

Exploring Barriers to Electrification

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ABSTRACT

In order to scale beneficial electrification (BE) efforts, several structural barriers must be reckoned with. Although not insignificant, structural barriers are fairly well known. However, little research has been done on the fuel preferences and perceptions of BE in low income communities. Even if a utility offered BE services at no cost to a customer, would they accept it? This paper/session will explore our research of disadvantaged communities in California's San Joaquin Valley; a socioeconomically depressed agricultural region in the Central Valley that disproportionately relies on alternative fuel sources (such as wood and propane) for heating and cooking (in large part due to their lack of natural gas service). Through surveys with thousands of residents in this predominantly Spanish-speaking migrant community, we will explore both structural and cultural barriers to BE.

Introduction

Beneficial electrification (BE) is an important strategy for the future of residential program design and residential building retrofits. This paper explores research gathered from disadvantaged communities (DACs) in the San Joaquin Valley (SJV) to provide a better understanding of how residents in these communities perceive BE, their concerns with fuel switching, and the potential benefits of BE, especially for customers who rely on alternative fuel sources. BE in these communities is one potential tool to address energy equity. Opinion Dynamics recently conducted research in California's SJV DACs where customers have a greater reliance on alternative fuels. This research was done as a part of Assembly Bill (AB) 2672 which "amended the California Public Utilities Code to include Section 783.5, which seeks to increase affordable access to energy for disadvantaged communities (DACs) in the San Joaquin Valley (SJV) and to improve the health, safety and air quality of these communities," as outlined in CPUC Decision 18-08-019 (hereafter, "the Decision").¹

¹ CPUC San Joaquin Valley Affordable Energy Proceeding, Decision 18-08-019, <http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M225/K574/225574950.PDF>, August 23, 2018

Data Sources

This paper utilizes the research findings Opinion Dynamics presented as part of the Data Gathering Plan outlined in the Decision in the SJV. SJV is home to many communities that lack access to natural gas pipelines, experience higher air pollution concerns, and are agricultural farming communities. Almost half of SJV residents are Hispanic and a large percentage of households are Spanish speaking.

In order to provide a deeper understanding of this research, the Decision defines SJV DACs as communities with the following demographic traits: (1) at least 25% of the residential households with electrical service are enrolled in the California Alternate Rates for Energy (CARE) program, (2) a population greater than 100 persons within its geographic boundaries as identified by the most recent survey, and (3) geographic boundaries no further than seven miles from the nearest natural gas pipeline operated by a natural gas corporation. SJV DACs consist of small, medium, and large communities. Small communities are defined as those with fewer than 1,000 households, medium communities as those with 1,000 to 10,000 households, and large communities as any with more than 10,000 households. SJV DACs are located in the counties of Fresno, Kern, Kings, Madera, Merced, San Joaquin, Stanislaus, and Tulare (Figure 1).

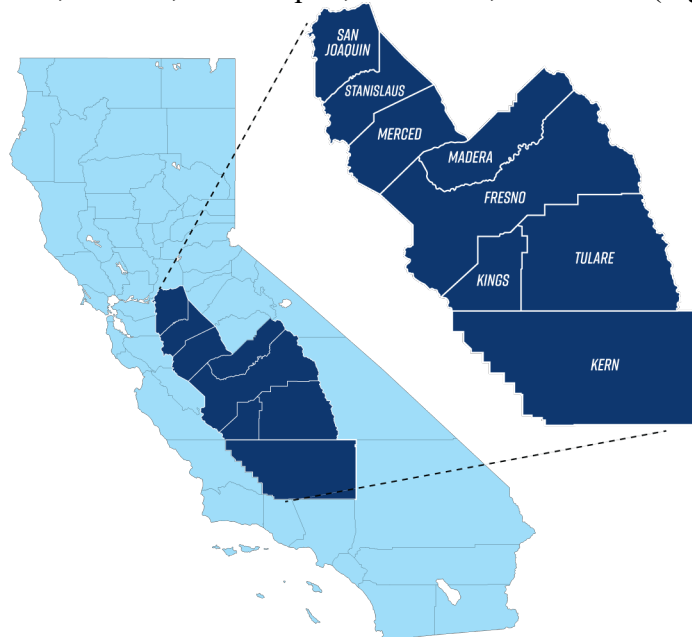


Figure 1. Counties of the San Joaquin Valley

We used numerous sources and data collection methods to conduct this project and address the research objectives. All primary data collection instruments were offered in both English and Spanish languages. Data collection methods and sources included the following:

- The IOUs' customer and billing data, which were used to develop survey samples and calculate energy usage, costs, and burden.
- A quantitative survey with 2,660 customers designed to address multiple research objectives. The survey sample was stratified to include a sufficient number of customers

who do not have access to natural gas, live in small communities, and who live in mobile homes.

- Home audits with subsample of 259 survey respondents (156 in-home and 103 virtual/teleconference), which verified survey responses that are prone to self-reporting error and collected information not suitable for a survey.
- Qualitative in-depth interviews with a subsample of 60 audit participants to provide a deeper understanding of alternate fuel usage, health and safety considerations, energy burden and perceived burden, as well as customer preferences.
- Interviews with four propane and five wood suppliers in February 2021. We used the interviews to verify the survey responses on alternative fuel costs.

A subgroup was created to analyze customers eligible for CARE and those ineligible for the CARE program. This subgroup was used to provide insights into low income customers within these communities. CARE eligibility was based on self-reported income and number of residents. Households were mapped to CARE eligibility rules. In addition, customers flagged as CARE in IOU records were flagged as CARE-eligible regardless of self-reported income and number of residents. We could not estimate CARE eligibility for customers who did not report income or the number of residents in their household (313 out of 2,660). Survey results reveal that 48% of SJV DAC residents are eligible for CARE, most of whom are enrolled (43% of all non-multifamily customers in the studied SJV DACs are enrolled in CARE).

Findings

In this section, we first present findings on overall energy costs and burden by SJV households that rely on alternative fuels. SJV households using alternative fuels also have higher energy burdens as a result. This background is followed by findings associated with fuel preferences and barriers to fuel switching for an electrified home.

Residents in the SJV without access to natural gas have higher energy costs due to alternative fuels.

This research sought to understand how the high energy costs of customers who do not have access to natural gas and rely on alternative fuels compare to those with access to natural gas. Results confirm that customers who do not have access to natural gas pay more to fuel their homes than customers with natural gas. The average annual total energy costs of customers without access to natural gas are 38% higher than customers with access to natural gas (\$2,312 vs. \$1,671) in Table 1.

Customers without access to natural gas rely on a variety of fuels to meet their needs. All-electric customers have lower total energy costs on average (\$1,687) and are comparable to the total costs of customers with natural gas. Propane use increases costs. Customers who use both propane and wood have the highest total energy costs (\$2,919). Customers whose only alternative fuel is propane pay an average of \$2,597 in annual energy costs. Customers whose only alternative fuel is wood have the next highest total average energy costs (\$2,029).

Study results confirm that propane is a much more expensive fuel than natural gas. Households that do not have access to natural gas and use propane spent on average nearly three times as much for propane than households with natural gas spent on natural gas (\$1,177 vs. \$403). The average wood user pays less annually (\$379), but most wood users only use wood for space heating, and some use wood as a supplemental source. Propane users typically fuel more than one end use with propane.

Table 1. 2019 Average energy costs for alternative fuel households

Fuel used	n*	Total costs	Electricity costs	Natural gas costs	Propane costs	Wood costs
Natural gas (a)	736–1209	\$1,671	\$1,303	\$402	N/A	N/A
No natural gas (b)	194–1269	\$2,312 ^a	\$1,496 ^a	N/A	\$1,177	\$379
All electric (c)	268–268	\$1,687	\$1,687 ^{adef}	N/A	N/A	N/A
Propane only† (d)	550–677	\$2,597 ^{ace}	\$1,432 ^a	N/A	\$1,222 ^f	N/A
Wood/Wood pellet only† (e)	47–87	\$2,029	\$1,545	N/A	N/A	\$323
Both propane and wood/wood pellets (f)	128–237	\$2,919 ^{acde}	\$1,375	N/A	\$1,049	\$395

a/b/c/d/e/f Indicates significant differences at a 90% confidence level between the following tests: ab,acdef.

* n values range due to several factors: incidence rates of the fuels used, missing cost data, and removing outliers.

†Propane only and wood only customers use only one alternative fuel. Respondents may also use electricity for a major energy end use.

As a result, BE is a tool that can be used to reduce costs for low income customers in disadvantaged communities and provide a safer alternative to propane and wood fuel sources.

High energy costs and lower incomes mean that these same households in the SJV experience higher energy burdens than comparable households with access to natural gas.

Energy burden is a function of household income and energy costs. The standard, basic calculation of “customer energy burden” is the sum of each customer’s household energy bills during a given year divided by their household income for that year, notated as:

$$\text{Customer Energy Burden} = \frac{\text{Annual IOU Bill Amounts} + \text{Annual Alternative Fuel Amount}}{\text{Annual Household Income}}$$

A weighted average of individual customer energy burden results represents the overall average energy burden metric.

As noted above, the average customer who lacks access to natural gas pays 38% more in annual energy costs than customers with natural gas. Customers without natural gas have proportionately higher energy burdens (5.9% vs. 4.5%) shown in Table 2. Annual household incomes do not significantly differ by natural gas access, so the difference in energy burden is driven almost entirely by higher energy costs.

Table 2. 2019 Average energy costs and energy burden

Fuel used	n*	Total costs	Energy burden
Natural gas (a)	619–1269	\$1,671	4.5%
No natural gas (b)	833–1391	\$2,312 ^a	5.9% ^a
All electric (c)	207–307	\$1,687	5.6% ^a
Propane only (d)	475–746	\$2,597 ^{ace}	5.8% ^a
Wood/Wood pellet only (e)	40–92	\$2,029	5.7%
Both propane and wood/wood pellets (f)	111–246	\$2,919 ^{acde}	7.0% ^a

a/b/c/d/e/f Indicates significant differences at a 90% confidence level between the following tests: ab,acdef.

* n values range due to several factors: incidence rates of the fuels used, missing cost data, and removing outliers.

The increased burden resulting from lack of access to affordable energy is not shared equally across all customers. Lack of access to natural gas has a disproportionately greater impact on low income customers (indicated by CARE eligibility) than non-low income customers. CARE-eligible customers who lack access to natural gas and live in small communities, mobile homes, or own their homes have particularly high energy burdens (11.1%, 10.1%, and 9.4% respectively). CARE-eligible homeowners have higher energy burdens than renters because they are more likely to use expensive alternative fuels, whereas renters are more likely to be all-electric. CARE-ineligible customers have only slightly higher energy burdens than those with natural gas suggesting they have the financial resources necessary to cope with the higher energy costs.

SJV customers had a more favorable impression of natural gas when compared to alternative fuels than electricity when compared to alternative fuels.

The findings up to this point show the additional burden put on residents in these SJV communities and support the need for energy equity through BE initiatives. As a part of this research, we explored customer perceptions of BE, electric and natural gas as a fuel source, and their theoretical willingness to switch their space heating, water heating, and cooking fuels. Next, we present customer perceptions of natural gas and electricity compared to their alternative fuel use.

First, we explored the perceptions of propane users when comparing propane as a fuel source to natural gas. Many propane users prefer natural gas to propane as a fuel source; about one-third (32%) of propane users indicate that natural gas is better than propane. The remaining respondents are either unsure (28%), feel the two fuels are equal (26%), or feel that natural gas is worse than propane (14%) in Table 3.

Table 3. Propane vs. natural gas, propane users

	n	Natural gas is worse than propane	Natural gas is equal to propane	Natural gas is better than propane	Unsure
Propane users	982	14%	26%	32%	28%

Responses among propane users, no natural gas.

Next, we compared propane users' perceptions of propane to electricity. Propane users do not prefer electricity over propane. Over one-quarter (28%) of propane users indicate that electricity is worse than propane. About one-fifth (18%) feel that electricity is better than propane. Approximately half feel the two fuels are equal (27%) or are unsure (26%), as shown in Table 4.

Table 4. Propane vs. electricity, propane users

	n	Electricity is worse than propane	Electricity is equal to propane	Electricity is better than propane	Unsure
Propane users	982	28%	27%	18%	26%

Responses among propane users, no natural gas.

When customers use wood as a main fuel source, they have a stronger preference of wood as a fuel source. Wood users do not prefer natural gas over wood as a fuel source. About one-third (34%) of wood users feel that natural gas is worse than wood. Over one-quarter (28%) indicate that natural gas is better than wood. Few feel the two fuels are equal (16%) and approximately one-fifth (22%) are unsure, shown in Table 5.

Table 5. Wood vs. natural gas, wood users

	n	Natural gas is worse than wood	Natural gas is equal to wood	Natural gas is better than wood	Unsure
Wood Users	197	34%	16%	28%	22%

Responses among wood users, no natural gas.

Similarly, when comparing wood to electricity as an energy source, half (49%) of wood users indicate that electricity is worse than wood. Wood users do not prefer electricity as a fuel source. One-fifth (19%) feel that electricity is better than wood. Equal numbers feel that the two fuels are equal (16%) or are unsure (16%), shown in Table 6.

Table 6. Wood vs. natural gas, wood users

	n	Electricity is worse than wood	Electricity is equal to wood	Electricity is better than wood	Unsure
Wood users	197	49%	16%	19%	16%

Responses among wood users, no natural gas.

Electrification building designs will need to overcome these perceptions, especially for customers who are used to wood as a fuel source and do not perceive electricity as positively as they perceive wood as a main energy source. This barrier exposes the need for additional education on the benefits of electricity as an energy source.

Residents living in SJV DACs indicated that they would be more open to fuel switching and a BE solution for space heating and water heating but have reservations with switching to electric cooking equipment.

Overall, customers would be willing to switch to a less expensive energy source, especially when it comes to space heating or water heating equipment. Customers are more open to switching to natural gas systems than electric ones. Electric equipment, especially electric cooktops, will require more customer education. While new electric induction cooktops provide better temperature control, customers' perceptions of electricity as a cooking fuel are informed by past experiences of cooking with a flame versus an electric cooktop. These perceptions will need to be overcome. Below, we provide specific results to support these conclusions.

When we asked SJV customers who currently heat with propane or wood if they would have any concerns switching to a natural gas heating system if it were provided and installed for free, two-thirds (68%) reported no concerns. Availability of natural gas was the biggest concern cited (16%) in Table 7. This concern is not surprising since many SJV households lack access to natural gas. However, this barrier for switching to natural gas is a benefit of electrification as the best solution going forward.

Table 7. Fuel switching to natural gas space heat

	No natural gas
n	464
No concerns	68%
Cost of fuel and equipment	6%
Availability of natural gas	16%
I prefer what I have	4%
I do not trust a free offer	3%
Other	3%
Unsure	3%

Comparatively fewer customers who heat with propane or wood have no concerns (56%) about switching to an electric heating system if it were provided and installed for free. Among those with concerns, the cost of electricity was the largest concern (18%), shown in Table 8. In-depth interviews revealed that customers already experience high electricity bills in the summer with their cooling systems and are concerned that the cost of electricity for heating may be prohibitively expensive.

Table 8. Fuel switching to electric heat

	No natural gas
n	464
No concerns	56%
Cost of electricity	18%
I prefer what I have	5%
Electricity is not available	9%
Electricity is not efficient	4%
I do not trust a free offer	4%
Other	5%
Unsure	5%

While willingness to switch out heating systems is relatively high, the strongest preferences, and in turn the biggest barriers, are associated with cooking equipment. All customers—regardless of natural gas access, current cooking fuel use, and home ownership status—prefer cooking with a flame over electricity. The strength of that preference varies, however, with current fuel use being the main differentiator. Customers who currently cook with a flame, be it natural gas or propane, strongly prefer cooking with a flame over electricity. Even, customers who currently cook with electricity prefer cooking with a flame than an electric cooktop.

Over half of customers who do not have access to natural gas prefer cooking with a flame (48% strongly, 11% somewhat) while only 18% prefer cooking with an electric cooktop (10% strongly, 8% somewhat). The remaining 21% do not have a preference and 2% are unsure. Among households who currently use a propane stove or range for cooking, 85% prefer cooking with a flame (73% strongly, 12% somewhat). Even those who currently cook with electric cooktops are more likely to prefer cooking with a flame (45%) than electric (26%) in Table 9.

Table 9. Cooktop preferences by natural gas access and major cooking fuel use

	n	I strongly prefer an electric cooktop	I somewhat prefer an electric cooktop	I have no preference	I somewhat prefer to cook with a flame	I strongly prefer to cook with a flame	Unsure
Total	2,660	3%	3%	13%	8%	70%	2%
Fuel access							
Natural gas (a)	1,391	3%	3%	13%	8%	70%	2%
No natural gas (b)	1,269	10%	8%	21%	11%	48%	2%
Major cooking appliance fuel use, natural gas							
HHs with electric cooking (c)	344	10%	6%	19%	7%	54%	3%
HHs with natural gas cooking (d)	938	0%	1%	10%	8%	78%	2%
HHs with propane cooking (e)	60	3%	0%	21%	14%	62%	0%
Major cooking appliance fuel use, no natural gas							
HHs with electric cooking (f)	779	15%	11%	27%	11%	34%	2%
HHs with propane cooking (g)	697	2%	2%	10%	12%	73%	1%

a/b/c/d/e/f/g Indicates significant differences at a 90% confidence level between the following tests: ab,cde,fg

To better understand cooking preferences, we asked customers who do not have access to natural gas and prefer cooking with a flame why they prefer a flame over an electric cooktop. The main reasons customers prefer cooking with a flame include the ability to control and adjust the heat (39%), as well as the time it takes to heat up and cool the burner (23%). In addition, customers have traditions they associate with flame cooking (11%) shown in Table 10. During the in-depth interviews, customers expanded on these traditions and preferences. Customers noted that there are specific types of food that they cook on a flame (e.g., tortillas or peppers), and they also believe food tastes better when cooked over a flame.

Table 10. Reasons for flame cooking preference

	No natural gas
n	826
Adjustability control	39%
Speed, heats up and cools down quickly	23%
Tradition and comfort with gas	11%
Natural gas is easier/better	6%
Cooking is more even/consistent with gas	7%
Food tastes better and cooks better	7%

Safety	2%
Cost/Gas is less expensive	4%
Other	11%
Unsure	2%

We asked SJV customers who do not have access to natural gas and use propane or wood for cooking whether they would be concerned with using an electric cooking appliance if the new appliance were provided and installed for free. Customers who had concerns were asked to describe them. A few respondents (less than 1%) who do not have a major cooking appliance (e.g., use a microwave or hot plate to cook) were also asked these questions.

Less than half (41%) of SJV customers who currently cook with propane or wood do not have concerns about switching to an electric cooktop, if it were provided and installed for free. Of those with concerns, the most commonly cited concerns were a preference for cooking with a flame over electric (23%) and the temperature control that a flame provides (11%). Some respondents were concerned with the cost of electricity (13%) shown in Table 11.

Table 11. Fuel switching to electric cooktop

	No natural gas
n	598
No concerns	41%
Prefer flame over electric	23%
Cost or energy use	13%
Perform or control	11%
No electric experience	4%
Equipment concerns, wiring	4%
Gas is more reliable	4%
Other	3%
Unsure	0%

Conclusions and Recommendations

Customers in SJV DACs are more likely to rely on alternative fuel sources and in turn have higher energy costs, energy burden, and a greater need for energy equity solutions than the average California utility customer. BE measures could provide an efficient and cost-saving solution for households in these communities. Customers without access to a safe, reliable, equitable energy source would benefit from electrification.

There are structural barriers to overcome for electrification in low income households in any community across the country. Structural barriers may include outdated or poor wiring conditions, electrical control panel condition and capacity, building envelope and weatherization concerns. In addition, these homes often have the potential for asbestos and mold concerns which need to be remedied before electric equipment is installed.

Structural concerns and housing conditions are an important barrier to the implementation of electrification retrofit and design. Customers themselves pose an additional barrier due to concerns with the energy costs associated with these upgrades across all equipment categories. Energy costs are high for these households, especially for households currently relying on alternative fuels or without proper heating equipment. The electricity costs associated with new space heating, water heating, cooking, and clothes drying equipment are unknown to these customers and a barrier to acceptance of BE.

Beyond energy costs there are other non-structural barriers to BE, related to customer preferences and perceptions. These attitudes and perceptions of electric equipment need to be overcome to gain interest from customers in electrification. The barriers related to household preferences and attitudes regarding switching the fuel their household space heating and water heating equipment are fairly minimal. When it comes to space heating and water heating, customers are mostly concerned with the cost of electricity for this new equipment.

Household cooking preferences are strong. When considering changes to customers' cooking equipment, especially for those that currently cook with a flame, there are greater hurdles to overcome. For electric cooking, there would need to be education around the benefits of an electric cooktop. If programs offer induction cooktops there are known benefits to this new technology; however, customers are generally not aware of these benefits. Induction cooktops provide better temperature control, are able to bring water to a boil and heat up the burner faster, are more efficient, and reduce energy costs when compared to cooktops with a flame. In addition, switching to an electric cooktop would resolve the health issues and hazards related to bringing gas or wood pollutants into the home and improve air quality. Customers are not aware of these additional benefits and would need to better understand these improvements. The one drawback to an induction cooktop is that customers would need to buy new pots and pans to see some of these benefits, which is a consideration to the success of the transition to this new equipment. The education provided should include not only the benefits for cooking and the ability to adjust and control the cooktop, but should also address the uncertainty around electricity costs and annual energy costs when switching to an all-electric home.

BE design and retrofit will increase home energy efficiency as well as reduce energy costs and health and safety concerns for customers nationwide. The barriers of cost uncertainty and cooking preferences as well as the strategies for overcoming these barriers will remain true for similar communities to the SJV DACs across the country.

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