



Annual Report FY 2017-2018

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PECAN STREET

From the Board Chair

There has never been a more urgent time for the kind of innovative, data-driven, real-world energy and water research that is conducted at and by Pecan Street.

From stronger and more deadly hurricanes to year-round wildfire threats, the impact of climate change can be felt from coast to coast. And now, according to the UN's Intergovernmental Panel on Climate Change, we are likely to see the worst impacts of climate change by 2040 if "business as usual" energy use and options go unchanged.

The need to transition to a carbon-free and low-water future is clear and urgent.

In the face of these dire warnings, I remain hopeful because American entrepreneurs and innovators have never been content with "business as usual." That's why America has led the world in disruptive innovations for the past



century – technologies and entirely new markets that seem to appear out of nowhere. I'm confident we will transition to a modern energy system that is clean, reliable and affordable because we have innovators, companies, researchers and citizens all committed to making this change happen.

Pecan Street is the place where these groups work together, with neighborhood testbeds and collaborative labs, to rapidly innovate and prove solutions that work in the complexities of the real world.

In the last year, Pecan Street's board of directors and staff have re-committed ourselves to our core strength and purpose: **to accelerate the transition to clean energy and integrated water management through development and adoption of innovative technology and policy**. Our research, data and technology give researchers, entrepreneurs, policymakers and impact investors the insight they need to change the world.

Over the coming year, Pecan Street will focus on using its data, research and technology resources to help solve three critical problems slowing the transition to 100% clean energy:

- 1. How do we make solar + storage more valuable and its benefits clearer to customers?
- 2. How do we better align load with solar generation to maximize solar's ability to reduce carbon emissions?
- 3. How can we ensure that increased renewable energy results in a more stable, secure and resilient grid that delivers affordable power to all customers while opening up new local economic opportunities?

I invite you to reach out to Suzanne and her team to understand how you can participate in this exciting movement. If you're already a partner, thank you for your support and commitment to finding smart ways to modernize our energy and water systems.

Sincerely,

James Marston Chairman, Pecan Street Inc.

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From the CEO

As Pecan Street approaches its 10th year of operation, I am pleased to share our annual report. The past year was one of successes, reflection and transition at Pecan Street.

Since I transitioned to CEO in March, I've focused on expanding our research network to deliver greater impact - digging deep to understand how we can better connect our diverse partners who benefit from the communities that have opened their homes to help develop and test solutions for smarter living. The feedback from our partners helped set a clear and inspiring vision that will guide our work in the coming year.



Pecan Street's research network remains unparalleled - over 2,500 researchers

in more than 60 countries have used Pecan Street's datasets to drive forward energy and water innovation. In fact, our data has been cited in more than 100 academic publications. This research led to new funding from one of America's pillars of scientific support, the Alfred P. Sloan Foundation. This grant, along with contributions from Lawrence Livermore National Lab, The Atkinson Center for a Sustainable Future at Cornell University, the Precourt Institute for Energy at Stanford University, and Landis+Gyr, allows us to carry our model for change into New York and California. The Sloan Foundation support also ensures that the data generated throughout Pecan Street's network will remain free to university researchers.

At our lab, we expanded our focus from development of specific technology solutions to exploring issues at the seams of smart grid and smart home. Through a better understanding of how new energy technology - such as solar + storage, vehicle-to-grid charge management, and smart home systems - impacts the grid, we hope to remove barriers that could slow the growth of renewables.

Our network of partners around the world continues to develop and rapidly scale the solutions that are helping to reshape humanity's relationship with the planet. We are working with an incredible group of industry partners to innovate within the finance sector – creating new platforms that more effectively connect entrepreneurs with a variety of entities that can provide critical early-stage financial support. Looking forward, our team is excited about opportunities to optimize investments in clean energy to achieve greater emissions reductions.

In the coming year, we will knit together the diverse efforts underway in California, Texas and New York to turbo-boost the transition to clean energy. To do that, we will continue to rely not just on our staff's research and technical expertise, but also on our network of volunteer residents and our university, industry and governmental partners. We will continue to accelerate innovation in clean energy and water management, and we look forward to delivering more solutions, faster.

Sincerely,

Jugame

Suzanne Russo CEO, Pecan Street Inc.

Leadership

STAFF

Data scientists, entrepreneurs, researchers, coders, city planners, lawyers, engineers and consumer product experts. Pecan Street's diverse staff represents the future of energy, water and technology industries.

Our staff of 10 offices at our lab in Austin's Mueller development, where we launched our first research project in 2010. That initial effort formed the foundation of our network of volunteer research participants, which has grown to include homes in other neighborhoods, cities and states.

In 2018, we began recruiting participants in our two newest markets — California's Bay Area and upstate New York.

BOARD OF DIRECTORS

Pecan Street is governed by a board of directors that reflects the expertise and diversity of disciplines of our staff, partners and supporters.

- Jim Marston (chair), Environmental Defense Fund
- Dr. Michael Webber (vice-chair), The University of Texas at Austin
- Debbie Kimberly (secretary), Austin Energy
- Carole Baker, Texas Water Foundation
- Callie Taylor, Greater Austin Chamber of Commerce
- Dr. Todd Cowen, Cornell University
- Dr. Emma M. Stewart, Lawrence Livermore National Laboratory
- Mitch Jacobson, Austin Technology Incubator
- Cora "Corky" Hilliard, Hilliard Resources
- Iga Hallberg, PivotMKTG



Fisayo Fadelu CFO & General Counsel









Grant P. Fisher CIO



Rachel Jenkins Director of Operations

Year at a Glance

We welcome you to review our entire report for detailed information on various projects and initiatives.

But if you're looking for a quick recap, we have you covered. Following are some of Pecan Street's most notable achievements from the 2017-2018 fiscal year.

ENERGY RESEARCH

- Developed low-cost solution to remotely diagnose HVAC system performance and causes of failure to improve thermal efficiency.
- Created and began testing an open standards platform that aggregates residential DER availability and provides remote DER management services.
- Launched the PLATFORM for Product Launch, which conducts low-cost performance testing and thirdparty verification for clean-tech start-ups.
- Released a revolutionary dataset of one-second, appliance-level home energy data.

WATER RESEARCH

- Released our high-resolution water dataset to more than 2,500 researchers around the world.
- Developed low-cost data management solutions for municipal water utilities that can help them better manage limited water supplies and promote development of best practices across regions.
- Deployed our custom water monitoring hardware at several Central Texas schools, and within a month, had detected an underground pipe leak that was wasting 400,000 gallons per month.

TRANSPORTATION RESEARCH

- Brought our unique public-private R&D approach to help solve first- and last-mile public transit challenges with neighborhood- and environmentally-friendly electric shuttles, providing more than 15,000 shuttle rides in three Austin pilots.
- Created Texas' only grid-connected R&D testing center for aggregated V2G management, in partnership with Austin Energy.

ORGANIZATIONAL IMPROVEMENTS

- Secured a \$1.1 million award from the Alfred P. Sloan Foundation and two \$1 million awards from the U.S. Department of Energy.
- Upgraded all of our data management and access procedures to comply with the European Union's new General Data Protection Regulations (GDPR).
- Launched a cybersecurity research program to ensure that new energy technologies enhance grid security.
- Continued to diversify revenue streams, and increased Pecan Street's net assets 23%.

Partnerships

FUNDERS & PARTNERS

Many thanks to the funders and strategic partners that make Pecan Street's work possible:

Austin Energy Austin Independent School District Austin Technology Incubator Austin Water Utility City of Austin City of Fremont Capital Metro Cornell University Cynthia and George Mitchell Foundation Environmental Defense Fund Landis+Gyr Lawrence Livermore National Laboratory LG Electronics Shell Alfred P. Sloan Foundation Stanford University Translational Research Institute U.S. Department of Energy The State of Texas The University of Texas at Austin Pecan Street's model of change relies on partnerships with the entities that shape our society, including established and start-up companies, universities, public institutions and citizens.

UNIVERSITIES

Universities and their researchers have been critical to Pecan Street's success. Starting with The University of Texas at Austin, our network of universitysponsored researchers now includes more than 2,500 researchers from more than 60 countries around the world.

In 2018, Pecan Street established strategic partnerships with the Precourt Institute for Energy at Stanford University and the Atkinson Center for a Sustainable Future at Cornell University to access their thought leadership and in-depth local knowledge as we expand our work in their regions.

CITIES & LOCAL GOVERNMENTS

Pecan Street was born from a partnership with our home city and the municipally owned electric utility, Austin Energy. That partnership remains strong and has grown to include partnerships with other key Austin public institutions, including Austin Water, Capital Metro and the Austin Independent School District.

CITIZENS

None of Pecan Street's work would be possible without the regular citizen scientists who volunteer to participate in our research. Many of our participants are eager gadget enthusiasts that want every new energy insight they can find. Others are climate warriors that want to help us help the innovators and policymakers that will reduce climate emissions. Whatever their motivation, Pecan Street is honored that they choose to work with us and trust us with their energy and water data.

Partnerships, cont'd

INDUSTRY

Pecan Street partners with industry leaders to combine our unique resources with their expertise and global reach to accelerate innovation.

This year, we partnered with Shell to accelerate innovation in energy management and distributed energy resources. Shell is leveraging Pecan Street's unique data analysis, lab and staff expertise in distributed energy solutions development. Pecan Street, in turn, is leveraging Shell's unique technical and market understanding and reach to rapidly scale solutions.

LG Electronics has worked with Pecan Street for over five years to conduct R&D of HVAC operational efficiency, smart appliance responsivity to time-of-use pricing, and characterization of home energy use.. LG Electronics has focused its more recent work with Pecan Street on optimization of residential solar and energy storage systems. Through this collaboration, LG has gained unique insights into design, integration and management strategies that will exponentially increase the value of residential energy storage systems to the grid while significantly reducing system-wide emissions.

We tapped into the expertise of our foundation and industry partners to serve as innovation advisors on the development and implementation of Pecan Street's start-up program, the PLATFORM for Product Launch.

The Innovation Advisory Council includes:

- Christophe Defert, Centrica Innovations Ventures
- Sergej Mahnovski, Edison International
- Tilak Gopalarathnam, LG Electronics
- Kirk Coburn, Shell Ventures
- Isaac Barchas, Translational Research Institute
- Jason Ballard, TreeHouse
- Melissa Uhl, Elemental Excelerator
- Bomee Jung, NYC Housing Authority
- Sarah Richards, Cynthia & George Mitchell Foundation
- Gregory Lopez, Leonardo DiCaprio Foundation
- Benjamin Gaddy, Clean Energy Trust

Pecan Street continues to leverage the private smart meter research network installed across some of our participating homes to conduct research at the seams between smart grid and smart homes, including cybersecurity, privacy, advanced communications, and grid edge intelligence. We are now expanding this high-impact research tool to New York State through additional support support from Landis+Gyr and Avangrid.

Partner Spotlight

Landis+Gyr has worked with Pecan Street for over five years, providing critical support to our research and development programs. Together, we developed a globally unique smart community research network of 250 dual-socketed smart meters on homes within Pecan Street's Austin residential energy testbed. The meters are controlled by Pecan Street through a donated license to Landis+Gyr's backend management system and operate independently of the utility, enabling critical insights into the seams between smart homes and smart grid.

"Working with Pecan Street has given us unique insights into our customers' needs and advanced our understanding of how smart meters can accelerate the transition to clean energy."

Ruben Salazar
Global Head of Research & Technology
Landis+Gyr

Finances

Pecan Street continues to experience steady financial growth as we maintain our historical funding sources and diversify into new revenue opportunities. In 2018, the organization increased its net assets through revenues from grants, contributions, sponsored research, fiscal sponsorship and licensing royalties.

ALFRED P. SLOAN FOUNDATION ANCHORED \$1.5M FUNDING COLLABORATIVE

In July 2018, we received a two-year \$1.1M award from the Alfred P. Sloan Foundation, approximately three times our previous largest foundation award. This award enabled Pecan Street to raise an additional \$400,000 that will collectively allow us to improve and expand our data resources and ensure that those resources are optimized for public good. The impact of this Alfred Sloan Foundation funding on the organization's revenues mix will be reflected in fiscal years 2019 and 2020.

U.S. DEPARTMENT OF ENERGY AWARDED TWO NEW GRANTS TO PECAN STREET

Pecan Street won two \$1 million federal grants in FY17-18. One of the awards, from the DOE's Solar Energy Technologies Office, funds activities to develop innovative financing pathways for clean energy start-ups. The other, from the DOE's Energy Vehicles Technologies Office, funds development of public-private sector partnership models that leverage electric transit innovations and behavioral research to solve last-mile transit challenges.

INCREASED NET ASSETS

The organization's net assets grew 23% (\$458,094) during the past fiscal year. This increase is largely due to additional corporate sponsored research projects and licensing royalties







FY 2017 - 2018 Revenue

Update from the Field Growing Pecan Street's Unique Volunteer Research Network

Launched in 2010 in Austin's Mueller community, Pecan Street's residential research network has become a globally unique resource for energy and water resource management and technology.

Now containing more than 1,100 homes and participants, it allows Pecan Street researchers and our partners to quickly evaluate how well a new program or technology works in the complex and messy realities of modern life. We have also used this network to field test new research techniques and technology, including a way to convert legacy analog water meters into internet-connected smart meters. Now, more than 300 homes in our network have Pecan Street smart water meters.

As Pecan Street approaches 10 years of research, we are pleased that we are now expanding and upgrading this valuable research asset thanks to new funding spearheaded by The Alfred P. Sloan Foundation. This new funding will allow Pecan Street to expand our research network into New York and California, upgrade our Austin testbed to collect new and higher-resolution data, and develop a national "Plant-to-Plug" dataset that will include an interactive portal for national grid system data.

In New York, we've partnered with The Atkinson Center for a Sustainable Future at Cornell University to develop a high-resolution data testbed of 100 homes and an independent smart meter research network of 200 homes. In California, we've partnered with Lawrence Livermore National Laboratory, Precourt Institute for Energy at Stanford University, and U.C. Berkeley to develop an advanced energy community testbed of 100 homes with solar, electric vehicles and energy storage.



The Colimon family is one of more than 1,100 volunteer participants in Pecan Street's research network. New funding will allow Pecan Street to upgrade the research equipment for all existing participants and expand into California and New York.

Our team continues to investigate solutions for gridedge management that leverages cloud-based computing, Internet-of-Things sensors and innovative software to expand the grid's clean energy capacity and make distributed energy resources an even better investment for households. This past year, for example, we worked with Eaton on an ARPA-E project to better align energy-intensive loads (air conditioners, electric hot water heaters and electric vehicles) with regional solar generation.

Learn more about what's involved in being part of Pecan Street's research network at pecanstreet.org/ resources.

Update from the Lab Energy Storage and V2G Testing Take Center Stage

Pecan Street's lab in Austin's Mueller community is the base of our operations and where our staff conducts early-stage technology testing and product development. Using the lab's several modular testing areas, we work with industry-leading companies and promising start-ups to develop transformative solutions for residential energy and water systems.

Leveraging the lab's fabrication equipment, we are able to rapidly build functional prototypes of solutions for feature-set testing, accelerating the cycle of innovation and significantly reducing costs.

Through a Department of Energy grant, we developed a first-of-its-kind vehicle-to-grid (V2G) testing center that combines Pecan Street's residential energy simulation capabilities with advanced charging infrastructure and electric vehicles. The center will initially be used to test EVs as a storage and generation resource for Austin Energy through various algorithmic approaches.

For an ARPA-E grant, Pecan Street developed hardware and software solutions for real-time, cloudbased and localized control of energy-intensive residential loads, specifically air conditioners, hot water heaters and electric vehicles. Combined with our real-time, sub-minute interval device energy use data, this technology is helping break new ground in aligning energy use with distributed PV generation and highlighting how homes can provide valuable services to the grid.

Pecan Street continues to work with partners to investigate optimization of solar + energy storage. Through the Austin Energy SHINES program, Pecan Street has created an OpenADR-compliant residential energy storage system (ESS) aggregator that pro-



In Fall 2018, Pecan Street installed Vehicle-to-Grid (V2G) equipment which will allow testing of electric vehicles as temporary energy sources for homes and offices.

vides a platform for third-party management of distributed energy storage systems. Pecan Street also leveraged the energy storage and smart inverter testing centers at the lab to resolve device-to-device communications issues, speeding up energy storage system response time and providing critical new ramping reserve capabilities. Pecan Street's team also investigated and resolved issues for smart inverter volt/VAR static compensation.

Six companies – three focused on residential water conservation and three focused on residential distributed energy – joined our first cohort in the PLAT-FORM for Product Launch program, which leverages Pecan Street's product development, testing and demonstration assets to validate new approaches to clean energy and water technology commercialization. The program has already helped the first cohort raise more than \$500,000 in new funding and will open applications for the next cohort in January 2019.

Update from the Cloud Pecan Street's Database Expands to a Petabyte

If Pecan Street's residential research network is the backbone of the organization, the database that houses hundreds of terabytes of research data is the nervous system.

Our database of high-resolution electricity measurements is unparalleled by any other data source. Built and maintained according to strict U.S. Department of Energy security and privacy standards, it grows by 100 million records a day and is available for free to university-sponsored researchers via our website (Dataport.cloud). More than 2,500 university-sponsored researchers from more than 60 countries have used our data, which has been cited in more than 100 published articles.

The expansion and upgrade of our field research equipment has necessitated a significant upgrade of our database hardware, too. Once the new field equipment is activated, our research homes will produce more data in the first month than we have collected over the last 10 years. To prepare for this new data flow, we have upgraded our servers, which enables us to store up to a petabyte of data and raw files at our lab.

This year brought increased attention to data security – due partly to news stories about breaches and partly to the adoption of the General Data Protection Regulation (GDPR) by the European Union. Pecan Street has worked diligently to bring all our systems, websites, and mobile applications into compliance with the GDPR and beyond with innovative and thoughtful implementations of data security and privacy measures.







In addition to the electric data from homes, Pecan Street has also been building a national plant-to-plug dataset that allows a new level of thoughtful and unique research. This effort will connect the homelevel energy use and generation data we already collect with national and system operator (ISO) data and allow us to better understand where power is generated, how it is traded, and finally, how it gets to users.

Energy Spotlight: Testing Solar + Storage Solutions



Because of the need to address the intermittency of solar and wind energy, energy storage has long been considered the Holy Grail of sustainable energy. Pecan Street is proud to be part of Austin SHINES, an innovative program led by Austin Energy that is driving forward progressive energy storage solutions.

Made possible by a \$4.3 million grant from the U.S. Department of Energy and support from the Texas Commission on Environmental Quality, the project is designed to optimize the value stream for solar and storage for grid, commercial and residential applications.

Austin SHINES will conclude in 2019 and has already won multiple awards, including the 2018 Greentech Media Grid Edge Innovation Award.

Austin SHINES supports the City of Austin's local solar, storage and 65% renewable energy goals. Pecan Street manages the residential portion of the project, which includes conducting research into how "smart" solar systems and energy storage — including vehicle-to-grid technology — can help make Austin's power supply cleaner, cheaper and more resilient. Pecan Street and Austin Energy are testing solar + storage technology with real customers on the real grid.

Over the past year, Pecan Street deployed residential gateways to perform the necessary communication and protocol conversion for the aggregation of a fleet of residential energy storage systems, as well as the energy monitoring hardware used to validate and verify system operation. This hardware enables the systems to respond to aggregated charge or discharge commands and bring the entire fleet of residential storage online in less than 8 seconds.

Already, we have discovered that the OpenADRcompliant platform for aggregation of DER can provide a utility critical flexibility to determine which DER management solutions to allow on its grid. This approach also allows for faster modular additions as new DER technologies like vehicle-to-grid services emerge and evolve. By the end of 2019, Austin SHINES will demonstrate how aggregated DER management solutions can provide more communitywide benefits and household-level benefits, in addition to independent system operation.

Water Spotlight: Smart Water Meter Technology

Pecan Street's suite of hardware and software turns legacy water meters into internet-connected smart meters.



Pecan Street's water program launched in 2015 with a \$4 million grant from the State of Texas Emerging Technology Fund to develop and prove residential water conservation solutions.

Step one was finding technology that could measure water to Pecan Street's standards. We quickly learned that there weren't any products or services that could provide-high resolution, near-real time data on water use and meet our requirements for data quality, accuracy, installation costs and data access.

Taking the lessons learned from evaluating current technologies and our experience in energy data measurement, we invented our own. The BluBand works with old, legacy water meters. That means utilities (or customers) don't have to replace entire water meters for it to work, keeping installation costs down. It's water-proof and battery-powered, so it can be installed in most environments. It's simple and can be installed by customers. And most importantly, it's incredibly precise. With help from the versatile BluBand, Pecan Street is capturing water data from more than 300 homes and businesses in Texas. This high-resolution water data has already proven helpful to property owners by allowing them to see minute-by-minute water use in near-real time. This has helped homeowners catch leaking toilet flappers, burst pipes and irrigation leaks before they get a budget-busting water bill and accidentally waste thousands of gallons of water.

Pecan Street's smart water meters helped one Central Texas school locate a 400,000 gallon leak, saving \$2,500-a-month.

In addition to BluBand, Pecan Street developed a suite of add-on products – BluCube, BluCellular, Blu-Enterprise and DataLogger – which extend BluBand's capabilities for different applications. The WiFi enabled BluCube is best for residential applications because it can be easily installed by a homeowner. BluCellular and BluEnterprise are best for commercial applications because they can be installed outdoors and are capable of reaching multiple meters at a greater distance.

Transportation Spotlight: Testing Last Mile Transit



One of the greatest barriers to mass transit use is the lack of stops close to where people start and end their trips.

Solving the last mile riddle and getting more people onto public transit, especially clean transit, will provide significant climate benefits and improved quality of life in communities across our country.

In partnership with Capital Metro and funded by the Department of Energy, the Electric Last Mile (ELM) project piloted electric shuttle services in three neighborhoods in Austin to develop models for clean, affordable and efficient last mile solutions.

The pilot sought to understand what elements of the ride-sharing economy and emerging electric transit technologies can be applied to last mile transit. Pecan Street leveraged our technology testing and integration services, information and data services, and our our community testbed to develop and test various models.

The demonstrations proved that this type of service is effective at getting individuals onto public transit. In order to produce a replicable plan for other communities, we are building a comprehensive dataset of consumer engagement and vehicle performance and a hardware kit for monitoring vehicle and ridership metrics.



A marketing poster for Pecan Street's eShuttle pilot in Austin. Pecan Street tested three routes: a downtown route, a neighborhood circulator and a shopping center route.

In the next phase of the project, Pecan Street will deploy the first fully-autonomous vehicle service in Austin. This exciting demonstration will feature a fixed-route vehicle that will drive itself between dedicated stops and shuttle passengers along a major corridor.



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