

Innovative Energy Technologies: *The Next Generation*

2020 Technology Guide for CMU Startups

Carnegie Mellon University

Wilton E. Scott Institute
for Energy Innovation

“*CMU is uniquely positioned to support entrepreneurs and innovators. We never know where the next breakthrough in energy will come from, but the Scott Institute helps us find it.*”

- **Reed McManigle**, CMU Center for Technology Transfer and Enterprise Creation Mentor-in-Residence and Senior Manager of Licensing and Business Development



OUR LIFESTYLE IS SUSTAINED BY ENERGY

Next generation energy technologies developed at **Carnegie Mellon University** have the ability to enhance energy generation and the consumption of that energy in our buildings, transportation, industry and homes. Some of these technologies are just emerging from the minds of **Carnegie Mellon University** undergraduates, graduate students, researchers, faculty and alumni while others have already entered, or are on the cusp of entering, the marketplace. However, to reap the benefits of these technologies in our everyday lives, it is critical that industry, policymakers and the public support their development from ideas generated in the laboratory to the commercial marketplace.

Contents

02 Energy Generation, Conversion, Storage and the Environment



05 Industry Device Manufacturing and Energy Efficiency



09 Commercial Facility and Residential Energy Management



12 Transit Energy Management



14 Index of Companies and Innovations





Aquion Energy

Storing Electricity in Water-Powered Batteries

Aquion Energy has developed the aqueous hybrid ion battery, a low-cost, long-lasting, large-scale aqueous electrolyte sodium ion battery that uses salt water to store electricity. The company was acquired June 2017. **Key researcher** is Jay Whitacre.

More information at: aquionenergy.com



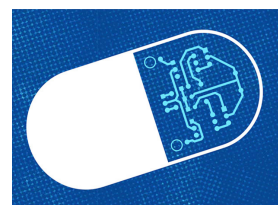
Ecotone Renewables

Creating Energy through Food Waste

Ecotone's "Seahorse" system takes in food waste from local grocers, college dorms, restaurants, and more. Through anaerobic digestion principles, Ecotone Renewables reuses food waste to create electricity, fertilizer and fresh produce.

Key researcher is Dylan Lew.

More information at: ecotonerenewables.com



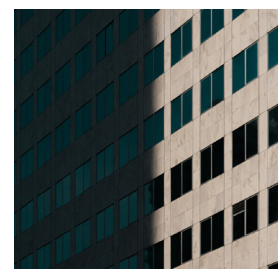
Edible Electronics

Organic Sensors that Prevent Health Complications

Edible electronics are biosafe, ingestible sensors powered by stomach acid that could provide information on early signs of bacterial infection, look for symptoms of gastrointestinal disorders, and even study the microbiome living inside people.

Key researchers are Christopher Bettinger and Jay Whitacre.

More information at: <http://bit.ly/2Mayu0R>



Electrochemical Synthesis of Cement

Rethinking Cement Generation

The production of cement is the largest industrial source of greenhouse emissions in the world. CMU researchers are developing an electrochemical method that would enable the synthesis of cementitious calcium silicate compounds at temperatures at or close to room temperature. This way, one could harness a source of renewable, carbon neutral electricity to produce the exact same product that any cement kiln is producing, but without the greenhouse gas pollution. **Key researcher** is Venkat Viswanathan.



FarmtoFlame Energy

Providing a Universal Solution for Converting Biomass into Electricity

Farm to Flame Energy converts agricultural waste to electricity in a unique smokeless process at half the cost of diesel fuel. Their revolutionary combustion process burns various forms of biowaste (reduced to fine powder) in place of fossil fuels. This fuel burns as intensely as traditional fuel sources, while being safe for the environment. **Key researcher** is Kwaku Jyamfi.

More information at: farmtoflameenergy.com

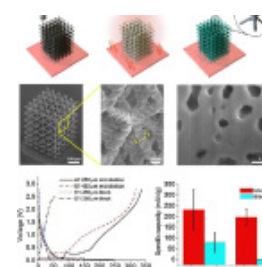


GeckoRobotics

Power Plant Inspections Using Robotics

GeckoRobotics has developed robotic systems to facilitate the inspection of boiler tubes in power plants. Their system is faster, more accurate and safer than current techniques. The company was assisted in its launch by Y Combinator. **Key researcher** is Troy Demmer.

More information at: geckorobotics.com

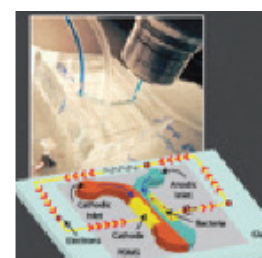


High-Capacity Lightweight Batteries

Increasing Battery Capacity through 3D Printing

CMU researchers are using 3D printing methods to create controlled, hierarchically three dimensional porous electrodes for lithium-ion batteries that will increase the battery capacity by at least 50 percent. **Key researcher** is Rahul Panat.

More information at: <http://bit.ly/2nSPq3V>



Microfluidic Microbial Fuel Cells

Creating Power from Organic Compounds

The Microfluidic Microbial Fuel Cell, which includes the world's smallest low-cost fuel cell, uses microbial electricity generation enabled by microfluidic flow control to produce power from natural organic compounds like bacteria. **Key researchers** are Kelvin Gregory and Philip LeDuc.

More information at: <http://bit.ly/2nPkKR3>



Mine Vision Systems

Mapping Mines with Accuracy

Mine Vision Systems has created a visual system that can be used for the mapping of underground mines with a high degree of accuracy. This accuracy enables monitoring from different perspectives for production, safety and equipment operators.

Key researcher is Brett Browning.

More information at: minevisionsystems.com



Platypus Technologies, LLC

Environmental Monitoring Through Autonomous Robot Boats

Platypus Technologies, LLC manufactures small, low-cost autonomous robotic boats that can quickly and efficiently sense environmental contaminants, along with other critical data, such as water depth, dissolved oxygen and pH.

Key researcher is Paul Scerri.

More information at: senseplatypus.com



Sensevere

Sensing Danger in Severe Environments

SenSevere provides semiconductor-based sensors for severe environments that detect hydrogen, hydrocarbons, ammonia and bromide. These have the power to improve environmental compliance and safety for the power generation, environmental and chemical industries. Sensevere was acquired in July 2018 by Sensit Technologies. **Key researcher** is Jason Gu.

More information at: <http://bit.ly/2OCa7w5>



Solar Selective Absorbers

Impacting Solar Thermal System's Design and Performance

Solar Selective Absorbers utilize solar thermal energy conversion and a mold stripping method that drastically increase throughput and decrease fabrication cost. These absorbers can significantly impact transformative advancements in solar thermal system's design and performance. **Key researcher** is Sheng Shen.

More information at: <http://bit.ly/2MLogV1>



SolePower

Increasing Industry Efficiency through Smart Work Boots

SolePower has created self-powering smart work boots that can be embedded with electronics including GPS, motion sensors, Wi-Fi, RFID and lighting. All are charged by the power of walking and can help provide data, signal unsafe conditions, and simplify monitoring of industry and company standards. **Key researchers** are Hahna Alexander and Matthew Stanton.

More information at: solepowertech.com



Tartan Battery Network

Developing a System for Recycling and Reusing EV Batteries

CMU researchers are developing a platform of services to support the reuse and recycling of electric vehicle (EV) lithium-ion batteries. They will assess and adaptively reuse batteries that have reached the end of their life for their initial application.

Key researchers are Jay Whitacre and Wei Wu.

More information at: <http://bit.ly/2JQd0Gd>



Teratonix

Replacing Batteries with Radio Waves

Teratonix develops a maintenance-free power source to replace batteries by converting ambient radio waves into electricity to combat challenges of expensive installation and high lifetime maintenance costs. **Key researcher** is Yi Luo.

More information at: teratonix.com



Watt-Learn

Creating a Reliable and Profitable Grid, One Battery at a Time

Watt-Learn is developing a cloud-based artificial intelligence software designed to maximize the longevity and value generation of grid-connected energy storage systems. The company's software maximizes the return on investment of battery projects at different scale, technology and use case while minimizing their degradation — enabling companies to reduce operating costs. **Key researcher** is Matineh Eybpoosh.

More information at: wattlearn.com



Anactisis

Retrieving and Reusing Rare Earth Elements

Anactisis economically recovers rare earth elements, used in many electronic technologies, from coal combustion fly ash to water used for hydraulic fracturing, geothermal energy and mine tailing settlement. **Key researcher** is Athanasios Karamalidis.

More information at: anactisis.com



Arieca

Developing Soft, Stretchable Metal Alternatives

CMU researchers have developed soft and stretchable materials that have the elastic properties of rubber and the electrical and thermal properties of metal. These materials can be used as stretchable circuit wiring, insulators and heat dissipating substrates. **Key researcher** is Carmel Majidi.

More information at: arieca.com



ATRP Solutions

Creating Polymeric Materials for Commercial and Industrial Use

ATRP creates well-defined polymeric materials that are utilized in various commercial products and applications like custom materials for oil field chemicals, used for hydraulic fracturing cleanout and drilling. ATRP Solutions was acquired by Pilot Chemicals Co. in July 2017. **Key researcher** is Krzysztof Matyjaszewski.

More information at: atrpsolutions.com

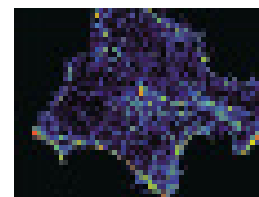


Blade Diagnostics Corporation

Extending Lifecycles of Integrally-Bladed Rotors

Blade Diagnostics Corporation develops tools and methods for evaluating and controlling how mistuning affects the vibratory response of critical, expensive integrally bladed rotors. **Key researcher** is Jerry Griffin.

More information at: bladediagnostics.com



Carbon Nanotube Aerogels

High Strength, Light-Weight Materials Without the Cost

CMU researchers are developing methods to link carbon nanotubes (CNT) in aerogel constructs to provide materials that are lightweight and high strength. Aerogel constructs enhance material qualities with very low concentrations of CNTs. **Key researcher** is Mohammad Islam.

More information at: <http://bit.ly/2Vsy5uV>

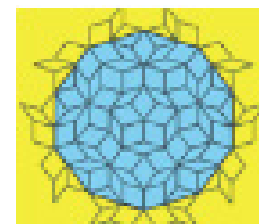


Carnegie Robotics

Improving Productivity, Reliability, and Safety with Robotics

Carnegie Robotics is the industry leader in building highly reliable robotics products to improve productivity, reliability and safety. The company's products have applications in the agriculture, mining, defense and oil and gas production markets. **Key researcher** is John Bares.

More information at: carnegierobotics.com



CorePower Magnetics

Increasing the Power and Efficiency of Magnetic Materials

The magnetic materials developed at CMU and NETL will increase power density, lower losses, increase efficiency and reduce size and cost in power electronics. The materials are essential elements of a variety of power electronics equipment for electric vehicles and other applications, such as transformers, inverters and motors. R&D 100 Award recipient in 2019. **Key researchers** are Paul Ohodnicki and Michael E. McHenry.

More information at: <https://bit.ly/2x7RbhY>

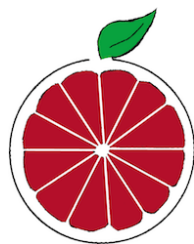


Fifth Season

Vertical Farming with Automated Robotics

Fifth Season develops automated robotics and software analytics to make indoor agriculture more efficient and environmentally friendly. The company grows produce using smart, indoor vertical farms that utilize 95 percent less water and increase labor efficiency by over 50 percent. **Key researcher** is Austin Webb.

More information at: fifthseasonfresh.com



Grid Fruit

Bringing Data-Driven Intelligence to Food Retail Operations

CMU researchers are developing software for dynamic, distributed, parallel management of load balancing in electric power distribution networks. The initial application is dynamic control of commercial refrigeration, to reduce energy costs and provide better control over maintenance costs. **Key researchers** are Soumya Kar, Javad Mohammadi and Jesse Thornburg.

More information at: gridfruit.com



Integrated Silicon Technologies

Cutting Costs on Continuous Casting

CMU researchers are developing an improved continuous casting process for making solar silicon wafers that will have dramatically lower cost by simplifying a formerly complex, expensive and wasteful process. **Key researcher** is Erik Ydstie.

More information at: <http://bit.ly/2pY55PX>



Liquid X Printed Metals

Pushing the Boundaries of Functional Electronics Fabrication

Liquid X Printed Metals are functional metallic inks with wide ranging applications within the printed electronics and additive manufacturing markets. These inks operate at the atomic level, allowing for processing advantages and better film properties than other metallic links. **Key researcher** is Richard McCullough.

More information at: liquid-x.com



Plextronics

Energy-Efficient Electronic Ink Manufacturing

Plextronics, an international technology company, specializes in electronic inks for OLED displays, and lighting and electronic polymers. Electronic "inks" enable cheaper, more energy-efficient electronics, such as TVs and lighting applications. Plextronics was acquired by Solvay in March 2014. **Key researcher** is Richard McCullough.

More information at: bit.ly/2IBwwWk

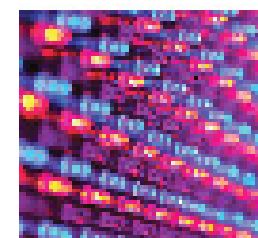


The Optimization Firm

Using Mathematical Models for Decision Making and Saving Costs

The Optimization Firm offers high-performance computing solutions for complex numerical optimization problems that help companies make complex decisions based on mathematical models. These slight improvements in operations yields savings of millions of dollars. **Key researcher** is Nick Sahinidis.

More information at: theoptimizationfirm.com

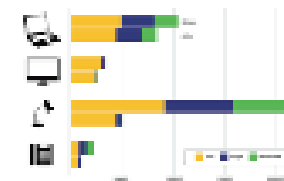


Vortxx Semiconductor

Current Generation Fabrication Equipment with Next-Gen Impact

This CMU spin-off is designing products that will reduce the density of electronics, therefore lowering power consumption. This approach achieves "next-generation" Moore's Law levels of performance while being able to utilize current generation fabrication equipment. **Key researcher** is Wojciech Maly.

More information at: bit.ly/2j4ZHqa



Building Ideas Group (BIG)

Energy Management for your Building Portfolio

BIG is a CMU spin-off developing data collection systems using energy usage analytics and visualizations to reveal actionable information for building occupants, managers and owners. BIG's review of energy savings opportunities helps facility managers target projects with the best return on investment. **Key researcher** is Azizan Aziz.

More information at: <http://bit.ly/2IPT99x>



Building Model Data Extraction Software

Building Model Simulation Made Easy

Lam's software automatically pulls data from digital building design models and populates data into the correct fields of compliance documents, saving days to weeks of time spent with the LEED application process. This software was licensed by Design Builder for state of the art building performance analysis. **Key researcher** is Khee Poh Lam.

More information at: designbuilder.com



Conservation Labs

Affordable Smart Water Technology to Manage Water Consumption

Conservation Labs is commercializing an easy-to-install water usage monitoring system, H2know. This system takes measurements from water pipes every second using patent-pending technology and a machine learning approach to translate those signals into accurate water flow estimates, leak alerts, and water insights.

Key researcher is Mark Kovscek.

More information at: conservationlabs.com

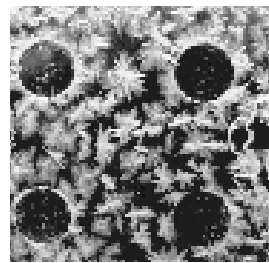


EEme, LLC

Converting Big Data into Actionable Energy Insight

This CMU spin-off processes data to predict the technical and behavioral energy efficiency (EE) potential and provide personalized EE recommendations for every residential user in a given service territory. Managers can also analyze their customers using the utility heat map dashboard. EEme, LLC was acquired by Tendril, January 2019. **Key researcher** is Enes Hoşgör.

More information at: <http://bit.ly/32lxXjK>

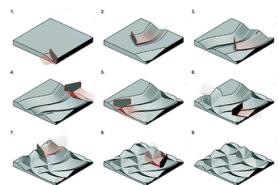


Encapsulated Phase Change Material Containers

Reducing Heating and Cooling Costs through Phase Change Containers

CMU researchers are designing a range of "containers" that are configured as decorative or functional architectural tiles, window shade louvers, furniture and other devices that are optimized to enable air flow and heat exchange, potentially reducing the cost of heating and cooling by 25 percent. **Key researchers** are Dale Clifford and S.C. Yao.

More information at: <http://bit.ly/2PRG97X>



Heat Dissipating Architectural Panels

Reducing Energy Cost and Consumption Using Custom Architectural Panels

CMU researchers are developing a CAD platform for creating custom architectural panels that incorporate thermodynamic principals of air flow to dissipate heat and reduce building energy usage. They are also developing 3D printing fabrication methods for these concrete architectural panels to provide a cost-effective system to enable creative, energy-efficient design.

Key researchers are Dana Cupkova and Josh Bard.

More information at: <http://bit.ly/36k6EII>



LeanFM Technologies

Saving Energy in Commercial Building Systems Using AI

LeanFM Technologies is a lifecycle software solution for economic, proactive and intelligent facilities management that leverages building information modeling and cloud computing technology to integrate heterogeneous building information recorded in disparate media. **Key researchers** are Burcu Akinici and Xuesong Liu.

More information at: leanfmtech.com



MellonHead Labs

Monitoring Residential and Environmental Water Quality

MellonHead Labs is a CMU spin-off developing water sensors that can be used to monitor changes in water quality inside the home or outside in streams, rivers and ponds, with a simple graphic representation of the interpreted data collection.

Research facilitated by the CMU CREATE Lab.

More information at: <http://bit.ly/2qkaaCv>



Module

Housing Designed to Grow alongside the User

Module's end-to-end platform, construction technology, and pay-as-you-go housing solution creates a sustainable, energy-efficient starter home that provides an affordable, flexible entry point for homeownership. **Key researcher** is Hallie Dumont.

More information at: modulehousing.com



Operetta

Changing the Way Mobile Users Connect to the Internet

OPERETTA is an energy-efficient optimal deployable bandwidth aggregation system that allows users to concurrently connect mobile displays to the internet in different ways, such as 3G, 4G, Wi-Fi and Bluetooth without changes in existing infrastructure. The system allows users to choose between interfaces based on factors such as speed, energy consumption and cost.

Key researcher is Khaled A. Harras.

More information at: <http://bit.ly/2VQhXDX>

SPARKMETER ⚡

SparkMeter

Offering Comprehensive Low-Cost Metering Solutions for Grids

SparkMeter electricity meters enable grid operators to implement pre-payment as well as real-time monitoring and control. By improving cost recovery, these grids become more reliable for lower-income households worldwide who currently rely on expensive, inefficient and dangerous fuels. **Key researchers** are Anthony Rowe and Dan Schnitzer.

More information at: sparkmeter.io



Speck

An Indoor Air Quality Monitor Enabling Users to Breathe Easier

The Speck airborne particle counting device monitors fine particle concentration levels in homes and displays the data in an understandable way. This empowers people affected by allergies or asthma to reduce particulate exposure by taking action to alter their environment. **Key researcher** is Illah Nourbakhsh.

More information at: specksensor.com



BioHybrid Solutions

Polymer-Based Protein Engineering

BioHybrid Solutions commercializes polymer-based protein engineering technology based on controlled radical polymerization for applications in such areas as pharmaceuticals, biocatalysis and energy. It allows for targeted and predicted modification of proteins, resulting in high-efficacy protein-polymer conjugates. **Key researchers** are Kris Matyjaszewski, Alan Russell and Antonina Simakova.

More information at: biohybridsolutions.com



Carbon Freight

Reducing Freight Transportation Energy Consumption

Carbon Freight builds durable, light-weight shipping pallets that reduce the amount of energy consumed for freight transportation. **Key researchers** are John Dieser and Glen Philen.

More information at: carbonfreight.com



Hyllion

A Trucking Revolution that Reduces CO2 Emissions and Fuel Consumption

Hyllion is engineering a revolution in the trucking industry by enabling immediate electric hybridization of Class 8 trucks. The Hyllion system is the only Class 8 hybrid solution on the market and delivers a positive cash flow the first month it is deployed. **Key researcher** is Thomas Healy.

More information at: hyllion.com

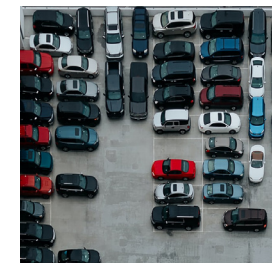


Ottomatika

Autonomous Car Software and System Development

Ottomatika provides software and systems development for autonomous cars. It focuses on automating driving functions of automobiles and other transportation to increase the safety, efficiency and affordability of vehicles in the transportation sector. Ottomatika was acquired by Delphi Automotive in July 2015, and later became Aptiv. **Key researcher** is Raj Rajkumar.

More information at: <http://bit.ly/2BcoYoW>



Non-Sensor Based Parking Management System for Reservation, Dynamic Pricing

Proposal for a Non-Sensor Based Parking Management System

CMU researchers are developing a non-sensor based method of determining parking spot availability, which incorporates an ability for drivers to reserve a parking spot while enabling the parking operators to implement dynamic pricing schemes to optimize the use of limited spaces. It also enables low-cost, efficient and crowd-sourced enforcement. **Key researcher** is Sean Qian.

More information at: <https://bit.ly/2VyKgqq>



Rapid Flow Technologies

Optimizing Traffic Signals Using AI to Help Drivers

Rapid Flow Technologies combines research from artificial intelligence and traffic theory to optimize traffic signals for the traffic that is actually on the road. This leads to less waiting, reduced congestion, shorter trips, less pollution and happier drivers. **Key researchers** are Greg Barlow and Stephen Smith.

More information at: rapidflowtech.com



Regionally-Aware Traffic Incident Response Management System

Understanding and Predicting Travel Time

Traffic management centers attempt to dynamically manage roadway traffic to respond to real-time incidents, such as disasters, crashes, events, flooding, etc. CMU researchers are developing a machine-learning based system that incorporates incident, weather and other real-time data, with a predictive assessment of how incidents in one sector will impact traffic flow throughout a regional traffic system, and provides proactive mitigation solutions in real time. **Key researcher** is Sean Qian.

More information at: <https://bit.ly/2yiPBKt>



RoadBotics

Enabling Data Driven Decisions through AI and Smartphones

RoadBotics uses computer vision and machine learning to analyze and map road conditions and irregularities. The technology can detect pothole severity, snow conditions on roads, signage visibility and much more. **Key researcher** is Christoph Mertz.

More information at: roadbotics.com



Virtual Traffic Lights

Eliminating Physical Traffic Lights with Autonomous Vehicle Communication

With this technology, cars and trains autonomously communicate with each other to determine right of way at intersections without traffic lights. Computer simulations indicate a potential 60 percent improvement in traffic flow in a full-city simulation.

Key researcher is Ozan Tonguz.

More information at: virtualtrafficlights.com

Company/Innovation

Key Researcher(s)

6	■ Anactisis	Athanasios Karamalidis
2	■ Aquion Energy	Jay Whitacre
6	■ Arieca	Carmel Majidi
6	■ ATRP Solutions	Krzysztof Matyjaszewski
12	■ BioHybrid Solutions	Krzysztof Matyjaszewski, Alan Russel, Antonina Simakova
6	■ Blade Diagnostics Corporation	Jerry Griffin
9	■ Building Ideas Group	Azizan Aziz
9	■ Building Model Data Extraction Software	Khee Poh Lam
12	■ Carbon Freight	John Dieser, Glen Philen
7	■ Carbon Nanotube Aerogels	Mohammed Islam
7	■ Carnegie Robotics	John Bares
10	■ Conservation Labs	Mark Kavscek
7	■ CorePower Magnetics	Paul Ohodnicki, Michael E. McHenry
2	■ Ecotone Renewables	Dylan Lew
2	■ Edible Electronics	Christopher Bettinger, Jay Whitacre
10	■ EEme, LLC	Enes Hoggör
2	■ Electrochemical Synthesis of Cement	Venkat Viswanathan
10	■ Encapsulated Phase Change Material Containers	Dana Cupkova, Josh Bard
3	■ FarmtoFlame Energy	Kwaku Jyam i
7	■ Fifth Season	Austin Webb
3	■ GeckoRobotics	Troy Demmer
8	■ Grid Fruit	Soumya Kar, Javad Mohammadi, Jesse Thornburg
10	■ Heat Dissipating Architectural Panels	Dana Cupkova, Josh Bard
3	■ High-Capacity Lightweight Batteries	Rahul Panat
13	■ Hyliion	Thomas Healy
8	■ Integrated Silicon Technologies	Erik Ydstie
11	■ LeanFM Technologies	Burcu Akinci, Xuesong Liu
8	■ Liquid X Printed Metals	Richard McCullough
11	■ MellonHead Labs	CMU Create Lab
3	■ Microfluidic Microbial Fuel Cells	Kelvin Gregory, Philip LeDuc
4	■ Mine Vision Systems	Brett Browning
11	■ Module	Hallie Dumont
13	■ Non-Sensor Based Parking Management System for Reservation, Dynamic Pricing and Enforcement	Sean Qian
11	■ OPERETTA	Khaled A. Harris
9	■ The Optimization Firm	Nick Sahinidis
13	■ Ottomatika	Raj Rajkumar
4	■ Platypus Technologies, LLC	Paul Scerri
8	■ Plextronics	Richard McCullough
13	■ Rapid Flow Technologies	Greg Barlow, Stephen Smith
14	■ Regionally-Aware Traffic Incident Response Management System	Sean Qian
14	■ RoadBotics	Christoph Mertz

Company/Innovation

Key Researcher(s)

4	■ SenSevere	Jason Gu
4	■ Solar Selective Absorbers	Sheng Shen
5	■ SolePower	Hahna Alexander, Matthew Stanton
12	■ SparkMeter	Anthony Rowe, Dan Schnitzer
12	■ Speck	Illah Nourbakhsh
5	■ Tartan Battery Network	Jay Whitacre, Wei Wu
5	■ Teratonix	Yi Luo
5	■ Watt-Learn	Matineh Eybpoosh
15	■ Virtual Traffic Lights	Ozan Tonguz
9	■ Vortxx Semiconductor	Wojciech Maly

Key

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- Industry Device Manufacturing and Energy Efficiency
- Commercial Facility and Residential Energy Management
- Transit Energy Management

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