MARKET BARRIERS TO WIDESPREAD DIFFUSION OF CLIMATE-APPROPRIATE HVAC RETROFIT TECHNOLOGIES

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Disclaimer

EXECUTIVE SUMMARY

This study seeks to identify market barriers and other factors impeding adoption and promotion of downstream climate-appropriate HVAC retrofit technologies, as well as develop opportunities to increase adoption and promotion by addressing market barriers.

This study focuses on two climate-appropriate technologies in particular:

- An evaporative pre-cooling condenser air retrofit unit; and
- A retrofit supply fan speed control.

These two technologies, and their diffusion in the small and medium-sized commercial buildings market within Southern California Edison's service area, serve as case studies for other climate-appropriate retrofit HVAC technologies.

To understand the market for climate-appropriate HVAC retrofit technologies, the project team conducted preliminary research to map the basic market structure and identify key market actors (also referred to herein as stakeholder groups). Next, the team developed a logic model to identify the relevant behavioral drivers applicable to each stakeholder group and outlined a broad study design and data collection strategy based on the model. They then collected data using interviews and surveys of stakeholders with and without experience with climate-appropriate HVAC.

The data collected was first sorted into broad categories defined by problems and solutions related to the three elements of the behavioral model outlined: motivation, ability, and trigger. Subsequently, the data were pile sorted and analyzed to identify the salient themes that emerged within each of those broad topics, and further pile sorted according to sub-themes and stakeholder groups. The team then made specific recommendations based on the analysis of the key issues and evidence of alternative solutions provided by study respondents, as appropriate.

As this was exploratory work based on data from a small sample, no formal quantitative analysis was conducted. However, when deemed useful, an indication of the prevalence of certain responses was provided.

The project team identified key factors that influence stakeholders' motivation, ability, and triggers to adopt and promote climate-appropriate retrofit technologies. Eight factors that particularly influence stakeholders' *motivations* to adopt and promote climate-appropriate HVAC retrofit technologies were identified:

- **Technology requirements and performance:** the human, material, and logistical resources required by the technology or policy for proper installation, commissioning, maintenance and performance
- **Technology costs:** the initial and ongoing financial costs, uncertainty surrounding such costs, and diffused responsibility for such costs
- **Additional benefits:** value besides energy savings provided by the retrofits
- **Access to information:** whether and how stakeholders can obtain pertinent information on retrofits
- **Endorsements:** the influence of recommendations by utilities, distributors and contractors, as well as the influence of social norms
- **Status quo bias**: the human tendency to prefer the current state of affairs
- **Stakeholder coordination:** the need for synchronized activities within and across stakeholder groups

- **Accountability and support**: the ability to hold responsible and gain assistance from appropriate parties in the event of a problem

In addition, the project team identified six factors that particularly influence stakeholders' *ability* to adopt and promote climate-appropriate HVAC retrofit technologies:

- **Technical feasibility:** the viability of a technology given the climate, building and rooftop air conditioning unit (RTU) characteristics, as well as the human resources required
- **Cost**: the financial cost of retrofits, the impact of potential utility incentives, and the uncertainties surrounding both cost elements
- **Effort**: the amount of work involved in selling retrofits, obtaining rebates, and installing and maintaining the equipment
- **Awareness, knowledge and communication:** stakeholders' level of awareness and knowledge about retrofit opportunities, as well as the transmission of information among stakeholders
- **Access**: the logistical details surrounding the acquisition of retrofits from those in the supply chain
- **Empowerment**: whether or not stakeholders are endowed with the power to adopt and/or promote retrofits

Numerous recommendations are provided for addressing the barriers identified.

ABBREVIATIONS AND ACRONYMS

AHRI	Air-Conditioning, Heating, and Refrigeration Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
CEC	California Energy Commission
CLTEESP	California Long Term Energy Efficiency Strategic Plan
CPUC	California Public Utilities Commission
DOE	U.S. Department of Energy
ESCOs	Energy service companies
ET Summit	Emerging Technology Summit
HVAC	Heating, Ventilating, and Air Conditioning
IHACI	Institute of Heating and Air Conditioning Industries
IRB	Institutional Review Board
LEDs	Light emitting diodes
M&V	Monitoring and verification
NATE	North American Technician Excellence
PNNL	Pacific Northwest National Laboratory
ROI	Return on investment
RTU	Rooftop air conditioning unit
SCE	Southern California Edison
UC Davis	University of California, Davis
WCEC	Western Cooling Efficiency Center

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BACKGROUND

Cooling for commercial facilities is predominantly provided by rooftop packaged air conditioning units (RTUs) and other unitary vapor-compression systems. Cooling from these systems alone accounts for roughly 25% of the annual electricity use[1] and more than 50% of the peak electrical demand in commercial buildings in California.[2]

Given the longevity of RTUs, retrofitting them with energy efficient upgrades has been identified as a promising strategy to reduce energy consumption among existing equipment. Specifically, the California Long Term Energy Efficiency Strategic Plan (CLTEESP) developed by the California Public Utilities Commission (CPUC) states as Goal 6 that "new climate-appropriate HVAC technologies (equipment and controls, including system diagnostics) are developed with accelerated marketplace penetration."[3] The push toward climate-appropriate technologies implies, by its very nature, the need for highly specialized technologies designed to deliver savings during peak demand periods, when air conditioning equipment must run at full tilt, given particular climatic characteristics. The hybrid equipment that participated in the University of California, Davis (UC Davis) Western Cooling Challenge[4] was shown to provide 40–65% savings in California climates during peak operating conditions. Thus, some technical solutions already exist. However, accelerated market penetration has not occurred.

The market potential for downstream climate-appropriate heating, ventilating, and air conditioning (HVAC) retrofit technologies is high, as there are more than one million conventional RTUs in California. In time, these conventional HVAC systems could be replaced by climate-appropriate systems. To this end, several initiatives are needed: programs, such as this research study, to understand the market barriers hindering adoption, as well as promotion on the part of manufacturers, distributors, design engineers, contractors, and consumers.

PROJECT OBJECTIVES AND SCOPE

The primary objectives of this study are to:

- Identify market barriers and other factors impeding downstream adoption and promotion of climate-appropriate HVAC retrofit technologies
- Identify opportunities to address, reduce, eliminate, or circumvent market barriers in order to increase adoption

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[1] California Energy Commission, 2006.

[2] Energy Information Administration 2014.

[3] CPUC 2011, p. 60.

[4] The Western Cooling Challenge is a multiple winner competition that encourages HVAC manufacturers to develop climate-appropriate rooftop packaged air conditioning equipment that will reduce electrical demand and energy use in Western climates by at least 40% compared to current federal standards. See http://wcec.ucdavis.edu/programs/western-cooling-challenge/.

Although prepared in response to CLTEESP, the scope of the report is focused more narrowly than defined in the Strategic Plan itself. Herein, market is defined as the manufacturers, buyers, and sellers of selected climate-appropriate HVAC retrofit technologies for small- to medium-sized commercial buildings, and other related market players and stakeholders. The stakeholders referred to throughout the report include manufacturers, distributors, and manufacturers' sales representatives; design and consulting engineers; contractors and technicians; consumers (e.g., building owners, facilities managers), utilities; policymakers; and technical experts. The stakeholder groups and the relationships among them are described in a subsequent section on the Decision-Making Framework. Decision-Making Framework

For illustrative purposes, this report focuses in particular on two HVAC retrofit technologies, which are described in greater detail in the next section:

- Technology A: an evaporative pre-cooling condenser air retrofit unit
- Technology B: a retrofit supply fan speed control

In contrast to the Energy Efficiency Strategic Plan, which covers all of California, this report focuses primarily on the service territory of Southern California Edison (SCE). However, although the details of emerging technology programs and markets differ across utility territories, valuable lessons can be drawn from the experience of stakeholders outside of SCE's service territory. For that reason, some of the data collected reflects market barriers or solutions identified by respondents with experience outside of Southern California.

OVERVIEW OF SELECTED TECHNOLOGIES

This section describes the two HVAC retrofit technologies examined in this study.

TECHNOLOGY A

Technology A is a dual-evaporative pre-cooler. This climate-appropriate add-on for conventional rooftops units uses direct evaporative cooling to reduce air temperature at the condenser inlet, then circulates the cooled water from this process through a heat exchanger at the outdoor air inlet to cool ventilation air. As one respondent said, "The technology is innovative compared to the status quo and has a very good foundation in the thermodynamics of it and how it works."

The technology can be installed with any new RTU or added to existing equipment as a retrofit, with only modest integration efforts, including connecting the unit to a water supply which may or may not already exist on the rooftop. The system features a simple stand-alone control scheme that does not require revision or integration with existing unit controls. Because it incorporates relatively few materials and standard, readily available components, it has generally lower equipment costs compared to other climate-appropriate hybrid cooling strategies.

A laboratory evaluation of Technology A indicates that it can reduce energy use by more than 40% during peak demand periods in Southern California climates.[5] Technology A is particularly effective for buildings with high peak demand from cooling and large annual cooling loads located in hot, dry climates.

After a Technology A unit is sold, through one of two channels described in a later section, the one of two approved contractors installs the equipment according to technical specifications outlined by the manufacturer.

In its direct sales, the manufacturer of Technology A has focused on a partnership with a single big box retailer. Their plan is to develop the strategy and marketing materials, perfect the model of developing the relationship, and then replicate the approach with other chain retailers. The decision to focus on chain retailers is a strategic one, as this quote highlights:

> *It's really a combination of the marketing advantage and performance advantage. Chain retailers' buildings basically operate on a schedule, they have high cooling loads and they have multiple units of the same type on the same building. That latter point relates to the opportunity to multiply our design by selling to one customer for many identical units.*

TECHNOLOGY B

Technology B is also a retrofit technology, but it is not climate-appropriate, per se, as the description below will clarify. It is used in this report as a point of comparison for climate-appropriate retrofits, represented by Technology A. As a retrofit, Technology B shares many of the same challenges and market barriers as climate-appropriate retrofits, such as high initial costs, unfamiliarity, dependency on RTU operation, and non-traditional distribution channels. Yet Technology B is an example of best practices that climate-appropriate retrofits should emulate. Thus, while Technology A highlights many of the market barriers climate-appropriate retrofits as

[5] Woolley 2012.

a group face, Technology B illustrates some ways of overcoming those market barriers through careful product design and deployment strategies.

With that caveat, Technology B is a retrofit supply fan speed control. This technology enhances RTU performance by adding three main features: a variable speed supply fan control (using a variable frequency drive), advanced economizer controls (including web-connected fault detection), and demand controlled ventilation. As described by one respondent, Technology B provides "three primary energy conservation measures bundled into one solution." Full application of the technology uses a platform that provides web-based visualization of RTU efficiency, system performance, fault detection, remote diagnostics, real-time efficiency and performance verification, and energy accountability tools.

This platform enables monitoring of all of a customer's RTUs with Technology B installed together. Technicians, facilities managers, and building owners can visualize the system and be alerted to problems immediately. As one respondent said, the technology "puts customers in touch with units, so they know when the dampers fail or when they've lost refrigerant charge or the heating is not working. [Technology B] can tell them those things and they could take that to maintenance. Customers ideally [are those] who will appreciate that, who care about fault detection, and who want to know [how their system is operating]."

This transparency creates accountability with respect to the RTU, but also to the retrofit unit as well. The latter means that the technology has the innate ability to verify and document its own performance. This has a distinct advantage in the realm of utility programs, as according to one respondent, it is how the manufacturer "proves that the product is still out there working [and generating the] persistent savings that the utilities are looking for."

An independent study conducted by the Pacific Northwest National Laboratory (PNNL) for the Department of Energy (DOE) estimated that Technology B reduces energy use by an average of 57%.[6] Technology B has the most potential for energy savings in commercial buildings with long run times, large motor horsepower, and a large (or oversized) cooling capacity. Technology B saves the most energy in two main ways: ensuring proper economizer operation, and reducing fan speed for continuous ventilation and part load operation.

Technology B comes as a pre-wired kit that contains numerous sensors and all the supplies required for installation. The technology can be integrated with an existing building management system or installed as a standalone building management system. Technology B retrofits are sold to major accounts directly by the manufacturer, and to smaller local customers through affiliate partners, as described in more detail later. Most affiliate partners are "turnkey" affiliates, meaning they handle sales and installation. Those affiliates that do not have installation capabilities partner with manufacturer-trained and approved mechanical contractors to do the installation. Thus, the manufacturer ensures proper installation through thorough preparation of its product, as well as careful vetting and preparation of its installers.

[6] Wang et al. 2013.

METHODOLOGY

STUDY DESIGN

This research study uses a range of qualitative data collection and analysis techniques to fulfill its objectives. Preliminary research enabled mapping of the basic market structure and identification of key market actors (also referred to herein as stakeholder groups). Next, a logic model was developed to identify the relevant behavioral drivers applicable to each stakeholder group (as described in the Logical Framework section below). Based upon the model, a broad study design and data collection strategy were outlined.

During the study design phase of the project, it was determined that semi-structured interviews would be the primary data collection methodology. Such interviews typically include a predetermined set of broad and narrow questions and additional spontaneous prompts or follow-up questions to pursue a line of inquiry further, as appropriate. This interviewing approach has many advantages: it provides structure and flexibility, it encourages detailed (and sometime lengthy) responses in respondents' own language (which provides insight into how people think and talk about the subject matter), and it can elicit many types of data. Semi-structured interviews balance depth and breadth, allowing researchers to systematically and efficiently collect and analyze rich, qualitative data from many respondents. This data collection technique is especially useful when conducting exploratory research, as is the case with this study, because it facilitates the discovery of previously unknown information and in-depth probing, where appropriate.

Specific interview protocols were designed for each stakeholder group to ensure thorough, consistent, and efficient data collection. Pre-determined questions in the protocols covered a range of topics:

- Respondents' experience with Technology A and/or Technology B. or other climate-appropriate HVAC technologies, if any
- Information received or transmitted about climate-appropriate HVAC technologies between stakeholder groups
- Market barriers respondents face in adopting or promoting climate-appropriate HVAC technologies
- Market barriers other stakeholders face in adopting or promoting climate-appropriate HVAC technologies

The interviews followed the respondents' lead and some questions were omitted or added as appropriate, according to the researchers' discretion. With consent of the interview subjects, each of the interviews were audio recorded to ensure accuracy in the data collection, as was the roundtable discussion, described below.

The semi-structured interviews were supplemented with several other data collection efforts. For example, numerous group discussions related to climate-appropriate retrofit technologies were observed and analyzed. The first was a roundtable discussion of various industry experts, convened by researchers from Western Cooling Efficiency Center (WCEC),[7] to begin to explore and identify the market actors and the barriers each faces. The roundtable discussion took place on December 5,

[7] WCEC is a group that stimulates the development of impactful cooling technologies that can enable reduced electrical demand, energy and water consumption in buildings. See http://wcec.ucdavis.edu/.

2013, and the 3 1/2-hour audio recording of it was subsequently transcribed and analyzed.

Data was also collected from two tripartite discussions between the Emerging Technology group of a California utility, a climate-appropriate HVAC technology manufacturer, and a customer who had participated in a demonstration project to field test the manufacturer's technology. Technologies from two different manufacturers were assessed during the demonstration project, so the configuration of each tripartite meeting involved the utility and customer in both cases, but a different manufacturer in each. The discussions were conducted at the conclusion of the demonstration projects and facilitated by project team researchers. They focused on lessons learned from the field tests, market barriers to wider adoption, and opportunities to address them. Due to the nature of the meetings, audio recording was not possible, but detailed notes were taken during the discussions and field notes were expanded upon afterwards.

Finally, data was collected from Market Barriers-related panel sessions at the Emerging Technology Summit, a biennial conference for multiple stakeholder groups to advance the adoption of emerging technologies for energy efficiency and demand response. Detailed notes were taken on the presentations and the subsequent discussions about market barriers and potential solutions as they pertained to climate-appropriate retrofits.

To prepare the data collected from the interviews and group discussions, audio recordings (when available) were transcribed, in part or in full. The data collected was first sorted into broad categories of problems and solutions to the three elements of the behavioral model cited above: motivation, ability, and trigger. Subsequently, the data was pile sorted to identify the salient themes (e.g., technology performance, awareness, and knowledge) that emerged within each of those broad topics. Data on each of the themes was further pile sorted according to sub-themes and stakeholder groups. As this was exploratory work based on data with a small sample size, no formal quantitative analysis was conducted. However, when deemed useful, an indication of the prevalence of certain responses was provided.

During the course of the study, it became clear that recruiting interview respondents who did not have experience with climate-appropriate technologies would prove difficult. Thus, an additional data collection effort was undertaken to collect data from those respondents. Specifically, separate online surveys were developed for contractors, technicians, and distributors that focused on the market barriers respondents and their customers face in adopting and promoting climate-appropriate HVAC technologies. Closed-ended questions were developed based upon the key findings collected from the interviews by that point, and open-ended questions allowed for the collection of additional issues not yet raised by interview respondents.

Given the very small sample size of each of the surveys, only limited quantitative analysis of the data was conducted. However, the survey data does provide an indication of the ways in which the barriers faced by adopters (i.e., interview and discussion participants) and non-adopters (i.e., survey participants) are similar and different.

Recruitment and Data Collection

Project team researchers engaged in recruitment efforts for four different data collection approaches: the roundtable discussion, interviews, surveys, and participant observation of panel discussions. In total, data was collected from 76 specific individuals and countless more who contributed anonymously to the group discussions. All of the original stakeholder groups identified, as well as market facilitators and regulators, were represented among the study participants.

Human Subjects Protection

UC Davis researchers engaged in research involving human subjects are required to have study plans and materials reviewed by the UC Davis Institutional Review Board (IRB). The job of the IRB is to ensure that human subjects and their sensitive information are adequately protected throughout the course of the study and thereafter. In compliance with this policy, the WCEC research team submitted an application for review in August 2014, which included a draft of all study materials (e.g., a study protocol, informed consent forms, and survey and interview protocols) to the IRB. The study was found to present minimal risk to research subjects and was deemed "exempt." Upon completion of the review, the researchers was granted permission to proceed.

In accordance with the data protection plan the researchers outlined in the IRB application, all data and supporting materials provided in the report have been anonymized.

Roundtable Discussion

Roundtable discussion participants were recruited through the professional network of WCEC researchers and SCE staff. Representatives from several stakeholder groups deemed by the researchers to have valuable input on the subject of market barriers were invited by email to participate. In all, 14 individuals agreed to participate, representing the following stakeholder groups: manufacturers' representatives, distributors, contractors, consulting engineers, utility staff, and technology experts. Participants gathered in person at SCE offices in Rosemead, CA, for 3 1/2 hours on December 5, 2013. The discussion was mostly participant-led, but the researchers provided some broad questions to guide the conversation. Roundtable discussants were not compensated for their participation in the study.

Interviews

Interview subjects were recruited from all key stakeholder groups, including manufacturers, distributors, and manufacturers' representatives, contractors and technicians, design engineers, utilities, industry experts, and market facilitators. Recruitment was conducted using a variety of methods, including purposive, convenience and snowball sampling techniques. An initial list of stakeholder representatives thought to be promising interview candidates was provided by SCE.

Some of those individuals were contacted directly by WCEC researchers, whereas others were initially contacted by SCE to make an introduction. In general, recruitment through this approach yielded few respondents. Thus, subsequent efforts to recruit participants focused on personal referrals from the manufacturers interviewed and from individuals the researchers met through professional networking (e.g., at the Emerging Technology Summit). In total, in-depth interviews were conducted with 16 individuals from across the various stakeholder groups.

Regardless of how the introduction was made, contacts were sent an email describing the research study and asking for their participation. After an interview time was established, participants were sent a copy of the informed consent document to give them time to review it before the interview. The consent document provided more information about the study and their rights as research participants, as required by the UC Davis IRB.

Interviews were conducted primarily over the phone, although several were conducted in person. Verbal consent was obtained and recorded at the beginning of each interview. The interviews were audio recorded, and each took about an hour. Interview participants were not compensated for their participation in the study.

Overall, recruitment for the interviews proved much more difficult than originally anticipated, especially among individuals who did not have direct experience with climate-appropriate technologies. As a result, the number of interviews conducted is smaller than anticipated, and the interview cohort does not include end consumers, as originally planned. However, the depth of the interviews and other discussions observed provided ample data to meet the study objectives.

SURVEYS

Recruitment for the contractor/technician and distributor surveys was done in person at the Institute of Heating and Air Conditioning Industries' (IHACI) trade show held on November 19, 2014, in Pasadena, CA. With substantial support from the IHACI organizers, WCEC researchers set up a booth with laptops and tablets available for respondents to take the online surveys. Potential respondents were recruited with flyers at the registration counter and in-person when passing by the booth. In addition, a researcher visited each of the HVAC distributors' booths to request their participation. Survey participants were offered a $5 gift card upon completion of the survey, and a chance to win $200, provided by IHACI. Survey data was collected from 13 contractors or technicians and 3 commercial HVAC distributors.

PANEL DISCUSSIONS

No recruitment was conducted for the tripartite group discussions or panel discussions at ET Summit. In some cases, participants were aware of the researchers' intent to collect data from the discussion for this research study and in other cases they were not. In both cases, however, the researchers took detailed notes about the market barriers and possible solutions, as they pertained to each stakeholder group. Data was collected from the 17 participants who attended the 2 tripartite meetings, as well as from the 16 panelists at the ET Summit and the numerous audience members who initiated relevant discussions after the panel.

TIMELINE

Preliminary data collection for this study began in November 2013 with the roundtable discussion. After a protracted delay due to staffing changes at the WCEC, work on the project resumed in June 2014. At that point, the study design was outlined and agreed upon with SCE and work continued according to the research plan. Recruitment for and implementation of the interviews took place from August 2014 until November 2014. The tripartite discussions took place in August 2014. Data was collected from the ET Summit in October 2014. Surveys were implemented at the IHACI trade show in November 2014. Data analysis and the writing of the draft final report was conducted between November 2014 and January 2015. The final report was completed in mid-February 2015, at which point the study was concluded.

DECISION-MAKING FRAMEWORK

Understanding stakeholders' barriers to adopting and promoting HVAC retrofit products requires several steps. First, researchers must identify the stakeholders and next, understand how stakeholders make decisions about HVAC retrofit technologies. Specifically, this means determining the process by which such decisions are made, the context in which the process occurs, and the influence of various factors at each contextual level. Lastly, stakeholders must identify opportunities to address these market barriers.

STAKEHOLDERS

The stakeholders referred to in this section and throughout the document include the following groups:

- Manufacturers, who create the retrofit technologies
- Distributors and manufacturers' representatives, who sell the retrofit technologies
- Design and consulting engineers, who specify the retrofit technologies in project designs
- Contractors and technicians, who install and maintain the retrofit technologies
- Consumers, who include the building owners who purchase the retrofits, and the facilities managers who retain responsibility for HVAC systems in general
- Utilities, which offer rebates for the retrofit technologies

The relationships among these stakeholder groups is illustrated in Figure 1.

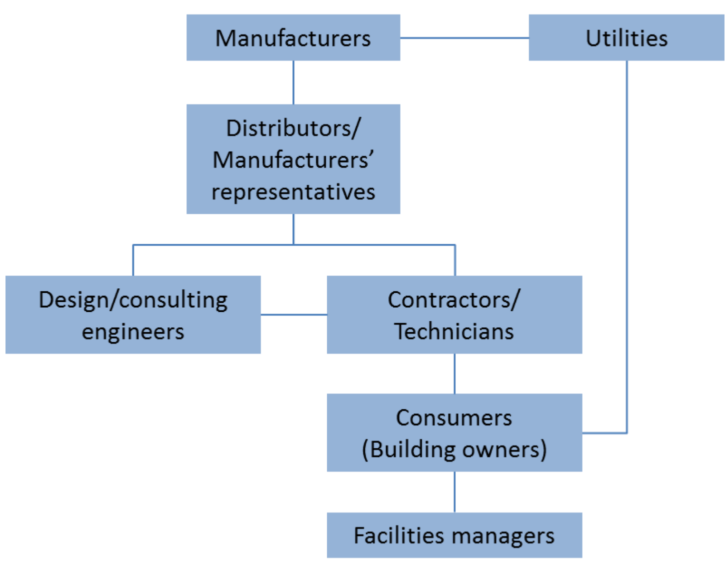

FIGURE 1. FLOW DIAGRAM OF STAKEHOLDER RELATIONSHIPS

BEHAVIORAL MODEL

Work on this study was driven by an understanding of the basic logic underlying stakeholder decision-making. Building on the Fogg Behavioral Model[8], which outlines three key elements of behavior change (i.e., motivation, ability, and a trigger), the project team developed the model shown in Figure 2 to represent the factors that influence stakeholders to adopt or promote climate-appropriate technologies.

FIGURE 2. BEHAVIORAL FORMULA

These three elements can be described as follows:

- ***Motivation*** encompasses elements such as needs, wants, beliefs, and incentives. Individuals must have the motivation to take action.
- ***Ability*** relates to the time, cost, effort, knowledge and feasibility related to a particular course of action. With motivation and ability, a stakeholder may have the *intention* to adopt and/or promote climate-appropriate retrofit technologies, but may not move to action.
- ***Triggers*** are often required to overcome the inertia of the status quo.[9] Triggers can come in various forms (and topic-specific examples are provided in the next section), but they each serve to significantly raise the motivation or ability (or both) to take a certain action, such that the initial barriers are overcome and *action* is taken.

In this context, the specific motivations, abilities, triggers, and resulting actions differ by stakeholder group, as shown by these examples:

- **Motivation**: Customers' motivations to adopt climate-appropriate HVAC technologies may include saving money on their electric bill, whereas contractors' motivations may include offering leading-edge technology that distinguishes them from the competition.
- **Ability**: Distributors may only be able to promote and adopt climate-appropriate technologies if they are certain they can make a profit off them. However, contractors can do so only if they have the technical skills to install the technologies and access to a distributor that carries them.
- **Action**: The relevant action for design engineers and customers is retrofit adoption. For distributors and contractors, the relevant action is to both adopt the technology and promote it to the next stakeholder in the supply

[8] See http://www.behaviormodel.org/ and Fogg 2009 for an overview.

[9] See Fogg 2009; and http://www.behaviormodel.org/triggers.html for an overview.

chain (i.e., the contractor, design engineer, or customer in the case of distributors, and customers in the case of contractors).

In elucidating the relationship between contractors and distributors, the ability example illustrates that abilities of some stakeholders are sometimes dependent on the actions of others. This interconnection can make the problem of low market adoption difficult to address. However, such barriers are more easily overcome when each factor, and the interactions among them, are identified in a structured manner—as the logic model presented here is intended to facilitate.

CONTEXTUAL OVERVIEW

Stakeholders' decisions to adopt and promote climate-appropriate technologies occur within a broader context and are influenced by factors within that context. As Figure 3 illustrates, the context in which a decision occurs (or does not) is composed of multiple levels. A decision made by an individual, is driven by the individual's motivations and abilities, and takes place in the context of the individual's knowledge, beliefs, emotions, and actions.

In the case of decisions related to HVAC retrofit technologies, the individual is embedded within an organization (e.g., firm, program, union) that has its own set of motivations and abilities to adopt or promote certain technologies. In turn, that organization is embedded within a supply chain comprising other organizations.

Finally, all these levels of the market hierarchy exist within a particular environment. Environmental factors (e.g., legal, economic, structural, institutional, social, cultural) shape the opportunities and incentives individuals and the firms they comprise face at a given time.

FIGURE 3. FOUR-LEVEL CONTEXT OF RETROFIT DECISION-MAKING

Stakeholders' decisions to adopt and promote climate-appropriate technologies are influenced by factors at the macro and micro levels, and interactions between the two. That is, individuals make such decisions in accordance with their motivations and abilities, within the confines of their broader context. Further discussion of that broader context is organized into three categories: the regulatory and economic environment, geographic environment, and the market conditions that relate to

HVAC retrofit technologies. The specific elements of each category were identified by study participants and by the researchers independently of the data collection.

Regulatory and Economic Environment

The economic and regulatory environment in which stakeholders make decisions about climate-appropriate technologies comprise numerous factors that impact stakeholders' motivations and abilities and thus strongly influence the outcome of those decisions. First, the regulations, codes and standards that govern the HVAC industry in California play a major role in shaping the requirements, opportunities, and incentives stakeholders face. For example, it is in response to regulation that utility programs exist to promote energy savings through retrofit installations.

Economic factors that influence stakeholders' decision-making include general economic conditions (e.g., robustness of the economy, access to credit, interest rates) and energy prices. The former can limit stakeholders' ability to adopt and promote retrofit technologies, even when the motivation is present. By contrast, energy prices (specifically, high energy prices that make stakeholders generally more responsive to energy efficiency opportunities) tend to be a powerful motivator to adopt energy efficiency measures.

Geographic Environment

The geographic location of a given stakeholder can play a role in driving decisions to adopt and promote climate-appropriate retrofits. In California, coastal regions require less mechanical cooling to maintain comfortable indoor temperatures throughout the summer. Thus, stakeholders in those areas have less motivation to embrace technologies that deliver cooling more efficiently. By contrast, inland areas of California have high summertime cooling needs, substantially increasing peak load demand. In theory, stakeholders in those areas should be relatively more motivated to adopt and promote technologies that can reduce energy use and peak demand.

Market Conditions

Climate-appropriate retrofit technologies compete against the status quo (i.e., existing installed equipment), newly installed conventional equipment, and other emerging technologies. The relative prices of each have a large influence on stakeholder adoption and promotion. Furthermore, the technical performance and reputation of various products and market actors can affect stakeholders' motivations to adopt and promote climate-appropriate technologies from among the alternatives.

The supply chain through which specific climate-appropriate technologies are distributed is an important component of the market context in which stakeholders make decisions. Figure 4 maps at a high level some differences in the supply chains for Technology A and Technology B. In the case of Technology A, the manufacturer retains responsibility for direct sales of equipment. Installation and maintenance services are provided by two HVAC contractors who have been trained by the manufacturer directly. In a second path to market, the manufacturer of Technology A employs a resale arrangement that allows a major RTU manufacturer to sell Technology A retrofits through its existing distribution channels (as well as units integrated with their own RTUs). Technology A is one of numerous third-party products resold by the RTU manufacturer.

The manufacturer of Technology B also employs a two-pronged distribution strategy. For major accounts, the manufacturer retains responsibility for marketing and sales. However, the primary channel is an indirect sales model wherein affiliate partners (i.e., approved installers or energy service companies) serve as retailers in their local markets. Many of the sales are currently initiated by customers contacting the affiliate partners, rather than the other way around, so it appears that the latter plays only a semi-active role in marketing the technology.

Technology B does not employ a traditional distribution model whereby HVAC distributors carry their products; Technology A does so only to a limited extent. Instead, both primarily retain ultimate control over their distribution networks; the manufacturer of Technology A through direct sales, and the manufacturer of Technology B through a vertically integrated model in which their affiliated partners sell equipment on their behalf. This arrangement has significant implications regarding the access of stakeholders further down the chain (i.e., design engineers, contractors and customers) to the products, as will be discussed later.

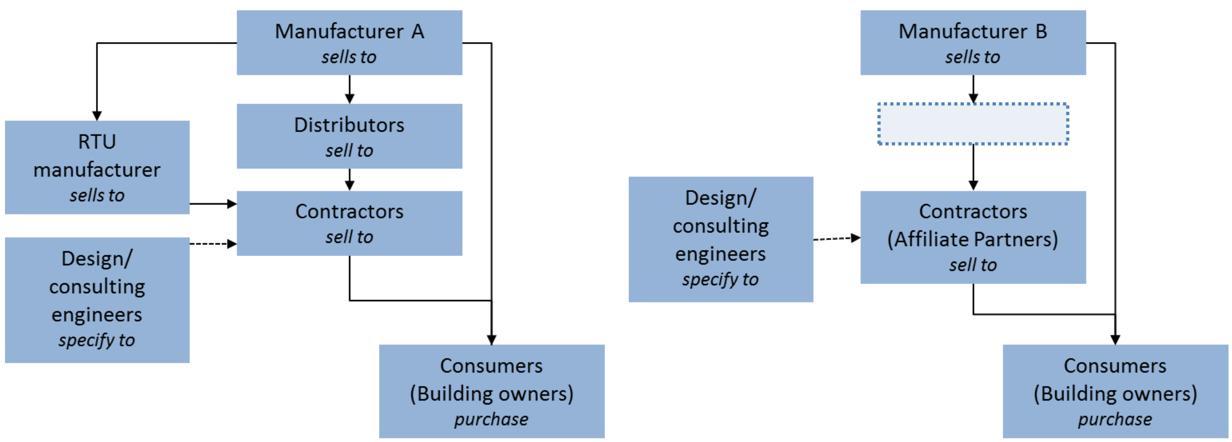

FIGURE 4. DISTRIBUTION MODELS OF TECHNOLOGY A AND TECHNOLOGY B

A separate but related aspect of the market conditions addresses the commercial presence of a manufacturer in a given locale (either directly or indirectly through representatives). A significant commercial presence in an area makes adoption of their product more likely by increasing access. It also boosts stakeholders' motivation to adopt by conveying a sense that adopters can and will be adequately served by the manufacturer, its representatives, and the contractors that work with their product.

Furthermore, geographic proximity seems to affect adoption and promotion. In the early phases of technology deployment, transmission is largely interpersonal. Thus, proximity to a stakeholder who has adopted or promotes climate-appropriate retrofit technologies, and the general market diffusion thereof, can impact individual stakeholders' motivation and ability to adopt or promote such technologies themselves.

Several respondents noted marked differences between the Southern and Northern California markets. One claimed that the "inherent problems [in] Southern California [come from] weak engineering." He went on to explain:

> *If you look at Northern California, they tend to have the most energy efficient way of thinking and approaching buildings. Southern California tends [to prioritize] the cheapest ways of building a building and it all stems from the strength of the energy consulting engineering role. In Northern California, the consulting engineers dominate. They are the powerhouse decision-makers. What they say, what they specify - they will hold contractors to that. In Southern California it's the flipside, it's what the contractors put down [that gets installed].*

The implicit assumption the respondent here makes, is that design engineers are more likely to specify energy efficient equipment than contractors, in general, and furthermore, that contractors in Southern California are more likely to overrule a design specification in favor of a cheaper, less efficient technology.

Thus, as the quote illustrates, the prevailing culture in a given market can influence not just what is recommended, and by whom, but also whether the recommendation is implemented in the final project. These dynamics can create an environment that is conducive to or hostile to retrofit technologies, even when other impediments are addressed.

The above has outlined the logic of stakeholders' decision-making with respect to adopting and promoting climate-appropriate retrofit technologies, and the contextual factors that influence the decisions that occur at the individual level. In the next section, key findings on the market barriers that stakeholders face are presented, according to the logic and structure outlined in the framework above.

RESULTS AND DISCUSSION

The key findings are structured in accordance with the behavioral model outlined in the section above. Specifically, factors affecting stakeholders' motivations, abilities and triggers to adopt and promote climate-appropriate HVAC retrofit technologies are discussed in turn.

MOTIVATION

First, it must be acknowledged that much of stakeholders' motivation for adopting and promoting climate-appropriate HVAC technologies stems from the policies that encourage these technologies. From a policy standpoint, among the many routes to energy efficiency (e.g., RTU replacement, quality maintenance, equipment standards), retrofits are essential to meeting energy and environmental targets. One respondent described the situation this way:

> *If you can't tackle [energy efficiency] with the retrofit side in the existing building stock, then you're not going to get anywhere significant. You could raise new construction standards all you want, [but] if 20 years from now, 80% of the buildings standing are buildings that are here today, we better be doing something about that 80% or it's just almost futile."*

For that reason, policymakers are intensely motivated to encourage the adoption and promotion of climate-appropriate energy efficient retrofit technologies.

However, as is illustrated in this section, many other factors influence stakeholders' motivations to adopt and promote climate-appropriate HVAC retrofit technologies. Eight factors are discussed in this section:

- Technology requirements and performance, including the human, material, and logistical resources necessitated by the technology or policy for proper installation, commissioning, maintenance, and performance
- Technology costs, including the initial and ongoing financial costs, uncertainty about costs, and diffused responsibility for such costs
- Additional benefits, meaning the value provided by retrofits besides energy savings
- Access to information, that is, whether and how stakeholders can obtain pertinent information on retrofits
- Endorsements, referring to the role that recommendations by utilities, distributors and contractors play, as well as the role of social norms
- Status quo bias, meaning the human tendency to prefer the current state of affairs
- Stakeholder coordination, referring to the necessity to synchronize activities within and across stakeholder groups
- Accountability and support, meaning the ability to hold responsible and gain assistance from appropriate parties in the event of a problem.

Technology Requirements and Performance

This section covers the technology requirements (i.e., installation and commissioning, operations and maintenance) and performance as they pertain to stakeholders' motivations to adopt and promote climate-appropriate HVAC retrofit technologies.

Installation and Commissioning

Proper installation of climate-appropriate retrofits is critical for energy and cost savings, protection of equipment, and customer satisfaction. Energy efficient retrofits are only as good as the installation. As one respondent put it: "You can have the best equipment, you can have the best program, but it's the contractor that has to help realize the true savings by putting the system in correctly." In fact, as another pointed out, energy saving retrofits only save the customer money if installed and maintained properly. Otherwise they can cost more than not installing them at all.

Codes and standards dictate the guidelines for proper installation of HVAC equipment and are meant to ensure that the efficiency achieved matches the potential efficiency. In theory, the desire to ensure proper performance should stimulate sufficient motivation to install and commission an RTU or retrofit to code. In practice, however, many jobs are not done to code for a variety of reasons, not least of which is the additional time and cost involved.

Stakeholders in the industry disagree about whether the code (and its enforcement) will eventually provide ample motivation to do proper installation and commissioning. Some feel the code "will continue to take us where we need to go." Others counter that as the code continues to be ratcheted up, the "variance between acceptance and the code continue[s] to widen."

The condition of existing RTU equipment can also influence customers' motivation to install a retrofit. If the RTU is new, customers may balk at the idea of spending more to increase efficiency further. On the other hand, if the equipment is relatively old, customers (and contractors) may not want to upgrade it with a retrofit. As one contractor said when asked to explain why he was not interested in installing Technology B in general: "Older technology has its limitations. Old and new equipment marriage has its challenges." Thus, although efficiency retrofits are technically feasible at both ends of this spectrum, the motivation may not exist at the extremes.

At the same time, retrofit technologies often come with higher implementation requirements and costs. They may require structural changes to the roof to address added weight or water and drain access. Also, since retrofits must be integrated with existing technology, both the retrofit and existing equipment have to be optimized for energy savings and delivery of a building's specific needs and requirements. Furthermore, maximum efficiency can be achieved only if certain conditions are met (e.g., dual paned windows, insulation). If the contractor does not appreciate and communicate these assumptions to the customer, the retrofit's performance may be disappointing. The technical and communication skills required for proper installation and optimal performance requires training and sophisticated understanding on the part of contractors, which may be lacking in some cases. Furthermore, customers may be unwilling to pay more for proper installation.

It should be noted, however, that the degree of complexity involved in installing retrofits varies by technology. Some technologies and manufacturers make it very straightforward and easy. For example, Technology B provides detailed instructions for all possible scenarios and a comprehensive installation kit that includes every possible material that might be required for installation.

However, not all technology installations are simple. Several respondents reported complications installing Technology A reported complications, despite the fact that the manufacturer provided a template for installation settings. At one site that installed Technology A units, it "took a while to get the device dialed in". In another project, three units were "installed by the same contractor and commissioned by the same folks, yet all three of them [were] set up and configured in wildly different ways." These types of problems can result from contractor inexperience or time and budget constraints, if the resources required for proper installation are not accurately estimated. Thus, unless the technology is fool-proof to install, or the contractor is intimately familiar with how to install it under any circumstance, there can be problems leading to call-backs or poor performance. Furthermore, even the uncertainty about installation requirements alone can add variability to the time and expense of installing a retrofit.

In short, the complexity and cost of proper installation and the uncertainty that surround these factors can hinder contractors' and customers' motivation to adopt retrofit technologies. In turn, this can suppress the motivation of distributors and sales representatives to adopt and promote such technologies.

OPERATIONS AND MAINTENANCE

As with all HVAC technologies, ongoing attention to climate-appropriate retrofit technologies is required, even for properly installed units. Steps must be taken to ensure that operation and maintenance yield the full value of the technology in terms of sustained performance and energy savings. As one respondent put it: "ultimately it's something they have to keep an eye on." Most contractors who participated as respondents in this study and had not had experience with Technology A, for example, were concerned about the maintenance requirements for evaporative technologies. They expressed concerns about water damage, cost, and quality; life of the parts; and efforts and costs required.

These concerns are compounded by the fact that proper upkeep of HVAC equipment is not universal, as distributors confirmed. As one said: "Contractors are not very likely to upkeep any type of maintenance. On most buildings, the only regular maintenance that is done is a filter change out. Anything in addition to that will likely not get accomplished." In many cases, maintenance is only prioritized when a unit stops working. Otherwise it is left to run until it gives up, as one respondent explained. Another respondent commented that if customers or occupants do not complain about the air conditioning, business owners and facility managers will not pay attention to the status of the overall equipment. Thus, proper maintenance of the retrofit or RTU should not be taken as a given.

Retrofits that use evaporative cooling have especially high maintenance requirements relative to technologies like Technology B. Some respondents interviewed mentioned problems experienced at sites where they had worked. Water leaks and a "wide open bleed port" were noted. One respondent described these as "growing pains" of the technology, and hastened to point out that the manufacturer is changing model styles to address the issues. But not everyone is so forgiving of technical problems such as these.

Monitoring and tending to the technology can be done by several different parties, each with different implications. Options include the manufacturer, the installing contractor, a maintenance contractor, or even, to a certain extent, a very engaged customer, or some combination thereof. Which party is ultimately held responsible for operations and maintenance of the retrofit technology has implications for the feasibility, risk, and domain confusion involved with a given arrangement, as described more below. These, in turn, can affect stakeholders' motivations to adopt and promote climate-appropriate retrofit technologies.

FEASIBILITY OF OPERATIONS AND MAINTENANCE

Despite some challenges, many agree that proper operation and maintenance is "simple, but critical." However, the feasibility of such depends on the responsible party having the skills, resources and motivation to operate and maintain the technology appropriately.

Relative to conventional equipment, it is more difficult to find a contractor that is able to "take care of the maintenance, [and] to fix it if something goes wrong." For many emerging technologies, there are simply not many contractors in a given area who have experience with a given technology, and the existing installing contractors may be spread thinly across service territories. As one respondent stated: "There is not a backbone infrastructure of technicians that are familiar with new technologies."

While existing maintenance contractors may be a possible alternative, some respondents felt that the typical training a contractor or technician receives is not sophisticated enough for them to fully understand how energy efficient technologies work, which hinders their ability to maintain retrofit technologies.

In addition, capable onsite maintenance staff may require further training to operate and maintain retrofit technologies, either immediately after installation or after the service contract expires. The most likely opportunity for receiving such training is from the installing contractor themselves. However, installers are not currently paid for the time such training requires. Furthermore, the installers themselves do not always have sufficient training to understand how the technology works and then to provide training on it. Even if none of those barriers is present, a simpler challenge may prevent this form of information transfer: sometimes facilities managers are not present when a retrofit is installed, denying them the opportunity to learn about the technology from the manufacturer and installing contractor.

There seems to be general consensus in the industry that service contractors are already relatively constrained, in terms of time and money. As one respondent put it: "In order to stay competitive in the market, to make ends meet, they have to cut a lot of corners." Adding to their list of maintenance duties may be unfeasible.

Furthermore, due to the dependent nature of retrofit technologies, (that is, because they interface with existing RTU equipment), contractors must make sure that both the retrofit and RTU work properly to ensure the energy savings and integrity of the equipment. For example, failure to maintain a Technology A unit can result in damage to an RTU, and failure to maintain an RTU can result in low energy savings by Technology A. Similarly, a broken economizer undermines the savings promised by Technology B. Thus, the retrofit and the interaction between the retrofit and the RTU adds to the maintenance requirements a contractor faces when overseeing a retrofit. Thus, retrofits with higher maintenance requirements may be non-starters for organizations whose in-house maintenance staff is already strained by existing maintenance and operational demands.

A further dimension to the feasibility of operation and maintenance of retrofit technologies is described thus: "Any contractor could do it, but it's whether they would do it. There [are] already a lot of tasks that need to be done that aren't done." Again, skills and resources matter, but so do incentives. In general, the HVAC service industry suffers from a chronic lack of transparency and accountability. Without additional measures, contractors (or facilities staff) are unlikely to be more diligent about maintaining retrofits than they currently are about maintaining existing installed equipment.

Thus, relatively simple factors, such as the skills, resources, and motivation of the party responsible for operating and maintaining a retrofit technology, can call into question the feasibility of a given arrangement. Doubts about the feasibility of such a critical element that impacts technology performance and cost savings can affect stakeholders' motivation to adopt and promote it, especially among potential customers.

Risks of Operations and Maintenance

Several types of risks are associated with the operations and maintenance of climate-appropriate retrofit technologies. At least one respondent expressed a concern that there can be a discrepancy between the prototype tested in the lab and the technology that goes on shelves, resulting in some risks once installed onto a rooftop. It is not clear to what extent these risks are real, but the fact remains that this perception is held by some stakeholders, which surely limits their motivation to adopt "proven" technologies.

In addition, risk arises from the technology's particular installation, operation, and maintenance requirements. As described above, proper installation of retrofits is critical to performance. To quote one respondent:

> *"A good idea cannot go right if it is not implemented exactly according to plan, and from what I have seen, a lot of what the manufacturers intend doesn't make it to the guy on the ground. In fact, a lot of times the guys on the ground don't even open the manual. So in a way, it doesn't matter if the manufacturer tried really hard and did a great job [documenting] everything. The guy on the ground doesn't even check and wants to treat it the way they have always treated it."*

While warranties can protect customers from the risk posed by defective equipment, it does not cover the risks associated with operations and maintenance. Respondents reported general concerns that depending on an industry that is already known for inconsistent maintenance, at best, increases customers' risk exposure. More specifically, commonly cited risks about the operation of Technology A included concerns about water leaks and water use, given the current California drought.

Risk aversion is a factor for other stakeholders, too. One respondent reported: "A building engineer just wants to keep everyone happy and does not want to get called all day about a room being too hot or cold. They want to keep it sort of stable in a way, so they [are] very risk averse in general." They are "not going to sacrifice something that they fear would [generate] a claim against them for under-designing [or] over-designing." Engineers are also concerned about liability.

Respondents also mentioned risks arising from the dependent nature of retrofit technologies. As mentioned above, retrofits work in parallel with RTUs, and therefore both must be operated and maintained appropriately. To quote one respondent: "There were a lot of things to do wrong before [without a retrofit] and there are more things to do wrong now [with a retrofit]." In particular, respondents noted concerns that if not maintained properly, a Technology A unit could damage a RTU. On the flip side, some maintenance personnel are worried that they will damage the Technology A unit, and thus void the warranty, if they have to remove it to replace a condenser coil, for example. For this reason, facilities managers sometimes object to the installation of retrofits like Technology A and others.

Many of the risks described above may be exacerbated because, currently, there is no critical mass of contractors who have experience with climate-appropriate technologies who could quickly, competently, and cost-effectively address issues should they arise. Thus, some customers may feel as though early adoption is akin to jumping without a backup parachute.

Each stakeholder group, and the individuals within it, may have different perceptions of, and propensities for, risk. For example, even after a utility has endorsed a retrofit technology and created an incentive to promote it, individual utility account managers may be reluctant to recommend it. As one respondent explained:

> *"The risk-reward for the individuals [at utilities] who are in the position to make an impact is just not going to work out [in favor of retrofits]. They just don't want to be responsible if something goes wrong, and there is not, institutionally a benefit to getting really aggressive in regards to promoting something that for whatever reason they don't have one hundred percent confidence in. They are [just not] personally incentivized in a way to do that."*

Many contractors perceive substantial risks in promoting climate-appropriate technologies. In addition to fears about souring their relationship with customers by suggesting expensive equipment, many are concerned that addressing increased maintenance requirements will not be adequately covered by their fixed-price service contracts. Furthermore, some technicians and contractors are aware of the problem-laden evaporative pre-coolers of the 1990s. Many of them are not receptive to the new and improved evaporative technologies such as Technology A because of that experience, however flawed the comparison.

Customers assume some risks when adopting new technologies, many of which are described above. It seems that certain types of customers are better suited to this than others. As one respondent noted, industries vary in their level of risk aversion. Some, such as hospitals, cannot tolerate any risk to their operations, while others, such as software companies, have an appetite and tolerance for new technology. It is very difficult to motivate risk-averse potential customers to try climate-appropriate retrofit technologies, given the real and perceived risks involved.

In addition, it appears that the risks are not evenly distributed across stakeholders. Specifically, some respondents argued that certain manufacturers, Technology A in particular, share very little of the risks under the current arrangement. "The problem, I would argue, is there is no risk at all. The manufacturer is not risking anything in letting somebody screw [the installation and maintenance] up because there is no feedback mechanism in the process." Of course, sales numbers are one form of feedback manufacturers receive, but with so little transparency in the industry (as described later), there is little scope for performance issues encountered at some sites to affect sales at others.

Finally, it should be noted that perception of risk can be as powerful a factor as actual risk. Unfortunately, many energy efficiency technologies have been brought to market over the years without adequate development or testing. They have undermined the reputation of the industry as a whole, such that even products with well proven performance records are often subject to skepticism and considered somehow suspicious or risky.

The risk that an action will not yield the intended outcome is known to dampen motivation. The myriad risks outlined above shed light on the many reasons stakeholders may be hesitant to adopt and promote climate-appropriate technologies, given their concerns that the technologies may not deliver the anticipated benefits.

DOMAIN CONFUSION IN OPERATIONS AND MAINTENANCE

Separate from the concerns over the feasibility and risks associated with operation and maintenance of retrofit technologies, some respondents mentioned a specific concern regarding confusion over whose domain such responsibilities fell under. One respondent reported that in a recent project he worked on involving the installation of Technology A, the customer was not required to purchase a maintenance plan from the manufacturer. This led to confusion over who would assume responsibility for maintenance, and whether or not the party responsible had the necessary skills and resources to do so. Ultimately, it fell to the facilities staff by default, but they are not always the best choice. "The guys who work for facilities [are] focused on making sure everything [is] running, not focused on how to do it efficiently."

Another specific concern some respondents conveyed on behalf of customers was that the latter may be confused over to whom to give the maintenance contract: their regular HVAC contractor, the mechanical contractor who installed their RTUs, or a manufacturer-approved installing contractor. Furthermore, customers need to know how to ensure they are not double-paying for the same services. These concerns highlight the challenges some customers face in managing and making decisions about how to address the HVAC services they require. As with the uncertainty surrounding other issues discussed above, this, too, can dampen customers' motivation to adopt climate-appropriate retrofit technologies.

ENERGY SAVINGS

Energy, and by virtue, cost savings are "clearly one of the most significant motivators for folks to be interested in applying new technology." However, such motivation is not universal. As one stakeholder put it: "There is a perception, maybe a reality, that the customers' first goal is not energy efficiency." For many, the status quo is adequate, as long as thermal comfort and energy bills are acceptable. Building owners, one respondent claimed, are "not so concerned with operating cost because the energy use is the energy use, is kind of the mindset."

Even among customers who are interested in saving energy through climate-appropriate technologies, several factors are at play that can compromise their motivation to turn interest into action. The first is simply that a lot of uncertainty surrounds energy savings from retrofits. As one respondent put it: "We get a lot of products out there making claims that they can't produce." Another explained that many companies are "just getting out there and selling their products instead of supporting their product and making sure their product actually works. Unfortunately, there have been a lot of cases where customers installed energy efficiency technology and then it [didn't] work and it [used] more energy. Unfortunately, a lot of these different organizations have really hurt the market because [they have] created a lot of doubt."

Regarding evaporative cooling technologies specifically, one respondent claimed there has not been adequate modeling or simulation to determine precise energy savings. Whether or not this is actually true, the fact that the perception exists among some stakeholders limits their motivation to adopt such technologies.

Apart from the uncertainty generated by unproven products, even "proven" energy saving retrofit technologies yield uncertain energy savings. Energy savings are highly dependent on individual circumstances (e.g., load factor, operating hours, climate), which complicates the analysis for prospective clients, utilities, sales representatives, and customers. Some commercial customers have addressed this by commissioning detailed energy analyses, but one respondent estimated that only 5–10% of commercial customers do this. For most, it is cost-prohibitive. Furthermore, the additional upfront cost of an energy analysis to determine potential energy savings hinders customers' motivation to pursue efficiency upgrades.

Getting a better sense of what energy savings might be before installation can positively motivate customers to adopt retrofit technologies, but the ability to monitor and verify the actual savings yielded after a product is installed is also important. Customers will certainly wonder whether energy savings will be as expected, given the installation, use, and maintenance of a particular retrofit technology. The knowledge that information about performance would be available after a retrofit is installed may increase a customer's motivation to purchase the technology in the first place.

For some technologies, monitoring energy savings after installation is more easily accomplished than others. Unlike Technology A, "Technology B has a really well designed and managed web-based interface system with monitoring capabilities and information about how much energy is saved over a baseline." But even Technology B has its challenges. For example, it is difficult to quantify the total energy savings derived from Technology B because, in addition to the direct energy savings derived from variable speed fan operation, more is delivered indirectly by addressing faults that the technology identifies. Technology B identifies problems faster than quarterly maintenance calls, between which the RTU may be "running wild for three months." However, energy savings is only reaped if the underlying problem is addressed. The manufacturer's impression is that customers who have purchased Technology B tend to respond quickly to maintenance issues, but that impression has not been verified.

Not all customers will be motivated by the assurance of energy savings. Those who do not hold energy consumption and costs as a significant interest will likely not be swayed by better certainty about energy savings. However, it may still be in the interest of utility programs to advance such energy efficiency measures for these customers. In this case, it is even more essential to have some assurance of persistent energy savings in order to justify utility investments in advancing the technology.

It should also be acknowledged that retrofits are not the only means of reaping energy savings. Customers contemplating a large retrofit project often consider a range of technical options, including RTU replacement. In the case of HVAC equipment, simple replacement of an RTU will almost always yield energy savings since codes in California push efficiency higher over time. While a retrofit may deliver more energy savings, even a simple replacement does better than the baseline, which is the more salient point of comparison for customers. In addition, RTU replacement has the added advantage of familiarity, ease of access, confidence and trust in the manufacturer, convenience (with many relatively inexpensive options for installing and service contractors), and, in some cases, lower equipment costs, relative to high-end, cutting edge EE equipment. Thus, the replacement option may undercut customers' motivation to adopt retrofits and contractors' and distributors' motivation to promote them.

Finally, the energy savings delivered by retrofit technologies has a particularly powerful effect on the motivation to adopt new technologies, because of their interaction with other behavioral principles. Specifically, while the cost premium is fixed, certain, and immediate upon purchase, the savings is uncertain, delayed, and difficult to verify. This is a lethal combination, given the human propensity to discount the value of benefits that are reaped in the future, intangible, or uncertain.

TRANSPARENCY

Transparency is a very important motivator, on all levels. Broadly speaking, HVAC suffers from low visibility and transparency. The technology is abstract to many end users. Furthermore, "When your heating and cooling system is up on the roof, it is tough to make a case to people about advanced HVAC strategies because it's really out there. It is on the other side of this big wall." The "wall" to which the respondents referred is both literal (i.e., the roof) and metaphorical for many customers.

At least what RTUs deliver—cooling—is familiar to customers. By contrast, the energy savings that retrofits generate is much more abstract because the user experience of comfort is not modified in any way and because the savings suffers from a lack of transparency. No clear and definitive mechanism exists for customers to "see" the energy savings retrofit technologies deliver. One respondent said: "I think that most customers either see it in their utility bill, if the retrofit was associated with a large enough effort that their utility bill might be affected, or they rely on what the utilities have told them." While better than nothing, these mechanisms are approximate, at best.

Lack of true transparency, for those who are skeptical, can be perceived as a sign that manufacturers have something to hide, even if they do not. This perception is not surprising since there are myriad products available that have failed to yield the energy savings they promised. Technology B addresses this challenge by providing customers' access to a web portal with the capabilities to monitor their energy savings. Technology A has yet to provide a similar tool to verify and monitor energy savings.

Recent efforts to improve fault detection and diagnostics of standard HVAC equipment highlight the importance of transparency as it relates to technology function. The nature of Technology B is such that it reports on its own functioning, as well as that of the rooftop unit systems to which it is added. Providing transparency into its own performance is relatively easy for the manufacturer to do, since monitoring and control are integral parts of the technology's core functions. The manufacturer is planning to integrate such a feature into Technology A. At the behest of utilities, the manufacturer of Technology A is investigating how to introduce fault detection and performance verification into the next generation of their product. Although the manufacturer has doubts about the value that customers will derive from these features—especially since they will entail added cost—input from other respondents suggests that the intangible contribution to transparency might be significant. Moreover, these features may be essential to advancing broad utility programs that will need to ensure reliable and persistent savings.

Finally, contractors offer another potential (albeit informal) source of information, and therefore transparency, about technology performance and energy savings: contractors can share the experience of one customer with another potential one. However, limited experience with retrofit technology currently restricts this source of information. For example, an installer of Technology A reported that he and other installers do not have access to economic data to help explain to customers how the technology will pay off, given the way the system is currently set up. Nor do they have access to data from the projects they have previously installed in the same area, which he felt would be convincing evidence for many of his customers.

TECHNOLOGY COSTS

Several factors related to retrofit technology costs affect stakeholders' motivations to adopt and promote climate-appropriate HVAC retrofit technologies. Each is discussed below.

FIRST COSTS

On average, energy efficient technologies are more expensive than their conventional counterparts. Economic theory would dictate that greater volume of sales and competition in the market would drive prices down. However, a bit of a chicken and egg problem is present. Production volumes cannot be increased (which would reduce costs through economies of scale) without higher sales, and higher sales may depend on lower prices. Competition from multiple manufacturers could lower prices, too, but stakeholders reported that many are reluctant to produce energy efficient products because they don't view them as cost-effective. It is true that some are not, but many are (or could be), and more could be developed.

The above describes the "market failure" that utility rebates are meant to address by providing support in the early stages of technology deployment. Indeed they do play a significant role in reducing the first cost customer's face, which in turn has implications for customers' motivation and ability to adopt climate-appropriate technologies, the former of which is discussed here.

Many respondents cited the high first cost of retrofit technologies as a factor limiting customers' motivation to adopt climate-appropriate retrofits. As one said, "People are not going to spend money they don't have and they are not going to spend money they don't need to, especially on capital equipment." Another said, "[Customers] rarely want to pay more for anything, but [in] certain niche markets [retrofits] would do well."

Even when customers have the ability to afford energy efficient upgrades, the first costs may demotivate them. For example, many respondents mentioned the influence of customers' required payback periods on adoption. As one said: "[Customers] will not look at anything less than a five-year payback." Of course this, too, varies across customers. Respondents noted that some want a three-year payback while others (e.g., cities and municipalities) can tolerate a ten-year payback.

In addition, even when the payback period is acceptable, the upfront cost can still be unpalatable. Sometimes, customers are steered away from energy efficient choices with higher first costs by contractors who "value engineer" the project down to the lowest cost. One distributor described his observations of this practice.

> *"It's very common. It's probably where one of the major areas of products that are trying to be energy efficient get changed to a more standard product in the process and more so in Southern California than I've seen in other areas. What the contractor does is presents a scenario and says 'Here is your building [with energy efficient upgrades] and it is going to cost five hundred thousand dollars' and then, 'here is your building [with conventional equipment] and it's going to cost you sixty thousand dollars'. Then the owner says 'I want the sixty thousand dollar building' and [he] doesn't even take the time to look into what the trade-off is [in terms of] energy efficiency."*

When funding a retrofit project through a utility program, first costs can be uncertain. Many respondents mentioned the financial risk customers assume due to uncertainty about qualifications for or exact amounts of utility rebates. In reality, utility programs fairly straightforward. Although getting information about the program and executing the process may be difficult, the rebate dollars are clear and known up front. However, the perception among many respondents is that rebates are uncertain and risky, which constitutes a significant market barrier, even if the perception is inaccurate.

This is further complicated when customers have a broad geographic presence. "Every utility has a different program and different requirements, so that makes it difficult when I have a [customer] that has [locations] throughout California. I may have one location that has a great, one year payback, another location has a three or four year payback because the rebate is not consistent." A number of respondents felt that this de-motivated customers to do projects in the areas with longer payback periods, even if they were still relatively short.

In addition, there appears to be varying degrees of motivation to sell retrofit technology among contractors, based on their own incentive structures. At least one manufacturer has observed significant differences in the level of interest among technicians who work for companies where they benefit from the profitability of the company, as compared to unionized technicians and other where they do not share in the profits.

Again, the initial costs associated with climate-appropriate retrofit technologies relative to conventional products can impact stakeholders' motivation to adopt and promote them. Some of this is due to higher equipment costs, which are largely a function of low sales volume. As several respondents pointed out, the components of Technology B and Technology A in particular, are not inherently expensive. When greater production levels are achieved, the price will drop significantly.

Typical industry operations also drive the cost difference between conventional and energy efficient equipment. One respondent described it this way:

> *The whole market [for conventional HVAC equipment and services] has driven itself into this ridiculously cheap construction strategy and methods and business management for technicians and installers that is frankly sloppy and really low quality. [Energy efficient products] can't compete on cost. In order to do the job right at this point, you might have to charge twice as much.*

ONGOING COSTS

Operations and maintenance costs also can impact customers' motivation to purchase retrofit technologies. How much value customers feel they are currently getting for their maintenance costs may play a role. If the perceived value is low, higher maintenance requirements (and thus costs) for some retrofits may be a non-starter. As one respondent said: "People think of HVAC as something low tech which makes them believe it needs low maintenance. Therefore, when the cost of maintenance is high, they don't understand the importance." Several respondents also noted that for evaporative technologies in particular, some customers have concerns about water bills. Additionally, it is again important to keep the alternative in mind. Conventional equipment is "generally cheaper [to maintain] than the higher end stuff," which may motivate the sale of a replacement RTU rather than a retrofit.

In general, a perception exists that HVAC maintenance requirements are not taken seriously by customers and sometimes contractors. "Customers don't want to pay for the adequate maintenance guys" or contractor services. Contractors pressed for time by narrow profit margins often cut corners on maintenance. Higher maintenance requirements only exacerbate the gap between what is needed and what stakeholders are willing to do.

On the contractors' and technicians' side of the equation, ongoing operations and maintenance requirements represent a potential revenue stream. In that respect, they should be motivated to promote retrofit technologies, to the extent that they could also sell a service contract. This is especially true for Technology A, and would be more so if relatively long (i.e., 10-year) maintenance contracts were required, as is currently being considered by industry stakeholders.

By contrast, Technology B doesn't require extensive ongoing maintenance, so it does not provide a significant, sustained revenue stream for installing contractors. However, installing a retrofit does provide an opportunity to earn a standard maintenance contract once the relationship is established. As a representative of Technology B explained, "Here [near our corporate headquarters], we are on the rooftops of our competitors. Once we get that relationship going, it gives us an opportunity to become the service provider. That happens frequently."

COST UNCERTAINTY

Uncertainty about the first and ongoing costs of retrofit technologies can significantly hinder customers' motivation to adopt the technologies. First costs have sometimes proven difficult to estimate. Some technologies are easier than others to estimate costs for without a lot of upfront work, as Technology A and Technology B appear to illustrate: Technology B is relatively straightforward to build a bid for, and Technology A more complicated. Although the manufacturer is currently working on an online system, it still will not have "the ability to estimate the cost of a Technology A project". This is because developing an accurate cost estimate requires inputting information about each individual RTU on which a Technology A would be mounted, a capability lacking in the current automated system. Rather, potential customers have to gather such details and work with the manufacturer to build an estimate manually. The initial uncertainty around the estimate may deter many customers. If they assume it will be more than they want to spend, they may decide that even pursuing a bid is not worth the time and effort.

In addition, several respondents noted the rebate risk associated with retrofit projects when monitoring and verification (M&V) is required to determine the rebate. Many respondents, and the customers they have worked with, perceive utility rebates as "unreliable." Furthermore, past experiences with rebates that did not come through make some customers unwilling to pursue new projects that involve a rebate. As mentioned before, this may be more perception than reality. It seems that some respondents confused the regulatory review of utilities' energy saving claims with the rebate determination process. Again, although the risk respondents reported may not be real, the perception that rebates are uncertain can hinder the motivation to adopt retrofit technologies.

Uncertainty around operations and maintenance costs, which are critical to ensuring proper functioning and energy savings, can demotivate a potential customer. Many respondents felt that stakeholders have little access to evidence of sustained savings or long-term costs. Part of this stems from uncertainty about the cost of service contracts. As one respondent put it, "Any contractor could do [proper maintenance], but what would they charge?"

Technology A is attempting to address the energy savings portion of the equation by developing a web-based "self-serve calculator" to project energy savings. However, the value is limited if potential customers do not also know the estimated first and ongoing costs, as noted above.

DIFFUSED RESPONSIBILITY

Another cost-related hurdle that can hinder the motivation to purchase retrofit technologies is the diffusion of responsibilities within a potential customer's organization. As one respondent explained:

> *"Often the person who would be the buyer and the person who recognizes the benefit are not necessarily the same. There [are] certain people within an organization who make capital expenditures and then there [are] other people who are responsible for managing the ongoing cost of things. Most of our benefit to the customer is racking up energy savings, but the person who is watching energy savings is not always the person who can make that first step [to purchase the retrofit]".*

Not only does this make coordination difficult, it also introduces a split incentive problem, even within a single organization. More specifically, in many cases, building owners are responsible for costs, while building managers would reap the potential benefit from energy savings. According to one respondent: "You are taking money from one individual and the payback is going to go to another, which creates a disconnect". The problem is even more pronounced in scenarios where building owners are responsible for equipment upgrades and maintenance, but where tenants are responsible for energy costs.

ADDITIONAL BENEFITS

Some respondents expressed the sense that the non-energy benefits of retrofit technologies may be key motivators for adoption among some stakeholders. On the surface, some retrofit technologies suffer from a lack of novelty appeal. "A new energy efficient cooling system is not giving something that is really exciting, it just happens to be doing the same thing [as conventional technology] and costing you less." Many agreed that customers are motivated to purchase equipment that gives "something better, faster stronger, more beautiful, more useful, more flexible", as is often the case with consumer goods. "It's the thing with the features [or] improve[ed] level of service [that] ends up dominating the consumer market."

Thus, many respondents pointed out that energy savings is not the only impetus for retrofits. While return on investment (ROI) is typically key to selling the customer on the technology, other benefits are important selling points, too. In fact, customers who seek the most energy efficient option have already overcome the barrier of higher first-cost and sometimes higher maintenance costs. Typically, these customers are looking for energy savings *and* other benefits or added features of a system, which may include the following:

- Increased comfort
- Improved air quality
- Reduced noise
- "A more aesthetic and enjoyable space"

- An improved work atmosphere through improved the ventilation and air quality
- Improved systems management (Technology B)
- Better service from the manufacturer
- Added convenience and visibility into the operation of the economizer, a key, but often overlooked, energy efficiency technology (Technology B)
- Cost avoidance through earlier fault detection (Technology B)
- Prolonged life of an RTU (Technology A)
- Environmental benefits yielded through energy savings and peak load reduction
- Psychological benefit of environmental altruism
- Increased grid reliability through peak load reduction (Technology A)—a benefit unlikely to attract the attention of many customers

The key is to know the potential customer well enough to identify which of these added benefits will help motivate a sale, as each industry and organization has its own set of objectives and motivational drivers. Similarly, there are messages that some people "just don't want to hear." One respondent described it this way:

> *"We train [our affiliate partners] on how to get the conversation started. [We have them say]: 'We're going to be able to assure your comfort and indoor air quality and do it with less energy. This is a proven product the utilities have validated independently.' When they see it as a utility funded initiative, it's different than 'I would like to sell you my preventative maintenance services'."*

Several respondents mentioned the varying degree to which environmental altruism may play a role in motivating stakeholder adoption. At least one claimed that it is easier to promote climate-appropriate technology in Northern California than in Southern California (even with smaller rebates) because stakeholders in the former seem to be more interested in the environmental benefits than the monetary benefits. Differences across companies were also mentioned. In particular, large companies with an explicit sustainability agenda are presumed to be more motivated to adopt energy efficient technologies, including climate-appropriate retrofits, relative to other organizations. Contractors vary on this dimension, too. Some expressed an environmental motivation for the work they did, while others did not.

One benefit contractors receive from adopting and promoting climate-appropriate retrofit technologies is differentiation from their competition. In a market dominated by competition on the basis of price alone, contractors who charge higher prices for higher quality service need tangible ways to set themselves apart and demonstrate their added value to potential customers. Providing leading-edge energy efficient solutions is one way contractors reported achieving this. One respondent reported that third-party sales representatives use Technology A as an add-on to their RTUs in a similar way—to differentiate themselves and be competitive among customers who are looking for more energy efficiency.

However, the additional features (or benefits) that accompany energy efficient retrofits may also pose a challenge, as they may make stakeholders' decisions more complicated. While comparing RTU models is relatively straightforward, comparing a particular energy saving retrofit technology with others may be more difficult because the technologies are often not comparable. Furthermore, there are sometimes multiple ways to achieve the same benefit.

The example one respondent gave was that while economizers save energy, they are expensive ventilation air devices. A dedicated outdoor air system might be a more efficient (and cost effective) way of delivering ventilation air than is Technology B. Another respondent explained the issue in more general terms: "other types of systems can be more efficient, along with being better for most buildings around [Southern California]."

In short, choosing from a range of different technologies that save energy is more difficult than choosing from among relatively comparable options (such as RTUs), and research from the field of behavioral economics provides ample evidence that too many options can overwhelm a customer and stall decision-making, despite the motivation to take action.[10]

ACCESS TO INFORMATION

Stakeholders' access to important information also plays a key role in the motivation to adopt and promote climate-appropriate HVAC retrofit technologies. Many respondents felt that additional credible data on performance of various retrofits is needed. In particular, verification of energy savings is especially important for emerging technologies, because they are unknown, and some uncertainty exists. One respondent described the customers' perspective this way: "Someone is coming to you and telling you that this [technology] will be A, B, and C, and you've never seen the system, and you're not even sure what A, B, and C look like. It's hard to agree to something like that."

Others mentioned that stakeholders have insufficient access to data on long-term savings, given the comprehensive costs of operation. A general consensus among respondents was that support is needed for more studies and efforts are needed to increase dissemination of existing studies.

Another element of access to information is the source of information itself. In general, manufacturers are not trusted to report on their own equipment. Therefore, data and analysis from pilot studies and demonstration projects conducted by credible third parties is required. As many stated, third-party data is important to convince customers. One respondent said:

> *"People are really reluctant [to] accept [new technology]. That's why it's important to have some of the backup documentation. So when they say, 'How well does this product work?' you know you could say, 'The Department of Energy study came back with an average of 57% of savings.' Having that validation is very helpful to the customer."*

Other trusted third-party sources of information noted by the respondents included the WCEC, E-Source, Minnesota Center for Energy and Environment, California Institute for Energy and Environment, utilities, and vendors.

[10] For an overview, see http://www.ideas42.org/choice-conflict/. For an example on consumer goods, see a TED Talk on the classic "jam study" at https://www.youtube.com/watch?feature=player_embedded&v=lDq9-QxvsNU. Papers on decision-making related to finances include DellaVigna (2009) and Agnew and Szykman (2005).

The employer of one person interviewed gets around the current dearth of information by performing its own due diligence, which involves running its own pilot tests for 3-6 months.

> *"It entails basically doing a test site to make sure it actually works. We [do it] on one of our own facilities or we have an agreement with a customer where we actually test that technology at no charge, and if it doesn't work we take it out without a charge to them. Before we sell the product, to create the baseline, we will install it and make sure we get good data on the energy savings, make sure there [are] no issues. And then we have the verification portion afterwards. So there [are] criteria: we go through the energy efficiencies. We make sure it doesn't affect indoor air quality or comfort of the occupants. We make sure it actually works, [and] doesn't adversely affect the [RTU] equipment. We basically just make sure it beats standards and does what it says before we recommend it to customers."*

While commendable, each contractor or design engineering firm relying on its own field tests is an inefficient way to address the lack of information on retrofit performance and costs. In addition, such firms lack some of the unique capabilities that make data from trusted third-party sources such as the DOE, PNNL and WCEC so valuable. Also, while all firms in principle have access to publicly disseminated information such as that produced by the organizations listed, not all firms are aware of such sources of information, nor how to use the information in their daily operations.

Some respondents also spoke of the role of contractors as trusted sources of information for customers, as they possess knowledge—for example on the installation process or customers' equipment—that other stakeholders do not have. However, their role as a provider of information on retrofit technology performance and energy savings is somewhat limited as they do not usually have access to data generated by projects they have previously installed. Some felt this would be a powerful motivator for customers, especially those in the same geographic area.

Contractors are also an important source of information for other contractors. In the absence of a consolidated data source on the topic, some contractors who are relatively inexperienced with a particular retrofit technology rely on their colleagues' estimates of implementation time and cost when preparing for a job.

Finally, customers' access to information impacts their motivation to adopt climate-appropriate retrofit technologies. Simple factors such as the amount of time or effort required to acquire the desired information can have a powerful impact on motivation and ultimate action (or inaction). In some cases, getting pricing information from manufacturers or sales representatives is difficult.

For example, obtaining a price quote on Technology A requires calling the manufacturer (or reseller), requesting an estimate, and waiting for a response. By contrast, the manufacturer of Technology B provides an online tool that, based on information entered by an affiliate on their customers' RTUs, location, utility territory, and hours of operation, will immediately generate a cost and yearly energy savings estimate. However, although such a tool provides immediate access to information, some customer effort is required. Gathering data on the RTUs takes time and effort, too. This effort is unavoidable, as the information is a minimum necessary input to such a model.

ENDORSEMENTS

Endorsement of a climate-appropriate retrofit technology carries substantial weight and plays a significant role in motivating customer adoption. But *who* recommends the technology appears to be as important as *what* they recommend. This is true down the supply chain, from manufacturers recommending a technology to distributors, distributors to contractors, and contractors or utilities to customers. For new technologies in general, manufacturers are the primary source of information. However, as one respondent explained, "all of these buyers have vendor fatigue when it comes to efficiencies."

Instead, many in the industry listen to third-party recommendations from E-Source, Minnesota Center for Energy and Environment, DOE, utilities, and key technology experts, such as WCEC and individual utility staff. An example of such an endorsement is E-Source naming Technology B the game-changing technology of 2013. In a more subtle way, the DOE's advanced RTU campaign, which includes retrofits and not just replacement, serves as an endorsement, although not of any particular technology. The endorsements from the likes of DOE and E-Source are so powerful, in fact, that some utilities have created prescriptive rebates without conducting their own demonstration projects, having been convinced of the value and reliability of Technology B based on the existing third-party data.

As mentioned earlier, independent parties (WCEC and PNNL, respectively) have verified the energy savings of both Technology A and Technology B. Although objective, these studies are interpreted as endorsements by many stakeholders.

Still, some respondents mentioned the lack of standards for many climate-appropriate technologies. The absence of a UL Laboratories listing, Air-Conditioning, Heating, and Refrigeration Institute (AHRI) certification, or American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) endorsement, for example, was cited as a limitation in promoting emerging technologies. Note, however, that ASHRAE, as a policy, does not list, certify, or endorse HVAC equipment in any way.

The sections below discuss the endorsement power of different key groups.

UTILITY

The utility "stamp of approval" (communicated through a rebate) on the technology is a powerful signal to customers about quality, reliability and energy savings potential. One respondent stated that "good information from the utility is priceless for driving behavior." In fact, one manufacturer explicitly trains its sales force to say: "'This is a proven product the utilities have validated independently' and when [the customers] see it as a utility-funded initiative, [their response is] different." Contractors who had worked with either Technology A or Technology B, and those who had not, confirmed that the utility's endorsement of the product was a "very important" factor in convincing their customers to install it. In fact, among those who had not worked with Technology A, the utility's endorsement of a technology rated more important in convincing their customers to adopt it than even the rebates or cost savings estimates.

Utility rebates represent the company "putting its money where its mouth is." Thus, rebates serve to bolster utility endorsements. One respondent observed that customer attitudes seem to be, "If there are incentives available to me that can reduce my cost, I am more inclined to listen [to a sales pitch] than if nobody is going to help me with it." Utility financing is another powerful signal of the utility's support for the product, which boosts a purchaser's motivation to adopt a technology.

The reason utilities' recommendations are so powerful is because they are a respected authority. The utility is seen by many as an unbiased third party when it comes to technology choice. "What they say is seen as the truth, as far as technology, by everyone from boiler room to board room." In fact, one respondent cited a survey he had heard about years prior in which utilities were ranked as the most trusted organizations in civil society. The rationale given by survey respondents is as follows:

> *"I don't think I have ever had them lie to me, I don't think I have ever had a bad experience. What do they have to gain? If they tell me something, then I think their credibility is probably there."*

Utilities are also perceived as relatively conservative and risk averse. Thus, if they support a technology, the implicit assumption is that it is a "safe bet".

On the other hand, "utilities have to [remain] impartial". It frustrates some manufacturers that utilities are not more proactive in promoting climate-appropriate technologies. This occurs at the organizational and individual level. Some noted that individuals within utilities are not incentivized to aggressively promote new technologies and therefore do not do so very often.

DISTRIBUTORS

As middlemen with many options to choose from and profits on the line, distributors may be the most conservative of the stakeholders. They are incentivized to play it safe and stock technologies they know will sell. Furthermore, they have a strong sense that their reputation rides on the performance of the equipment they sell. One distributor described it this way:

> *"We will not sell a product just to sell a product. We [have to] stand behind it, so because of that we have a lot of exposure. We have to make sure that we have confidence or faith in that product before we can promote it ourselves because one bad job and your reputation is tarnished. We are very selective in how we take on and promote a product."*

Thus, when a distributor decides to sell (or not sell) a climate-appropriate technology, it sends a strong signal to the market, whether intentional or not.

CONTRACTORS AND TECHNICIANS

Contractors and technicians often serve as trusted advisors to their customers. As one manufacturer said:

> *"When the [owner] calls someone to come and fix their system, they're not calling me. They're not calling the distributor. They're not calling the [California Energy Commission (CEC)]. They're calling a contractor. And so that contractor can influence a lot of things."*

In fact, in one project described by a respondent, the contractor reviewed the recommendations of the design engineer and helped guide the customer's choice. A contractor that recommends adding on an energy efficient retrofit can play a significant role in customer adoption of such technologies.

But such influence depends in large part on the contractor's experience with a particular technology. If the contractor has a good impression of and experience with a given technology "he's gonna want to use that and promote that". If the contractor does not, the contractor won't promote it. Acknowledging this, one contractor who had no previous experience with Technology A, when asked why he was concerned his customers would not like it, said "*I'd* be very concerned. Why wouldn't *they*?"

However, contractors' role as a reference can be limited, too. To be influenced positively by a contractor's recommendation, the customer must trust it. One contractor reported that customers are "not really sure [we]'re telling the truth because we don't have the backup information" on energy savings, operational costs, or other critical elements. Furthermore, many customers bristle at sales pitches, making contractors leery of recommending retrofits for systems that are already working, albeit inefficiently. In other cases, although contractors and technicians are manufacturers' "eyes and ears," some only focus on their "need to get to the next call." In those cases, either contractor time constraints or their mindset limits the role they can play in motivating adoption of retrofit technologies.

Some contractors are simply not motivated to promote climate-appropriate (or energy efficient) technologies. They may be afraid of alienating customers by recommending additional costs, even if they know that those costs would yield savings for the customer in the long run. Although energy efficient products often are cost effective over time, contractors may have no incentive to urge those options over the conventional alternatives if their margin is the same and the former involves some risk, either real or perceived.

In fact, several respondents noted that even when an emerging technology has been promoted and adopted for a given project, or when the customer has independently indicated interests in an energy efficiency solution, contractors may derail its installation. Either to curry favor with their customer or to mitigate their perceived risk involved with installing an emerging technology, contractors are reported to "value engineer" the technology choice such that the "bottom common denominator" is chosen. By presenting the more expensive efficient option and the conventional option using price as the only criterion for comparison, contractors at times undermine the endorsement of other stakeholders who have worked to influence the customer to adopt the former.

It is also important to note that peer-to-peer endorsements are important motivators for technology adoption, especially among contractors. In fact, of the contractors surveyed who had not worked with Technology A, the majority of them rated "talking to contractors/technicians who have worked with [the technology]" as very important or important for increasing their comfort in recommending and working with the technology. The ratings of importance were on par with those of additional training and hands-on experience with the technology.

Across multiple stakeholder types, it seems that new technology needs a "champion." For example, a single individual brought together the manufacturer of Technology A and the major RTU manufacturer that now distributes Technology A. Some sales representatives and utility staff were noted as being more enthusiastic promoters of retrofit technologies. As one respondent explained, in many cases "personality and individual interests drive factors." On the other hand, "HVAC is a small industry. Everyone knows everyone. Word travels fast, and your reputation precedes you." This suggests that some parties' word may carry more weight than others. That said, there is clear consensus that recommendations for specific technologies impact stakeholders' motivation to adopt and promote them.

Social Norms

In addition to overt endorsements, stakeholders seem to be influenced by what they observe of their peers and environment. "I think that to a very large degree [consumers] are influenced by what they see others doing." Respondents reported instances of stakeholders (and customers) adopting or not adopting Technology A or Technology B precisely because an associate had had a good or bad experience with it.

The sense that "no one wants to be the first to try the technology" highlights another chicken-and-egg problem in the industry. In the words of one respondent, "There are not enough people out there [adopting climate-appropriate technologies], so people aren't going to do it." As another said, "Customers (and other stakeholders) may think, "'Why do I want to be the first?' No one wants to be a guinea pig."

This phenomenon, which also holds for contractors, distributors, and design engineers, is referred to in the behavioral sciences literature as the "social norms effect."[11] Over time, social norms change if the majority follows the early adopters' lead. However, climate-appropriate HVAC technologies are still far from being the norm, and although there are some early adopters, their lead has not yet amounted to a critical mass.

Low visibility may be one factor contributing to the low acceptance of climate-appropriate HVAC technologies. It is difficult to be influenced by peers' choices when the technologies are largely invisible. To illustrate, one respondent made the comparison with LED light bulbs, which contractors and customers can readily observe on the shelf at home improvement stores. Their presence signifies more than availability; it communicates a de facto endorsement by the store and suggests that other customers are purchasing LEDs. By contrast, customers don't go to "Home Depot to buy an air conditioner. They go to a contractor and then take the word of a contractor." Thus, with HVAC technologies, the social norms are largely conveyed to customers through the contractor, rather than by peers or environmental factors directly. To the extent that contractors have not yet widely accepted or adopted climate-appropriate retrofit technologies, it is difficult to leverage the opportunity for them to endorse the products with their customers, raising the latter's motivation to adopt them.

Finally, several respondents noted that distinct differences between Northern and Southern California exist, in terms of norms. The former tends to be more energy and environmentally conscious, and HVAC choices are often driven by design engineers. By contrast, the Southern California market is purported to be more cost-conscious, and driven by contractors. If that is indeed the case, these are relevant social norms which themselves currently constitute a set of market barriers.

[11] For an overview, see http://www.ideas42.org/social-norms/ and http://www.ideas42.org/social-norms-and-energy-conservation/. For a discussion of social norms to promote energy conservation, see for example Schultz, et al, 2007.

STATUS QUO BIAS

In general, humans are subject to status quo bias.[12] Many respondents cited this bias as a factor that limits stakeholders' motivation to adopt climate-appropriate retrofit technologies. Among the barriers they mentioned were "resistance to newness", "unfamiliarity," "institutional momentum," and an "anti-newness" that is part of "human nature". Here is a longer, illustrative quote:

> *"It's just like anybody; no matter what they do in their lives, in any work area, there are people who want to just feel comfortable. They don't mind the rut. And then you get guys who love challenges and love the opportunity [posed by new technology]."*

Many respondents mentioned these propensities, particularly in the case of contractors and technicians. They mentioned that "old school" technicians "are stuck in their ways. They don't like to change. They won't adapt." Another said, "Contractors and technicians are stuck in a distant past. They feel that if what they're doing is making money, then there is no need to try and change the way they do things." Union membership was another factor that some respondents associated with resistance to new technology, although little explanation was provided.

Respondents also mentioned that older technicians may remember poorly performing iterations of evaporative pre-cooling technologies from the 1990s. Technology A "is a different technology [than the earlier evaporative coolers], but [people] associate it with something they had experienced before." Some respondents thought that some contractors were not "open to the new and improved Technology A now because of that experience."

Contractor reticence can have implications that further demotivates customers to adopt retrofit technologies. Reportedly, some contractors inflate their bids on jobs with unfamiliar technology because they want to mitigate against uncertain cost overruns. "It's understandable, but puts energy efficient technologies at a further disadvantage," as one respondent observed.

Other stakeholders in the supply chain are subject to status quo bias, too. Even within a given distributor's sales force, "There are early adopters, middle, and laggards. Maturity, comfort within the industry and personality all drive that." One distributor described his experience with several new technologies (neither Technology A nor B) this way:

> *"I will be the first to admit, I was skeptical when I first saw it and it took me a good year or two actually to get on board. Now, looking back in retrospect, I kind of feel silly. How can you even question this type of product? But if it does not have a history [locally], you're going to be very skeptical of it."*

In addition, "engineers tend to stick with what they know and what they have familiarity with because it minimizes their exposure to liability." As mentioned earlier, industries vary in their appetite for new technology. Biotech and other technology-based industries tend to be more open to new technology, and less wedded to the status quo.

[12] For an overview, see http://www.ideas42.org/status-quo-bias/.

Status quo bias applies more specifically to the technology, too. Respondents observed that people have a tendency to replace equipment with what they had before because "people go with things that are safe." Familiarity with a product matters. People in the HVAC industry "go with what they know." "Not everyone out there is driven by the same motivation to explore and apply and adapt new technologies." Initially there may be resistance. "It may take a few times before [a new technology is] embraced." People need experience with technology to get "used to it." Ideally, the outreach, sales, and training processes are designed to provide this opportunity, such that the status quo bias can be overcome by relevant stakeholders.

STAKEHOLDER COORDINATION

Respondents mentioned the importance of stakeholder coordination in generating organization-wide motivation to adopt and promote climate-appropriate technologies. Starting from the top of the chain, distributors often learn about new technologies at industry meetings and trade shows, such as those held by ASHRAE. They check out the booths, discuss technologies, and advance the conversation to the executive team. However, the decision to distribute a particular technology is localized within each office or region, so buy-in at the top does not necessarily translate at the local level. Even when it does, individual sales personnel have discretion over what they recommend. Thus, getting a distributor's local office to carry the product is not always enough to ensure it is promoted among that office's customers.

Whether pitched by a distributor, contractor, design engineer, or utility account manager, energy efficiency retrofit projects "have [at times] not gotten consideration at the right places either because the gatekeepers are the facility guys and they don't get the economic benefit, or somebody is looking at this in the wrong light."

Even when the pitch is successful, there can be problems with stakeholder coordination. For example, respondents told of instances in which decision-makers high up in the company decided to install Technology A, but the decision was not communicated to the facilities managers or technicians. In some cases, the latter only learned of the decision when the installing team arrived on the roof. The breakdown in communication between high level decision-makers in a company and those responsible for day-to-day operations of the facilities leaves contractors caught in the middle. Installing contractors must then inform the technicians about the decision to install Technology A and educate them about the technology itself. That takes time and training that are not always available to the installers. Clearly, the circumstances are not ideal for the transmission of information, which is especially important when a service contract is not required or is only short-term before maintenance is transferred to the facilities manager's domain.

Because Technology A can make a facilities manager's job more difficult, the fact that the managers are neither consulted nor informed of the impending change sets the project off on the wrong foot. It is critical that the people in charge of the technology on a daily basis adopt the technology, too, and they will be more motivated to do so if given the proper notification and education in advance.

ACCOUNTABILITY AND SUPPORT

Transparency without accountability has limited value. To be motivated to adopt and promote retrofit technologies, each stakeholder group needs to know that the others will provide the appropriate support and be accountable if something goes wrong, especially given the perceived risks involved with new technology.

Distributors, contractors, design engineers, and customers want to know that whoever sold or installed the technology will provide ongoing support when needed. One contractor reported that he inquires among his colleagues about a manufacturer's "response time to emails or issues" before recommending it to his customers. It's "important to make sure you have a well-supported product" before promoting it. Similarly, when distributors were asked what would make them want to learn about and begin carrying Technology A, one said, "Product support is crucial. I need a knowledgeable person to contact when I have questions I am unable to answer on my own."

Technology B, with its on-board diagnostic capabilities, highlights the human factors well. Once technical issues are identified and diagnosed in the field, the question focuses on whether the people responsible for addressing the issues will respond appropriately. For example:

> *"When an economizer fails to open at the appropriate time, will it actually get a solution or will it just be data that ends up in there. The capabilities are there. But are the relationships, and the roles and responsibilities, and the associated dollars structured in a way that ensures that it happens?"*

Similar questions could be raised about maintenance issues arising with Technology A, or any other HVAC technology. Certainly, given the concerns described in the section on the risks related to operations and maintenance above, this is a valid point.

A bigger issue at play that few stakeholders mention explicitly, but that is certainly a factor limiting, is the motivation to adopt any new technology. As one respondent explained, "There is a natural time process to [get the market to] accept [new technologies] and a lot of [manufacturers] cannot afford to weather that storm."

The concern that a nascent company could go out of business and no longer be available to honor its warranty and provide support for its product may be a significant market barrier. The recent closure of Coolerado highlights the salience of this concern. This is not to suggest that Coolerado will not honor its warranties, but rather to make the point that this industry can be unpredictable, and such events likely scare off potential customers for other climate-appropriate technologies manufactured by lesser-known companies.

As with all of the other factors described above, accountability and support play a significant role in stakeholders' motivation to adopt and promote climate-appropriate retrofit technologies.

ABILITY

In this section, six factors influencing stakeholders' *ability* to adopt and promote climate-appropriate HVAC retrofit technologies are discussed:

- Technical feasibility, referring to the viability of a technology given the climate, building and RTU characteristics, and human resources required
- Cost, including the financial cost of retrofits, impact of potential utility incentives, and the uncertainties surrounding both
- Effort, referring to the amount of work involved in selling retrofits, obtaining rebates, and installing and maintaining the equipment

- Awareness, knowledge, and communication, referring to stakeholders' level of awareness and knowledge about retrofit opportunities, and the transmission of information among stakeholders
- Access, meaning the logistical details stakeholders face in obtaining retrofits from others in the supply chain
- Empowerment, meaning whether or not stakeholders are endowed with the power to adopt and/or promote retrofits

TECHNICAL FEASIBILITY

Installing and operating retrofits can be technically complicated. Numerous logistical considerations regarding the site include installation location constraints, weight-bearing capacity, water access, utilities available on site, and purpose of the conditioned space (e.g., hours of operation, special requirements). In addition, the retrofit technology must be integrated with an existing RTU. Customers and contractors may have concerns about the performance of existing RTUs with integrated retrofits, due to their age or condition (especially given the prevalence of broken economizers). Several respondents reported that among the existing stock, there remain a lot of "20-year old units still 'clunking' away on rooftops, barely holding on, but still working." Furthermore, it is common for units to be neglected until they stop working entirely. Ultimately, a poorly performing RTU limits the energy saving potential of energy efficiency retrofits, which can in turn hinder stakeholders' ability to adopt the technology. As one contractor reported, when initially introduced to Technology A, he was very concerned about compatibility with existing RTUs because he worried "the equipment would develop problems that [they would be] unable to detect and properly fix."

Assuming it is technically feasible to integrate a retrofit technology with an existing RTU, then there are implementation requirements to consider. Many times, the precise installation requirements vary across RTUs, given differences in the model and condition of the existing equipment. This variation requires installing contractors to customize the installation slightly and be prepared for almost anything. The perception remains, at least among some stakeholders, that the technology requires sophisticated skills that many technicians may lack, which can lead to technical and other problems.

The manufacturer of Technology B attempts to address this by providing training to all its certified installers, as described in a later section. It also supplies "Every little thing that is needed to add [Technology B] on [to an RTU], but not all [manufacturers] do." The uncertainty created by the latter can add time and expense to the process of installing a retrofit, although it may not compromise the technical feasibility, per se. A Technology B installer also reported that they often draw on the preliminary work done for the sales pitch (using Google Earth images) to prepare for the installation.

However, the complications do not end with installation. Technical feasibility issues often arise later, as the following interview excerpt describes.

> *"There is [a] verification portion where you go back. [You check on things like the] interaction between end user and the building. Maybe their run time hours are long but they're actually not in the building that long. Or maybe there are other issues. For example, they put Technology B in, but you're still having some temperature issues. You go in and you find some duct work is leaking or just disconnected above the ceiling. A*

> *lot of times there is an underlying issue that has to be addressed. Also, with a retrofit, you're putting the retrofit on the existing piece of equipment, so you want to make sure you do your due diligence to make sure that equipment can go to the intended specification or capacity. There may be repair issues with the equipment that may have been neglected for years. So, just slapping on an energy efficient piece—it takes a little bit more time."*

The manufacturer of Technology A ensures proper installation, in part, by allowing only approved contractors to install the equipment according to technical specifications. However, this strategy does not address possible underlying issues that may arise from the RTU itself. Also, with only two approved contractors, the potential for scaling up deployment is severely limited.

In contrast, the perception is that installation of a conventional RTU is relatively straightforward. "You're just putting in a piece of equipment and walking away. You may have to come back if there are comfort issues but you're never going to really identify if the units are running efficiently all the time." This quote reflects a pervasive attitude in the industry. However, it is not actually true that installing an RTU is necessarily simpler than a retrofit. Contractors still have to be prepared to adapt to many challenges that could arise as well. The difference is that they have dealt with them before. Furthermore, although contractors have managed to do installations with little or no follow-up, this does not represent a best practice. These realities aside, the perception that RTU installation is easier can make retrofits seem complicated by comparison.

Thus, the complexity of installing and ensuring the proper operation of a retrofit and the existing equipment on which the retrofit depends (e.g., RTU, duct work, thermostat) has significant implications on stakeholders' ability to adopt and promote climate-appropriate retrofit technology. It requires well-trained, highly skilled, and diligent contractors who are willing to troubleshoot whatever issues arise with any of the equipment, from the point of installation onward, and customers who are willing and able to pay for their services.

COST

Several factors related to retrofit technology costs affect stakeholders' ability to adopt and promote climate-appropriate HVAC retrofit technologies. Each is discussed below.

FINANCIAL COST

Many proven energy efficiency retrofit technologies can save customers money under the right circumstances. This is certainly true of both Technology A and Technology B. Furthermore, retrofits can be less expensive than equipment replacement. Even so, their financial cost can hinder stakeholders' ability to promote and adopt them.

Near the top of the supply chain, the relatively high cost and low volume of retrofits can make carrying them unfeasible for some distributors whose profit model is built around high volume of a relatively limited inventory. The work required to sell the units simply may not be justified by the profit margin they can earn. In the words of one distributor who does not carry either Technology A or B, "[the] price point must allow the distributor to maintain profit while also satisfying the building owner".

Design engineers and contractors face similar hurdles.

In addition, the financial cost of retrofits may affect potential *customers'* ability to adopt them in many ways. Currently, access to comprehensive (i.e., holistic and long-term) cost analysis is limited. This leaves customers with the first cost as the only data point on which to base a purchasing decision. For many companies, this cost is unfeasible, especially given that ongoing costs can be significant in some cases. Long-term maintenance contracts can mitigate the ongoing cost uncertainty somewhat, but the comprehensive costs of system maintenance (e.g., covering duct work and RTUs) must be fixed and known to provide a better estimate of long-term costs for the retrofit option.

Even when long-term costs are not a barrier, initial costs can be. Some companies are capital constrained, especially recently. Respondents reported that during the past several years, many customers deferred retrofit projects due to the poor economy, even when the projects "penciled out." Thus, customers may have the "motivation or the willingness to try something different, [but] they may not have the financial capability to do it." Frustratingly, "Even if [the technology] is something that people can see is a good idea, [they know] it will save them energy but it will cost them this much, [some] just don't have the flexibility to do it. You have to find a way over that hump for a lot of these technologies." Utility financing is a tool that helps some customers in other territories overcome the hurdle of the initial cost. Rebates also play a role, as described in more detail below.

Typically, customers have very narrow criteria for determining the affordability of a project. "Businesses have planning timeframes they work with. It's industry- and business-specific. A payback period that is longer than the planning horizon won't fly." Thus, even when a retrofit project is net-positive (i.e., the projected savings exceed the projected costs), companies with the motivation to adopt retrofit technologies are still not able to pursue them if the project does not meet their required return on investment or fit within their planning horizon.

UTILITY INCENTIVES

Utility support for climate-appropriate retrofit technologies plays a significant role in determining the ultimate cost (and therefore affordability) of the technologies they incentivize. Respondents reported on many aspects of utility programs that ultimately affect customers' ability to purchase retrofit technologies.

First, respondents clarified that rebates often cover specific functions of a technology, not a technology itself. Not surprisingly, utilities typically give a greater incentive for the greater number of functions that they recognize. Both Technology A and Technology B compete with products that have fewer functions, and thus are subject to lower rebates when classified as comparable to the simpler technologies. As one respondent described, "a lot of the incentives were only incentivizing [evaporative pre-cooling, but not ventilation] because that's what all the other providers are doing." Technology B faces a similar scenario in some utility territories. Essentially, the technology provides energy savings through three mechanisms (i.e., an advanced digital economizer controller with fault detection, a variable speed drive, and demand control ventilation). Some utility programs offer rebates for only a single function, whereas others offer a rebate for all three.

Additionally, respondents talked about how the value of a rebate is determined. In some cases, the rebate is a flat rate per ton. In others it is based on projected energy savings that can be validated through a measurement and verification process. Both methods have advantages and disadvantages that can affect stakeholders' ability to adopt selected retrofit technologies. Again, despite any confusion about how actual rebates are calculated, the stakeholders' perspective, however misguided, is informative.

Many respondents noted that flat-rate incentives (i.e., dollars per ton) have the advantage of being simple to calculate and known in advance. This makes decision-making easier for many stakeholders involved. On the other hand, such incentives create an inherent unfairness in the market because they do not account for differences in energy savings generated across different climate or operating conditions. "You are going to get the same value on [a] building [even] if it's in a hotter climate" and thus saves more energy. This may work out on average for the utility, but may not offer sufficient incentive to customers for whom the measure will be most effective or for customers with multiple sites that would generate differing levels of savings.

By comparison, incentives based on energy savings for a particular application and climate are fairer, as they reward each unit of energy saved. However, they have the distinct disadvantage of taking a substantial amount of time and effort to determine. One respondent explained the situation this way:

> *"We've really been fighting hard for Technology B to get the rebate to be prescriptive, where it's based off per ton or per horse power unit. In the past, it's been measurement and verification, which takes a lot of time. Some of these companies, they can't do big projects where you have hundreds of thousands of dollars in rebate money that you're not going to get payback on for six months after the project has been implemented. So that rules out doing more projects."*

The employer of this respondent addresses this barrier by having the customer sign the rebate over to them, and reducing the initial cost of the project by the rebate amount, less 10% for absorbing the risk. This seems to help some customers afford a large project and eliminate some uncertainty, but it requires significant capital reserves (and confidence in the utility rebate) on the part of the implementing firm. This certainly is not a feasible route for all companies that install retrofit technologies.

Ultimately, someone has to take on that risk. When utilities assign a rebate to customers up front according to the projected savings, the utility assumes this risk. The recent ruling on HVAC quality maintenance programs is a case in point. Utility projections were deemed wrong, and CPUC overturned their filing, resulting in significant losses by the utilities. Thus, in the future, utilities may have less appetite for providing risk mitigation without additional assurances of the projected energy savings.

In addition to the specific way in which rebates are calculated, respondents also commented on the actual value of rebates. As one stakeholder involved with Technology B said, "We would expect a higher incentive, given the cost of power and the value that the savings represented. We know what energy savings are worth." The respondent was referring to the value of the energy saved relative to avoided generation costs, and suggested there is scope to increase the incentive. Others echoed that sentiment.

Thus, when considering the rebates for retrofit technologies, stakeholders appear to examine many factors, including the method and fairness for calculating rebates, their relative value across utility territories, their value and timing relative to initial costs, and their value relative to generation costs. Some of these factors can have significant impacts on the affordability of retrofit technologies, while others may have more symbolic meaning.

A further complication of the utility incentive scheme that many respondents mentioned is the cost implications of the conditions of certain rebate programs. For some technologies, including Technology B, rebates are only offered in conjunction with participation in a broader "HVAC optimization program." In SCE territory, a customer can become eligible for a rebate on a Technology B unit by enrolling in SCE's quality maintenance, installation, or renovation programs. Although the relatively high incentive (i.e., $310 per ton vs. $150 per ton paid by Pacific Gas and Electric Company) is "very tantalizing," this approach has its drawbacks.

Each of the programs that act as a "gateway" to the Technology B incentive has specific requirements that constitute barriers to adoption. Three-year service contracts are seen by many as too burdensome a condition to access a $310 per ton incentive for Technology B. For some companies, a three-year service contract may be too expensive, conflict with an existing contract, or extend beyond the company's planning horizon.

In other cases, significant preliminary work is required (e.g., taking air flow measurements) to determine if the program will provide benefits, but the utility only pays for the work if it is determined that benefits will result. Other programs require the use of specific software, which adds expense and training time. For many potential customers, these types of requirements are "kind of a deal killer."

One respondent further complained about the inherent unfairness of embedding a rebate for a particular technology within a broader program:

> *"The energy savings from [Technology B] dwarfs the energy savings from any of those other measures. So, to get to the goal, you gotta go through a lot of little incremental benefits. The program folks acknowledge there is no other single part of the program that will produce as much energy savings as the Technology B will with the fan control, but it's the last thing they are promoting, the last thing they're funding, and to get there you have to go through the minefield."*

The respondent further clarified.

> *"It's not that those programs don't have their merits. It's, in fact, part of what we like to see, one way or the other. We want to make sure the quality maintenance representative helps, that both programs require that the refrigerant charge be adjusted, that the economizer actuator and the economizer itself works, etc. So there is absolutely merit in those programs. The devil is always in the details."*

According to some, the "details" of program participation do hinder adoption. By contrast, "no strings attached [rebates] allow [for] broader market uptake of [climate-appropriate] products."

To circumvent some of the barriers identified above, customers can pursue custom rebates instead, "but that is kind of problematic in its own way." There are greater labor costs associated with that route, less information upfront, and more uncertainty.

Finally, although from a given utility's point of view, the differences in rebate value and requirements across utilities may not matter terribly, it does to other stakeholders. This variability adds a layer of complexity for manufacturers, contractors, and design engineers when they work with potential customers who have locations across California or around the country. This complexity, on top of all the others described above, can hinder stakeholders' ability to adopt and promote climate-appropriate retrofit technologies.

COST UNCERTAINTY

Known costs can be one set of hurdles to adoption and promotion, as described above. However, not all aspects of the cost may be certain and known. Operation and maintenance is one source of uncertainty which was discussed above. Rebate uncertainty is another.

As one respondent explained:

> *"There's a little add-on that says 'rebate may vary based on blah, blah, blah.' There is always that condition that basically puts the risk on [the customer's] end. The customers are thinking, 'Well, you say I may get this rebate, but what if I never get it?"*

These types of cost uncertainty can represent additional hurdles to adoption and promotion, even for stakeholders who would have been able to afford the estimated costs associated with retrofit technologies.

In fact, some signs indicate that the incentive levels, for example, may in fact be adequate, but that the uncertainty around them is the principal problem. As one respondent put it, "I don't think a four-year payback is objectionable as much as a *possibly* four-year payback is objectionable." Thus, even if a rebate can bring the payback period down to within the required ROI and planning window, "if the rebate is uncertain, a project may not go forward." In fact, the relatively high value of rebates, up to 50% of project costs according to one example given, makes the uncertainty of incentives more detrimental, even if that uncertainty is perceived and not real.

Uncertainties around installation and maintenance requirements can have hidden costs implications, too. Several respondents mentioned that the uncertainty of costs associated with unfamiliar technologies leads some contractors to inflate their bids to mitigate against cost overruns. Although a reasonable way to deal with cost uncertainty, this strategy further hinders customers' *ability* to afford climate-appropriate retrofit technologies with initial costs many already consider high, as well as limits the *motivation* to adopt retrofits, as mentioned earlier.

Many studies have demonstrated savings for climate-appropriate technologies in the field (e.g., those by WCEC, PNNL), but uncertainty lingers because the long-term persistence of savings has yet to be demonstrated by third-party observation. This means that the long-term cost effectiveness of the technologies is uncertain.

From a behavioral perspective, the costs of climate-appropriate retrofit technologies, as they are currently imposed, are very problematic. This is easily illustrated through a simple characterization of the cost-benefit proposition. That is, while the initial cost is certain, known, and immediate upon purchase, the savings (i.e., the benefits) intended to offset such costs are uncertain, delayed, and difficult to verify. The field of behavioral economics contains ample literature to explain why, given those facts, it is very difficult to convince stakeholders to adopt and promote climate-appropriate retrofit technologies on the grounds of cost savings.

EFFORT

Selling, installing, operating and maintaining climate-appropriate HVAC retrofits can involve substantial effort on the part of the various stakeholders who adopt and promote them, representing yet another barrier to widespread diffusion of the technologies.

SALES

The sales process can involve a significant amount of effort, as it requires conveying information about an unfamiliar technology. As one distributor put it: "If it is an emerging technology, it can be a very lengthy process" compared to a "proven, established" product.

The manufacturer of Technology B tries to address this by teaching its affiliate partners how to do a lot of preliminary work on a customized proposal based on an audit performed largely through Google Earth and other internet research. The manufacturer of Technology B also provides partners with access to a proposal-building tool:

> *"We created a web pricing tool. It's a webpage that our partners go to and can easily calculate the energy savings using local weather data and local utility and rebate structures that are in our database. This tool will calculate the energy saving and then it also will price the project using cost tips from us. [For example] how much margin they want to put on it; what they want to sell their labor for, and the additional travel cost. [The tool will] produce a full [proposal, which our affiliates can take to their customers and say] 'Here's the economics, it's going to cost you [this much], rebates are expected to be X, estimated energy savings are here, customer price is this, simple payback is 2.1 years.' This tool does a lot."*

Through this approach, the manufacturer has reduced the effort required of its sales force to create the proposal and pitch a project, as the proposal does much of that work for them through careful vetting and compilation of valuable information.

REBATES

An integral part of the sales pitch (and process) is gathering and conveying information on utility rebates, and subsequently securing them. Stakeholders from the top to bottom of the supply chain cited the effort required to navigate the rebate landscape as a hindrance for them. The process is complex.

> *"Our experience is you need a secret decoder ring to decode all the nuances because there are third-party implementers involved, there are the utilities themselves, there is the training organization involved, there is old information floating around, programs are changing, and nobody knows exactly sometimes."*

Furthermore, there is "contradictory information out there in the marketplace. People are involved in running the program, people who work for the same company on the same program are telling us and our partners and our affiliate's different things, and sending documents that are contradicted by other information that we have." The process was described by respondents as "sloppy" and "clunky."

One specific source of the complexity is the eligibility criteria regarding the equipment that retrofits may be integrated with in order to qualify for a rebate. One respondent said, "It can't be older than certain age. It can't have a factory controller on it. The dampers have to have nylon gears instead of metal for leakage." With non-uniform equipment across a particular rooftop, let alone across multiple customer locations, determining eligibility on the basis of equipment alone can be onerous.

Furthermore, rebate programs differ across utility areas, which increases the effort required for stakeholders working with customers with geographically diverse locations. Not only that, respondents have the sense that it makes the technology itself appear questionable somehow. One respondent explained:

> *"I can't go to [a fast food chain] and say to them, 'Hey, this is the way the program works, and we can do all your stores.' I say, 'No, we can't do all your stores. We can't even do every unit on the stores' because the small print has too many restrictions associated with it."*

Stakeholders maintained a sense that if rebates could be made more consistent across utilities, "it would make it a lot easier to sell the projects."

The customers who engage with the rebate process directly also expend a lot of effort. A significant amount of information needs to be collected and provided on the SCE forms to determine if a customer (and equipment) is eligible for a rebate or program. As one informant said: "It seems like you would have to hire your HVAC technician to come out and answer the questions for you just to see if you're qualified to participate. Unless you have an on-staff building maintenance person that can do that, it seems like kind of a hurdle to pay someone just to inspect it for you."

Of course, when eligibility for a rebate on a particular technology is embedded within a quality maintenance program, as is the case for Technology B, many of the details that determine eligibility would already be known. This makes it easier to earn that particular rebate, but does not address the initial hurdle of qualifying for the program in the first place. In addition, "It makes it very difficult when [utilities] are constantly changing the requirements of the programs."

Respondents noted that challenges with the rebate process have killed retrofit projects they've been involved with because customers had trouble along the way. It is "overly complex" in the view of some. As one respondent said, "Don't think that if you follow [SCE's] method [to] qualify for the rebate [that] you won't get tripped up halfway through the process." Numerous respondents stated that the process needs to be simplified, accelerated, and made easier and more transparent, the end result being that "if you buy this, you get this rebate."

INSTALLATION & OPERATION

Retrofits also involve a significant amount of effort for the installing and service contractors involved. Typically, contractors (and sometimes their customers) prefer to work with standard, widely available, and homogenous equipment, as it makes their job easier. But an inherent feature of working with retrofits is that they must be integrated with equipment that varies in model, age, and condition.

The effort required to install a retrofit can vary depending on the technology and the site. For example, installation of Technology A will be easier at sites that already have water access on the roof. Technology B is relatively simple to install, but the manufacturer has further reduced the effort required by providing the following:

> *"A kind of turnkey solution where they have everything [in] the package. It's all pre-setup. All [the] wiring [is] pre labeled. They even give [you] the zip ties needed to install the product. Some other technologies may require a lot more investment on our end to make sure we have the procedures and get everything down. Or we have to secure parts from a third party, but maybe they are not readily available."*

Furthermore, energy efficient equipment "involves a higher level of commissioning. In order to get that high efficiency, you gotta make sure that you have everything dialed in. You can't just slap a piece of equipment in and walk away." The installing contractor may have to deal with ongoing issues, as mentioned above. Even maintaining the RTU can require more effort after a retrofit is installed. For example, contractors may have to "remove Technology A to replace a condenser coil. It makes their job harder, by complicating access to the RTU." For this reason, facilities managers sometimes object to installing Technology A.

Finally, some emerging technologies require additional effort to operate and maintain, such as attention to the mechanical needs discussed above. In addition, some retrofit technologies require the use of proprietary software that is "not as well understood as the others." The learning needed to effectively utilize a new software adds to the level of effort associated with adopting climate-appropriate technologies. Although, to be fair, this problem is not unique to climate-appropriate technologies, but perhaps applies to new technologies in general.

Addressing the barriers associated with high levels of effort required of stakeholders during the sales, rebate, and installation processes and beyond could help to encourage the adoption and promotion of climate-appropriate HVAC retrofits.

Awareness, Knowledge, and Communication

Awareness is a necessary pre-condition for adopting and promoting climate-appropriate retrofit technologies. People and organizations cannot adopt or promote what they do not know about. Furthermore, given the complex nature of the technologies and decisions related to them, *awareness* is not enough. Stakeholders also need *knowledge* about them, and that knowledge must be *communicated* to the necessary parties. This section discusses each of these three factors.

Awareness

The level of stakeholder awareness of retrofit technologies and their applications affects each stakeholder's ability to adopt and promote them. Various stakeholders try to raise awareness about retrofit technologies in numerous ways. Manufacturers provide training on their products; utility programs provide incentives for specific technologies; distributors offer information sessions to their customers; and contractors present technology options to their customers. The extent to which each of these groups pursues such activities varies. One distributor described the very active role his firm takes:

> *"Our main goal is to educate the engineering community and get the word out. A typical process would be, after we take on a line and we get very heavily trained in it, to the point where we feel like we are experts enough to talk intelligently about the*

> *product, then we go out and aggressively promote that with our consulting engineers and owners and contractors. We do a lot of presentations, called lunch and learns, where you go there and you provide food and then you do an hour presentation on it. But we also have been [providing] training sessions, newsletters. We have a product demonstration where we go through interactive training demos. Basically, we try to educate the HVAC community on [a] particular product or even just generic technologies."*

Despite the activities of some, general awareness of climate-appropriate retrofit technologies appears to be rather low across all stakeholder groups at present. First, a lack of awareness of, and consensus around, the term "climate-appropriate" appears common. Respondents noted that most customers have not heard the term. Contractors and others have a similar limitation. To illustrate, one-third of the contractors and two-thirds of the distributors that took our survey were not familiar with the term "climate-appropriate" as used to describe HVAC technologies. Instead, they use terms such as "regional systems" or technologies "for our market". While more-informed stakeholders appear to be more familiar with the term, many do not have a clear sense of what it means or share a common definition.

Also lacking is awareness about specific climate-appropriate technologies. For example, some respondents reported that utility account representatives are not aware of all the technologies their own utility programs support. In addition, only 2 out of 12 and 1 out of 3 installing contractors who completed the surveys had heard of Technology A or Technology B, respectively. There is a general consensus that customers' awareness of retrofit technologies is relatively low, too, especially among "high up decision-makers". The latter do not seem to have much awareness of available rebates or utility incentives, either.

Part of the problem appears to be a failure to fully leverage all the opportunities for raising awareness. At the most basic level, utility programs do not necessarily utilize the term "climate-appropriate" or apply that label to specific technologies. In addition, promotion of climate-appropriate technologies has been lackluster, according to some. For example, although Technology A "has been recommended by the utilities," design engineers typically learn about it through "word of mouth, internet searches, or a combination of both". The manufacturer of Technology A's outreach efforts to design engineers and manufacturers' representatives has been happening "organically". But such a process is slow in the absence of a critical mass of adopters.

Similarly, some respondents believe that the utilities' efforts to raise awareness about retrofit technologies, and the rebates that support them, are inadequate. In particularly, although there are "many rebates and ads to promote them targeting residential customers, [there is] not so much [outreach] for commercial [customers]."

Another part of the problem may be a lack of coordination about which stakeholder group should lead efforts to raise awareness. Because of their direct relationship with customers, many believe that contractors should play this role. However, as one contractor explained, "Contractors are not well positioned to raise awareness because people think we're just there for the sale". Manufacturers have a similar limitation. Thus, it is important to consider the impact of the messenger type on how the message will be received.

In summary, given the complexity of retrofit technologies, and the decision-making process stakeholders would use to choose to adopt and promote them, awareness is insufficient.

KNOWLEDGE

Stakeholders need adequate knowledge of the technologies, and any other information they require, in order to be able to make informed decisions. Not surprisingly, knowledge varies widely across stakeholders and opportunities to increase it are complicated.

Manufacturers require knowledge of the regulatory system to know how to position their products and make them compliant with codes and standards. Several respondents commented that the system is especially complex in California. "The CEC is like a nation unto itself. It takes significant leadership to navigate what they are doing. The regulatory side can be filled with so many potholes. It's very difficult to know everything you have to comply with." As one suggested, utilities can be valuable partners in navigating the regulatory landscape, "but the question is how versed are they with all the regulatory [issues]."

The rebate process is another aspect of retrofit adoption that requires significant knowledge. Larger companies may have direct relationships with account representatives from the utility, or be able to afford a consulting or contracting firm to guide them through the process. However, even these measures may not be a panacea. Several respondents claimed that some account representatives lack knowledge about the incentives for which their customers qualify, leaving the customers uninformed despite having access to a "knowledgeable" party. Smaller companies without such access must navigate the system on their own. Some may not have adequate knowledge or resources in order to do that effectively.

In addition, companies may need significant knowledge about the technologies themselves to adopt or promote them. More sophisticated or unfamiliar technologies like Technology A and Technology B require a more knowledgeable sales team to promote them. They must be relatively highly skilled and technologically advanced enough to "accelerate the learning curve for customers by fully explaining the technology, heading off critiques, understanding and recommending appropriate application, knowing how a building works and how a business works." As one distributor explained:

> *"You learn the technical details of [a] product but you are always going to go beyond that. If you are presenting a black box and say 'Just trust me, it's going to work', [the customers] are not usually going to go for that. You have to explain every step, especially in an emerging technology, and exactly how it works because there [are] a lot products that have a sort of negative perception as an emerging technology product. [If you don't explain it thoroughly,] it becomes a sort of black box voodoo magic. You shake your magic wand and it works somehow. That's a very negative perception that some products have out there."*

To address the heightened stakeholder needs for knowledge of retrofit technologies, some manufacturers provide extensive training covering technical issues and more. For example, the manufacturer of Technology B provides sales and estimate training. A representative from the company flies out to a location where a representative from each of the affiliates in the region have convened and instructs them on how to gather information on potential customers' equipment, use the online tools to develop a proposal, and communicate with potential customers about Technology B and what it can do for their business. The attendees then lead internal training back at their offices.

Contractors who work with retrofits need to have sufficient knowledge of the technologies, too. Respondents described it this way: "Familiarity with a product matters"; and "[if the contractor] knows your product, and he knows how it is to put it in, there [are] not call-backs." As another put it: "Onsite maintenance guys can [maintain a retrofit] (and do, after the service contract expires), but they need further training".

The manufacturers of Technology A and Technology B both provide training to their approved installers or affiliate partners on their equipment, installation, application, and maintenance. The manufacturer of Technology A delivers its initial training through a webinar, while the manufacturer of Technology B does so largely in person and through video courses.

Many respondents commented that hands-on training is required for contractors to acquire adequate knowledge of a technology before being charged with installing or maintaining it on their own. As one said: "You need to understand the engineering, but engineering data alone is no substitute for seeing and touching the technology in person. They need to have that 'aha' moment".

Distributors also prefer to have a tangible aspect to their training on a technology. One said: "We need to see examples. We need to kick the tires, so to speak, before we will even try to push new technology".

The manufacturers of Technology A and Technology B both provide the opportunity for that through hands-on, field training. Technology B in particular seems to provide very comprehensive field training, down to the smallest detail, as described by one company representative:

> *"We usually have two-man teams, and we're teaching them like an instructor would in a classroom but we're doing it out in the field. So we're showing them how to apply the product, make good decisions about location for the enclosure, where to mount the drive, certain nuances about how the sensors have to be mounted, the dos and don'ts.*
>
> *We also have a master installation manual and then in the appendix there are photo-based illustrations showing how you do a Lennox unit under seven and a half tons in this model, how you do a Carrier unit of this class. The most common systems that you tend to find out there, they're the ones that we are working through. We just keep building it out, making this supplement so they have a good reference. There is a wiring diagram. We want them to understand that there are commissioning aspects to the product where we want to make sure the startup is done, so there is a startup sheet. How you collect all the information needs to go in there. It's an extremely thorough process and then we decide the safety aspects of making sure that the unit is powered down.*
>
> *[We try to] minimize the discomfort that the customer [experiences by doing] several things like: don't go around and open the panel on every unit up here. Work one at a time from beginning to end and get it done, then move to the next one.*

They get them up on the internet, we can see them, fully commission them, close that unit up and move on. You don't need to go back to that unit now.

So there are things about the way [to install the units that] we learn after doing thousands of these that are the best practice. [For instance], it's real [important not to approach] from this side because you are going to risk drilling into the condenser coil. Somebody did that once. We don't want anyone doing it again. So they may think they got it figured out but they don't always have it figured out. So it's not just instructional in that way. It's also about them becoming beneficiaries of our collective experience."

The installers confirmed the value that such detailed training provides. It gives the technicians the chance to ask questions, learn how to make modifications to accommodate different RTUs, learn by doing, and gain confidence in their ability to eventually do it alone. One side benefit an installer mentioned was that the hands-on training allowed him and his technicians to verify the manufacturer's claims about ease of installation.

"We learned that [Technology B] was in fact as easy to install as they had said. We were actually able to install the product a lot faster than they said it would take. Most companies kind of oversell how easy it is and then you get up there and you find problems with the install[ation] of it. It was kind of a nice to actually get to do an installation and come back and get the feedback from my technicians that it was really easy."

However, field training is not always so thorough. One Technology A installer reported that the training provided by the manufacturer of Technology A covers equipment, installation, application, and maintenance, but not economics or data on energy savings. This is due to the fact that contractors do not play a role in selling Technology A. However, installers still felt they could benefit from that information. Furthermore, the training is not thorough enough to gain a broader awareness of the principles behind the technology to understand, for example, why one would choose one setting in Southern California and another in Fresno. "We need to understand why we are doing what we're doing more, not just how to do it."

Other critical details that hands-on training can provide include a realistic sense of implementation time and cost. As mentioned earlier, uncertainty about these details can lead some contractors to inflate their bids, hindering customer adoption. In the absence of such information provided through training, one installer reported consulting colleagues outside his firm to gather information in order to be prepared for his first few jobs.

Even when routine maintenance is provided by a service contractor, facilities managers often retain some responsibility for overseeing HVAC equipment. The problem, as several respondents noted, is that because many facilities managers have little knowledge of the equipment on the roof, technical problems may go undetected between service calls. Furthermore, they are often excluded from trainings provided on retrofits. At times, facilities managers are not present when a retrofit is installed, denying them the opportunity to learn about the technology from the manufacturer. Respondents stated that a small number of facility managers will take the time to ask a contractor or installer to demonstrate and explain the retrofit to them, but that is only possible if they are included in the process in some way. As the person in charge of day-to-day operations, facilities managers need knowledge of the technology, too, even if they are not ultimately responsible for maintaining it, if only to be able to alert the service contractor of a problem. Furthermore, when maintenance contracts expire, responsibility typically reverts to the onsite maintenance team.

Customer knowledge needs to include adequate understanding of the costs and benefits associated with a retrofit project. These needs were described in detail as they relate to customers' *motivation* to adopt retrofits, but they also affect their *ability* to do so. Many firms simply cannot (or cannot afford to) make decisions based on partial information. Filling this knowledge gap requires providing relevant and timely information to the appropriate party, in a form they can understand, and from a source they trust. Many of the challenges associated with providing such information have already been discussed in other sections, but is reiterated here briefly, given the important role customers' knowledge plays in their ability to adopt retrofit technologies.

COMMUNICATION

Transmission of awareness and knowledge often requires communication between stakeholders. As one contractor put it, "A lot of times it's about asking the right question to your customer." The extent to which all relevant stakeholders are involved in the information-gathering, consensus building, and decision-making processes affects the ability of each to acquire the knowledge they need to be able to adopt and promote climate-appropriate retrofits.

Some respondents noted that a breakdown in communication often occurs between high level decision-makers in a company and those responsible for day-to-day operations of the facilities. For example, several times respondents noted instances when local staff were "left in the dark" about the decision to install retrofits. This prevents facilities managers from acquiring the knowledge they need, as described earlier, making their job more difficult. It also leaves contractors, who may lack the skills and mandate to bridge that communication gap, caught in the middle.

Acknowledging the importance of communication, training on Technology B includes information on how to communicate with customers. They provide a "little cheat sheet that has the main talking points for customers, what they typically are going to ask, and answers to those questions."

ACCESS

Individuals can only select from among the options they can access. Thus, stakeholders' ability to adopt and promote climate-appropriate retrofits rests in part on their access to the technologies.

A major component of accessibility in any given market is the supply chain. In an industry with so many gatekeepers—distributors who select technology from manufacturers, distributors who make their choices available to contractors and design engineers, who in turn pass those choices (or not) on to customers—the access of one stakeholder group depends in large part on the access of another one higher up the chain. Many respondents noted that distribution of energy efficient HVAC equipment in general is rather limited. Only certain channels provide access, and one has to know which they are.

This holds true for Technology A and Technology B. The specific distribution strategies employed by the manufacturers of the two technologies were described in a previous section. Here the aim is simply to highlight how access to various points on the distribution chain can affect stakeholders' ability to adopt and promote retrofit technologies like Technology A and Technology B.

At the top of the chain, distributors play a key role in determining the access others further down the chain have to a given good. The manufacturers of Technology A and Technology B both serve as their own distributors (as one of two distribution methods), to some extent constituting a bottleneck to the adoption of their own products. This is certainly true of Technology A, with its (self-proclaimed) virtually singular focus on courting a particular big box store, to the exclusion of other sales activities.

Contractors play various roles in the sales process, depending on the manufacturer. In the case of Technology A, contractors are not involved in sales. However, since the latter have the customer relationships, they appear to be an important resource that is not currently being exploited. As one installer put it, "We have the rapport, trust, of our customer base. We could be selling it, too, with more information."

That is exactly the model the manufacturer of Technology B employs for its primary distribution channel (in addition to direct sales). Their network of 65 affiliate partners (who are also installers in many cases) sell Technology B on behalf of the manufacturer. This approach broadens the company's geographic reach, providing access to more customers than if efforts were limited to direct sales. The drawback to this approach, however, is that it requires installers to expand their core competency. The manufacturer provides sales training, but even trained installers are not equivalent to an experienced sales and marketing team promoting the product.

Technology A is also distributed through third-party resale by a major RTU manufacturer. While this arrangement gets Technology A to market much faster and across a broader geographic area than the manufacturer alone could manage, it presents some drawbacks. Some stakeholders expressed a sense that third-party products are not promoted by the reseller's sales staff as vigorously as their own products. Promotion of Technology A by the reseller's sales representatives appears to be inconsistent both across geographic regions and individuals within particular locations. Adoption among the sales force is happening "organically, not happening institutionally." Another respondent confirmed that although the reseller "won't rep[resent] a product that [it doesn't] stand behind, individual representatives have their own opinions".

Part of this misalignment may stem from an actual conflict of interests between the RTU's units and Technology A. A customer installing a Technology A unit along with a new RTU will require a smaller RTU than they would without Technology A. To the extent that the RTU's sales representatives are more heavily incentivized to sell their own products than third-party products, this can create a conflict of interests at the individual level, too.

Another level down the distribution chain, design engineering firms influence the customer access to retrofits. Furthermore, there is a gatekeeper within the gatekeeper, as the Principal Engineer at a design firm will often determine the "approved" technologies from which project engineers on staff must choose.

Similarly, contractors' access, which determines customers' access to technologies, depends on the distributors with which they have a relationship. According to one respondent, contractors typically work exclusively with 2–3 distributors. If those distributors carry climate-appropriate retrofits, then the contractors they serve, and the contractors' customers, have access to the retrofits. But again, this model assumes that the manufacturer and distributor have formed such a relationship, which, to date, is the case to a degree for Technology A, but not for Technology B.

Finally, respondents conveyed a sense that a technology's commercial presence affects stakeholder access on a practical level. The concept of presence includes whether a manufacturer has the ability to support a deployed product and maintains a local sales and support team, as well as the ability of local contractors to install, maintain, and fix the technology. In essence, should a given technology lack a critical mass of adopters, other stakeholders lack access to adequate resources that might be needed. This situation appears to influence stakeholders' ability to adopt and promote climate-appropriate retrofits, even if only in an abstract manner.

Numerous respondents conveyed the message that access to Technology A, and other evaporative technologies in general, was rather limited in Southern California. The "distribution chain here is very sparse", said one Los Angeles-based respondent. This observation holds true for stakeholders at each level of the distribution chain described above (e.g., sales representatives, design engineers, and contractors).

One method of increasing access is to make products and parts available on the internet, a strategy used by other climate-appropriate HVAC technologies, according to several respondents. While an internet presence increases accessibility, goods thus offered lack the support provided by stakeholders in the traditional distribution chain. This can introduce another set of challenges, such as increased likelihood of improper installation. Thus, the issue of access is more nuanced than it may appear. For accessibility not to be a market barrier, stakeholders need to have the ability to obtain climate-appropriate technologies when, where, how, and from whom is convenient for them, on par with conventional technologies.

EMPOWERMENT

A final and critical element of the ability to adopt and promote retrofits is empowerment. The preceding five factors related to the ability to adopt are necessary but not sufficient conditions. The "right" stakeholder must also be endowed with the power to do so. One respondent described the challenge this way, some stakeholders "may have the interest or the motivation or the willingness to try something different and not have the responsibility or flexibility to do it". This can occur in a variety of ways, but the two most commonly mentioned themes were diffused decision-making and constraints on technology choice.

DIFFUSED DECISION-MAKING

Essentially, this issue centers on whether the potential barriers of technical feasibility, cost, effort, awareness and knowledge, and access are adequately addressed for each of the stakeholders in a given organization whose buy-in is required to make decisions about adoption and promotion. That is, are those empowered to make an adoption decision convinced that the necessary conditions have been met? The complex nature of organizations and diffused responsibilities for HVAC-related issues often makes this difficult to achieve.

Typically, several individuals within a given organization must support adopting or promoting retrofits to drive adoption. Coordination of those key stakeholders can be difficult. For example, manufacturers often reach out to the executive team of distribution companies at national conferences. However, the actual decision to distribute a particular technology is sometimes localized within each office or region, and buy-in by the executive team is not sufficient to ensure it will carry over to local offices.

On the customer side, a common barrier that was reported is that often the person charged with approaching a potential customer, does not have access to the "right" person, i.e., someone high enough within an organization to have the power to agree to a retrofit project, particularly at large companies. For example, "the Affiliate Partners are not going to reach the guy that [makes purchasing decisions for] let's just say [a major movie theater chain]. They may do some maintenance there, but those decisions are made in San Antonio or Boston or somewhere".

Often, larger customers have a utility account representative with access to relatively high level decision-makers, at least at the local level. But many times even their contacts are not high enough in the organization. Many large companies have centralized decision-making processes that supersede local authority. For example, some large organizations have sustainability officers who make company-wide decisions about energy efficiency projects. They typically work out of the office headquarters, out of reach of most utility account managers. As one respondent described it, "the store manager with the account [representative] is lower down the chain than the national sustainability manager." If decisions on energy efficiency projects are centralized, the relationship between the store manager and account representative is almost moot, since the former is not empowered to decide to pursue a retrofit project. Of course, this is not universally true. In many cases, utility account representatives do work closely with national energy managers or sustainability managers. In those cases, the problem described above is avoided. But there can be other challenges to coordinating a decision under those circumstances.

Rarely is there a single decision-maker whose buy-in is necessary. There are often several critical decision-makers at a given organization, and they may span multiple areas and levels of an organization. One respondent described his firm's strategy this way:

> *"[We start with the] facility manager [because] energy savings affect him, but he doesn't have the capital to pay for [a retrofit project].You [also] have to talk to the finance manager that handles the capital money. You've got to do your soft circles to get your approval from each level."*

This challenge is mirrored on the "promoter" side, too. Rarely does a single person trying to promote retrofits among an organization (e.g., manufacturer's representative, distributor, utility account manager) have access to all of the key decision-makers on the "adopters'" side. The challenge is to coordinate outreach efforts and elicit coordination among the various decision-makers within potential customer organizations, so that all empowered parties can sit down together and make a coordinated decision. Some deployment models are better positioned to utilize such an approach than are others.

Constraints on Technology Choice

Finally, other factors may constrain technology choice. For example, customers may have specific objectives for an energy efficiency project that they communicate to the mechanical engineer or contractor up front. These may stem from the customers' budget, preferences, or policies (e.g., U.S. manufacturer, highest efficiency, lowest cost, preferred or previous manufacturer, LEED rating, desire for a homogenous technology selection, desired features such as multi-speed, demand control ventilation). Such criteria limit technology options, and ultimately choices, as typically, the engineer or contractor would present a list of technical options that meet the client's objectives, and exclude those that do not. The technology choice is further constrained by the engineer's own knowledge, experience, and expertise.

Thus, even when design engineers and contractors are empowered to promote retrofits, their ability to do so may be limited by their clients' restrictions or their own lack of ability to promote them due to insufficient knowledge.

TRIGGERS

As described above, a trigger is a mechanism that serves to significantly raise an individual's motivation or ability (or both) to take a certain action. Although they are typically only considered triggers if a given action is taken, in this context, triggers will be discussed even if they are not always effective in that narrow sense. For example, triggers may come before or after other factors related to motivations and abilities are addressed. That is, triggers may push stakeholders over the final hurdle blocking adoption or promotion, or they may be the mechanism that initiates the process by which stakeholders begin to develop the motivation and ability to adopt or promote retrofit technologies. Examples of triggers working in both ways are provided.

A typical trigger in the HVAC industry is equipment failure or performance degradation. The latter may be observed through loss of efficiency (as reflected in higher electricity bills) or decreased occupant comfort. Triggers such as these are very effective behavioral drivers because individuals are loss averse, meaning they are willing to pay a relatively high price to avoid the loss of things they currently possess which they perceive to have positive value (e.g., money, time, comfort, efficiency).[13] Furthermore, the scope for procrastinating, a common problem even when the motivation and ability to take a particular action exist, is limited because space conditioning is typically considered an essential service in a commercial space. By contrast, retrofit technologies do not have a hard deadline like replacements do. Building owners can procrastinate indefinitely, without concretely experiencing their foregone energy savings. Retrofit technologies face this significant behavioral challenge in most circumstances.

Offering retrofits with new RTUs can help to leverage the purchase of new equipment as an opportunity to promote retrofits. However, this approach is not without limitations. Many times, when equipment is purchased due to equipment failure, the replacement is chosen quickly. Some businesses that have high cooling loads or view occupant comfort as critically important (e.g., restaurants, hospitals, server rooms) may not feel they have the luxury of time to consider options beyond a simple replacement.

Another barrier is the fact that many new RTU models have advanced technical capabilities, including those provided by Technology B. Although Technology B arguably performs some functions better than an advanced RTU, while providing the assurance of persistent performance, customers are unlikely to perceive the need for a separate (retrofit) product when an all-in-one alternative exists.

Other mechanisms can serve as triggers for stakeholders to adopt and promote retrofit technologies. Training and outreach, provided by and aimed at any of the stakeholder groups (other than manufacturers), can serve to increase both the motivation and the ability to adopt and promote retrofit technologies. At the most basic level, outreach efforts about a technology (or a rebate program that supports it) can raise awareness and knowledge, two necessary conditions for adoption. They can also motivate stakeholders by providing compelling information that generates interest in the technology—information that may also constitute required inputs to

[13] Kahneman, D. and Tversky, A., 1984.

the decision-making process, thereby also boosting the stakeholders' *ability* to adopt it. Outreach efforts may be the spark that gets stakeholders thinking about retrofits for the first time, or the final push they need to adopt or promote a retrofit after already having had the motivation and ability to do so.

Changes in energy costs, or mechanisms that draw attention to the costs associated with conditioning a building, can also serve as triggers for installing retrofits, or at least exploring the opportunities they present. Examples include electricity price increases or change in pricing structure, increases in cooling requirements (e.g., due to increased hours of operation or cooling load), or an energy audit. Each of these events calls attention to energy costs, and may trigger stakeholders to consider ways to lower them by reducing energy consumption. Again, such triggers could lead one stakeholder who already has the motivation and ability to install a retrofit to stop procrastinating and finally do it, and another to begin to consider a retrofit, in which case the action triggered might be gathering more information.

Changes in codes, standards, and regulations can trigger adoption and promotion of retrofit technologies, particular among utilities first. Each time a technology is deemed to meet the codes and standards, it boosts utilities' motivation and ability to support it through a rebate program. That trickles down to the other stakeholders.

In a related point, it must be noted that given the structure of the market, technology adoption by one stakeholder group often serves as a trigger for adoption by another stakeholder group further down the supply chain. For example, when distributors begin carrying a retrofit technology, contractors suddenly have the potential to gain awareness of and access to it. The same is true of design principals and their engineering staff, and contractors and their customers. This reflects the integrated nature of the industry, and how many pieces and players must move together to effect change.

Finally, changes in customer needs can serve as a trigger for the purchase of retrofit technologies. As business needs change or new tenants take over a commercial space, energy use, ventilation needs, and customer priorities may shift. Several respondents noted that retrofits they knew about or were involved in coincided with the repurposing of a building or change in occupancy.

Although retrofits cannot count on some of the fail-safe triggers for purchase that conventional RTUs enjoy, numerous mechanisms can boost stakeholders' motivation and ability to adopt and promote climate-appropriate retrofit technologies. In the later section on recommendations, some suggestions are provided on how to leverage these opportunities more fully.

TOP BARRIERS IDENTIFIED

Many different market barriers to adoption and promotion of climate-appropriate retrofit technologies are described in the Results section of this report. The findings presented are thorough and detailed. However, some market barriers are more significant than others. During the interviews and surveys, respondents were asked to highlight what they thought were the biggest barriers to adoption and promotion. Those findings are summarized here.

The following are the top market barriers reported that apply to all stakeholder groups:

- Risk
- Energy efficiency industry's reputation as "gimmicky"
- Poor access to decision-makers

- Lack of awareness
- Lack of knowledge
- Lack of familiarity and resistance to newness

The following are the top market barriers reported that apply more specifically to contractors:

- Lack of knowledge and understanding of new technology (including misconceptions about how evaporative cooling works)
- Insufficient education to understand new technology
- Concerns about maintenance requirements and potential problems

The following are the top market barriers reported that apply more specifically to customers:

- Return on investment
- Lack of clarity on project costs
- Insufficient promotion of commercial energy efficiency products by utilities
- Concerns about the technology (in part driven by memories of bad previous technologies)
- Push-back by facilities personnel
- Lack of a cohesive team that presents credible, cost effective, and compelling opportunities to building owners

Although the relative significance of these barriers is not measurable in any meaningful way, these lists provide some insight into which barriers the stakeholders interviewed rank at the top. By extension, it can be inferred that these are the areas that stakeholders would prioritize when developing a strategy to address the myriad market barriers.

SYNTHESIS OF KEY FINDINGS

Among the key findings identified in this report, several broad themes emerge: dependency, risk, transparency, accountability, and trust. Together, these themes characterize the nature and inherent challenges of the climate-appropriate retrofit market. As the market barriers to adoption and promotion of climate-appropriate retrofit HVAC technologies are not independent of one another, it is vital to consider how they interact—to complicate or ameliorate–each other. Viewing the market barriers through the lens of these five broad themes, as discussed below, facilitates such considerations.

DEPENDENCY

The nature of HVAC technologies, and retrofits in particular, drives many dependencies in the industry, from dependencies within the technology itself (e.g., controller and economizer, retrofit and RTU), to dependencies among the people and organizations involved. For example, stakeholders can only choose from among the options available to them, which are determined by decisions made by the stakeholder(s) above them in the supply chain (e.g., the contractor and the distributor). These dependencies, or interactions between stakeholders' various motivations and abilities, complicate efforts to encourage adoption and promotion of climate-appropriate retrofit technologies, as no single market barrier is to blame.

These dependencies reflect the integrated nature of the industry, and how many pieces and players must move together to effect change. They also serve as a reminder that the levers described in the recommendations section of this report would be most effective if adopted in sets, rather than piecemeal, to take advantage of synergies and trickle-down effects.

RISK

Stakeholders up and down the supply chain expressed concerns about the risks involved in adopting and/or promoting climate-appropriate retrofit technologies. Risks they cited related to technical issues (e.g., system performance, maintenance requirements), commercial issues (e.g., profitability, ROI), and stakeholder behavior (e.g., contractors' reliability, manufacturer support). Although not explicitly described as risk-mitigation measures, many of the recommendations below are precisely that. This stems from the fact that risk, above all else, is perhaps the most critical factor that needs to be addressed. Ultimately, other vital efforts—for example, to improve affordability, access, and performance—are wasted if retrofits are still viewed as risky. If stakeholders perceive that the technologies are risky in some way, uncertainty will cast doubt on every piece of information they consult.

TRANSPARENCY

Motivation is highest when the results of one's actions are highly visible. Dashboard gas mileage displays and solar generation web apps, to name just two examples, leverage this principle to provide the feedback end users require to adopt a new technology whose benefit would otherwise be difficult to verify.

Currently, customers have no clear mechanism to "see" the energy savings generated by some retrofit technologies. Given that energy savings (or the related cost savings) are typically the primary motivation for adopting retrofits, transparency is vital. Stakeholders desire more credible data on system performance and energy savings *before* adopting retrofits, and the ability to track the energy savings against expectations *after* adopting retrofits.

ACCOUNTABILITY

Transparency must be coupled with accountability, that is, the ability to hold someone responsible if something goes wrong. Stakeholders cited concerns about the lack of accountability for manufacturers and contractors, in particular, under existing deployment models. Given the risks that stakeholders perceive regarding retrofits, stakeholders need an appropriate option for redressing problems, even if the risks are substantially reduced, such as through mechanisms like contracts and warranties. But the key findings also identified several less formal accountability measures that stakeholders value, such as manufacturer or distributor support and responsiveness. Attention to the supporting role such factors can play in addressing stakeholder concerns about accountability is important, as there needs to be an initial method of recourse before resorting to contract or warranty enforcement.

TRUST

Given the relative novelty of climate-appropriate retrofit technologies, the technologies, market actors, performance data, and program support are unfamiliar to many stakeholders across the supply chain. One way to overcome unfamiliarity is to gather information, which stakeholders report doing, formally and informally, from other stakeholders, third parties, peers, and hands-on experience. However, not all sources are considered equal: trust in the information source is essential. For that reason, technology recommendations from the utility, a reputable distributor or contractor, or an eminent third party are cited by many stakeholders as highly influential in motivating adoption and promotion of climate-appropriate retrofits.

By contrast, lack of trust throughout the industry poses a significant market barrier. Stakeholders report mistrusting information on technology performance and energy savings, utility rebates, contractors' skills and reliability in addressing maintenance issues, and manufacturers' provision of on-going product support, to name a few examples. Trust is built over time and through experience. In the short-run, however, the mechanisms recommended to lessen risk and increase accountability would serve as an appropriate alternative while trust develops throughout the market.

CONCLUSIONS

Six key conclusions emerge from this study of the market barriers to adoption and promotion of climate-appropriate retrofit technologies.

First, information plays a vital role in the adoption and promotion of climate-appropriate retrofits. Stakeholders require information about the technologies and associated economics. Stakeholders need or can obtain information from numerous sources, including other stakeholders. General provision of information is often insufficient; it must reach the precise individual or individuals who require the information. The relationship between the information source and the recipient matters, i.e., known, trusted sources are most valuable.

If properly informed about climate-appropriate retrofits, some stakeholders would not view the cost as an impediment but others would. Not surprisingly, the initial cost-related hurdle is obtaining adequate information on first costs, rebates, operating and maintenance costs, projected savings, and ROI. For some stakeholders, addressing those market barriers would be sufficient for adoption. For others, the current costs and/or ROI would remain a barrier.

A prevailing perception that retrofits involve substantial risk is partially supported by the evidence. Few stakeholders have access to resources to develop custom estimates of energy savings, nor the means to verify them after installation. No one is accountable to deliver the anticipated energy savings. Low market penetration and weak commercial presence provide few resources for support. In addition to these factors which pose actual risks, the perceived risks of rebate uncertainty and poor technical design limit adoption and promotion of climate-appropriate retrofits.

From a behavioral standpoint, a simple cost-benefit analysis of retrofits reveals an obvious problem. That is, while the initial cost is certain, known, and immediate upon purchase, the savings (i.e., the benefits) which are intended to offset such costs are uncertain, delayed, and difficult to verify. Under these conditions, it is very difficult to convince stakeholders to adopt and promote climate-appropriate retrofit technologies on the grounds of cost savings.

There are logistical constraints to adoption and promotion. Even in the absence of other market barriers, some stakeholders are prevented from adopting and promoting climate-appropriate retrofit technologies simply due to lack of access. The distribution channels for Technologies A and B are very limited, as is the commercial presence and network of contractors who have experience working with them.

Finally, stakeholders differ in the specific impediments to adoption they face. Some have the motivation but not the ability (for example, because costs are too high). Others have the ability (i.e., they could afford a retrofit), but no motivation because they have no awareness of the opportunity. Still others have both the motivation and ability to adopt a retrofit, but require a trigger to spur action. Thus, broad efforts are required to address the wide variety of stumbling blocks stakeholders face. The recommendations in the next section reflect and address the diversity of needs.

RECOMMENDATIONS

As the discussion of key findings illustrates, numerous market barriers hinder the adoption and promotion of climate-appropriate HVAC retrofit technologies. This chapter presents specific recommendations to address many of the issues identified. The recommendations themselves were developed by the research team, drawing on both analysis of the key issues and evidence of alternative solutions provided by study respondents, as appropriate. Again, the discussion is structured in accordance with the behavioral model outlined above, that is, according to factors affecting stakeholders' motivations, abilities and triggers to adopt and promote climate-appropriate HVAC retrofits.

Given that, recommendations regarding several topics (e.g., utility rebates, cost uncertainty, installation and operation) are addressed in the sections on motivation *and* ability, and sometimes under multiple factors within the same section. For example, utility rebates are discussed in relation to first costs and cost uncertainty, as they relate to *motivation*, and again in relation to cost, effort, and awareness as they relate to stakeholders' *ability* to adopt and promote retrofits. This is not to suggest that efforts to address the multiple factors relating to the same topic should not be coordinated. Indeed, all potential changes to a rebate program, for example, should be considered together. This structure in which the recommendations are presented is intended to emphasize the way in which the specific recommendation would target a certain aspect of the problem (i.e., motivation or ability). Structuring the discussion in this manner also highlights the fact that multiple behavioral factors must be addressed, and that some efforts to mitigate the market barriers would target more than one factor simultaneously.

There is another set of recommendations that, although framed in multiple ways across different recommendations, would be addressed with a single approach. For example, recommendations are provided to increase stakeholder access to information in order to increase the *motivation* to adopt and promote retrofits. Recommendations are also provided on how to increase stakeholder awareness and knowledge in order to improve their *ability* to adopt and promote retrofits. Again, the recommended actions to improve access to information, awareness and knowledge, for example, would address these issues together, but the discussion of them is separated to make clear the distinctions among them from the perspective of behavioral science. Where appropriate, overlaps of this type or the type described in the previous paragraph are noted.

The recommendations are framed according to the behavioral factors outlined to ensure that maximum benefit is generated from each potential change. As discussed in the earlier section on the behavioral model, both motivation and ability are critical, although high levels of one can compensate somewhat for lower levels of the other. By explicitly acknowledging and describing how the recommendations address specific behavioral aspects of the market barriers that exist, the principles of behavioral science can be leveraged to increase the effectiveness of recommended actions to target technical, commercial and logistical barriers.

MOTIVATION

In this section, recommendations are presented for increasing stakeholders' *motivations* to adopt and promote climate-appropriate HVAC retrofit technologies, thereby overcoming some of the market barriers they face.

As before, the recommendations are organized under the following eight themes, which are defined in the Results section:

- Technology requirements and performance
- Technology costs
- Additional benefits
- Access to information
- Endorsements
- Status quo bias
- Stakeholder coordination
- Accountability and support

TECHNOLOGY REQUIREMENTS AND PERFORMANCE

INSTALLATION & COMMISSIONING

- **Require advanced training for contractors to qualify for installation and maintenance**.

  As climate-appropriate retrofit technology advances, so must the skills of the contractors installing, commissioning and maintaining such technologies. Manufacturers, distributors, design engineers and utility programs should determine an appropriate minimum level of training (or experience) required of the contractors with whom they work on projects involving such technologies. Some options include North American Technician Excellence (NATE) or other certification, testing contractors' knowledge and skills through field or case study exams, and manufacturer training.

- **Adjust technology design to limit implementation errors.**

  Technologies vary in the extent to which implementation is flexible. Some allow a degree of contractor discretion; others do not. Flexibility requires high levels of training, communication, and coordination among stakeholders and technologies to enable selection of the appropriate settings. When the aggregate choices made by the entire network of individuals are optimal exactly right, energy performance will benefit. Given the problems observed, it seems evident reducing flexibility would mitigate risks. Technologies should be designed to preclude downstream opportunities to make bad decisions. Thus, it is recommended that technology designs be improved, or installation/commissioning procedures simplified, such that implementation risks are lessened. This could be achieved by providing both a "default setting" that allows few, if any adjustments, and a fully flexible setting, or just the former. It is possible this could also be achieved through automated auditing and diagnostics of system performance after the fact, as is performed by Technology B, provided the structure of responsibility is set up to ensure that mistakes identified are actually addressed.

- **Provide detailed installation protocols.**

  The nature of retrofit installation is that every job is slightly different, given the existing RTU, its condition, and its configuration, among other factors. Even when contractors possess adequate knowledge of a particular retrofit technology, they still have to make adjustments for the specific circumstances of a job. Room for error can be minimized if manufacturers provide very thorough installation instructions. For example, if there are settings on the RTU and retrofit that can or must be adjusted upon installation, the manufacturer should specify those settings precisely to optimize performance. Such specifications should be RTU-specific, when appropriate. Utility programs should require manufacturers of rebate-eligible technologies to provide installation protocols and trainings that adhere to these principles.

OPERATIONS & MAINTENANCE

The following recommendations address some of the market barriers related to operations and maintenance, as they pertain to feasibility, risk, and domain confusion.

- **Require longer maintenance contracts.**

  To mitigate issues of feasibility, risk, and domain confusion, utility programs supporting emerging climate-appropriate technologies should require customers to purchase maintenance contracts (a recommendation reiterated by some distributors who have not yet adopted Technology A or B.). Relatively lengthy contracts (e.g., 5–10 years) would be most effective for ensuring optimal operating conditions, technical performance and energy savings, and recovery of the utility's investment.

- **Hold manufacturers responsible for the performance of their technology.**

  Currently, the proper setup and maintenance of a technology is left to the customer, facility manager, maintenance service provider, or another party, which often results in in-field performance that does not live up to expectations and manufacturer intentions. In the current paradigm, the manufacturer's interests and motivation mainly stop at the sale of the equipment (as discussed earlier, there is limited feedback and accountability). One solution would be to design deployment structures that make manufacturers responsible for persistent performance of a machine. This might require an ongoing funding mechanism. Alternatively, the ongoing effort associated with the assurance of persistent performance could be built into the upfront cost of a technology. Solutions like Technology B provide an automated way to ensure the persistence of performance on an ongoing basis. This provides transparency, but not accountability. However, the information available could be utilized by someone to scrutinize or audit energy performance.

  Several options exist for the levers that could be used to accomplish this recommendation. Stakeholders, especially utility programs, could utilize a specification for equipment that requires a warranty of performance. There could also be some sort of ongoing financial incentive associated with the persistence of performance. The optimal solution will depend on the particular technology, but mechanisms such as these should be explored.

- **Be upfront about risks.**

  All technologies involve some risk. The difference with climate-appropriate retrofits, as with other new technologies, is that unfamiliar risks generally provoke substantial user hesitancy (and sometimes fear). Stakeholders should aim to demystify the risks involved by being upfront about them and educating other stakeholders in the supply chain until they become familiar with, and willing to accept, the risks. In addition, stakeholders should be taught how to mitigate risks since the power to avoid a risk shifts the perception (and ideally the likelihood) of the risks coming to fruition.

  For illustrative purposes, consider the risk of water leakage or waste with evaporative technologies, about which numerous stakeholders expressed concern. Those who have successfully promoted such technologies have done so in part by addressing these concerns directly. That is, they acknowledged the risk (e.g., by telling customers they may find very small puddles on the roof) and armed customers with the information to mitigate them (e.g., by urging installation and maintenance by an approved contractor). The alternative—dismissing concerns—tends to backfire because it reinforces the stereotype of emerging technologies as opaque and "shady."

- **Promote phased adoption.**

  Sometimes direct experience provides the most compelling evidence. Stakeholders should provide customers with opportunities to try climate-appropriate retrofit technologies on a limited basis. So as not to undermine other recommendations contained herein (e.g., longer maintenance contracts), it is recommended that "limited basis" be applied to the size or scale, rather than duration of a project. More specifically, stakeholders should urge customers to "pilot test" retrofits on a subset of RTUs on a given roofs, or at a subset of locations.

  As with customer targeting, the projects in a trial run should involve units with the highest potential savings. For RTUs, that would be those of a specific age and condition. For locations, it would depend on climate, operating hours, and load profile. If pilot projects incorporate other recommendations in this section to ensure, for example, transparency and accountability, experience with, and evidence of, the technology's performance should sell the customer on a second phase of adoption (i.e., to retrofit more RTUs or locations).

- **Ensure technology design conveys confidence.**

  Details such as the aesthetics of a technology can influence a stakeholders' motivation to adopt it. A pleasing design conveys confidence, whereas it is difficult to promote a "science project or Frankenstein-looking [piece of] equipment." The same principle holds true for a manufacturer's website, promotional materials, and communications. The more professional those appear, the more confidence they will inspire, leading to greater adoption. These details are particularly important for an industry that has been plagued by low quality and unproven products. To the extent possible, every aspect of a technology's design and representation should convey confidence that the manufacturer designed and built a high quality product and a lasting business.

ENERGY SAVINGS

- **Target customers with the highest potential for energy savings.**

  A more compelling economic argument can be made for customers with relatively higher potential for energy savings, based on such factors as cooling loads, runtime hours, and location. All else equal, such customers should have a higher motivation to adopt climate-appropriate retrofit technologies. Thus, stakeholders should prioritize promoting adoption among those customers first. As the market develops (and prices fall), the economics will improve over time for customers for whom the technologies would save them less energy (and money), all else equal.

  Stakeholders who promote retrofit technologies (e.g., utility account managers, manufacturers' representatives/distributors) should begin the process of prioritizing customers by analyzing information already possessed on existing customers. In some cases, that may be sufficient to determine which customers to target. In other cases, more information may be needed. Lessons can be drawn from manufacturers on how to identify potential customers for whom their technology would yield the most energy savings. As described above, manufacturers have developed relatively low-cost ways of collecting data (e.g., Google Earth, reviewing customer websites for operating hours and location) that help them target the most promising customers. To the extent appropriate, other stakeholders, including utility programs, should adopt these methods.

- **Prioritize the technology with the greatest energy saving potential.**

  Customers can reap energy savings in many ways, such as replacing RTUs or installing various retrofits. Efforts to promote adoption of climate-appropriate retrofits should acknowledge the alternative options, and ensure that the particular technology promoted is the most cost-effective means of improving energy efficiency. Although retrofit technologies would explicitly compete with each other (and other options) in this manner, utility programs should remain agnostic about the technology choice, and simply promote the one with the greatest energy saving potential in a given circumstance. (It should be noted, however, that many retrofit technologies do not compete with each other in any technical sense. In fact, Technology A and Technology B, for example, are complementary.)

  As with targeting the customers with the highest energy-saving potential, a strategy to promote the most cost-effective technology in a given situation would help to ensure that adopters received the greatest possible benefit (and therefore had the most motivation to adopt), avoid "value engineering" to the cheapest alternative in the eleventh hour, and develop customer confidence that the most appropriate technology, rather than a sub-optimal option, is being promoted.

- **Estimate energy savings conservatively.**

  Given the legacy of energy efficient technologies that overpromise and under-deliver on their energy saving claims, it is important that those promoting climate-appropriate technologies avoid the temptation to overstate energy saving claims. Doing so means being upfront about the precise conditions under which maximum savings can be achieved, and the factors that may reduce actual energy savings from the maximum possible.

- **Urge customers to adopt other measures that maximize energy savings.**

  When possible, urge customers to adopt a whole building approach to advancing energy efficiency. Efficient HVAC equipment should be considered as part of an integrated system, rather than as a unit separate from the rest of the building.

For example, the energy savings from reducing thermal loads, repairing leaky ductwork, and upgrading or re-commissioning controls could easily double the energy use reductions available from a retrofit project. Climate-appropriate technology manufacturers, distributors, contractors, and others should communicate this to customers to set realistic expectations, and emphasize that customers can impact performance by the ensemble of choices they make. Furthermore, utility programs supporting climate-appropriate retrofit technologies should, to the extent possible, coordinate customer participation in other complementary utility programs to maximize energy savings.

- **Avoid undue restrictions on participation in efficiency rebate programs.**

  Currently, some technologies (e.g., Technology B) are utilized as enticements to enroll in broader utility programs (e.g., quality maintenance programs). While in theory this approach should yield greater energy savings—by both boosting adoption and increasing the energy savings among dual enrollees relative to those that adopt only a single measure—it should be avoided when possible. Each condition for program participation should be carefully considered to ensure the benefits it will outweigh the (lost) customers it will exclude (voluntarily or involuntarily). Furthermore, if utilities wish to encourage enrollment in multiple programs, or programs with multiple facets, those with the highest energy saving potential should be the gateway program, not the other way around.

Transparency

- **Provide transparency about the energy savings of climate-appropriate retrofit technologies.**

  Verification and transparency of energy savings is especially important for emerging technologies because they are unfamiliar to users and have a relatively short track record. When compared to conventional equipment, energy efficient technologies typically carry a cost premium, which is justified by the savings they are purported to generate. However, the (upfront) cost premium is fixed, certain, and immediate (upon purchase), whereas the savings is uncertain, delayed, and difficult to verify, as mentioned earlier. From a behavioral standpoint, this puts energy efficient technologies at an extreme disadvantage. One way to mitigate this is to provide more transparency about the energy savings to be expected from more efficient options.

  Big box stores do this for consumer appliances, frequently using the credibility of the DOE ENERGY STAR program, by providing estimates of the annual cost of operation (based on electricity, gas and/or water usage). Although the estimates are based on generic examples that may not reflect how a particular consumer would actually use an appliance, the standard scenario under which all are evaluated provides a baseline for comparison. Stakeholders promoting climate-appropriate technologies should provide similar ex-ante comparisons, or at least a common reference point to compare system efficiency potential, to motivate customers to adopt the technologies.

  In addition, retrofit technologies should be designed to incorporate capabilities to verify energy savings ex post. A relatively simple way of achieving this would be to establish a target level of energy use or performance for a machine, based on careful and conservative modeling, and have the technology itself raise a flag when realized performance falls below the target. A similar mechanism could be developed for the economics of a project, which could be communicated directly with business personnel.

Note there is value in providing a stream of data that monitors the performance of a retrofit technology, even if customers never use the data. The fact that a monitoring system is in place and that data could be reviewed at any time signals manufacturer confidence in the system's operating performance and increases customer confidence—just as customers value the provision of bank statements, even if they never open them. The information stream also offers as a mechanism for audit and verification to ensure the persistence of savings. Knowing this mechanism is available should mitigate the perceived risk related to performance uncertainty, thereby increasing motivation to adopt climate-appropriate technologies.

- ***Communicate about realized performance in economic terms.***

  Given the importance of the payback period in motivating customers to adopt climate-appropriate retrofit technologies, it would be beneficial to provide customers information about their expected payback period. Efforts to generate such information should be further leveraged to provide accountability by tracking progress over the projected payback period. Just as many mortgage lenders provide a running tally of principal and interest payments and balances to date, stakeholders promoting climate-appropriate retrofits (e.g., utilities, manufacturers) should create a tool that tracks kilowatt hours and dollars saved to date, as well as progress towards payback, in absolute terms and relative to the projection.

  This strategy may address customer concerns that actual payback periods may exceed the projection without their awareness. Providing this type of transparency would likely increase the motivation to adopt retrofits among many customers, and provide validation of system performance, which would be useful in convincing follow-up among potential customers skeptical of the technologies. Although these measures alone may not be adequate, they are a valuable first step. (See the discussion below about pairing measures for transparency and accountability.)

- ***Enable technologies to recognize and communicate about system problems.***

  The ability to know immediately when a system is not working properly is a vital feature of new technology, to ensure both transparency and maximum energy savings. Some retrofit technologies have these capabilities already built-in (e.g., Technology B). Other manufacturers should be encouraged to incorporate this feature into their systems as it would improve transparency (reducing the perception of risk, and increasing motivation) and also increase the actual savings realized (by immediately identifying problems when they inevitably occur).

- ***Tailor communication about system performance to its intended audience.***

  Although technical in nature, system problems also have economic consequences. For a given project, multiple parties are likely to have a vested interest in either the technical performance (e.g., facilities manager, contractor, manufacturer, utility) or the economic performance (e.g., building owner, service company, if applicable) of a retrofit. To ensure the recipient is motivated to act on the message received, communications about performance should be tailored to the domain of the recipient. For example, technical faults should be directed to technical experts (e.g., facilities managers, contractors, manufacturers).

Similar mechanisms could be established for economic performance. "Economic flags" could be raised if energy and cost savings fall outside the predicted range. If directed to business personnel with the financial incentive to investigate, this could be a valuable mechanism for ensuring proper maintenance and sustained energy savings.

- ***Weigh the costs and benefits of providing transparency measures.***

  The measures recommended above can be expensive. Given that cost is a significant barrier to the adoption of climate-appropriate retrofits, providing flexibility around these measures so as to avoid unnecessary cost increases can also add value. As stated earlier, offering transparency-related services sends an important signal about the manufacturer's expectations about the performance of its technology. For some customers, the option to purchase such capabilities might provide sufficient reassurance, even if the capability is not purchased. For others, monitoring the transparency-related communications or mechanisms for a period of time would be adequate. In order to address customers' competing motivations to keep costs down and ensure they receive the value they expect, manufacturers and utility programs should provide some flexibility by offering a variety of options. A particularly effective option may be for manufacturers to offer transparency-related services for free during a trial period, after which customers could cancel the service or assume responsibility for the cost. It is likely that this option may be technically and financially feasible for some technologies and not others, but stakeholders should at least consider whether it is an appropriate for all technologies.

- ***Utilize utility rebates to support strategic aspects of a project in order to yield multiple benefits.***

  Customers are not the only stakeholders that benefit from improved transparency of system performance. Utility programs that require documentation of ongoing energy savings to justify their claims also benefit. If, as is recommended above, customers are allowed to customize the level of transparency they wish to purchase, but utility programs require more, the program should cover the additional costs. Indeed, it may prove effective for utilities to pay for these services. Doing so would provide the utility with reliable insight needed to verify the persistence of system performance and energy savings, while also providing transparency for customers, which would increase their motivation.

  This could be a very effective mechanism for utilities to narrow the gap between ex-ante and ex-post energy use numbers. The same hardware could also be utilized to provide utility capabilities for demand response or dispatchable efficiency measures.

  Note that transparency need not be identical across stakeholders. Customers could receive one type of communications commensurate with their needs and willingness to pay, and utility programs could receive another. Such customization would address differing needs while fairly allocating the associated costs.

TECHNOLOGY COSTS

FIRST COSTS

- **Improve the rebate process.**

  Among many stakeholders, there is a general lack of awareness of, and information about, the incentives available for climate-appropriate retrofit technologies. More outreach is needed to alert stakeholders to the opportunities, to promote purchase of the technologies with partial support for first costs from utility programs. The information stakeholders need to make decisions about adoption (e.g., eligibility requirements, costs, benefits, operating requirements) should be readily available and easy to navigate. Such materials and the process by which they are acquired should bolster the motivation to adopt retrofits, not serve as yet another barrier due to inconvenience, lack of clarity, or complexity.

- **Aim rebates at the most effective point in the network of market actors.**

  Utility programs should consider adopting upstream rebates for climate-appropriate retrofit technologies, as many similar programs have already done, to address several of the market barriers described in the previous section (e.g., rebate uncertainty, complexity). Upstream rebates can serve as a stronger motivator for manufacturers to increase production, thus lowering technology costs through economies of scale. In addition, upstream rebates may help to level the playing field between conventional and efficient technologies. Targeting incentives at distributors would also improve knowledge, availability, and trust among all market actors, thus boosting their motivation to adopt climate-appropriate retrofits, which in turn broadens access among customers. In contrast, targeting rebates at customers only helps to ease the decision one customer at a time. Thus, addressing the market barriers of the gatekeepers first should be the priority.

- **Expand utility financing.**

  Utility financing sends a strong signal of support for retrofit technologies. As a first benefit, this financing helps mitigate the first costs that customers face (as addressed below in the discussion of customers' ability to afford the financial costs of retrofits). Further, the convenience of utility financing, especially with on-bill payments, and the endorsement it implies are likely to increase customers' motivation to adopt climate-appropriate retrofit technologies. This approach has worked for retrofit technologies in other utility territories.

- **Reframe energy efficiency equipment as investments, not expenses.**

  Traditionally, HVAC equipment is (rightly) viewed as a capital expense that is subject to depreciation. By contrast, climate-appropriate retrofit technologies that can achieve a return on investment can appropriately be viewed as capital investments. In recognition of this, several early adopters (including a nationwide drugstore chain) now treat efficiency projects, such as climate-appropriate retrofits, as investments for the purpose of their internal accounting. In such organizations, efficiency project finances are no longer processed as part of the facilities budget, but instead are handled along with other strategic investments. This reframing of the first costs associated with retrofit technologies should be urged more broadly. When business managers begin to view energy efficiency as a potential investment opportunity, many will have greater motivation to consider such projects.

Ongoing Costs

Reframe ongoing costs as investment protection.

It is well known that many customers resist paying for adequate HVAC maintenance services until there is a problem with system performance. Perpetuation of this trend with retrofit technologies undermines energy efficiency, cost-effectiveness, and utility programs' energy saving claims. Just as first costs should be viewed as an investment rather than an expense, the ongoing costs to maintain retrofits (and the RTUs they work with) should be reframed as necessary (and cost-effective) expenses to protect one's investment, which can appropriately be viewed as the goose that lays the golden egg. Not only does appropriate routine maintenance protect the equipment itself, but it also protects the stream of cost savings the equipment generates. Stakeholders should be urged to view ongoing costs as the (relatively small) price required to garner the projected savings and payback each month. Utilities could consider providing financial incentives to cover these ongoing services, since they are in a position to recognize the value of the investment, whereas customers may naturally think of ongoing costs as more of a liability to be avoided.

Cost Uncertainty

- **Mitigate rebate uncertainty**

  Rebate risk (and the cost uncertainty this creates) is always a problem when M&V is required to determine the ultimate rebate value. Several alternatives should be considered to mitigate this market barrier and its negative effect on customer motivation to adopt climate-appropriate retrofit technologies.

  First, utility programs should consider alternative rebate options. One such option is a prescriptive rebate to the customer that would involve no risk and no delay in delivering the rebate. Both of these factors would increase the motivation to adopt retrofits among many potential customers. Another option is upstream rebates, as described above. They, too, eliminate uncertainty around the initial capital costs.

  In addition, other stakeholders should consider the ways they can reduce rebate uncertainty. At a minimum, HVAC distributors, sales representatives, and contractors selling the equipment to customers should ensure they have robust means of estimating potential energy savings (and in turn the expected rebate), and clearly communicate to customers the conditions under which such projections should hold (e.g., routine maintenance, no change in operating hours or cooling loads).

  As possible, stakeholders should consider reducing the cost uncertainty customers face by assuming it themselves. For example, one design engineering firm interviewed for this study assumes the rebate risk by deducting the projected rebate amount from their total project cost, and having the customer write the rebate over to them. To mitigate its own risk in doing this, the firm deducts only 80% of expected rebate from the project cost. Their experience has been that customers are willing to forego the 20% to ensure they receive 80% of the expected rebate with 100% certainty. Other stakeholders should consider options like this, as appropriate.

- **Advance creative ESCO models for HVAC as a service**

  Facilities invest an incredible amount of time in the management and upgrade of HVAC systems. Staff made responsible for these systems are often not knowledgeable about the systems' proper operation and performance. For large projects especially, an energy services company (ESCO) could provide heating, cooling, and HVAC services for a flat fee, and could take on ownership, management, and upgrade of equipment. ESCO personnel, unlike facilities staff, would be better trained and more capable of dealing with HVAC equipment, and would naturally be incentivized to improve equipment efficiency (to increase profits). The customer would reap the benefit of reduced costs (considering they could eliminate redundant facilities staff), as well as the reduced risk and uncertainty. The customer would also avoid making warranty calls to a manufacturer, dealing with capital planning, or assuming the risks associated with unexpected costs due to equipment failure.

First-cost dominated decision-making has driven the HVAC industry toward cheap construction with lackluster performance. The consequences are apparent. The ESCO model makes a sale by improving reliability for customers (they know upfront how much it will cost, with no surprises), and uses energy efficiency as the avenue toward direct profits for the services company. At the same time, overall costs for a building could probably be reduced, and building owners would reduce the liability and risk associated with depreciating assets. Instead of setting aside capital reserves, these funds would be freed up for companies to immediately invest in other profitable business ventures. This model should be carefully considered by relevant stakeholders and perhaps tested on a trial basis.

- **Promote information-sharing to reduce cost uncertainty**

  As relatively new products on the market, many stakeholders who deal with (or could deal with) climate-appropriate retrofit technologies, face other sources of cost uncertainty, besides that derived from rebate risk. Several contractors (including ones who had and had not worked with Technology A or Technology B) told us they did not, or would not, know how to appropriately bid for a job that involved installing a retrofit technology. This uncertainty stems from unfamiliarity with the technology in general, as well as the added complication of uncertain and inconsistent conditions of the RTUs themselves.

  Several stakeholders reported that they consult "colleagues in the industry, whether they are competitors or allies" regarding the "actual cost of implementation." Since implementation costs can have a significant impact on customers' ROI, and in turn their motivation to adopt retrofits, stakeholders with experience costing retrofit projects should be encouraged (and perhaps incentivized) to anonymously share the information they have gathered with others in their industry, to the extent appropriate. Utility programs should consider facilitating this by gathering publicly available data and requesting further data from installers, and compiling it in an anonymous database for the reference of all stakeholders. This information should be made available to facilitate communication and motivation. For example, web media should be produced for particular audiences to review the latest understanding and best practices related to application of these efficiency measures.

- **Encourage strategic project design and implementation**

  As mentioned above in the recommendations on energy savings, when a willing but reluctant customer is identified, stakeholders should offer strategically chosen options for project design. Again, this would involve encouraging the customer to "pilot test" the technology at their most promising location or with a subset of RTUs best suited for retrofits. Several respondents reported having used these techniques to reduce their customers' exposure to cost uncertainty, which boosted the latter's motivation to try out the retrofits. A positive experience with a pilot test often paves the way for expanding the scope of the project later on.

DIFFUSED RESPONSIBILITY

Align decision-makers by reframing the value proposition.

Some of the recommendations above on addressing the market barriers related to first and ongoing costs involve encouraging a shift in perspective and by extension, perhaps even the individuals involved in the financial decision-making (e.g., moving retrofits from the facilities budget to an investment fund). If adopted, these changes should also address the issues that diffused responsibility for project costs poses for many potential customers (i.e., difficulty coordinating and split incentives). Removing these barriers would boost the motivation to adopt retrofits as internal parties become more aligned.

ADDITIONAL BENEFITS

- **Promote retrofits' additional (non-energy saving) benefits.**

  Sometimes customers want more than just energy savings. They want improved comfort, convenience, or air quality, or to reduce their impact on the environment. Retrofits can offer capabilities that address some of these needs. For example, some retrofit technologies (e.g., Technology B) may increase visibility into the operation of HVAC systems, while others (e.g., Technology A) claim to prolong the life of an existing RTU. These additional benefits can increase stakeholders' motivation to adopt the technologies that offer them.

  In the consumer appliance market, benefits (or features) like these are used to distinguish products from their myriad competitors. For example, laundry dryers can be compared on price, operating cost, and fuel type. But marketers prefer to extol the features they offer: the ability to sterilize stuffed animals, dry clean, or operate in eco-mode. Stakeholders promoting retrofits should adopt a similar approach by expanding their marketing strategies beyond energy savings. Interestingly, the ESCO model is primarily designed to sell the additional benefits, (e.g., comfort, reliability, improved ventilation, reduced CO_2 emissions, green image) while using energy efficiency as the avenue for profit.

  Several respondents noted that additional benefits are particularly important among customers who have already self-identified as being interested in energy efficient options. Typically, they have already overcome the barrier of higher first cost and are looking for other benefits or features from a piece of equipment. For those customers, the marketing strategy should de-emphasize the economics of retrofits and highlight the additional benefits instead.

  Note, however, that the additional benefits a retrofit may offer do not carry universal appeal. Stakeholders need to know their customers, determine which features will motivate them most, and highlight those benefits. There cannot be a "one size fits all" marketing plan.

In addition, although retrofit projects are technical and financial in nature, they can elicit emotional responses. Since emotions are powerful motivators, stakeholders should leverage an emotional appeal (e.g., happier occupants/customers, environmental heroism, the coolness of being an early adopter), to an appropriate extent, with the knowledge that not all decisions are made according to the bottom line.

- **Use more familiar technologies as “bait” for adopting HVAC retrofits.**

  Climate-appropriate retrofit technologies are unfamiliar, abstract, and nearly invisible to the end user, as are many of the functions they serve. Yet building owners must make substantial financial decisions about how to invest in these systems despite incomplete or imperfect information. When selling a retrofit that offers substantial energy savings, it can be helpful to include other selective upgrades that deliver added benefits (real or imagined) that are more apparent from the user’s or owner’s perspective.

  Thermostats could work particularly well for this purpose, especially now that several nicely designed (and highly desired) products are on the market (e.g., Nest). Despite their relatively low cost compared to retrofits, there is evidence that customers can be motivated to adopt (or accept) large technology changes if lured by an appealing way to interface with the new, unfamiliar, and invisible equipment. Thermostats have been used by numerous utility programs to incentivize (or “bait”) customers to enroll in various programs (e.g., demand response) and by contractors to sell new equipment. Utility programs promoting climate-appropriate technologies should consider bundling retrofits with relatively inexpensive thermostat upgrades to generate interest in, and support for, adopting the retrofits.

ACCESS TO INFORMATION

As mentioned in the introduction to this section, the detailed recommendations presented here are described from the perspective of stakeholder *motivation*. Practically speaking, these recommendations would also increase stakeholders’ *ability* to adopt and promote retrofits by raising awareness and knowledge, which are discussed later. Thus, considering the recommendations of each of those topics together would be beneficial.

- **Arm stakeholders with relevant information.**

  Because knowledge is power, informed stakeholders are empowered stakeholders. Efforts should be made by all stakeholder groups to inform members of their own and other groups about climate-appropriate retrofit technologies (e.g., their existence, costs and benefits, available incentives). In some cases, providing the basic information will be sufficient to encourage adoption. Individuals are most motivated by information that is appropriately targeted. Thus, the key is providing relevant information, at the appropriate level of detail, to the appropriate stakeholder. Stakeholder activities to promote climate-appropriate retrofits should tailor their strategies accordingly.

- **Maximize existing third-party data by increasing dissemination efforts.**

  Many stakeholders have utilized existing evidence on the performance, costs, and benefits of climate-appropriate retrofit technologies to successfully promote their adoption. But many others are not yet aware of the availability of such information. Greater efforts are needed to improve awareness of, and access to, existing third-party studies from credible sources, such as DOE, WCEC, and others. Manufacturers, distributors, design engineers, and contractors should all be encouraged to familiarize themselves with the studies that are available, and provide them, as appropriate, to their potential customers along with traditional marketing materials. Utility programs should spearhead this effort by developing and publicizing a resource (such as the ETCC website), in a user-friendly format that serves as a clearinghouse for all relevant information that exists in the public domain.

- **Generate additional evidence of technology performance.**

  Many stakeholders agreed that additional data on retrofit performance is still required, particularly as they are still new technologies with short track records. Many respondents would like to see additional credible data generated from pilot or demonstration projects and compiled by trusted third-party sources. Utilities should continue to play an instrumental role in facilitating such efforts and disseminating the results.

  To yield the maximum benefit from additional studies, future efforts should focus on demonstrating the technologies at locations strategically chosen to represent the most promising potential customers (e.g., common building type, high cooling load, and long operating hours). This approach would complement the recommendation to target customers with the greatest potential for energy savings (as described above). In addition to building a credible foundation of highly relevant performance information, these field evaluations would also help to develop, guide, and document the best practice approaches for effective application of retrofit measures.

- **Increase access to energy saving analysis.**

  Respondents in this study reported that many commercial customers who have detailed energy analyses conducted are convinced to look beyond the first costs of climate-appropriate retrofit technologies (and energy efficient technologies in general). However, costs for such services prohibit many customers from taking this approach. Therefore, utility programs should expand access to simple and accurate long-term cost and energy saving analysis.

  There are numerous ways to achieve this. A service to provide customized energy modeling could be made available to customers screened as being potentially good candidates for a technology (or set of technologies). Alternatively, several generic models – either static or dynamic - could be developed, based on common customer and building types that present significant energy saving potential from retrofits. Such models would give stakeholders a starting point for estimating the energy savings many customers may receive from retrofits.

Technology B provides this service through a simple and accessible web-based tool that helps to project energy savings. However, this type of service may be more convincing if hosted by the utility. For example, a utility-hosted online model could use historical meter data together with simple user inputs to project the expected savings generated from particular retrofits. This capability is important because, as the key findings above illustrate, giving customers greater access to cost and energy saving analysis is likely to make selling high efficiency, high cost equipment easier.

ENDORSEMENTS

In an industry that has been plagued by untested, underperforming, and "gimmicky" technologies, product endorsements and stamps of approval of other types from trusted and reliable sources are vital to encouraging stakeholder adoption.

In the HVAC industry, endorsement has largely come from industry associations such as AHRI. However, current industry standards are not designed to rate the performance of climate-appropriate advances and do not offer any way to clearly compare these measures against current industry standard options. Recognizing the need for broad industry recognition of climate-appropriate technologies, utilities and others interested in increasing efficiency should encourage and be involved in the development and advancement of industry standard tools, methods of testing, and related activities for these technologies.

Utilities, distributors, contractor/technicians, and stakeholders' peers are all also valuable sources of endorsements. Specific recommendations for harnessing the potential for each group follow, while the first recommendation below applies to all stakeholders.

- **Cross-reference other stakeholders' endorsements.**

  Complementary endorsements, that is, endorsements for the same product derived from different sources can be powerful motivators. Endorsements that cross-reference each other serve both to double the channels for raising awareness and to corroborate (thereby bolstering) the other's message. To that end, utility programs should, in the context of their own endorsement, reference other credible third parties' endorsements in order to garner the maximum benefit from both. Distributors and contractors should do the same, and highlight the fact that utility support constitutes an endorsement. Receiving multiple, complementary messages can increase trust in a product's performance and raise the motivation to adopt retrofits by generating more confidence in them and by subtly conveying the impression of a social norm (another behavioral tool, the recommendations for which are discussed below).

UTILITIES

- **Increase the visibility of utility endorsements.**

  Several stakeholders wanted utilities to be more proactive in their endorsement of the products they support through their programs. As one respondent put it, "nobody benefits as much as the utilities from [the] demand reduction [these technologies deliver], so they should be more involved in "making the sale." In fact, some utilities do take a very hands-on approach to product endorsement. For example, one utility reportedly included Technology B in its brochure, and referred to it by name in its HVAC catalog. A different utility initiated a strategy to co-market Technology B along with the manufacturer. Representatives from both the manufacturer and the utility took an active role in introducing potential customers to the technology and educating them on the incentives available. In that case, it was noted that the "utility's voice opens up a lot of doors." To the extent possible, utilities should provide direct and visible endorsements of retrofit strategies that are proven to offer significant savings.

Note that stakeholders did acknowledge the need for utilities to remain manufacturer-agnostic. However, they provided suggestions for promoting specific technologies without violating impartiality. As a general principle, however, efforts to advance retrofit solutions should recognize that reputation and customer trust suggest that utility endorsement of technologies can play a major role in raising awareness and motivating technology adoption among relevant stakeholders. Such endorsements may also serve to incentivize non-participating manufacturers to enter the climate-appropriate energy efficiency marketplace.

Distributors

Manufacturers of climate-appropriate retrofit technologies should be urged to pursue traditional distribution channels for the sale of their products. By carrying a particular product, distributors send a signal that they endorse that product, which can in turn raise contractors' and design engineers' motivation to adopt it. Specific recommendations have been developed for the traditional distribution model, which is recognized as offering several benefits.

- **Leverage the alignment of distributors' and customers' incentives.**

  In the traditional distribution model for HVAC equipment, distributors represent multiple products, several of which may serve similar functions. Therefore, distributors and the companies they work for scrutinize the available technologies (formally and informally) to determine which ones to carry and promote. (As mentioned earlier, individual distributors exercise some discretion over which technologies they promote, from among all those their company carries.) As part of the vetting process, sales representatives "play the devil's advocate." They are the "skeptics" to counterbalance the "optimist" manufacturers. As one respondent explained, "that combination is what works for the customer. A proper sales rep is going to have all the right questions and find out all the pitfalls. All of it is going to be presented on the table." This critical vetting process provides distributors confidence that the technologies they choose to carry will meet their standards and live up to the expectations. Thus, a distributor's decision to carry a product represents an endorsement of sorts.

  Customers benefit from having access to retrofit technologies distributed through traditional channels because the process described helps to weed out sub-par technologies, or those that are not market-ready. To the extent possible, this alignment of customer and distributors' incentives should be leveraged.

- **Leverage distributors' knowledge of local market conditions.**

  Distributors possess detailed knowledge about the local markets they serve. They are better positioned to sell climate-appropriate retrofit technologies than are manufacturers' representatives based outside a particular region. As one respondent explained, "the local person is going to know what the hot topics and the buzzwords are, and the things that are really going to click" with the customer. By contrast, manufacturers' representative who do not possess such knowledge can lose credibility, and therefore sales, without even realizing it. Thus, knowledge of the product alone is not sufficient for an endorsement in some cases. A meaningful endorsement, one that motivates customer adoption, addresses the technology's suitability to local conditions. To that end, manufacturers and distributors should be urged to leverage their collective knowledge of the technology and local market to promote retrofit adoption.

In fact, it is not necessary to adopt the traditional distribution chain in order to reap the benefits of local experience. Manufacturers of retrofit technologies that employ a different model can also leverage this resource by developing a geographically diverse and locally-rooted sales force. The manufacturer of Technology B has done this through an affiliate's model. This is a reasonable alternative, although it takes time to establish and foregoes the benefits of a traditional distribution chain described above. However, in cases where manufacturers opt to represent their products themselves, they should be urged to develop distributed networks with deep local knowledge.

- **Leverage distributors' relationship with and access to customers.**

  Distributors and sales engineers have substantial influence over technology selection. However, many could do more to leverage the access they have to their customers. For example, distributors should view operational issues as an opportunity to engage the customer about other concerns. One distributor reported using sales calls to educate his customers on market trends and changing regulations. He viewed this as a way to add value and build trust with his customers. Later, when trying to sell energy efficient products that would benefit the customer, the foundation of trust had been laid. In that context, the distributor's recommendation (and implied endorsement) carried more weight, thus increasing the likelihood that it would motivate adoption on the part of the customer.

  Another distributor described how he initially sells a customer only "run of the mill" equipment until the customer is comfortable with his recommendations. Later, he is able to "substitute it with emerging technology because [the customer] had that trust factor. They weren't going out on the limb. [Instead, they think] 'I know you as a person, and I trust you as a person, and I will like [your recommendation]'."

  In both cases, the distributor acknowledges the additional trust that is required for a customer to accept his endorsement of a climate-appropriate technology. However, approaches like these do not appear to be the norm. Many distributors do not take such an active role in engaging and informing their customers. More distributors who promote climate-appropriate retrofit technologies should adopt similar methods of developing close relationships with their customers and providing more value-add, acknowledging that making a sale of a retrofit can be a long and indirect process.

CONTRACTORS

- **Leverage contractors' relationships with their customers.**

  In many cases, customers have stronger relationships with contractors (and technicians) than with all other stakeholders. As one contractor described it, "We have the rapport, trust, of our customer base." As such, contractors can have tremendous influence over their customers. Thus, contractor endorsements can be a powerful source of customer willingness to adopt a particular technology.

  To maximize this opportunity, one contractor reported that his strategy involves initially promoting new technologies to his longest-standing customers, i.e., those who have developed the most trust in his judgment. He has found that they are more receptive than are other customers to his guidance towards new technology. Thus, whether contractors play a direct role in equipment sales (as is the case for Technology B) or merely an indirect one in guiding technology choices, this opportunity should be leveraged to motivate retrofit adoption among customers. This may require, among other things, increasing contractor awareness, potentially changing distribution strategies, encouraging the inclusion of contractors during the technology selection process, and training contractors to serve as technology and/or utility program ambassadors. More detailed recommendations for these activities can be found elsewhere in this report.

SOCIAL NORMS

- **Leverage the power of social norms by providing evidence from relevant examples.**

  Stakeholders are most likely to be persuaded to adopt (and promote) climate-appropriate retrofit technologies if they perceive the evidence in its favor as relevant and applicable to their case. For example, a light commercial customer may not be especially encouraged by a case study of energy savings from a technology installed in a data center. Thus, stakeholders (e.g., distributors, design engineers, contractors, customers) should be urged to behave like comparable peers who have already adopted such technologies. To the extent possible, stakeholders in the position to apply such social pressure (e.g., manufacturer's vis-à-vis distributors) should collect and disseminate evidence on the successes of other stakeholders as a means of broadening adoption. For example, a contractor reported that his company does this by sharing data on existing customers with new customers. This approach complements the provision of third-party evidence from remote lab and field tests by making it more concrete, suggesting that the findings hold true in the local context and conveying the message that adoption is a (albeit new) social norm.

STATUS QUO BIAS

- **Select target stakeholders that are less prone to status quo bias.**

  In the early phases of deployment, retrofit technologies need ambassadors at all levels of the distribution chain. Thus, individuals need to be recruited from each stakeholder group. It is best to focus such efforts on those who have the greatest potential to become early adopters, rather than waste resources targeting everyone. For example, the manufacturer of Technology B, which sells and installs its product through its network of contractors, develops its commercial presence through such an approach by telling its partners: "Give us your technicians who want to grow, want to learn, want to add value to your organization and are motivated. Don't give us the guy who has been working with you for thirty-five years, who's just marking time here because his pension is going to take over soon. That is not the guy we want."

Similarly, manufacturers seeking representation by HVAC distributors should recruit from among the sales force individuals who are most inclined to adopt new technology. Portfolio and sales records would help identify those individuals. In general, it is better to have 1 motivated representative in 10 different offices than 10 ambivalent representatives in a single office.

Sales efforts should also utilize this approach. Developing a critical mass, and shifting the norm such that a tipping point can be achieved, requires converting as many early adopters as possible. Given the numerous market barriers that emerging technologies face, it is best to focus sales (and utility outreach) efforts on the most likely adopters.[14]

- **Provide opportunities for personal experience with the technology.**

  Overcoming status quo bias is difficult. One approach it is to ensure that the evidence presented in favor of new technologies is compelling. Perhaps the most effective means of doing that, as mentioned by numerous respondents, is to provide opportunities for personal experience with the technology. As one respondent said, there is "no substitute for seeing and touching the technology in person. [Potential adopters] need to have that "aha" moment." For contractors, design engineers and distributors, that means hands-on training should be encouraged.

  Customers can also benefit from hands-on training, or something more involved, such as a free trial. At least one design engineering firm utilizes this approach. They offer to install one test unit as first step in a larger roll-out plan. That first unit allows the customer to get hands-on experience with the technology and see for themselves that it works, before committing to a large project.

  Of course, a free trial is not always a feasible approach. However, all stakeholders are encouraged to emulate the spirit of this strategy by providing as much in-person exposure to the technology as possible. For example, utility programs should facilitate stakeholder contact with the technology by providing information about the opportunities offered by manufacturers and their representatives and distributors, typically through trainings.

  Going a step further, utility programs should consider utilizing ongoing demonstration sites for the added purpose of hosting tours that would give stakeholder representatives a chance to see the technology in action and talk to the installing contractor and facilities manager. To the greatest

[14] As discussed earlier, this is a function of energy saving potential and openness to new technologies, among other things. For a discussion of the latter, refer back to the key findings on how customers in various industries differ in their risk aversion.

extent possible, stakeholders should be given the opportunity to personally engage with the technology in order to boost their motivation to overcome their status quo bias and adopt something new.

- **Remind stakeholders that the status quo also has risks.**

  For an apples-to-apples comparison, the benefits and risks of adopting climate-appropriate retrofits should be presented in comparison to the benefits and risks of remaining with the status quo. For distributors, design engineers, and contractors, sticking with the status quo entails the risk of missing out on an emerging market and being usurped by more advanced competitors, as several respondents acknowledged. Both result in loss of potential revenue. For customers, the risk is primarily financial losses through higher energy use, image (as related to sustainable business practices), and the risk of having to invest in upgrades later on (i.e., when energy prices make the need even more compelling) instead of now.

  Ample evidence exists that individuals are loss averse. Stakeholders should leverage this principle by providing information on potential losses (e.g., lost revenue, waste on high energy bills) to the stakeholders below them in the supply chain.

STAKEHOLDER COORDINATION

The recommendations below seek to strengthen stakeholder coordination, with the aim of motivating promotion and purchase of climate-appropriate technologies.

- **Engage facilities managers.**

  Of the various stakeholders involved in the process of selecting and implementing a retrofit technology, facilities managers were the ones most often cited as likely to be left out of the process. Despite that, respondents acknowledged the importance of their involvement and support. Many agreed that more communication, coordination, and training are needed to ensure support from facilities managers, who are the critical stakeholders on a day-to-day basis. Thus, facilities managers should, to the extent possible, be involved in the discussion of retrofit (or other) options, educated in advance of installation, present for the installation, and encouraged (and incentivized) to take an active role in reporting system issues to the maintenance provider and/or manufacturer. Whoever sells or recommends the retrofit technology to the customer—be it the manufacturer, a distributor, design engineer or contractor—should urge the decision-makers to involve the facilities manager from the beginning. Utility programs should make this recommendation explicit, too, in whatever format is appropriate to help increase the motivation of all vital parties involved in retrofit adoption.

ACCOUNTABILITY AND SUPPORT

For many stakeholders, enhanced transparency, which could be delivered through the various mechanisms recommended in the above discussion, would go a long way to increasing motivation to adopt climate-appropriate retrofit technologies. Others, however, may remain concerned that in the absence of accountability measures, mechanisms for additional transparency alone will not provide sufficient assurance of performance, energy savings, or cost recovery. Thus, additional accountability measures may be required.

- **Develop enhanced, alternative deployment models.**

  Some stakeholders are concerned that under the current deployment model for most climate-appropriate retrofit technologies, each party is at best held accountable for providing some minimum level of service. Ultimately, no one is held responsible for ensuring that the system delivers the energy savings promised. One way to address this is to deploy retrofits through ESCOs. The latter would provide a guarantee for the energy savings, given agreed upon operating conditions and maintenance services paid for by the ESCO. The cost of service could be paid for out of the energy savings delivered, and failure to generate energy savings would result in loss of revenue for the ESCO. This model, while sacrificing some of customers' cost savings to pay for the ESCO, would ensure that a specific party (i.e., an ESCO) is accountable for both energy savings and system maintenance, two distinct problems with retrofits as they are currently deployed. Further details are provided in the discussion above related to addressing cost uncertainties.

ABILITY

In this section, recommendations are presented for increasing stakeholders' *ability* to adopt and promote climate-appropriate HVAC retrofit technologies, thereby overcoming certain of the market barriers they face. As before, the recommendations are organized under the following six themes:

- Technical feasibility
- Cost
- Effort
- Awareness, knowledge, and communication
- Access
- Empowerment

TECHNICAL FEASIBILITY

- **Encourage comprehensive installation guidelines and kits.**

  The manufacturer of Technology B sets a good example of effective manufacturer actions to ensure proper installation of a retrofit. Their installation kit includes a detailed installation manual and an appendix with photo illustrations demonstrating how to install the retrofit on specific RTU models. The kit also includes "every little thing that is needed" to install the retrofit, down to the "zip ties." Other manufacturers are urged to follow this example to help contractors navigate the variability in the field and reduce the chances of hassles, delays and unexpected costs that arise from having to obtain extraneous materials to adapt installation to diverse equipment.

- **Carefully select and train installing contractors.**

  Installation of Technology A and Technology B is permitted by manufacturer-approved and trained contractors. Although this can represent a bottleneck in the early phases of market deployment (if few such contractors exist), it is in principle a good idea. It is recommended that manufacturers of climate-appropriate retrofit technologies carefully select the contractors they agree to train, screening for the experience and knowledge required to deal with the complexities of installing retrofits on RTUs of varying models and conditions. The vetting process itself can be done a variety of ways, requiring for example, professional certification, minimum years of experience, a personal reference, or passage of a written or practical exam. The precise experience and knowledge needed by an installer, and means to assess them, depends in large part on the technology itself, so those details should be left to the discretion of the manufacturer.

- **Urge detailed preparation for installation.**

  While conditions in the field vary substantially, some surprises can be mitigated by engaging in thorough preparation. Contractors should be urged to utilize all available resources (including Google Earth) to compile useful data about a retrofit job before the date of installation. Installers of Technology B currently use this approach to great effect.

- **Improve coordination with the regular service provider.**

  Better coordination is needed between the party providing routine service and maintenance (whether a facilities manager or a contractor) and the contractor responsible for maintaining a retrofit. Because much of a retrofit’s performance relies on that of the RTU, the technologies, and the people responsible for their operation, must be coordinated. At a minimum, the regular service provider should be made aware of the retrofit installation. Better still, the provider should be present during the installation to learn about how the retrofit interfaces with the RTU under the provider’s charge.

  In addition, technical options can also help ensure better coordination. For example, Technology B provides visibility into the operation of the RTU. This allows the retrofit service contractors to alert the RTU service contractor (or facilities manager) to any performance issues that may arise. Such transparency is a valuable tool in facilitating timely coordination (and accountability) among the various parties responsible for the performance of the inter-dependent RTU and retrofit.

COST

As mentioned in the introduction to this section, recommendations related to costs are discussed in several places, including here. In this section, the emphasis is placed on how efforts to address costs effect stakeholders’ *ability* to adopt and promote retrofits, while earlier sections focused how addressing costs would influence stakeholder *motivation*. Both motivation and ability are required for adoption, although the behavioral mechanisms through which relate to market barriers differ.

FINANCIAL COST

- **Improve access to comprehensive cost analysis.**

  The current limited access to holistic and long-term cost analysis hinders customers' ability to make decisions in favor of adopting retrofits. Expanding that access is needed to allow all potential customers to make informed decisions. To this end, manufacturers should be urged to further develop the cost estimate tools they provide, and utility programs should consider building their own so that customers could compare across multiple retrofit options.

  Such tools should incorporate and emphasize the value proposition offered by the retrofits, examining the several types of cost offsets at play: first costs vs. ongoing savings, increased costs of service, data, water, and monitoring vs. decreased electricity costs. All of these should be emphasized and incorporated into a final analysis, and perhaps even a compelling narrative. Such tools would provide potential customers with the information they require to adopt retrofits, as well as a verifiable set of benchmarks they could refer to later to ensure that the value proposition is realized after installation.

- **Expand financing options.**

  Providing financing for spreading out the first costs of retrofit projects addresses a critical market barrier many customers face. Additional options should be developed for utility financing (paid back through a utility bill or some other means), manufacturer financing, and third-party financing. As mentioned above, greater availability of financing would increase the ability *and* motivation to adopt and promote retrofits among many stakeholders.

- **Encourage phased adoption.**

  Similar to a recommendation above regarding mitigating cost uncertainty, phased adoption of retrofit technologies (i.e., across a subset of RTUs or customer locations) should be encouraged as a simple means of increasing customers' ability to pay for (scaled down) retrofit projects. This approach addresses the cost barrier, while providing customers with the opportunity to experience the technology for themselves, which should address many other barriers described above.

- ***Assist manufacturers in scaling up production.***

  The high cost of some retrofit technologies poses a market barrier for customers who might otherwise purchase them, as well as distributors and contractors trying to sell them. This problem is most severe in the early phases of market deployment, as the production levels initially remain low. For technologies with inexpensive components, the potential for reducing the cost is especially large. Thus, manufacturers should be urged (and perhaps supported) to increase production in order to take advantage of economies of scale. There are numerous ways of doing this. For example, manufacturers could be connected with venture capitalists. In addition, utilities could provide manufacturers financing and/or place large orders for the technologies, which, as a guarantee of sale, allow manufacturers to ramp up production (much like the community-supported agriculture model). All options that would result in increased production and decreased first costs should be considered.

UTILITY INCENTIVES

This is one of several places where recommendations related to rebates are discussed. In this section, their effect on stakeholders' *ability* to adopt and promote retrofits is emphasized, while the earlier sections focused on the effect on stakeholder *motivation*. To reiterate, the specific actions recommended to improve aspects of utility rebates do not necessarily need to be tailored to either stakeholder motivation or ability. Rather, understanding the behavioral mechanisms through which changes to the rebate programs would address market barriers can help stakeholders ensure that such changes are more effective.

- **Increase the value of rebates.**

  Perhaps the most obvious way to increase customers' ability to pay for retrofit technologies is to increase the dollar value of rebates. Climate-appropriate cooling strategies such as Technology A are especially effective at reducing peak demand. In addition to their annual energy savings benefits, application of these strategies should be thought of as avoided generation, transmission, and distribution capacity. As the California population grows toward 50 million, and electricity demand grows apace, the application of efficiency measures with substantial savings at peak can offset the need for public investment in more extensive grid infrastructure. Therefore, these options should be valued as equivalent to the development of new capacity. As with federal tax credits on hybrid and electric vehicles, utility incentives for climate-appropriate technologies could be reduced (and phased out) over time as the market develops.

- **Change the structure of rebates.**

  Getting customers to commit to the necessary maintenance and service costs associated with retrofits has been a problem. One option, noted elsewhere, is to simply require the purchase of a relatively long maintenance plan. However, customers' ability to pay for such a requirement should be considered. One option to address multiple barriers at once would be for utility programs to change the way they provide incentives. For example, incentives that cover the full initial cost of retrofits could be offered on the condition that customers pay for the maintenance and service to ensure that the equipment continues to operate well. A compelling case could be made for the fact that maintenance costs would represent only a fraction of the value of the energy saved, thus requiring no additional out-of-pocket expenditures by the customer.

  Alternatively, the reverse arrangement should be considered. Customers could be urged to seek financing for the initial costs, and make payments on the financing from the ongoing energy savings. The cost of maintenance and service, in this case, could be covered by a utility program. Such costs could be reduced by negotiating bulk discounts with service contractors. This arrangement would ensure that maintenance and service, and in turn energy savings, would be reliable. In this case, the utility would effectively pay for a higher net-to-gross ratio by ensuring the persistence of energy savings, while simultaneously reducing customer perception of risk. Essentially, the utility would pay to 'guarantee' savings for the customer and the utility itself.

- **Support standalone retrofits.**

  Currently, some retrofit technologies are eligible for a utility incentive only as part of a broader utility program. While pairing complementary measures (such as quality maintenance and retrofit installation) undoubtedly increases energy savings relative to a single measure alone, the coupled measures may be cost-prohibitive for many potential customers, thus reducing energy savings at the program level. Utility programs should consider a range of ways to support retrofit technologies, i.e., as standalone installations or components of a broader program. San Diego Gas & Electric's two-level model—which supports Technology B at one incentive level when installed alone (informally referred to as the "silver plan"), and at a higher level when installed as part of a quality maintenance program (the "gold plan")—provides a good example for consideration. Flexible options such as this should be considered to address customers' diverse needs and resources.

COST UNCERTAINTY

Each of the earlier recommendations to address cost uncertainty as it affects stakeholders' *motivation* to adopt and promote climate-appropriate retrofits would also improve stakeholders' *ability* to do so, so comments here are brief. It is important to note that many stakeholders deal with cost uncertainty by inflating prices. Several contractors interviewed noted this as common practice. Design engineers (or customers themselves) may explicitly factor in the uncertainty by increasing the high end of a project cost estimate, just to be on the safe side. Each of these strategies, while appropriate business strategies, can in fact further limit customers' ability to pay for retrofits. Thus, the recommendations earlier about reducing cost uncertainty should be viewed as means to increase both motivation and ability to adopt and promote climate-appropriate retrofits.

EFFORT

SALES

- **Target likely customers first.**

  As described above, customers with the greatest energy saving potential should be targeted first as they should, all else equal, have the greatest motivation to adopt appropriate retrofit technologies. As an added benefit, this strategy should reduce the sales effort.

  Identifying suitable candidates requires some additional upfront work. Several respondents shared their strategy of using Google Earth to identify the building size and number and characteristics of RTUs, as well as perusing the customer's website to estimate runtime hours. This research is used to "prequalify" potential customers and generate a preliminary estimate of the expected energy savings. By pre-screening customers and presenting such detailed and customized information, without requiring any input on their part, the sales pitch becomes relatively easy.

Stakeholders have also found that targeting existing customers first makes for easier sales pitches. With a prior relationship, trust, and information about the customer's existing equipment, conducting a quick analysis of the feasibility of the retrofit and the likely value it would generate takes relatively little effort.

All stakeholders in the position of formally or informally selling retrofit technologies (i.e., manufacturers, distributors and sales representatives, design engineers and contractors) should consider ways of reducing their required efforts by targeting likely customers first.

- **Clearly define the limits of the sales pitch.**

  Selling a retrofit technology, and even the maintenance and service that should accompany it, does not require supplanting the existing HVAC service contractor or facilities manager. Several respondents noted that this makes the sales pitch more palatable. Retrofit technologies have the advantage of not directly competing with existing technologies. "This is a fundamental difference: [You're] not asking them to switch their service maintenance business over to [y]our partners. You're selling something that does not require them to select you as their first contractor choice. You're just giving them something that they don't have and that the other guys have not offered them." This can make the sale pitch easier, while also making all building owners potential customers, regardless of the existing HVAC contracts they may have. Stakeholders who sell or promote retrofits should emphasize this aspect with prospective customers.

- **Streamline the sales process.**

  Even when using the above techniques, the sales process can require a lot of effort. A system developed by the manufacturer of Technology B provides a valuable example of how efforts can be minimized through upfront research, analytic tools, and a well-defined process. The process begins with data collection, as described above, followed by a meeting with the potential customer to gather additional information. If the sales associate can gain access to the roof, he notes whether it has an economizer and takes a picture of the unit and name plate. If not, an equipment list is requested. The information compiled is then fed into an estimating tool (likened to Turbo Tax) that calculates the expected energy savings and payback period. That information is relayed back to the potential customer and the conversation continues.

  There are enormous benefits to developing a streamlined process such as this, and other stakeholders who sell retrofit technologies should follow this example, adjusting the details as appropriate for their specific technology. Ultimately, when less effort is required to sell a customer on a retrofit, more customers can be reached.

REBATES

- **Simplify the rebate application process.**

  Many stakeholders reported problems with the effort required to navigate the rebate process. Complex and confusing rebate applications can place an undue burden on all stakeholders in the supply chain, from manufacturers and sales representatives, down to design engineers and customers. If stakeholders are unable (or unwilling) to overcome this barrier – even if it is the only one remaining – retrofits do not get installed. Respondents noted that customers have been lost in the eleventh hour because they could not navigate the rebate process. Utility programs should make every effort to simplify the rebate process such that the effort required of customers and other stakeholders is minimized. For examples of how to do this, utilities should look to their peers to identify best practices from other territories.

- **Standardize rebate programs across multiple utility territories.**

  Many respondents reported the challenges posed by variations in utility rebate programs across territories. For example, developing large-scale retrofit projects requires working with customers who may have locations in several utility territories (or more). Navigating the rebate landscape for locations in each territory separately increases the effort required of the party tasked with that job. To the extent that rebate programs or applications could be standardized, even in small ways, it would improve stakeholders' ability to adopt retrofit technologies by lessening the effort required to do so. The common application for American colleges and universities is a good example of how many recipients of admissions applications worked together to create a standard application to lessen the burden on applicants applying to multiple schools. Use of a standard application does not preclude schools (or in this case utility programs) from requiring additional materials, but it does streamline at least a portion of the process. Utility programs, perhaps with the CEC's guidance, should consider options such as this to minimize the effort required of rebate applicants.

INSTALLATION & OPERATION

The effort required to install and operate climate-appropriate retrofits would be lessened as a by-product of several of the recommendations relating to technical feasibility, described above. Thus, there are no additional recommendations for addressing efforts in these areas.

AWARENESS, KNOWLEDGE, AND COMMUNICATION

The detailed recommendations presented here are described from the perspective of stakeholder *ability*. Practically speaking, these recommendations would require addressing stakeholder access to information, which was discussed in the earlier section on *motivational* factors. Again, it is suggested that the recommendations of all of these topics be considered together as they are inextricably linked.

AWARENESS

Several of the recommendations on stakeholder endorsements would serve the added purpose of raising awareness about climate-appropriate retrofit technologies and the utility programs to support them. Here are a few additional recommendations.

- **Increase efforts to inform market actors about retrofit options.**

  Utility programs have many highly visible campaigns to promote energy efficiency programs among residential customers, but fewer such campaigns for commercial customers. To increase awareness about rebates and retrofit options for commercial customers, utility programs should heighten their outreach efforts, by both augmenting efforts through existing channels and pursuing new channels, such as social media and peer-to-peer marketing.

  Likewise, retrofit manufacturers should increase their efforts to raise awareness about their products. Outreach via word-of-mouth, as is largely the case currently for Technology A, is unlikely to lead to widespread adoption. A more ambitious strategy is required to raise awareness about this and other climate-appropriate retrofit technologies. One manufacturer interviewed courts contractors directly, taking them to the race track and talking casually about their products. There are numerous other options for increasing awareness, several of which are discussed in the recommended improvements to the distribution chain.

- **Ensure that technology promoters are well informed.**

  Several respondents noted that utility account representatives do not always possess up-to-date information on utility programs. To the extent this is true, it represents a lost opportunity. Utilities should increase efforts to ensure that their programs are well-known among account representatives. The same holds true for distributors. Those that carry climate-appropriate retrofits should ensure that their sales representatives are aware of them and can provide at least minimal information about them to potential customers.

- **Target high level decision-makers.**

  Several stakeholders mentioned the need to target high level decision-makers, many of whom currently have little awareness about energy efficiency equipment and rebate opportunities. Stakeholders across all groups (e.g., utility account representatives, manufacturers, distributors, design engineers) who are in the position to do so should take steps to raise awareness among critical decision-makers. In addition, policy organizations with greater visibility, such as the CPUC and CEC, should utilize their clout to inform high level decision-makers of the opportunities.

KNOWLEDGE

- **Create more opportunities for stakeholders to learn about retrofits.**

  For many stakeholders, knowledge must follow awareness. With many respondents reporting a lack of contractors, distributors, or design engineers who are knowledgeable about climate-appropriate retrofit technologies, more efforts are needed. This may include actions such as offering more trainings or certification programs to contractors, distributors, and design engineers; donating more equipment to trade colleges to educate future contractors; or creating additional promotional materials.

- **Pool knowledge resources**.

  More efforts should be made to leverage the knowledge that does exist among stakeholders. To this end, the manufacturer of Technology B does convenes its affiliates once a year to network and share ideas and information. Several respondents reported consulting colleagues or competitors to gather information they were missing. All stakeholders should be urged to do the same on a formal or informal basis.

  One interesting option suggested by a respondent was to convene a panel of experts to share their particular knowledge with potential technology adopters. The panel could include a representative from the CPUC to explain why energy efficiency retrofits are needed, a utility representative to describe various programs available to support retrofits, representatives from several manufacturers to describe their products, services and warranties, and an installing contractor (or several) to explain the logistics of installation and operation. While in practice this may be difficult to achieve, it is in principle a valuable illustration of the potential for pooling knowledge resources. Such an approach could be adopted as is (for implementation during a contractor trade show, for example) or approximated by compiling videos or written materials from each of these stakeholder groups. Regardless, all stakeholders should pursue opportunities to pool knowledge within and across the groups to which they belong.

- **Promote retrofits among the most knowledgeable stakeholders first.**

  In the early phases of technology deployment, retrofits need powerful ambassadors and champions. It is widely acknowledged that more sophisticated (or even merely less familiar) technologies demand greater knowledge on the part of the stakeholders who adopt and promote them.

For example, a sales team has to "accelerate the learning curve for customers by fully explaining the technology, heading off critiques, understanding and recommending appropriate application, knowing how a building works and how a business works, [and] compar[ing a retrofit] to conventional equipment." Thus, distributors should be encouraged to assign their most experienced staff to represent climate-appropriate technologies.

Similarly, contractors' roles have become more sophisticated as technologies have evolved. Contractors have to know how to communicate with customers and answer their questions, as well as handle the variety of technical issues that arise with retrofits. Recruiting relatively more knowledgeable contractors to promote climate-appropriate retrofit technologies makes training them on the retrofits easier. One contractor interviewed who installs Technology A, for example, now only hires technicians with NATE certification. He finds it is easier to train them on the technology because they have a greater knowledge base on which to build.

As both of these examples illustrate, increasing the number of knowledgeable stakeholders is accomplished more easily by promoting retrofits among those who are relatively the more knowledgeable to start. Thus, stakeholders undertaking knowledge-building should consider adopting this strategy.

COMMUNICATION

- **Encourage better communication within and across stakeholder groups.**

  Some of the gaps in awareness and knowledge can and should be addressed simply through better communication. For example, multiple respondents reported that often, some stakeholders are left out of the technology adoption process. Facilities managers in particular are frequently overlooked. To the extent possible and appropriate, all stakeholders be involved in the information gathering, consensus building, and decision-making processes. Excluding key parties undermines efforts to promote widespread adoption of retrofit technologies.

ACCESS

- **Increase the commercial presence of retrofit technologies**.

  Stakeholders can only adopt that to which they have access. If a distributor does not carry it no local contractor can install it, and in turn the contractors' customers cannot purchase it. Distribution channels need to be strengthened, as described earlier. More contractors need to be trained and approved to provide installation and maintenance services. Manufacturers generally need to grow their commercial presence in key markets. More specific recommendations on how to accomplish this are provided in earlier sections. They are reiterated here (in brief) simply to emphasize how they affect access to, and in turn the ability to adopt, retrofit technologies.

EMPOWERMENT

DIFFUSED DECISION-MAKING

- **Tailor outreach strategies to communicate with key decision-maker(s).**

  Numerous respondents reported challenges in identifying the appropriate person to target when promoting retrofit technologies. Because responsibility for such decisions is often shared by multiple parties or retained at a high level, decision-makers can be hard to reach. Once the appropriate person or persons are identified, it is important to consider who (on the promoter side) has access to them. Typically, contractors and account representatives have contacts with decision-makers in small, local organizations. By contrast, national companies that make decisions about technology upgrades at the corporate level would be out of their reach. For example, a store manager who maintains a relationship with a utility account representative would be superseded by a national sustainability manager.

  Similar complications appear among other stakeholder groups. Manufacturers may engage distributors at the executive level, but the decision to distribute a particular technology is typically localized within each office or region (and then again is subject to the discretion of the individual sales representative). Design engineers must specify equipment that has been approved by the principal. Thus, manufacturers and their representatives need to pitch to distributors' regional offices and principals of design engineering firms first, and then ensure that the message is diffused throughout the organization.

  Outreach strategies need to be tailored to the specific circumstances of each case. Furthermore, once the appropriate contact person(s) has been identified, the outreach strategy (and its representative) should be selected such that access is assured.

- **Consider a team-based outreach strategy.**

  Given the diffuse nature of responsibility for decisions about energy efficiency projects at many organizations, stakeholders promoting retrofits should consider a team-based approach, where appropriate. For example, large retailers could be approached by a manufacturer and utility representative together, since the latter would have access to key decision-makers and the former would have intimate knowledge of the technology being promoted. For smaller customers, partnerships between sales (or manufacturers') representatives and installing contractors could be powerful, since the former has information on the technology and economics and the latter has a relationship with customers.

- **Consider top-down and bottom-up outreach approaches.**

  Efforts to promote climate-appropriate retrofit technologies can be top-down, bottom-up or both. There are pros and cons to each. By targeting people higher up in a large organization, one can potentially achieve a larger sale. However, this approach presents complications (e.g., lack of access, multiple utility territories) that have been discussed already. By contrast, starting with the facilities manager and working up the chain can be time consuming. There is no single right answer. The recommendation here is simply to think broadly about the options, and be flexible based on the organization targeted.

CONSTRAINTS ON TECHNOLOGY CHOICE

- **Recognize insurmountable constraints and cut bait.**

  In the above discussion of other factors that may constrain technology choice, several were mentioned. Of these, some are mutable. Budgetary limitations can be addressed with project financing. Preferences can be influenced with persuasive information. Contractors' and design engineers' knowledge, experience, and expertise can be increased, or the parties involved can be replaced. Recommendations for addressing these types of factors have already been discussed.

  However, there are some factors that may simply be immutable. Examples of these include the requirement to purchase American-made equipment or obtain a specific return on investment or payback period. When immutable constraints are encountered, stakeholders should recognize them as such and conserve resources by quickly moving on to promote the technology to the next potential customer (or other stakeholder).

TRIGGERS

In this section, several recommendations are presented for leveraging existing triggers and creating new ones to stimulate adoption and promotion of climate-appropriate HVAC retrofit technologies.

- **Leverage RTU performance issues to discuss retrofit options.**

  RTUs trigger their own replacement when they begin to fail. Retrofits (prior to installation) do not have that advantage, as discussed in the key findings. However, efforts to promote retrofits can utilize RTU performance or comfort issues, maintenance calls, expiration of service contracts or warranties, and RTU replacements as opportunities to open a discussion about retrofits and the benefits they provide. Distributors, contractors, design engineers, and manufacturers should all be urged to leverage such opportunities.

- **Leverage RTU purchases to discuss retrofit options.**

  The purchase of a new RTU presents an opportunity to sell a climate-appropriate retrofit to accompany it. For retrofits that are distributed through traditional channels, offering an upgrade, in the form of a retrofit, would be particularly easy to do. Distributors could embed the option in their existing technology selection process. A simple mechanism, such as a check box (literally or figuratively), could be added to the ordering form. Such a "built-in upgrade option" would likely serve as a powerful trigger for many to at least consider purchasing the retrofit. An example of this from another industry is the extended warranties on consumer goods that are offered at the point of sale. To the extent possible, the occasion of a RTU sale should be leveraged to promote retrofits in order to take advantage of the power of simple triggers.

- **Draw attention to energy costs.**

  Although electricity prices themselves cannot be manipulated by the utility to trigger adoption of energy efficient retrofits, attention can be drawn to energy costs. Customers should be prompted to explore whether they have experienced an increase in electricity bills. Similarly, energy audits should be offered to draw attention to energy use. Mechanisms like these, which stimulate customers to think about their energy costs and the potential for lowering them, can serve as triggers for adoption (or at least consideration) of retrofit technologies, and as such should be encouraged.

- **Leverage technology adoption by one stakeholder to promote adoption among others.**

  When a distributor begins carrying a retrofit technology, the contractors it serves suddenly gain access to and (hopefully) awareness of it. The same is true of design principals and their engineering staff, and contractors and their customers. The dependent nature of the industry should be leveraged to use opportunities created by adoption by one stakeholder group to stimulate adoption by others down (or even up) the supply chain.

- **Strengthen and raise awareness about rebate programs.**

  Separate and apart from their influence on customers' motivation and ability to adopt climate-appropriate retrofit technologies, rebate programs can act as triggers for adoption. As such, the recommendations provided above for improving rebate programs would also bolster the latter's power as triggers for adoption.

  Utility programs should consider incorporating language in their outreach materials that strengthens the potential rebates have for triggering adoption. For example, specific behavioral principles could be leveraged, e.g., stimulating loss aversion ("you could be overpaying for your cooling!"), imposing deadlines to overcome procrastination, or making social comparisons. To the greatest extent possible, utility programs should leverage such principles to improve the effectiveness of outreach efforts and stimulate adoption.

- **Increase training and outreach activities.**

  In addition to the other benefits they provide (e.g., increased knowledge and awareness), as described in earlier sections, training and outreach activities can serve as triggers for adoption by the stakeholders they target. Thus, more efforts should be made to train contractors, distributors, and design engineers and raise awareness of utility programs among account representatives and commercial customers. Specific recommendations on how to do this are described above. The general recommendation is reiterated here to emphasize how such activities can also serve to trigger adoption, in addition to increasing the motivation and ability to adopt retrofits.

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