PECAN STREET

Technology Roadblocks to the Clean Energy Future

October 2020

pecanstreet.org

The clean energy future we've been promised is taking a long time to arrive. What's standing in its way? Pecan Street examines four roadblocks that are holding back innovation and adoption of cleantech products, services and systems.

Introduction

A great number of trends, technologies, policies and market conditions have significantly improved the promise of clean energy products and services. The cost of solar systems and batteries has never been lower. Sophisticated home automation technology allows customers to control nearly every electrical outlet and appliance from their smart phone, whether they're at home, at work, or on vacation. In many markets, renewable energy has reached price parity with fossil fuel electricity. Nearly every major auto manufacturer makes a 2020 model year electric vehicle or has plans to make one or more models soon.

Why then, amidst all of this technology and market progress, does the electricity market in 2020 look so much like it did in 2010, or even 2000?

Energy markets are complicated, and adoption of new technologies is affected by multiple variables. Upfront cost is perhaps the most consumer-facing factor. Solar energy has reached price parity with fossil fuels, but installing a rooftop solar system on a house requires a significant customer investment. EVs are more affordable than ever, but they still cost more than their gas-powered equivalent.

Policy, too, has a significant impact. Electric and natural gas utilities have enjoyed 100 years of near monopoly market domination that was not only created by policy, but is now protected by it. For as much as utility executives deride the role of regulation, they live in a much more predictable world than companies that face genuine competition.

There are other variables that have hindered progress and adoption of cleaner, more advanced energy products and services. These technology roadblocks may not be as obvious as cost or policy, but they're just as, if not more, important.

About Pecan Street Inc.

Pecan Street's mission is to accelerate the transition to clean, low-carbon energy and integrated water management through innovative technology and policy. Our research, data, and technology expertise give researchers, entrepreneurs, policymakers, and impact investors the insight they need to change the world.

Pecan Street is the only organization that combines expertise in the "Internet of Things," high-velocity data acquisition, big data analytics, and lean product development to drive disruptive climate innovation.

Our real-world testbed of volunteer research participants is the first of its kind on the planet and has become an international model for how to develop and conduct energy and resource research and product testing. Our commercialization lab is an affordable, world-class proving ground for major corporations and startups alike. And our database, the largest source of disaggregated customer energy data, is used by university researchers and industry-leading companies around the world. Learn more at pecanstreet.org.

Roadblock #1: Lack of High-Fidelity, Widespread, Accessible Energy Data

Since we instrumented our first research volunteer's home with energy monitoring equipment in 2010, Pecan Street has collected more than a petabyte of energy use and generation data from nearly 1,000 homes. Our equipment takes up to 120 measurements per second from each home, producing more than two billion datapoints per day and more than a trillion datapoints since we began.

Our database, is, by far, the largest collection of residential energy use and generation data on the planet. This large amount of data has allowed us to perform very precise historic analysis of when energy is used and generated. But outside specialty research organizations like ours, the industry is not yet able to perform the kind of artificial intelligence algorithms that would truly automate a residential customer's energy life the same way that location data has propelled mobile apps.

Such functionality across the industry would not only require more and better data, but also the infrastructure in homes that would collect and transmit it in real-time and make it available at the right time in the right places to the right devices. Pecan Street's proprietary research equipment is installed after a volunteer has expressed interest in our research. Most prospective customers of a cutting-edge energy saving device or service likely would not allow a company to install data collection equipment before they buy the product. In today's data-sharing culture, however, they would likely consider granting that company access to data that is already being collected by their utility, so long as they trust the company and the utility.

The need to create and collect more energy data underscores two key challenges to overcoming this roadblock: access and security. Compared to 20 years ago, existing utility technology like smart meters can capture a great deal of data. But customers need access to high-resolution, real-time, continuous data streams of their electricity use and the ability to share it – also in real time – with whomever they trust and choose. With the exception of some small scale demonstrations, utilities do not do that today.

In addition to utility data, customers should have access to data produced by the energy-related products they buy. From smart thermostats and rooftop PV to electric vehicles and home automation systems, myriad new data streams are coming online each year, but their data is locked away in a proprietary data stream over which they have no control.

As with all data, customer energy data must be secure. But this should be easier to overcome than the access barrier. Banks handle and share personal financial data millions of times a day with other institutions. Securing sharing privileges for a stream of kilowatts via a customer's online account profile is not a grand technical challenge for utilities or energy product companies.

Suggested Reading

Follow the hyperlinks below to read more on this topic.

- McKinsey & Company — Analytics for Grid Decision Making — bit.ly/PSI-McKinsey
- Scott Madden — The Value of Data to Grid Transformation — bit.ly/PSI-Madden

Roadblock #2: Lack of Interoperability

In the early days of the digital photography revolution, new cameras were boxed with proprietary photo management software CDs. Some included a proprietary cable. When the iPod was introduced, it only worked with Macs.

Eventually, each of these products spread to broader markets by adopting standards that made buying and using the products easier for customers. Windows users could eventually use iPods, and customers can now download photos from their cameras to whatever photo software they prefer, no cable necessary.

Energy technology is not yet to this critical level of interoperability. There's no equivalent to the USB standard for DER connections. For customers who have invested in several cleantech products, it's unlikely that their smart solar inverter communicates with their smart thermostat or EV charging station. Smart inverters don't even respond in a standardized way to central utility commands. Just imagine buying a laptop, a phone, a printer and a WiFi router today that wouldn't all connect together seamlessly.

This silo phenomenon isn't unique; it happens in most new fields. But it slows down adoption because it creates barriers for customers and innovators. Customers have to learn far more than they should have to about which products work together and spend more to get the right combination. Companies have to either invent their own connectivity technology or choose sides. The more systems are standardized, the faster the products that use them are developed and adopted.

Recent developments, including IEEE 1547-2018, SunSpec and California Rule 21, are pushing this issue in the right direction. Even so, there is still a concern about communication protocols and conformity - whether all systems can communicate between each other and aggregators (or researchers, like Pecan Street). Our researchers have experienced this poor interoperability while conducting field trials and verification tests and have been able to overcome it – when the technology is open source – with custom hardware/software workarounds.

By establishing performance and communication standards, making compliance with these standards a requirement for relevant permitting or to be eligible for rebates and incentives from utilities, the electricity industry can shepherd consumer tech companies toward the interoperability that benefits all customers.

Suggested Reading

Follow the hyperlinks below to read more on this topic.

- IEEE Spectrum — A Plug-and-Play Microgrid for Rooftop Solar — bit.ly/PSI-IEEE
- Quality Logic — The Drama of CA Rule 21 — bit.ly/PSI-QualityLogic
- Pecan Street — What Rule 21 Gets Right and Wrong — bit.ly/PSI-Rule21

Roadblock #3: Clean Energy Technology Is Designed for Specialization, Not System Optimization

Despite the rhetoric of smart meters and smart inverters, the grid is still a collection of individual devices with narrow functions that operate on their own.

In an age where our phones can perform tasks that used to require large desktop computers, there's no reason energy devices shouldn't be "smart" enough to not only perform their specific tasks, but also work with other devices to multiply their benefit to the customer and the energy ecosystem.

The data needed for these decisions are already collected by most of these smart devices, but they aren't allowed, by policy or programming, to change operations based on what they "observe" in a home or on the grid. Nor are they designed to learn from or share with each other.

Solar inverters, for example, are capable of a lot more than what we currently use them for. If designed to optimize the customer's entire energy system, including, for example, energy storage, inverters could autonomously shift load to periods of high clean energy generation, notify the utility of adverse conditions or even take action without direction from a utility to help stabilize the grid or mitigate potential congestion issues. Further, providing smart inverters access to historical load patterns could allow them to create schedules for economic dispatch of solar and energy storage systems. Providing them access to data from other systems connected to the same transformers would bring more value to the utility and customers.

Pecan Street developed an open source prototype product that connects multiple energy components and acts as a residential microgrid. The Energy Switch includes built-in energy storage, integrates a home's solar generation and makes intelligent decisions about when and how to balance solar and grid supply with household demand and customer preferences. Not only did Energy Switch demonstrate that the performance of solar and storage components can be optimized through automation, it highlighted the need for an energy operating system to coordinate all the DER and smart home technologies now available to households with grid condition and weather data in order to maximize their benefit to the household and the grid.

The market is moving in this direction, and as solar and storage adoption continues to grow, economies of scale will make this kind of R&D investment much more attractive for companies and investors.

Suggested Reading

Follow the hyperlinks below to read more on this topic.

- Solar Builder — Can the Solar Sector and Grid Planners Meet in the Middle? — bit.ly/PSI-SolarBuilder
- Austin Energy — Optimal Design Methodology — Austin SHINES — bit.ly/PSI-Shines
- Pecan Street — Energy Switch: A Microgrid In a Box — bit.ly/PSI-EnergySwitch

Roadblock #4: Lack of Data and Governance Structures to Harness the Power of AI

Intelligence on the grid edge has been a talking point for years, but the system, overall, has not shifted or shared its intelligence. AI can change that.

Beyond energy data, other data streams are needed to optimize and personalize the energy system: weather, market, emission, customer location, and lifestyle data. Most of these are ubiquitous, free, or both; access is not the problem. Gathering, aggregating, and sharing them quickly, on the other hand, are all challenges that require a platform that enables real-time integration and coordinated response among devices and between them and the grid.

Today's technology has the ability – but not necessarily the permission or expectation – to shift the grid from a centrally-controlled system to a largely autonomous, bifurcated decision-making system that balances grid-edge responsiveness with system-wide security and reliability.

As we move toward an increasingly data-driven and digitized world, artificial intelligence (AI) systems are necessary to use this data for grid system security, reliability and affordability. One advantage of clean energy over traditional fossil fuel energy is the technology embedded in solar, wind, storage and smart grid systems that adds flexibility, security, and efficiency to the grid. As more clean energy resources are deployed, AI that can manage their intermittency and take full advantage of their built-in intelligence is critical to ensuring the full benefits of ratepayer-based investments in energy generation are passed along to every single customer.

We know this can be done because high-speed data exchange is the core of the modern internet and mobile app economy. Millions of people around the world can play the same online video game with near zero latency. Billions of financial transactions take place every second between individual users, their banks and online retailers.

Done right, the creation of more data and an open and secure data exchange platform that standardizes these datasets would yield significant grid system benefits, including security, safety, decarbonization and affordability. Without utility or regulatory leadership on this platform, individual companies will continue to develop their own proprietary platforms and enrollment programs, which will suppress interoperability, increase demand response and grid management costs, and slow overall technology adoption.

Suggested Reading

Follow the hyperlinks below to read more on this topic.

Utility Dive — Utilities Say They are Prepared to Meet Cyber Threats. Are They? — bit.ly/PSI-Dive

Pecan Street — Data: The Fifth Utility? — bit.ly/PSI-5thUtility

Renewable Energy World — Grid-edge Intelligence Will Be the Hallmark of the Utility of the Future — bit.ly/PSI-REWorld

Overcoming Cleantech's Roadblocks

These roadblocks illustrate the many moving pieces required to optimize a decentralized and interoperable energy ecosystem. Removing them will require action from a variety of players.

Pecan Street's Work

Our staff identified these technology roadblocks as a result of more than a decade of researching and developing energy technology for corporate, government and advocacy clients. This work continues, as does our commitment to inform public discussions about how policy and technology can increase renewable energy and, consequently, reduce emissions.

Much of our work targets these roadblocks. For example, our network of consumer energy users and the database formed by their data are first-of-their kind assets that have spurred policy changes and hundreds of peer reviewed papers. Our work on Austin Energy's Austin SHINES project included a custom aggregator platform that demonstrated the speed, reliability and efficiency of residential PV and smart energy storage. Through these efforts, we have, in most instances, overcome these roadblocks. Our hope is that entrepreneurs, engineers and researchers won't have to overcome such obstacles alone or one-by-one. An intentional effort by key stakeholders can remove them for everyone.

Academics and Startups

Academia and the startup community have led a great deal of cleantech innovation, from improving efficiency of solar PV to load-shifting algorithms. This trend will surely continue. Such exploration and innovation takes funding, however, and investments in forward-looking energy technology is tightening, whether it is federal funding through the Department of Energy or private investment capital.

State and Local Governments

Given the impact advanced energy technology could have on economic growth, improving grid resiliency, flattening demand, and reducing emissions, state and federal governments should increase investment in energy research that accelerates our transition to a cleaner, more distributed, more resilient, and more modern grid. Research that addresses these roadblocks head-on would be among the most productive uses of energy-related public funding.

Utilities

Perhaps the most powerful actors in overcoming these roadblocks are utilities and their industry. Enthusiastic and genuine leadership – including investments that demonstrate their commitment – will be the single most powerful force for change. On the contrary, half-hearted support or opposition from large utility players will delay or even doom meaningful progress.

Regulators and Elected Officials

It is impossible to note the central role of the country's utilities without also highlighting the role of the elected and appointed officials who regulate them. Local, state and federal regulators could provide meaningful direction, motivation, latitude, or mandates for utilities to accelerate their commitment to these changes.