undergo testing at EPRI Thermal Laboratory, PG&E Applied Technology Services, and UC Davis Western Cooling Efficiency Center



Indoor Unit Setup at PG&E



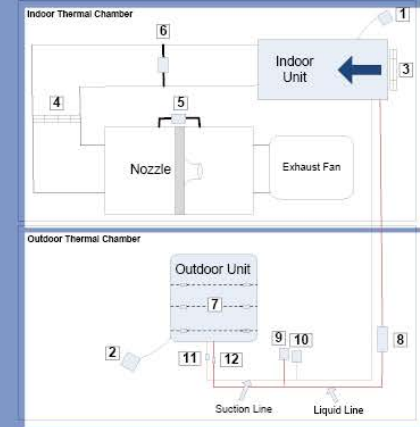
EPRI Thermal Lab Environment Chambers



Outdoor Unit



Ductwork Setup in WCEC Testing Chamber



Schematic of Test Setup

Laboratory Evaluation: Phase 1 and Phase 2

Field Installation: Host Sites

PG&E site
Sacramento
Climate Zone 12



SCE site
Chino Hills
Climate Zone 10

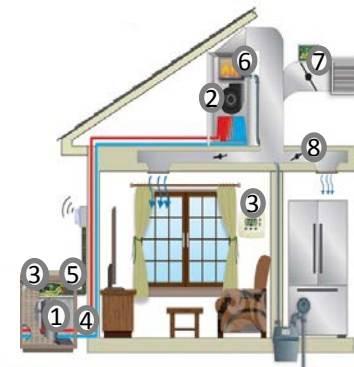


SDG&E site
San Diego
Climate Zone 7



Project Summary Results

- **Variable Capacity Compressor and Variable Speed Indoor Blower**
 - Next-Gen RSCS provides 22-32% cooling energy savings and over 90% of annual heating load without backup for CA.
- **Auto Demand Response (DR)**
 - Variable capacity heat pump maintains customer comfort during DR event.
- **Alternative Refrigerant**
 - R-32 improves cooling efficiency by 2-3% and peak demand reduction by 7-8% compared to R-410A across CA climate zones.
- **Zonal Control**
 - Zoning should be required for variable capacity heat pumps *with ducts in unconditioned space*.
- **Fault Detection and Diagnostics (FDD)**
 - Inform maintenance alerts to avoid inefficient operations. High energy reductions possible.
- **Integrated Ventilation**
 - Additional 1-4% cooling energy savings and 1% for heating using VCHP with heat recovery ventilator (HRV).
- **Dual Fuel (Intelligent Heating)**
 - Dual fuel functionality adds system versatility for future intelligent heating capability.

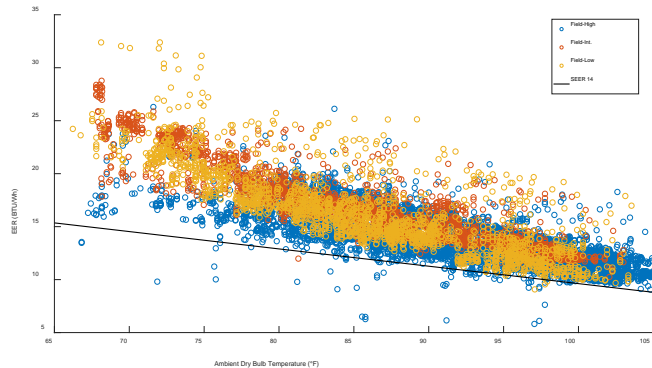


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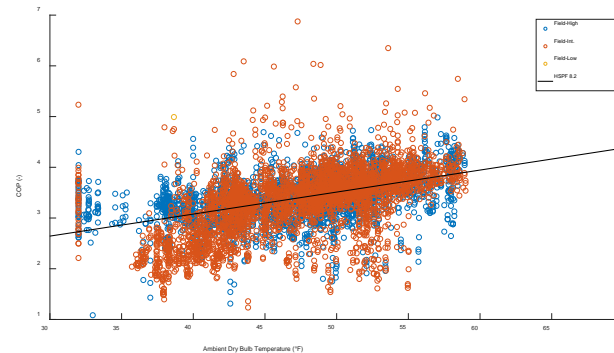
Heat Pump Evaluation Results

- Variable Capacity Compressor and Variable Speed Indoor Blower

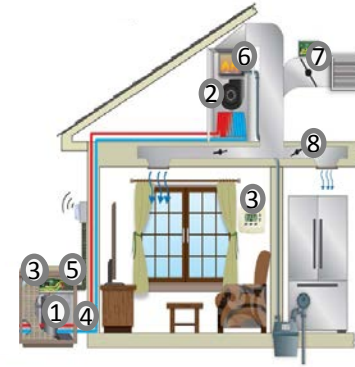
Variable capacity heat pump (SEER 21/HSPF 9.6) field data shows **efficiency improvements** over baseline (single speed SEER 14/HSPF 8.2)



Unit cooling efficiency results @ PG&E site



Unit heating efficiency results @ PG&E site



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Next-Gen RSCS provides 22-32% cooling energy savings and over 90% of annual heating load without backup for CA

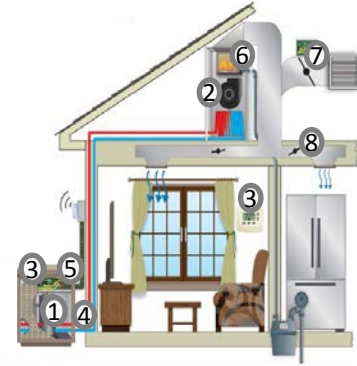
Alternate Refrigerant Testing Results

- Alternative Refrigerant tested at EPRI lab (awaiting EPA approval)

R-32 (GWP 675)

*Effective drop-in refrigerant in a Variable Capacity Heat Pump (VCHP)
compared to R-410A (GWP 2100)*

- R-32 reduced system charge by 29%.
- R-32 improved cooling performance by 1.2 - 3.0%.
- R-32 provided peak power reduction of 6-8% at 95- 115°F.
- R-32 increased heating capacity by 5% at 25°F and by 10% at 62°F.



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Lower GWP refrigerant improves energy efficiency
Lower GWP refrigerant reduces refrigerant charge

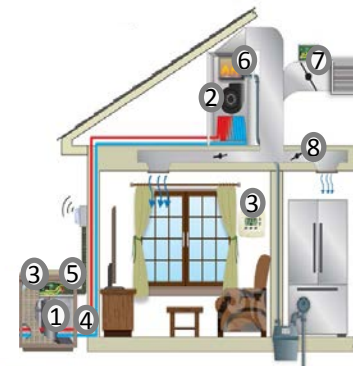
Dual Fuel Heating Capability

- **Dual Fuel Heating**

means electric variable capacity heat pump with natural gas furnace for back up

- Key Metrics to Assess:

- **Breakeven temperature:** *Temperature below which it is cheaper to provide heat with natural gas*
- **Balance point:** *Temperature below which heat pump can no longer provide all the heating requirements of the space*



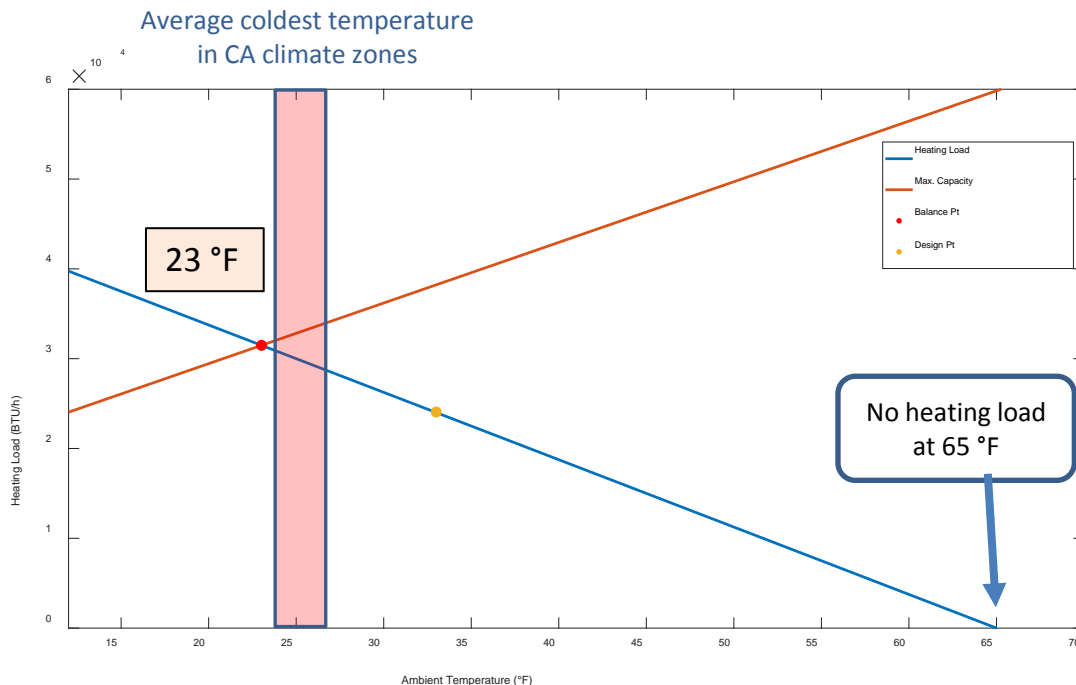
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Dual fuel functionality adds versatility to Next-Gen HP system to provide intelligent heating capability in the future

Dual Fuel Heating Capability

Design Point for PG&E site

Outdoor Temperature	33°F
Indoor Temperature	70°F
Heating Load	24,000 Btu/h

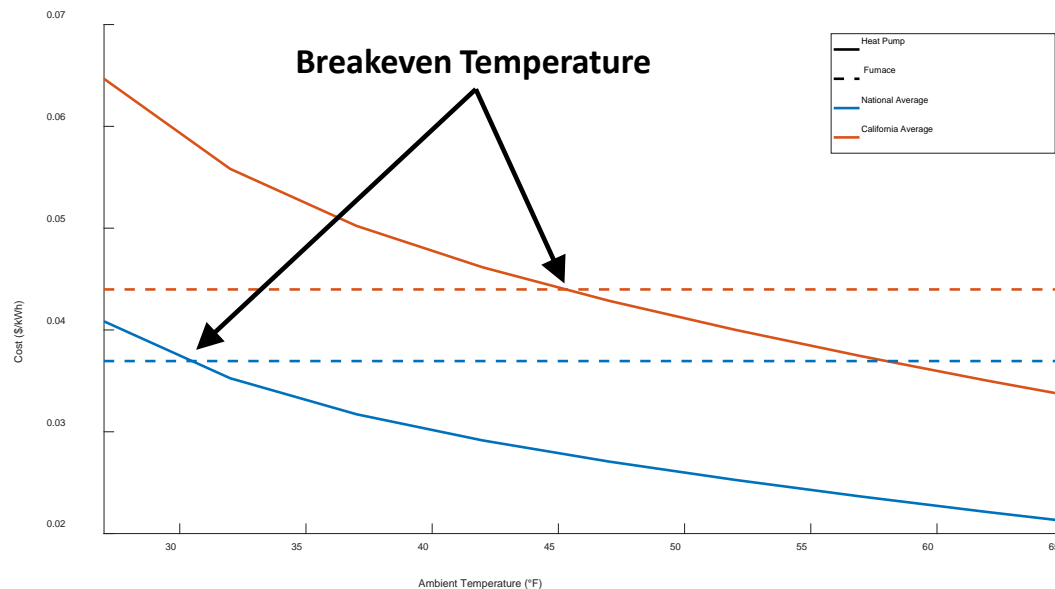


Heat pumps are well suited for CA climate zones since they can meet almost all loads in the heating season *without backup*

Dual Fuel Heating Capability – Continued

Utility Rates Information

	Electricity [\$ /kWh]	Gas [\$ /thm]
California Average	0.19	1.25
National Average	0.12	1.05



Utility rates are **primary drivers** for incentivizing heat pump usage

Homeowner's Feedback

- Homeowners appreciate how much quieter the Next-Gen HP System operates compared to previous single speed AC unit
- Homeowners like how quickly it cools or heats the space
- Homeowners like having app-based controller with Thermostat to turn on specific zones
- Homeowners like the ability to control temperatures in individual spaces (control zones independently)
- Zonal control added complexity to the system use
 - Airflow was too forceful in certain zones, thus noisy in certain rooms
 - Adjusting weighting of the zones with Zonal Control board mitigated this effect

Some Thoughts

- Variable capacity heat pumps are here today
- Higher efficiency during cooling
- Can meet most heating climates in Western USA
- Other advantages – Customer comfort, zoning, FDD, etc.
- Can be combined with gas heating for colder climates
 - Electricity and gas rates drive customer behavior

Thank you!

Together...Shaping the Future of Electricity

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Back up Slides

Climate Zone Impact: Modeled Equipment Performance

CA Climate Zone	City	Annual Energy Savings for Cooling Season
1	Arcata	-
2	Napa	32.3%
3	Oakland	25.5%
4	San Jose	29.6%
5	Santa Maria	28.8%
6	Los Angeles	30.2%
7	San Diego	28.3%
8	Long Beach	29.9%
9	Burbank	29.7%
10	Riverside	30.3%
11	Red Bluff	28.5%
12	Stockton	28.6%
13	Fresno	28.2%
14	29 Palms	25.7%
15	Blythe	22.4%
16	Bishop	28.2%

CA Climate Zone	City	Percentage of Modeled Annual Heating Load Satisfied by VCHP
1	Arcata	91.3%
2	Napa	91.1%
4	San Jose	94.2%
5	Santa Maria	91.6%
10	Riverside	93.9%
11	Red Bluff	88.6%
12	Stockton	87.5%
13	Fresno	87.5%
14	29 Palms	88.9%
15	Blythe	95.5%
16	Bishop	59.6%

- VCHP: Variable Capacity Heat Pump
- VCHP Specs: SEER 19-21 / HSPF 9.6-10.0
- Cooling Baseline: SEER 14 single speed AC
- Heating Baseline: HSPF 8.2

Comparison of R-32 and R-410A in Variable Capacity Heat Pump

Equipment Cooling Efficiency Improvement for California Residences

California Climate Zone	Representative City	VCHP R-410A	VCHP R-32
1	Arcata	-	-
2	Napa	32.3%	+1.8%
3	Oakland	25.5%	+2.4%
4	San Jose	29.6%	+2.5%
6	Los Angeles	30.2%	+2.2%
7	San Diego	28.3%	+2.2%
8	Long Beach	29.9%	+3.0%
10	Riverside	30.3%	+2.2%
12	Stockton	28.6%	+2.5%
13	Fresno	28.2%	+2.6%
15	Blythe	22.4%	+2.7%

22 – 32% cooling efficiency improvement with **R-410A VCHP**

*Additional 2 – 3% with **R-32 VCHP***

Equipment Cooling Peak Demand Reduction for Residences

Outdoor Temperature (F)	VCHP R-410A	VCHP R-32
95	3.7%	10.4%
105	3.3%	10.3%
115	2.6%	10.8%

3 – 4% peak demand reduction with **R-410A VCHP**

*Additional 7 – 8% with **R-32 VCHP***

R-32 improves cooling efficiency by 2-3% and peak demand reduction by 7-8% compared to R-410A across CA climate zones