

# Virtual Audits and Other Novel Alternatives to On-site Data Collection in Hard-to-Reach Communities

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## ABSTRACT

“Hard-to-reach” customers are critical for inclusion in baseline studies and evaluations; however, true to their description, they are difficult to recruit. Using findings from two different studies, this paper explores alternative data collection methods. One study collected baseline data from homes in disadvantaged communities in California —many in remote regions. The other study was an impact evaluation of multifamily buildings, and many residents qualified for income-eligible housing. This paper examines various remote approaches in which the residents or property managers facilitated auditors in obtaining data through photos, video, and/or interviews. While the move to virtual data collection was due to COVID-19, the paper explores the viability and benefits of using these methods post-pandemic.

Because both studies included a mix of in-field and virtual data collection, they provide a unique opportunity to compare in-field and virtual approaches. This paper compares recruitment rates of each approach and examines trends by community size, income, and digital connectedness. We describe challenges specific to virtual data collection, such as data that cannot be captured and concerns with reliance on a verbal response from property managers or residents in such cases. This paper also discussed cost differences and level of effort for the auditor and the resident.

The paper concludes with recommendations for when virtual audits can be used successfully for conducting residential audits, including data collection criteria, customer contact information needs, and demographic considerations. These findings can be directly applicable to residential baseline, market, and impact evaluation studies, even after COVID-19 restrictions are lifted.

## Introduction: Defining the “New Normal” for Evaluation

COVID-19 temporarily halted in-field data collection and required the authors to turn to virtual data collection. This primarily included the use of videoconferences with a resident or property manager via a cell phone app, requesting that residents or property managers document building equipment type and condition via their cell phone camera. At the same time, state governments and utilities are placing much-needed emphasis on diversity, equity, and inclusion (DEI). Both factors inspired us to explore how we can better collect data from traditionally hard-to-reach customers – meaning that have historically not participated in programs and evaluation studies.

As we emerge from the pandemic, our experience described above caused us to ask the following questions:

- Which of the virtual methods explored under COVID-19 restrictions should be used, and under what circumstances, after the pandemic?
- How can these methods and other strategies be utilized to increase DEI in evaluation studies?
- Instead of going backwards to pre-COVID-19 methods, what should the *new normal* look like for on-site data collection?

Presented with a unique opportunity due to COVID-19, the research team applied lessons learned from our work during the COVID-19 stay at home orders to provide lasting best practices to the industry regarding data collection from hard-to-reach customers.

Multiple utilities currently offer virtual energy audits for residential customers, where based on a live videoconference, energy professionals recommend energy efficiency measures (Central Alabama Electric Cooperative 2021; Midwest Energy Efficiency Alliance 2020; TVA EnergyRight 2021; West Boylston Municipal Light Plant 2021). However, based on a key-word search, we did not identify a paper that has comprehensively investigated the use of virtual data collection methods for evaluations and market studies. Below, we present two case studies that inform our experience and best practices gained, with regards to virtual audits and novel approaches to data collection for hard-to-reach residential customers in a variety of housing types (single-family, multifamily, and mobile homes). This paper does not include any findings on commercial customers.

## Background of each Study

**San Joaquin Valley (SJV) Study:** The first study was a baseline study of homes in disadvantaged communities in California's San Joaquin Valley (SJV Study).<sup>1</sup> Many of these homes lack access to natural gas, resulting in disproportionately high energy burden for many customers that use propane, as well as air quality concerns for those that use wood-burning appliances. In recognition of these impacts, a 2014 California Assembly Bill required the California Public Utilities Commission to increase affordable access to energy for disadvantaged communities in the SJV and improve the health, safety, and air quality of these communities. The purpose of the SJV Study was to gather data to establish baseline conditions of homes in these communities, including single-family detached, attached (buildings with three units or fewer), and mobile homes. Results will be used to support economic feasibility analysis of energy options for these communities. The study team collected data in three stages:

1. Customer surveys (primarily conducted online)
2. In-home audits conducted by trained auditors (a nested survey of survey participants from stage 1). This stage is the focus of this paper.
3. Customer in-depth-interviews (also a nested sample, and not discussed in this paper).

During surveys, customers self-reported information on their homes and appliances. In interviews, customers detailed their behaviors and preferences. The purpose of the in-home audit was to collect information that required a trained person to identify and document. During the audits, auditors collected building information, including building systems (e.g., central cooling and heating, hot water, plumbing, electrical, and insulation), interior appliances (e.g., refrigerators, clothes washers, room heaters and air conditioners, and water heating), exterior appliances (e.g., pool pumps), envelope conditions (e.g., windows, doors, and roofing), and data on electrical systems and electrical capacity. The team conducted 259 total audits: 156 in-field and 103 virtually.

**Multifamily Impact Study:** The second study was an impact evaluation of multifamily buildings that participated in one of two retrofit programs for residential buildings in a state in the Northeastern region of the U.S. (Multifamily Impact Study). One of these programs served all multifamily customers, while the other was restricted to income-eligible (low-income) multifamily customers. The primary purpose was to verify energy and demand savings from the installation of energy efficiency measures installed in both common areas and dwelling units. The original work plan called for data collection through in-field verification. The team shifted to primarily using virtual data collection due to COVID-19.

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<sup>1</sup> Section 783.5 of the California Public Utilities Code defines a San Joaquin Valley DAC as meeting the following criteria: > 25% households with electrical service are enrolled in the California Alternate Rates for Energy (CARE) program; population > 100 people; geographic boundaries no further than seven miles from the nearest natural gas pipeline; and in designated counties.

The table below summarizes each study used to support the findings in this paper.

Table 1 .Summary of studies

Study	Purpose	Type of Data Collected	Sample Size
SJV Study	Establish baseline conditions of homes in SJV, California	Residential energy assessment, including building information, major building systems, and data on key end uses throughout home	259 homes (156 in-field, 103 virtual)
Multifamily Impact Study	Conduct impact evaluation for multifamily utility programs	Verification of in-unit, common area, and exterior equipment installed through utility programs	80 multifamily buildings, of which 56 served income-eligible residents

### Description of Data Collection and Recruitment Methods

**SJV Study:** For recruitment in the SJV study, as part of the online survey (the first stage of the study), customers were able to indicate interest in participating in an in-home visit in exchange for a \$100 gift card. For both the in-home audits and virtual audits, the study team reached out to customers that had responded “yes” to this question through a combination of email and phone. The study had subgroup targets for community size (small, medium, large) and home type (e.g., mobile, single family attached, single family detached); consequently, when contacting customers that indicated interest in an audit, the study team oversampled for respondents in subgroups with low populations: primarily small communities and mobile homes. The study team followed up with nonresponsive customers by both email and phone until we received a response from the customer, up to six outreach attempts. For customers in small communities and mobile homes, we increased the maximum outreach attempts. To increase the diversity of participating customers, we varied the time of day and day of week of telephone outreach, offered evening and weekend audits, and worked with a community-based organization (CBO) to recruit small community and Spanish-speaking customers. The CBO, Self-Help Enterprises, supported customer outreach through the entire study through community outreach, invitations to community-based organization (CBO) partners, schools, and local agencies.

For the SJV study, during in-field [in-person] audits, a trained auditor collected data through a comprehensive walk-through of the home’s interior and exterior, and they entered data into a mobile-ready application. The virtual audit used a live two-way video stream between the home resident and the auditor. The virtual audit process collected the same information, but the auditor guided the customer through their home (i.e., asked the customer to walk to specific rooms or appliances), and the customer showed the auditor their home’s equipment through a videoconference. For information like equipment plates, the auditor would ask the customers to zoom in for a screenshot. For the videoconference, the team primarily used the Microsoft Teams™ platform, because it allowed the auditor to connect to this application on his/her computer, which enabled the auditor to easily take screenshots and enter data into the mobile data collection application while on the videoconference. However, the team switched to different platforms (Zoom™, Facetime®, WhatsApp®, and Facebook® Messenger) to accommodate customers that had difficulty or hesitancy downloading Teams.

At the onset of the shift to virtual data collection, the team used an online photo submission platform (JotForm)—in which the customer clicked on a link to a form that provided instructions with example photos—and asked the customer to upload similar photos. The team initially used this approach to try gather photos before the virtual audit (videoconference) to shorten the length of the virtual audit. However, several customers that expressed interest in a virtual audit did not complete the online photo submission form, so it appeared to be a barrier to participation. In addition, the virtual audits without the photo submission were typically 30 to 45 minutes, which appeared to be an acceptable amount of time

to participating customers. The online photo submission form was still used, in combination with phone interviews, in cases where videoconference quality was poor. As described later, the study team found that a videoconference was more appealing to residential customers than the online photo submission.

**Multifamily Impact Study:** For the multifamily impact study, the data collection approach depended on the location of the equipment (common area, exterior, or in-unit) and the type of equipment. For common area heating, ventilation, air conditioning (HVAC), and domestic hot water (DHW) equipment, a team member provided property managers with a list of measures installed in their building, including locations and types of fixtures/equipment installed, and offered several options for documenting the equipment. Property manager could email photos, submit a JotForm for photo submission, or participate in a scheduled video conference using Teams (similar to the SJV audit); property managers received \$200 for completing any option. For interior lighting measures, since it was impractical for property managers to document a representative sample of fixtures or remove fixture covers, a team member conducted a phone interview with the property manager. The property manager answered questions regarding the type and approximate quantity of fixtures installed and whether the lighting measures were still installed and operating, and they received \$75 for the interview. The study team also conducted limited on-site data collection, primarily for exterior measures, including exterior lighting and outdoor units for heat pumps, since property managers did not need to provide site access.

For in-unit measures, because the program worked with building owners and managers (rather than residents), residents’ contact information was not available. Consequently, the research team developed postcards branded with the program logo, with simple instructions, that requested their participation by either emailing photos or joining a videoconference for a virtual walk-through, in exchange for a \$25 gift card. For buildings where property managers reported they would assist with distribution, the research team mailed packages of postcards to the property manager to distribute to residents and a flyer for facility managers to post in a common area. For all other buildings, the research team mailed postcards directly to residents. In addition, the team requested that property managers document measures in dwelling units and offered \$25 per vacant unit. As described later, participation was very low for dwelling units, so the research team ultimately conducted file reviews and used the small amount of virtual data to spot-check information for a small sample of projects. The team verified a variety of measures, including in-unit and common area lighting, low-flow fixtures, air sealing, heat pumps, and operational measures. In addition, because remote verification of the air sealing measure would have yielded low quality documentation, the team conducted in-depth interviews for a \$200 incentive with ten participating air sealing contractors (representing the majority of projects) to explore the air sealing measure and provided recommendations to improve its savings calculation and on-site verification processes. Table 2 below summarizes the data collection methods offered in the multifamily impact study.

Table 2. Data collection methods offered in multifamily impact study

Measure Location and Equipment Type	Data Collection Method(s) Attempted
Common Area HVAC and DHW Equipment (Including number of equipment and equipment plate photos)	Property managers given option of: <ul style="list-style-type: none"> <li>• Submit photos using email attachments, <i>or</i></li> <li>• JotForm: online form for photo submission with instructions and example photos, <i>or</i></li> <li>• Videoconference with auditor at a scheduled time</li> </ul>
Common Area (Interior) Lighting	Phone interviews with property manager about the type and quantity of fixtures/equipment installed and asked if it was still installed and operating
Exterior Lighting	In-field data collection, typically with property manager notice but without their coordination
Dwelling Unit Measures	Residents (or property managers for vacant units) given option of

	<ul style="list-style-type: none"> <li>• JotForm: online form for photo submission with instructions and example photos, <i>or</i></li> <li>• Videoconference with auditor</li> </ul> <p>Due to low participation rates, file reviews were primarily used</p>
Dwelling Unit Air Sealing	In-depth interviews with participating contractors

## Comparison of Data Collection Methods

### Recruitment Impacts and Customer Acceptance

**SJV Study:** Table 3 summarizes the customers recruited for the in-home audits in the SJV study. Note that for the first two months of the data collection, customers were given a choice between a virtual and an in-home audit. Starting in mid-November 2020, due to increased rates of COVID-19, the team switched to only offering virtual audits. Concurrently, in the latter part of the study, the team focused on recruiting customers in small communities in order to meet the study subgroup objectives. Table 3 indicates a high percentage of customers on subsidized utility rates. Overall, 20% of customers that completed in-field audits and 20% of customers that completed virtual audits reported 2019 annual household incomes in the lowest bracket (less than \$20,000 per year).

Table 3. Customer demographics for in-field and virtual audit participants in the SJV Study

	In-field Audits Completed	Virtual Audits Completed
Total	156	103
Home type	Single-family detached: 106 Single-family attached: 25 Mobile: 25	Single-family detached: 63 Single-family attached: 3 Mobile: 37
Community size	Small: 41 Medium: 71 Large: 44	Small: 52 Medium: 47 Large: 4
Natural gas access	Natural gas customers: 62 No natural gas access: 94	Natural gas customers: 2 No natural gas access: 101
Subsidized utility rates	CARE customers: 86 No CARE: 58 Unknown: 12	CARE customers: 68 No CARE: 28 Unknown: 7
Main household language	English: 153 Spanish: 3 Other: 0	English: 84 Spanish: 18 Other: 1
Wi-Fi access	No home access: 15 Home internet access: 124 Only through data plan: 17	No home access: 15 Home internet access: 75 Only through data plan: 13
Smart phone	No cell phone: 1 Non-smart cell phone: 9 Smart phone: 146	No cell phone: 0 Non-smart cell phone: 5 Smart phone: 98

During the period when customers were offered both in-field and virtual audits, the vast majority of customers chose in-field. However, once the team switched to offering only virtual audits, the recruitment rate for virtual audits was similar to the previous recruitment rate for in-field.

In terms of customer acceptance, the videoconference method appeared to be an acceptable method for customers in the SJV Study. Many customers were not responsive or declined citing time constraints for both the in-field and virtual audits. A few customers (approximately three) reported that

they did not want to participate in the virtual audit, because it was more work for them compared to the auditor conducting the audit on his/her own.

One requirement created by the shift to the virtual audit was that the customer needed to have both a smartphone and Wi-Fi. We did not find a strong relationship between DEI metrics and having Wi-Fi and smart phone access. Most customers in the study had both in-home Wi-Fi and smart phones. There were at least four customers that were not able to participate in the virtual audit, because they did not have a smartphone and/or Wi-Fi. Additionally, at least four customers noted they did not want to participate in a virtual audit because they lacked confidence in their technical abilities or did not want to be burdened with conducting the audit themselves. Where possible, the community-based organization loaned customers a smart phone if they lacked access to a smartphone, but given the large size of the SJV region and logistical challenges, this was often not feasible. While this illustrates a downside of this method, the known number of customers who could not participate due to a technological barrier was less than 10% of customers that participated in virtual audits, even among these primarily remote communities. This results in some minor sampling error, but it is unclear if the homes that we were not able to audit were significantly different in terms of home characteristics than the homes that we were able to audit. Overall, the team was able to recruit many hard-to-reach customers for virtual audits, including many low-income, mobile home-dwelling, and Spanish-speaking customers.

**Multifamily Impact Study:** Table 4 below provides recruitment outcomes for the various methods attempted. In general, the study team had the most success with property managers opting to send photos via attachment or providing a telephone interview. Only one opted for the videoconference and none opted for the JotForm. Among residents, recruitment was very low. The team mailed 500 postcards, of which 10 residents responded, of which 3 participated. While the study team expected that leveraging property managers to distribute postcards to residents would be more successful (e.g., property manager may know which residents are more willing to participate, and a common area flyer would appear to be more of a trusted advertisement), this method was generally unsuccessful. Despite the offering of financial incentives, given time constraints, many property managers did not follow through with distribution or did the bare minimum (put postcards in mailboxes but no flyers).

The table below shows the outcomes of the various recruitment methods for data collection that required property manager, resident, or contractor recruitment.

Table 4. Remote data collection recruitment outcomes for Multifamily Impact Evaluation

Data Gathering Method	Response
<b>In-depth Phone Interviews (60 minutes)</b> with air sealing contractors regarding air sealing practices and savings calculations	<b>Highly effective:</b> 6 of 12 participating contractor companies completed interview
<b>Common Area:</b> property manager photo submittal through email or text	<b>Moderately successful:</b> 28 of 80 projects verified this way, although almost all required multiple reminders. Effective way to gather common area documentation that requires equipment plate information.
<b>Common Area:</b> Property manager provided 15-minute interview to verify installation and operation, primarily of lighting equipment or equipment lacking documentation in project files	<b>Minimally successful:</b> 8 out of 80 projects verified this way. Effective for property managers who were not able to go in-field due to COVID-19 or were extremely limited in time.
<b>Common Area:</b> Property manager live video (Facetime, video conference)	<b>Not effective:</b> Only 1 property manager selected this option. Other property managers may have anticipated more issues with technology (uncertainty of a consistent internet connection while moving throughout a multifamily building), or may have preferred emailing photos since they could do it on their own time.

Data Gathering Method	Response
<b>Common Area:</b> Photo submittal through Jot Form	<b>Not effective:</b> No property managers selected this option
<b>In-Unit Measures:</b> Postcards to residents requesting photo submittal through Jot Form or short video conference	<b>Not effective:</b> 3 responses out of 500 postcards

In general, recruitment of property managers and residents was difficult for remote data collection, and it was more challenging than in-field data collection in previous, similar projects. Several property managers noted that they were under increased strain due to the pandemic. Some were not allowed on site except for emergencies (so could not take photos), and others reported working with reduced staff. A few property managers reported they were not familiar with the measures installed, since the measures evaluated (in program years 2017 to 2019) were installed prior to their employment, even though study team members clarified that we could provide them with a list and location of measures. Most property managers were simply unresponsive. Besides time constraints, the study team speculates that property managers that are more familiar with requests for in-field data collection requests, and it is less labor-intensive, since they must provide access, but may not be present, during the entire in-field data collection, or they can at least multitask (e.g., check emails on phone) while the auditor collects information. The study team cannot provide an informed hypothesis for the low recruitment rate among residents beyond typical reasons (postcard is mistaken for junk mail, time constraints, etc.).

## Data Quality

This section discusses the data quality of virtual methods compared to in-field methods.

**SJV Study:** In general, data quality was high for almost all fields, and in almost all virtual audits. However, in some cases in the SJV study, the picture quality of the videoconference was not always high enough to capture information such as nameplates and model numbers. This could be due to poor Wi-Fi connection, poor camera quality, poor lighting, or a customer holding the phone unsteadily. In such cases, the auditors typically asked customers to read out model numbers so auditors could record them. In a few cases, the team used a combination of telephone interview and photo submission (either as email attachment or through the online photo submission platform) as opposed to the videoconference. Table 5 summarizes the data quality of different data types collected virtually in the SJV study. As shown, the quality of interior and exterior appliance and equipment information can be the same for virtual compared to in-field, whereas smells and condition assessments would be lower quality. In addition to the data types in the table, there were some data fields such as wall insulation and potential for asbestos containing materials that are hard to obtain, even for trained auditors in the field. For these data types, we relied on vintage tables in both the in-field and virtual audits.

Table 5. Summary of data quality by data type for SJV study

Type	Feasibility of virtual data collection	Quality of virtual documentation (photo clarity, etc.)	Quality of virtual compared to in-field
Appliances Basic Characteristics	High	High	Same
Appliance Nameplate	High	Medium. Requires adequate Wi-Fi or data connection, sufficient lighting, and customer to hold phone steady long enough for auditor to capture clear photo	Can be same with right measures in place

Presence of Supplementary Equipment	Medium. Requires auditor to ask very specific and sometimes multiple questions to collect information	High	Can be same with right measures in place
Exterior Equipment	High	Medium. Wi-Fi must also reach outside, and must be captured during full daylight hours, which increases scheduling challenges. Alternatively, photos can be used.	Can be same with right measures in place
Smells (e.g., mold, tobacco smoke)	Low. Not possible for auditor to assess. Can rely on resident to relay information, forgo this information, or attempt to gather other information that meets the same goal.	Not applicable	Low
Condition Assessment (i.e., good, fair, poor) of doors, windows, roof	Low. In-field, auditor makes an assessment of condition by scanning all doors and windows while walking through home. Virtually, not reasonable for customer to show all doors and windows, so customer shows a sample.	Medium. Without manual touch, could be harder to assess condition and presence of drafts.	Medium

Overall, the data quality of virtual audits was high, with the exception of a few data elements that we could not detect virtually (smells) or raised sensitivity issues, such as asking customers about the presence of mold, mildew, and smoke. While the auditors were able to view most of the home during the videoconference, the possibility of missing some aspects of the home was higher because the auditors were not there in person. This was both because a camera has a more limited field than a person’s vision, and because the auditor was limited to what the customer showed the auditor. While the auditor guided the customer, there was less chance that any item not in the virtual audit guide would be captured, so a comprehensive audit guide was critical.

**Multifamily Impact Study:** The multifamily impact evaluation was also generally successful in collecting data with high quality using virtual methods where in-field or virtual access was provided. However, property managers were less willing to cooperate in virtual data collection than the residential customers in the SJV study. Consequently, the multifamily impact study relied solely on file review for some projects. This reduced the overall data quality of the study, since the research team could not verify that the equipment had been retained, and because some project files were missing.

Table 6 provides a detailed ranking of feasibility of virtual data collection by measure type based on the findings of this study. As shown, virtual data collection methods can be used successfully for many measures, particularly if combined with a file review. For sampled measures, the research team recommends targeting at least 10% as a representative sample, similar to in-field methods. Due to expected challenges recruiting residents to participate, the feasibility of using remote verification is shown as low for all in-unit measures requiring resident photos, and medium if resident surveys could be used.

Table 6. Feasibility of remote methods and expected data quality in multifamily buildings

Measure Type*	Location	Remote Verification Feasibility	Remote Methods Expected Data Quality	Summary
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Cooling, Heating, DHW Systems	Common Area	High	Medium	<b>Effective:</b> Equipment plate information easy to capture through customer photos. But photos cannot capture operation.
Wi-Fi Thermostats	Common Area	High	High	<b>Effective:</b> Thermostat type easy to capture through customer photos. Recommend sampling if multiple thermostats installed.
Common Area Lighting	Common Area	Medium	Medium	<b>Moderately Effective:</b> Customer photos or interviews can verify technology (incandescent/halogen, LEDs, fluorescent). Use invoices to determine wattage, since customer should not remove fixture cover. May be difficult to obtain a representative sample of measures.
Exterior Lighting	Exterior	Not Evaluated		The research team captured this in-field. For remote areas, the property manager could verify lighting technology with photos or interviews, similar to common area lighting.
Attic Insulation	Common Area	High	High	<b>Effective:</b> Most multifamily attics are accessible to property manager, who can verify type of insulation via interview, and depth of insulation via photo.
Roof & Wall Insulation, Duct sealing	Common Area	Low	Low	<b>Not Effective:</b> Measures often not visible. Use vintage tables for existing condition and invoices for installed measure, similar to in-field methods.
Low Flow Fixtures	In-Unit	Low	Low	<b>Not Effective:</b> Photo quality often poor. Resident often needs to unscrew faucet aerator for flowrate.
In-Unit Lighting	In-Unit	Medium	Medium	<b>Moderately Effective:</b> Resident photos or survey can capture technology (incandescent/halogen, LEDs, fluorescent). Use invoices to determine wattage.
Refrigerator Replacements	In-Unit	Low	High	<b>Moderately Effective:</b> Equipment information (make/model) easy to capture in customer photo.
Air Sealing	In-Unit	Low	Low	<b>Not Effective:</b> Virtual blower door testing not possible. Resident photos could show sealing around common leakage areas.
Window Replacements	In-Unit	Medium	Medium	<b>Moderately Effective:</b> Window condition and number of panes can be confirmed using photos or resident survey; specifications must be verified via file review, similar to in-field verification.

\*This table does not specifically address in unit mechanical measures, because it was difficult for the property manager to enter units. For these measures, the team expected the quality to be the same as if the equipment or fixtures were in the common area.

### Cost considerations

While the studies did not directly compare costs between in-field and virtual data collection, based on simple estimates and the lessons learned from both studies, virtual data collection should be cheaper. Not surprisingly, virtual data collection reduced travel time. Virtual methods also allowed more flexibility in scheduling, because sites visits did not need to be geographically close together.

However, for the SJV study, remote site visits took longer for a few reasons. The recruiters spent more time assisting customers with downloading the Teams platform. It was also roughly 25% more time to conduct a virtual audit, since the auditor needed to guide the customer through the process. There was more rescheduling with the virtual audits, because there were more no-shows. Given this, recruiters

added more reminders to the process, which also increased time. The SJV study offered the same incentive to the customer for in-field and virtual audits, so budget was not impacted by incentives.

For the Multifamily Impact Study, the research team spent more time recruiting property managers to participate in virtual data collection than is typical compared to obtaining permission for an on-site visit. This was likely in part due to COVID-19- issues, including inability to enter the site for some property managers and lack of time due to additional tenant requests during shelter-in-place. However, property managers are consistently time-strapped, so it will likely always be difficult to recruit for virtual data collection. Higher incentives were used to recruit property managers, which added to project costs.

For both studies, the research team developed virtual data collection instruments and processes—such as JotForms, postcards, and processes for video conferences and sending photos. For the SJV study, this was in addition to standard data collection instruments (including an application-based tool for audit data entry used). This added to budget, and some of these tools were rarely used. However, given the diversity of property managers and residential customers—particularly low-income customers—it did allow more customers to participate by offering multiple participation options.

As shown in the table below based on average labor rates across multiple projects, we estimate that – as long as recruitment is not more difficult - virtual data collection is approximately \$200 cheaper per audit compared to in-field for audits with a one- hour travel time in each direction, and approximately the same cost (\$39 cheaper) per audit for audits with a half hour travel time in each direction. These estimates only account for additional steps specific to each method, not costs required for all methods such as recruitment, the basic audit, and analysis.

Table 7. Comparison of incremental costs for in-field and virtual data collection – per audit

Method	Additional Steps for Virtual Vs. In-Field	Hours	Rate (\$/hr)	Labor	Expenses (Mileage)	Total
In-field	<i>Travel Scenario 1: 1 hr each direction</i>	2	\$140	\$280	\$35	\$315
	<i>Travel Scenario 2: 0.5 hr each direction</i>	1	\$140	\$140	\$17	\$157
Virtual	Assisting Customers to Download Teams	0.25	\$110	\$28		
	Additional Rescheduling (Assume 10% increase)	0.25	\$110	\$28		
	Additional Time to Conduct Audit	0.25	\$140	\$35		
	Time to Develop Additional Data Collection tools (Divided by 100 Audits)	0.2	\$140	\$28		
	<i>Total Additional Costs: Virtual</i>			\$118		\$118
Comparison	<b>Infield Scenario 1 - Virtual Costs</b>					<b>\$197</b>
	<b>Infield Scenario 2 - Virtual Costs</b>					<b>\$39</b>

### Summary Comparison of Data Collection Methods

The research team found that virtual data collection offered us the ability to reach physically remote communities, greater time flexibility for us and participants, and the ability to reach non-English speakers. However, virtual audits require connectivity via a smart phone and Wi-Fi, and customers’ unfamiliarity with videoconferencing software requires additional staff time.

With regards to preferences of different virtual methods among customers, the research team found that customers were generally diverse with their choices, and we detected no uniform preferences. However, in general, more residents preferred conducting audits via video, while property managers preferred emailing photos. We expect these preferences to hold even in a post-pandemic environment. Few participants from either study chose the JotForm. Table 8 summarizes the pros, cons, and potential applications of different virtual data collection methods. Videoconference is the most effective at gathering detailed data on multiple many areas and appliances, but also requires a high level of effort for

both the customer and the team. On the other hand, phone interviews require minimal coordination and technology, but cannot provide any visual confirmation.

Table 8. Overview of data collection methods pros, cons, and potential applications

Data collection method	Pros	Cons	Customer level of effort	Team level of effort	DEI considerations	Recommended applications
Videoconference	Effective at gathering most information required in residential audit	Requires coordinating a time to meet live	High	High	Requires: smart phone, good Wi-Fi, steady hands	Studies that collect data directly from residents, or any application that requires viewing many areas and appliances
Photo Submittal Through Email or Text	Done at customer's preferred time	Relies on customer to take initiative. Customer may not capture the correct information without clear instructions	Medium. Potential customer perception that this is high	Medium. Requires providing very clear guidance	Requires: smart phone	Studies that collect data on a few pieces of equipment, including from property manager documents for common area HVAC and DHW Equipment, or as follow-up to videoconference
Photo Submittal Through Online Platform	Done at customer's preferred time. Online platform provides clear ask for customers and examples	Relies on customer to take initiative and to learn to use the online platform	High	Low	Requires: smart phone	Back-up option if videoconferencing is not feasible or preferred by customer, or one-off requests such as photo submission that benefits from example
Phone Interview	No prior coordination needed. Team can call and conduct interview at that time	Low rigor. No visual confirmation, and can only confirm installation	Low	Low. Can complete interview in 15 minutes during initial contact with customer	No advanced technology required	Use in combination with file review for measures with low feasibility of remote verification (e.g., lighting), or where documentation is low (e.g., to fill data gaps from file review)

In addition to best practice recruitment practices for both in-field and virtual data collection, such as outreach at different times of the day and days of the week, using multiple outreach methods (email and phone), offering multiple language options, and offering incentives for participation, the authors provide the following additional recommendations specific to virtual data collection:

For videoconferences:

- Work with a community-based organization to recruit hard-to-reach customers
- Offer the videoconference in a platform that is native to the customer's phone. If that is not possible, prepare the customer ahead of a videoconference by assisting with software download
- Provide numerous reminders
- Ahead of videoconference, review an online mapping platform with satellite imagery to get oriented with the property, including presence of rooftop equipment, and home relative size.
- During videoconference, start with an introduction that includes what to do if the Wi-Fi connection is lost, and provide a phone number for troubleshooting.

- Give real time instructions on how to take photos (i.e., where to find the nameplate, how to zoom in, how to focus camera) and instruct customer to pan to get context and potentially catch items that may otherwise be missed.
- For safety considerations, instruct the customer to not walk and look at phone at the same time.
- All auditors should use the same script for instructing customers (at least in an outline form) to ensure consistent, comprehensive data collection.

For emailing photos:

- Provide clear instructions. For complicated requests, provide sample photos (through online photo submission form, or embedded in an email).
- Offer multiple submittal options (online form, email, text).

For phone interview:

- Ask succinct, simple questions that cover one or a few systems.
- For verification studies, assume the customer was not present during installation.

## **Now What? How and When to Incorporate Virtual Methods in a Post-Pandemic World**

Virtual data collection methods can be an effective way to engage hard-to-reach customers, especially as online tools, software programs, and data become more available and widely used. Also due to the pandemic, people are more willing to conduct activities online (as opposed to in-person). COVID-19 has popularized the use of videoconferencing platforms, so many users have become familiar with them and already have them downloaded to their phones, reducing staff coordination time. One area that should be explored in future studies is the preferred videoconferencing platforms by different low-income groups, and any differences in data quality or features (e.g., zooming capabilities) among these platforms.

Post-pandemic, there are several considerations for when study teams should use virtual vs. in-field data collection. Virtual data collection could be cheaper if a study only needs a few pieces of information from each participant, such as nameplates or information on a few appliances, in which case residents or property managers could send photos. For comprehensive audits (like the SJV study), in-field is generally better unless it is a large geographic region where virtual is cheaper. It is also important to study Wi-Fi penetration and smart phone access in the target area. According to BROADBAND NOW (2021), there are 1.3 million people in California without access to a wired connection capable of 25 Mbps download speeds, and 889,000 residents do not have any wired internet providers available where they live. While this is only 2% of the 39 million Californians, many are hard-to-reach customers. For example, while Native American reservations are large geographic regions (so virtual data collection could reduce project costs), many lack internet coverage.

For DEI considerations, offering customers multiple options is ideal. This is because residential customers are incredibly diverse, so different customers will prefer different options, and because some participation pathways may not be possible for some customers. For example, while expensive, offering virtual could enable the study to capture customers in a larger geographic area, and in-field allows those without cell phones and/or internet service to participate. At a minimum, virtual data collection studies should suggest one method to customers (e.g., videoconferencing), but allow alternative methods (e.g., online photo submission). If in-field is the primary data collection method, a virtual participation method could be provided to capture unique customers, such as a handful that speak a less common language, to allow translators to join inexpensively.

Virtual data collection methods were successful in two different projects targeting hard-to-reach customers during the pandemic and offer effective solutions for residential data collection even post-pandemic.

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