Fuel Substitution Infrastructure Market Study

Stakeholder Presentation

Conducted in Coordination with Guidehouse under the Potential and Goals Study (Group E)

Presented March 5, 2024; Updated May 8, 2024

Agenda

- Study Overview (15 min)
- Study Results (20 min)
- Data Tool Demo (20 min)
- Q&A (30 min)

STUDY OVERVIEW

Key Research Questions

- What percentage of buildings require an infrastructure upgrade to install a fuel substitution measure or combination of fuel substitution measures?
- What are the average costs for infrastructure upgrades needed to support the installation of fuel substitution measures?
- What other electrification measures (e.g., PV, EV chargers, etc.) have been installed in the past, or will be installed in the future, that will be impacted by fuel substitution infrastructure upgrades?

Key Research Tasks

- Fuel substitution scenario development
  - Identify the relevant fuel substitution scenarios to be considered as part of this study
  - Limited to current list of approved fuel substitution measures
- Three web-based survey efforts
  - Residential Occupant Survey
  - Nonresidential Customer Survey
  - Electrician Survey

Residential Occupant Survey

- Targeted completions with 427 SF and 213 MF occupants
  - Geographically distributed across CA CZs
  - Ultimately completed surveys with 395 SF and 160 MF market-rate occupants
- Inventory major equipment and fuel types
- Presence of EV chargers, solar PV, battery storage
- Determine the current electric panel size
- Inform fractional attribution assessment
  - What electrification measures are currently installed, when were they purchased, and in what order?
  - What electrification measures are of interest moving forward? In what order?

Residential Occupant Survey – Panel Calculations

- Document current electric panel size
  - Self-report plus panel photos
- Use equipment list to calculate current electrical load
  - Use 2023 NFPA 70 National Electrical Code load calculations
- Calculate remaining panel capacity available
- Apply fuel substitution scenarios
- Determine which fuel substitution scenarios trigger substantial infrastructure upgrades (i.e., panel upgrade or optimization)

Residential Fuel Substitution Scenarios

1. Replace gas heating equipment with HVAC heat pump(s)
    a) Number of units depends on pre-existing equipment
    b) Heat pump technology dependent on current HVAC distribution system
    c) Conventional cooling equipment also replaced by HVAC heat pumps
2. Replace gas water heating equipment with HPWH
    a) Number of units depends on pre-existing equipment
3. Replace gas heating equipment AND water heating equipment with fuel substitution measures
    a) Combination of scenario 1 and 2 where applicable
4. Replace all eligible gas equipment with fuel substitution measures
    a) HVAC
    b) DHW
    c) Cooktops
    d) Dryers
    e) Pool heaters

Nonresidential Customer Survey

- Targeted 600 completions
  - Geographically distributed across CA CZs
  - Ultimately completed surveys with 579 customers
- Verify building type
- Determine size of the building/business in question
- Determine current electric panel size
- Inventory key HVAC, water heating, and cooking equipment
- Presence of EV chargers, PV
- Inform fractional attribution assessment
  - What electrification measures are currently installed, when were they purchased, and in what order?
  - What electrification measures are of interest moving forward? In what order?

Nonresidential Customer Survey – Panel Calculations

- Document current electric panel size
  - Self-report plus panel photos
- Use 2022 peak demand data to calculate current electrical load
- Calculate remaining panel capacity available
- Apply fuel substitution scenarios
- Determine which fuel substitution scenarios trigger panel upgrades

Nonresidential Fuel Substitution Scenarios

1. Replace gas heating equipment with HVAC heat pump(s)
   a) Number of units depends on pre-existing equipment
   b) Heat pump technology (packaged vs. split) dependent on current HVAC distribution system
   c) Conventional cooling equipment also replaced by HVAC heat pumps
2. Replace gas water heating equipment with HPWH
   a) Number of units depends on pre-existing equipment
   b) Individual and central HPWH system scenarios
      i. Central systems limited to MF applications
3. Replace gas fryers with electric fryers
4. Replace gas convection ovens with electric convection ovens
5. Replace gas fryers and convection ovens with electric systems
6. Replace all eligible gas heating and DHW equipment
7. Replace all eligible gas equipment
   a) HVAC
   b) DHW
   c) Cooking

Electrician Survey

- Targeted 70 completes
  - Split between residential and nonresidential
  - Respondents could answer for both sectors
  - Sampled from D&B Hoovers licensed electrician list
- Completed surveys with 45 residential and 33 nonresidential electricians
- Geographically distributed across the state
- Provided cost estimates for various fuel substitution scenarios.
  - Labor
  - Materials
  - Miscellaneous (e.g., permits)
  - Total

SAMPLE OVERVIEW

Summary of Survey Completes

- Aggregated CA climate zones into climate regions used by the EE Potential and Goals Study
- Comparable representation among 'Hot-Dry' and 'Marine' climate regions
- Cold climate region is the smallest but also only represents CZ16

Climate Region	Single-Family*	Multifamily*	Nonresidential	Residential Electricians	Nonresidential Electricians
Cold	29	14	29	2	2
Hot-Dry	155	55	288	25	19
Marine	211	91	262	18	12
Total	**395**	**160**	**579**	**45**	**33**

Climate Zone	2023 PG Study CZ Reference Location	Mapping CZ to Climate Region
1	CZ01 - Arcata	Marine
2	CZ02 - Santa Rosa	Marine
3	CZ03 - Oakland	Marine
4	CZ04 - Sunnyvale	Marine
5	CZ05 - Santa Maria	Marine
6	CZ06 - Los Angeles	Marine
7	CZ07 - San Diego	Hot-Dry
8	CZ08 - El Toro	Hot-Dry
9	CZ09 - Pasadena	Hot-Dry
10	CZ10 - Riverside	Hot-Dry
11	CZ11 - Red Bluff	Hot-Dry
12	CZ12 - Sacramento	Hot-Dry
13	CZ13 - Fresno	Hot-Dry
14	CZ14 - China Lake	Hot-Dry
15	CZ15 - El Centro	Hot-Dry
16	CZ16 - Mount Shasta	Cold

*Excludes 87 completes that were identified as equity customers and are being included in equity infrastructure cost study

Opinion Dynamics

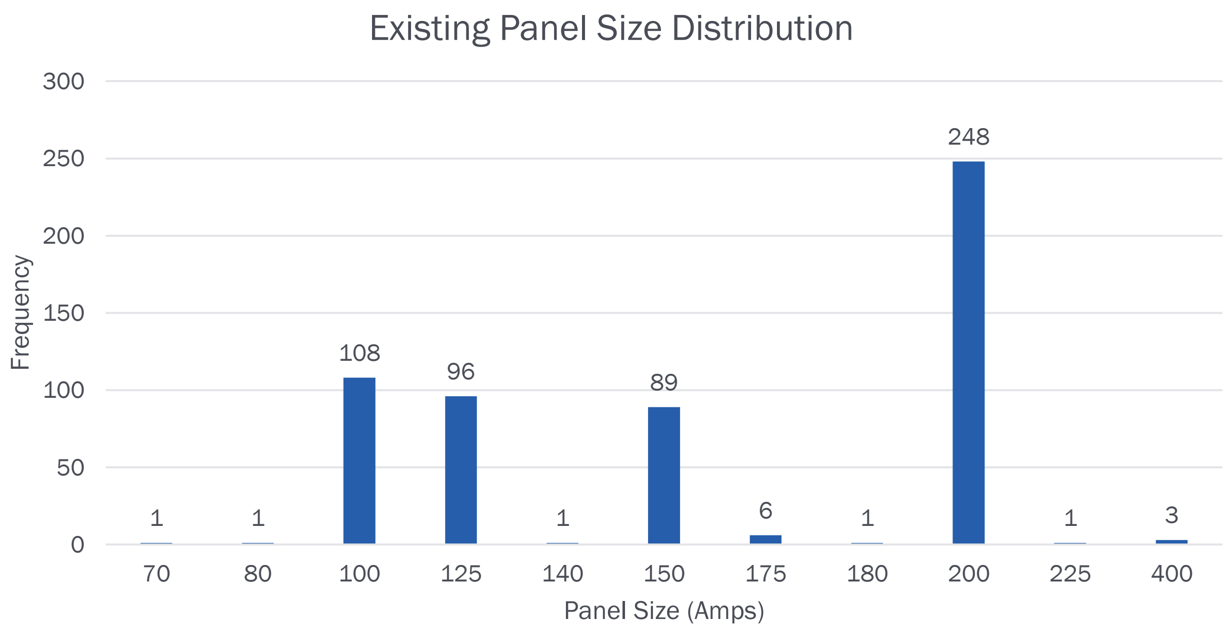
RESIDENTIAL RESULTS

Residential Analysis – Technical Engineering Needs Assessment vs. Workforce Implementation Likelihood

- **Technical Engineering Needs Assessment Results:** Customers' infrastructure needs based solely on our engineering-based analysis of whether a given fuel substitution scenario would necessitate additional panel capacity and/or breaker slots
  - Closely aligns with infrastructure need data from TECH Clean California
- **Workforce Implementation Likelihood Results:** Attempted to account for the fact that, in the field, electricians may do or recommend something different based on their own practices that may not follow the method we used to determine technical needs
  - Electricians reported not always using panel optimization when technically feasible to create space in a panel with no open breaker slots but remaining capacity, instead electing to do a full panel upgrade regardless in some cases
  - Applied adjustment factor based on residential electrician survey responses
- **KEY NOTE:** The report highlights the technical need results, and this deck highlights the likelihood results; both are included in the data tool deliverable for this study

Residential Existing Panel Size Distributions

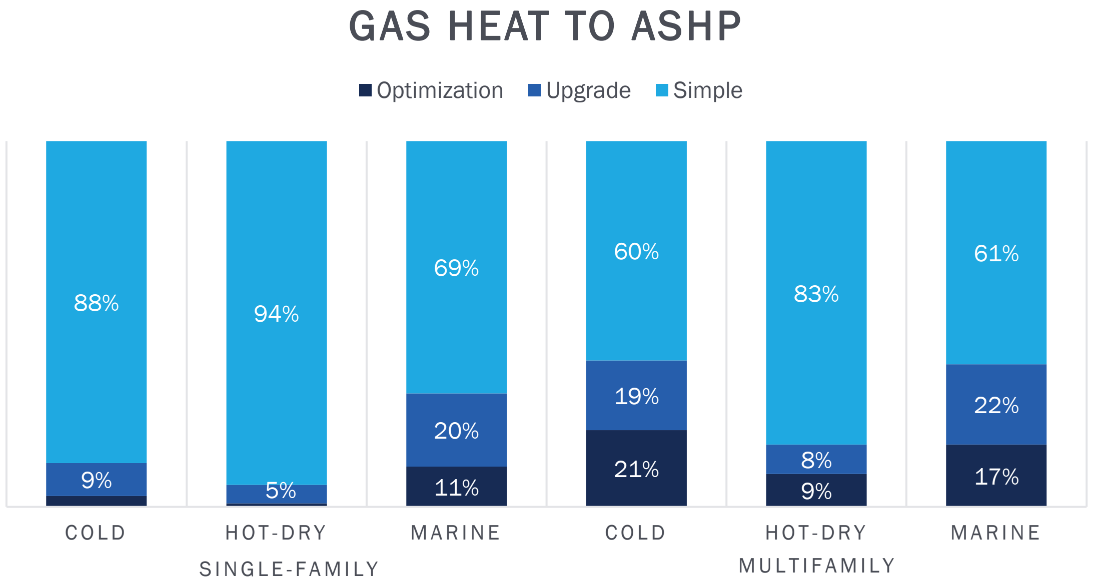
- Predominant panel size is 200A
- Other common panel sizes are 100A, 125A, and 150A
- A smattering of other rare panel sizes
- Most residential panels are located on the exterior of the building



Residential Heating Scenario Results

- Costs are weighted by outcome results and represent one piece of heating equipment
- Infrastructure needs are highest in ‘Marine’ CR for SF and ‘Cold’ for MF
  - More panel upgrade needs than panel optimization needs for single-family and marine multifamily
- Statewide weighted costs per unit of heating equipment
  - SF - $1,955
  - MF - $2,594
  - All - $2,351

Climate Region	Sample Size	Relative Precision @ 90% CI	Panel Optimization Likelihood	Panel Upgrade Likelihood	Simple Connection Likelihood	Weighted Average Infrastructure Cost
Single-family						
Cold	16	19%	3%	9%	88%	$ 2,020.93
Hot-Dry	84	9%	1%	5%	94%	$ 1,793.72
Marine	143	7%	11%	20%	69%	$ 2,617.72
Multifamily						
Cold	5	--	21%	19%	60%	$ 3,223.27
Hot-Dry	23	16%	9%	8%	83%	$ 2,408.28
Marine	44	12%	17%	22%	61%	$ 3,238.72

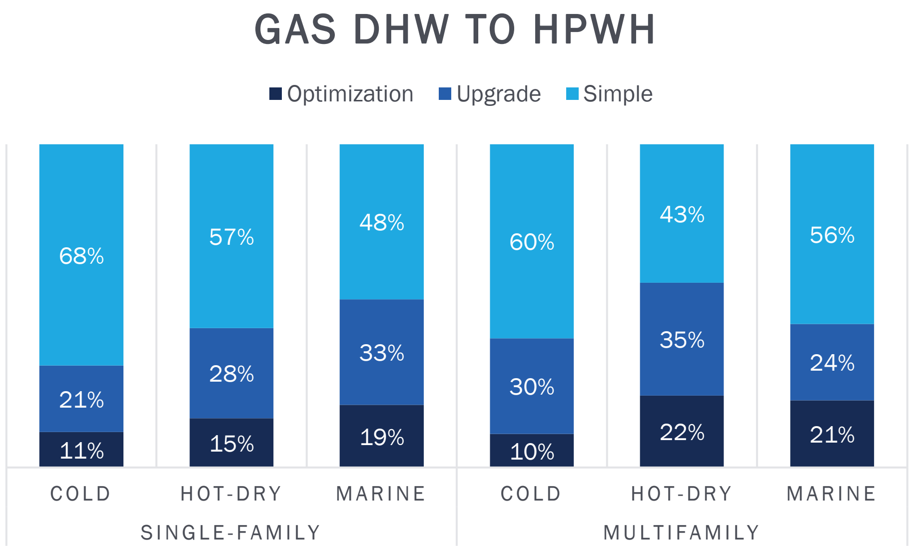


Percentages less than 5% are not labeled

Residential Water Heating Scenario Results

- Costs are weighted by outcome results and represent one piece of water heating equipment
- Upgrade needs highest in 'Marine' CR for SF and 'Hot-Dry' for MF
  - More panel upgrade needs than panel optimization needs
- Statewide weighted costs per unit of water heating equipment
  - SF - $4,003
  - MF - $4,927
  - All - $4,589

Climate Region	Sample Size	Relative Precision @ 90% CI	Panel Optimization Likelihood	Panel Upgrade Likelihood	Simple Connection Likelihood	Weighted Average Infrastructure Cost
Single-family						
Cold	19	18%	11%	21%	68%	$ 3,615.42
Hot-Dry	109	8%	15%	28%	57%	$ 3,984.91
Marine	150	7%	19%	33%	48%	$ 4,256.21
Multifamily						
Cold	5	–	10%	30%	60%	$ 4,495.84
Hot-Dry	28	15%	22%	35%	43%	$ 5,063.44
Marine	45	12%	21%	24%	56%	$ 4,539.93



Residential Multifamily Pricing

- Asked about MF pricing relative to SF
- Mixed results
  - Lower prices primarily attributed to shorter electrical runs
  - Higher prices attributed to lack of attic or crawl space access, dealing with landlords/property managers
- Weighted average of responses indicates MF is 13% more expensive than SF

Would your cost estimates change if the heat pump was installed in an apartment with its own electrical panel in the unit?

	n	Yes, decrease	Yes, increase	No, unlikely to change
MF Pricing	35	40%	34%	26%

By what percent would you increase/decrease your costs for a heat pump installation at an apartment in a multifamily building compared to the single-family estimates provided earlier?

	n	% Decrease	% Increase
MF Pricing	26	15.9%	55.5%

Residential Panel Optimization Pricing

- Outside of sub-panels, electricians reported never using many of the panel optimization strategies identified in the survey
- The team used the sub-panel costs as the value for all optimization pricing in the data tool given this is the strategy that is used in most circumstances

How often do you use each of the following panel optimization options when you have constrained space in a panel?

What is the typical cost (labor and materials) associated with the panel optimization options you have experience with?

Optimization Approach	n	Most often	Often	Sometimes	Rarely	Never	Don't know	Pricing
Smart circuit breakers	45	4%	4%	13%	24%	48%	4%	$1,064
Smart panel	45	0%	4%	18%	24%	51%	2%	$4,424
Circuit pausers	45	2%	4%	9%	18%	58%	9%	$1,435
Load-sharing	45	7%	9%	20%	22%	40%	2%	$1,186
Sub-panel	45	31%	40%	29%	0%	0%	0%	$2,211
Meter collars	45	0%	2%	2%	18%	67%	11%	$1,831
Other	45	11%	7%	4%	13%	20%	44%	$1,077

Residential Electrician Pricing Variance

- Coefficient of Variation (CV) tells us the relative size of the standard deviation compared to the mean
- CV ranges from 0.42 to 0.87 across all residential pricing scenarios
- Individual price responses differ from the mean by 42% to 87%, on average, depending on the scenario
- CV < 1.0 is indicative of relatively low variability within the responses

Scenario			
Gas Fired Furnace w/CAC to ASHP	**n**	**Average Cost**	**CV**
Connect ASHP to panel (A*)	42	$1,576	0.87
Upgrade wiring and connect ASHP to panel (B)	42	$2,068	0.87
Gas Fired Furnace w/no CAC to ASHP			
Install 200A panel, install 240V circuit and disconnect, connect ASHP to panel	42	$5,605	0.52
Gas Wall Furnace w/no CAC to Mini-Split ASHP			
Install 240V circuit and disconnect, connect ASHP to panel (A)	41	$2,083	0.83
Install 200A panel, install 240V circuit and disconnect, connect ASHP to panel (B)	44	$6,158	0.46
Install 200A panel, install 240V circuit and disconnect, upgrade wiring, connect ASHP to panel (C)	45	$7,060	0.46
50-gallon gas DHW to HPWH			
Install 240V circuit and disconnect, connect HPWH to panel (A)	44	$2,591	0.56
Install 200A panel, install 240V circuit and disconnect, connect HPWH to panel (B)	42	$6,385	0.43
Install 200A panel, install 240V circuit and disconnect, upgrade wiring, connect HPWH to panel (C)	42	$7,004	0.42
Gas Furnace w/CAC AND Gas DHW to ASHP and HPWH			
Install 240V circuit and disconnect for HPWH, connect both ASHP and HPWH to panel (A)	41	$3,433	0.85
Install 200A panel, install 240V circuit and disconnect for HPWH, connect both ASHP and HPWH to panel (B)	41	$7,247	0.55
Install 200A panel, install 240V circuit and disconnect for HPWH, upgrade wiring, connect both ASHP and HPWH to panel (C)	43	$8,219	0.52
Gas-powered Range to Induction Range			
Connect induction range to panel (A)	43	$1,726	0.81
Install 200A panel and connect induction range to panel (B)	44	$6,240	0.49
Install 200A panel, install 240V circuit and disconnect for new induction range, upgrade wiring, connect induction range to panel (C)	42	$6,923	0.49

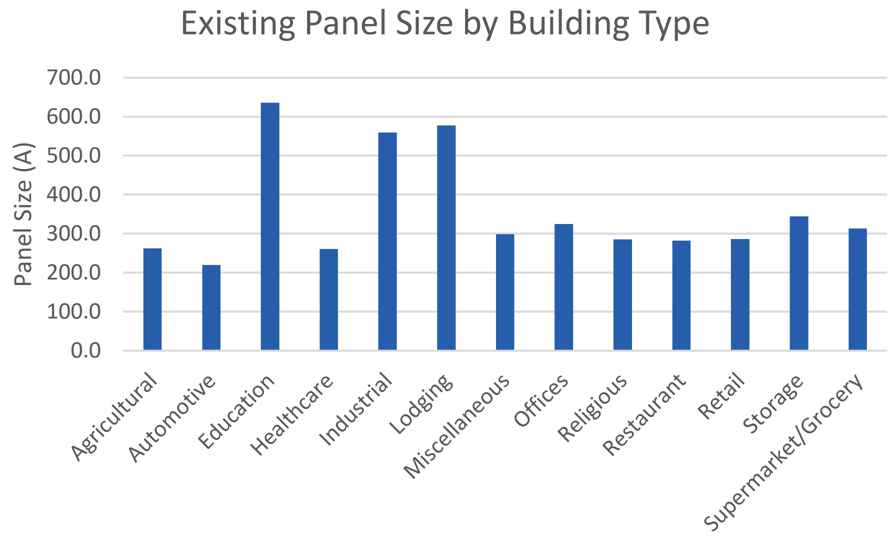
NONRESIDENTIAL RESULTS

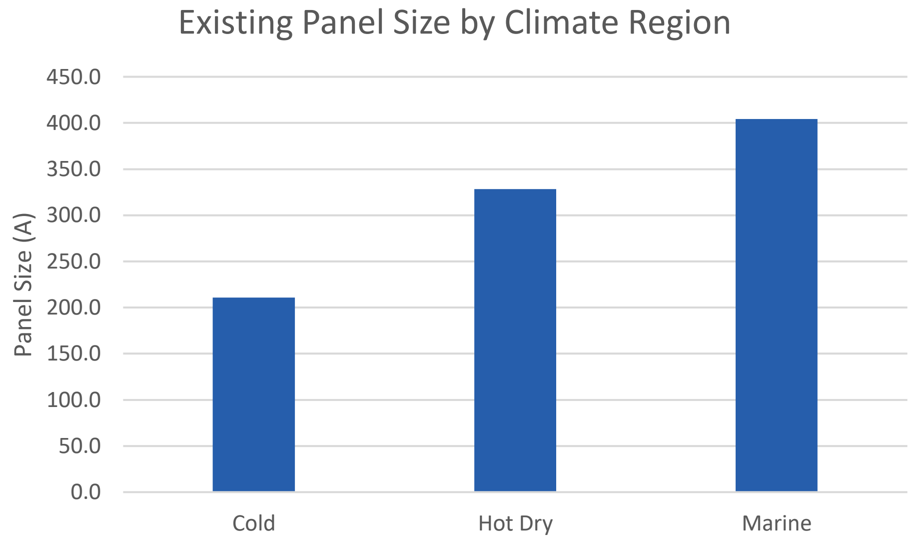
Nonresidential Analysis – Technical Engineering Needs Assessment vs. Workforce Implementation Likelihood

- **Technical Engineering Needs Assessment Results:** Customers' infrastructure needs based solely on our engineering-based analysis of whether a given fuel substitution scenario would necessitate additional panel capacity and/or breaker slots
  - Closely aligns with infrastructure need data from TECH Clean California
- **Workforce Implementation Likelihood Results:** Attempted to account for the fact that, in the field, electricians may do or recommend something different based on their own practices that may not follow the method we used to determine technical needs
  - Electricians reported not always using panel optimization when technically feasible to create space in a panel with no open breaker slots but remaining capacity, instead electing to do a full panel upgrade regardless in some cases
  - Applied adjustment factor based on nonresidential electrician survey responses
- **KEY NOTE:** The report highlights the technical need results, and this deck highlights the likelihood results; both are included in the data tool deliverable for this study

Nonresidential Existing Panel Size Distributions

- Wide range of existing panel sizes within different building types
- Education, industrial, and lodging building types have the largest panel sizes
- Most building types have an average panel size between 200A and 400A, suggesting a strong mix of the two panel sizes
- Marine climate region has the largest average panel size

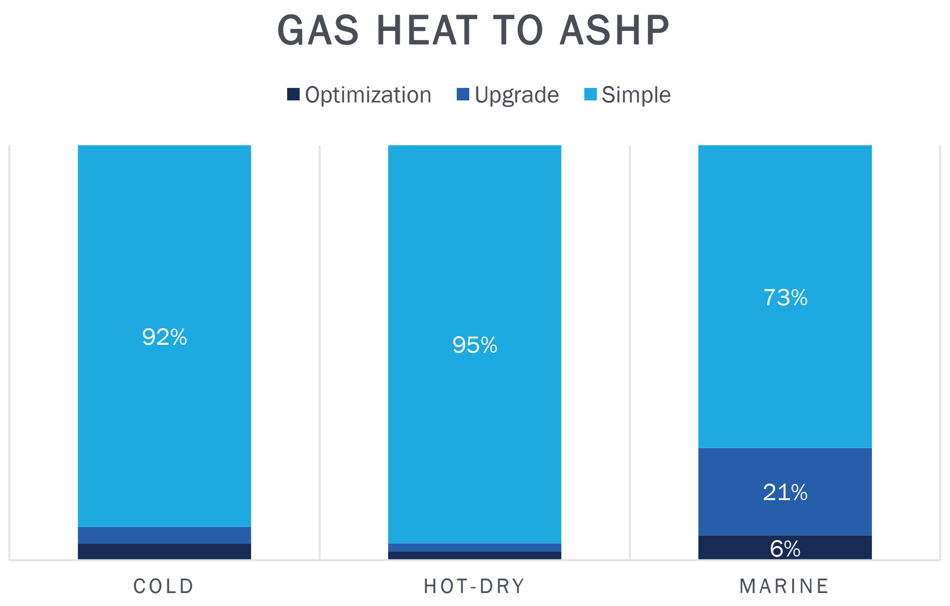




Nonresidential Heating Scenario Results

- Again, costs represent a weighted average of the scenario outcomes and represent one piece of heating equipment
- Infrastructure needs are relatively modest in comparison to residential heating results
- Statewide weighted costs
  - $3,294 per unit of heating equipment

Climate Region	Sample Size	Relative Precision @ 90% CI	Panel Optimization Likelihood	Panel Upgrade Likelihood	Simple Connection Likelihood	Weighted Average Infrastructure Cost
Cold	12	–	4%	4%	92%	$ 2,645.96
Hot-Dry	64	7%	2%	2%	95%	$ 2,406.85
Marine	67	9%	6%	21%	73%	$ 4,595.34

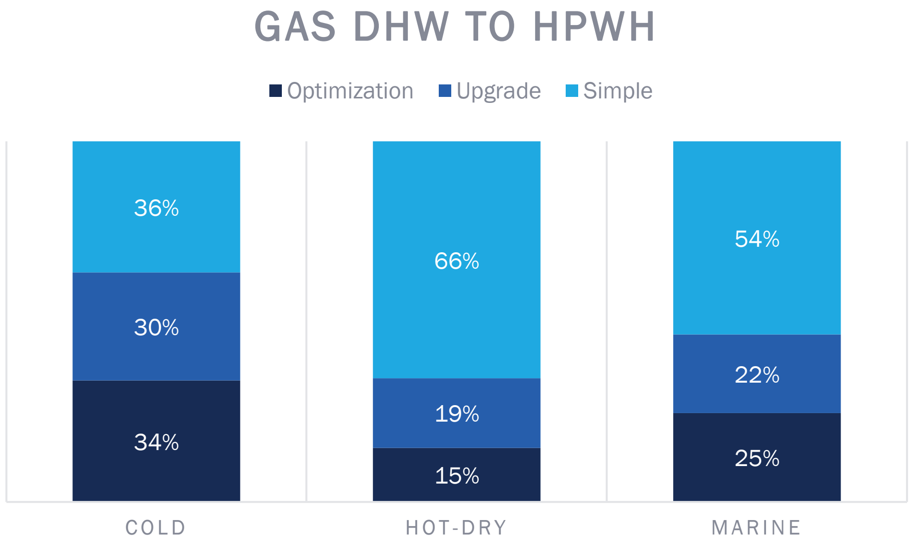


Percentages less than 5% are not labeled

Nonresidential Water Heating Scenario Results

- Infrastructure needs are substantially higher in the ‘Marine’ and ‘Cold’ climate regions than in the ‘Hot-Dry’ in the water heating scenario
- The need for panel upgrades vs. optimization services are split fairly evenly
- Statewide weighted costs
  - $6,151 per unit of water heating equipment

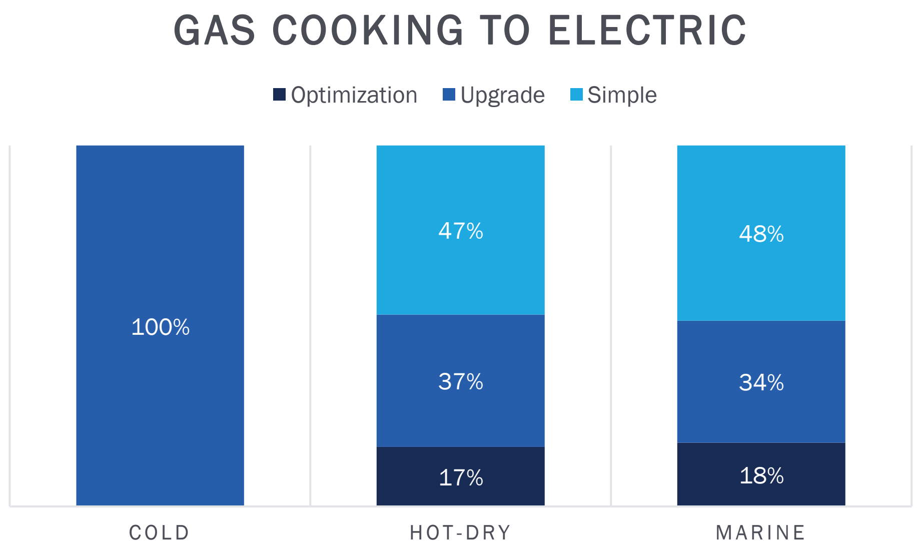
Climate Region	Sample Size	Relative Precision @ 90% CI	Panel Optimization Likelihood	Panel Upgrade Likelihood	Simple Connection Likelihood	Weighted Average Infrastructure Cost
Cold	11	--	34%	30%	36%	$ 7,205.35
Hot-Dry	67	10%	15%	19%	66%	$ 5,691.28
Marine	71	10%	25%	22%	54%	$ 6,187.38



Nonresidential Cooking Scenario Results

- Infrastructure needs substantial in the cooking scenario with more than half of ‘Hot-Dry’ and ‘Marine’ climate region projects needing a panel upgrade or optimization services
- Upgrade needs outweigh optimization needs in this scenario
- Statewide weighted costs
  - $8,617 per unit of cooking equipment

Climate Region	Sample Size	Relative Precision @ 90% CI	Panel Optimization Likelihood	Panel Upgrade Likelihood	Simple Connection Likelihood	Weighted Average Infrastructure Cost
Cold	1	–	0%	100%	0%	$ 13,624.40
Hot-Dry	32	15%	17%	37%	47%	$ 7,550.05
Marine	33	14%	18%	34%	48%	$ 7,300.44



Nonresidential Panel Optimization Pricing

- Outside of sub-panels, electricians reported never using many of the panel optimization strategies identified in the survey
- As with residential, the team used the sub-panel costs as the value for all optimization pricing in the data tool given this is the strategy that is used in most circumstances

How often do you use each of the following panel optimization options when you have constrained space in a panel?

What is the typical cost (labor and materials) associated with the panel optimization options you have experience with?

Optimization Approach	Most often	Often	Sometimes	Rarely	Never	Don't know	Pricing
Smart circuit breakers	3%	12%	9%	27%	48%	0%	$971
Smart panel	3%	0%	6%	24%	67%	0%	$3,720
Circuit pausers	0%	0%	12%	21%	67%	0%	$1,300
Load-sharing	0%	9%	27%	18%	45%	0%	$3,688
Sub-panel	21%	45%	33%	0%	0%	0%	$2,594
Meter collars	3%	0%	3%	12%	73%	9%	$1,792
Other	0%	0%	24%	3%	33%	39%	$1,647

Nonresidential Electrician Pricing Variance

- Coefficient of Variation (CV) tells us the relative size of the standard deviation compared to the mean
- CV ranges from 0.32 to 0.84 across all nonresidential pricing scenarios
- Individual price responses differ from the mean by 32% to 84%, on average, depending on the scenario
- CV < 1.0 is indicative of relatively low variability within the responses

Scenario	n	Total Mean	CV
Packaged AC/Gas Furnace to Packaged HP with Electric Resistance Back-up			
Connect packaged HP to panel (A)	29	$2,099	0.84
Install 600A panel and connect packaged HP to panel (B)	31	$16,799	0.63
Add 200A panel and connect packaged HP to panel (C)	25	$5,616	0.70
Install 600A panel, upgrade wiring, connect packaged HP to panel (D)	30	$16,367	0.56
60-gallon gas DHW to 80-gallon HPWH			
Install 240V circuit and disconnect, connect HPWH to panel (A)	33	$3,430	0.54
Install 400A panel, install 240V circuit and disconnect, connect HPWH to panel (B)	28	$9,458	0.32
Add 200A panel and connect packaged HP to panel (C)	17	$4,946	0.45
Install 400A panel, install 240V circuit and disconnect, upgrade wiring, connect HPWH to panel (D)	32	$15,100	0.57
Gas Fryer to Electric Fryer			
Add circuit and disconnect, connect fryer to panel (A)	32	$2,904	0.63
Install 400A panel, add circuit and disconnect, connect fryer to panel (B)	27	$10,108	0.41
Add 200A panel, add circuit and disconnect, connect fryer to panel (C)	24	$7,407	0.62
Install 400A panel, upgrade wiring, add circuit and disconnect, connect fryer to panel (D)	32	$15,610	0.59
Gas Oven to Electric Convection Oven			
Add circuit and disconnect, connect oven to panel (A)	32	$3,840	0.59
Install 600A panel, add circuit and disconnect, connect oven to panel (B)	32	$17,141	0.60
Add 200A panel, add circuit and disconnect, connect oven to panel (C)	25	$7,385	0.62
Install 600A panel, upgrade wiring, add circuit and disconnect, connect oven to panel (D)	32	$18,262	0.59
Gas Oven AND Gas Fryer to Electric Convection Oven and Electric Fryer			
Add circuit and disconnect, connect oven and fryer to panel (A)	31	$5,405	0.60
Install 600A panel, add circuit and disconnect, connect oven and fryer to panel (B)	31	$18,160	0.61
Add 200A panel, add circuit and disconnect, connect oven and fryer to panel (C)	24	$7,156	0.54
Install 600A panel, upgrade wiring, add circuit and disconnect, connect oven and fryer to panel (D)	33	$20,092	0.63
Forced Air Gas Fired Furnace AND 60-gallon DHW to ASHP and 80-gallon HPWH			
Add circuit and disconnect, connect HPWH and ASHP to panel (A)	32	$5,334	0.67
Install 400A panel, add circuit and disconnect, connect HPWH and ASHP to panel (B)	33	$15,680	0.60
Add 200A panel, add circuit and disconnect, connect HPWH and ASHP to panel (C)	25	$9,190	0.71
Install 400A panel, upgrade wiring, add circuit and disconnect, connect HPWH and ASHP to panel (D)	33	$17,190	0.55

Opinion Dynamics

REGRESSION OVERVIEW AND RESULTS

Regression Methodology

- Explored the relationship of various inputs on the likelihood of needing substantial infrastructure work (e.g., panel upgrade or optimization)
- Ran a two-stage analysis to understand drivers of the panel upgrade/optimization outcome
  - Stage 1: correlation analysis to understand the extent and direction of **individual** relationships of variables of interest and panel upgrade/optimization outcome
  - Stage 2: multivariate regression to assess **combined** relationship between variables of interest and panel upgrade/optimization outcome
  - Multivariate approach is more appropriate for explaining the outcome as it accounts for a variety of customer characteristics that interact to affect the outcome

Residential Multivariate Regression Results

- Age of home and climate region are the best predictors of panel upgrade/optimization outcome
  - Older homes (primarily 1976-1999) much more likely than newer homes (2000 or later)
    - 1.7 – 2.1x more likely
  - Marine climate region much more likely than cold region
    - 2.1 – 3.8x more likely
- Baseline equipment is also a statistical predictor though less influential than age of home or climate region
    - Homes with existing AC 1.3x more likely to need upgrade

Characteristic	Heating Only		Water Heating Only		Heating and Water Heating		All Applicable Equipment	
	Direction	Adjusted Odds Ratio	Direction	Adjusted Odds Ratio	Direction	Adjusted Odds Ratio	Direction	Adjusted Odds Ratio
Age of Home (Reference: 2000 or later)								
Before 1950								
1950-1975	Positive	2.1						
1976-1999	Positive	2.1	Positive	1.6			Positive	1.7
Unsure								
Climate Region (Reference: Cold)								
Hot-Dry							Positive	2.4
Marine	Positive	2.3	Positive	2.1	Positive	2.9	Positive	3.8
Baseline Equipment & Systems								
Electrical Cooling System	Positive	1.3	Positive	1.2	Positive	1.4	Positive	1.3
Electrical Heating System	Negative	0.6			Negative	0.4	Negative	0.7
Electrical Water Heating System			Negative	0.1	Negative	0.1		
Panel Size	Negative	0.99	Negative	0.99	Negative	0.99	Negative	0.99
Solar Panels								
Electric Vehicle								

Inculded in multivariate analysis and effect is significant
Included in multivariate analysis but effect not significant
Excluded from multivariate analysis because effect not significant in univariate analysis

Nonresidential Multivariate Regression Results

- Multivariate results for nonresidential are more limited in terms of explaining what is driving the need for infrastructure upgrades
  - This is likely driven by the wide diversity of buildings within the nonresidential market. Even within a specific building type (e.g., Healthcare), we can see a huge range of building sizes, technologies, etc.
- Climate region and the presence of existing electrical heating/water heating equipment do exhibit statistically significant relationships with the panel upgrade/optimization outcome

Characteristic	Water Heating Only		Heating and Water Heating Equipment		All Applicable Equipment	
	Direction	Adjusted Odds Ratio	Direction	Adjusted Odds Ratio	Direction	Adjusted Odds Ratio
Building Type (Reference: Retail, Restaurant & Supermarket)						
Agriculture, Automotive & Industrial					Negative	0.3
Education, Lodging & Offices						
Healthcare						
Miscellaneous, Religious & Storage						
Climate Region (Reference: Cold)						
Hot-Dry	Negative	0.2	Negative	0.3	Negative	0.3
Marine	Negative	0.3	Negative	0.3		
Baseline Equipment & Systems						
Electrical Cooling System						
Electrical Heating System	Positive	1.3	Negative	0.4		
Electrical Water Heating System	Negative	0.1	Negative	0.4	Negative	0.5
Panel Size						
Solar Panels						
EV Chargers						
Inculded in multivariate analysis and effect is significant						
Included in multivariate analysis but effect not significant						
Excluded from multivariate analysis because effect not significant in univariate analysis						

Opinion Dynamics

KEY TAKEAWAYS

Key Takeaways

- Infrastructure upgrade needs vary by scenario but can be significant in the residential sector
  - Statewide results, weighted by climate region and building type, indicate 10% - 37% of housing units, depending on the scenario, are likely to receive a panel upgrade to accommodate fuel substitution measures
  - Another 8% - 23% are likely to receive panel optimization services depending on scenario
- The costs associated with residential fuel substitution measures are substantial
  - Simple connection costs exceed $1,000
  - Optimization services start above $3,500
  - Panel upgrade costs exceed $5,000

Key Takeaways Cont.

- Nonresidential infrastructure upgrade needs are also substantial, though the needs vary quite a bit by scenario
  - Statewide results, weighted by building type, suggest that at least 10% - 47% of sites are likely to need a panel upgrade, depending on scenario; highest likelihood being in the cooking scenario and lowest being in the heating scenario
  - Statewide results, weighted by building type, suggest that 4% - 25% of sites are likely to need panel optimization, depending on scenario; highest likelihood being in the combination space and water heating scenario and lowest being in the heating scenario
- The costs associated with these needs are substantial
  - Simple connection costs exceed $2,000
  - Optimization services start above $4,500
  - Panel upgrade costs exceed $13,000

Future Research Opportunities

- Conduct site visits to refine the electrical panel load and remaining capacity calculations
  - More accurate assessment of current electric equipment and wattages
  - Particularly valuable for nonresidential buildings
- Conduct more thorough cost research
  - Consider validating cost data through alternative approaches such as mystery shopping visits or contractor bid templates
- Focus future research efforts on measures/building types with the largest infrastructure needs

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Questions?

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