ET Summit 2023

CalNEXT
ENERGIZING CALIFORNIA'S FUTURE

Presented by
ETCC
EMERGING TECHNOLOGIES COORDINATING COUNCIL

Equitable Decarbonization Support Research

1:20-2:20 PM PT

Rebecca Rothman, VEIC

Disadvantaged Community and Hard-to-Reach Community Benefits

- Intake Question
- Specialist Evaluation
  - Benefit from Project Execution - Monetary
  - Benefit from Project Execution & Outcomes - Engagement
  - Benefit from Project Outcomes – Energy Burden, Environmental Justice, Program Access
- Tracking Project Execution and Technology Transfer

Equitable Decarb Projects

Residential Housing Characteristics Study

Low-Income Multifamily Housing Characteristics Study

Mobile and Manufactured Housing Market Characterization Study

Residential Housing Characteristics Study

Anna Solorio, Project Lead

Irina Krishpinovich, Presenter

HVAC, Plug Loads & Appliances, Water Heating

TSR

Residential Housing Characteristics Study Overview

- Existing conditions, or "electrification readiness" among single family homes in disadvantaged communities (DAC), low-income, marginalized, or hard to reach must be assessed to establish a baseline to inform programs or policies aimed at serving this sector.
- This study collected and analyzed data and industry literature to understand housing conditions and occupant characteristics for this sector.
- Characterized existing DAC/SFR building stock and electrification readiness based on census analysis and a limited number of field surveys.
- The field surveys were conducted in the homes of households participating in PG&E's Energy Savings Assistance Program (ESA).

Census & Building Data Analysis

aesc alternative energy systems consulting

ASK energy

Field Survey Operations

ORTIZ THE ORTIZ GROUP

CHOC COMMUNITY HOUSING OPPORTUNITIES

Analyzed census data to understand the current state of DAC SFR building stock and its relevance to electrification

- Internet Access
- Householder Age
- Building Type
- Gross Rent % of HH Income
- Mortgage % of HH Income
- Ability to Speak English
- House Heating Fuel
- Household Income
- # People per Household
- Possession of Smartphone
- Year Structure was Built
- Range Fuel Type
- Dryer Fuel Type
- Garage Size
- Square Footage
- Insulation: Ceiling, Floor, Walls
- Electric HVAC Systems

Create and validate a field survey to collect information from low-income residential utility customers

Housing Characteristic Survey

ESA Contractor - Field Data Collection

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

3. Basic Home Data

Building Type

- ◯ Single Family Detached
- ◯ Duplex, Triplex, or Fourplex
- ◯ Mobile Home
- ◯ Modular Home
- ◯ Other

Garage?

- ◯ Yes
- ◯ No

If yes, is there room in the garage for a water heater?

- ◯ Yes
- ◯ No

Housing Characteristic Survey

ESA Contractor - Field Data Collection

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

5. Space Heating

Do you use space heating equipment in your home?

- ◯ Yes
- ◯ No

If yes, is the heating system meeting your needs?

- ◯ Yes
- ◯ No

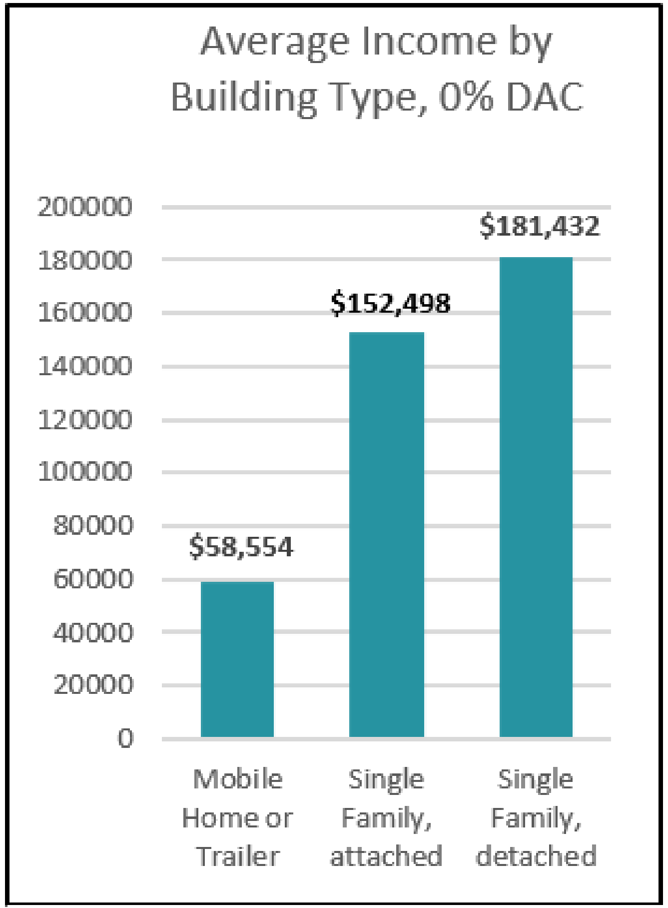
Do you use portable electric resistance heaters?

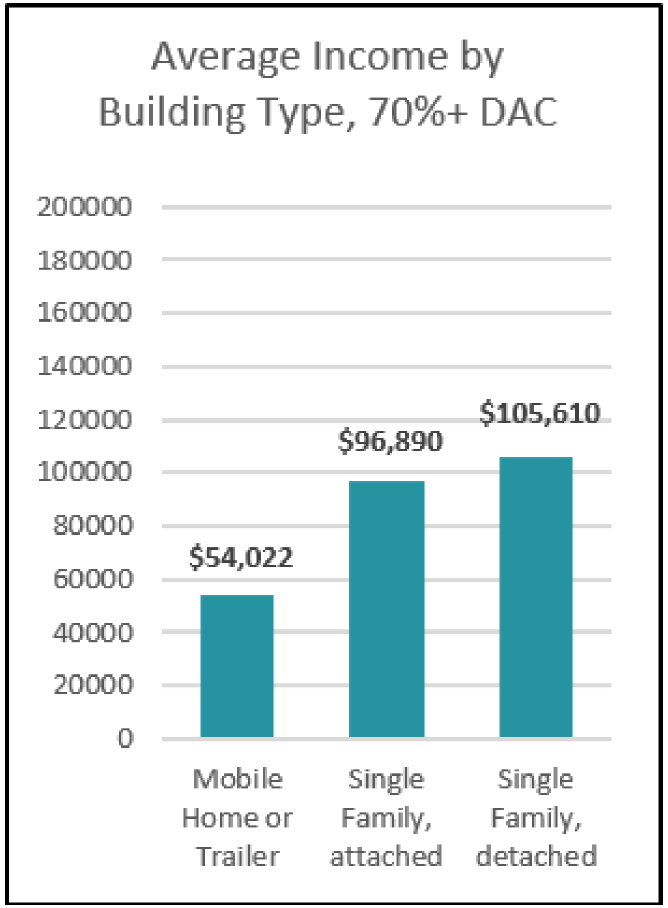
- ◯ Yes
- ◯ No

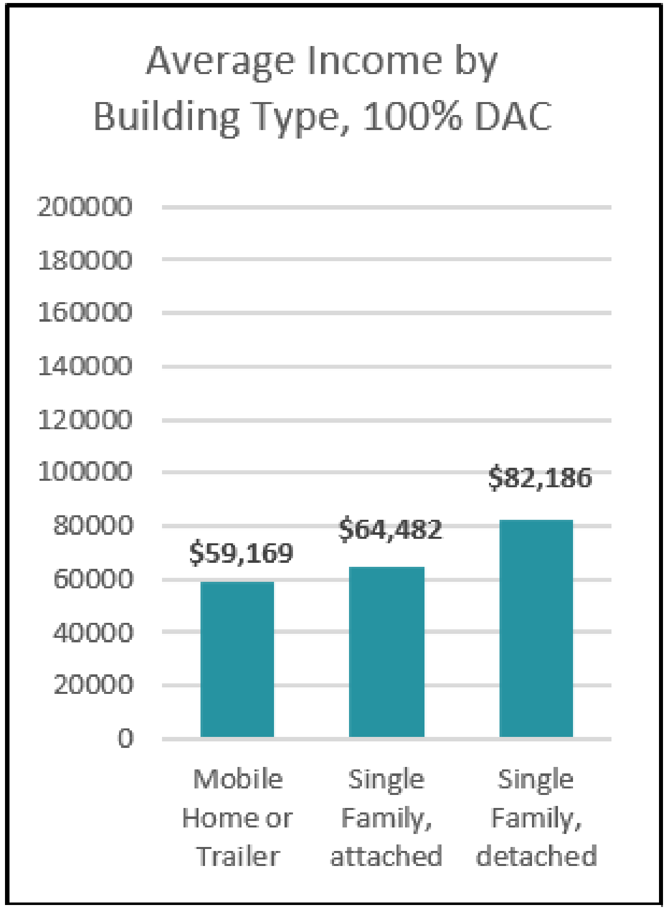
If yes, how many?

Record qty

Income by Home Type: Analyzed per DAC







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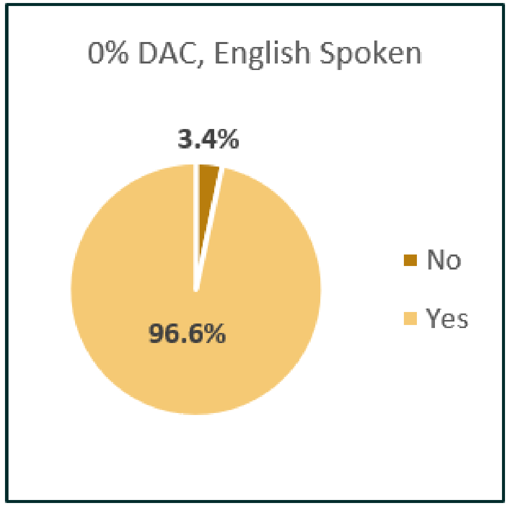
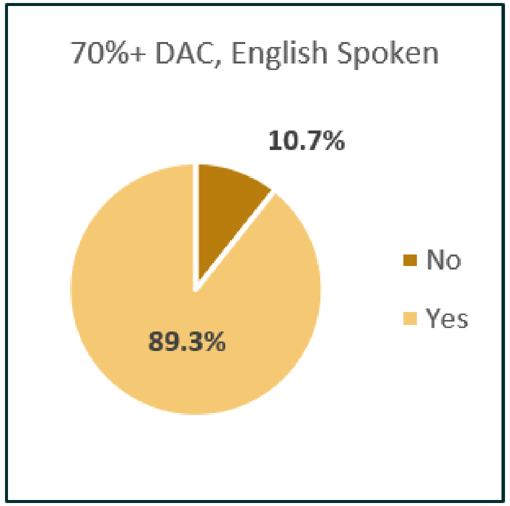
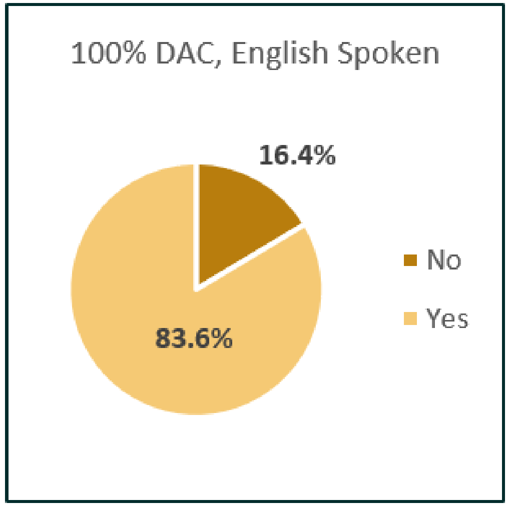
Data Findings

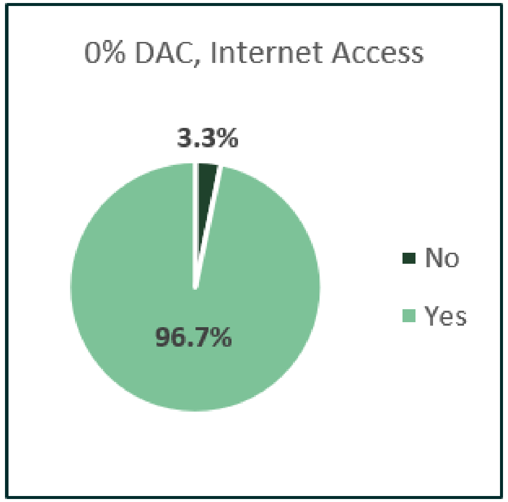
English speaking resident

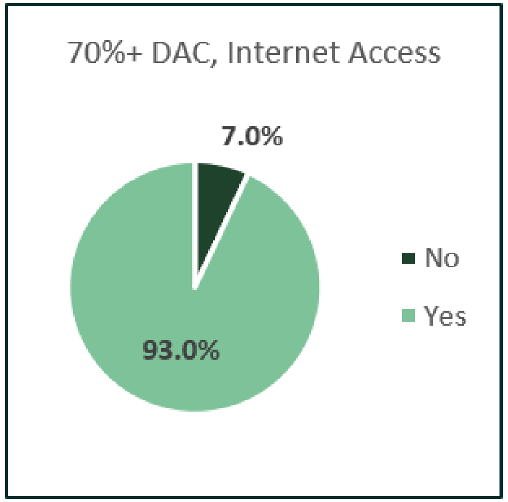


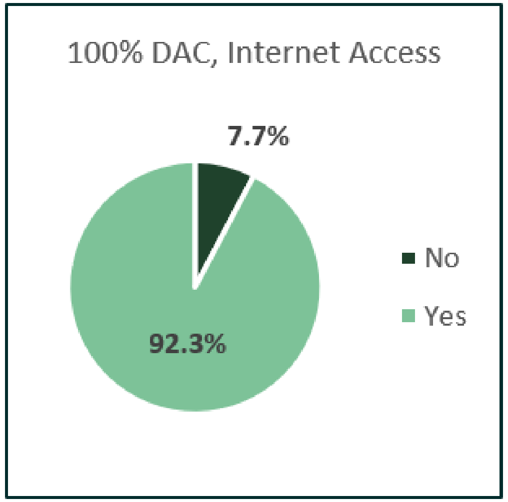




Internet access








EMERGENCY SHUTDOWN INSTRUCTIONS
EARTHQUAKE GAS SHUTOFF
(925) 803-8003


lighting
info


NOTICE
Furnace
Kitchen
Clothes Washer
Clothes
Dryer
A.C
Range


GARAGE


DANGER
PELIGRO
WARNING
DO NOT RELOCATE
SUB PANEL
A/C
Electrical Service Approved

- 50 field surveys were conducted (Northern CA only)
- Additional surveys are planned (2024) to include statewide representation
- Cost estimates on partial electrification:
    - Heat Pump Water Heater upgrade: $1,900.00
    - Electrical system upgrades: $3,500 – $10,600

Irina Krishpinovich

Program Manager

The Ortiz Group

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Low-Income Multifamily Housing Characteristics Study

Kevin McGrath / Project Lead

Whole Buildings, HVAC, Water Heating

Electrical Infrastructure, High-Efficiency HVAC, etc.

TSR

Why Examine this Market Segment?

- Households residing in multifamily buildings are a sizeable portion of the overall population and low/moderate income (LMI) population in California.
- Deploying advanced electric technologies to multifamily buildings housing LMI households is critical to meeting California's decarb goals, and this requires targeted solutions that will work in this type of housing.
- New technology solutions are coming to market, some well suited to the multifamily market with the potential to offer simpler installation processes and lower costs to tenants.
- However, there are gaps in data for understanding the electrification challenges and barriers for this segment of the housing market, and analyses of available data are needed to understand the current opportunities and barriers.

Project Components

Data Analysis

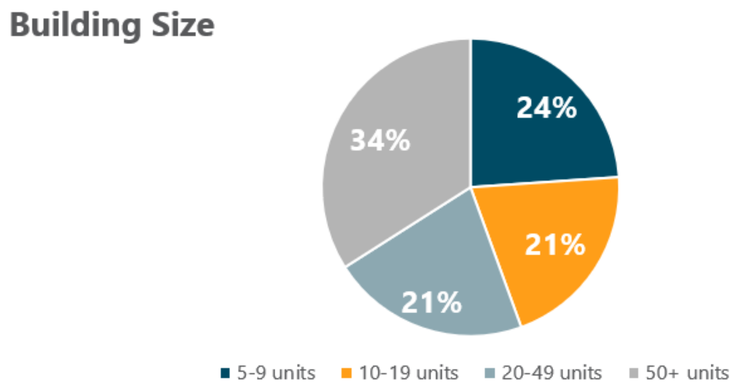
Analyze available data from Census and DOE to provide CA-specific info about market size, building typology, and geographic distribution. Identify areas where data gaps exist for in-unit and whole building energy equipment.

Field Study

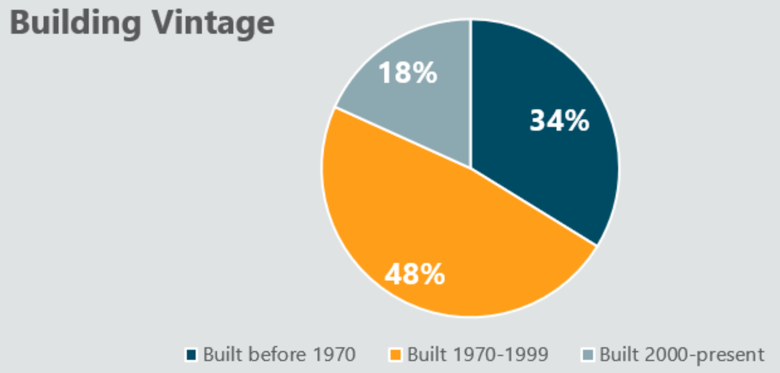
Gather data on existing in-unit and whole building energy equipment. Develop hypotheses and recommendations for programs targeting the affordable multifamily housing space.

Key Findings to Date: Housing Characteristics

- 1.95 million LMI households reside in multifamily (5+ unit) buildings
  - 3/4 live in buildings with unitized HVAC equipment but 2/3 live in buildings with central DHW systems
  - 2/3 of heating equipment 15+ years old
  - Over half have existing electric heat and existing central AC but heat pump penetration minimal
  - DHW mainly fueled by natural gas



Source: 2021 ACS PUMS

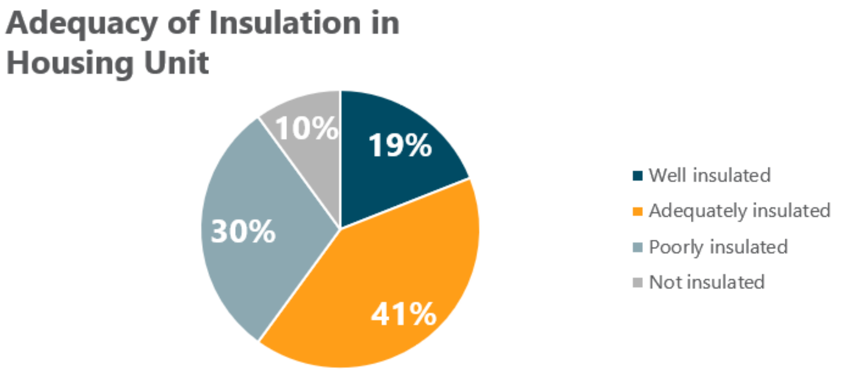


Source: 2021 ACS PUMS

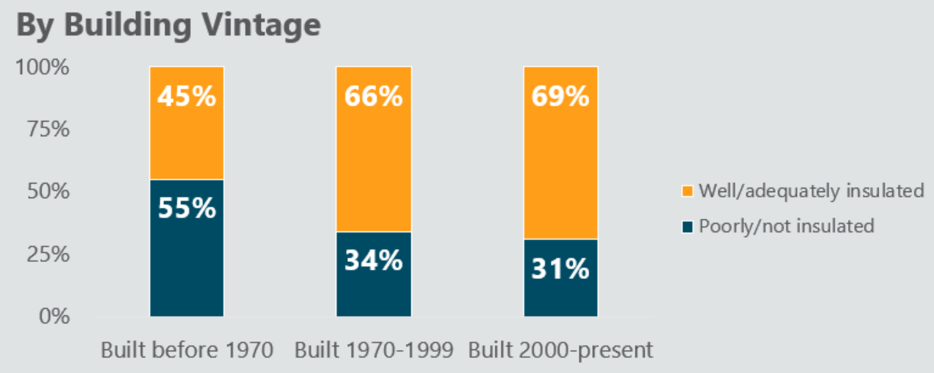
Sources: 2021 ACS PUMS

Key Findings to Date: Housing Conditions

- Stucco most common exterior wall type followed by wood
- Windows mostly single-pane and original (even in buildings constructed before 1970)
- Over a quarter of residents report apartment is drafty most/all the time
- Almost 1/3 report using secondary heating equipment (mostly portable electric space heaters)



Source: 2020 RECS



Source: 2020 RECS

Sources: 2020 RECS

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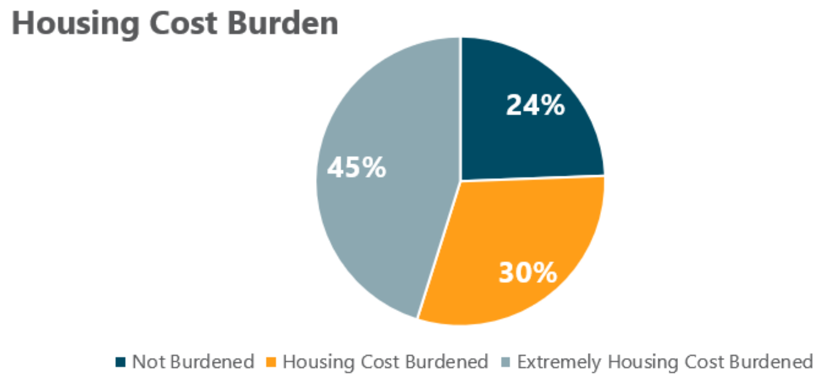
Key Findings to Date: Resident Demographics

- Most LMI households living in multifamily buildings rent their units (92%)
- >1/4 have income below HHS poverty guidelines
- 3/4 are housing cost burdened
- 1/3 have an elderly household member and nearly 20% face English-speaking barriers in the home



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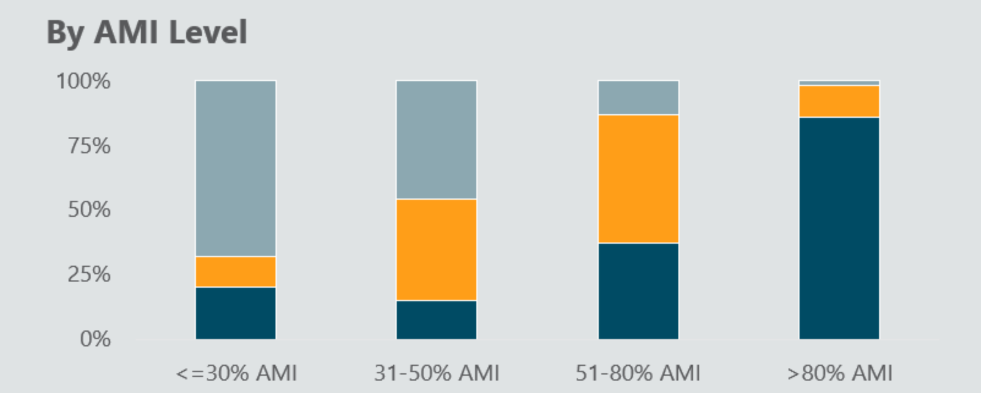

Source: 2021 ACS PUMS

Sources: 2021 ACS PUMS

Field Study Overview

- Context: in-depth data collection from 50 buildings from affordable housing properties in the Bay Area; included campus/property, building, common area, and unit-level data collection
  - About 1/4 garden style, 1/4 low-rise (<5 floors), 1/2 mid/high-rise (5+ floors)
  - About 1/4 built before 1970, 1/3 built 2000 and after
  - For individual buildings, about 46% with 50+ units
  - Most with some type of property subsidy, over half with utility allowances; <10% naturally-occurring affordable housing

Field Study High Level Findings to Date

- Most buildings with multiple electric subpanels but sizeable portion with only one main electric panel
- Panel upgrades will be needed for electrification in units served by gas
- HP HVAC penetration is low in both units and common areas; common area HVAC typically different from residential units
- Common window type (sliders) may limit opportunity for some newer HP HVAC technologies
- Most DHW central or small clustered, opportunity for large electrification upgrades but potential for transformer limitations
- Stucco is common exterior wall material and likely minimal insulation material
- Common area laundry rooms are prevalent, mostly existing gas dryers – opportunity for replacement with HP dryers with infrastructure upgrades
- Potential lighting opportunities: less than half of properties with >75% LED penetration

Remaining tasks:

- Analyzing data collected from field study of affordable multifamily buildings
- Combining field study information with data analyses from additional resources (AHS, CA RASS)
- Final report due at end of October 2023

Kevin McGrath

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Mobile and Manufactured Housing Market Characterization Study

Kevin McGrath / Project Lead

Whole Buildings, HVAC, Water Heating

Electrical Infrastructure, High-Efficiency HVAC, etc.

TDR

veic

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Why Examine this Market Segment?

- Mobile and manufactured homes (MMH) are a source of affordable housing and a hard-to-reach portion of the residential market segment
- No uniform building codes in effect prior to 1976 and no meaningful update to building codes since 1994
- Residents of manufactured homes face higher energy use intensities and energy burdens than other housing types
- Growing interest in building high-performance, all-electric manufactured housing but concerns over maintaining affordability of units with many residents already housing cost burdened

Project Components

Market Characterization

Lit review of existing studies, original analysis of Census and DOE data to provide CA-specific info on stock of existing MMH; review of codes impacting MMH; outreach and in-depth interviews with state agencies regulating/overseeing programs for MMH, IOU program implementers, trade organizations, park owners, and residents-owned communities.

Energy Modeling

Development of energy models for baseline (existing) and new MMH by climate zone; analysis of energy, peak load, carbon, and cost reduction savings potential for retrofit and whole home replacement scenarios.

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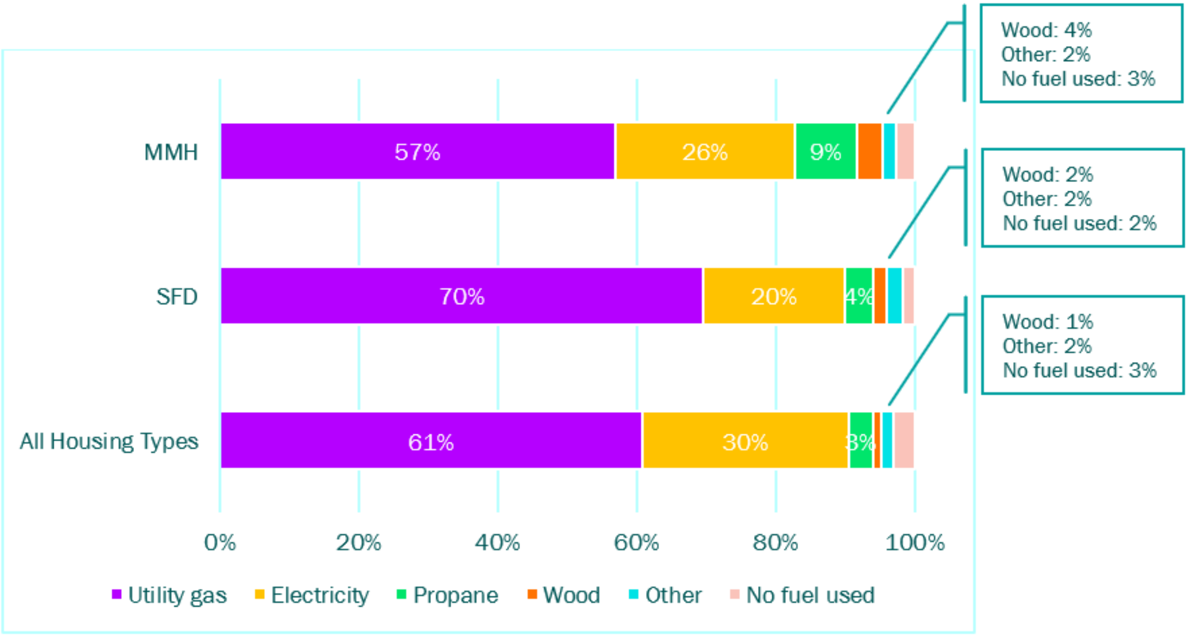
Key Findings to Date: Housing Characteristics

- At least 500K MMH units statewide (~440K occupied as primary residence)
- Over 4,000 mobile home parks in California
- 52% of MMH units constructed before 1980
- Less than 16% of units using electric heat have a heat pump



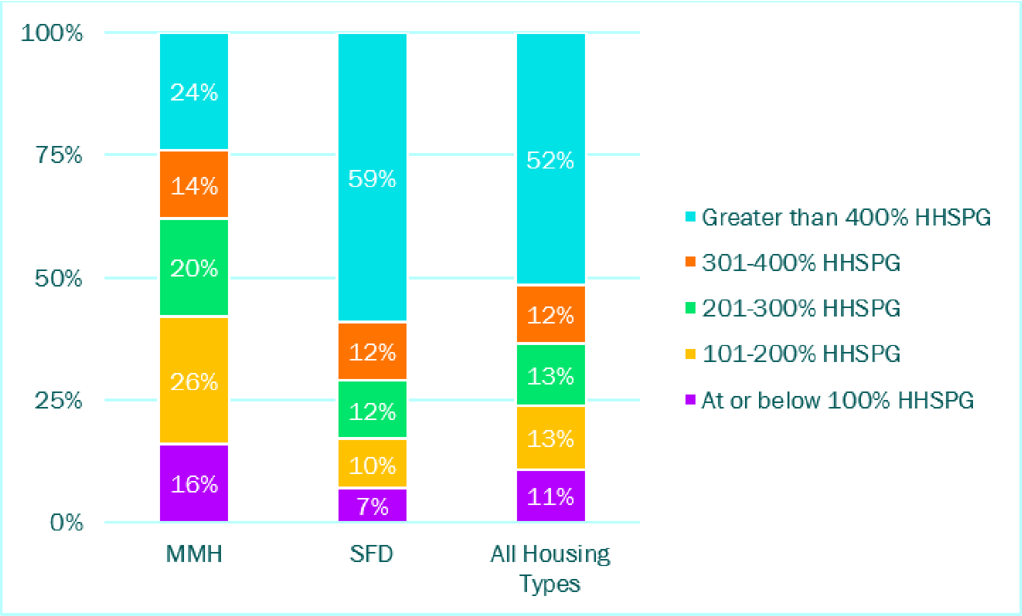
Main heating fuel used in MMH in California.

Source: 2021 ACS PUMS

Sources: 2021 ACS PUMS, 2022 HIFLD data

Key Findings to Date: Resident Demographics

- More than a quarter of MMH units located in DACs
- About three quarter of MMH residents own their homes
- Despite lower housing costs for MMH units, nearly 40% of residents are housing cost burdened
- Lower average energy costs than SFD residents but higher energy burden and higher energy cost per unit size



Share of occupied MMH, SFD, and all housing types in California by household poverty level.

Source: 2021 ACS PUMS

Sources: 2021 ACS PUMS, 2019 ACS combined with CalEnviroScreen 4.0, DOE LEAD Tool

Key Findings to Date: Interviews

- Minimum standards for MMH based on HUD Code, not California's Building Energy Efficiency Standards (Title 24)
- Electrification challenges noted by interviewees:
  - Master metering to parks
  - Limited amperage to individual lots in parks (usually less than 100 amp, sometimes 30 amp)
  - Panel upgrades needed in individual units
  - Spacing between lots (e.g., added costs for trenching lines)
  - Available space for HPWH or HVAC heat pump
  - Poor ductwork
  - Challenging to do envelope measures
  - Need to gain buy in from park manager, difficulties gaining buy-in from parks
  - Affordability challenge – factories ready to supply high-efficiency MMH but demand for standard units high

- Ongoing in-depth interviews with park owners, occupants, and other stakeholders
- Energy modeling of retrofit packages for existing MMH vs new MMH constructed to voluntary high-performance standards
- Development of retrofit vs replace decision tree to help guide programmatic decisions
- Final report due at end of October 2023

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Q&A

C&I Electrification

2:21-3:20 PM PT

Derek Okada

C&I Electrification Considerations

1. Panel upgrades and electric infrastructure upgrades are major barriers and these are areas of opportunity for programs to help offset the cost of these upgrades.

2. Increases in efficiency for electric foodservice equipment compared to gas is usually less with kitchen equipment (~30% increase in efficiency) than going from gas space or water heating to heat pump technology (~200% increase in efficiency).

3. There are many non-energy benefits associated with FS electrification that could be opportunities to incrementally increase adoption of FS electrification:
   - Indoor air quality, heat management in the kitchen, faster cooking times (productivity increase), greater cooking uniformity

All-Electric Commercial Kitchen Electrical Requirements

Kyle Booth, Energy Solutions

Process Loads

Restaurant and Food Equipment

Technology Support Research

Objectives

1. Determine electric load requirements for converting mixed-fuel kitchens to all-electric commercial kitchens
2. Estimate electrical service upgrade costs for all-electric commercial kitchens
3. Estimate potential electric load growth due to all-electric commercial kitchens
4. Evaluate the following kitchen types: quick-service restaurants, full-service restaurants, and institutional kitchens.

Data Collection Methodology and Approach

- Commercial foodservice supply chain interviews:
  - Design/build firms and consultants
  - Electricians
  - Chain restaurants
- Electrical load data and cost estimates
  - Electrical panel schedules and line drawings
  - Cost estimates from electricians
  - Equipment specifications from equipment dealers

Market Characterization

Foodservice Category	Counts	Percent of Market
Quick-Service Restaurant	40,477	37%
Full-Service Restaurant	29,137	27%
Institutional Foodservice	20,002	18%
Snack and Nonalcoholic Beverage Bars	14,247	13%
Other	4,818	5%
Total	**108,681**	**100%**

Source: Energy Solutions Project Team and *Characterizing the Energy Efficiency Potential of Gas-Fired Commercial Foodservice Equipment*

Average Site Capacity and Increase in Electrical Requirements

Category	Existing Service Capacity (A)	Existing Connected Amps	Utilized Capacity
Quick-Service	600	467	77%
Full-Service	640	533	87%
Institutional	700	338	45%

Category	Added Amps	All-Electric Connected Amps	Connected Amp % increase	Variance to Existing Service (A)	Amperage % Variance to Existing Service
Quick-Service	222	688	50%	88	15%
Full-Service	371	904	79%	264	41%
Institutional	181	520	56%	-180	-26%

Average Peak Demand per Facility

Category	Existing Peak Demand (kW)	All-Electric Peak Demand (kW)	Peak Demand Increase
Quick Service	58	92	58%
Full Service	72	123	71%
Institutional	41	61	50%
Average	57	92	65%

Estimated Increase in Electrical Load

Category	Number of Facilities	Total Existing Connected MW	Added MW	All-Electric Total Connected MW
Quick-Service	40,477	6,719	3,920	10,639
Full-Service	29,137	5,986	4,276	10,262
Institutional	20,002	2,339	1,166	3,505
Snack & Beverage	15,117	1,389	10	1,399
Total	104,733	16,433	9,372	25,805

Average Cost of Electrical Upgrades

Category	Average Number of Equipment Converted	Total Cost Per Site
Quick-Service	5	$123,000
Full-Service	8.2	$160,000
Institutional	4.8	$40,000

Category	Number of Facilities	Total Market Cost (Billions)
Quick-Service	40,477	$4.99
Full-Service	29,137	$4.67
Institutional	20,002	$.81
Total	89,616	$10.46

Estimated Demand Cost Increase per Facility

Category	Existing Annual Peak Demand Cost	All-Electric Peak Demand Cost	Additional Annual Peak Demand Cost
Quick Service	$5,500	$10,400	$4,990
Full Service	$7,490	$14,900	$7,420
Institutional	$3,400	$6,200	$1,640

Program Design Considerations

- Holistic view of electrification
- Incentivize electrical service upgrades
- Create pathway for phased electrification retrofits
- Explore options for operating cost reduction
- Market engagement and training
- Support foodservice manufacturers with electric equipment development

Areas for Further Study

- Hot water and HVAC load analyses
- Kitchen exhaust reduction
- Indoor air quality analysis
- Utility infrastructure upgrade costs

Final Report

Kyle Booth

Senior Staff Engineer

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Market Potential for HP Assisted Hot Water Systems in Foodservice Facilities

Amin Delagah, TRC

Water Heating

Commercial-Duty Water Heaters

TDR

Water Heating in Commercial Kitchens

- 90% gas-fired systems at an estimated 340 Mtherms of gas use per year
- Heat pump water heating (HPWH) provides a path to decarbonization
- Literature review identified appropriate HP technologies, hot water loads in foodservice segments, and related health codes
- Interviewed owners, designers and experts and identified early adopters
- Drivers identified; HPWH have:
  - Lower operating costs in minority of applications depending on local utility rates
  - Source and site energy savings
  - Discharged cooled air byproduct may be used to cool kitchens
  - Increases resiliency

Water Heating in Commercial Kitchens

- Barriers identified; heat pumps:
  - Have higher upfront costs (equipment, design, installation, electrical upgrades)
  - Have higher space and water storage requirements (footprint, weight)
  - Broad lack of familiarity with technology and application with owners
  - Health department water heater sizing guidelines don't incorporate HP sizing
    - May effectively disallow HP only installation (no backup gas or electric resistance)
    - Electric resistance WH thermal efficiency of 0.98 is used to calculate kW input (power)
    - If allowed by local jurisdiction, the HP is oversized by up to 400 percent

Source: CCDEH

Formula 2 (for electric water heaters):

$$KW\ input = GPH\ X\ {}^{\circ}F\ Rise\ X\ \frac{8.33lb}{gallon\ of\ water} \div Thermal\ Efficiency^{1}\ X\ 3412\frac{BTU}{KW}$$

KW input = 54 GPH X 50°F X 8.33 lbs / 0.98 X 3412 BTU/KW = 6.7 KW

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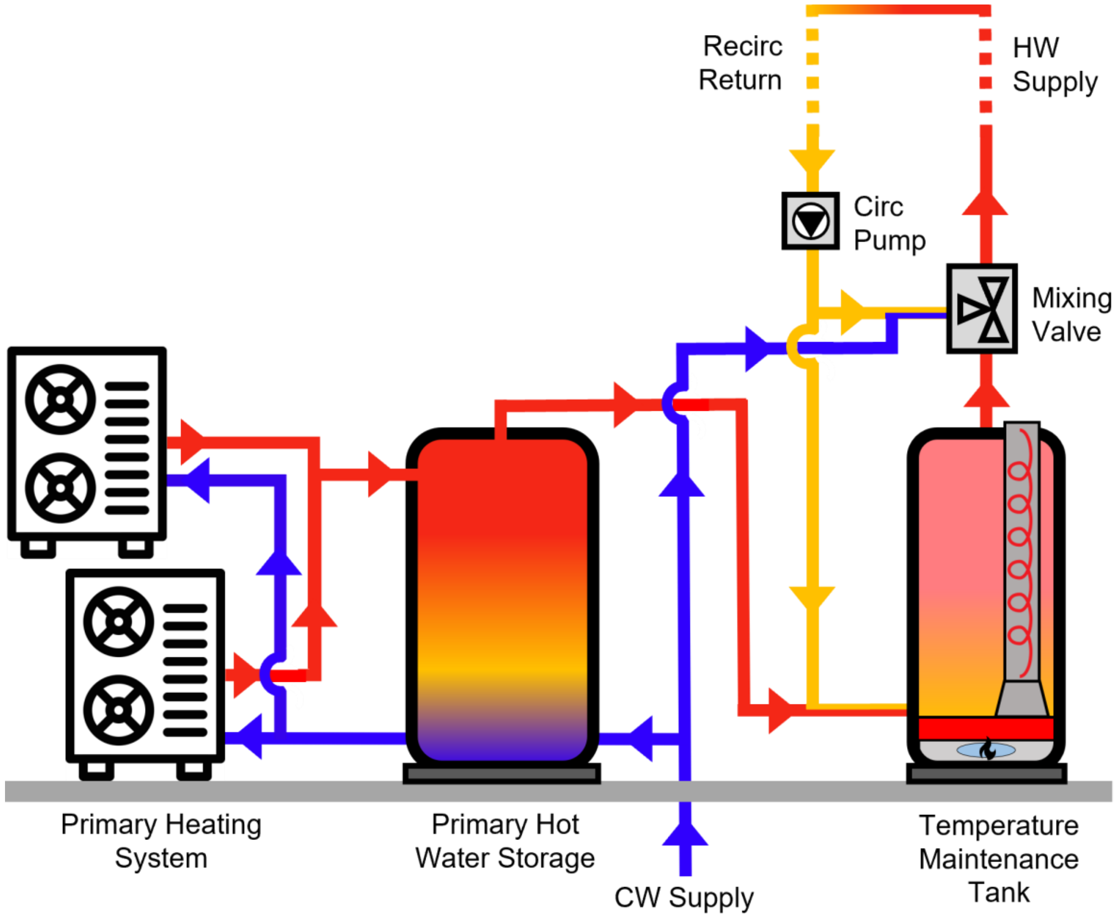
Overcoming Regulatory Barriers with HP Assist

- Using a heat pump and storage tank upstream, in series with the existing gas heater in an “assist” fashion, is one way to overcome HP sizing barrier
- HP may be setup to only operate during off-peak periods between 9pm to 4pm
- In facilities with small hot water loads, there is a regulatory path to use light-commercial integrated HP/electric resistance heaters that meet electrical input power requirements.



Final Remarks

- Using a HP-assist can address HP sizing barrier and reduce operating costs by operating during off-peak hours and offers a more accessible step closer to full decarbonization
- Electrical panel upgrade and wiring and space requirements are the two biggest physical barriers for any foodservice business with an existing gas water heater
- Higher upfront costs are an especially relevant barrier for quick and full-service restaurants, as a smaller integrated/hybrid HPWH is not an option for these larger hot water users
- Currently very limited adoption of HPWH in commercial kitchens via pilot projects in California
- Zero emission WH (GHG, NO_x) CARB rule anticipated in 2025 for 2030 start date
- Zero NO_x WH measure anticipated in Nov. for Bay Area and South Coast AQMD for 2031 start

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This project was funded by CalNEXT.

For more information, contact Marc Fountain at Mfountain@trccompanies.com.

The project report can be found at https://calnext.com/wp-content/uploads/2023/07/ET22SWE0019_Final_Report.pdf.

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Industrial Heat Pump Market Study

Colin Lee
Process Loads
Steam & Hot Water Systems
Technology Development Research (TDR)

Scope

We are proposing to perform a technology and market assessment to:

1. Size the potential market of industrial heat pumps in CA,
2. Identify the highest benefit applications and locations,
3. Identify commercial and pre-commercial technologies and manufacturers,
4. Identify technology feasibility including technology and market barriers and opportunities, and
5. Recommend utility interventions to support market adoption.

Expected Outcomes

- The final report will outline the electrification options for industrial process heating systems in industrial facilities in CA using industrial heat pumps.
- Additionally, the study will determine the market size for industrial heat pump retrofits in CA.
- This study will unveil expected energy savings, cost effectiveness, technology barriers, as well as any financial and market barriers.
- The study will include recommendations for the next steps, including the potential for a follow-up field demonstration study.
- The final report would show the benefit of this technology and provide resources for the public and the stakeholders to show the savings customers could achieve.

How will this project impact the EE portfolio:

- The technology aligns well with energy efficiency, decarbonization, and load/grid flexibility.
  - Reduces water heating loads in industrial process heating applications

- Installation of this technology will allow for electrification of large boiler systems used in industrial facilities, which may be in HTR and DAC.

- As Technology Development Research (TDR), the proposed project executes emerging technology research that researches technologies nearing commercialization and supports the IOU energy efficiency portfolios, GHG reduction and load flexibility.

- With CA's goal to accelerate heat pump installations, having market information about efficient technology that can replace fossil-fuel based industrial process heating technologies will be beneficial to understanding barriers and solutions to build successful adoption programs.

Other than fitting under TPM and EE portfolio demands, why is this research important/ chosen:

- Before spending more money on an installation and M&V effort, we believe that this technology should be evaluated from a theoretical standpoint to evaluate the market potential, most beneficial applications, and barriers to broader adoption.
- The industrial sector accounts for more than 25% of GHG emissions and 50% of the thermal energy for production is from on-site energy usage.
- Per ACEEE, industrial heat pumps are increasingly used in Europe, Japan, and Australia but are not very well established within the United States.
- As of the 2022 study, less than 5% of process heat used electricity and was generally sourced from fossil fuels. This suggests a large growth opportunity for this market.
- This technology proposes to provide carbon free heating to industrial processes, thus may be applicable to a variety of industrial facilities.
- The market study will identify how technology is expected to work in numerous industries, temperature applications within California.

Are there other research projects/ideas that could complement this project?

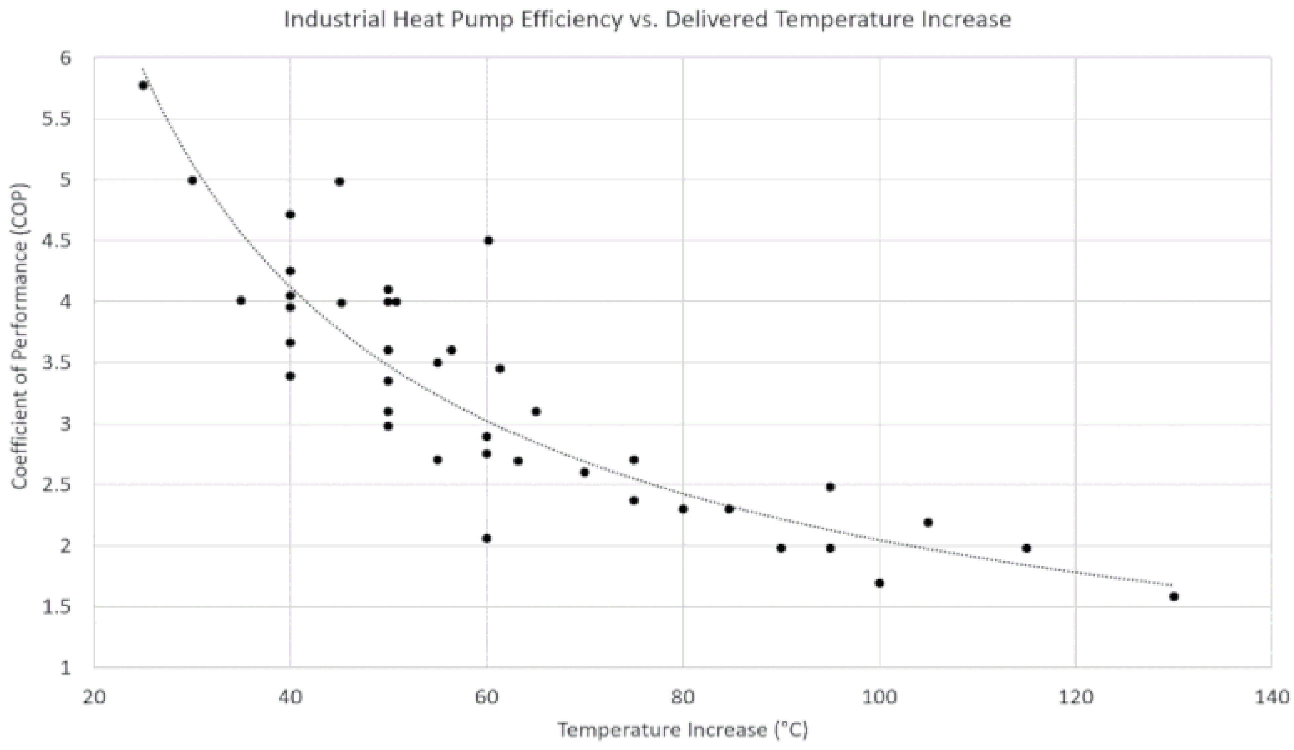
- Pilot deployments and M&V studies on industries never studied before
- Technology R&D on increasing applications of industrial heat pumps (increasing temperature lift, reducing equipment size, noise, etc.)
- Studies on niche applications of industrial heat pumps (industries not covered in this project)

How market participant feedback will be obtained:

- Manufacturer and vendor interviews
  - Outreach to gather information on technology maturity, development trajectory, targeted markets, feasibility, opportunities, barriers, and costs.
  -
- Identify program pathways by interviewing industry experts
  - Develop recommendations for targeted testing

Preliminary Findings

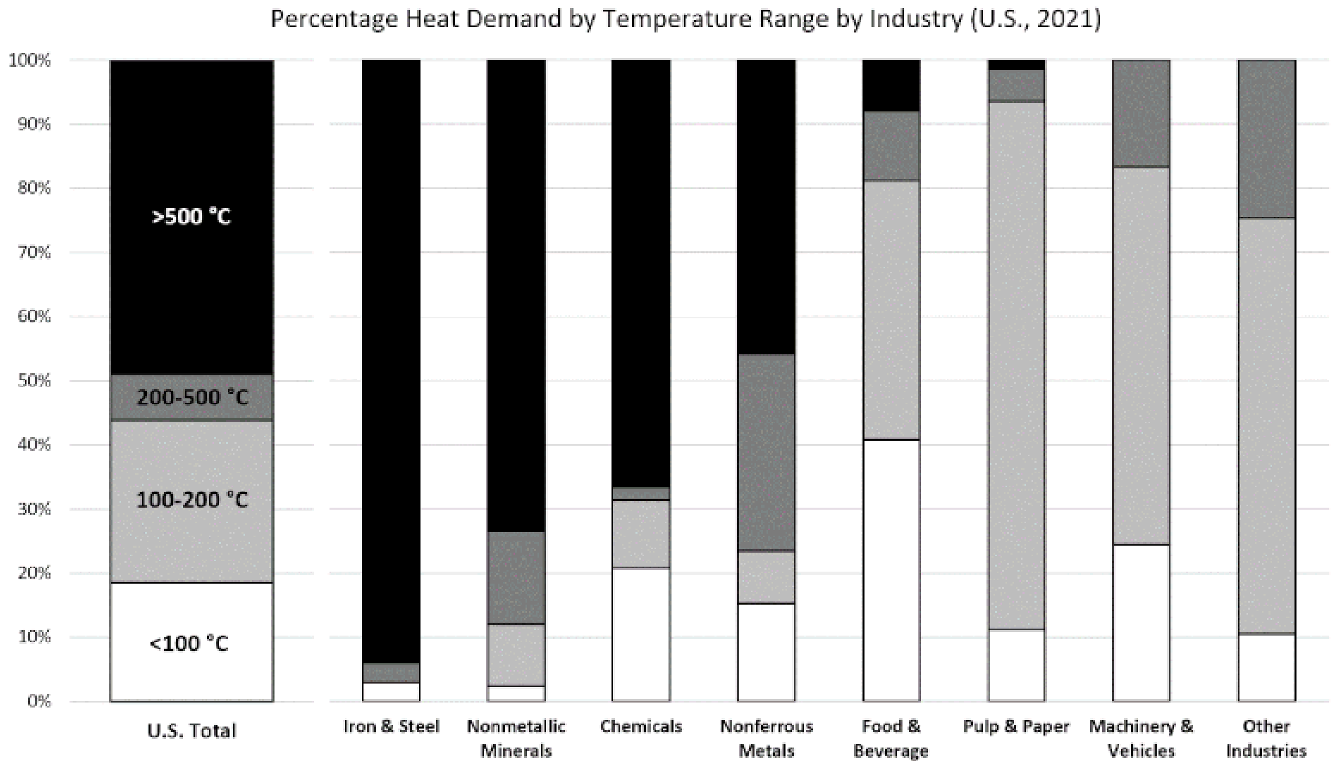
- A heat pump is a device that transfers heat from a lower temperature (T source) to a higher temperature (T sink) level.
- Can be very efficient (COP > 5) – depending on operating temperatures
- Typically, an industrial heat pump will take heat from a source around 77-95°F (25-35°C) and can output temperatures as high as 329°F (165°C).
- The efficiency of a heat pump declines with greater temperature increases, therefore leaving limited target industries for industrial heat pumps.



Source: https://doi.org/10.1016/j.energy.2018.03.166

Preliminary Findings

- Roughly 35% of industrial heat needs are at temperatures up to 165 °C (329 °F), the maximum temperature that can be supplied by commercialized industrial heat pumps
- If supplied with electricity from zero-emissions sources, such as solar, wind and nuclear power, this heat can be emissions-free.
- Below 100˚C (212 °F) are called high-temperature heat pump (HTHP)
- While HP with steam delivery temperatures greater than or equal to 100˚C (212 °F), are termed steam-generating heat pumps (SGHP) or very high temperature heat pump (VHTHP). Commercially available IHPs supply temperature ranges between 90˚C (194˚F) and 165˚C (329 °F).



Source: Rissman, J., 2022. Decarbonizing Industrial Heat via Heat Pumps. https://www.industrialheating.com/articles/97313-decarbonizing-industrial-heat-via-heat-pumps
Data sources: Fraunhofer Institute, U.S. EIA

Preliminary Findings

M Jibran, S. Zuberi, Ali Hasanbeigi, William R. Morrow. Electrification of U.S. Manufacturing with Industrial Heat Pumps. Lawrence Berkeley National Lab (2022). Report # LBNL-2001478.

- IHP Market Estimates for 11 different industries used two different scenarios:
  - Conservative case: Only high temperature heat pump (HTHP) applications are considered meaning applications requiring temperatures less than 100°C (212°F) and boiler pre-feed are only considered.
  - Aggressive case: Both HTHP and steam generating heat pumps (SGHP) are considered. The maximum heat sink temperature of SGHP was considered to be 150 ° C (302 ° F). This is because of the lack of availability of SGHP manufacturers who can deliver temperatures over 150 ° C (302 ° F). As well, a temperature lift higher than 130 ° C (266 ° F) is techno-economically not favorable.

Source: M Jibran S. Zuberi, Ali Hasanbeigi, William R. Morrow. Electrification of U.S. Manufacturing with Industrial Heat Pumps. Lawrence Berkeley National Lab (2022). Report # LBNL-2001478.

Preliminary Findings

Meat processing industry

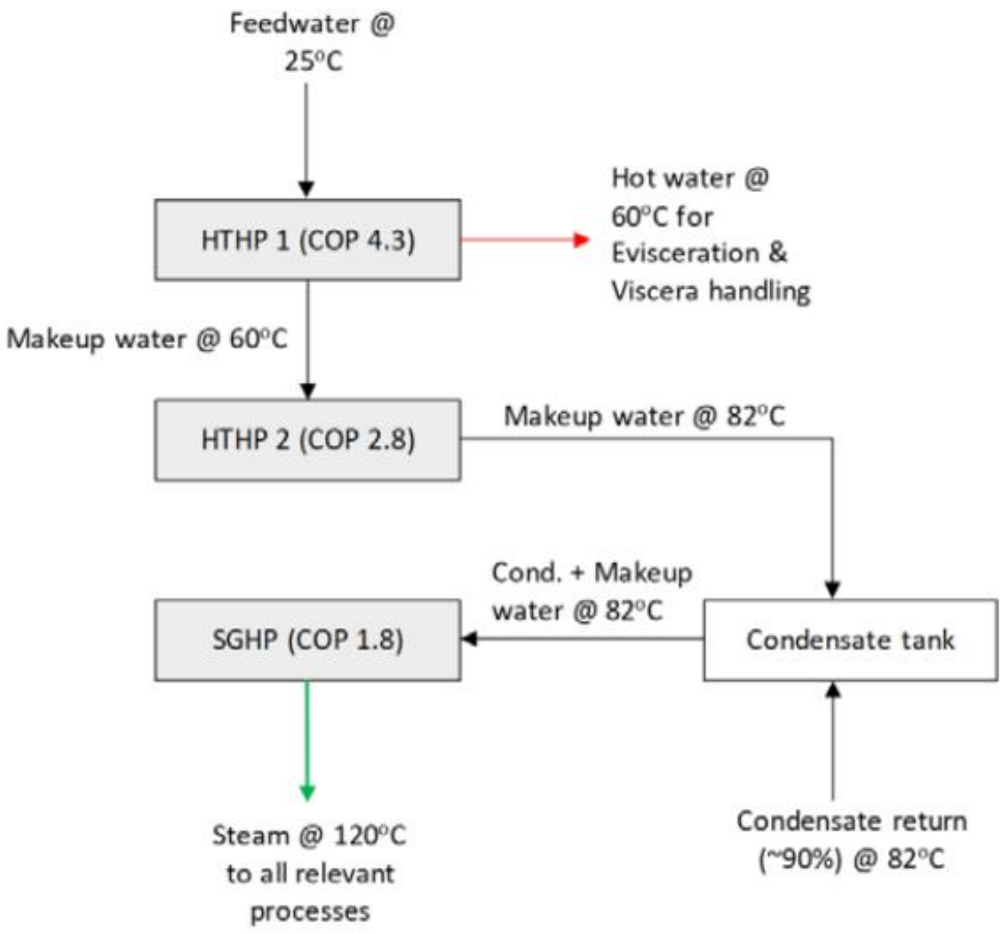
- Approximately 25M tons of red meat processed in 2021 and is expected to grow to 30M tons in 2050 (estimated based on (USDA ERS, 2022))
- A variety of process steps may utilize either HTHP (<100°C, 212°F) or SGHP (100 - 165°C) (212°F - 329°F)

Conventional process				Process steps	Modified process with IHP		
Direct fuel use	Fuel use in boilers	Steam or water temp.	Electricity use		Direct fuel use	Electricity use in IHPs	Electricity use in other processes
GJ/t	GJ/t	°C	kWh/t		GJ/t	kWh/t	kWh/t
			2.6	Slaughter			2.6
			0.3	Blood processing			0.3
	0.2	120	0.3	Blood dryer			0.3
	0.2	120	2.3	Scalding & dehairing			2.3
			1.0	Hide removal & proc.			1.0
0.1				Singeing & polishing	0.1		
	0.3	60		Evisceration			
	0.5	60		Viscera handling			
			1.0	Trimming		313.0	1.0
			1.9	Cutting & deboning			1.9
	0.4	120	6.1	Edible rendering			6.1
	1.5	120	24.3	Inedible rendering			24.3
	0.2	120		Inedible rend. drier			
			8.1	Recovery system			8.1
0.3	0.1	120	19.3	Processing	0.3		19.3
			36.5	Packaging			36.5
			93.7	Chiller			93.7
0.4	3.4		197.5	Total	0.4	313.0	197.5

Notes:
SEC values are per tonne of meat production.
Boiler system efficiency is assumed at 78% (adapted based on U.S. DOE/Energetics, 2022).
Process steps highlighted in green color show the processes with heat demand at temperatures suitable for IHP applications.
1 GJ = 277.78 kWh

Sources: M Jibran S. Zuberi, Ali Hasanbeigi, William R. Morrow. Electrification of U.S. Manufacturing with Industrial Heat Pumps. Lawrence Berkeley National Lab (2022). Report # LBNL-2001478.
USDA ERS, 2022. Livestock and Meat Domestic Data. https://www.ers.usda.gov/data-products/livestock-and-meat-domestic-data/ (accessed 4.5.22).

Preliminary Findings



- One HTHP for Evisceration & Viscera Handling (60°C, 140°F)
- A different HTHP can be used to further preheat makeup water from 60°C to 82°C (140 to 180°F) to reduce energy loss when mixing condensate within the condensate tank for steam generation
- A SGHP for steam generation (120°C, 248°F)

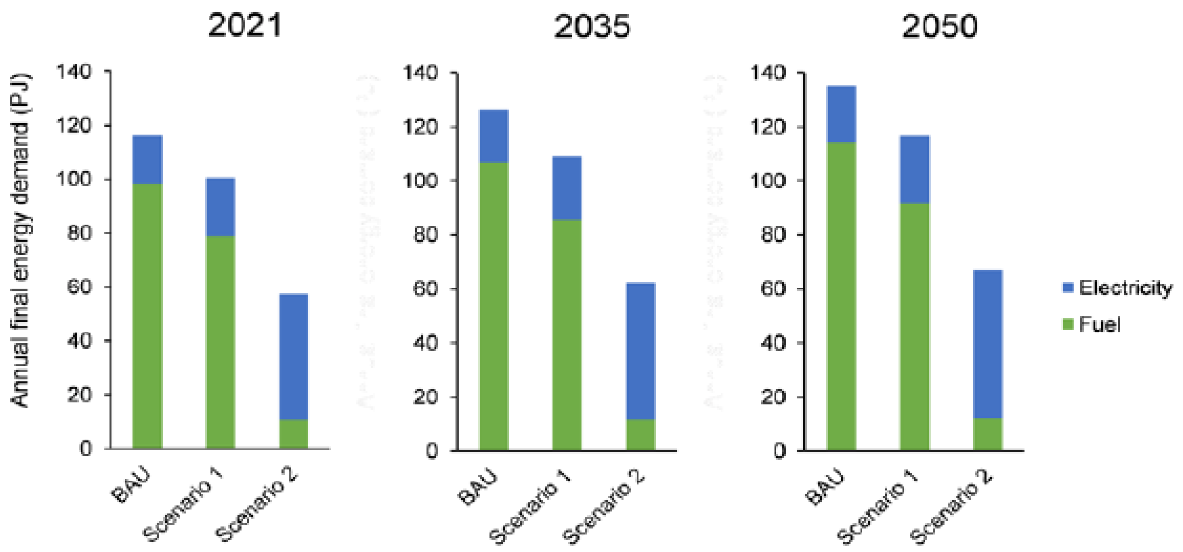
Sources: M Jibran S. Zuberi, Ali Hasanbeigi, William R. Morrow. Electrification of U.S. Manufacturing with Industrial Heat Pumps. Lawrence Berkeley National Lab (2022). Report # LBNL-2001478.

Preliminary Findings

- Total US Meat Processing Estimates:
  - Heating capacity for HTHP: 850 MW
  - Heating capacity for SGHP: 2620 MW

- BAU = Business-As-Usual
- Scenario 1 – Only HTHP: 18 PJ Energy Savings
- Scenario 2 – HTHP & SGHP: 69 PJ in Energy Savings

- By 2050, 102 PJ of fuel demand could be reduced with a 33 PJ per year (9.2 TWh per year) electricity demand increase for Scenario 2



Source: M Jibran S. Zuberi, Ali Hasanbeigi, William R. Morrow. Electrification of U.S. Manufacturing with Industrial Heat Pumps. Lawrence Berkeley National Lab (2022). Report # LBNL-2001478.

Preliminary Findings

- Focusing on California:
  - Total Red Meat Processed: 1.4M tons/25M tons
  - Heating capacity for HTHP: 47MW/850 MW
  - Heating capacity for SGHP: 145MW/2620 MW

- BAU = Business-As-Usual
- Scenario 1 – Only HTHP: 1PJ/18 PJ Energy Savings
- Scenario 2 – HTHP & SGHP: 3.8PJ/69 PJ in Energy Savings

- By 2050, 5.6 PJ of fuel demand could be reduced with a 1.8 PJ per year (0.51 TWh per year) electricity demand increase for Scenario 2

United States Census Bureau

North American Industry Classification System (NAICS)

	Total US Employment	California Employment	%
NAICS Code 311612 (Meat Processed from Carcasses)	121,195	6,486	5%
NAICS Code 311613 (Rendering and Meat Byproduct Processing)	10,300	788	8%
Total	131,495	7,274	5.5%

Source: https://www.census.gov/programs-surveys/economic-census/year.html

Preliminary findings

- An example of a IHP revamp in a meat processing facility was seen in a slaughterhouse in Switzerland where a HTHP system comprised of three CO_2 heat pumps with a heating capacity of 800 kW and COP of 3.4 was used to heat process water to 90°C (194°F). The heated water was used for various purposes including cleaning, slaughtering, boiler feedwater, and space heating. (Arpagus and Bertsch, 2020)
  - This resulted in a 30% reduction in annual CO2 emissions (510 tons)

Source: Arpagaus, C., Bertsch, S., 2020. Industrial Heat Pumps in Switzerland: Application Potentials and Case Studies. Bern. https://www.aramis.admin.ch/Default?DocumentID=66033

Next Steps

- Food & Beverage Industries
  - **Meat processing industry ✓**
  - Dairy industry
  - Beer industry
  - Canned vegetable and fruit processing industry
  - Cane sugar refining industry
  - Beet sugar industry
  - Corn wet-milling industry
  - Soybean oil industry
- Textile industry
- Pulp and Paper industry
- Automotive industry

- Manufacturer Outreach
  - Inventory industrial heat pump technologies and products available in the industrial market space
  - Identify necessary technology safety standards
  - Pre-commercial technologies/Development Trajectory
    - Identify any recent innovations/development technologies/manufacturers
- Recommend utility interventions to support market adoption
- Technology Transfer opportunities to be evaluated

Thank you!

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Q&A