ILLUME

INGENUITY AND RESILIENCE

2020

WHAT'S INSIDE

We are proud to share the second volume of ILLUME's annual publication, *Ingenuity and Resilience*. This year, we chose to take on the most pressing topic of our time: climate change. As we examine the path forward in these pages, we have chosen a "yes, and" approach. Yes, we need to dramatically change our energy infrastructure to achieve the mandates set for us by our fellow citizens, our state governments, and the international community. And, we see a path forward that is equitable, sustainable, and profitable.

Yes, as experts in this field, we know that there are no easy solves. And, we feel that we are uniquely positioned to articulate a way forward from the view of the consumer, discussed in three important themes: beneficial electrification, a just transition, and technological ingenuity. We believe these three themes serve as a guide for our industry during our most pressing call to action. In these pages, we call out bright spots and opportunities without glossing over where we must do better. Throughout, we hope we provoke thought and provide inspiration. Thank you for giving us your precious time.

Let's Take Off Our Rose-Colored Glasses.

The climate is changing rapidly, and we have a short, 10-year runway to avoid irreparable harm.[1] We're putting climate in focus because our responsibility to act as industry leaders has never been more pressing. We need to get clear fast and move with urgency.

As strategists, we have to make decisions with a limited understanding of the future. We cannot predict the future, nor can we will our version of the future into being. Instead, we must determine the conditions that will influence our future and determine how to maneuver, toward our goals, within those conditions.

There are two truths, one environmental and one social, that we have to contend with to design the policies, programs, and interventions necessary to ready our communities for climate change.

Truth 1. The impacts of climate change are occurring now. And they will continue to occur with greater frequency and devastating effects.

Truth 2. Income inequality is growing. The wealthy will continue to amass more wealth. The poor will get poorer.

Solving for climate and equity is the critical work of our time. Now that our glasses are off, how might we act in light of these truths?

"The future is already here—it's just not evenly distributed."
– William Gibson

This quote is often used to describe innovation, but it works on multiple levels. When examining responses to climate change, this quote makes us question: What environmental and social events are occurring now that indicate how we might respond to climate challenges in the future, if the status quo is maintained?

Grids

Pacific Gas & Electric's (PG&E) recent forced blackout was an aggressive response to growing wild-fire risks that left roughly two million people in the dark.[2] Brought about by a complex combination of suburban sprawl, poor land management and maintenance practices, and climate change, it is a clear example of the inequities built into our adaptation to a changing climate.[3]

PG&E's Public Safety Power Shutoffs (PSPS) highlight the equity issues that are inherent to our response to climate change. People who can afford to deploy back-up generators or solar-and-stor-age solutions will have the luxury of flipping the switch, while disadvantaged populations will bear the burden of going days without power.

Vulnerable people suffered the most from the shutoff—the elderly and people with disabilities who depend on medical equipment at home—as did low-income families who faced food insecurity without refrigeration.[4]

Nets

Income inequality is at its highest level in the U.S. since the Census Bureau started tracking it more than 50 years ago.[5] According to a recent report released by the Federal Reserve, 50% of U.S. residents hold less than 10% of total assets. Further, the wealth share of the bottom 50% has dropped by 2.4% and the wealth share of the 50 – 90% has dropped by 6.5% from 1989 – 2018, indicating that the middle class is, in fact, disappearing.[6]

Safety nets are a perfect description of how we have dealt with economic inequality. Have you ever tried to pull yourself out of a net or hammock quickly? It is nearly impossible. So is adapting to sudden change when you are living paycheck to paycheck.

Our social safety net programs are band aids, not vaccinations, and our energy programs are no different. To address the heart of the challenges ahead, we need to re-envision how we think about the intersection of resiliency and the economics of day-to-day life. No amount of weather stripping will help a person save for first and last month's rent when they need to move out of a floodplain.

It is in our collective best interest to tackle climate change and inequality. It is in utilities' best interest as well. We must ensure that the public can afford power, as well as work to alleviate the growing disparities between those who can afford to adapt and those who cannot.

Chairs

We need to approach problems differently. As social scientists, we know that our social, political, and cultural environments determine how well we will weather our greatest challenges.

First, we need to think small to impact big changes. To tackle our biggest challenges on micro levels we need to focus on communities. By bringing communities to the table, we can begin to co-create energy programs and policies that suit the unique needs of the regions we serve. What types of technologies are customers interested in receiving? How might they be delivered? Who should own these assets? How might they be paid for? These questions will serve as the building blocks to savvier, more resilient energy resources.

Second, we need to take seriously the challenges of vertically integrated utilities. Our current electric grid is failing us. Old, big, and inefficient, it no longer serves the demands of our societies and climate. We need to save the role of the utility while we transform our grid. Here's why.

Utilities have a mandate to serve. And we need them to continue to serve. Big tech and Silicon Valley are not held to the same standards of service. We quickly fetishize new technologies and cast them as a panacea to our problems, but the reality is that innovation with effective regulation is, and has been, the only mechanism to ensure that the interests of the public are maintained. This is how the benefits of industrial advancements are democratized.

There are roles utilities can play that no other entity can:

1. Democratizing emerging technologies so all benefit from innovation
2. Creating data and interoperability standards that foster ingenuity and reliability
3. Enabling connected platforms and networks for a responsive and adaptive grid
4. Building utility-connected microgrids with sufficient redundancies in generation and storage
5. Centering human resiliency in infrastructure design, development, and evaluation

So, how might utilities maneuver in the future? Val Jensen's interview on the following pages offers excellent insight into how Exelon is thinking about the challenges of climate change and poverty. In *From Grid to Human Resilience: Lessons from Public Health*, we explore how we can shift our framework for resiliency from one that responds to emergencies, to the daily act of preparing communities for the impacts of climate change. In *Get Smart! Applying Smart Thermostat Lessons to DERs* we offer ways in which the implementation of smart thermostats provide a playbook for utilities to scale DER technology adoption and drive participation in programs essential to creating an adaptive grid. While in *Reach Anxiety,* we argue that barriers to EV affordability are making it more difficult for cities and states to achieve aggressive EV mandates. Throughout this magazine, we shed light on the issues of climate and equity and the solutions that can make a dent in our biggest challenges.

VAL JENSEN

Sees the Future, It's Connected Communities

ILLUME Co-Founder Anne Dougherty *sits down with Val Jensen to talk about his role as Vice President of Strategy & Policy at Exelon Utilities, the utility of the future, equity, and connected communities.*

You've recently assumed a new role at Exelon, tell me about it.

A little over a year ago, I moved over from Commonwealth Edison (ComEd) to take a new job—a newly created job—to manage strategy and policy for the combined Exelon utilities. My job is to work with each of the six companies, and all of them collectively, to develop a strategy for how the utilities will evolve and to establish the policy that will enable that strategy.

What does that look like for you day-to-day?

It has two big pieces as the names implies—strategy and policy. The strategy side began with a fairly high-level sketch of what our strategy would look like that we presented to the board last September and they approved. Since that time, we have been working to identify the specific capital investments that would be needed in our grid infrastructure and our customer infrastructure to accomplish that strategy.

The second part of the job is working with each of the utility companies to identify policy investments—the policy areas that we want to focus on—that enable the capital investments that will ideally be accepted by policymakers. Our current focus areas include electric vehicles, storage, energy efficiency, distribution planning, and decarbonization.

> "Affordability is code for income insecurity, for not having enough money to afford everything needed to lead a safe, healthy life."

What would you define as success in your role?

This is a long game. We're looking at 2030 in the shortest term but realize that this will play out beyond that. To explain this, I need to explain the strategy itself.

We began a number of years ago to try to answer the question: What is the utility of the future? Like most utilities, we spent a lot of time looking at trends in distributed energy resources and customer behavior and realized after three or four years that it was a completely unsatisfying exercise.

We were trying to predict when certain things were going to happen and then determine what kind of behavior we would need to respond to that. We realized that these trends were always changing.

We stopped in our tracks and asked ourselves, **"What do we believe is true? What do we know to be true about the world that we operate in?"**

We came up with a pretty short set of things:

1) Technology will continue to get better, faster, smaller, cheaper, more interconnected, more powerful.

The technology that is fundamental to our operation, or tangential—technology that our customers use—had been and will continue to get better in many ways irrespective of us.

2) Customers want to be in control, and they want choices.

As managers of natural monopolies, we have been lulled into believing that customers like and expect to be served by a monopoly utility. We forgot that, given the chance—and that chance is increasingly enabled by technology—customers will make choices that erode monopoly position. There is no monopoly in history that I'm aware of that has survived the onslaught of technology.

These truths, combined that with the fact that the climate is being profoundly changed as the result of the things that we do, quickly gets you to a set of plausible futures.

That's where we had been a couple of years ago. The world can only look certain ways given these core truths. We then added onto that an understanding of what our business was. I think most utilities have continued to believe that they are purveyors of kilowatt hours. It became clear to us that that's not what we do.

We are restructured. We operate in restructured states. Kilowatt hours are not something that is core to our business. I know that sounds strange, but we really just operate these networks—these increasingly digital networks—that connect customers to suppliers, and suppliers to suppliers. We connect people to make it possible for them to do what they want to do. And yet, we have this business tied to kilowatt hours. This inevitably led to the question, what business are we in?

We landed on an idea that has become quite popularized in the past couple of years: We are a platform. We enable and curate transactions. Fast forward to a year ago, we have these truths and this business model, but what we were lacking was a sense of how those ideas could be combined to produce an actionable strategy.

One of my pet peeves about strategy as practiced is that it's too often seen as an exercise in predicting and responding. In fact, I think strategy is about being very deliberate about what we want to happen or to become, and then pursuing those options that have the highest likelihood of getting us closest to that place. Accepting that even the most deliberate strategy is probably not going to perfectly hit the mark over time, the probability that it misses the mark is way higher if you don't even know where or what the mark is.

To make this long story shorter, we decided that we wanted to deliberately build what we called connected communities. We have a long and rather formal definition of what those are to us, but when you boil it down, it's a 21st century version of the public service company.

That fact that we're physically connected to literally every entity in our jurisdiction creates an opportunity to use those links to enable not only more energy service transactions, but more social and economic connections as well. We can help connect communities within our cities and ensure that the places we serve remain vital and healthy and growing.

I can't pick up and move to Arizona and start a utility. I'm stuck in Chicago and Washington and Philadelphia and Baltimore. My future rides on the future of those communities and we want to be very deliberate in our work with these communities to build healthier, more connected places for our customers to live and work.

As we spent more time thinking about how to turn these ideas into something real, it occurred to us that we had some growing up to do. I don't mean that flippantly. We thought about the journey from here to the connected community as a maturation process, a process of acquiring the capabilities our network would need to function as the platform for connected communities. We concluded we need four sets of capabilities.

Those capability sets include **(1)** getting really good at reliability and customer service, **(2)** becoming more sophisticated about security and resiliency; ensuring that this platform can overcome challenges both physical and cyber, **(3)** creating increased choice for our customers through distributed energy resources, accommodating—fairly and efficiently—all of the resources technology is bringing to our cities, and **(4)** decarbonization, building on the other three stages to help our cities decarbonize. This is a combination of enabling customers to connect to zero-carbon sources of electricity and converting end uses that use fossil fuels to electricity, starting with transportation.

Taken together, this vision represents significant capital investment. What we are going back to the board with this year is a much more detailed manifestation of the high-level picture we presented last year. We're still aiming for connected communities but showing them what we need to invest in and build to enable that to happen.

The strategy for me is reinventing this business, and the exciting work now is helping our six utilities figure out how they work with their six communities to make this connected community a reality.

For example, in Chicago there is a neighborhood called Bronzeville that we're working with to explore how microgrid technology can be combined with distributed energy resources and some really interesting ideas about how customers relate to one another to build a ComEd version of the connected community. We are looking at similar efforts in disadvantaged communities in Washington, Philadelphia, and Baltimore. The theory is that these initial communities are seeds being planted in our six jurisdictions. As we make further investment, the number of connected communities within our territories grows to the point that we ultimately have a very different kind of utility that is much more **distributed, decentralized, democratized, decarbonized**.

> *"I can't pick up and move to Arizona and start a utility. I'm stuck in Chicago and Washington and Philadelphia and Baltimore. My future rides on the future of those communities and we want to be very deliberate in our work with these communities to build healthier, more connected places for our customers to live and work."*

What do you view as the role of these competing businesses—the Teslas, Googles, and others—that are looking to bring distributed generation and other IoT (Internet of Things) technologies that are not necessarily interoperable into the connected future?

Our platform, if it works well, allows the customer to connect to whomever they want to for energy service. My job is to make that connection possible and efficient. That's the job I feel like I'm pretty good at as a utility. In fact, the more Googles and Teslas and others who use my platform to connect with customers the more valuable my platform becomes. By establishing that value, it's easier for me to make the case to policymakers that I need investment in the platform to facilitate these kinds of transactions. So, in the near term, these third-parties are really valuable to our customers and our business model generally.

If a customer continues to plug into my network, it's not so essential that she gets everything through me. But there are some utilities that hope to own the behind-the-meter customer relationship and obsess about losing their connection with the customer. I would agree that losing touch with customers is a bad thing with bad consequences in any business. Hope is not a strategy and there are many ways to remain relevant, all of which, in the end, boil down to finding ways to bring more value to that customer. I don't think we can do that by ourselves. But I do strongly believe that I can do that by being the platform that allows my customer to wring more value out of her connection to the grid that we run.

I'm never going to be as innovative or quick-to-market or flexible as a start-up. Our solution—which is still to be tested by time—is to at least make sure that if this start-up has a product or service my customer might want, I help make it possible for my customer to get access to it. Whether that ensures long-run business success for me, I can't say. But I do have a strong sense that if I can't make it possible for my customer to get access to it or worse, if I deny access to it, I'm one step closer to oblivion. I will focus my capacity for innovation on making my platform as easy to use and efficient as possible.

To your question on interoperability, I think it's to everyone's advantage that there be at least some basic level of interoperability such that everybody can plug into the grid and use it to do what they need to do, accepting reasonable limits to ensure reliability and security for all customers. One of the enduring lessons I chose to take from the Apple story is that if you build a closed system, you've locked yourself out of a majority of the market. Maybe it's not exactly a "let a thousand flowers blossom" situation, but I do think it is the right and the wise approach to let our customers have access to as many products and services as possible. Our job will be to help curate and facilitate.

One of the first pillars of your strategy is one of resiliency and reliability—the primary mandate of a utility alongside equity. How do you set yourself up to provide this as you are working in a world with so many actors on the grid?

Really good question. We've approached it from a couple of different angles. The one that has dominated most recently emerges from our thinking about climate change. We began with a really serious look at what it would take to limit temperature rise to 2°C. Tough problem, but there are pathways to the result. However, as we pursued that analysis we began to be dogged by the question: What if China or India doesn't think the way we think about mitigation? What if not every country, state, city, and business actually does what is needed to limit emissions sufficiently? Put aside the fact that we might invest lots of money in things that ultimately don't produce the result we needed. If we do not succeed in limiting temperature rise to 2°C what climate change-induced impacts will we be faced with and what will it take to adapt to those impacts?

> "We're trying to rethink affordability from the ground up."

That led us to an exploration of climate change vulnerability and to an initial look at the investment that would be needed in the grid to enhance its resilience in the face of climate change impacts. The obvious first-order conclusion was that our systems were not designed to be resilient in the face of increased storm frequency and severity, sea level rise, and extreme heat. Resilience in the days when this system was being built went hand in hand with building a large, interconnected system. I think that interconnectedness is still a huge piece of what resilience means. But with distributed energy technology and control systems getting better and better, resilience can be enhanced through a more distributed grid; the system can be made less brittle, so that major events won't necessarily be catastrophic.

How is Exelon thinking about equity, and where do you see that playing in the future of connected communities?

We probably are not as precise as we could be when we use the word "equity." Sometimes we mean that people in like circumstances are treated similarly, sometimes we mean that everyone has access to the same options, and often we use equity as shorthand for affordability and specifically affordability for those customers facing economic hardship. Each of these meanings presents some challenges that we collectively need to work through. But affordability for us is a threshold issue for the industry. I think that either we exert some leadership, think differently and help figure out a more comprehensive and sustainable way to ensure affordability, or we greatly diminish our right to shape our own future.

The traditional approach, as you know, has involved some combination of charging certain people less to make it easier to pay bills, giving away money to people who can't pay their bills, and low-income energy efficiency.

Giving the money away is, if you really think about it, really about finding ways to pay ourselves—the utilities. That money just gets recycled. The energy efficiency piece is sort of interesting but it's completely inadequate to the problem. We've been spending a huge amount of time with not terribly great results.

Affordability is code for income insecurity, for not having enough money to afford everything needed to lead a safe, healthy life. And that puts the issue of affordability, in some peoples' minds, way beyond what the utility industry can resolve. We get that. But acknowledging we can't solve the problem by ourselves doesn't mean we have to accept that the things we currently do are the only things we can do.

Income insecurity is a problem that affects close to 30% of our customers, which means it is deep within our communities. So, we're trying to rethink affordability from the ground up and to re-envision how we would approach this with some combination of traditional financial assistance and energy efficiency, rate design and billing reinvention, community development, workforce development, innovative community-based energy projects, and access to clean transportation. All of the dimensions of community building that, taken together, add up to whether a household can afford to participate in this energy economy. This, in many ways, is the essence of the connected community we want to help build.

I'll quickly add that we don't know how to do this. It's probably fair to say it isn't a core competency. So, we are trying to assemble a group of smart people from around the country to start a conversation of what affordability and access means in the utility industry. Can we collectively change how we think about this problem and get some ideas that are more comprehensive, more sustainable, community-based and (the toughest one) more scalable. The way we are doing this now is not ultimately sustainable and it's not scalable.

If we really want to re-envision ourselves as a public service company for the 21st century, part of that mission is to solve for a more durable solution to affordability. The old public service companies came to this late in the game and the job was never one of ensuring that everyone could pay for energy, it was making sure everyone had access to it. As society has matured, our notion of what affordability is has to evolve as well. It sounds grand, and I don't have any idea how to do it aside from starting to make calls to the people who might be willing to help us start to figure it out.

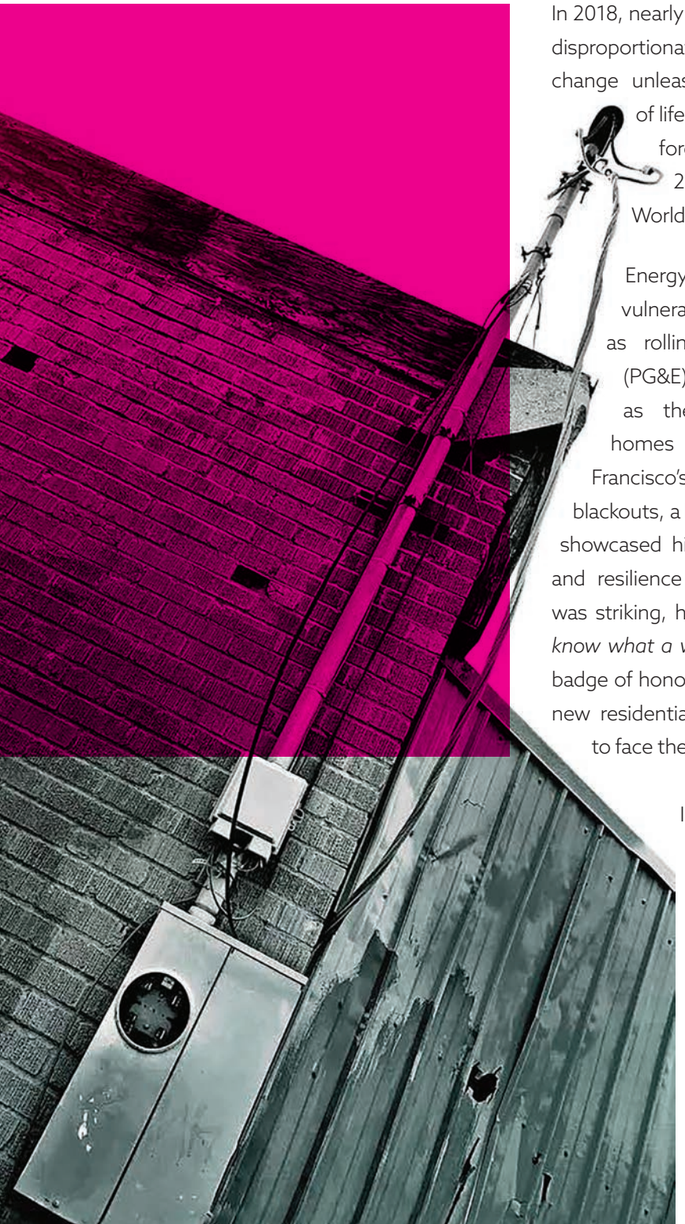
From Grid to Human Resilience: *Lessons from Public Health*

In the late 1990s, neighborhoods in the shadow of coal-fired power plants had higher than average rates of asthma, heart attacks, and strokes.

These neighborhoods were mostly comprised of low-income residents and people of color. In this context, an Environmental Protection Agency (EPA) working group studied the burden of increased exposure to hazardous waste and contaminants in vulnerable communities as a result of utility activities.[1] And while it was widely understood that low-income communities and communities of color faced disproportionate effects of energy generation, the EPA found, "a general lack of data on environmental health effects by race and income." Since then, several research studies have pointed out that people with less than a high school education, or those who are unemployed or living in poverty, were more likely to be exposed to hazardous particulates.[2]

In a 2011 study of coal-fired power plants, the American Lung Association concluded that people, "who have low incomes or who are members of ethnic or racial minorities bear a disproportionate share of the effects of air pollution because they live closer to industrial facilities, including power plants, and high traffic areas."[3] People with cardiovascular disease, asthma, and other lung diseases faced increased risk from air pollutants—and adding insult to injury—these were blind spots in federal data.

Adopting a public health framework foregrounds equity, cuts across economic, social and environmental contexts, and requires that we operate under a goal of collective well-being.



In 2018, nearly two decades later, disadvantaged communities faced disproportionate environmental and health burdens as climate change unleashed the California wildfire season. The tragic loss of life, destruction of homes, businesses, and natural forests was accompanied by air quality indices (AQIs) of 200 or greater—classified as "very unhealthy" by the World Air Quality Index project.[4]

Energy infrastructure, both culprit and victim, was left vulnerable in the face of fires. 2019 was no different, as rolling blackouts ordered by Pacific Gas & Electric (PG&E) during the month of October disrupted lives as the utility cut power to approximately 700,000 homes and businesses.[5] In a radio interview with San Francisco's KQED during PG&E's latest round of California blackouts, a homeowner who lost one home back in 1991 proudly showcased his two Tesla Powerwall batteries. His determination and resilience in the face of California's mountainous tinderbox was striking, his voice stoic. *"I lived through one disaster, and so I know what a wildfire is like."*[6] His solar-plus-storage setup is both a badge of honor and a symbol of his resentment. But if DERs are the new residential high ground, then low-income families may have to face the view from below, with the lights off.

In this moment, we must ask ourselves: Who is paying for the real cost of energy? What action is required to ready our most vulnerable communities for the future that lies ahead?

From Grid to Human Resilience

We often foreground grid resiliency in response to emergencies such as the California wildfires. And, we have to look beyond the generation and movement of kilowatt hours to understand the building blocks of resiliency. The threats of climate change demand that we think of resiliency as the daily act of preparing communities to withstand increasing threats to their well-being. As we work to identify a framework for resiliency in the energy sector, we need to broaden our view.

So how do we navigate this new normal? The field of public health may have some answers. The public health framework defines resiliency as, "processes and skills that result in good individual and community health outcomes, in spite of negative events, serious threats and hazards."[7] Public health also offers concepts that are useful for thinking around social challenges. For example, the idea of "herd immunity" emphasizes that the well-being and resiliency of any one person or community is only as secure as the whole. Through this broadened lens, we propose that resilience frameworks in energy should:

1. Underscore the ability of all communities to overcome threats
2. Emphasize the resiliency of people (and not just the technologies they rely on)
3. Focus on positive outcomes

Adopting a public health framework and way of thinking foregrounds equity, cuts across economic, social and environmental contexts, and requires that we operate under a goal of collective well-being.

Resiliency indicators. When it comes to health, communities lack resiliency if certain groups disproportionately bear the burdens of climate change. If for example, some communities suffer more when there are power outages or suffer from asthma or heat-related illnesses.[8] The burden on low-income and communities of color has been heavy, and the long-awaited benefits from the shift to renewable energy have been slow to arrive.

Research already shows that rooftop solar is primarily concentrated in higher income households. And though low-to-moderate income households represent 43% of the U.S. population (and the next likely wave of rooftop solar expansion), it is unclear what proportion of these households live in buildings suitable for solar.[9] Even in progressive California, a leader in renewable energy, a peer-reviewed analysis of distributed solar shows that solar adoption rates in the state's most disadvantaged communities are more than eight times lower than in the state's most privileged communities.[10] This imbalance highlights why renewable and energy efficiency initiatives need to be designed with all populations in mind, or else risk furthering adaptation inequality. On the upside, utilities and program administrators have a far reach. Whether in customers' homes, at their places of work, or in their social environments, utilities have the ability to impact customers on a scale that few other industries can. Utilities are uniquely positioned to take action on issues at the intersection of energy, health, and resiliency.

ILLUME has compiled a few notable examples of resilience initiatives where our industry is doing more to take individual and community health measures into account.

The California Energy Commission has developed a set of indicators related to clean energy access, investment, and resilience in the state's low-income and disadvantaged communities.[11] To arrive at the list, the commission combed through research that exposed concerns such as: High levels of asthma-related emergency room visits in San Joaquin Valley, electricity bills greater than $300 in more than 140 low-income Census tracts in Southern California Edison's service territory, as well as the winter energy burden for low-income communities in Northern California who rely on high-cost heating fuels.

The Maryland Energy Administration put in place a $5 million program to support community resiliency hubs to provide basic services in an emergency (e.g., heating and cooling, refrigeration for medicines and milk for nursing mothers, and charging for small devices like phones); these will be powered by solar and battery storage.[12]

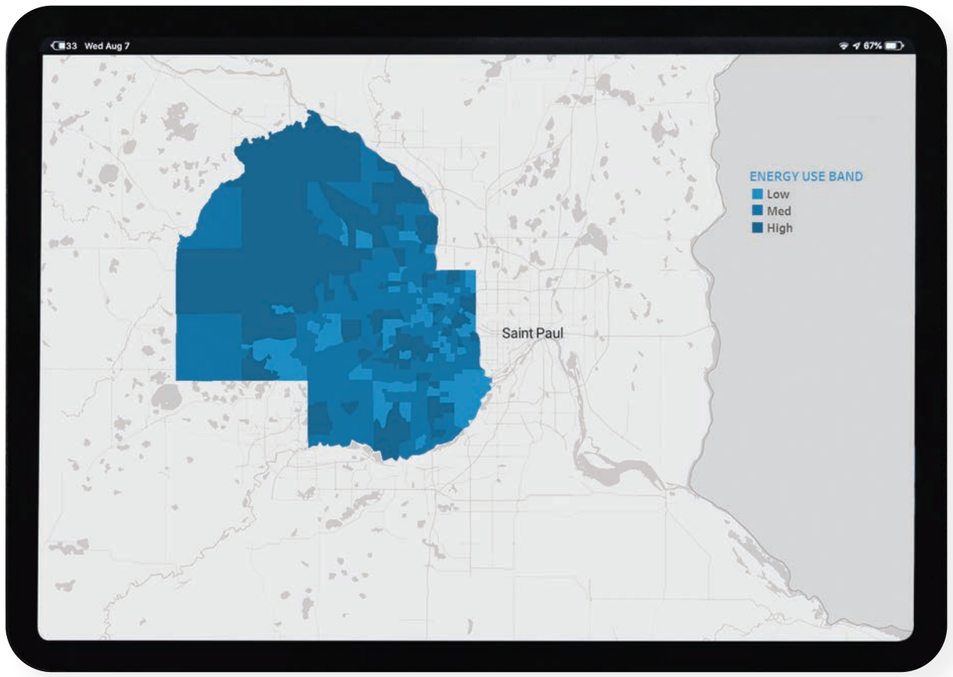
The Los Angeles Department of Water and Power (LADWP) has developed 15 equity metrics to address, among many needs, those of customers with economic and environmental vulnerabilities such as communities with limited access to tree shade, which increases the urban heat island effect. LADWP caught our eye because of transparency and reporting measures that ask the utility to account for its outreach strategies, and call out issues that get in the way of program implementation (e.g., "some customers cannot afford to front the initial cost of EV charger installations").[13]

The Resilient Power Project is a joint initiative of the Clean Energy Group and Meridian Institute, focused on building resources in affordable housing, low-income and disadvantaged communities. The Project aims to deploy solar and storage to, "help power essential services during extended power outages and to reduce the economic burden of energy costs in vulnerable communities."[14]

San Francisco's Solar-Plus-Storage for Resiliency Project is an effort to integrate solar and energy storage into the City's emergency response plans. In addition to exploring the feasibility of solar plus storage installations throughout the city, the project developed resources and tools for other municipalities nationwide to do the same.[15]

The effects of climate change threaten our health, energy infrastructure, communities, and families like never before. The energy industry has shifted markedly in the past decade, grappling with the limits of vertically-integrated utilities, the reduction of energy-efficiency savings revenue recovery options, and rapidly evolving competition. However, the utility industry does have assets that no other business can claim: ubiquity of service and communities that require it. Now is the time to double down on efforts to support resiliency and equity within our communities as moral and business imperatives.

CenterPoint Doubles Down on Data to Deliver Smarter Programs



Unlike most businesses that struggle to capture information on their customers, utilities are swimming in it. However, being data rich presents its own challenges: **How does a utility, operating across multiple verticals, create an intelligence platform for decision making? What data matter? What do not? And how might data be structured for efficient and decisive action?**

Like many of his utility counterparts, Carter Dedolph, a Conservation Improvement Program Implementation Manager at CenterPoint, sought to harness data to "provide a more efficient way for energy efficiency program dollars to reach higher results." In partnership with ILLUME, CenterPoint created a holistic customer insights dashboard to answer complex questions about energy savings and program participation, and to efficiently respond to stakeholder demands.

CenterPoint has long been interested in an energy efficiency dashboard but a confluence of factors made 2019 the right time to start—the right combination of data availability, software readiness, customer interest, and a quickly changing energy future. With the stars aligned, how did they act on this need?

CenterPoint has a wealth of customer data on energy use, program participation, and customer characteristics. However, to effectively leverage this data for decision making, it had to be contextualized with important social information and processed to meaningfully inform conclusions. ILLUME wrangled program, Census, demographic, and tax assessor data and appended it to CenterPoint's consumption data to create a customized and nimble dashboard for its team to answer their program and strategy questions with interactive data visualizations.

With a primary and immediate goal to increase residential energy efficiency program participation, CenterPoint will continue to improve upon the dashboard to serve multiple needs. In addition to energy efficiency efforts, CenterPoint can use the tool to measure energy efficiency equity, tackle community climate goals, develop and monitor tailored marketing campaigns, and potentially harness the dashboard for DERs planning. ***With direct access to this intelligence, how will CenterPoint better serve their customers?***

A Dashboard for Energy Efficiency That Informs Planning for Emerging Trends

Energy efficiency programs help pay for products and services that save customers money on their energy bills—there aren't many downsides. So, why do some customers participate while others do not? It's complicated and caused by a variety of reasons; perhaps as many reasons as there are customers. CenterPoint would love to engage with each customer, but with limited program marketing budgets, that's not possible. With this tool, CenterPoint can identify key barriers and develop targeted strategies to increase program engagement across as many customers as possible, at minimal program costs.

The dashboard concept, which uses data visualization software and is designed to interface with the utility's servers, uses GIS information at the neighborhood-level to show trends like previous program participation. With this data, CenterPoint can target, implement, and monitor the success of programs for neighborhoods with characteristics like:

- High site-level savings (e.g., based on audits and direct-install program data)
- Relatively low past participation rates
- Key customer characteristics (e.g., home vintage, percent with limited English, and median income)

Utilities like CenterPoint foresee a variety of emerging trends that could impact their business operations in the relatively near future. Climate mitigation efforts could completely change the energy resource mix, distributed resources could upend utilities' current resource planning practices, and, in the center of it all, customer service is paramount and needs to be provided equitably. With an energy efficiency dashboard, CenterPoint can start shaping their strategy around these disruptive and emerging trends.

Climate Goals

Like other cities and large utility customers in the U.S., the City of Minneapolis is taking a proactive role in climate action. As Minneapolis embarks on its ambitious climate goals, it has become clear to CenterPoint—as they build a dashboard to pinpoint barriers to energy efficiency participation—that partnering with the City would be a win-win.[1] The Minneapolis pilot provides CenterPoint a manageable area for piloting the dashboard before they expand it to their Minnesota service territory (while energy efficiency provides the City with direct and measurable reductions in carbon emissions). Increasing efficiency for the end-user (e.g., with insulation) is often the most cost-effective way to reduce carbon emissions. In this way, CenterPoint and Minneapolis can use the dashboard to expand current energy efficiency programs, reducing carbon emissions and gaining perspective on the potential for energy efficiency along the way (e.g., by understanding barriers to participation and the cost of overcoming them). Thinking further ahead, CenterPoint is laying the groundwork for how they can engage with other communities in their service territory.

Equity

Energy efficiency equity is an emerging and dynamic issue. A full spectrum of utility customers pay into energy efficiency programs, but a smaller percentage participate each year. This means program benefits are not equally shared among ratepayers. While CenterPoint implements robust income-eligible energy efficiency programs to address this issue, there is increasing scrutiny in the industry about the accessibility of programs across a variety of demographics. Recognizing this trend and its importance to the City of Minneapolis, CenterPoint's dashboard can support initiatives around energy efficiency equity by monitoring past trends of participation across demographics (e.g., income, age, and primary language), uncovering participation barriers, and designing campaigns to access hard-to-reach customers.

DER Planning

Distributed Energy Resources are typically discussed for electric utilities, but the same framework applies for natural gas companies as well. Smart thermostats and energy efficiency can serve as a DER for natural gas companies to avoid infrastructure upgrades in constrained areas. Implementing DERs is an emerging concept, and CenterPoint can begin to understand when and how to implement it through this tool. By identifying their areas of constrained infrastructure, they can consider the feasibility of targeted marketing based on neighborhood characteristics and past participation data. Similar to other value streams, the dashboard allows CenterPoint to monitor their progress over time.

How Did We Do It?

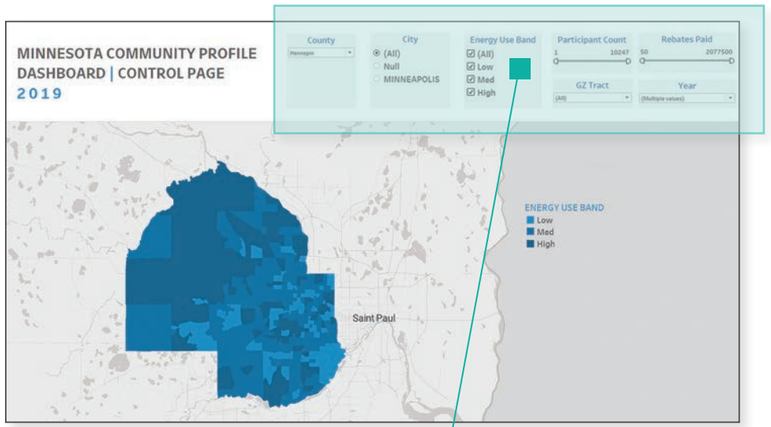
More and more, innovative energy utilities like CenterPoint are taking a page from software development and start-up culture—who live and die by the Agile methodology—to create their own software solutions. ILLUME and CenterPoint are using sprints (or phases) that hold the team to fast and hard deadlines as they build the dashboard. Each phase ends with a working software prototype (or minimum viable product). At each phase, no matter how finished or un-finished the product, the project team has an opportunity to provide rich feedback and reflect on where the project should go next. Throughout this process, ILLUME is working with CenterPoint to iterate on the dashboard tool while tracking ideas that could be used for future phases.

How Does it Work?

1

Map Interface:

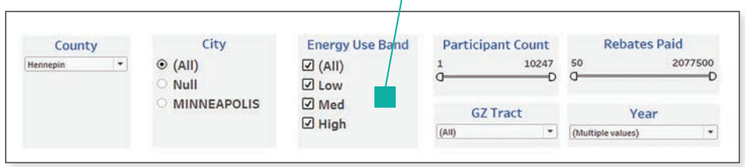
The tool is designed to incorporate metrics (by Census tract) alongside an interactive map. The map displays energy use quartiles across the tracts and users can scroll over each Census tract to learn about the proportion of multifamily versus single-family homes, for example.



2

Filter on Key Parameters:

Users can then set key filters for customer characteristics (e.g., median income), savings opportunity (e.g., home vintage and size) or historic program activity (e.g., energy efficiency conversion rates).



3

Review Additional Metrics:

After setting filters, users can review additional metrics on a second dashboard page to inform their program marketing strategy (e.g., the percent of residents with limited English).

4

Targeted Implementation:

Lastly, users will implement their strategy and revisit the tool to monitor their progress and continue to refine their approach.

As consensus on the key data fields associated with energy efficiency and how to tap hard-to-reach customer segments builds, for now (Phase 1 of the project), the analysis team is collecting tax assessor data, energy usage data, and customer characteristics available to CenterPoint, such as Census data and past energy efficiency program data.

The team is balancing the costs and benefits associated with introducing additional data sources, data fields, and more advanced analytics (e.g., estimating customers' balance temperatures or propensity modeling) in future phases.

Climate Change is Here. Is Your City Ready?

Are you going to be underwater or sweating it out? That depends on where you live, and how proactive your city is in adapting to climate change.

In an effort to shift climate change conversations from abstraction to reality, the team at ILLUME used the Notre Dame Global Adaptation Initiative's (ND-GAIN) Urban Adaptation Assessment to assemble these maps to showcase climate readiness scores across five U.S. cities.

New York City, NY

Readiness	Heat Risk	Cold Risk	Drought	Sea Level Rise	Overall Risk
47 (HIGH)	80	75	76	28	59

NYC IS ADDRESSING RISK THROUGH:

- Using cooling centers in public buildings to help vulnerable residents
- Making upgrades to utility delivery systems to protect customers from extreme weather events
- Setting Climate Resiliency Design Guidelines to make buildings more climate resilient

Madison, WI

Readiness	Heat Risk	Cold Risk	Drought	Flood	Overall Risk
83 (HIGH)	28	22	37	39	32

MADISON IS ADDRESSING RISK THROUGH:

- Improving storm water management practices
- Providing financing for energy efficiency upgrades to buildings
- Offering a group purchase program for residential rooftop solar panels

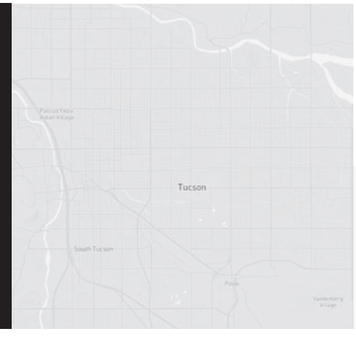
What is the Urban Adaptation Assessment?

ND-GAIN is an interactive database showing vulnerabilities to climate change and adaptive characteristics of 270 cities in the U. S. and Puerto Rico with populations above 100,000. The database expresses all scores on a 100-point scale and defines climate change adaptation in the form of:

- Protection that enhances resistance to the hazard, e.g., embankments to protect roads from flooding
- Accommodation to work with the hazard conditions, e.g., turning a road into a causeway so water can flow under it
- Retreat by avoiding the hazard, e.g., re-locating a road

For each city, the initiative calculates risk scores for flood, heat, cold, sea level rise, and drought, along with scores based on economic, governance, and social readiness. Scores of 40 and above receive a HIGH designation. Scores below 40 are designated as LOW. Want to see the risk and readiness score for a particular city? Check out https://environmentalchange.nd.edu/resources/nd-gain/ to see how your city stacks up.

Tucson, AZ

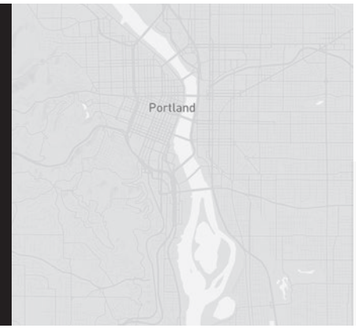


Readiness	Heat Risk	Cold Risk	Drought	Flood	Overall Risk
60 (HIGH)	43	35	35	39	38

TUCSON IS ADDRESSING RISK THROUGH:

- Recharging groundwater reserves
- Setting a 50% reduction goal for carbon emissions from energy use, water consumption, and transportation by 2030
- Preparing for drought by banking water for future needs, reducing water demand, and using reclaimed water

Portland, OR

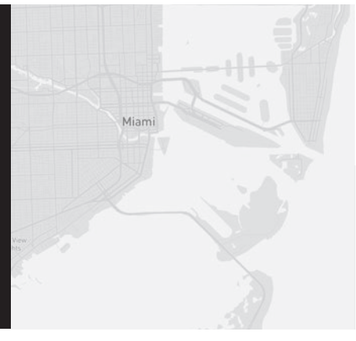


Readiness	Heat Risk	Cold Risk	Drought	Flood	Overall Risk
55 (HIGH)	46	43	48	43	42

PORTLAND IS ADDRESSING RISK THROUGH:

- Enhancing protection of watersheds and rivers that provide surface water, expanding groundwater capacity and aquifer storage and recovery
- Investing in road, rail, bridge, bike lane, and sidewalk projects
- Using interactive online effectiveness maps encouraging residents to plant more trees and install green roofs

Miami, FL



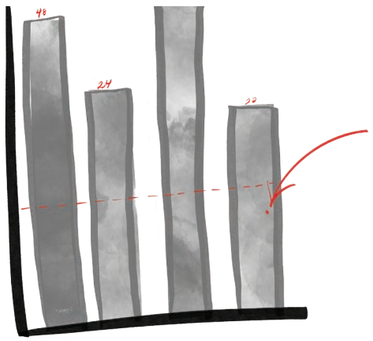
Readiness	Heat Risk	Cold Risk	Drought	Sea Level Rise	Overall Risk
40 (LOW)	84	82	55	44	67

MIAMI IS ADDRESSING RISK THROUGH:

- Increasing tree canopy coverage to 30% by 2020
- Restoring living shorelines by planting and maintaining native vegetation to slow beach erosion
- Designing parks and open spaces to manage flooding and reduce the urban heat island effect

Map credits: Mapbox

Using Art to Personalize Data



This is your customer.

Who are they? What do they expect from you? How will they grow with you or without you as your business evolves? These are questions you cannot answer when they are represented as pixels in a chart. As you look to reinvent your future, you need your customers' voices.

The fundamental assumptions utilities have built their business models on are changing.

In times of rapid change, thinking of your customer as a pixel in a graphic won't cut it.

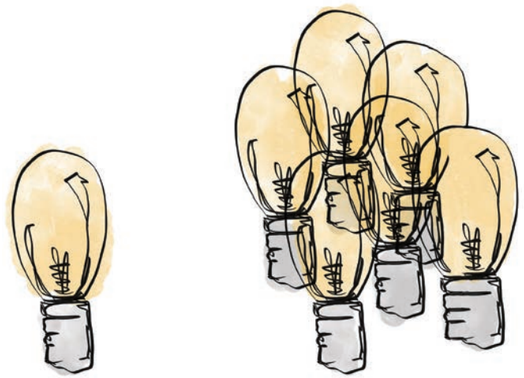
As you grapple with more challenging questions such as engaging the "hard to reach" or understanding why customers don't participate in your programs, putting empathy first can help you bring your customers, and your future, to life.

More than an entry in a spreadsheet

Putting empathy first requires asking the right questions to understand who your customers are. What's it like for them to adopt a completely new product? What factored in to their decision making? How did that impact their energy use? These questions are hard to answer in the data alone. You need to ask, and understand, why.

We recently built a customer journey map for an upstream lighting program.

We spoke with customers and retailers for a year and accompanied them (virtually) on a shopping trip to purchase a light bulb.

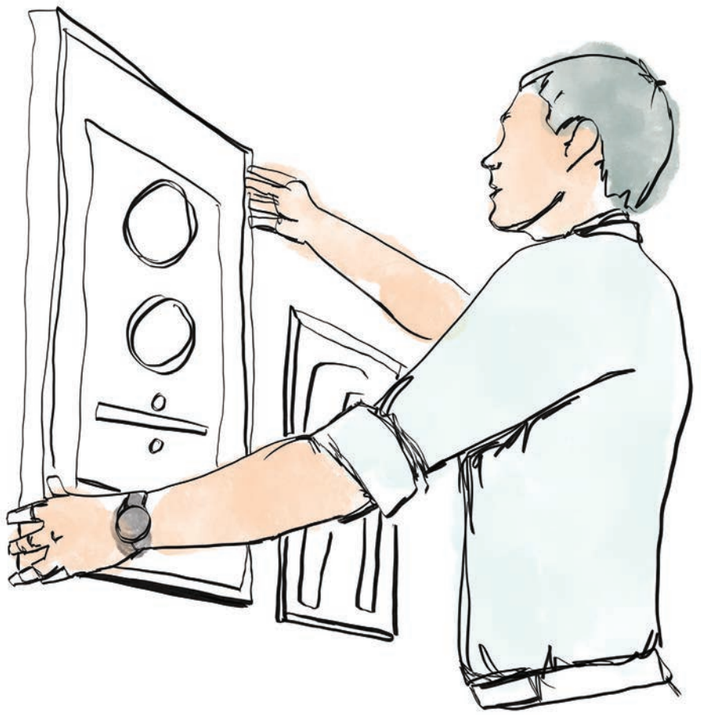


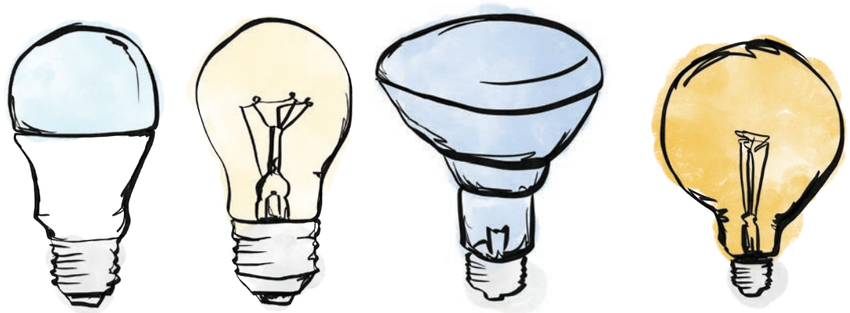
Turns out, purchasing light bulbs is really emotional.

To provide our respondents with an adequate level of respect, and our client with a full representation of that emotional journey, we needed a highly visual journey map.

ILLUME's team hand drew and collaged each key step of the journey.

For example, when a customer was frustrated and frazzled by picking a new light bulb, our team represented shards of color shooting around the background. ILLUME created 36 individualized pieces of art to fully capture the customer's experiences while making our thesis clear and impactful.





Lost in this process. Ultimately, she chooses to be ambivalent about bulbs because it's too hard to make the decisions.

Text highlighting her mood and general outlook
"It doesn't really matter."

Debra, behind and amongst the shards. She's frustrated.

Shards to represent being frazzled and not having all the pieces.

As part of our journey map work with ILLUME client, Georgia Power, we asked customers to walk us through things like the joy of personalizing and creating a home, the frustration from a shopping experience that should be otherswise 'easy,' and the "Goldilocks" effect of wanting just the right amount of choices.

With light bulbs, we've all been there! Frustrated, overwhelmed, or annoyed by a process. We've seen the eye-popping wall of bulbs at Home Depot and twisted one that's in the wrong color.

Our journey map work for Georgia Power's residential programs helped the large southern utility orient to the true customer experience, and design strategies around marketing, messaging, and programs to best meet customers where they are.

Using art is a way to create robust findings that ignite empathy and harness the care for your customers as people, not just data.

To enact true change, you have to work with the customer and understand what they need.

Redrawing Our mental maps of Income-Eligible Customers

Addressing inequality requires that we test our own assumptions. What pictures of our customers are no longer serving us?

As energy utilities have become highly adept at gathering and analyzing data, their ability to understand low-income communities to inform program design is vastly improving. With terabytes of customer data and powerful software at hand, utilities have an opportunity to rethink what they know (and don't know) about income-eligible customers.

Technologies like Geographic Information Systems (GIS) can help utilities uncover nuances that can lead to better engagement in low-income communities. By making sense of patterns and clusters of information through maps, analysts can use GIS to inform program participation and deliver insight that can reduce adoption barriers.

Looking at income data in the absence of geographic context can lead to miscalculations in estimating household energy burden. GIS information in the form of county assessor data can help utilities pull information, like age of home, to uncover hidden energy costs from inefficiencies like single pane windows, poor insulation, and energy-hogs like outdated appliances. Using GIS can help us take a second look at gaps in knowledge and start to redraw what we thought were fixed maps.

ILLUME has used GIS to explore the experiences of income-qualified customers through a number of projects. Through these efforts, we have discovered energy efficiency deserts—a similar concept to food deserts—based on the distance between homes and retailers offering energy efficient products. We have also created dashboards to illustrate the ways that different equity indicators cluster across regions to support our clients in their planning and outreach strategies.

We mapped income-eligible customers in Arizona, home to one of our ILLUME offices, to illustrate the value of mapping in challenging our assumptions about income-eligible communities.

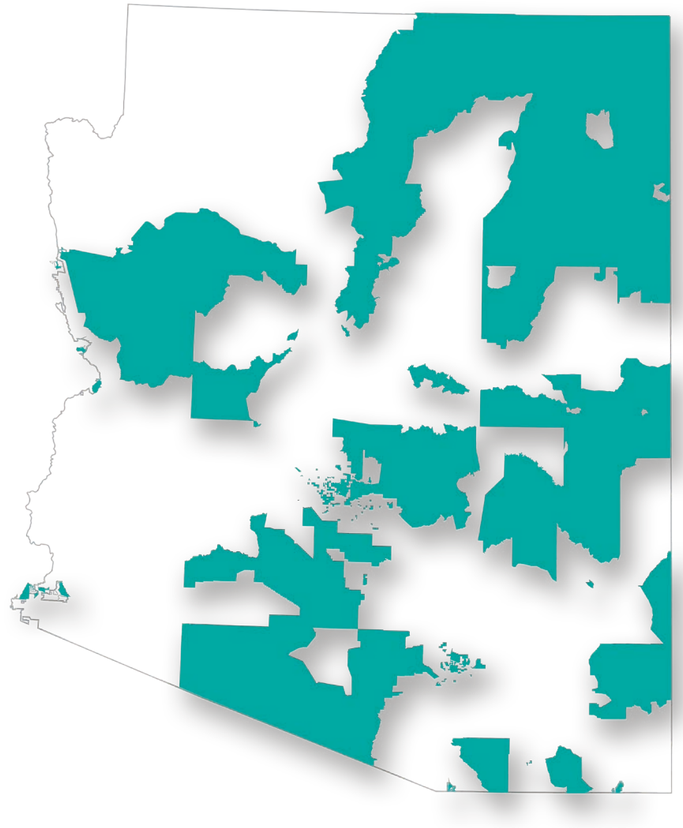
Median Household Income

Below Median AZ Income

Above Median AZ Income

Income-eligible customers are, of course, defined by their income levels. The map above illustrates Census tracts that fall below the Arizona median household income of $56,581 (in 2017). We can see here that Phoenix and Tucson, the state's two largest cities, have clusters of tracts below median income. The map also highlights the prevalence of rural tracts with median incomes that fall well below the state median income.

Stereotypically, many people think of income-eligible customers as living in dense urban areas. And, while many do, this bias overlooks diverse, income-eligible customers living in rural areas. In fact, families that live outside of cities face the highest energy burden in the U.S. — almost three times greater than families of similar household income who live in cities. In 2017, the rural poverty rate in the U.S. was higher than metro areas, 16% compared to 13%.[1]



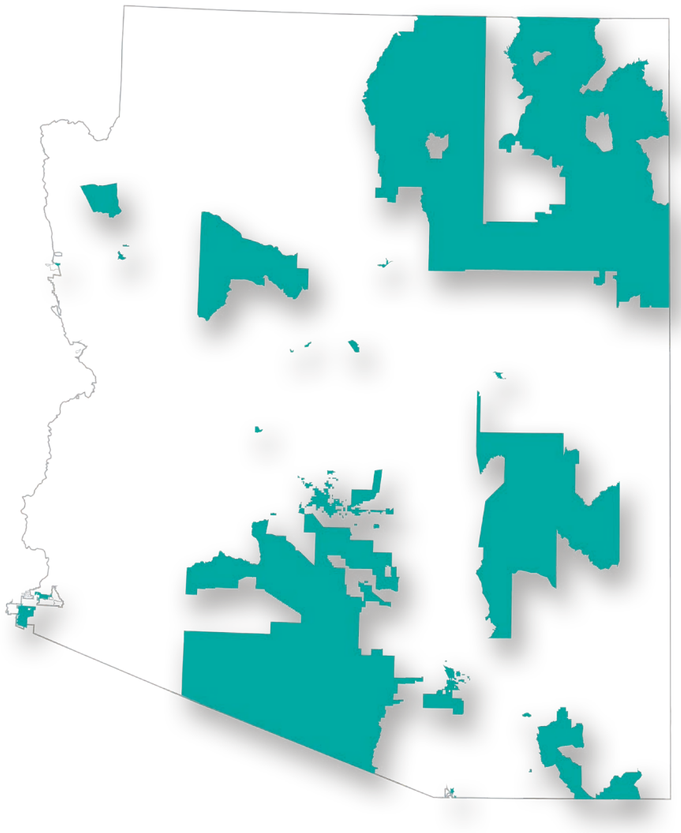
Level of Income Inequality*

High Inequality

Low Inequality

In addition to mapping income eligibility, mapping income inequality provides us with a deeper understanding of broad societal dynamics that may be at play in these communities. The map above highlights that high levels of income inequality exist not just in urban areas in Arizona, but in rural areas as well. Importantly, we can see that the areas of high income inequality don't perfectly align with low-income areas. Customers who are income-qualified yet live in areas of high inequality may have a more difficult time accessing affordable goods and services. Thus, if reducing inequity or energy burden is a goal, income levels alone are not a sufficient metric to target these populations.

* These maps reference income inequality using the Gini coefficient, a common measure used by economists to study the distribution of wealth across a nation's residents. The Gini coefficient ranges from 0, indicating perfect equality (where everyone receives an equal share) to 1, indicating perfect inequality (where only one recipient or group of recipients receives all the income).



Ability to Pay†

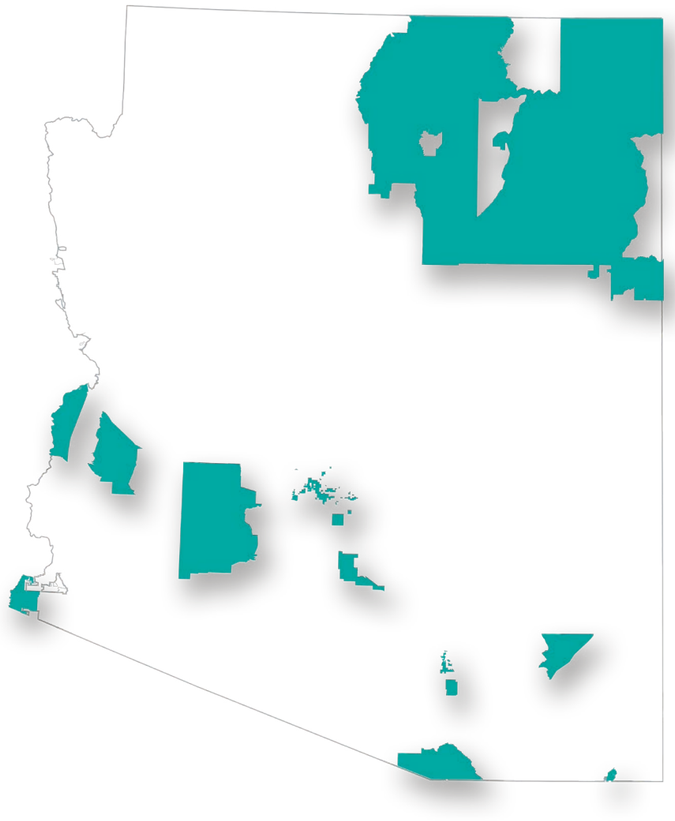
High Vulnerability

Low Vulnerability

Now that we have a better understanding of income and inequality in Arizona, we can narrow our focus to customers who may have difficulty paying their bills. Mapping a customer's ability to pay their bills (above) provides more detail on the challenges customers may face day-to-day. Ability to pay vulnerability is a proxy for a customer's available household budget (income minus housing costs). Again, we see similar patterns as income and inequality distributions in that Phoenix and Tucson both have concentrated populations that are more vulnerable, and this persists in some rural areas as well.

We have now targeted a population of interest: economically vulnerable, income-eligible populations. Probing further, we can map limited English proficiency households to understand if messaging strategies need to be customized for these populations.

† ILLUME used NREL's Solar for All data to generate this map. Ability to Pay is calculated through an Analytical Hierarchical Process which serves as a proxy for a consumer's available household budget (income minus housing costs). This weighting method reconciles the relative importance of income versus housing costs, where income is a first order factor and housing is a second order factor.[2]



Limited English Proficiency‡

More than 10% of households

Less than 10% of households

The map above reveals a large concentration of households in the northeast corner of the state, in the Navajo Nation, where English proficiency is lower. The prior maps pointed out lower levels of income, greater income inequality, and higher rates of economic vulnerability (ability to pay their bills) in this area relative to the rest of the state. Because this population likely faces different barriers to participation in energy efficiency programs relative to other income-eligible populations, outreach materials will need to be customized so that they are both culturally relevant and overcome language barriers. A simple translation won't be enough.

Mapping helps identify patterns, reveals gaps in our knowledge, and identifies interesting or unexpected patterns. With these data in hand, we can use customized messaging strategies in targeted communities that really resonate.

‡ The U.S. Census Bureau defines a "limited English speaking household" as one in which all household members (over 14-years-old) have at least some difficulty with English.

WHAT'S *the Deal with* BE?

The grid is on course to carbon neutrality. And while we can argue about how we get there and on what timescale—from a carbon perspective—it is imperative we electrify our cars and buildings.

Beneficial Electrification (BE) is having a moment and the industry is buzzing with questions. While we're still working toward a common definition for BE, it's critical to start asking: Are BE efforts being designed to serve everyone equally?

Defining Beneficial Electrification

Electrification refers to converting end uses historically powered by gas, coal, and oil to electricity. BE takes that definition further, adding an element of ***do no harm*** (so that electrification meets one of the following conditions, without negatively affecting the other two).

Saves consumers money in the long run

Enables better grid management

Reduces negative environmental impacts

BE Bright Spots

Although the West Coast usually gets all the BE attention, we've been keeping a close eye on the Southeast, Midwest and rural co-ops. So as groups like the Beneficial Electrification League (National Resources Defense Council and the National Rural Electric Cooperative Association) promote BE across the industry, let's ensure vulnerable communities are not left stranded, paying higher costs for fossil-based energy sources while their more affluent neighbors enjoy clean, carbon-free electricity. Here are a few bright spots as we read the tea leaves on beneficial electrification.

The South Atlantic Plugs In

A hub of research universities and a destination for business and financial services, North Carolina, home of Duke Energy, is proposing a comprehensive electric vehicle (EV) pilot to assess different charging load profiles from residential EV, fleet EV, school bus EV, transit bus EV, and DC Fast Charging (DCFC).

Why it caught our eye? E-qui-ty. The Southern Environmental Law Center wrote a letter to the North Carolina Utilities Commission in support of this pilot to reduce barriers to EV adoption for low and moderate income communities since deferred fuel costs and repair costs benefit these communities.[1] A portion of the pilot will support public transit electrification and associated cost savings for public agencies in North Carolina and ensure electrification projects benefit all customers (including non-EV owners and low/moderate income customers).

The West Coast Makes EV Rebates Effortless

Southern California Edison's (SCE) EV rebate program is literally designed for customers to breeze through the application process on their way to a $1,000 rebate for vehicles purchased after January 1, 2019.

Why it caught our eye? Used. Vehicle. Incentives. While you can't drive off in a new Tesla on less than $40,000, customers can opt for a used Nissan Leaf from anywhere between $13,000-23,000. Did we mention the SCE website's ease of use? All you need is your SCE Service Account Number, Vehicle Purchase or Lease Agreement, and Current Vehicle Registration Card.[2]

The Electrified Midwest Looks out for Rural, Vulnerable Communities

ComEd's project in Bronzeville is designed to deliver resilient microgrids, shared electric mobility services, energy storage, and other new technologies.[3]

Why it caught our eye? This large-scale, modern project builds grid resiliency and reduces the energy burden of vulnerable communities. Also, Bronzeville is a historically underserved community in Chicago that now can offer EVs for residents in senior living communities.

Speaking of the Midwest, we're keeping close tabs on BE research coming out of the Environmental and Energy Study Institute (ESSI), who partnered with several organizations conducting research on rural co-ops to produce the 2019 report, ***Equitable Beneficial Electrification for Rural Electric Cooperatives: Electrifying Residential Space and Water Heating.***[4]

Why it caught our eye? Vision meets equity. The report sees BE as a means for rural electric cooperatives to decarbonize their power grid. Plus, this research (with question items on how co-ops interact with low-income customers and communities of color) was disseminated across 300 co-ops that ultimately serve 3.7 million members in the Midwest.

HERE'S THE DEAL...

BE is enabling utilities to navigate a path towards a clean energy future via the electrification of buildings and vehicles. However, we must keep a close eye on future BE rate cases and legislation to ensure vulnerable communities are not stuck with the bill as affluent customers exit the grid in the name of resiliency and climate change mitigation.

ALL-ELECTRIC: Beneficial Electrification Gets a Second Shot at Ubiquity

The **"Live Better Electrically"** campaign of the post-World War II era was one of the most effective mass marketing home campaigns ever.[1]

Westinghouse and General Electric, looking for ways to drive demand for electricity in 1950s America, spent millions of dollars promoting the sale of electric power and appliances.

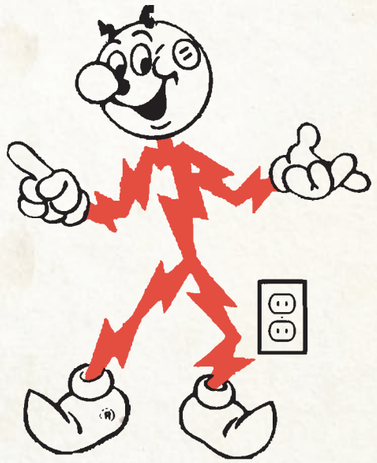
An Interview with Kathy Kuntz

Electrification at the turn of the millennium tapped into a unique set of existential themes—climate, equity, health, safety. Beneficial electrification only lives up to those values if we achieve a cleaner grid, save customers money in the long run, and do it in an equitable manner.

Some uses have already achieved cost-efficiency—electrifying some buildings and many vehicle types.[2] And, on the buildings side, California and communities in Colorado are experimenting with campaigns to switch to heat pumps and create new building standards.

Just this summer, California opened up the state's $1B energy efficiency budget to build electrification.[3] It's clear that the electrification trend is growing.

For more than 20 years, our industry has been promoting high efficiency natural gas appliances. Pivoting to electric end uses—while technically feasible and arguably beneficial from a climate standpoint—will not be easy. It will take time and intense effort to work with manufacturers, distributors, and contractors to support new technologies. Not to mention it will take years to change regulatory schemes that have long forbade incentives for fuel switching.



Reddy Kilowatt is a fictional character that acted as corporate spokesman for electricity generation in the United States and other countries for over seven decades.

Research questions about how people view natural gas in their homes, what they think about electric appliances versus their gas counterparts, and what they would be willing to pay to incorporate new technologies are all central to understanding how to increase adoption. ILLUME is pushing forward discussions of beneficial electrification and what it will take to understand and move the market in the coming years. We are excited to devote these next few pages to an interview with Kathy Kuntz, an industry thought leader, to talk about some of the key themes and tensions around beneficial electrification.

Kathy, Founder of Kanndo Consulting and former Executive Director of Cool Choices, believes that addressing climate change requires both technological breakthroughs and engaging millions of people. She has spent most of her career developing and implementing programs that facilitate change and believes communities can mobilize residents and businesses to achieve deep emission reductions via electrification, clean energy, and energy efficiency.

Q How has your perspective on electrification changed over the last several years?

A It's changed dramatically. I distinctly remember being at a climate advocates conference, three or four years ago, when a presenter talked about scenarios to get us to zero emissions by 2050. He said that one of the metrics would be to get sales of high-efficiency heat pumps to overtake the sale of boilers and furnaces by 2025. The room was full of advocates, so they are like 'ok.' But as a program implementer, I went into a tailspin. Because for 20+ years in this industry, we have been telling people to move away from electric heat. It's been one of the most consistent things we've said. The Wisconsin Energy Bureau used to monitor the number of electric water heaters left in the state and we watched the number go down each year. And a decade later we are going to now tell contractors and homeowners the opposite? Changing how people think is a gargantuan task. I totally get why electrification is the answer. The question is how! Since that first discussion three to four years ago I've been obsessing about how we might get this done. I think a lot about how we make inroads and start to make progress toward full electrification given our ambitious climate goals. On transportation, I think we're starting to see a little progress, but relative to buildings in the Midwest, we've got a great deal left to do—we've not yet even engaged the industry players effectively.

Q How does renewable energy fit into the electrification movement?

A We don't yet have a clean electric grid and yet we need to start electrifying things right now given the lifecycle of products. For example, we only replace boilers every 20+ years, so we can't achieve deep goals unless we start electrifying some of those items right away. For heating equipment, we'll likely only get two opportunities to get this right before 2050! So, we are doing two things at once: making the grid cleaner and transitioning people to electric transportation and buildings.

Of course, there's a tension: the grid isn't yet emission free, so folks can use that as an excuse to stay with fossil fuels. I hear this most around electric vehicles (EVs). In Wisconsin, more than half of our electricity still comes from coal—it's dirty. And even so, it turns out that EVs are cleaner than most of the vehicles on the road today. As our utility adds more renewables to its mix, that electricity gets cleaner and cleaner. Humans are creatures of habit and we resist change. I'm accustomed to heating my home with natural gas, so when you tell me electricity is better, I'll look to a reason why you're wrong so that I don't have to change. Noting that my electricity comes from coal, which has more emissions than natural gas, is a reason to resist electrification—it's an excuse to keep doing what I've been doing. To achieve electrification, we're going to have to address this head on, and, among other things, that means helping consumers understand the emissions associated with various options.

Q What role do you see for electric utilities?

A It's going to be critical that utilities are transparent. As a consumer, I can see my usage on my utility site. I want to see my carbon emissions too, or at least a decent proxy of my emissions. There should be a way for me to explore how my emissions change when I replace my gas furnace with an electric heat pump or trade in my gas car for an EV. As people are increasingly concerned about climate change, they are going to want to see these data.

For air source heat pumps, we need to be strategic where we strategize in these markets—data I've seen says they are already cost-effective when compared to propane or fuel oil. But natural gas heated homes might not be the best first target. A target for utility air source heat energy efficiency programs might be new homes in rural Wisconsin, for example. The builder/homeowner needs to decide to put in a propane or fuel oil tank or pay for a natural gas line. In that circumstance, they should think hard about electric. As an urban dweller in Madison, switching to a fuel pump isn't going to be the most rational thing to sell today. Although the niche in the urban market is circumstances like AC failure. There should be a program that incentivizes me to put in an air source heat pump that does all cooling (and some of my heating) so my furnace life will extend because it is only heating on the coldest days. It has to make sense to the consumer. The pitch cannot be that the heat pump will cost you more, but your kids will have a planet to live on.

We know—from decades of energy efficiency programs—that math is necessary but not sufficient to inspire change. People will need to see benefits that motivate them to change. Driving an EV is like paying just $1/gallon for gas but the biggest benefit of an EV is that it's fun to drive.

The building heating and water heating challenge is enormous. For decades, efficiency programs in Wisconsin asserted that heating anything with electricity was a bad idea. Now, to address climate issues, we will encourage certain electric heating technologies and discourage gas. Folks are going to resist! Contractors are tied to manufacturers that don't make heat pumps and they will also have anxieties about the reliability of new equipment versus the gas-fired stuff they are familiar with. Change involves risks and we've got to think creatively about how we share that risk with the market providers—it's a huge opportunity for the utilities to be a credible partner. There's also a broader challenge here about how this is framed. Again, when I don't want to make a change, I look for reasons not to—so if my utility is telling me to electrify my car and house I might wonder if they are just trying to sell more electricity. Transparency is really important. How do you show in the long run this is better?

"For heating equipment, we'll likely only get two opportunities to get this right before 2050! So, we are doing two things at once: making the grid cleaner and transitioning people to electric transportation and buildings."

Q What about a role for the natural gas utility?

A In Wisconsin, our investor-owned utilities are combination utilities— they sell both electricity and natural gas. The potential for electrification obviously looks different to a combination utility versus a gas-only utility. That said, I think there are big equity concerns as we move toward electrification. A few years ago, we talked about the potential for an electric utility death spiral and now there's a potential for a gas utility death spiral where affluent customers transition to all-electric homes, leaving fewer and fewer customers to pay for the natural gas infrastructure. As cities like Berkeley, CA begin to ban natural gas in new homes, we need to think carefully about the best ways to transition away from natural gas, and certainly all utilities need to be part of that conversation.

Q In your home state of Wisconsin, you've had a long history of advocating for climate change mitigation through energy efficiency and renewable energy. With Wisconsin Governor Tony Evers's recently unveiled plan to have the state go carbon neutral by 2050, how will you continue to lead the way to beneficial electrification?

A As an activist in Wisconsin, I'm advocating for spots where we can find wins around electrification, wins that will multiply. I'm really interested in the EV market. There's huge potential for collaboration around EVs—it's screaming for a market transformation approach. I have been talking to utilities and other stakeholders about coming together and building a program.

> "Increasingly, electricity is fundamental to life. As electricity becomes even more fundamental to life (transportation, heating, communications), disconnections are more and more problematic."

And definitely there are other niches—rural homes with propane heat, certain air conditioning applications, new construction where we could prevent new gas lines. All of those niche applications will help to build the expertise we need to do even more. Additionally, I'm really concerned about how we help communities achieve their ambitious climate targets. After the push to set big goals—clean energy or zero emissions by 2050—some policymakers think they are done, but setting a goal is just talk. We haven't done anything yet that counts in my book. In Madison, we've set big goals, but we continue to approve new buildings that make it harder to achieve those goals. Very few policymakers are connecting those dots. A critical point here is to figure out a strategy that is effective for holding folks accountable for the goals they are setting. I've spent the last decade thinking about how you get people to change—I believe deeply in the power of positive reinforcement. In approving the wrong buildings there isn't a moment of positive reinforcement—and I know shaming doesn't work. These are community-scale goals—achieving them isn't as simple as assigning someone to get it done. People throughout a system have to change.

Q What are your thoughts on California's $1B in efficiency funding now open to electrification and can we use this landmark decision to expand this to other states?[4]

A The California decision is important because people look to California as an example. What I really appreciated was that the Commission really thought through the math about who could claim savings and how that affected others—the electric utility pays the incentive when someone electrifies a home and then that utility claims the energy savings and, in addition, the gas utility's goals go down because that is a home they can no longer make more efficient. I appreciate how thoroughly they think through the math because that provides a better path for other states. The math can kill you. If gas utilities are penalized for electrification, then there will be issues.

Electrification may have important equity implications. One of the things we are talking about in some of the local discussions about climate planning is for limited income households that are reliant on fuel oil or liquid propane (LP)—switching them to a heat pump now might improve quality of life. We know we can be subject to a shortage of propane, fuel spikes, etc. That creates chaos for everyone on LP but especially for limited income households. So, what if instead they were on electricity and the price doesn't jump up in January? I want to explore how electrification might yield broader benefits—quality of life, stability—it might eliminate a fuel crisis that is currently too routine for these households in the middle of winter.

Q As we move toward a more electrified future, how can we ensure that we do so in a way that is equitable to our most vulnerable communities?

A One of the huge challenges is that these electric technologies have a higher first cost. Certainly, we need to think about financing and buy down options. At the same time, ideally the ongoing costs should be lower. I've been thinking about this a lot around EVs. One of the solutions is that used EVs are depreciating faster than gas vehicles—partly because of federal incentives. So, you can very often get really terrific bargains in the used EV market. (I should know—I bought a used EV myself!) We need to think creatively about how to help move more of those used EVs into disadvantaged neighborhoods.

Bigger than access to technologies, though, we've got to figure out how to have more voices at the table in program design. We can talk forever about financing and other tactics, but we need to hear from the actual people if that is something that would help or not. We need conversations that enable us to understand what matters to local communities.

In conversations about electrification, the advocates I know are already talking about the need to revisit shut off policies. Increasingly, electricity is fundamental to life. As electricity becomes even more fundamental to life (transportation, heating, communications), disconnections are more and more problematic. I haven't heard anyone talking about that beyond advocacy circles. The current utility shut off rules—including ours in Wisconsin—are grounded in tragedy: legislation happened here because someone died one winter without power. We decided that wasn't ok. As we transition to hotter summers under climate change, is it really safe to leave folks without power in May or June? We need to talk about this as we move forward on electrification.

reach anxiety

As concerned citizens demand action to address climate change, cities and states are adopting ever more aggressive electric vehicle (EV) targets to tap the breaks on the country's biggest contributor of carbon dioxide emissions. Despite these policies and incentives, we are still facing considerable barriers to adoption, especially when it comes to affordability. Which has us wondering... when it comes to EVs and equity, can we ensure that everyone can sit in the driver's seat?

CITIES AND STATES TAKE MATTERS INTO THEIR OWN HANDS

According to the most recent U.S. Energy Information Administration's energy review, in 2018 the transportation sector accounted for more than 1.9 MMT of carbon dioxide (CO_2) emissions, earning the dubious distinction of the number one polluter ahead of the industrial, residential, and commercial sectors.[1]

Dissatisfied with the status quo, states are taking matters into their own hands. Ten states have followed California, the first state in the country to establish Zero Emission Vehicle (ZEV) legislation to support its aggressive goals. For example, the State of Minnesota hit the ground running with its framework, *Accelerating Electric Vehicle Adoption: a Vision for Minnesota,* calling for a 20% increase in EVs by 2030.[2]

In neighboring Tennessee, the state's *Drive Electric Roadmap* lays out an aggressive timetable to get 200,000 EVs on the road in the next 10 years (an increase of 3,900%). Cities are not far behind, navigating unchartered territory as they develop their own frameworks to reduce the impact of transportation emissions. In the South, the city of Atlanta passed an EV ordinance requiring all new homes and facilities to accommodate EVs.

STATES WITH AGGRESSIVE EV GOALS

LOCATION	# EVs ON ROAD	EV GOAL #	PERCENT INCREASE	GOAL YEAR
Tennessee	5,000	200,000	3,900%	By 2028
Massachusetts	18,000	300,000	1,567%	By 2025
Minnesota	7,000	200,000	2,757%	By 2030 (20% of sales)
California	550,000	5,000,000	809%	By 2030

69% of African American customers in Atlanta feel neutral or positive about the ability of EVs to meet their needs. Nearly 80% indicate price is a barrier.

—ILLUME/Georgia Power Research

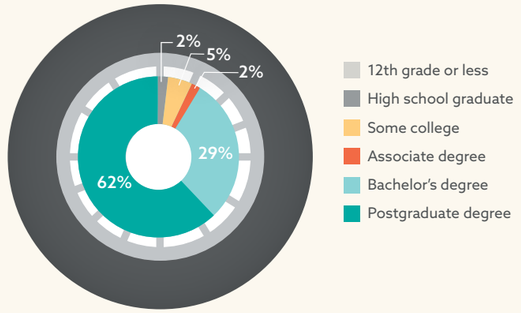
EVERYONE IS TALKING ABOUT EVs, BUT OWNERSHIP IS LIMITED TO FEW

EV proliferation is a trending topic in industry panels and conference discussions. EV talk has evolved from skeptical, to theoretical, to tactical. Similarly, the EV market is showing signs that we're on a path to ubiquity as Amazon announced its fleet electrification, Tesla, Rivian, and Ford are electrifying America's internal combustion darling—the pickup-truck—and the Federal Transit Administration invested $80M in grants to electrify public buses.[3] Yet data compiled by ILLUME shows that EV ownership is out of reach for many.

EDUCATIONAL ATTAINMENT

EV Owners Are Mostly College Graduates

When we look at the intersection of EVs and educational attainment, these two factors provide unsettling insights into equity and early adoption. According to the Year Three Report of the Massachusetts Offers Rebates for Electric Vehicles (MOR-EV) program, 91% of EV owners who responded to the survey have a Bachelor's or Postgraduate degree.[4]

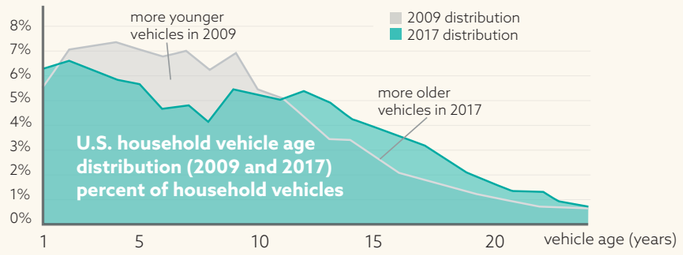


Source: Massachusetts Department of Energy Resources

VEHICLE AGE DISTRIBUTION

U.S. Households Are Holding on to Their Vehicles Longer

Americans are holding on to their vehicles longer. This doesn't bode well for aggressive EV targets if we're expecting Americans to change car ownership habits, let alone pivot to more expensive modes of transportation.[5]



The turnover of household vehicles has slowed since 2009. The 2017 National Household Travel Survey (NHTS) reported that households held on to their cars, trucks, and vans longer. The average vehicle age has increased from 9.3 years in 2009 to 10.5 years in 2017, suggesting that many households have delayed the purchase of a new vehicle thus continuing a trend of U.S. households operating vehicles longer.

Source: U.S. Department of Transportation, Federal Highway Administration, 2017 National Household Travel Survey

CHARGING INFRASTRUCTURE

EV Owners Want Quick Charging, Governments Want to Pay Less for Charging Infrastructure

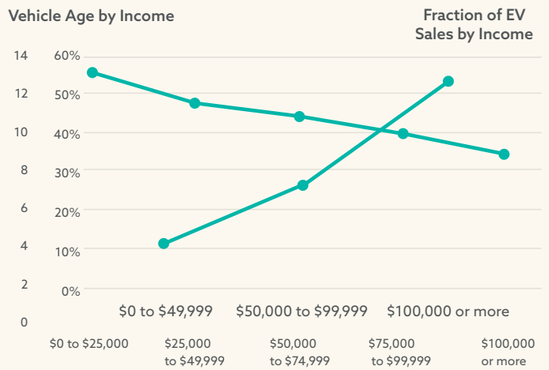
The equity gap does not present a short-term threat for EV makers like Tesla and Porsche that have come to depend on affluent customers and export markets. But as fewer people participate, it creates a dual economy wherein less affluent customers are subsidizing clean energy for the few while at the same time paying higher costs for fossil fuels—and postponing a switch to cleaner vehicles—further delaying the benefits EVs can offer.

TYPE OF STATION	SPEED OF CHARGE (miles per minute)	EST. PER INSTALLED STATION COST (USD)	MINUTES OF CHARGE TO DRIVE 100 MILES
Level 1 120 Volt (AC)	0.1	$500 - 1,000	1080 min (18 hrs)
Level 2 240 Volt (AC)	0.4	$2,000 - 5,000	240 min (4 hrs)
50 KW (DC)	2.9	$60,000 - 100,000	35 min
150 kW (DC)	8.7	$100,000 - 150,000	12 min
350 kW (DC)	20.4	$150,000 and up	5 min

Source: Minnesota Department of Transportation, Accelerating Electric Vehicle Adoption: A Vision for Minnesota (2019)[6]

EQUITY IN AN EV FUTURE

As Average Income Americans Are Holding on to Aging Cars, the Affluent Are Claiming EV Rebates



While EV sales are increasing, so is the average vehicle age of an owned car. Households with the lowest incomes are holding on to their cars the longest, 13 years on average. Incentives have encouraged EV purchases, but who is buying? Not the average household. A Congressional Research Service study found nearly 80% of EV credits were claimed by households with adjusted gross incomes of more than $100,000.[7] **The average U.S. household income in 2018 was $61,937**. To meet our aggressive EV goals, we will need to determine how to get EVs to everyone.

Source: U.S. Department of Transportation 2017 National Household Travel Survey,[8] National Center for Sustainable Transportation.[9]

WAITING FOR THE LIGHT
TO TURN GREEN ON EQUITY

As states like California aggressively position themselves to put 1.5M EVs on the road by 2025, here's ILLUME's take on what it's going to take to get the rest of the country there—equitably.

EVs Are Still For The Wealthy

States need to combine aspirational roadmaps with financial incentives/innovative car-ownership structures to give underrepresented communities access to lease, purchase, or share EVs. In a study that looked at the intersection of income and EVs (Massachusetts Offers Rebates for Electric Vehicles: MOR-EV), less than 5% of new EV owners in the Commonwealth reported median household incomes between $24,999 and 49,999. The median household income of new EV owners in Massachusetts? $150 - 200k.[10]

Battery Costs Drive Upfront Price Parity

In 2015, batteries accounted for half the cost of an EV. And though research by BloombergDEF[11] predicted this percentage could drop to 20% by 2025 (and bring about greater price parity between EVs and internal combustion vehicles), a new MIT report suggests not to expect much downward movement in the price of EVs since the price of batteries is unlikely to reach $0/kWh with production volume increases.[12]

Think Beyond New

The market for used and "certified-used" EVs is out there. Many consumers don't want to purchase a new car (and by extension a new EV) because of concerns around depreciation, environmental consciousness, or fear of new technology. Current EV programs are most likely reaching environmentally savvy early adopters with resources to make this type of purchase. To reach our aggressive goals, we need to figure out ways to engage all buyers.

Luxury EVs And Trucks Are Driving Prices The Opposite Direction

2019 was a year of EV debuts from the Porsche Taycan ($103k), Tesla Cybertruck ($39 – 69k), Ford Mach-E SUV ($43k), and other plug-ins that don't dip below the $39,000 mark. However, nearly 60% of respondents in a national survey who were considering buying or leasing a new or used vehicle within the next two years said a lower purchase price would be most effective in increasing the likelihood of buying an electric vehicle.[13] Another affordability obstacle? Long term car loans of more than 60 months accounted for 72% of new car loans in Q1 of 2019 according to Experian.[14]

Diverse Communities Want In

Empowering diverse consumers with information on the costs/benefits, range, and infrastructure needs of EVs is critical to moving the market. An EV survey by the Union of Concerned Scientists and Consumer Reports showed that people of color are more likely to consider an EV for their next vehicle compared to all buyers combined (42 percent vs. 36 percent).[15] ILLUME research conducted for Georgia Power in Atlanta found similar sentiments, as 69% of African American customers feel neutral or positive on the ability of EVs to meet their needs. However, nearly 80% indicate price is a barrier when thinking about EVs.

A Business Case For Charging Infrastructure

Drivers are accustomed to stopping at the gas station, loading up on snacks, and traveling hundreds of miles. Though most EV charging takes place at home, utilities, cities, and the private sector may have an opportunity to think through new business cases. This year, a Maryland gas station operator was the first in the country to convert his gas station into an electric fueling station thanks to a grant by the Electric Vehicle Institute and the Maryland Energy Administration. Drivers will appreciate fast charging with their coffee and donuts, while gas station owners may be ready to part ways with structured oil and gas station contracts that limit suppliers and maintenance support.[16]

Get Smart!

Applying Smart Thermostat Lessons to DERs

The transition to a clean energy grid is underway.[1] Distributed energy resources (DERs) are roughly doubling every five years and will continue to proliferate.[2,3] As utilities and program administrators aim to integrate and capitalize on DERs as part of their energy and offerings mix, we would do well to examine the ways in which DERs are fundamentally different, and require different strategies, than typical energy efficiency programs. What go-to-market models are necessary to both drive adoption of DERs and maximize their grid benefits? Fortunately, the path of smart thermostats provides valuable lessons that can inform how we leverage DERs in the industry.

Smart thermostats, which bridge both energy efficiency and demand response programs, offer a wide range of capabilities.

Most notably for DERs, smart thermostats have been successfully deployed to deliver load management and demand response. Millions of smart thermostats are already installed, arguably the industry's earliest and most widely adopted DER, and smart thermostats are supported by utilities using a scalable incentive structure.[4]

As a model, smart thermostats provide important instruction on how to (1) scale DER technology adoption, (2) drive participation in demand response programs, and (3) ensure continued engagement to provide reliable, dispatchable resources. Our lessons learned can be directly applied to batteries and connected fuel generators and other forms of demand response, such as electric vehicles and water heaters.

Path to DERs at Scale, from Adoption to Participation to Engagement

Bringing dispatchable DERs to scale involves far more steps than for traditional efficiency products or other utility offerings. For energy efficiency programs, participation and product adoption are relatively synonymous and continued engagement is limited. For DERs, for example, customers can't participate in a bring-your-own-thermostat (BYOT) demand response program until they own a qualifying smart thermostat. Furthermore, many BYOT participants purchased their thermostat well before they ever heard of a BYOT program. In other words, product adoption and DER program participation may be disparate and unrelated actions for customers in a DER program. In terms of customer engagement, the interactions for DERs far exceed any other utility-to-customer communication. Customers pay their bills monthly, but they're not expecting unscheduled messages regarding their appliances.

Adoption

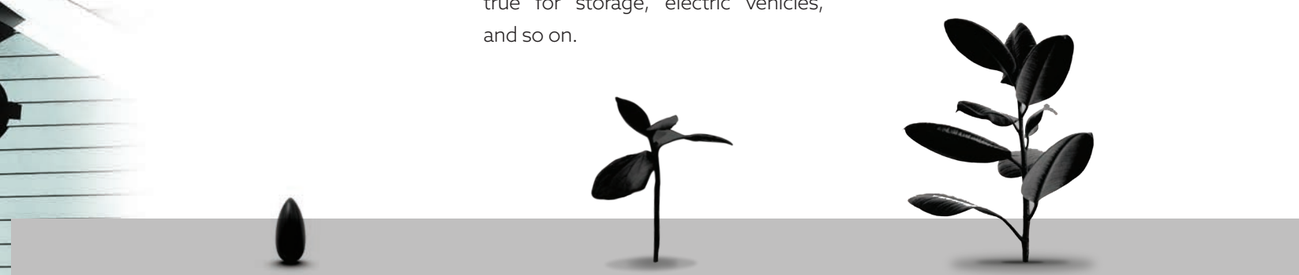
Customers must purchase and install their DER technologies. For smart thermostats, most customers purchased their device unaware that it was DER-ready and unaware of DER programs. Product adoption was driven by headlines, product design, multiple value streams, and energy efficiency incentives, not DER program incentives.

Participation

Utilities can't use customers' dispatchable DER products until customers agree to participate—without participation, a DER product is just another device. For example, smart thermostat owners may refuse to allow their utility to notify them of demand response events, essentially reducing smart thermostats to a nice-to-have upgrade on a standard programmable device. While this may net energy savings, it is not a dispatchable resource for a utility. The same is true for storage, electric vehicles, and so on.

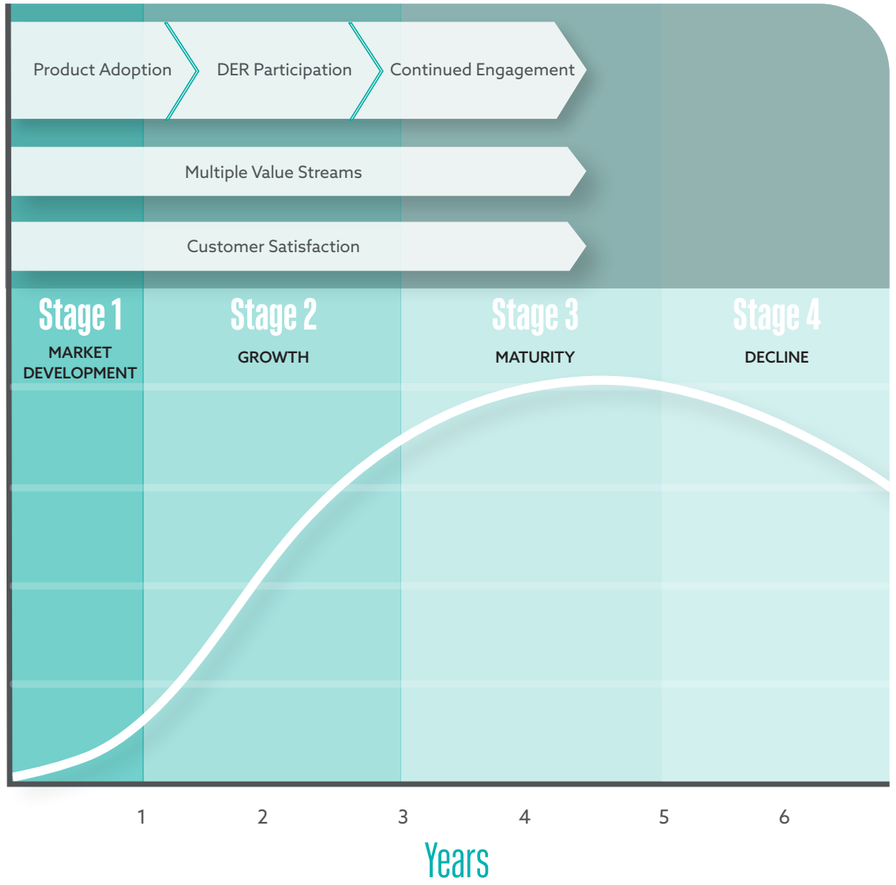
Engagement

Continued engagement matters. It's essential for utilities to foster an environment where customers are happy and willing to allow their DER to remain in utility programs. This takes adequate payment, good communication, consideration of comfort and convenience, and customer choice—all components of current smart thermostat DER programs.



DER Life Cycle Product Life Cycle - Entire Industry

DER Path to Scale



The traditional product life cycle is four stages: market development, growth, maturity and decline.[5] DERs are firmly in the market development phase, but there are some signs that certain DER products and services may reach the growth phase within the next five to ten years.[6]

Driving DERs to Scale

Bringing DERs to scale is challenging. In some ways, it's a new concept for customers and it involves changing customers' existing relationships with utilities. Based on the history of smart thermostats to date, utilities can drive DER through collaboration, leveraging multiple value streams, focusing on customer satisfaction, and using key vendors.

Collaborate and leverage multiple value streams—it will introduce conflicts, which is a good thing.

Smart thermostat providers found support from utilities, regulators, advocacy groups, and ENERGY STAR®. Smart thermostats presented opportunities for each of these groups, and smart thermostat companies did an excellent job of engaging across value streams. Utilities promoted the measure to help them hit savings targets, and regulators were supportive, demonstrating commitment to economic progress in an Internet of Things (IOT) world. Environmental advocacy groups supported smart thermostats because they saw opportunity for not only energy savings but also greater load flexibility to support higher penetrations of renewable energy. Meanwhile, ENERGY STAR® reinstated their thermostat designation and implemented product testing in an innovative way using product-collected data.

Engaging across these value streams involves collaboration, which has had challenges, but maybe that's a good thing. One of the clearest examples of conflict is with smart thermostat evaluation. Energy efficiency measures typically need to demonstrate that their societal benefits (e.g., avoided utility infrastructure and generation costs) outweigh the incremental cost of the product. Some of the most prominent smart thermostats are about 20 times as expensive as the baseline product, which sets a high minimum threshold for energy savings. Traditionally, cost tests do not allow for evaluators to incorporate other benefits (e.g., from demand response or even non-energy benefits), but this framework is changing, and some utilities are merging demand response and energy efficiency departments. While we can expect debate over using energy efficiency funds to support DER adoption, given the battles over net-metering, this approach might be the best tool we have during these early days of the clean energy transition.[7]

What are the additional value streams for other DERs? Utilities are already looking to support customer-side battery adoption by leveraging demand response, arbitrage (shifting energy use to lower cost times), and enabling the battery to operate as a back-up generator for the customer. The path for getting DERs to scale will involve multiple value streams.

Keeping Customers Happy Is Worth Compromise

DERs won't scale up without customer satisfaction, which involves convenience, customer choice, data privacy, and careful messaging.

- Make it easy to buy and receive the rebate instantly. Smart thermostats leveraged new streams for product adoption (e.g., ComEd's Marketplace)[8] where rebates are instantaneous, and the customer doesn't have to follow up later and take time to dig up their account number.

- Make it easy to install (or ensure a professional can easily install it). Smart thermostats developed an easy-to-use self-install guide, where previous thermostats recommended professional installs. Nest even has a service to help customers find knowledgeable contractors familiar with installing their product,[9] which demonstrates a framework for easy installation that can apply to batteries, water heaters, and other DER-ready products.

- Promise and deliver ongoing convenience. Smart thermostats promised thermal comfort without being wasteful and with minimum involvement from the customer.

- Make DER participation easy. Customers can sign up for DER programs through their smart thermostats with one click and participate in automated DER management.

- Give customers choice and make it easy to opt-out. Customer choice is important for satisfaction, and smart thermostat companies made it easy for customers to opt out at any time, sometimes by simply hitting the up or down arrow on the thermostat.

- Don't ask too much. Keeping customers happy involves compromise, which might mean prioritizing comfort over savings and/or thoughtfully minimizing asks on the customer. Smart thermostats, for example, typically max-out their demand response events between a 2-4°F shift in setpoint.

- Implement messaging carefully. Customers will participate in DER programs for different reasons and will have a variety of values. Programs can motivate customers by articulating the environmental benefits, financial benefits, the simplicity of participation, or through other messaging styles informed by social marketing.

- Minimize sharing customers' data. Data from smart thermostats are debatably owned by customers, and customers will be more likely to participate if they know their data is secure. If we want people to be a part of our DER future, we're going to have to think creatively about what data is critical and where there's room for compromise.

There are great opportunities to use vendors to implement scalable DER programs.

Implementing DER programs is complicated, but vendors can help. Customer acquisition and customer satisfaction are challenging, and perhaps most importantly, managing data and communication across multiple manufacturers and technologies can be a breaking point. Energy Hub, Uplight, and other providers have successfully implemented DER programs with multiple smart thermostat vendors across the U.S. These same companies are planning ahead and already offer similar programs for customer-side batteries and for at-home electric vehicle charging.

DER Programs Are Evaluable

Smart thermostat DER programs are not only evaluable, but prime candidates for experimentally designed research studies. In evaluation we often try to answer the question: What would have happened without the program? Fortunately, with tens of thousands of connected devices, it's relatively easy to withhold a random control group, which simplifies the interpretation of results. This concept not only applies to evaluation but more detailed research as well. Program administrators could develop experimental studies to test the effect of different messaging campaigns on opt-out rates; to test the difference in savings between mild, standard, or aggressive pre-event cooling; or even to test the prominence of customer fatigue for demand response events on sequential days.

What's Next?

ILLUME is currently conducting research around smart thermostat demand response that will set precedents for future demand response operations, answering research questions like:[10]

- How many events can you call before fatiguing customers?
- How long can the events run before customers opt out?
- How can you better message and communicate for your demand response programs?
- How can you maximize participation and reach a variety of customers?

While smart thermostats continue along their adoption curve and as utilities take their current DER initiatives to scale, we'll be watching for what technologies come next and what path they follow:

- Will electric vehicles be successful following in the path of smart thermostats, or will they break new ground?
- What is the next stage for smart thermostats, and are we on the front or back of their growth curve?
- What other DER technology will follow behind electric vehicles?

While there are many yet-to-be-answered questions, we are eager to see which go-to-market models are the most successful in driving DER adoption while maximizing their benefits to the grid.

"Alexa! Show Me My Smart Home!"

If you happen to bump into one of your customers browsing through the appliance section at their local big box retailer, odds are they're imagining the bliss of setting their temperature without getting up from the couch, dreaming of cueing their favorite album from the backyard, or conjuring up new ways to turn off unecessary lights. Enabling grid resiliency or load management?... Not so much.

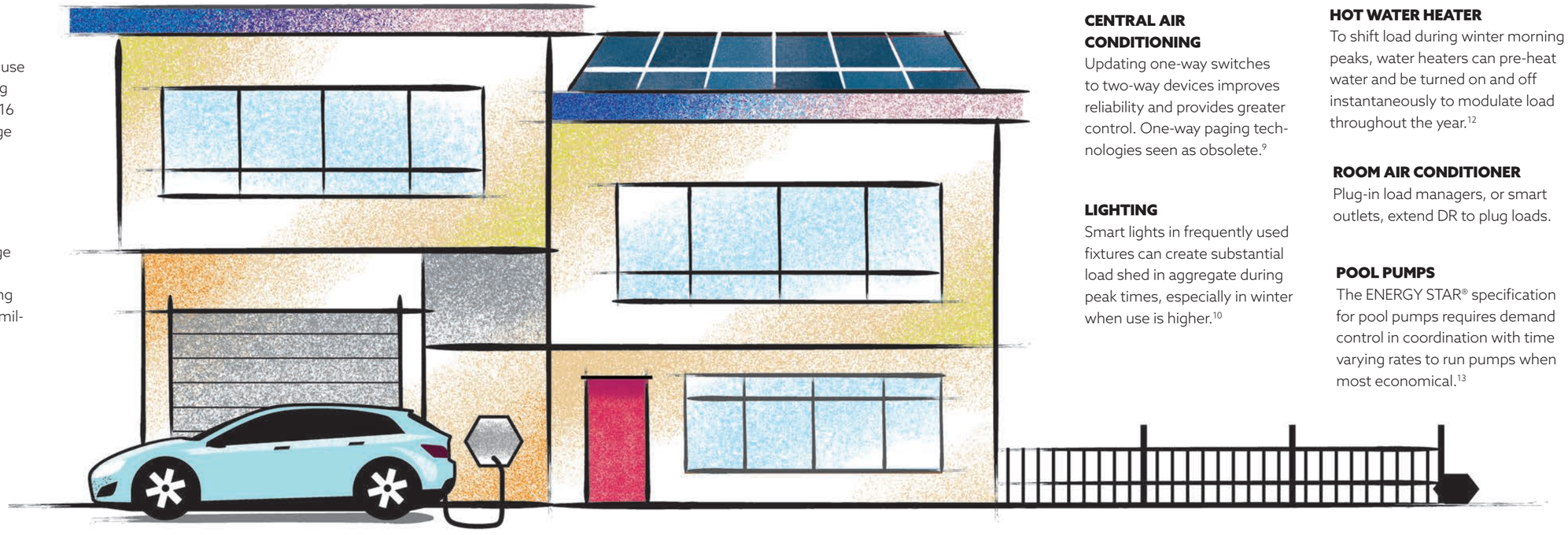
Customers are looking for features like simple interfaces, interoperability, voice control—a trend that will only grow.[1] Utilities can now offer new ways to meet customer expectations and enable seamless participation in DR programs through the smart home. Customers get more control, utilities get deeper penetration of DR. Another positive side effect of this trend? Lower utility bills. Automation may help customers save money through time-varying rates without needing to know specifically what to turn off, how, and when. So, what technologies are offering new load management opportunites? "Alexa, show me my smart home!"

SMART THERMOSTAT
More than 1.3M customers are enrolled in thermostat programs.[2] Analysts forecast connected thermostat sales to reach 14.5M units by 2022.[3]

BATTERY STORAGE
New software optimizes battery use to take advantage of time-varying rates. Great timing too! From 2016 to 2017 residential battery storage grew by 200% in MW.[4]

ELECTRIC VEHICLES (EVs)
Charging at night takes advantage of time-varying rates to save customers money on this growing technology; experts forecast 18 million EVs on U.S. roads by 2030.[5]

RESPONSIVE HOME APPLIANCES
(DISHWASHER, CLOTHES DRYER, REFRIGERATOR)
DR for smart appliances could reduce bills 2–9% across major appliance types with the caveat that displays and Wi-Fi control may increase draw.[6,7]



SOLAR PANELS
Residential solar can be paired with management systems and smart inverters to respond to events on the grid through voltage control and frequency stability.[8]

HOME ENERGY MANAGEMENT SYSTEM
Customers can take advantage of time-varying rates through energy management.

CENTRAL AIR CONDITIONING
Updating one-way switches to two-way devices improves reliability and provides greater control. One-way paging technologies seen as obsolete.[9]

LIGHTING
Smart lights in frequently used fixtures can create substantial load shed in aggregate during peak times, especially in winter when use is higher.[10]

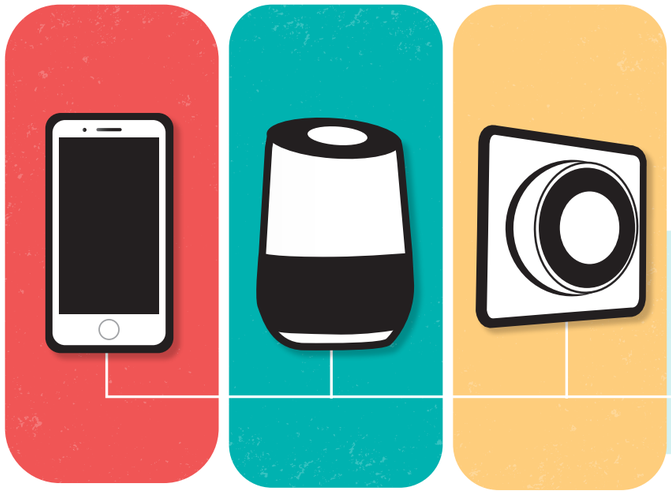
DEHUMIDIFER
In humid climates especially, control can shave demand on plumbed dehumidifiers that run continuously (one study found average demand of 349W).[11]

HOT WATER HEATER
To shift load during winter morning peaks, water heaters can pre-heat water and be turned on and off instantaneously to modulate load throughout the year.[12]

ROOM AIR CONDITIONER
Plug-in load managers, or smart outlets, extend DR to plug loads.

POOL PUMPS
The ENERGY STAR® specification for pool pumps requires demand control in coordination with time varying rates to run pumps when most economical.[13]

From WIDGETS to ECOSYSTEMS



As venture capital and private equity funds race to utilize a growing network of smart devices and high-resolution energy data, are we ready for the connected future these providers might enable?

The proliferation and rapid adoption of smart devices has been so transformative that, in 2018, researchers estimated a quarter of homes with broadband had at least one smart home device and that nearly half of all American homes will be considered "smart" by 2020.[1] While smart device vendors were working tirelessly in 2014 to gain share in this multibillion dollar market, Google surprised the industry by announcing their acquisition of machine-learning experts, Nest Labs. This marked an important shift in the pursuit of innovation away from smart device hardware and toward the connected infrastructure these devices create. Two years later, cloud-computing giant, Oracle followed suit by acquiring OPower, a residential efficiency company, and repositioning it as an enterprise software-as-a-service (SaaS) provider poised to leverage the rapid expansion of available residential energy data and device interactions.

Google and Oracle's expansions were harbingers of trends to come. Now, more and more companies are positioning themselves to take advantage of the upswell of high-resolution energy data, the Internet of Things (IoT), and cloud-computing to create a dynamic energy ecosystem in the home. Big data analytics in the energy sector has a compound annual growth rate of more than 10% and home data analytics alone is estimated to be an $11B market by 2026.[2,3] In the first half of 2019 alone, we've watched Tendril acquire EEme, EnergySavvy, and FirstFuel—then the merger of Tendril with Simple Energy to form Uplight. With so many companies pivoting into this space, it's time to ask ourselves: What will an energy ecosystem enable? Are we ready to take advantage?

Smart Home Ecosystem: Made up of apps, smart devices, and cloud service, it allows users to control devices in the home from anywhere.

Opportunities. In the near term, these providers are working to create customized and actionable data-driven energy advice and a modern platform for customer engagement. Many of these companies promise to provide an open application programming interface (API) that enables integration with other systems and smart devices, removing the critical challenge of interoperability and expanding utilities' potential reach into customers' homes.

In the long-term, these vendors may also provide utilities the ability to:

- Expand and enhance demand management through deeper penetration of demand response (DR)-enabled devices.
- Support different rate designs in connected homes that can be optimized and automated to respond to different price signals.
- Balance renewable energy through optimizing the home energy load shape to better align with generation.
- Deepen customer engagement through an expansion of communication channels in the home, e.g., through smart assistants.

Challenges. Seamless integration and automation of home connected devices on the front end and rigorous analytics with customized insights on the back end are only the first steps to success. Forcing this new wave of technologies into existing program designs and evaluation frameworks could prevent utilities from realizing the full potential of new offerings. Instead, we will need innovative program design to make this work as we explore a flood of questions. Is this an evolution of your Bring Your Own Thermostat (BYOT) or Home Energy Report program? Or part of a new non-regulated opportunity? What is the baseline against which we can quantify savings for such an offering? What is the measure-life? How can we define the incremental cost? Is this best suited for energy efficiency or demand response?

How can we create a new paradigm? The shift from widgets to ecosystems is happening. Here are steps you can take to prepare for and navigate the transition.

SCAN

Your portfolio. Do you already have a BYOT or BYO-device offering? What about a disaggregated home energy report-style program? Identify what offering(s) might make sense for your portfolio.

Your customers. Conduct or leverage existing research to understand what smart products your customers may already have adopted, which ones they would consider buying from their utility, and what natural opportunity may exist.

CREATE

A strategic goal. What type of offering do you hope to create? What does success look like and what are measurable metrics?

A map. Create short- (0 – 6 months), medium- (6 months – 1 year) and long-term tasks (1+ years) that will allow you to meet your goal.

SOCIALIZE

Learnings within your team. Identify or create a communication channel to share this strategy. Seek to grow understanding and knowledge here; begin to speak the same language.

Findings inside your organization. Establish a peer group to strategize how new findings can support alignment with broader goals within the company.

DEVELOP

Internal teams. Reach out to internal teams (Demand Response, Distributed Energy Resources) to form partnerships or peer groups that enable ongoing sharing of research findings.

External partnerships. Attempt to establish relationships with other utilities when directly competing is not a conflict in order to share findings from research, pilots, and evaluations; share experiences with vendors.

Through collaboration. Create field trials or pilots that can meet the objectives of multiple groups and/or multiple funding streams.

Your value stack. Establish success metrics that would allow you to capture energy efficiency, DR, DER, revenue, and other impacts.

INTEGRATE

A usability study. If the offering you're looking to incorporate involves a new and never-tested user interface, consider testing with a small sample of customers first.

Field trials. Before scaling up, trial your new offering with small groups of staff or friends and family. This is a great way to test implementation without the risk of creating customer dissatisfaction.

ROLL OUT

Ongoing research efforts. Monitor and digest the results of related research and watch key market actors. Use existing memberships to stay current with emerging and expected trends. Follow standards development, such as the Environmental Protection Agency (EPA) ENERGY STAR® Smart Home Energy Management Systems.

Early findings from field tests and pilots. Capture early findings from your tests/ pilots to gain insight into your customers' journey, understanding of, experience with, and expectations around connected technologies and offerings.

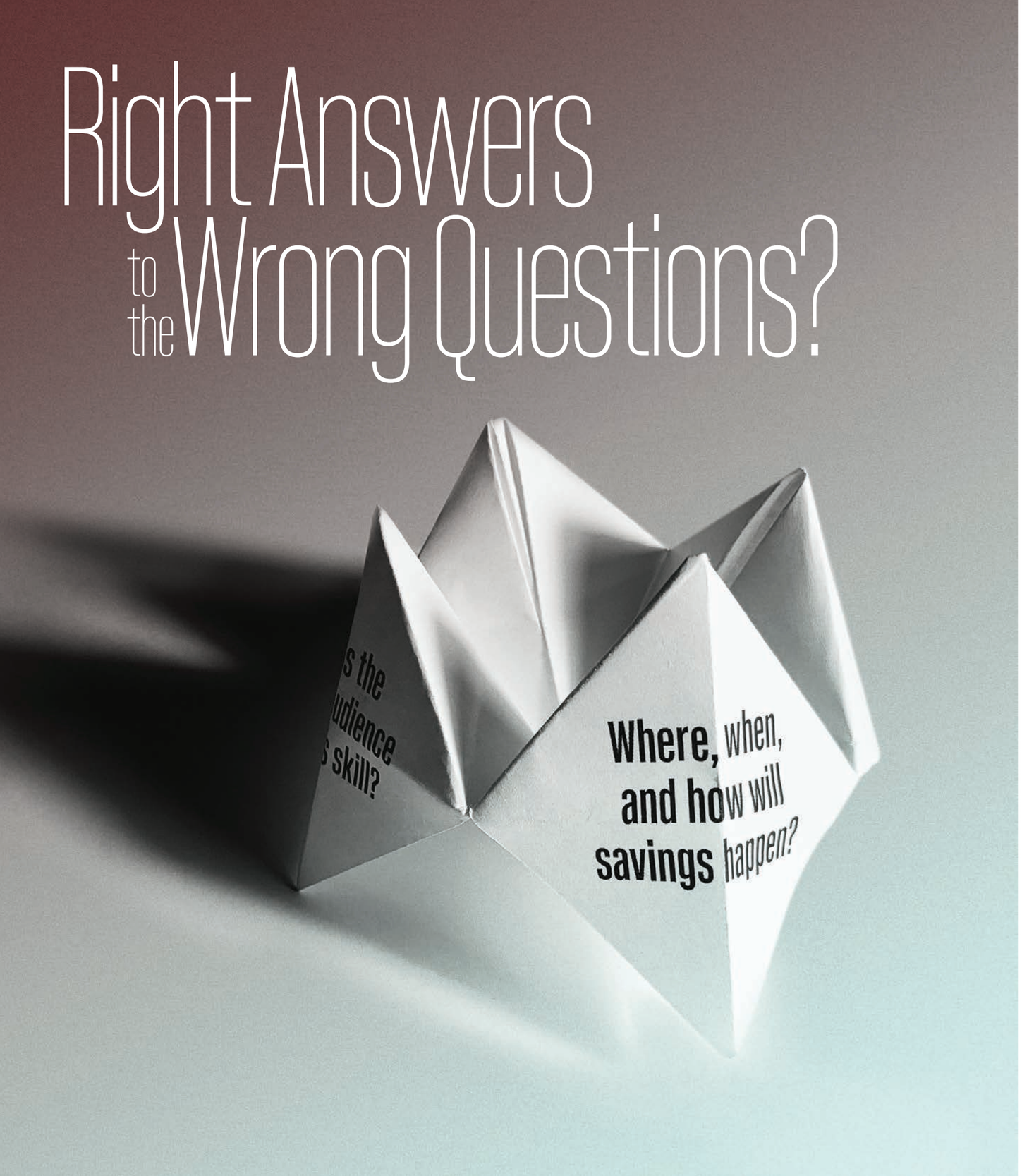
TRACK

Your findings. Review and synthesize additional research to determine next steps and research needs. Pilot implementation findings can be a good place to start.

Next steps for your organization. Is additional research needed ? Are there opportunities for pilots, field tests, or manufacturer partnerships?

REASSESS

Right Answers to the Wrong Questions?



Choosing Research Methods Wisely

If you've spent time around young children, you know a thing or two about fielding hard questions.

Questions about planets, dinosaurs, and philosophy can challenge what we learned in school and test the limits of our knowledge and our assumptions. The most straightforward questions can be the most difficult to answer.

Our industry is facing questions that are anything but straightforward: Is the grid resilient enough to withstand extreme weather and cybersecurity threats? Is the industry prepared to mitigate and adapt to climate change? Do we have the right technologies to transition to a clean electric grid?

In this context of rapid change, new and untested opportunities to reduce, shift, or strategically electrify energy can emerge. Anxious to put new technologies and approaches to use, utilities and energy services providers quickly turn to evaluators to ask critical design questions. These conversations often include this deceptively tricky question:

"How many people do I need to engage to measure effects?"

Ready for it... *It depends.*

We know. This answer is equally unsatisfying to give as it is to receive. But it really does depend on the answer to many other questions.

Policy and evaluation practitioners have championed highly rigorous evaluations to ensure energy savings are real and ratepayer dollars are responsibly spent. Rightfully so, we value techniques that are highly defensible: randomized control trials, well-defined baselines, and high-confidence, low margin of error studies. Sometimes approaching research with the standards of evaluation can be costly and deliver fewer valuable insights; other research methods might be better suited for nascent offerings.

Do you feel like running a full-scale pilot is too much (too soon), and yet you're still not sure which research method is best suited for the task?

If the answer is 'yes', then congratulations. You've saved yourself a mountain of unnecessary research.

With adequate background research, we can field a pilot with increased confidence so that customers sign up, equipment is successfully installed, customers use it, and we know where to look for savings. Just remember that **pilots should run like a program at-scale.** As evaluators, we understand the rigor needed to design a pilot and generalize from its results. By keeping those needs in mind, we can approach earlier stages of research with the right levels of rigor and flexibility to ensure the right questions are answered at the right stage of your product development.

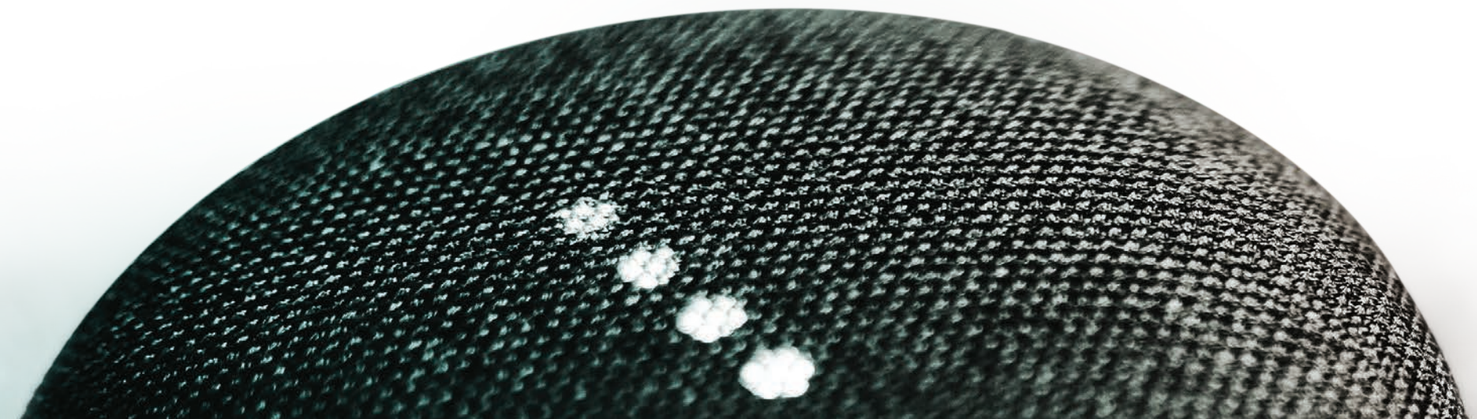
Decisions, decisions...

The challenge: Can smart speakers encourage energy savings?

Context: Smart speaker 'skills' could be a play for utilities to engage with customers. But can smart speakers really help customers save energy?

Before asking, "Alexa! How many customers do I need to test savings from smart speaker skills and actions?" here are a few variations of questions and answers to help you evaluate new equipment, new delivery channels, and new program approaches.

To help you sort through a few preliminary research methods before jumping in with both feet, we put together a Quick Start Guide so you can align questions and methods.



You want to save energy through smart speakers? Here are a few questions you should ask yourself:

WHERE, WHEN, and HOW will effects happen?

Use ethnographic research with customers in their homes to understand how they manage energy use, whether they are seeking/open to ways to change it, and what devices/behaviors COULD be controlled.

After you have a theory of how energy savings will happen, test the theory with a **small-scale demonstration** to assess the possible magnitude and variability of savings.

WHAT is the content of the skill?

If the skill is not designed, **test prototypes** with a small number of customers to provide feedback on possible approaches.

WHO is the target audience for this skill?

Use market research to identify the target market and size it. Quick focus groups, small scale surveys, or background research could be valuable here.

WHAT will the customer experience be like?

Use **small scale field tests** to better understand the customer experience, and especially, any issues that may cause frustration or dissatisfaction.

HOW MUCH budget is available for a pilot?

Preliminary research can save time and budget by providing answers to critical questions sooner. These answers also mean pilots can be much more targeted, less risky, and less costly.

CAN participants install and set up the speaker themselves? If so, will they leave it installed?

Deploy small scale field tests. Start with employees or "friends and family" to understand installation challenges and develop an approach to ensure equipment is installed correctly when rolled out to less friendly participants.

Isolated but Innovative

Learning from Islands

Island living has many charms—you need only turn on HGTV or flip through the pages of an in-flight magazine to briefly indulge in the appeal of escaping to an island. While the perks of living on an island may seem as endless as the ocean views, living surrounded by the ocean has its drawbacks. Stable, reliable access to power is taken for granted on the mainland U.S., but on an island, this isn't the case.

In the face of unstable access to traditional—and typically fossil fuel-based—generation sources, islands have become fertile ground for testing deployments of renewable resources and inventive strategies for load management. We invite you to take a tour of three U.S. islands where local utilities and governments, alongside residents and business owners, have developed novel approaches to ensure consistent access to clean and renewable power that might just inspire creative actions on the mainland.

Puerto Rico's microgrid network will feature eight subgrids, powered by smaller generators.

Puerto Rico

The hurricanes of September 2017 devastated the island of Puerto Rico. First, Hurricane Irma downed powerlines and caused flooding. Then, a mere two weeks later, Hurricane Maria raged across the island and caused the longest blackout in U.S. history—it took 328 days for power to be restored to all neighborhoods.[1] Most of the generation facilities, located on the south side of the island, sustained minimal devastation. However, the transmission and distribution lines that provide power to the mountainous regions and the highly populated communities on the north side of the island sustained significant damage. The average citizen went 84 days without power after Hurricane Maria.[2]

> Lacking electricity for months on end, individuals, businesses, and communities turned to microgrids with solar-plus-storage systems to provide power and pump water.

Lacking electricity for months on end, individuals, businesses, and communities turned to microgrids with solar-plus-storage systems to provide power and pump water.[3] Looking toward the future and in response to concerns about a vulnerable centralized system, the Puerto Rico Electric Power Authority (PREPA) put forth an innovative plan to redesign the power system and decentralize generation, dividing the island into several mini grids (with smaller microgrids) together under normal operation, or independently, in the case of a disaster.[4] The plan also increases reliance on solar energy with battery storage for resiliency and as a step towards meeting a goal of 100% renewable generation by 2050. All in, Puerto Rico is significantly reducing the likelihood of a repeat of the 2017 outages.

Artist representation of a dynamic load bank.
Source: Hawaii Natural Energy Institute

Hawaii

Hawaii has some of the highest electricity costs—more than double the national average—driven by the reliance on coal and petroleum to meet the state's energy needs.[5] Given these high costs, renewables, particularly solar, have offered the opportunity for Hawaiians to produce their own energy at a lower cost. Commercial and residential customers have adopted solar in large numbers and, in 2018, the state set a goal of 100% renewable energy generation by 2045.

High solar adoption has brought its own challenges, such as overproduction, which can lead to blackouts. The Island of Moloka'i, serviced by Maui Electric Co. (MECO), has developed programs to counteract overgeneration, and stands as a model for the rest of the state with higher levels of solar penetration than the other islands. MECO recently installed a state-of-the-art resistive dynamic load bank to accept excess solar energy. The bank removes energy from the grid when energy is overproduced and allows for an additional 725 kW worth of new rooftop solar energy panels to be built without overloading the grid.[6] Additionally, MECO recently approved purchasing electricity from a new solar project with a 3-megawatt battery expected to come online in Moloka'i in late 2019. This utility-scale energy storage model will allow excess solar energy to be banked and then used when solar production is not available.[7] Hawaii is one to watch as the state works toward 100% renewable energy in the next few decades.

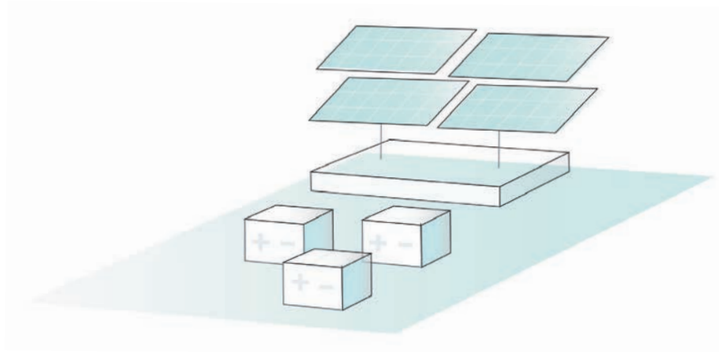
Isle au Haut, Maine

As Maine's rocky coast curves east and the cold water becomes more hospitable to seals and lobsters than humans, crustaceans scurry over a 6.5-mile 15 kV underwater cable that connects Isle au Haut with the mainland that provides it with power. Because this cable is two decades past its expected life, residents worry it will be too expensive to replace and the island will revert to diesel to power its homes, school, town hall, and local store. With an eye on cleaner and more resilient alternatives, Isle au Haut Electric Power Company plans to convert to a non-profit co-op and sever its reliance on Emera Maine.[8] Jim Wilson, president of the island's utility has thought through this scenario many times. "We can fail but if we do, it's our own fault. The other side of that coin is that if the mainland grid goes dark, Isle au Haut will be insulated from that broad-scale failure."[9] In doubling down on stability, the tiny island on the tip of Maine will likely produce 100% renewable power through a 300Kwh solar array, 1 MWh of battery storage, and microgrid. Another win-win for islanders? Avoided costs of grid-purchased power.

"We can fail but if we do, it's our own fault. The other side of that coin is that if the mainland grid goes dark, Isle au Haut will be insulated from that broad-scale failure."

— Jim Wilson

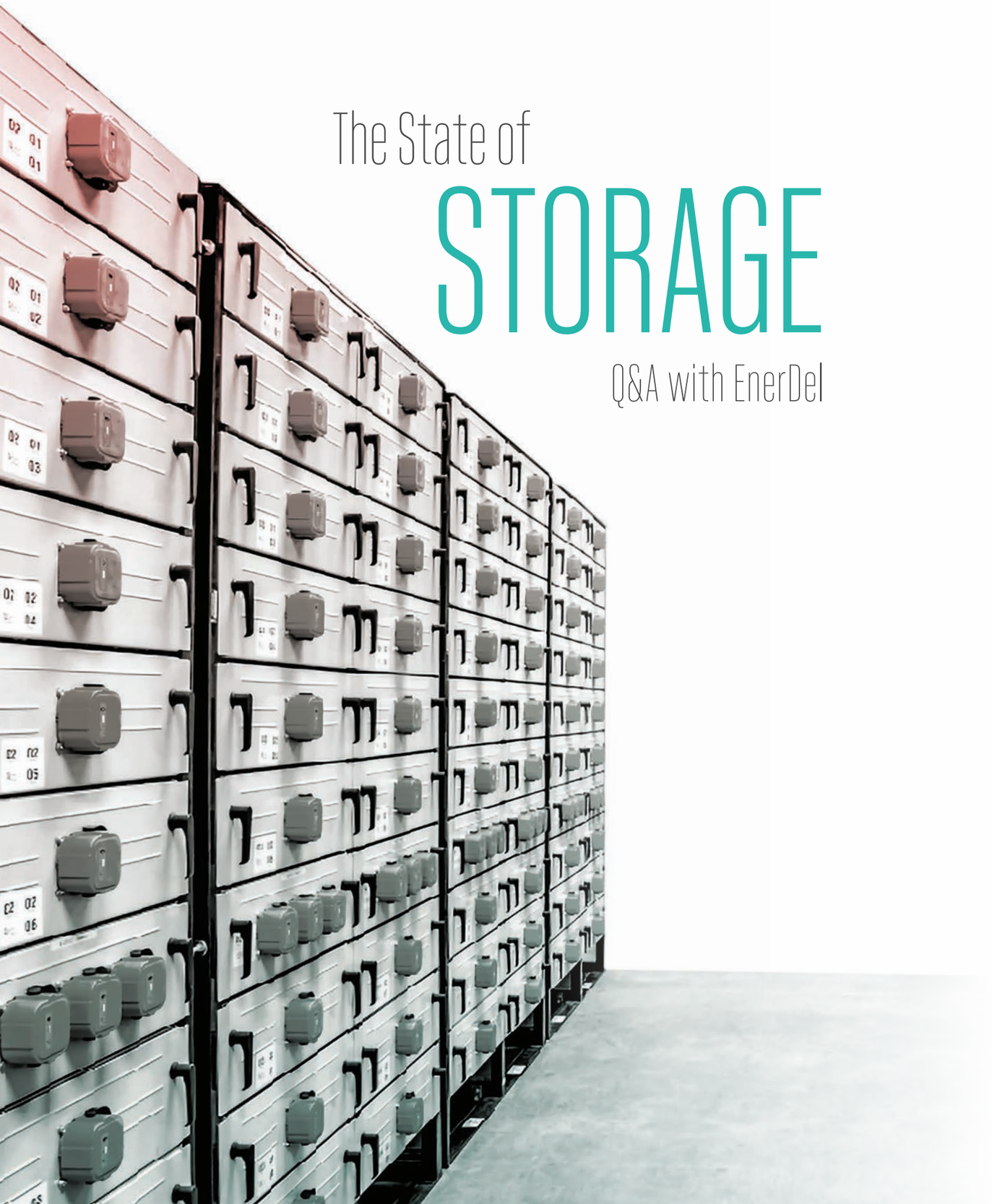
President, Isle au Haut Electric Power Company



A rendering of Isle au Haut's solar-plus-storage microgrid.

Our Take

If necessity is the mother of invention, then we hope mainland utilities are taking a page from islands. As customers increasingly demand utilities come to the table with bold solutions to climate challenges and the industry transitions away from fossil fuels, there will be a lot to learn from these island testing grounds.



The State of STORAGE

Q&A with EnerDel

ENERDEL™

It is nearly impossible to talk about a cleaner, safer, and more resilient energy infrastructure without talking about battery technology for electric vehicles (EVs) and electric grid energy storage. Which begs the question: are there domestic battery companies positioned to meet our needs?

Founded in 2004, Indianapolis-based EnerDel, Inc. produces energy storage and battery systems for heavy-duty transportation uses, on- and off-grid electrical, mass transit, and task-oriented applications. Eager to learn more about battery storage, ILLUME Managing Consultant, Kimberly Jaeger Johnson got us an inside scoop at EnerDel (her father and sister are employees) and sat down with the company's Head of Global Sales and Marketing, Charlie Travis; Director of Business Development, Bruce Silk; and Principal Software Engineer, Ron Jaeger to bring you a manufacturer's perspective on the state of energy storage.

How would you describe EnerDel to your neighbor?

A: We're delivering zero emissions/zero noise energy and power to communities. Whether it's powering more zero emissions vehicles or more microgrids to replace diesel engines and gas generators, we're deploying equivalent energy producing systems using lithium batteries to clean the air and get rid of noise.

A: We focus on the heavy-duty market as opposed to the automotive market, i.e., trucks and original equipment manufacturers (OEMs). With our hybrid bus pack, we work with a lot of different local and state transit agencies. With the grid product, we work with some utilities and the military.

What is the current market landscape for your clients?

A: Adoption of electric vehicles and this whole technology has been great, but as people begin to acquire these assets, they start realizing where other problems crop up. A great example is a large commercial fleet of electric vehicles or a transit agency that wants electric buses. If they get a substantial amount, the infrastructure to charge them suddenly becomes the weak link. It may require them to upgrade the service to their facility. They start thinking about how much money it would cost to charge during the day versus overnight, what driving routes would have the best performance.

Some are forward looking and realize they may have an opportunity to add their own renewables to roofs, and it starts a really great discussion. They're starting to understand what they can do and what they're going to need if they deploy a much larger fleet of EVs. It's exciting how people can take this technology and come up with all these ideas. It's great!

A: Most battery manufacturers are focused on high-volume commodity and low-priced operations. So, if it's an electric car, they'll only make batteries and the car company will only make cars if there's a high volume to be produced that will cover the costs of their production. For medium and heavy-duty trucks and buses, it's tougher because the volumes are smaller. There's a difference between how a consumer uses their vehicle and how a transit or government agency uses their truck or their bus. It's a much more difficult, demanding application. There are significant differences in the usage profiles. At EnerDel, that's our specialty. We make more advanced batteries at a lower volume that have a higher value. Instead of just battery cells and lithium commodities, we're able to deliver systems.

A: There are companies out there selling electric cars, chargers for the cars, and solar panels for renewables. Cities are also pushing commercial fleets to deliver packages with less pollution. It just so happens that these functions are an ecosystem that all fits together. In the end, all of those things need advanced lithium ion batteries to make them perform properly. It's that kind of demand that creates the need for EnerDel.

A: You have about 200 cities across the world that have signed up to go zero emissions for mobility (automotive) and power integration (utilities). About 50 bigger cities in the United States and about half of the states in the U.S. have all signed up with California for the same kind of objectives. These mandates are out there driving demand.

How do you see the future landscape of the grid and battery storage?

A: Utilities are going there. It's proliferating. It's going to be ubiquitous in every region, and utilities own a lot of the operations in various states. They tend to make long-term investments. Instead of building new power generation from coal, gas, or nuclear, they're looking at batteries. Batteries manage those peaks and valleys of the demand loads. It brings reliability and consistency, and this storage that has never existed before. It's a new market segment that we're very focused on. We provided a similar product solution to Portland General Electric years ago. We have a mature, commercially available, off-the-shelf product that's ready to go. We're excited!

What are some market trends you're keeping an eye on?

A: Battery life—which the market is definitely interested in—is important. Everybody desires the longest life possible. We do a lot of analysis to make sure we can meet customer expectations, although it's fair to say that expectations are high in all our markets. EnerDel started making batteries and testing them over 10 years ago. Those same cells are here, still running. It's like a live laboratory here of real-life battery testing, and of course there are batteries out in the field, in buses, etc. These batteries are almost as good as they were 10 years ago. That just speaks to the quality of what we developed then, and they've been improved over time. The data that we have compiled over the years is great. Believe it or not, that data is plowed back into the battery management system. We update our software to better control our own batteries, we adjust our software to maximize that information. It's priceless information and the only way you can get it is to collect it over a very long time.

A: We've always had an eye toward making sure we could recycle our products easily. We always knew we wanted to be responsible stewards in this business. We were thinking about what happens when our batteries reach the end of their useful life and how to responsibly recycle them. That thought has gone into our design from day one.

We've heard that the EV market will tip once EV batteries can hold a charge equivalent to that of about a tank of gas (about 250 miles). Has that factored into your design or approach?

A: We take calculated measured steps forward with cell development. The goal is to always increase cell capacity which would directly relate into a battery pack that could potentially get that mileage. We could do it today—your pack may be really big. The Holy Grail is the smallest pack that would get you there. Cell development has to always progress with the safest implementation of the advances of cell technology.

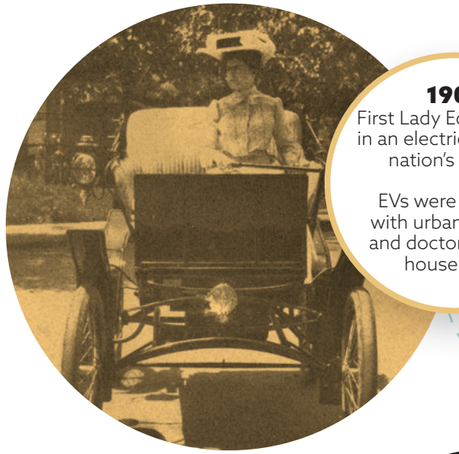
From your personal perspective, what are your thoughts on how your work will affect future generations?

A: It's a really great motivating thing—less dependency on fossil fuels and cleaner air—everybody benefits.

> "Batteries manage those peaks and valleys of the demand loads. It brings reliability and consistency, and this storage that has never existed before."

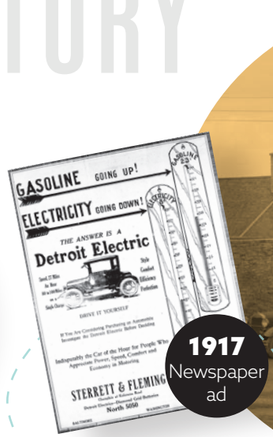
electric cars: an offbeat HISTORY

Believe it or not, Electric Vehicles (EVs) first made their debut in 1904 during the era of the horse and buggy! In honor of more than a century of electrified vehicles, ILLUME dug into automobile archives in search of a forgotten history.[1]



1904
First Lady Edith Wilson in an electric car at the nation's capital.

EVs were popular with urban dwellers and doctors making house calls.



1917
Newspaper ad

1937
Buzzkill! As Prohibition ended, so did the early heyday of EVs due to better roads and cheap, plentiful fossil fuels.

1904 1917 1937

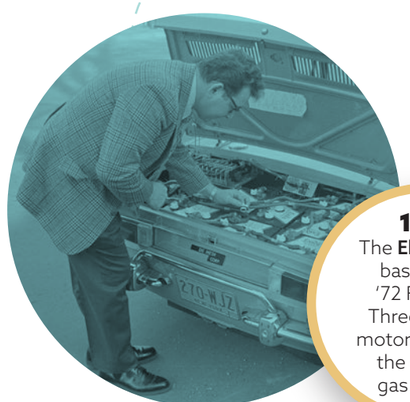
1919

1919
Promotional trip from Seattle to Mt. Rainer in a Detroit Electric car.

1919
Electric car charging.

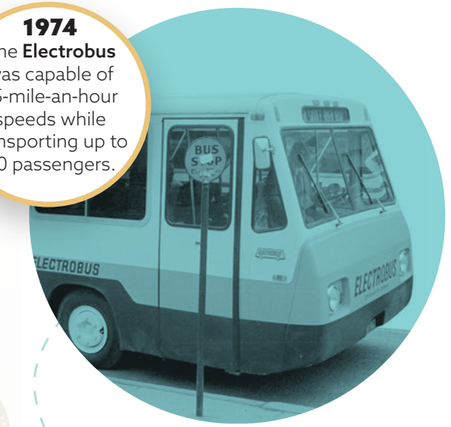
Environmental concerns, crude oil supply disruptions, and the Clean Air Act in 1970 were catalysts for an EV resurgence.

1970 1973



1973
The **Electra** was based off a '72 Fiat 850. Three electric motors replaced the original gas engine.

Who says the two-wheel crowd wasn't in on the fun?

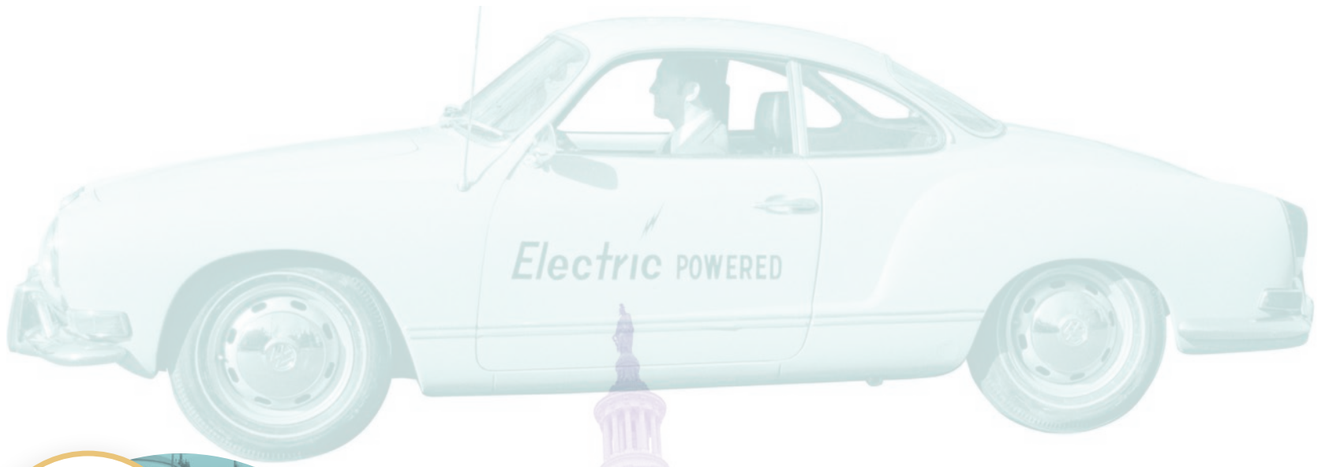


1974
The **Electrobus** was capable of 35-mile-an-hour speeds while transporting up to 40 passengers.

1974 1977

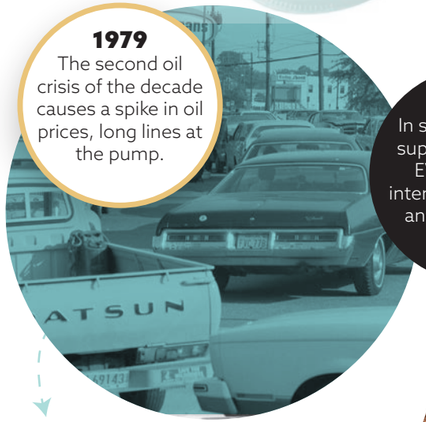
1974-77
The **Citicar** by Sebring-Vanguard sold enough units in 1976 to be the #6 automaker in the US.

Photo credits: U.S. Library of Congress



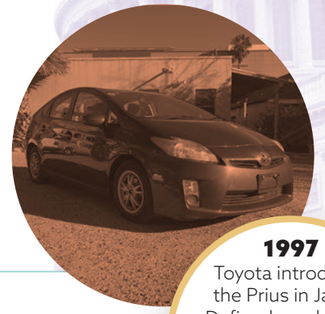
1979
The second oil crisis of the decade causes a spike in oil prices, long lines at the pump.

In spite of gasoline supply disruptions, EVs declined in interest due to range and performance issues.

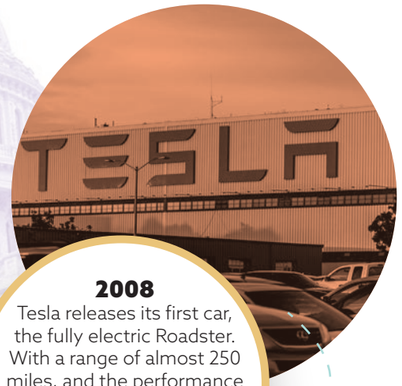


1979

1990s



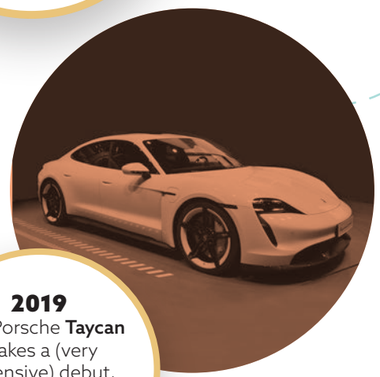
1997
Toyota introduces the Prius in Japan. Defined as a hybrid-electric vehicle (HEV) it was released outside of Japan in 2000, and is still available in 2019.



2008
Tesla releases its first car, the fully electric Roadster. With a range of almost 250 miles, and the performance and top speed on par with many sports cars, Tesla delivered on two drawbacks to battery-powered vehicles.

2008

2019



2019
The Porsche **Taycan** makes a (very expensive) debut, announces half of its cars will be electric by 2023.

While sweeping revisions of the 1990 Clean Air Act and 1992 Energy Policy Act got the legislative wheels turning, some serious battery technology research was taking place.

Quietly, automotive manufacturers were still taking the path of modifying internal combustion models to electric. Widespread interest from the buying public was muted in large part by afforable gasoline prices.

Photo credits: U.S. Library of Congress • Shutterstock

let the truck wars BEGIN!

2019 was the year of the pickup truck as Tesla, Ford, Rivian, and Bollinger announced plans to electrify one of America's most beloved automotive symbols. Expect nothing less than outrageous stunts like trucks pulling trains, trucks pulling trucks, or trucks getting shot at (yes, that happened) as competing auto manufacturers make their case to the American truck-buying public as they electrify the darling of the internal combustion engine.

Tesla Cybertruck

Tesla's *Blade Runner* inspired pickup truck channels visions of a Lamborghini/Stealth Fighter crossover. With three battery ranges (250, 300, and 500 miles per charge) and an onboard power station in both 120v and 220v, the Cybertruck does 0-60 mph in under 2.9 seconds.[2] Elon Musk's team did their homework with one exception: In taking a jab at Ford's "toughness," Tesla took a sledgehammer to the Cybertruck's driver-side door (Look! No scratches), and in the process of bragging about their truck's "Armor" glass, shattered the windows of the Cybertruck during the live reveal in November. We're just glad they didn't shoot it (again).

All-Electric Ford F-150

Not to be outdone by the EV/Space rocket/Solar-plus-Storage/Tunnel-boring company, Ford released a video of its All-Electric: F-150 Prototype as it towed 1 million pounds of train cars. So how "all-in" is Ford when it comes to electrification? $11 billion-all-in. Not to mention a $500m investment in automaker, Rivian (developers of an EV skateboard platform), which likely means Ford understood it needed a partner from the onset if it was to leapfrog competitors in the EV space. Though *Car and Driver* speculates the release date of the all-electric F-150 won't come until 2021, in November of 2019 Ford unveiled the Mustang Mach-E SUV firing a shot across Tesla's bow by leveraging its thoroughbred emblem in a race to compete with their Model S and Model 3 lineup.[3]

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"Our greatest weakness
lies in giving up.
The most certain way
to succeed is always to
try just one more time."

— Thomas Edison

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