Tunnel Vision: The Impact of Ignoring Behavior in Technological Innovation

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ABSTRACT

The successful adoption of new technologies and energy saving interventions is central to our clean energy future, yet energy efficiency industry R&D budgets are primarily allocated to identifying technologies, assessing their field performance, and estimating their potential impact. In this technology-centric focus, R&D efforts ignore the behaviors that need to be shaped (or re-shaped) to make adoption possible, or better yet, likely.

In this paper, the authors explore three case studies conducted with three utilities and organizations testing emerging commercial equipment. In each case, the technology saved energy in field tests, and while incorporated into the program portfolio or pilot program, adoption sputtered. Via interviews with contractors, distributors, manufacturers, installers, and customers, the authors found that market actors relied on their trusted advisors, and familiarity with the status quo of technologies, practices, and communication channels. These behavioral barriers, when left unaddressed, served to dampen the adoption of new efficient technologies.

From here, the authors make the case for R&D frameworks to study more than the technical excellence of a product. Instead, R&D must include methods to explore and account for the social factors that will allow programs to work with human tendencies to create viable and resilient pathways to change. The authors present an R&D framework that creates a parallel path to technological investigation, one that focuses understanding on the social and behavioral aspects of a technology, and identifies the interventions needed to overcome barriers introduced by them.

Introduction

The common guiding principle of R&D programs within the energy efficiency industry cluster around a call to find and assess new technologies and offerings that will create savings (of energy, demand, water, customer bills, etc.). For many utilities, this goal is of escalating importance against the backdrop of increasingly aggressive savings targets combining with the loss of the large amount of attributable savings provided by efficient lighting technologies (Livingston 2010). It's understandable then that R&D teams devote their resources to identifying and vetting the technical performance of new and emerging equipment and devices. Beyond the must have of proving that a technology can safely provide its intended utility, measuring the technical savings potential and performance of a technology is critical to identifying whether to proceed in developing it and its priority compared to other development opportunities. As technologies become market ready, laboratory, field tests and pilots can help identify in which applications and with which customer segments new equipment may create the largest impacts, and, finally, what the cost-implications are for deploying it at scale.

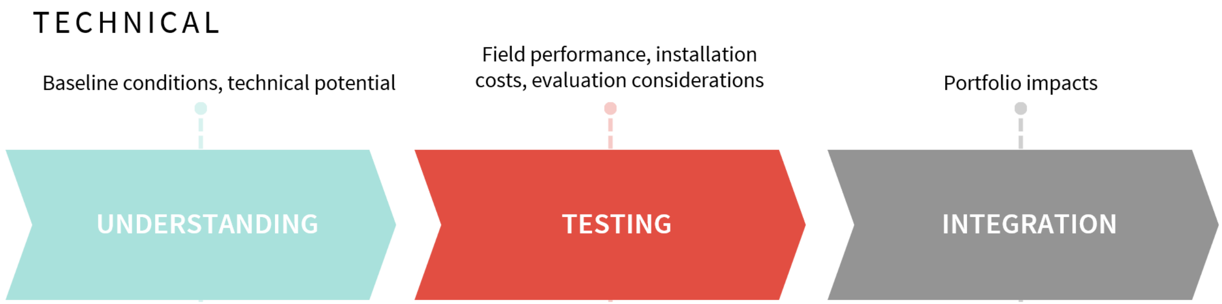

Figure 1. An example list of typical assessments made of emerging technologies within R&D programs, placed along a common developmental timeline.

Where R&D teams, frameworks and assessments often first consider human behavior is through the act of estimating a technology's market potential. This assessment is conducted to cull the more theoretical technical potential via relegating savings to only the customer segments and applications within which the candidate technology is feasible and/or cost-effective. The calculation of a technology's market potential typically also assumes some level of adoption.

And it should. The widespread and persisting adoption of energy savings technologies is inherent to creating savings at scale and meeting savings targets. But measurements of a technology's savings potential and performance, even in the field, leave unidentified and unexamined the behaviors that need to be shaped (or re-shaped) to make adoption possible, or better yet, likely.

Instead, R&D teams need to identify and understand the barriers that stymy adoption and then create, test, and assess the set of interventions (market, behavioral, etc.) that can cost-effectively overcome them. This work can and should be done as comprehensively and methodologically as the technical investigation of new technologies, and in parallel. Failure to understand key barriers, minimal effort to design or test interventions and attempts to create adoption that begin after market introduction can be too little, too late, and may result in poor first impressions, failures and experiences that are difficult to overcome.

'Like' for Like

To be clear, it's not lost on R&D teams that the newness of an emerging technology will create barriers to adoption, the impacts of which could range from necessitating training and education to significant financial intervention. Where emerging technology is similar in utility, function, design, footprint/form factor and maintenance, we often consider it to offer a near like-for-like replacement opportunity and, as such, lower barriers. That's why emerging technologies that both save energy and represent a like-for-like replacement may well be considered the holy grail of an R&D effort.

But is this assumption correct? There is evidence that the existence of like-for-like options do not guarantee adoption even if they save energy. In 2019, one midwestern utility's R&D team conducted a field study of new efficient 38-50W evaporator fan motors for walk-in coolers and freezers. The primary objective of the study was to quantify the electrical energy savings and demand reduction from retrofitting motors in small business applications across the state. Ultimately, the field study indicated that these motors reduce annual energy consumption by 52% to 83% when replacing the permanent split capacity and shaded pole motors common to the area, application, and customer segment. What's more, the retrofit process was found to be straightforward. 'As long as the technician conducting the retrofit had prior refrigeration service experience and requisite tools, the retrofits went smoothly and quickly.' In fact, based on the average electricity rate and labor costs, these retrofits resulted in a simple payback of less than 2 years (Slipstream 2019, 54-56).

The utility expanded their commercial program offerings to include rebates for these new motors. They also provided training direct from the manufacturer and through a training team supporting the implementation contractors. And yet, these energy saving and near like-for-like motors went largely unadopted.

Our team was asked to conduct research to understand the reason for the lower-than-anticipated uptake. In short, we found that contractors:

- Preferred true like-for-like replacements
- Didn't trust the product given that only one manufacturer was offering it at the time
- Felt the new motors didn't offer significantly compelling benefits beyond current products to warrant investing in training for staff and adding to their product line-ups

While the new efficient fan motors were similar enough and easy to install, the contractors we interviewed rarely, if ever, installed them. They shared that the refrigeration market is not standardized, and that with so many proprietary systems and specific configurations, they believe that replacing motors with identical models is the best way to ensure the system will run. Keeping products cool is critical for customers with reach-ins and walk-ins, and both affiliated and non-affiliated contractors expressed that identical replacements reduce risk for their customers and reduce chances of call backs for them.

Examples like this one highlight why we can't let the apparent similarity of a new technology to its incumbent convince us that minimal intervention will be necessary to spur adoption. The decades of effort, successes and failures, required to transform the residential lighting market serves as an important example of the level of market intervention required to create the adoption of a seemingly similar option (Goebes 2016). Instead, we must first gain a comprehensive understanding of what adoption requires, including the actors and barriers involved. Then we must identify, tailor and test interventions to address barriers specific to each market actor.

In the example of efficient evaporator fan motors, if the behaviors of the market actor network had been thoroughly examined in parallel to the motors themselves, this utility may have been better able to ready the local market to adopt this technology. The good news is the team was correct to target training to contractors over directly marketing this product to customers. We learned via interviews that customers tend to not be directly engaged with their refrigeration equipment, as critical to their business as the system may be. Instead, we found that customers are reliant on their repair and service contractors when making refrigeration equipment decisions.

But there is a lot to consider about contractors as the key market actors. First, contractors are generally risk averse. In interviews, contractors expressed hesitancy to try new technologies because if something goes wrong, they are responsible for it. They prefer 'tried and true' products to new ones. Some contractors are even hesitant to install a like-for-like replacement for a motor that is still working, and at least one unaffiliated contractor was adamant that he wouldn't offer to replace a working motor to save a few dollars: "if it's not broke, don't fix it."

Second, contractors rely on a short list of trusted resources and in interviews they emphasized the importance of supply houses for information about new products, new regulations, training, and even equipment warranties. At the time of our study, and as is common with emerging technologies, this product was not distributed through supply houses or distributors, but only through its sole manufacturer.

Had the R&D team ignored the seeming similarity of these motors to their incumbent and instead examined the behaviors and networks of local contractors, they may have been able to include and assess behavioral interventions in their field tests of the motors, such as offering warrantees for incentivized installations, creating opportunities for in field demonstrations of the product, and engaging distributors to assort and stock these products. From there, the team may have better been able to determine whether there exist cost-effective mechanisms to help spur adoption.

All that Glitters

Perhaps more common in R&D, we encounter emerging technologies that are notably different than their incumbent, but for which the R&D team believes the demonstrated and documented achievement of savings and other benefits is sufficiently compelling to move a market. Take for example non-residential networked lighting controls (NLC).

The 2015 U.S. Lighting Market Characterization estimated that only 18% of lamps in commercial buildings are used in conjunction with lighting controls (Department of Energy 2015, 84). While the penetration of sensors has increased in the last six years, it is likely that ample potential remains across the non-residential sector. In addition, the steep decline in the cost of sensor technology has enabled more cost-effective savings opportunity in lighting controls, including through the adoption of advanced lighting controls. LED lighting has further expanded the opportunity for advanced lighting controls compared to fluorescents, as LEDs are digital, which enables integration with controls beyond relays and timers and the ability to be dimmed to a finer gradation of illumination levels.

One of the most anticipated emerging opportunities for non-residential lighting, a NLC system consists of a connected network of individually addressable luminaires and control devices, allowing for multiple control strategies, programmability, building- or enterprise-level control, zoning and rezoning using software, and measuring and monitoring. The claimed potential benefits of NLCs include:

- Reduction in energy bills from optimized hours of use
- Enhanced control to optimize usage to match occupancy and daylighting
- Demand response capabilities
- Extension of the useful life of lighting fixtures due to lower hours of use
- Reduction in maintenance costs due to longer lives and more targeted maintenance
- Reduction in cooling system energy consumption (from less heat being introduced into occupied space)
- Asset tracking to enable location of inventory within a facility
- Light and health integration to address our growing understanding of the relationship between light and human circadian health.
- With so much to offer, why has there not been widespread adoption of NLCs by commercial customers? Two utilities have reached out to us to get help answering this

question. After speaking to customers, contractors, distributors, and manufacturers across two regions, we found:

- Lack of knowledge or awareness about NLCs across customers and contractors
- Customer understanding of the benefits of NLCs is currently limited to the value of occupancy sensing
- Customer and contractor discomfort with newer technologies, including concern about networked technology and security risks
- Concerns about the cost of NLC systems being too expensive and not having an adequate ROI over and above LEDs

It seems that the many potential benefits promised by NLC manufacturers did not function to reduce barriers to adoption. Instead, customers and contractors seemed confused and unclear, if not weary, of the NLC system complexity that enables many of the promised benefits. Would NLCs create compatibility issues, and could manufacturers promise future proofing? What about future replacements, will these products be available 5 years from now, 10? Will they still operate, or will they become 'stranded assets'?

A 2018 ACEEE study reported similar findings, highlighting first cost, complexity, and education as key barriers to the adoption of controlled lighting (Yamada 2018, 4-11). Many end-users do not understand the benefits of connected lighting, making the added cost seem unnecessary. Market actors agreed that many customers are not aware of the benefits of controlled lighting and, more generally, lack the comfort and familiarity required to adopt them. Low control adoption rates may also be compounded by a lack of knowledge among contractors. Some contractors confessed they themselves are not fully knowledgeable about more sophisticated controlled lighting measures or systems.

With so many barriers, why did some customers adopt NLCs? From our research, many of the customers who installed NLCs had one thing in common – a champion within the organization (commonly a decision-maker or primary user of the system) who was already interested in the technology and/or understood the value of an NLC system, or less common, a champion who was convinced of the value proposition by a compelling contractor.

The Role of Behavior in R&D

As the case studies above show, the technological similarity, performance or promise of a new product or technology cannot alone always ensure adoption, even when demonstrated and assessed. Ironically, as the importance of having an internal champion is to the successful adoption of an NLC system, even when a technology is designed to solve for or minimize human behavioral elements, successful technology adoption relies on human behaviors. R&D efforts would benefit from examining and shaping the social and behavioral factors that influence adoption. First, R&D teams need to gain a nuanced understanding of the constellation of market actors that use or interact with a technology, how each actor uses and considers the technology, and how actors gather and spread information and influence one another. Teams can then establish what variation from current market practices and status quos a new technology might necessitate. And from there teams can explore and test mechanisms and levers to address and overcome barriers.

The good news is these behavioral factors have long been researched and discussed. In a scoping study on energy efficiency market transformation, the authors identify a range of behavioral elements that might impact adoption of energy efficient equipment (Eto, Prahl, Schlegel 1996). These include organizational practices and customs, barriers information or search costs, performance uncertainties, asymmetric information, hassle or transaction costs, access to financing, and bounded rationality, to name a few (Eto, Prahl, Schlege 1996, 13-16). We also understand the factors that drive this behavior, as there is substantial social science research around cognitive effects that combine to create a preference for the familiar, the known, and, in the case of technology adoption, the incumbent technology or product. Specifically, the combination of a human bias towards the status quo and the disproportionate level of loss-aversion compared to gain-seeking can combine to create a situation where there is widespread reluctance to change, even in the face of a more efficient and improved alternative. Similarly, our human preference to look to those who are familiar and trusted, and for organizations to develop entrenched cultural norms, can lead to slower adoption curves. In brief, these factors boil down to change is hard and people trust who (and what) they know.

In the remainder of this section, we provide a primer on some of the key cognitive biases and behavioral effects that impact how people perceive new technologies. We also summarize social science research that points to the importance of familiarity and relationships in how humans make decisions. And we attempt to show how these behavioral barriers, when not sufficiently addressed, serve to dampen the adoption of new efficient technologies.

The Status Quo

In "Eager Sellers and Stony Buyers: Understanding the Psychology of New-Product Adoption," John Gourville (2006) draws on behavioral economics research to present the "9x" effect. This is a phenomenon whereby the creator of a new product or service values their product or service 9 times more than the customer. He derives this 9x effect by understanding the forces that lead customers to overvalue their current solution (by 3x) and for product creators to overvalue what the new product brings (by 3x) thereby creating a chasm between the value the product team sees their product bringing and the value the customer sees in it.

Gourville's 9x framework draws on several principles from behavioral economics:

- Loss aversion is perhaps the most significant of these principles. Research has demonstrated that losses have a greater impact than gains. That is, the value people place on avoiding a loss is greater than the value they place on the equivalent gain (Kahneman and Tversky 1979; Tversky and Kahneman 1991).
- The endowment effect, so titled by Richard Thaler (Thaler 1980), is the effect whereby people tend to value an object that they own already more highly than the same object if they did not already own it (Kahneman, Knetsch, and Thaler 1991).
- Status quo bias is the cognitive preference for, and over-valuing (in an economic sense) of, the item or object that a person already has. Multiple studies have demonstrated this status quo bias which leads people to prefer the things they have over something new (Kahneman, Knetsch, and Thaler 1991).
- The "curse of knowledge" is the phenomenon when people have a piece of information or understanding, they tend to have trouble imagining or predicting what others without that information will do. In studies, people overestimate the ability of others to find a hidden object if they know its location, or to solve a puzzle if they know the answer (Kennedy 1995). Gourville points out that technology developers experience this when they overestimate the likelihood of people to adopt their product.

In the context of technology adoption, the implication of these cognitive biases is that people may be attached to their current solution over a new technology, even if the new technology provides advantages in terms of efficiency, convenience, cost savings, or other benefits. Similarly, program teams and manufacturers may overestimate the relative benefit of their program or solutions due to the "curse of knowledge." ln the 1996 scoping study, the market barrier of "bounded rationality" or relying on a "rule of thumb" in making decisions captures this same phenomenon (Eto, Prahl, and Schlegel 1996:15).

To combat this 9x effect, Gourville suggests that product developers consider the behavior change they are asking of customers to adopt their product and to focus on what the tradeoffs are between the current norm and the new product behavior. He suggests that products that offer significant increase in product value without requiring a significant behavior change may be easier for customers to adopt. In the case described above of the efficient evaporator fan motor, contractors strongly valued the status quo of shaded pole motors. Although additional savings were achieved in the field tests, that was not sufficient reason for contractors to shift their practice. The manufacturer and program team overestimated the impact of these preferences for the status quo when introducing this new measure.

Gourville notes that those products that offer significant product value but require significant behavioral changes for customers (i.e., moving further away from like-for-like replacements) will require an even longer ramp-up period and more opportunity for gaining familiarity with the product.[1] For example, in the case of NLC, few customers were using the system to their fullest capacity, instead using the systems more for simple occupancy sensing. At this point, occupancy or motion sensor devices have become more familiar to customers and therefore were more easily adopted than some of the more complex systems that a true NLC offered.

Culture and decision-making

Another critical element of the status quo is the impact of culture, at an organizational or household level. In a commercial context, the sense that there is a norm for how things are done—and indeed, these may be so engrained as to lack conscious reflection—is a hallmark of 'culture.' In commercial contexts, one arena where culture is often at work is in decision-making processes which often include processes that are institutionally engrained. In the context of technology adoption and decision making, understanding cultural norms that may shape product use or adoption—that is, understanding how "things are done around here"—is tremendously beneficial in any attempt to intervene in the status quo. The decision-making process in an organization is likely to differ or be shaped by the organizational culture, so understanding how decision-making works within an organization can be useful for identifying moments or opportunities to intervene. Similarly, understanding components of an organization's culture, such as relative tolerance for risk can aid in assessing the likelihood of a new technology to be adopted. Organizations with a relatively higher level of risk tolerance and a more flexible, dynamic orientation may be more likely to be on an earlier adoption curve. Conversely,

[1] We note that Gourville builds on Roger's theory of diffusion which provides a framework for understanding how new technologies move into wide-spread adoption (Rogers 2003). First introduced in his 1962 book, Rogers identifies 5 stages of decision-making that inform adoption: knowledge (or awareness), persuasion, decision, implementation, and confirmation (or continuation). He also outlines five categories of adopters based on the relative brevity or length of their adoption process: innovators, early adopters, early majority, late majority, and laggards. These categories are widely used to describe technology adoption to the point where 'early adopter' has become part of common parlance in the industry.

understanding that an organization has a lower risk tolerance and less flexibility in practices may require different sales strategies, more real-world, practical examples, and different sets of trainings as a new technology or intervention is adopted.

In the case of the efficient evaporator fan motors, we can see these effects in practice. In this case, contractors were the key market actor affecting the uptake of this measure, as contractor recommendations drive the equipment choices of their customers. Contractors knew that a refrigeration failure is a serious concern for their customers, so they relied on the motor types and makes that they were familiar with and trusted. Contractors were hesitant to make any changes to their current practices that had been working well. By contrast, the manufacturer and R&D team focused on the increased potential savings and overvalued the importance the savings opportunity would have for contractors. In part because of this expectation that the new product offering would be valued in the same way by contractors as it was by the program staff and manufacturer, there was not sufficient scaffolding or framing to convince or persuade contractors the value in switching.

The habits and cultural norms around how and when contractors made recommendations, the rules they followed about when to recommend a repair vs. replace, and the other market actors they interacted with (e.g., suppliers/distributors, customers, competitors, etc.) all reflect cultural norms within the ecosystem. Merely including a new measure in the program was not sufficient to overcome these cultural norms and habits.

Familiarity bias

Humans are social creatures, and we make choices within our specific context, not a vacuum. Cultural norms and organizational cultures shape not only people's actions or behaviors, but how they understand and explain those behaviors. This includes how people within an organization look to others for guidance in decision making, how authority and trust work within an organization, and how leaders and influencers gain their status within an industry.

Studies have shown that people tend to choose the more familiar option, even if it is not as ideal in objective terms as the alternative. This bias can be understood in the context of increased feelings of safety and security around known options, that is, a familiar option entails less risk and is cognitively less challenging because it requires a reduced mental load in decision-making (Park et al. 1981). This cognitive bias operates alongside the status quo bias (described above) and can result in a preference for a known or familiar option.

In the context of group dynamics and cultural norms, a preference for what is familiar is an indicator of pro-social behavior as individuals look to their social networks to gauge their behavior and concept of norms. In effect, familiarity and status quo bias extend not only to how an individual behaves, but to other individuals within their network Understanding who an individual understands as their peers, competitors, advisors, and aspirational figures can clarify the range of considerations they may make and the technologies they may be familiar with.

With an understanding of a given market actor's broader network, a program could provide more tailored information addressed to the audience. For example, in the context of NLC, we saw that the successful adoption within a business often relied on an individual champion. While not always the business owner, these champions were in positions of decision-making or other authority to be able to create the necessary change to normal practices to adopt and use these systems consistently.

An Expanded Framework

The authors of this paper present a framework that expands on common research and development efforts, largely driven by engineering principles, to include a parallel examination built from social and behavioral science. Using this dual-path framework, R&D teams assess the potential of a given technology in two ways. One is a technological pathway, which focuses on establishing the technological viability and savings potential of a product. The second is a market pathway which focuses on understanding the key behavioral factors of the relevant market actor network and identifying and testing interventions designed to cost-effectively integrate the product into a program or portfolio.

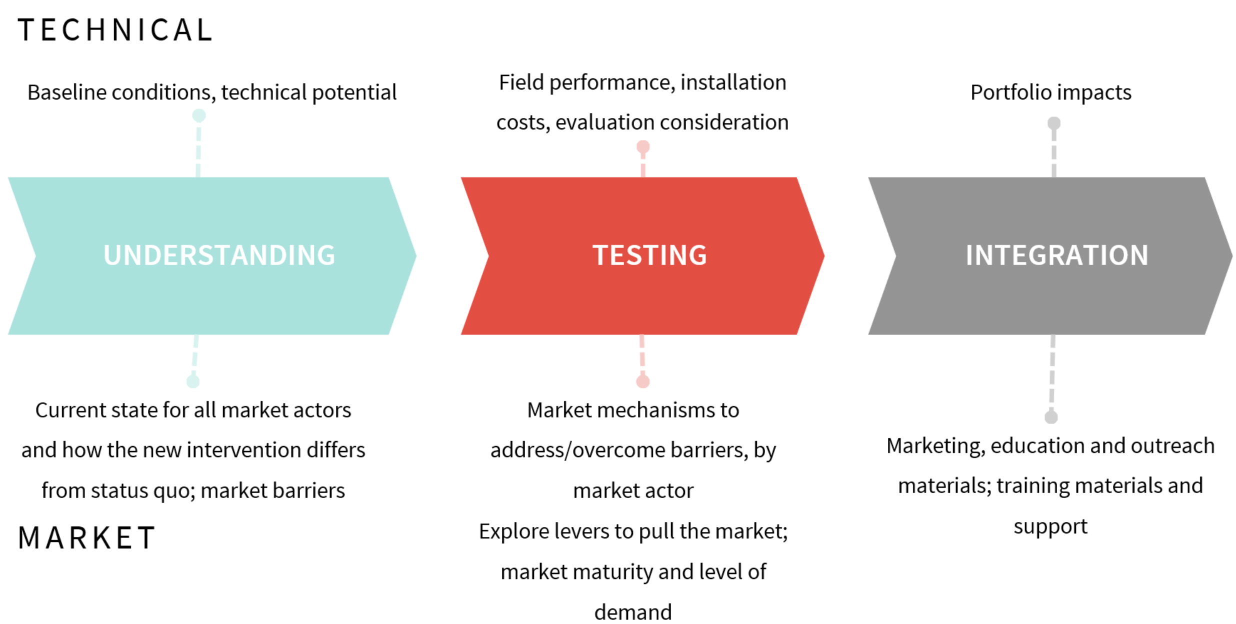

Figure 2: A parallel path framework enabling the assessment and development of the market and technical aspects of emerging technologies.

Just as the technical pathway has tests and research efforts at each stage, the market pathway includes a set of staged research activities designed to assess market maturity and readiness, identify and test interventions and support integration. Crucially, this framework requires conducting this research at an early stage and in parallel with the technological examination to enable an R&D team to shape and ready markets for new products.

We describe the details of this expanded framework below.

Understanding

In this initial phase, R&D teams need to understand three key things: baseline conditions and practices, technical and market potential, and key market actors and networks. R&D teams establish baseline conditions to understand market applicability and ultimately to estimate the technical and market potential of a product. On the market side, establishing baseline practices, or current state for all key market actors, includes understanding the current practices, networks and interactions typical between market actors.

Understanding baseline practices allows teams to assess market readiness by identifying the variation in practice needed to create adoption and the level of intervention required to overcome behavioral barriers. In this framework, teams can consider the comprehensive viability of the technology across the estimates of its technical potential, market potential and market readiness.

Social Network Analysis

One tool that R&D teams can use in the Understanding stage is social network analysis, a tool used by social scientists to map formal and informal social relationships and networks (Otte 2002). In these maps, nodes that are closer together have more influence on each other, while those further apart have less influence. Similarly, larger nodes exert a greater influence than smaller nodes. This network analysis is grounded in Actor-Network Theory which is a theory of understanding actions in the context of shifting networks of relationships, in which human actors are only one component alongside ideas, processes, and objects (Latour 2005).

In the context of understanding technology adoption, understanding who people in a specific industry or company look to for guidance, what sources they turn to when learning about product, and who they see as their competitors, all can be important in understanding how a specific technology might be taken up more substantially in one business, industry, or region than another.

Identifying these networks of influence and how different actors within a market are connected can enable an understanding of the status quo (addressed above) and the range of actions and frames that will likely be familiar to a particular segment or group. For instance, the importance of supply houses in providing training and product recommendations to contractors may be an important consideration for utilities to consider as they introduce new and emerging technologies into their programs. Working with distributors and supply houses as partners, not only through rebates (as in a midstream program), but through enabling supply houses to be ambassadors for a particular product.

Understanding how new interventions or technologies require individuals or systems to change can allow R&D teams to address them. In the NLC studies described above, the instances where there was a successful adoption and integration of NLCs were all cases where there was an internal champion within the organization who spearheaded the effort and ensured that, once installed, the systems were used as designed. If we were to produce a network of influence for these cases, we would find that the champion of the technology had significant influence over others in the organization and hence was able to create buy-in across the organization.

At this stage in the process, identifying and understanding networks of influence along with the status quo and the norms and practices of various market actors can enable an R&D team to design effective interventions to leverage networks of influence and address barriers related to reliance on a status quo.

Testing

In this phase, teams conduct pilots to assess field performance, installation costs, and, if necessary, evaluation considerations. Where possible, teams use these pilots and field tests to also test and assess market mechanisms and behavioral interventions designed to improve market readiness and spur adoption. In some instances, piloting market mechanisms and other interventions can serve to soften markets, via creating critical demonstrations, case studies, and even beach heads of key market actors.

Teams should assess these pilots to understand the efficacy, cost-effectiveness and scalability of these interventions. The ability to test for both the performance of the technology itself as well as the efficacy of various interventions better enables teams to make the critical decision of which technologies to integrate into offerings.

Decision-making and prioritization

One of the challenges of R&D, especially across diverse offerings, is the capacity to meaningfully compare emerging technologies to identify which to prioritize. Similarly, as teams shift from looking only at widgets to include innovations such as energy efficiency as a service, new delivery mechanisms, or new models of financing, comparing different interventions this effort can be mind-bendingly complex. Not just a comparison of apples to oranges, it can feel like a comparison of apples to shoes or fish to bicycles.

In these cases, we find that this dual-path framework can be a tool to aid decision making and compare technologies and interventions across a portfolio. Specifically, we consolidate the technical side to a savings estimate and the market size to be a qualitative assessment of magnitude of barriers and then represent these on a matrix to show the balance of savings opportunity and relative magnitude of barriers to adoption and the team's confidence in overcoming them.

While this kind of matrix visualization can be helpful in the abstract, where we see its greater value is in enabling comparisons between emerging technologies and opportunities. Using potential portfolio-level savings on one axis and an assessment of level of barriers/difficulty of overcoming behavioral barriers on the other axis can provide a framework for comparing the very disparate interventions that R&D teams are now considering. Such comparisons can support a team in making decisions around where to prioritize funding for new pilots or projects. Those interventions with high savings and low barriers can be prioritized immediately, while those with high savings and larger barriers can be longer term priorities, while those with lower savings and high barriers can be deprioritized.

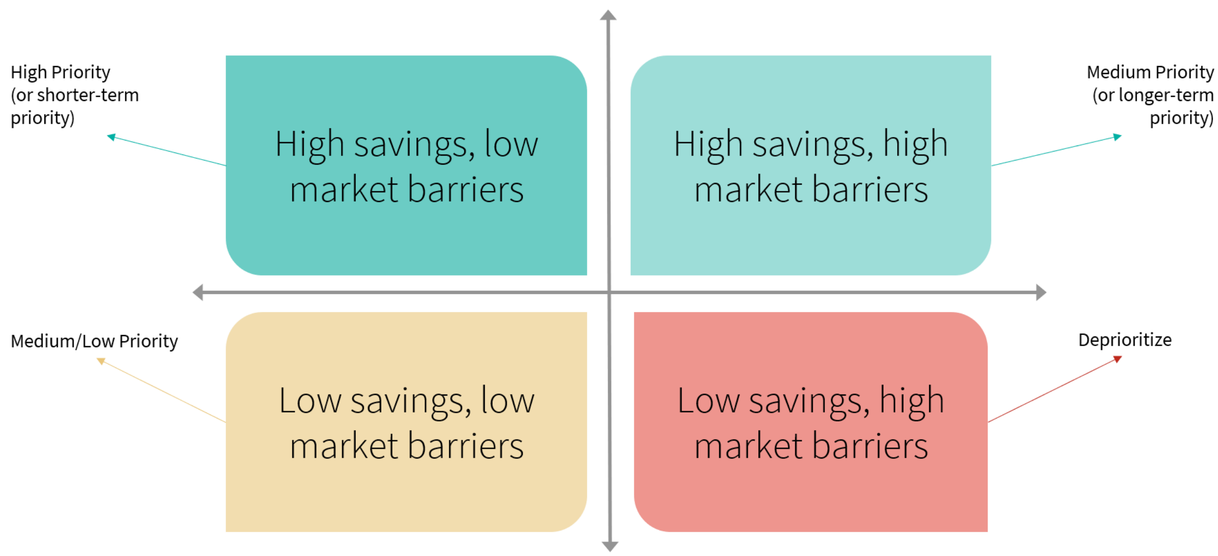

Figure 3. Prioritization matrix of emerging technologies

The authors recognize that the matrix above offers the semblance of clarity but the trick of it is in establishing the decision-making criteria that determines the thresholds. For this matrix to be a useful tool, an R&D team will need to assess where the dividing line between low and high savings is (the point at which the X-axis intersect the Y-axis) and similarly, the team will need to identify a consistent way to gauge barriers and the magnitude of those barriers to adoption on the market side. For one client of ours, we use a framework looking at the difference from the status quo for key market actors to assess the magnitude of market barriers – where the difference from the status quo is greater, the barriers are likely to be higher. We use this framework based on the behavioral science cited above that suggests there are strong cognitive biases toward what's known and familiar.

In order for a comparative tool like the matrix to work, it needs to be applied consistently, and this requires decision-making as a team. And this, in turn, may require reflection on how even as R&D professionals we are also humans and subject to these very same cognitive biases that impact contractors and customers. We may have preferences for some technologies, end-uses or market segments based on our own experiences and previous work that impact how we place value or consideration on the findings of a given study. Tools such as this matrix can help to ensure that across a team and across projects, we are able to compare our findings, perhaps a bit objectively. But at the end of the day, we're only human.

Integration

At this phase, teams work to integrate the technology into an offering or portfolio. Technical considerations include portfolio impacts at scale and costs at scale. On the market side, R&D activities include developing and executing training content for contractors, distributors, or program staff, and/or developing marketing and outreach materials to raise awareness for customers or other market actors.

Conclusions

Responding to aggressive savings goals and the realities of climate change requires big changes. And we know that big changes and unfamiliar things often make humans uncomfortable. Great design, while compelling and even when proven, cannot overcome the greater challenge of changing human behavior: (1) people tend to live their lives in largely unconscious patterns, and (2) they trust who (and what) they know. Even when humans are convinced that change is needed, it is still difficult.

Using a dual-path framework in the R&D process, the industry can assess and develop the potential of a given technology or intervention across both its performance and market opportunities. Conducting this work in parallel with the technical research on savings and performance in the field can enable an R&D team to develop and meaningfully test the mechanisms needed to address social barriers and to create the widespread and persisting adoption necessary to create savings at scale.

References

Department of Energy Office of Energy Efficiency and Renewable Energy. 2015. *2015 U.S. Lighting Market Characterization. Washington D.C.: Department of Energy*

Eto, Joseph H, Ralph Prahl and Jeff Schlegel. 2016. *A Scoping Study on Energy-Efficiency Market Transformation by California Utility DSM Programs.* Berkeley Lab

Goebes, Marian D., Michael Mutmansky, Doreen Caruth, Adam Scheer, Brian A. Smith and Robert Kasman. 2016. *Clearing the Path to Market Transformation in the Rapidly Evolving World of Residential Lighting.* ACEEE Summer Study on Energy Efficiency in Buildings, https://www.aceee.org/files/proceedings/2016/data/papers/2_677.pdf

Gourville, John. 2006. *Eager Sellers and Stony Buyers: Understanding the Psychology of New Product Adoption.* Harvard Business Review. https://hbr.org/2006/06/eager-sellers-and-stony-buyers-understanding-the-psychology-of-new-product-adoption

Hinds, Pamela J. 1999. *The curse of expertise: The effects of expertise and debiasing methods on prediction of novice performance*. Journal of Experimental Psychology: Applied. 5 (2): 205–221. doi:10.1037/1076-898X.5.2.205.

Kahneman, D. & Tversky, A. 1979. *Prospect Theory: An Analysis of Decision under Risk.* Econometrica. 47 (4): 263–291. CiteSeerX 10.1.1.407.1910. doi:10.2307/1914185. JSTOR 1914185.

Kahneman, D., J. Knetsch and R. Thaler. 1991. *Anomalies: The Endowment Effect, Loss Aversion, and Status Quo Bias*. Journal of Economic Perspectives, 5 (1): 193-206.

Kennedy, Jane. 1995. *Debiasing the Curse of Knowledge in Audit Judgment*. The Accounting Review. 70 (2): 249–273. JSTOR 248305

Latour, B., 2005. *Reassembling the Social: An Introduction to Actor-Network-Theory.* Oxford: Oxford UP.

Livingston, J., J. Callahan, and R. Fedie, 2010. *The E3T Framework: Fast-Tracking Emerging Technology Development in the Pacific Northwest.* In *Proceedings of the 201 ACEEE Summer Study on Energy Efficiency in Building*. Washington, DC: ACEEE. https://www.aceee.org/files/proceedings/2010/data/papers/2041.pdf

Otte, Evelien; Rousseau, Ronald. 2002. *Social network analysis: a powerful strategy, also for the information sciences.* Journal of Information Science. 28 (6): 441–453. doi:10.1177/016555150202800601

Park, C. Whan; Lessig, V. Parker. 1981. *Familiarity and its impact on consumer decision biases and heuristics.* Journal of Consumer Research. 8 (2): 223–230. doi:10.1086/208859

Rogers, Everett M. 2003. *Diffusion of Innovations.* New York: Free Press.

Samuelson, W., R. Zeckhauser. 1988. *Status quo bias in decision making*. Journal of Risk and Uncertainty. 1: 7–59. CiteSeerX 10.1.1.632.3193. doi:10.1007/bf00055564.

Slipstream. 2019. *Q-Sync Motor Performance in Walk-in Coolers and Freezers.* Madison, WI: ComEd. https://slipstreaminc.org/sites/default/files/documents/publications/q-sync-motor-pilot-project-final-report-public-20191009.pdf

Thaler, Richard. 1980. *Toward a positive theory of consumer choice.* Journal of Economic Behavior & Organization. 1 (1): 39–60. doi:10.1016/0167-2681(80)90051-7.

Tversky, A., D. Kahneman. 1991. *Loss Aversion in Riskless Choice: A Reference-Dependent Model.* The Quarterly Journal of Economics, Volume 106, Issue 4, November 1991, Pages 1039–1061, https://doi.org/10.2307/2937956

Yamada, Mary; Mellinger, Dan; Lawrence, and George; Goetzler, Bill. 2018. *Lighting isn't Finished: Pivoting beyond the LED Bulb.* ACEEE Summer Study on Energy Efficiency in Buildings