Conducting Field Validations of Commercial Energy Efficiency Technologies with Underserved Communities

Preprint

Kelsea Dombrovski

National Renewable Energy Laboratory

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National Renewable Energy Laboratory
15013 Denver West Parkway
Golden, CO 80401
303-275-3000 • www.nrel.gov

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CONDUCTING FIELD VALIDATIONS OF COMMERCIAL ENERGY EFFICIENCY TECHNOLOGIES WITH UNDERSERVED COMMUNITIES

1 ABSTRACT

Underserved communities in the United States often experience the negative impacts of climate change and environmental degradation but enjoy few of the benefits of technological and environmental advances. The White House has addressed this inequity through the Justice40 initiative, which requires 40% of the benefits of select federal investments to be directed to underserved communities (The White House, 2022). Clean energy and energy efficiency are two highlighted investment categories, so the U.S. Department of Energy will guide implementation of the Justice40 initiative by, among other things, decreasing energy burdens, increasing parity in clean energy technology access and adoption, and increasing energy resiliency. A strategy for reaching these goals is to evaluate and validate new energy efficiency technologies in commercial buildings in underserved communities, where buildings may be older, smaller, and have deferred maintenance due to historical underinvestment. This paper develops guidance for researchers pursuing field validations with underserved communities. Historical redlining and past negative experiences with government and large institutions may make residents wary of participating in these field validations. Researchers, therefore, may need to spend more time building relationships and matching technologies to buildings. In this paper, we analyzed technical reports to identify common field validation building characteristics and conducted semi-structured expert conversations to identify key stages and major themes of engaging underserved communities. Results indicate there may be flexibility in site selection and there are steps researchers can take to support collaboration with communities. Results also suggest benefits to both the community and energy efficiency research.

The White House. (2022). *Justice40*. https://www.whitehouse.gov/environmentaljustice/justice40/

1.1 Keywords

Underserved communities, field validation, energy efficiency, technology, energy equity

1 INTRODUCTION

There is a history of environmental and energy injustice in the United States, with underserved and disadvantaged communities (DACs) experiencing many of the negative impacts of climate change and environmental degradation but few of the benefits of technological and environmental advances. The U.S. federal government recognizes the need to change course and has issued a directive to distribute the benefits of government investments more equitably. The White House's Justice40 initiative requires 40% of the benefits of select federal investments be directed to DACs (The White House, 2022). Clean energy and energy efficiency are two highlighted investment categories, so the U.S. Department of Energy (DOE) developed policy priorities to guide implementation of the Justice40 initiative, including decreasing energy burdens, increasing parity in clean energy technology access and adoption, and increasing energy resiliency (U.S. Department of Energy, 2022). Research, development, validation, and deployment are key components of technology development in the clean energy and energy efficiency sectors, and new technologies can support the Justice40 initiative and DOE's resulting policy priorities. This paper examines the validation stage of new commercial building technologies in detail.

Commercial building field validations involve installing a new technology in an operating building and evaluating the technology's performance over a period of time, often a year or more. Sometimes the building owner is responsible for purchasing the equipment, other times a manufacturer donates the technology.

Researchers frequently describe validations as occurring in newer, larger, more technologically sophisticated buildings. Fewer validations occur in buildings in underserved areas or in older small- and medium-sized buildings. Conducting validations with a narrow set of building owners and building types can result in gaps in research knowledge; reduced technology exposure for thousands of building owners, tenants, and occupants; and reduced potential for energy savings among groups experiencing energy burdens (Gilleo et al., 2017; Miller et al., 2013). With deployment of energy technologies increasing, now is the time to make access to energy efficiency upgrades more equitable. It is particularly important to make their benefits more widely available to underserved populations, which are often most impacted by high energy costs (Ross et al., 2022; Russell et al., 2015).

1.1 Terminology

In its working definition of DACs, DOE describes communities experiencing a combination and accumulation of energy burden, socioeconomic vulnerabilities, environmental and climate hazards, and dependence on fossil fuels (U.S. Department of Energy, 2022). DOE's Energy Justice Mapping Tool (U.S. Department of Energy, n.d.-a) helps users identify these communities. There are currently several mapping tools available that use different metrics and criteria to identify disadvantaged or underserved communities, including the Environmental Justice Screening and Mapping Tool (U.S. Environmental Protection Agency, n.d.), the Climate and Economic Justice Screening Tool (Council on Environmental Quality, n.d.), and the Low-Income Energy Affordability Data Tool from DOE's Office of Energy Efficiency and Renewable Energy, (U.S. Department of Energy, n.d.-b). This paper uses DOE's description of DACs and adds groups historically underrepresented in field validations—community-serving organizations, for example—to more inclusively describe the communities this work is intended to reach. Further, this paper will use the term "underserved" in lieu of "disadvantaged," because conversations with experts revealed "underserved" more accurately represents the societal positioning of the community. This term is also supported by other works (Zhou et al., 2022) and is referenced in the White House's description of disadvantaged—"disadvantaged communities that are marginalized, *underserved*, and overburdened" (The White House, 2022).

Although the terms field "validation" and "demonstration" may seem similar, this paper will use field "validation" to describe the installation and evaluation of a new technology in the field. The technology will be demonstrated and explained to the building owner, tenant, and occupants, but it will first and foremost be validated according to technical guidelines.

1.2 Background

Although conducting field validations in underserved communities is relatively new, existing literature provides background on engaging underserved communities, shared community visions of the future, and the role of new technologies. Engaging building owners for field validations is somewhat different

than engaging communities more broadly: researchers frequently seek a single contact—often a building owner—and focus on topics specific to that contact. More general engagement guidance is still relevant, though, and greater community engagement can come into play when sharing results and technology information with a neighborhood, business association, or other local group.

Histories of discrimination and lack of resources have greatly reduced underserved communities' trust in institutions. It is important to listen to local stories describing past damaging interactions and understand their impacts (Garcia & Garfinkel-Castro, 2019; Morley, 2019). Engagement with community members on buildings-related projects may, for example, trigger memories of past development projects that perpetuated power and resource distribution imbalances (Morley, 2019). The same is true when siting new energy developments, and energy justice and community input are seldom considered (Ross et al., 2022). Policies and procedures need to be updated to embed equity into procedures and hold project organizers and participants accountable (Park, 2014).

Both historic and contemporary data are key in community-engaged evaluation and decisions (Park, 2014), but existing demographic and geographic data do not always fully or accurately represent life in communities (Morley, 2019). In addition to learning more about historic discrimination and underinvestment, researchers can use social media and other more localized media to find examples of the lived experience in an area (Garcia & Garfinkel-Castro, 2019).

Communities can also develop positive visions for their futures, both collective and individual, beyond what data reveal. Idealized futures could be imagined as safe and secure and include universal amenities like reliable utilities and affordable energy bills. Shared ideas can lead to a sense of belonging (Jasanoff & Simmet, 2021), and collective visions can exist within a neighborhood, block, or group of building occupants. Community members need to have the opportunity to contribute and analyze information to develop solutions and visions for their future (Bailis et al., 2017). Involvement in validation projects is one way to support community visions of the future.

Imagined futures need to consider both social livelihood needs like safe neighborhoods and technological needs like the production of renewable energy, as well as the equitable integration of both types of needs (Jasanoff & Simmet, 2021). Technology, however, can be institutionalized to develop a status quo or hierarchical future, leading to marginalization of less powerful groups (Jasanoff & Simmet, 2021). Systems integrating social and technological elements need to weave these facets together so they benefit all users (Miller et al., 2018). Collaboration between groups is important for developing strong social bonds and combating hierarchical structures. It can be challenging to ensure equitable outcomes, and it is important to track progress and adjust methods as needed (Morley, 2019).

Researchers may have experience developing new technology based on prior research and gaps in the market without much engagement with a diverse set of stakeholders. But when community members—in the form of building owners in the case of validation projects—are involved, solutions are more tailored and creative, decisions and adoption happen more quickly, there is space for community members to learn and contribute, and resources can be engaged more easily ([Creighton, 2005] as cited in [Garcia & Garfinkel-Castro, 2019]). Thoughtful community inclusion can also boost community support for renewable energy developments (Liu et al. [2020] as cited in Ross et al. [2022]). Excluding stakeholder input can lead to incomplete solutions that cause future harm; engagement needs to become standard practice to halt this cycle (Miller et al., 2013).

Engaging a community for the first time can be more art than science and can be challenging for the inexperienced (Garcia & Garfinkel-Castro, 2019). Understanding the community, its trials, and its physical space is an early step in successful collaboration (Bailis et al., 2017; Garcia & Garfinkel-Castro, 2019). Connecting with staff at trusted organizations, businesses, and institutions and reaching out to community members with them can help build trust, and the resulting relationships with local leaders should be cultivated and maintained (Garcia & Garfinkel-Castro, 2019; Gilleo et al., 2017; Morley, 2019). Engagement will be ongoing, and conversations should focus on community assets and building on those assets rather than on area deficits (Garcia & Garfinkel-Castro, 2019). This approach will help community members feel and recognize that their input is valuable (Garcia & Garfinkel-Castro, 2019).

Building upon initial conversations, building owners need to understand how their input influences the work, and their input needs to be included in the collaboration (Morley, 2019). Lack of experience with field validation can be a barrier to participation (Garcia & Garfinkel-Castro, 2019), and researchers need to explain processes and highlight contribution opportunities. Agreed-upon evaluation metrics should be openly discussed to indicate progress (Park, 2014), and there should be single, clear points of contact for

both the building owner and researchers to simplify communication (Gilleo et al., 2017). The technologies must function in low-resource contexts, and researchers should recognize the technology's limitations and that it may not satisfy all the building owner's needs. Challenges solvable by technology alone are typical only in wealthier, higher-resourced communities (Bailis et al., 2017).

Current literature speaks to the different stages and aspects of engaging underserved communities. There does not yet appear to be much information in the literature about the "how" of engaging underserved communities for commercial technology validations. This investigation aims to help fill this gap.

2 RESEARCH OBJECTIVES

The objective of this research was to develop guidance for engaging building owners traditionally excluded from field validations of commercial energy efficiency technology. This guidance is applicable to researchers conducting field validations as well as researchers and other organizations seeking to expand participation in energy efficiency programs. We sought to present this guidance along two main lines—characteristics of buildings hosting validations and developing local partnerships. In this way, researchers and other readers of this work have strategies they can apply to selecting a building and working with its owner.

3 METHODS

We collected and analyzed data using qualitative research methods (see Figure 1). Content analysis of technical reports identified common required and desired field validation building characteristics, and inductive thematic analysis of semi-structured expert conversations identified key stages and major themes of engaging underserved communities.

3.1 Technical report content analysis

We performed content analysis on seven (7) field validation technical reports by reviewing their required and desired building characteristics and then identifying themes. We also identified required or desired characteristics that may not exist in older or smaller buildings. This assessment increased understanding of typical building requirements, determined how the validation project requirements compare to building characteristics in underserved communities, and identified which, if any, requirements can be waived or modified. The reviewed reports were the results of work done by National Renewable Energy Laboratory researchers and were published between 2019 and 2021. The reports described studies of a range of new or updated technologies, thus providing subject matter diversity.

3.2 Semi-structured expert conversations

Twenty-nine (29) semi-structured conversations were conducted via a video meeting platform from June 2022 to September 2022 with experts in field validations, community engagement and equity, energy management, and research logistics. Conversations were 30 to 60 minutes in duration. Most often, just one expert was present, although there was one instance of three experts in one conversation, and one instance of two experts in one conversation. Questions were semi-standardized based on the expert's field, and flexibility was built in to capture additional information. Participation was voluntary and participants did not receive compensation. Initial participants were identified by researchers connected to the project, and additional participants were identified through snowball sampling (recommendations and contacts from existing participants) and "cold" contacts of relevant experts. There is a larger proportion of participants associated with national laboratories because lab researchers' work involves field validations, and they are a target audience of this effort. A representative sample of all possible experts was not a goal; responses are not meant to be generalized to all experts on this topic but are representative of the engaged experts' expertise and procedural feedback.

We asked field validation experts (see Figure 2) about procedure, required and desired building characteristics, typical methods for engaging building partners, common approaches to sharing results, and experience partnering with a building owner in an underserved area, if applicable. We asked engagement and equity experts for guidance on working with underserved communities, including what researchers should learn about underserved communities, suggestions for approaching building partners, how to best

communicate with building owners, anticipated barriers and challenges, and results sharing. We asked energy management program officers about challenges connecting with building owners, suggestions for approaching them in underserved communities and describing the details of energy technology, maintaining relationships with building owners, and acting as subcontractors to conduct the outreach portion of the project for other organizations. Finally, we asked research logistics experts about agreements between the research organization, technology company, and building owner, as well as about human subjects research and institutional review board (American Psychological Association, 2017) procedures.

Detailed notes were taken during these conversations, and inductive thematic analysis identified key stages and major themes of engaging building owners in underserved communities. Responses were compiled by question and then distilled to identify themes within the question and the overall results. A chronological presentation of the stages and their included **themes** (called out in **bold**) is in Results.

3.3 Limitations of methodology

To achieve a broad perspective on this topic, we prioritized speaking with individuals with specialized expertise from different types of organizations. The sample is not representative of all experts in each field, but rather consists of experts with firsthand, relevant experience.

We were not able to obtain the perspective of a technology company, but this omission does not affect the outcome of this investigation. Additionally, deep work with building owners and managers is beyond the scope of this work; efforts like the small building energy equity engagement project described in Antonopoulos et al. (2022) help small building owners identify challenges and potential solutions to ensuring their buildings contribute to national decarbonization goals.

We did, however, want to include a building manager's or owner's perspective. The building manager engaged for this work manages a building housing a community-serving nonprofit, and although it is not located in an underserved community based on the Energy Justice Mapping Tool (U.S. Department of Energy, n.d.-a), it is adjacent to a designated area and represents a group not as regularly engaged in field validations, namely nonprofits.

4 RESULTS

We analyzed technical reports to identify required and desired field validation building characteristics. In addition, we conducted semi-structured conversations with field validation, community engagement and equity, energy management, and research logistics experts to identify the key stages and major themes of engaging underserved communities.

4.1 Results of building characteristic analysis and expert conversations

The technical report analysis resulted in twelve categories of required or desired validation building characteristics, with each category including between one and five more specific characteristics (Table 1). This analysis determined common validation building characteristics, assessed the prevalence of these characteristics in older or smaller buildings, and considered how these characteristics could be adjusted or reconsidered when conducting studies in underserved communities. Researchers can use these results to assess building characteristics essential to the research effort as well as requirements that are more flexible. What is required or desired for one study may be irrelevant to another, and building characteristics are both objective (commercial building required) and subjective ("good" internet connection required). The reports covered plug load management, condenser fan motors, air cleaning, cooling tower water treatment, and electrical submetering. The categories and characteristics are detailed in Table 1, which also includes a brief discussion of each category.

In addition to analyzing technical reports to identify required and desired field validation building characteristics, we conducted a total of 29 semi-structured conversations with a range of experts who provided guidance for finding and working with a building partner from an underserved community (Figure 2). The results of the expert conversations are presented here in stages that roughly follow the chronological order of preparing for and conducting validations (Figure 3). The themes related to each stage are in **bold**.

4.2 Stage 1—field validation considerations in underserved communities

Address energy use, emissions, and climate change. Several experts emphasized the need to be thoughtful about which validations should be evaluated in buildings in underserved communities. Technologies designed to function with cutting edge building upgrades or meant for larger buildings, for example, may not be suitable. Underserved communities may, however, still be suitable test beds for technologies that address energy use, emissions, and climate change**.**

Buildings in underserved communities often use more energy than those in more upscale areas, and the condition of the buildings as well as their typical fuel sources contribute to this increased energy use. Validating new technologies in underserved buildings can therefore result in greater greenhouse gas emissions savings than in buildings that are already relatively energy efficient.

Experts also cited the outsized impact of climate change on underserved communities and the need to prioritize social equity. New technologies can help building owners and on-site contacts moderate rising energy bills resulting from extreme temperatures and make the buildings more comfortable and resilient as the climate continues to change. (Note that, although they can be the same person, there are instances in which the building owner makes high-level equipment and research participation decisions and an on-site contact such as a property manager is responsible for maintenance, repairs, and tenant relations, among other things. The on-site contact is often the party in regular communication with researchers; some building owners do not live locally and may not regularly engage with researchers beyond higher level discussions.)

Prioritize energy equity. Many conversations emphasized the importance of prioritizing equity because of the systematic lack of investment in underserved communities and the subsequent lack of opportunities for residents to become as prosperous as residents of more affluent communities. Historical redlining and limited access to loans and other sources of capital to finance improvements were cited as examples of obstacles to upward mobility. There were also multiple mentions of the sentiment, “lifting up the most underserved lifts up all,” echoing the idea that bridging the efficiency gap in buildings in underserved communities could have a greater impact on overall building efficiency than making improvements to already more efficient buildings. Validation projects can help boost investment in the community and provide opportunities for residents to prosper because energy efficiency improvements free up capital that would otherwise go to energy costs.

Improve technology development. There were multiple mentions of the improved technology development that could result from rethinking traditional validation buildings. Several researchers mentioned that data from more diverse buildings and conditions could help support technology development and highlight strengths or gaps in a technology’s design. Other experts explained that solutions only designed for more upscale and upgraded buildings may be detrimental to owners of older buildings in underserved areas because the owners’ unique needs were ignored during technology development.

Increase adoption. According to community engagement experts, informing underserved communities about new, effective technology can help build awareness, thus increasing adoption. Business and building owners often handle multiple duties and do not have the capacity to research new technologies or building improvement options. Inclusion in a field validation provides the opportunity to learn about the technology firsthand; become comfortable with it and aware of its capabilities; and share experiences with building occupants, colleagues, and other interested parties.

Do no harm. Several experts warned, however, that engaging underserved communities in field validations should not be done to “check the box’” of including a previously excluded group and researchers should take care to do no harm. It is important and valuable to include a diversity of building partners in validation opportunities, but this inclusion needs to be thoughtful, respectful, and treated as a long-term partnership investment rather than a requirement to satisfy and move on. There were also several firm reminders that technology is not to be “tested on” underserved communities.

The technology to be verified must be at a readiness level that is presumed to be functional and beneficial, and have a very high likelihood of success; underserved communities should not be test subjects for underprepared researchers or projects. Experts emphasized the need for certainty that the technology is ready for a field validation and the location is right for the technology. For example, would this technology be a good fit in this context, even in a perfectly updated building? Could the building actually benefit more from air sealing and insulation than from the latest technology? Researchers need to identify appropriate opportunities to engage underserved communities and avoid any possibility of causing harm to vulnerable populations.

Simplify communication. Several experts identified the multiple roles and responsibilities owners must take on, given that they likely do not have the resources to support a large staff. Using smaller buildings for field validations can, however, have the silver lining of a single point of contact rather than multiple layers of management, and that can improve communication efficiency and partnership opportunities. Several experts suggested resources on small buildings and small portfolios that could help build understanding of the unique constraints and conditions of those settings (Langner et al., 2013; National Renewable Energy Laboratory, n.d.).

4.3 Stage 2—research design and project planning

Focus on research design flexibility. After deciding to engage an underserved community, researchers may need to adjust their typical research design and project management approach to a focus on research design flexibility. Field validation researchers explained that successful research design often includes two components—understanding the information needed from the technology validation and understanding occupants and their behaviors. When designing research in buildings in underserved communities, researchers must set realistic expectations and build flexibility into the research plan. Older, smaller buildings with more deferred maintenance may require more of the research team's resources and time. When possible, several experts suggested involving the building owner, tenants, and occupants in the development of the proposal and project plan so the research becomes a productive partnership rather than leaving these parties feeling inconvenienced and inconsequential. A few researchers also suggested thinking about ways to integrate lab and field evaluations to ensure the success of field validations: if there is greater integration of these stages, it may be possible to have more certainty about a technology's success in the field or to work out more technology issues prior to field deployment.

Integrate energy equity metrics. Several researchers suggested integrating more energy equity metrics into projects in addition to the evaluation metrics appropriate to the technology. One expert specifically suggested consulting the Tarekegne et al. (2021) energy equity metrics review. Other researchers and experts explained that the commercial (rather than residential) setting of the validations may make certain equity metrics more or less applicable, depending on the technology being validated. Several experts suggested including metrics that are of interest to the building owner, on-site contact, or broader community. These metrics could include energy efficiency, financial considerations, social equity, and/or occupant well-being. Findings should be shared with building owners and on-site contacts, and, if appropriate, with a wider community such as a neighborhood group, business development organization, or other organization that could benefit from the results.

Develop a flexible project timeline and budget. A practical project timeline and budget flexibility need to be built into the validation effort. Researchers and outreach experts alike stated that preparing for and conducting work in underserved communities will take more time and resources than working with established partners, and that this increase in resources should be accounted for in the budget, communicated to the funder, and explained to all involved parties. A few researchers emphasized the importance and significant time investment of bringing key parties together—researchers, the technology company, the funder, and the building owner—all of whom are involved in the validation itself. The local utility and community-based organizations can also be important partners before and after the validation.

There is increased interest in engaging building occupants to learn about the impact of the technology, and including human subjects in research requires institutional review board guidance. Researchers should speak with their respective institutional review board (American Psychological Association, 2017) subject matter expert or liaison as early as possible to understand the trainings, approvals, and other processes involved.

Plan to compensate organizations and building contacts. Compensation was a common theme in nearly all conversations. Experts were aligned on the following categories of compensation—organizations connecting researchers to building owners should be compensated for time spent on the project or even employed as subcontractors to provide structure to the compensation, as should building owners or on-site contacts. Experts also agree the technology should be gifted to the building owner and the installation costs should be covered by the validation project. The building owner should not pay for the technology and installation or participate in a cost share arrangement. Several equity experts also suggested planning a budget line item to replace the building's equipment if the technology fails.

4.4 Stage 3—finding a building partner

Consult online tools. After deciding to work with a building partner in an underserved community and making project plan adjustments, researchers will select the geographic area and validation building. There are several online tools that use different methodologies for identifying underserved communities, including the Energy Justice Mapping Tool (U.S. Department of Energy, n.d.-a), the Environmental Justice Screening and Mapping Tool (U.S. Environmental Protection Agency, n.d.), the Climate and Economic Justice Screening Tool (Council on Environmental Quality, n.d.), and the Low-Income Energy Affordability Data Tool, (U.S. Department of Energy, n.d.-b). To optimize the value of these tools, experts recommended considering the technology to be validated and its climatic requirements, such as humidity levels and exterior temperature changes, if relevant. Then they recommend beginning a regional search with those parameters. Researchers may have a region in mind and have existing connections in that region. They can then use the tool to identify areas near existing contacts, if relevant. If the technology does not have a climatic requirement, they could begin by thinking about where they have community connections and then using the tool to identify more specific areas of interest. There are multiple ways and stages at which a mapping tool can help identify an underserved community as defined by the selected tool.

Understand underserved areas. Several engagement and equity experts emphasized the need to understand underserved areas, especially the chosen research area, including both the history and current circumstances of the neighborhood, city, and region. Researchers should investigate histories of redlining and other forms of systematic disinvestment and disenfranchisement to better understand the barriers and challenges faced by community members and the reasons they may be hesitant to enter into a partnership with a large institution. Another suggestion was for researchers to attend community events and set up an information table with friendly representatives to create familiarity with the research organization, meet community members, and be available for questions and casual conversation in an approachable space. There were also recommendations concerning the future of the building, especially if the area is gentrifying and current residents are being displaced due to rising housing costs. Having broader knowledge of the area builds important understanding and context for the validation's fit in the neighborhood.

Work with a bridging organization. Many experts emphasized the benefits of working with a bridging organization—an established organization or existing connection in the area—to help researchers find building owners (see Figure 4). These organizations should be local and have trusting relationships with building owners, who are often their constituents. Regional (multistate) organizations were seen as too far removed from the building owner level, although these organizations may have relationships that could connect researchers and building partners. A common theme was the importance of researchers building a trusting, cooperative, and mutually beneficial relationship with the bridging organization. In addition, the bridging organization should be compensated for its work connecting the researchers to building owners, and several experts suggested hiring the bridging organization as a subcontractor. Experts also suggested nonmonetary forms of compensation and recognition, such as including the bridging organization and building partner's logos and names in reporting, as appropriate and with permission, to give them recognition for the role they played in the research. It may also be helpful and of interest to building partners to tour the researchers' lab or other buildings hosting validations.

Researchers need to be clear and transparent with the bridging organization about the proposed research and what is needed from building owners. The bridging organization's name and reputation is tied to their recommendation to work with the researcher, and they want to remain a trusted community resource. Researchers should make it easy for bridging organizations to reach out to their constituents by providing plain language descriptions of the technology, the project, and the risks and benefits. These descriptions should include translated materials if necessary as well as the contact information of a reliable and responsive project contact. These descriptions may be inserted into organizational newsletters and other updates. Researchers should be prepared to attend meetings—in person or virtually—to pitch the project to the bridging organization's members. Finally, bridging organizations and building partners may have other needs or challenges researchers can assist with, such as finding and applying for funding for energy saving building upgrades and learning where to look for reports and other resources.

A few engagement experts suggested finding key partners who could become champions and examples of positive partnership. This is possible if the relationship is successful and the partner is interested. The new technology may have glitches or not perform properly, but if the experience is handled

well, the partnership can act as a catalyst for future collaboration and serve as an example for building owners who may be hesitant to participate. A list of possible bridging organizations is shown in Figure 4.

Select a building. Several experts suggested selecting a building that houses a community-serving organization to host the validation. These organizations often have limited budgets and could benefit from reduced energy bills and access to new technologies that would otherwise be financially out of reach. There may also be opportunities to engage the organization's clients and provide educational opportunities. Examples of community-serving organizations are places of worship, community centers, and nonprofits. Experts also suggested engaging small businesses and minority- and women-owned businesses to work toward eliminating support gaps that have grown wider over time. Most broadly, experts suggested inviting parties such as building owners, tenants, occupants, and clients—who are connected to the building but not typically included in traditional validation projects—to participate in some way.

Analyze building characteristics. Results from the technical report analysis indicated a variety of technical and interior building characteristics necessary for most validations, and experts expanded on these findings. For example, several researchers stated that site visits are critical before all field validations, but especially when the buildings may have deferred maintenance or unique characteristics. It is important the building be in a condition to introduce the technology: there may be building upgrades related to energy efficiency, deferred maintenance, or code compliance that need to be completed first. Engagement and equity experts emphasized that the field validation project should pay for as many required upgrades as possible in preparation for technology installation, or recognize where these upgrades are needed before installing the new technology. One expert mentioned the importance of the building owner reviewing the insurance policy to be clear what it covers.

The researchers also emphasized that the building cannot be an outlier and should be somewhat representative—a religious building used regularly for religious purposes, for example. If its unique characteristics make study results inapplicable to other commercial buildings, as in the case of a religious building that has been retrofitted for use as a restaurant, it would not be a good candidate.

Another important consideration is access to qualified contractors. It is not uncommon to have hiccups with a new technology and providing good service to the building owner or on-site contact is important for a positive relationship and successful validation. Finally, one researcher emphasized that the technology under study can scale with building size, and smaller technology—residential technology, for example—could be validated in smaller buildings.

Pitch the project. When pitching the project to bridging organizations and building owners, it is important to keep their perspectives in mind, and experts shared a variety of views on communicating field validation opportunities. The technology is cutting edge, but researchers should understand that building owners may not immediately see its value. It is important to communicate the technical value of the technology but to also explain it in terms of its potential to solve problems beyond improving energy efficiency. A few conversations included the term "code switching," referring to a strategy for building rapport and fostering communication with building owners about what the technology is capable of and why installing it may be valuable to them.

One engagement and equity specialist cautioned researchers to be careful with terminology, even with what may seem like common terms. A concept like "net zero," for example, could be perceived as only relevant to "rich" and affluent communities, which may be out of step with how local contacts identify themselves and their neighborhoods. Emphasizing universal values can be more successful—discussing saving money, for example, rather than taking positions that might seem more political or polarized, such as mitigating climate change. The messaging needs to be very clear, and one expert suggested something as simple as "this is what we are investigating, this is how to apply and participate, and this is what we will need from the building and owner."

Solve non-energy problems. A very common theme in expert conversations was the need to find and solve problems for building owners and on-site contacts that go beyond saving energy; this is sometimes referred to as providing co-benefits. Several experts emphasized that although building owners do care about reducing energy use, they often have larger or more pressing business or building concerns. If the new technology can solve some of their existing problems, building partners can put resources elsewhere, such as towards enhanced services or business operations. Identified problems included safety and security, health and wellness, business and building operations, time and cost of maintenance, water usage, foot traffic, and occupant comfort and experience. Experts emphasized, however, that it is important to learn about the specific challenges a particular building owner faces. For example, some local

jurisdictions have “clean,” “green,” or “sustainable” building ordinances, and building owners may be interested in learning how the technology can help them satisfy those requirements. HVAC consistency also came up, and some building owners expressed interest in having more granular control over spaces that are used infrequently, such as conference rooms.

Consider building owners. Building owners and on-site contacts are essential to the success of field validations, and there are specific considerations for building owners in underserved communities. Logistically, large buildings often have many layers of management, and smaller buildings in underserved communities may only have one or two layers of management, which can mean simpler communication. Because the building owner or on-site contact is managing many aspects of operations, they may be busy and should be compensated for time spent on the project. Experts suggested researchers begin with tangible examples of the technology and explain its functions beginning with something approachable, visual, and easy to understand. Researchers also need to help the building owner determine whether this technology offers enough value to be worth their time.

It is also important to consider the split incentive—the building owner may purchase the equipment (up-front cost), but the tenant may pay the energy bills (operating cost)—and how that affects the parties’ willingness to participate. Experts advised that researchers explain each step of the process very clearly, clarify what building owners and on-site contacts can expect, and give them the tools to succeed. Further, researchers must be prepared to develop longer-term relationships and remain in contact with building owners and on-site contacts.

Communicate transparently. Transparency in communication, risk explanation and mitigation, and expectation management are critical to the success of finding a building partner and developing a relationship. Trust and clarity need to be built first with the bridging organization. To achieve this, researchers need to acknowledge and explain the risks associated with the technology, what the technology can and cannot do, and who is responsible for remedying negative impacts. Researchers need to explain that the new technology may not operate exactly as the technology it is replacing, and they should be prepared with examples of others participating in the validation of this technology; building owners may be more comfortable knowing they are not the only participants. In addition, they must explain why this technology can be trusted even though it is new. Building owners and their tenants will also want to know how disruptive the process will be. One expert suggested compiling a journey map of the building owner’s participation in the research to help the researchers understand where burdens will arise. This map can then be shared with building owners.

Energy cost savings—or lack thereof—will also need to be explained up front. Bill savings are positive, but while the new technology may reduce energy use, bill savings may not materialize if there is a rate change or electricity is more expensive than gas. Although experts encouraged gifting the technology and compensating the owner or on-site contact for their time, the tenant or owner will still be responsible for the energy bills and needs to be prepared for changes in the bill. Sustaining savings can be challenging, so researchers should be sure the technology is delivering benefits to the building owner beyond initial adjustments to their bills or operations.

Finally, transparency around up-front costs is important. If similar buildings in the area were interested in purchasing the technology, would they be able to? What would it cost to maintain this equipment, and is skilled labor available locally? Setting expectations for the building owner, bridging organization, and other building managers who might be interested in the technology will be important, and the attainability of the technology needs to be understood by all. It may be that the technology performs well with great benefits, but peer buildings could not adopt it, in which case researchers and the technology company would need to consider appropriate messaging.

Consider building tenants. Many experts emphasized the need to consider building tenants—not just the building owner or on-site contact—from the beginning of the search process. Tenants may need to participate in the research or may be affected in other ways, including installation, maintenance, or equipment malfunctions or disruptions to the building environment such as changes in temperature, lighting, or indoor air quality. Because of this, tenants need to be considered and included in discussions of agreements, disruptions, and other aspects of the validation. One expert suggested scheduling two meetings—one with the building owner and one with tenants—to understand the perspective of each. Several experts explained that tenants should be signatories to participation agreements alongside building owners, and that there should be protections in place so building owners will not increase rents or remove

tenants in the event that the building upgrades increase the property's value. Experts recognized, though, that it is beyond the researchers' role to try to influence legal contract processes.

4.5 Stage 4—working with the building owner or on-site contact

Develop clear agreements. After finding a building partner, researchers must cultivate the relationship thoughtfully and institute safeguards to reduce negative impacts. Several experts emphasized the need for agreements to be clear and straightforward, with any technical or legal language explained. Building owners and on-site contacts need to understand their responsibilities over the duration of the validation and tenants should also be considered and included in agreements. In addition, if the technology does not work as expected, the agreement should describe the process of purchasing and installing replacement equipment. All agreements should be translated into the building owner or on-site contact's preferred language and should include references to code violations or other health and safety challenges that could affect the building and the validation project.

Identify points of contact. Experts explained that clear points of contact on both the building and research side are essential. Building owners and on-site contacts need to know who to contact about questions and equipment issues, and researchers need to know who to contact with questions or updates about equipment inside the building. All parties should collaborate on a plan to ensure reasonable access to each other, and researchers should emphasize the importance of identifying a new building point of contact promptly in the event of staffing changes.

Plan for disruptions. Researchers need to plan for disruptions the new technology and the validation process might cause. Experts advised that if researchers need information about the building ahead of time, they should develop easy ways for the building owner to convey that information. For example, although still requiring owner approval, taking photos of existing equipment would be a lighter lift than copying down and sending unit information. In the event of a disruption, researchers need to communicate its likely effects as well as the steps they are taking to mitigate the impact. They could, for example, install the replacement equipment when the building is closed. It is also important that researchers or hired contractors handle the safe disposal of any equipment that may be removed.

Monitor, evaluate, and maintain equipment and systems. Equipment approachability was mentioned by several experts. Following installation, the installed technology should be convenient to use if it requires regular interaction from the building owner, on-site contact, tenant, or occupants. The project plan should include a training component appropriate for all involved parties, and clear instructions should be given to each party. Researchers should establish a point of contact the building owner or on-site contact can call when issues arise during monitoring, evaluation, and maintenance, as well as identify local contractors who can assist. If building owners decide to keep the equipment and assume responsibility for maintenance tasks and costs, researchers and contractors can discuss the technology and answer the building owner's questions in the course of regularly scheduled check-ins during the monitoring and evaluation period.

Consider study impacts on the building owner. At the end of the study, many experts suggested gifting the technology to the building if it is functioning and the building owner wants to keep it. Gifting technology could come at a considerable cost, and this should be addressed in early discussions. Researchers should consider the cradle-to-grave impact of the technology for the building owner. If the technology will not remain in the building, the initial agreement should identify the equipment that will replace it and the party responsible for the replacement.

4.6 Stage 5—after the research

Maintain relationships and build connections. Engagement and equity contacts explained that it is essential to maintain and continue to build connections with the building owner and the bridging organization following the study. Both groups may have future questions, ideas, and feedback researchers can assist with, and researchers may need input or have future partnership opportunities. Many underserved communities have experience with research that did not benefit community members and have been taken advantage of in other ways. Technology validations must not repeat these mistakes, and researchers must follow through on all established agreements before requesting anything additional from partners.

Offer ongoing support and resources. Once a research partnership has ended, building owners may have additional questions related to energy efficiency or building operations. Researchers should assist with these inquiries and share other resources as necessary and possible. If additional opportunities for research or funding come up, researchers should make a point of sharing this information with partners. In other words, researchers should proactively continue the relationship(s).

Share results and findings. Engagement and equity experts emphasized the importance of sharing results and findings. When results are finalized, thoughtfully distributing the results can have a substantial impact on understanding and future adoption. Although energy savings are important, they may not be a priority to the building owner. Reduced costs or improvements elsewhere in the building—in indoor air quality, for example—may be essential information for the building owner and others curious about the technology. Several experts mentioned that sharing results should be built into the budget. This could take the form of printed information and a site visit to share the results at a community or organizational meeting, with meals and childcare provided for attendees. Thoughtful sharing of results can increase comfort with new technology and provide data the community can use to apply for grants for additional building improvements, further reducing energy consumption and saving money. In addition to a report and a meeting, results can also be shared on the websites of the research organization, building and/or business, and bridging organization as well as through tangible products such as informational posters that could be displayed in public locations in the neighborhood.

4.7 Additional feedback

Develop requirements for requests for proposal. Many experts offered additional advice and suggestions, which fell loosely into two themes. Several experts advised against a request for proposal requirement that all field validations be conducted in small to medium buildings in underserved communities. Some technology will not be relevant and will not address pressing issues faced by buildings in these communities. Another suggestion was that requests for proposal applicants seriously consider demonstrating their technology in an underserved community and then justifying why it would or would not be a good fit. There were also a few suggestions to build partnerships prior to responding to a request for proposal to involve the building owner or on-site contact from the beginning and provide a clearer description of the research design as part of the proposal. Several experts suggested requests for proposal include evaluation metrics beyond cost and energy savings. For example, including metrics assessing energy justice, such as the effect on energy burden, or metrics of interest to the building owner, such as the effect on occupant comfort, would be valuable additions to studies.

Expand community engagement. Finally, there were ideas about how to expand technology validations beyond building owners and bridging organizations. Several experts supported the idea of having local trade school instructors and students participate in installations to learn about the technology, and there were suggestions to seek out minority-owned contracting businesses to do the installation and maintenance. This additional engagement with existing organizations in these spaces can expand and extend the reach of these opportunities.

5 CONCLUSIONS

Literature pertaining to community engagement, technology adoption, and collective visions of the future lays the groundwork for working with underserved building owners on commercial technology field validations. Lessons from past work are helpful guideposts as researchers pursue new partnerships and goals. The work described in this paper expands on previous studies to develop guidance for field validations, an emerging way of introducing new energy efficiency technologies to a broader set of building owners.

Evaluation of past field validation reports provides an understanding of commonly required and desired validation building characteristics. Although building needs will vary based on the study, researchers have opportunities to think creatively about which building features are needed and which they can work around to increase validation participation opportunities, gather additional and varied data, and better provide technical assistance and opportunity to building partners in underserved communities.

There are many reasons to include underserved communities in field validations when the validation is the right fit for the building and the community. In some cases, a building in an underserved

community may not be the right fit. Working with buildings in underserved communities will require more time and resources than working with traditional field validation partners because of the need to build connections, evaluate building conditions, and ensure mutual benefits. The use of these additional resources can lead to expanded benefits, as these partnerships will present opportunities to gather unique findings and build long-term relationships. Preparing a longer timeline, larger budget, and more flexible research design will support project success while expanding the validation's impact and data collection opportunities.

Engaging with the community to find a building partner is perhaps the most important aspect of conducting field validations in underserved communities. Relationships with building owners, bridging organizations, and tenants are crucial to a successful validation and ensure valuable data collection by prioritizing equity in the validation process and approaching excluded communities with respect.

Working effectively with the building owner or on-site contact is important in all technology validations, but it is especially important when working with underserved communities. These groups have not historically been shown the respect, support, and follow-through they deserve, and have had fewer opportunities to improve the buildings in their area. Researchers have the chance to collaborate with communities and building owners or on-site contacts while improving building function and researcher-partner connections.

Although the validation may be the initial impetus for connecting with the bridging organization and building owner, it could be the beginning of a relationship that leads to ongoing collaboration. Continued partnership is key for successfully growing adoption and understanding of as well as comfort with new energy efficiency technologies.

Expert input from multiple fields is important in developing guidance for field validations in underserved communities. The practice will involve scientific and interpersonal nuances and proficiency and should not be expected to be fast and simple. The required relationship building will take time, but will ultimately strengthen the research, foster ongoing relationships among participants, and enhance the knowledge and future opportunities of the community partner.

6 DISCUSSION

This paper presents results from the literature, existing field validation technical reports, and expert conversations, and the results provide guidance on community outreach and equitable engagement, building characteristics, and partner collaboration, respectively. This guidance can help achieve the White House and U.S. Department of Energy goals of providing clean energy benefits to underserved communities and increasing the deployment of energy saving technology.

Key findings include the need to thoughtfully consider the fit between a technology and an underserved community, adjust project planning to account for increased time and budget, develop flexibility and creativity around building requirements, meaningfully engage when looking for a building partner, recognize the community's and building owner's goals, solve problems beyond reducing energy use, consider impacts to building tenants, respectfully engage with building occupants during the validation, follow through on sharing results, and maintain ongoing relationships with connecting organizations and building partners.

Future research should confirm this guidance by applying it to a validation in an underserved community. This guidance can and should evolve as validations are conducted in a greater diversity of buildings and locations to increase instances of equitable decarbonization, technology adoption, and positive partnership.

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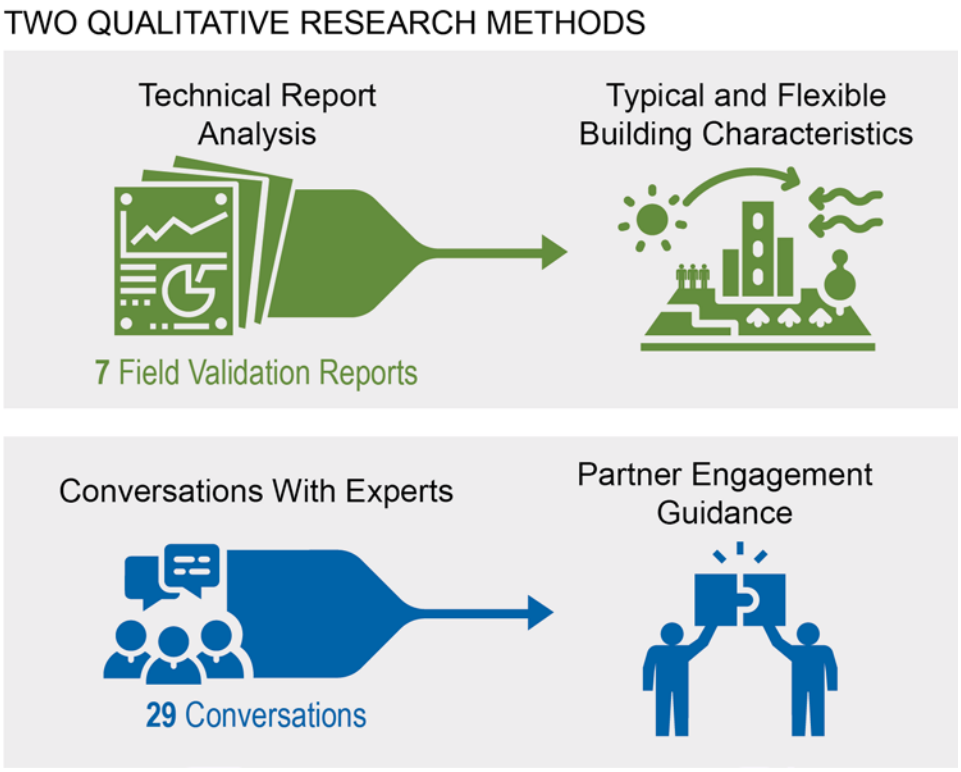

Figure 1. Selected methods and applicable results. *Credit: Marjorie Schott, NREL*

Table 1. Characteristics and categories for buildings hosting validations as determined via technical report review. *Credit: Marjorie Schott, NREL*

Categories	Characteristics	Discussion	Recommendations for Researchers
Building Type 	1. Commercial 2. Represent target market 3. Multi-tenant 4. Small (~15,000 square feet) 5. High-efficiency, all-electric, well-operated	The first four characteristics are common to many buildings; the fifth indicates a more advanced building less likely to be found in an underserved community.	Help increase the use of advanced technologies by encouraging manufacturers to expand their products' range of use cases.
Existing System Capabilities 	1. Ability to synchronize new and legacy equipment 2. Technology or equipment utilized or affected by the technology being evaluated 3. Remote monitoring capability 4. Remote control capability 5. Building automation system	The first three characteristics are typically available or achievable with simple equipment like cellular modems. The final two may be challenging in older, under-resourced buildings.	Proactively improve product flexibility by ensuring the technology is a good fit for the building and remembering that the building must be representative and produce replicable results. If the barriers are too great, address them in future research.
Electrical Infrastructure 	1. Clearly mapped electrical infrastructure 2. Requirements around risers, panels, circuits, and capacities	Information about the existing infrastructure is helpful to both the building owner and the researcher.	If infrastructure information is unavailable, assist with cataloging to determine whether the existing infrastructure is appropriate for this study.
Loads 	Measurable loads in the technology-affected area, such as plug or ventilation loads	Building owners may not understand the different types of loads in their buildings.	Assist building owners with this assessment.
Internet/ Wi-Fi 	Good to excellent wireless service	In older buildings, rural areas, and locales with less internet infrastructure, reliable service can be a challenge. Fast, reliable wireless service is helpful, but many studies can proceed without it or with limited service.	Improve internet functionality by using cellular modems during the study. Clearly communicate whether wireless service improvements end when the study ends. Wireless service challenges can also alert the technology company to the need for alternative solutions.
Spatial Needs	1. In the electrical room 2. Inside panels 3. In other technology-specific locations	Finding space in older or smaller buildings, or buildings used beyond their original function to	Together with the technology company, consider new and alternative methods of working within space constraints, which

Categories	Characteristics	Discussion	Recommendations for Researchers
	4. Ability to maintain, monitor, account for, and possibly manipulate environments around technology	satisfy businesses' needs (for example, a church building that is now a restaurant), may be challenging.	would be beneficial to both the technology company and future customers.
Existing Building Information 	1. Up-to-date building drawings 2. Ventilation and commissioning 3. Functionality of existing equipment 4. Access to available reports, such as testing, adjusting, and balancing [TAB] reports 5. Other logs and building system records, like maintenance records and past building uses 6. Someone familiar with the building's systems	Especially in smaller buildings, information about existing challenges and the functionality of current equipment may be available, but—depending on the building's tracking and monitoring procedures—it may be difficult to get detailed information.	Determine whether the information is necessary for the validation, and, if it is, explore alternative strategies such as installing logging equipment before the study begins, conducting a detailed site visit, or getting an energy audit, possibly at no cost through the utility.
Study Length 	Buildings need to be available for the duration of the study, whether it is multi-month or multiphase	This requirement is standard.	Explain expectations to building owners and on-site contacts to minimize disruptions.
Point of Contact 	1. On-site manager and staff representative to act as liaisons 2. Building owner willing to be involved 3. An on-site contact—who may or may not be the owner—for regular monitoring	Responsive points of contact and clear communication between on-site contacts and researchers are critical to a successful project.	To minimize the burden on the partner, develop the most direct line of communication and engage the minimum number of building staff required. Also, build support for the project by educating the building owner about the technology, validation, risks, and research plan and providing a single, specific point of contact with the research team. In addition, develop a transition plan in case points of contact change to ensure smooth communication and continuity in data gathering.
Building Owner 	1. Open to new technology 2. Willing to participate, engage, and provide feedback 3. Comfortable with the study length 4. Understands system operations or closely	Building owner and tenant operations should be prioritized over the field validation.	Acknowledge that business operations trump validation concerns. During the study, help building owners develop knowledge about building equipment and operations that will prove useful going forward, and clarify the owner's role

Categories	Characteristics	Discussion	Recommendations for Researchers
	coordinates with the system operator		versus that of an on-site contact who is regularly present at the site.
Occupants 	1. Willing to participate in the study as needed 2. Comfortable with study length 3. Able to regularly interact with the technology as required 4. Aware of the technology functionality 5. Aware of the point of contact 6. Equally informed—all shifts have the necessary information	Occupant engagement will vary from study to study, but occupants may play a larger role moving forward given the increased awareness of energy equity.	Coordinate with the owner or on-site contact to ensure new staff are familiar with the study and be prepared for occupant engagement if it is a component of the research.
Coordination 	Depending on the building management structure and the size of the validation study, participants may include: 1. Building and equipment owner 2. Technology company and data acquisition manager 3. Legacy/existing system data acquisition manager 4. Project leader and data analyst 5. Building occupants	Building owners and on-site contacts in underserved communities typically wear many hats and have many demands on their time.	Make coordination as clear and simple as possible to avoid burdening building owners and on-site contacts.

Figure 2. Counts of experts and fields. *Credit: Marjorie Schott, NREL*

STAGES	THEMES		DISCUSSION
1 Field Validation Considerations in Underserved Communities	• Address energy use, emissions, and climate change • Prioritize energy equity • Take advantage of opportunities to improve technology development	• Increase energy efficiency technology adoption • Be respectful and do no harm • Simplify communication	• Ensure the validation is the right fit for the building and the community • Recognize the benefits of working with an underserved community
2 Research Design and Project Planning	• Focus on research design flexibility • Integrate energy equity metrics along with technology evaluation metrics	• Build flexibility into project timeline and budget • Plan to compensate organizations and building contacts	• Understand that validations in underserved communities take more time and resources • Allow time to build connections, evaluate building conditions, and ensure mutual benefits • Build extra time, budget, and research design flexibility into the project
3 Find a Building Partner	• Evaluate and consult online tools • Understand underserved areas, especially the chosen research area • Work with a bridging organization to find a partner • Select a building • Analyze technical and interior building characteristics	• Pitch the project • Solve problems beyond saving energy • Consider the unique concerns of building owners • Communicate transparently and honestly • Consider the unique concerns of building tenants	• Engage with the community to find a building partner • Establish and nurture relationships with building owners, bridging organizations, and tenants • Prioritize equity in the validation process and approach traditionally excluded communities respectfully
4 Work With the Building Owner or On-Site Contact	• Develop clear, straightforward agreements • Identify points of contact • Plan for disruptions	• Monitor, evaluate, and maintain the equipment and systems during validation • Consider impacts on building owner at the end of the study	• Work closely and effectively with the building owner or on-site contact • Show respect, support, and follow-through during the project • Focus on collaborating with communities and building owners or on-site contacts while improving building function and enhancing researcher-partner connections
5 After the Research	• Maintain existing relationships and continue to build connections • Offer ongoing technical support and resources	• Share results and findings	• Treat the validation process as the beginning of an ongoing relationship • Nurture partnerships established during the project to foster adoption and understanding of energy efficiency technologies
Additional Feedback	• Develop requirements for requests for proposal	• Expand community engagement	• Seek expert input from multiple fields when developing proposals for field validations in underserved communities • Expect the engagement process to involve scientific and interpersonal nuances and proficiency and to take extra time

Figure 3. Timeline for preparing for and conducting validations with underserved communities. *Credit: Marjorie Schott, NREL*

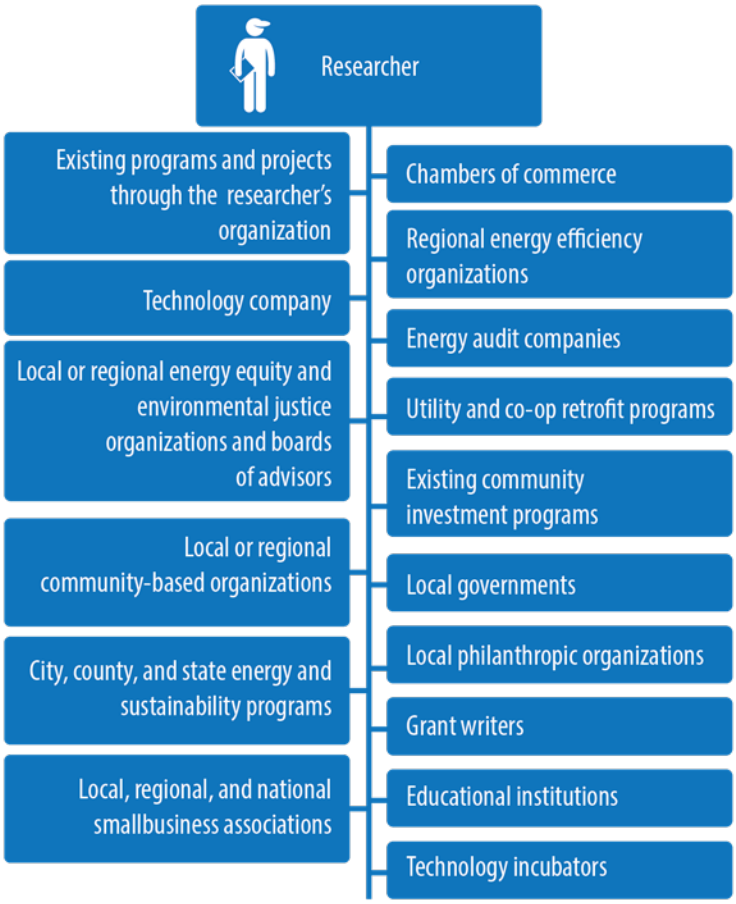

Figure 4. Bridging organizations and connections. *Credit: Marjorie Schott, NREL*