

Year in REVIEW 2019



From the Program Managers

The energy landscape is evolving rapidly, and the pace is only expected to increase in the coming years and decades. Businesses, governments, and civil society are working with urgency to address the dual challenges of increasing energy demand and climate change. For many years, Shell has been at the forefront of energy system transformation as an active participant and leader in transitioning the economy to ensure a low-carbon, sustainable, and prosperous future. Similarly, the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) has dedicated its resources to the research and development of renewable and alternative energies since its founding more than four decades ago.

With this shared vision and commitment to action, Shell and NREL are ideal partners. We have come together to make our technical, financial, and market strengths available to the startup community—where real market revolution is born. The result: Shell Gamechanger Accelerator[™] Powered by NREL (GCxN).

Since its inception just over a year ago, GCxN has achieved a number of major milestones and is beginning to show real impact in building a vibrant ecosystem to accelerate the energy transition. We have explored multiple technical themes but have maintained a singular focus on low-carbon or zero-carbon energies.

Two cohorts of a combined eight startups have entered the accelerator, addressing critical issues spanning long-term energy storage, fast electric vehicle charging, and the grid of the future. These companies come from across the United States and beyond. Each of the companies received a major boost from the technical expertise and funding provided by NREL and Shell, and some of them have received further financing from venture capital firms since entering GCxN. Many of these startups have also received attention from the media and potential customers, boosting their reputations and advancing their push for market adoption and penetration.

We are pleased and proud to present the following review of GCxN's first year. We highlight our eight cohort companies and their significant successes and early impacts. We describe the considerable ecosystem of partners that supports GCxN with referrals and market expertise, the company selection process, and the team behind the scenes that keeps the program up and running. This is just the beginning, as we look forward, together, to a future in which energy is clean, affordable, and sustainable.



Adam Duran GCxN Program Manager, NREL



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Global Energy Game Changers: NREL and Shell Growing the GCxN Partnership

An Interview with Martin Keller and Yuri Sebregts

Energy circa 2019 presents a conundrum—it is imperative in modern-day civilization, but it often comes at an environmental cost. Here we talk to two energy leaders, NREL Director Martin Keller and Shell's Chief Technology Officer Yuri Sebregts, about the partnership they forged to address today's energy challenges.



Martin Keller Director, NREL



Yuri Sebregts Chief Technology Officer, Shell

What interests you most about the work that NREL and Shell have been doing together?

Keller: NREL has been partnering with Shell on advanced energy technologies since 2006. Our long relationship demonstrates NREL and Shell's dedication to

transforming the world's energy supply. A lot has changed since our first biofuels project with Shell. We now collaborate on solar technologies, battery storage, and an array of grid technologies. And the Shell GameChanger Accelerator Powered by NREL aims to bring cleantech innovation to the market. The boundless possibilities of our partnership that is what I find most interesting. Sebregts: Shell's partnership with NREL covers both fundamental research in cutting-edge scientific areas and entrepreneurship programs that aim to speed up technology commercialization. We characterize our collaboration as "multiple themes, singular focus" —we work together on many important themes such as energy storage, grid management, electric vehicle charging, and others, all with the singular focus of accelerating energy transitions through technology development, deployment, and scale to the market. The shared vision of having market adoption and accelerating energy transitions as the end goal is what I find most interesting and encouraging about the collaboration.

What do you want Shell to know about NREL; NREL to know about Shell?

Keller: NREL focuses on research, development, and deployment for next-generation energy technologies. We are transforming energy by bringing renewable and

alternative energy technologies to market through more than 800 active partnerships with over 500 industry, university, foundation, and government partners. It is important to me that everyone at Shell knows that we are using our expertise in advanced scientific research and our state-of-the-art facilities to reduce risk and bring promising energy technologies to market. We partner on basic scientific research in the laboratory and scaleup technologies for market application. In addition to our scientific contributions, NREL's annual economic impact is estimated at more than \$1 billion.

Sebregts: Shell is a company with a long and proud history that has evolved with societal and customer needs for more than 100 years. Currently, Shell's vision and strategy is rooted in the company's purpose of "powering progress together to provide more and cleaner energy solutions." Building a strong foundation in renewables science and technology underpins our growth ambitions in the new energies business, and our collaboration with NREL is very much a key contributor to our future success.

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In your dealings with Shell/with NREL, what aspect of the company/ lab has surprised you most?

Keller: As one of the world's largest and most technically savvy integrated energy firms, Shell has world-class facilities and renowned research experts, much like NREL. Perhaps I am most

surprised that Shell and NREL have so much in common. We are both working on commercializing innovative and game-changing technologies. It is interesting that, despite our quite different origins, Shell and NREL are converging at this point in time to tackle some of the world's greatest energy challenges. **Sebregts:** Perhaps what surprised me the most is the immediate and natural chemistry between Shell and NREL scientists and technologists in our joint projects and programs. From what I can tell, the level of interactions is both very broad and deep: we collaborate seamlessly because of our shared deep expertise and skill sets, as well as our passion for making a real impact in the energy future. To me, I am confident that the Shell-NREL collaboration is a game-changing partnership that will keep delivering real results for many years to come.

About Shell GameChanger Accelerator™ Powered by NREL (GCxN)

The Shell GameChanger Accelerator Powered by NREL (GCxN) is a multimillion-dollar, multiyear program developed in collaboration between Shell GameChanger and NREL focused on discovering and advancing emerging clean technologies with the potential to dramatically alter the future global energy landscape. GCxN identifies promising startup companies through our Pipeline Partners, an extensive ecosystem of clean-tech business incubators, accelerators, and universities. Invited companies receive access to up to \$250,000 in non-dilutive funding in the form of technical experts and facilities to develop and demonstrate new energy technologies.

GCxN seeks companies operating in the new energy space, with rotating technology focus areas that span the energy continuum from generation to transmission and distribution. Companies applying to GCxN can be classified into three tiers based on technology readiness level (TRL), each with their own unique challenges on the path to commercialization:

- Tier 1 Bench Scale: TRL 1–5, Early stage with physical proof that the concept may work.
- Tier 2 Prototype: TRL 6–7, Prototype available for testing and validation.
- Tier 3 Commercially Ready: TRL 8-9+, Production models available in limited quantity.

GCxN's goal is to help companies at each technology tier meet critical milestones to advance to the next stage of development, accelerating their time to market while minimizing the risks associated with commercializing next-generation technology. Over the course of 18–24 months, participating GCxN companies gain access to NREL and Shell's world-class facilities and researchers, who help develop, test, validate, and incubate the companies' technologies, helping them meet critical validation milestones on the path to commercialization.

About Shell

With 82,000 employees operating in over 70 countries, Shell is an international energy company that aims to meet the world's growing need for more and cleaner energy solutions in ways that are economically, environmentally, and socially responsible. To achieve this goal, Shell has several open innovation programs that partner with creative people, companies, and organizations to innovate new and better ways to unlock energy sources and meet the growing world demand.

The **Shell GameChanger** program, open to the public, is designed to de-risk early-stage energy ideas (pre-seed/seed) quickly by offering a combination of proof-of-concept funding and technical expertise. Founded in 1996, GameChanger has worked with more than 1,500 innovators and turned more than 100 ideas into productive reality. GameChanger provides companies with support, expertise, and seed funding while they maintain the independence to make their own decisions. The global program operates in the United States, Netherlands, the United Kingdom, Brazil, China, and India, and actively invests in a broad spectrum of energy technologies spanning upstream, downstream, new, and digital technologies.

Expertise provided to the GCxN program is from Shell's **New Energy Research & Technology (NERT)** team. NERT has two essential aspects to its mission: to provide technical assurance for all projects that the New Energies business requires and to provide the fundamental research for short-, medium-, and long-term organic growth in the New Energies domain.

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GCxN provides funding, technical expertise, and market knowledge to help cleantech startups avoid the "valleys of death" on their paths to commercialization.

About NREL

Established in 1977 as the Solar Energy Research Institute and designated a national laboratory in 1991, the National Renewable Energy Laboratory (NREL) is one of 17 active U.S. Department of Energy national laboratories. NREL's 2,700 employees are focused on research, development, and deployment of next-generation energy technologies, particularly in the areas of renewable and alternative energy.

With its internationally renowned scientists and world-class facilities, NREL is a perfect partner for Shell GameChanger in supporting passionate cleantech entrepreneurs. NREL provides GCxN with unbiased third-party technology development, validation, and demonstration capabilities to advance and de-risk early-stage technologies.

Through collaboration with NREL's **Innovation and Entrepreneurship Center**, GCxN gains access to a strong network of national and international Pipeline Partners—academic, industry, and government institutions with market knowledge and convening power to help startups expedite the path to market for potentially game-changing technologies.

GCxN Process

Applicants interested in participating in GCxN undergo a rigorous, multistage review process designed to identify the most promising cleantech startups according to three primary factors: viability and potential energy impact, fit for laboratory assistance, and alignment with the GCxN program mission. The process for identifying and selecting GCxN cohort companies is:

Topic Selection

Shell and NREL decide on the technology focus for each cohort and release a call for referrals to an ecosystem of academia, industry, and university partners—GCxN Pipeline Partners.

Referrals

Pipeline Partners refer qualified startup companies to the program.

Applications

Referred companies review program agreements and complete GCxN's online application.

GCxN Technical Review

Technology experts at Shell and NREL review applications on technical merit and select finalists.

Secondary Review and Pitch Day

Finalists are invited for an in-person secondary review and pitch competition in front of the GCxN review committee.

Cohort Selection and Kickoff

The cohort is selected, and companies are invited to a kickoff event.

GCxN's first two cohorts were selected and announced globally in 2018–2019, with the third cohort currently under review and selection planned for announcement in early 2020. Since its founding, GCxN has explored novel clean energy technology themes spanning the energy continuum—the grid of the future, long-duration energy storage, electric vehicle (EV) fast charging, and commercial-scale perovskite manufacturing.

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A First-Year Success Story: Feasible, Inc.

Someone had to invent the tire gauge. Someone had to invent the thermometer... the tachometer... the odometer.

For each tool now regarded as essential to driving, there were inventors and entrepreneurs who developed that instrument, perfected it, and brought it to wide-scale use.

Feasible, Inc., a startup in Emeryville, California, is hoping to be one of those few, gamechanging instrument creators. Its goal: to facilitate revolutionary leaps in EV deployment by using ultrasound in the process of making EV batteries.

In the year since being accepted into the GCxN program, the Feasible team of nine, led by CEO and co-founder Andrew Hsieh, has been making great strides: raising private funds from Chrysalix Venture Capital (a global venture capital fund in which Shell is a limited partner), winning a spot in the Elemental Excelerator, and convincing a manufacturer to let them test out their gear at the facility.

And then there's the EV-sized, custombuilt battery cells shipped from Indiana and currently being put through the ringer at NREL in Colorado.

The beginning of the journey

The idea for Feasible's ultrasound technology was first unveiled to the world in 2015, in a groundbreaking paper Hsieh published in *Energy &* *Environmental Science.** Hsieh and his co-authors at Princeton had found that ultrasound could be used not only to estimate battery charge levels and predict battery flaws, but could do this for multiple chemistries—making it a potentially universally applicable tool. Just in time for the age of increased electrification.

The early promise of this technology won Feasible financial support from ARPA-E and the National Science Foundation, a Small Business Innovation Research award, and a coveted spot in the Cyclotron Road Fellowship based in Berkeley, California (now Activate).

GCxN funds custom-built test batteries

When Feasible applied to the GCxN program in 2018, the company was still determining what kind of customers it would be serving, and could only try out its acoustics-sensing platform (called EchoStat) on small batteries, like those used in laptops.

Since the award, the Feasible team has worked with NREL expert Ying Shi to design tests to flesh out what ultrasound can do for EV batteries (and the industry as a whole).

And they scaled up their testing in a big way.

Hsieh and his team contracted with the Battery Innovation Center to make 35 custom battery cells that are big enough for use in EVs. In December, the Feasible team took measurements with the

* A.G. Hsieh, S. Bhadra, B.J. Hertzberg, P.J. Gjeltema, A. Goy, J.W. Fleischer and D.A. Steingart. 2015. "Electrochemical-acoustic time of flight: In operando correlation of physical dynamics with battery charge and health." Energy & Environmental Science 8 (5): 1569–1577. doi 10.1039/C5EE00111K.

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EchoStat as the batteries were coming off the line at the Battery Innovation Center facility in Indiana.

Those large-format batteries are now at NREL where they are undergoing more rounds of testing. The results will be studied to see what new kinds of insights ultrasound can give us about batteries, and what kinds of predictions can be made about their lifespans.

"GCxN has been a really big catalyst," said Hsieh. "It allowed us to test our technology on commercially

relevant cells. That's really important as we refine understanding of how we create economic value for our customers."

In 2020, the Feasible team will continue to refine the EchoStat, and will hire two new employees: a Director of Engineering and a Head of Product Development. They have new funding from Chrysalix Venture Capital and new ties to the energy ecosystem and burgeoning Asia-Pacific markets, thanks to their acceptance into the Elemental Excelerator. The future looks bright.

GCxN Cohort Companies

AllCell Technologies

AllCell Technologies is making lithium-ion batteries safer and faster to charge with a passive thermalmanagement material incorporated into its lithiumion battery packs. This patented phase change composite material is used to spread and absorb heat as the batteries cycle and generate heat. AllCell's batteries are powering May Mobility's self-driving cars: already on the road in Detroit.

Antora Energy

Antora Energy is building a unique "heat battery" to solve the problem of long-duration grid storage. Its technology uses materials to store energy; when that energy is needed, it can be translated into electricity through the use of a special type of solar cell. This technology will improve grid resiliency and provide long-duration storage at an estimated 1/20th the cost of conventional batteries. **Antora Energy has demonstrated a record-breaking 30-plus percent efficiency in its solid-state heat engine.**

Electrical Grid Monitoring

Electrical Grid Monitoring Ltd. is developing its Meta-Alert system to perform self-learning analytics on the grid. By monitoring an entire electric grid in real time via distributed communications technology, its system produces insights for optimal grid management and operation. An Electrical Grid Monitoring demonstration project is underway with the New York Power Authority.

Feasible, Inc.

Feasible, Inc. is developing a technology platform that uses soundwaves and data analytics to deliver insights about batteries across the value chain. At scale, the Feasible, Inc. technology will enable widespread adoption of clean energy sources by improving the performance and safety of battery packs and decreasing their lifetime costs. Chrysalix Venture Capital, in which Shell Ventures is a limited partner, recently invested in Feasible, Inc.

Intertie

Intertie has developed a modular smart grid technology, the EV ChargePod, that advances the grid of the future by simultaneously delivering ultra-fast EV charging, intelligent storage, solar integration, and other electric services, while improving grid reliability and raising utilization. Intertie's modular fast-charging system avoids demand charges while delivering up to 180 kW of power.

Hygge Power

Hygge Power is building a new platform for flexible energy storage in apartments, homes, and small businesses. Its in-home network of small storage devices works together to act as one giant battery, allowing renters and homeowners to deploy backup power where it's most important at a lower cost. The solution provides critical power during disruptions, while providing system data to reduce energy costs and inform tailored insights. **Hygge Power raised \$2 million in capital and is working with four utility partners.**

Microgrid Labs

Microgrid Labs is developing a modeling, simulation, and optimization software platform for fleet managers to help them make decisions about how to cost-effectively and quickly electrify their multi-vehicle fleets, such as city bus agencies, school bus fleets, and commercial truck operators. Microgrid Labs was awarded a National Science Foundation Small Business Technology Transfer grant to develop its platform with U.C. Berkeley.

Span

Span is reinventing and redesigning the inhome electrical panel. Its goal is to make it easy and inexpensive to integrate renewable energy sources into the average electrical panel. **CEO Arch Rao spent five years at Tesla Energy developing the Powerwall.** "The innovation needs to happen now—in order to make an impact in the future. That's really what we're so focused on. It's what Shell's focused on. It's what NREL's focused on. We all share a common vision going forward."

– Zander Mrlik, COO, Intertie

GCxN in the News

Throughout its first year, GCxN has garnered attention, including national and international media coverage. We've provided a few highlights, below:

Shell Targets Grid and EV Charging Technologies in Accelerator Programme

Current News UK, November 14, 2019: After multiple rounds of evaluation, five companies have been chosen to take part in the accelerator, which is supported by the U.S. Department of Energy's National Renewable Energy Laboratory.

How a New Class of Startups are Working to Solve the Grid Storage Puzzle

MIT Technology Review, October 10, 2019: Form Energy, Antora, and others are trying to develop very cheap, very long-lasting storage to clean up the electricity system.

Supercharging Batteries with Sound

Supercharging Batteries With Sound

What we're up to at Feasible Inc.

Medium, September 27, 2019: While energy density is an important factor for cutting cost per kWh, efficiency and consistency in battery production processes is an important part of the equation. To date, battery production has been more of an art than a science.

A Global Energy GameChanger: Shell and NREL are Teaming Up to Deliver Startup Technology to a Rapidly Transforming Energy Market

NREL, July 24, 2019: As demand for renewable energy increases worldwide, energy companies are taking aggressive steps to meet it.

The Span Panel Makes Adding Solar & Storage a Plug & Play Affair

CleanTechnica, September 19, 2019: Span is bringing intelligence to the home base of a home's electrical system with a new smart electrical panel that was designed from the ground up with home solar, energy storage, electric vehicles, and smart home tech in mind.

Shell New Energies Director on Investing in Clean Energy: "It's About Survival"

GreenTech Media, April 1, 2019: Oil major has been on a clean-energy acquisition spree, and "absolutely" intends to become a regional electric utility in the U.S.

Our Ecosystem

GCxN is a by-invitation-only incubator. During each biannual call for participants, GCxN applicants are referred to the program through a carefully curated international ecosystem of cleantech business incubators, accelerators, funds, and universities: our Pipeline Partners. These partners represent the leading edge in academia, research, and industry, each providing unique insights into cleantech as well as their local startup communities.

55 PIPELINE PARTNERS AND COUNTING

Looking Ahead with the GCxN Steering Committee

Just over a year old, GCxN is already making an impact. Eight cleantech startups are further along the pathway to commercialization than they were a year ago. Eight innovations in energy storage, EV fast charging, and the grid of the future are closer to realization. Our cohort companies have hired employees, NREL and Shell have expanded their market knowledge, and investors are paying close attention.

While we're proud of our accomplishments, our work is just beginning. The global energy power and influence represented by our two organizations is particularly well-suited to effect real change in energy technologies and markets. Real change takes time and we know we're on the right path to facilitate and expedite that transition.

NREL and Shell look forward to continuing our important work by supporting technology development and validation at our existing GCxN cohort companies. In addition, over the coming year we plan to add new cohorts of cleantech startups that are innovating in additional markets. Our goal is to work together to transition to a low carbon future. We will continue moving toward that goal by identifying and advancing the next generation of transformative, game-changing energy technologies.

Richard Adams Director, NREL Innovation & Entrepreneurship Center

Lene Hviid Global Manager, Shell Research Connect & GameChanger, GCxN Board Chairman

Ajay Mehta Global Manager, New Energies Research & Technology, Shell

Shell + NREL: A Global Energy GameChanger

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