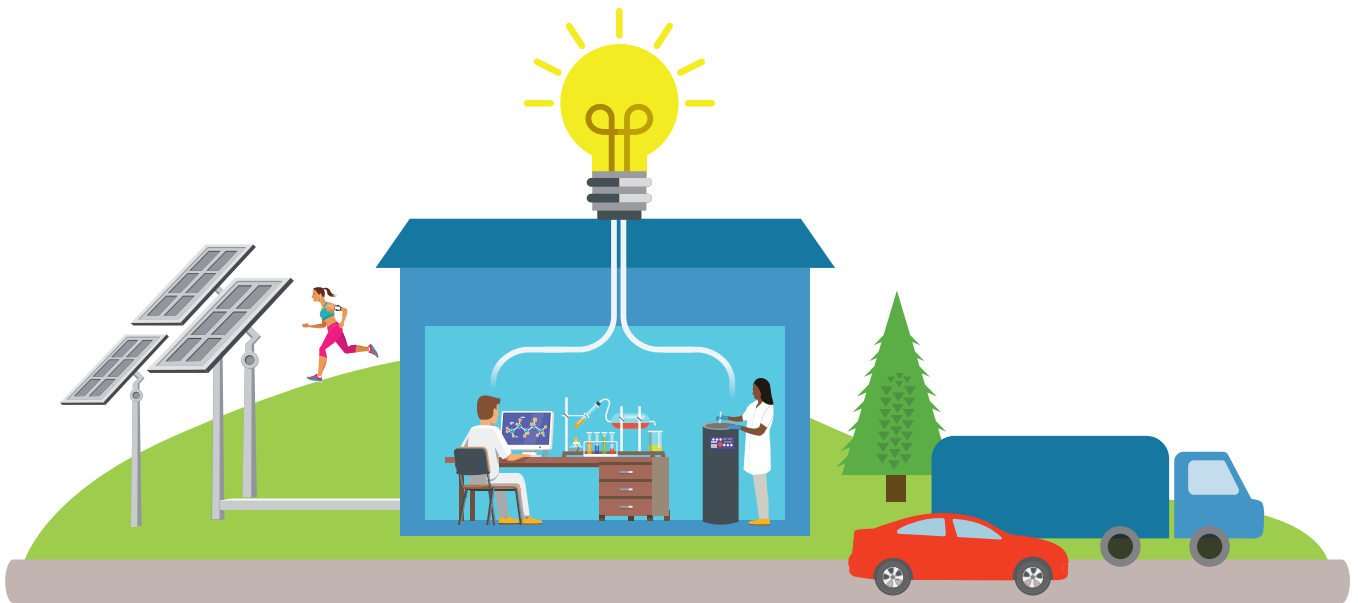


TECHNOLOGY GUIDE

# Innovative Energy Technologies: The Next Generation



**Carnegie Mellon University**

Wilton E. Scott Institute  
for Energy Innovation

# Our lifestyle is sustained by energy.

CMU Civil and Environmental Engineering Professors and LeanFM Technologies Chief Officers Burcu Akinci (Innovation) and Xuesong (Pine) Liu (Technology) deliver an intelligent facility management platform that enhances operations.



Hyllion created a regenerative braking device that can be installed on long-haul trucks. Pictured here is Hyllion CEO and CMU alumnus Thomas Healy, who was named to *Forbes* 30 under 30 Energy 2017.



Hahna Alexander, a CMU alumna and the co-founder and CEO of SolePower, creates products, like the one pictured at the right, to generate on-the-go, renewable power for mobile energy needs.



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 university while others have already entered, or are on the cusp of entering, the marketplace. These next-generation technologies have been developed by undergraduate and graduate students, researchers, faculty and alumni from all across Carnegie Mellon.

Technologies such as these can reduce the cost of energy generation and consumption, mitigate the resulting pollution emitted to the environment from that energy and improve the reliability and resilience of our energy system. 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.

The development and dissemination of this guide was made possible through the generosity of Michael and Janet Jesanis and the NiSource Charitable Foundation.

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# Energy Generation, Conversion, Storage and the Environment

## Stationary Source Energy Generation, Storage and Conversion



### ECOTONE RENEWABLES

**Key Researchers:** Sasha Cohen Ioannides and Alexis Hoane

Ecotone has developed an integrated food production system, the SeaHorse, that takes in food waste from local grocers, college dorms, restaurants, and more. From here, the SeaHorse uses anaerobic digestion principles to reuse this food waste and create electricity, fertilizer and fresh produce. Notable achievements:

- Finalist in the DOE Cleantech University Prize 2018 National Competition
- Placed first in the undergraduate track at CMU's 2019 McGinnis Venture Competition and received \$4K
- Won first place, \$35K in project funding and Ford Transit Connect passenger van during the 10th Annual Ford College Community Challenge

More information at: [ecotonerenewables.com](http://ecotonerenewables.com)



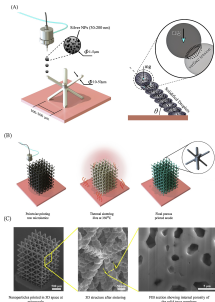
### AQUION ENERGY

**Key Researcher:** Jay Whitacre

Aquion Energy, a CMU spin-off company, has developed the aqueous hybrid ion (AHI) battery, a low-cost, long-lasting, large-scale aqueous electrolyte sodium ion battery that uses salt water (sodium sulfate in water) to store electricity. The Cradle to Cradle Certified battery is optimized for stationary storage applications, such as micro-grid support, off-grid generator optimization and grid-level energy services. Notable achievements:

- Won the 2011 World Technology Award
- Named to *MIT Technology Review's* 50 Disruptive and 50 Smartest Companies and the Global Cleantech 100 lists
- Received funding from Bill Gates, Kleiner Perkins Caufield & Byers, Foundation Capital, Advanced Technology Ventures and others
- Acquired in June 2017 by U.S.-based branch of Titans Energy Technology Group
- Whitacre, who was named to *Fortune Magazine's* Top 25 Eco Innovators List, has received the:
  - 2015 \$500K Lemelson-MIT Prize
  - Carnegie Science Center Advances Materials Award
  - Caltech Resnick Sustainability Institute Award
  - 2017 \$50K Leigh Ann Conn Prize for Renewable Energy

More information at: [aquionenergy.com](http://aquionenergy.com)



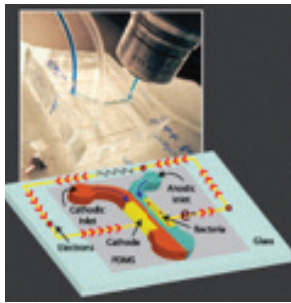
## HIGH-CAPACITY LIGHTWEIGHT BATTERIES

**Key Researcher:** Rahul Panat

CMU researchers are using 3D printing methods to create controlled, hierarchically three-dimensional porous electrodes for lithium-ion batteries. Three-dimensional porous electrodes in energy storage devices allow uniform transport of ions, fast charging cycles and high electrode utilization. The method will increase the battery capacity by at least 50 percent compared to conventional block electrode batteries.

More information at:

[sciencedirect.com/science/article/pii/S2214860418302379#bib0095](https://www.sciencedirect.com/science/article/pii/S2214860418302379#bib0095)



## MICROFLUIDIC MICROBIAL FUEL CELL

**Key Researchers:** Kelvin Gregory and Philip LeDuc

The Microfluidic Microbial Fuel Cell developed at Carnegie Mellon, which includes the world's smallest low-cost fuel cell, converts bacteria into power. The device — no bigger than a human hair and 300 times smaller than a raindrop — uses microbial electricity generation enabled by microfluidic flow control to produce power from natural organic compounds. Potential uses:

- Remote electricity generation
- Self-powered sensing devices for remote locations
- Glucose sensors in the human body
- Conversion of waste biomass to fuel for large-scale electricity generation

More information at:

[cmu.edu/cee/news/news-archive/2013/2013-energy-part-one.html](http://cmu.edu/cee/news/news-archive/2013/2013-energy-part-one.html)



## SOLAR SELECTIVE ABSORBERS

**Key Researcher:** Sheng Shen

Solar Selective Absorbers utilize solar thermal energy conversion as opposed to solar photovoltaics. Metal-based wafer-scale nanophotonic solar selective absorbers with excellent solar selective absorptivity and thermal stability are utilized, using a template (mold) stripping method that can drastically increase throughput and decrease fabrication cost. These new solar selective absorbers with 3-D nanophotonic structures can significantly impact transformative advancements in the design and performance of solar thermal systems.

More information at: [onlinelibrary.wiley.com/doi/10.1002/adma.201501686/full](https://onlinelibrary.wiley.com/doi/10.1002/adma.201501686/full)

## ■ Energy Generation, Conversion, Storage and the Environment

### Teratonix

*Ambient Energy Harvesting*

#### TERATONIX

**Key Researcher:** Yi Luo

For IoT system integrators and IoT end users who deploy low-power devices at scale and face the challenges of expensive installation and high lifetime maintenance costs, Teratonix develops a maintenance-free power source to replace batteries. The company converts ambient radio waves, ubiquitously available in urban environments, to electricity. Notable achievements:

- Placed second in the Allegheny Cleantech University Prize Collegiate Competition sponsored by CMU's Scott Institute and DOE
- Won the Transformational Idea Award at the First Look West (FLOW) Competition, sponsored by DOE
- Placed second in the TransTech Energy Business Development Conference's Pitch Competition
- Placed second in CMU's McGinnis Venture Competition
- Participant in Shell's GameChanger program

More information at: [teratonix.com](http://teratonix.com)

### Personal Device Energy Generation and Storage



#### EDIBLE ELECTRONICS

**Key Researchers:** Christopher Bettinger and Jay Whitacre

CMU researchers have developed edible electronics that are sensors made of nutrients — powered by stomach acid. Ingestible sensors could provide information on early signs of bacterial infection, look for symptoms of gastrointestinal disorders, monitor uptake of medications, and even study the microbiome living inside people. All components are made of organic and biosafe materials. After the capsule dissolves, power is generated when the sodium ions from the cell interact with the water in the body. The battery is made of nontoxic materials that pass through the human body in a few hours once the material encapsulating it biodegrades.

More information at:

[cmu.edu/homepage/health/2013/spring/incredible-edible.shtml](http://cmu.edu/homepage/health/2013/spring/incredible-edible.shtml)



### SOLEPOWER

**Key Researchers:** CMU alumni Hahna Alexander and Matthew Stanton

SolePower has created self-powering smart work boots. They can be embedded with electronics including GPS, motion sensors, Wi-Fi, RFID and lighting. All are charged by the power of walking. They can help provide data, signal unsafe conditions, and simplify monitoring of industry and company standards. As an individual walks, the power generated is stored in an external Power Pack. Mobile devices are then charged at the same rate as via a computer by connecting the device to the Power Pack's USB port. Notable achievements:

- *Popular Science* 2014 invention award
- Africa Energy Award for Innovator of the Year
- AOL co-founder Steve Case's Rise of the Rest's Innovation Award

More information at: [solepowertech.com](http://solepowertech.com)

### Sensing and Mapping



### GECKO ROBOTICS

**Key Researcher:** Troy Demmer

Gecko Robotics 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. Notable achievements:

- 1st place in Energy category of the 2016 Rice Business Plan Competition
- 1st place at 2016 TransTech Energy Business Development Conference
- Gecko Robotics is working in 14 states.
- Has raised over \$9 million

More information at: [geckorobotics.com](http://geckorobotics.com)

## ■ Energy Generation, Conversion, Storage and the Environment



### **MINE VISION SYSTEMS**

**Key Researcher:** Brett Browning

Mine Vision Systems has created a visual system that can be used for the mapping of underground mines. Unlike prior systems, this system provides a high degree of accuracy. This accuracy enables monitoring for production and safety. It can also provide visual information from different perspectives for equipment operators.

More information at: [minevisionsystems.com](http://minevisionsystems.com)



### **PLATYPUS TECHNOLOGIES, LLC**

**Key Researcher:** Paul Scerri

Platypus Technologies, LLC manufactures small, low-cost autonomous robotic boats. They have the ability to sense environmental contaminants, along with other critical data, such as water depth, dissolved oxygen and pH. The boats can work toward environmental monitoring needs associated with the petrochemical industry. Such tasks using the boats can be done more cheaply, efficiently and quickly than other existing technologies. Each robotic boat uses a base station that can communicate using wireless, 3G or EDGE within a 1.5-mile range. Notable work:

- In 2014, the company's boats helped scientists measure water quality in Kenya's Mara River.

More information at: [senseplatypus.com](http://senseplatypus.com)



### **SENSEVERE**

**Key Researcher:** Jason Gu

SenSevere provides semiconductor-based sensors for severe environments. These include elevated temperatures (500°C) and pressures (2500 PSI) as well as corrosive environments or deep sea wells. The sensors can detect hydrogen, hydrocarbons, ammonia and bromide. This has the power to improve both safety and environmental compliance for the power generation, environmental and chemical industries. These sensors can also be used in energy exploration, refineries, nuclear facilities and transportation. Notable achievements:

- Participant in the National Science Foundation I-Corps program
- Acquired by Sensit Technologies in 2018

More information at:

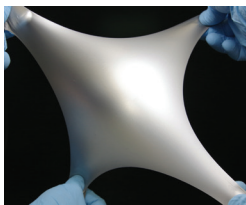
[engineering.cmu.edu/news-events/news/2017/05/19-hydrogen-sensor.html](http://engineering.cmu.edu/news-events/news/2017/05/19-hydrogen-sensor.html)



# Industry Device Manufacturing and Energy Efficiency

## Energy, Materials and Manufacturing

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### ARIECA

**Key Researcher:** Carmel Majidi

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. Potential uses:

- Wearable technologies like smart textiles and orthotics
- Human-compatible robotics
- Electrically and thermally conductive rubber in uses such as:
  - Thermal pads in computing
  - Gaskets in machinery and automobiles

More information at: [arieca.com](http://arieca.com)

### BLADE DIAGNOSTICS

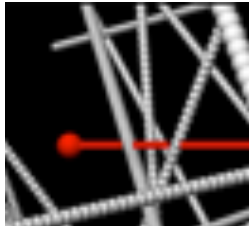
### BLADE DIAGNOSTICS CORPORATION

**Key Researcher:** Jerry Griffin

Blade Diagnostics Corporation develops tools and methods for evaluating and controlling how mistuning affects the vibratory response of Integrally Bladed Rotors. Their innovations identify and predict effects of mistuning and vibration in these critical and expensive engine blades. Notable achievements:

- Received four Phase II SBIR awards
- Awarded RIF post-SBIR transition contract in 2012
- Their tool, SmartBlend, is now a part of the repair workflow at the U.S. Tinker Air Force Base in Oklahoma City.

More information at: [bladediagnostics.com](http://bladediagnostics.com)



### **CARBON NANOTUBE AEROGELS**

**Key Researcher:** Mohammad Islam

CMU researchers are developing methods to link carbon nanotubes in aerogel constructs to provide materials that are lightweight and high strength. Carbon nanotubes (CNTs) have been shown to give a remarkable range of performance enhancement qualities to materials in which they are incorporated. Aerogel constructs enable these performance qualities to be achieved with very low concentrations of CNTs. Potential applications:

- Polymeric strengthening applications
- Transparent or non-transparent electrodes for computer displays, touchscreens and photovoltaics
- Uses for supercapacitors and batteries with high storage density

More information at: [sites.google.com/site/islamgroupcmu](https://sites.google.com/site/islamgroupcmu)



### **CARNEGIE ROBOTICS**

**Key Researcher:** John Bares

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. Notable achievements:

- Products are based on prototypes developed at the CMU National Robotics Engineering Consortium.
- Awarded \$23 million AMDS contract in 2014

More information at: [carnegierobotics.com](http://carnegierobotics.com)



### **FABRICATION OF SOLAR SILICON**

**Key Researcher:** Erik Ydstie

CMU researchers are developing an improved continuous casting process for making solar silicon wafers. The process is based on the float-glass process used to make plate glass, and will have dramatically lower waste and cost. For instance, the process will lower the cost of solar electricity by simplifying a formerly complex, expensive and wasteful process.

More information at: [youtube.com/watch?v=WJi3YBrxvHA](https://youtube.com/watch?v=WJi3YBrxvHA)

## ■ Industry Device Manufacturing and Energy Efficiency



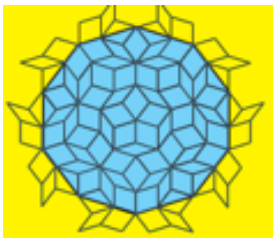
### LIQUID X PRINTED METALS

**Key Researcher:** Richard McCullough (former CMU faculty member)

Liquid X Printed Metals (Liquid X) is an advanced material manufacturer of functional metallic inks with a wide range of applications within the printed electronics and additive manufacturing markets. The company's technology is at the atomic level, which allows for processing advantages and better film properties than other metallic links. Processing advantages include:

- Inks are particle free with tunable viscosity and low conversion temperatures.
- Thin films can be made with high conductivity and excellent adhesion
- Inks can be printed via inkjet, flexography, gravure and aerosol jet.
- Upon application of energy (thermal, photonic, IR), inks convert to metal films/ traces that have electrical conductivities close to that of the bulk metal — even at nanometer scale thickness.

More information at: [liquid-x.com](http://liquid-x.com)



### MAGNETIC MATERIALS

**Key Researcher:** Michael E. McHenry

The magnetic materials developed at CMU 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, such as transformers, inverters and motors. Potential applications and funding information:

- A large-scale, 35-ton transformer could be redesigned to about 450 pounds.
- Could enable more widespread adoption of rooftop solar energy production by commercial enterprises
- Funded by the Advanced Research Projects Agency – Energy

More information at:

[arpa-e.gov/?q=slick-sheet-project/magnet-technology-power-converters](http://arpa-e.gov/?q=slick-sheet-project/magnet-technology-power-converters)



### PLEXTRONICS

**Key Researcher:** Richard McCullough (former CMU faculty member)

Founded in Pittsburgh, this international technology company specializes in electronic inks for OLED (Organic Light Emitting Diode) 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. Current and future research includes:

- Developing electronic polymers that can be used for lithium-ion battery and polymer metal capacity applications
- Future applications expected to be organic photodetectors, thin film transistors and photovoltaics

More information at:

[solvay.com/en/media/press\\_releases/20140324-Plextronics.html](http://solvay.com/en/media/press_releases/20140324-Plextronics.html)

## Optimization of Industry Energy Use

**Rare Earth Elements**

|    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| La | Ce | Pr | Nd | Pm | Sm | Eu | Gd | Tb | Dy | Ho | Er | Tm | Yb | Lu |
| 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 |

Lanthanides

|    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| H  | He |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Li | Be | B  | C  | N  | O  | F  | Ne |    |    |    |    |    |    |    |    |    |    |
| Na | Mg | Al | Si | P  | S  | Cl | Ar |    |    |    |    |    |    |    |    |    |    |
| K  | Ca | Sc | Ti | V  | Cr | Mn | Fe | Co | Ni | Cu | Zn | Ga | Ge | As | Se | Br | Kr |
| Rb | Sr | Y  | Zr | Nb | Mo | Tc | Ru | Rh | Pd | Ag | Cd | In | Sn | Sb | Te | I  | Xe |
| Cs | Ba | La | Hf | Ta | W  | Re | Os | Ir | Pt | Au | Hg | Tl | Pb | Bi | Po | At | Rn |
| Fr | Ra | Ac | Lr |    |    |    |    |    |    |    |    |    |    |    |    |    |    |

### ANACTISIS

**Key Researcher:** Athanasios Karamalidis

Anactisis economically recovers rare earth elements from coal combustion fly ash and water that is used for hydraulic fracturing, geothermal energy and mine tailing settlement. Rare earth elements are needed for many electronic technologies, but material supply is limited, and access is often restricted. Notable achievements:

- Funded by a U.S. Department of Energy SBIR grant
- Participant in the National Science Foundation I-Corps program
- Funded by National Science Foundation SBIR grant

More information at: [anactisis.com](http://anactisis.com)



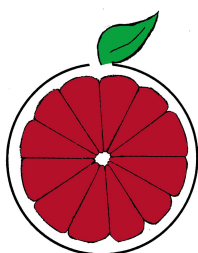
### ATRP SOLUTIONS

**Key Researcher:** Krzysztof Matyjaszewski

ATRP Solutions specializes in atom transfer radical polymerization (ATRP), developed by CMU Professor Krzysztof Matyjaszewski. ATRP creates well-defined polymeric materials that are used in a variety of commercial products and applications. For example, ATRP has created custom materials for oil field chemicals, which are used for hydraulic fracturing cleanout and drilling. Notable accomplishments:

- Raised a Series A round lead by Birchmere Ventures in June 2014
- Acquired by Pilot Chemical Co. in July 2017

More information at: [atrp-solutions.com](http://atrp-solutions.com)



### GRID FRUIT

**Key Researchers:** Soumya Kar, Javad Mohammadi and Jesse Thornburg

Researchers at CMU are developing software that will enable dynamic, distributed, parallel management of load balancing in electric power distribution networks. Their initial targeted application is dynamic control of commercial refrigeration, to reduce energy costs and provide better insights and control over maintenance costs. Replace with: Researchers at CMU are developing software that will enable dynamic, distributed, parallel management of load balancing in electric power distribution networks. Their initial targeted application is dynamic control of commercial refrigeration, to reduce energy costs and provide better insights and control over maintenance costs. Notable accomplishments:

- A participant in the National Science Foundation I-Corps program
- Approved as a DOE SHINES project to demonstrate "Sustainable and Holistic Integration of Energy Storage and Solar Photovoltaics"

More information at: [gridfruit.com](http://gridfruit.com)

## ■ Industry Device Manufacturing and Energy Efficient



### **GREENOX CATALYSTS, INC.**

**Key Researchers:** Terry Collins and Colin Horwitz

GreenOx Catalysts, Inc. designs, develops and supplies iron-based oxidation catalysts. These "green" catalysts reduce energy, water and chemical use, which lowers waste disposal costs, and can be used in many commercial applications. Development partners include VeruTEK Technologies, Recombinant Innovation and Scion laboratories.

More information at: [greenoxcatalysts.com](http://greenoxcatalysts.com)



### **THE OPTIMIZATION FIRM**

**Key Researcher:** Nick Sahinidis

The Optimization Firm offers high-performance computing solutions for complex numerical optimization problems. These solutions help companies make complex decisions based on mathematical models. An example of what the company can assist with is the pooling problem that refinery operators worldwide encounter. Even the slightest improvement in these refinery scheduling operations yields savings of millions of dollars. The company offers:

- ALAMO software for building models from data and simulations
- BARON software for global optimization of mixed-integer nonlinear optimization problems

More information at: [theoptimizationfirm.com](http://theoptimizationfirm.com)



### **VORTXX SEMICONDUCTOR**

**Key Researcher:** Wojciech Maly

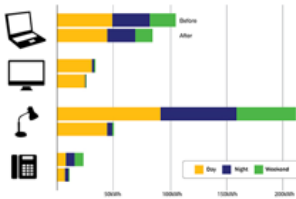
This CMU spin-off is designing products that will reduce the density of electronics, therefore lowering power consumption. This approach achieves "next-generation" Moore's Law levels of performance while being able to utilize current generation fabrication equipment. While it is in its early stages, simulations prove the feasibility of this approach. Notable achievement:

- Funded by the Defense Advanced Research Projects Agency (DARPA)

More information at: [bit.ly/2j4ZHqa](https://bit.ly/2j4ZHqa)

# Commercial Facility and Residential Energy Management

## Commercial Facility and Residential Energy Management



### **BUILDING IDEAS GROUP (BIG)**

**Key Researcher:** Azizan Aziz

BIG is an upcoming CMU spin-off that develops systems for data collection using analytics and visualization on energy usage to reveal actionable information for building occupants, managers and owners. BIG's review of energy savings opportunities over a portfolio of buildings helps facility managers target projects with the best return on investment. Notable accomplishment:

- Helped reduce PNC Bank's energy consumption by 35 percent during a pilot project

More Information at: [buildingideasgroup.wixsite.com](http://buildingideasgroup.wixsite.com)



### **BUILDING MODEL DATA EXTRACTION SOFTWARE**

**Key Researcher:** Khee Poh Lam

Lam's building model data extraction software automatically pulls data out of digital building design models and populates data into the correct fields of compliance documents. While the LEED application process can take days to weeks just for the energy efficiency section, which contains approximately 1,400 fields, this software can make the application process happen in a matter of minutes.

- Saves costs and reduces entry errors in LEED application process
- Facilitates "what if" assessment of different design options to determine their impact on LEED scores
- Has been licensed to DesignBuilder

More information at: [designbuilder.com](http://designbuilder.com)

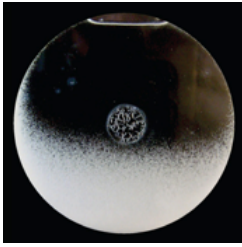


### **BUILDSIMHUB INC.**

**Key Researcher:** Weili Xu

BuildSimHub Inc. provides energy modeling solutions throughout a building's life cycle. It brings innovative technologies to make energy modeling efficient and more accessible by the AEC industry. Since 2017, the company has launched its cloud-based product, BuildSimHub, which is the first GIT-based (version control software system) energy model management platform. The platform offers project management, team collaboration and workflow automation, creating an end-to-end solution for architecture and engineering firms and building system manufacturers.

More information at: [buildsim.io](http://buildsim.io)



### ENCAPSULATED PHASE CHANGE MATERIAL CONTAINERS

**Key Researchers:** Dale Clifford and S.C. Yao

These phase change materials store or release heat during a freeze/thaw phase calibrated to occur at room temperature, potentially reducing the cost of heating and cooling by 25 percent. The team is 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. Notable achievements:

- Currently funded by the National Science Foundation and the American Institute of Architects

More information at: [cmubiologic.weebly.com/frick-environmental-center.html](http://cmubiologic.weebly.com/frick-environmental-center.html)



### LEANFM TECHNOLOGIES

**Key Researchers:** Burcu Akinci and Xuesong Liu

LeanFM Technologies is a lifecycle software solution for economic, proactive and intelligent Facilities Management (FM). LeanFM leverages Building Information Modeling (BIM) and cloud computing technology to integrate the heterogenous building information that is recorded in disparate media, making FM greener and more efficient. Notable achievements:

- Recipient of the *Pittsburgh Business Times* inaugural 2017 Innovation Award
- Recipient of a National Science Foundation SBIR grant

More information at: [leanfotech.com](http://leanfotech.com)

## Residential Design and Energy Management Services



### EEME, LLC

**Key Researcher:** Enes Hoşgör

This Carnegie Mellon spin-off processes smart meter interval data using proprietary load disaggregation algorithms to predict the technical and behavioral energy efficiency (EE) potential by EE measure for every residential user in a given service territory. Residential users are given personalized EE recommendations along with relevant economic metrics, while program managers can analyze their customer base using the utility heat map dashboard. Notable achievement:

- Their Green Button compatible platform solution is designed to connect all EE stakeholders.
- Acquired by Tendril in 2019.

More information at: [eeme.io](http://eeme.io)



### MODULE

**Key Researcher:** Hallie Dumont

Module housing creates a more sustainable, energy-efficient starter home. Their end-to-end platform and construction technology provides an affordable and flexible entry point for homeownership. With this pay-as-you-go housing solution, a one bedroom starter unit can turn into a three bedroom house, providing buyers with the right amount of space at the right time.

More information at: [modulehousing.co](http://modulehousing.co)

## ■ Commercial Facility and Residential Energy Management

### OPERETTA

#### OPERETTA

**Key Researcher:** Khaled A. Harras

OPERETTA is an energy-efficient optimal deployable bandwidth aggregation system. It builds on previous attempts to improve multi-interface mobile devices, such as smartphones, by allowing users to concurrently connect to the internet in different ways, such as 3G, 4G, Wi-Fi and Bluetooth. The systems allows users to choose between interfaces based on factors such as speed, energy consumption and cost. It also operates without changes in existing infrastructure.

More information at: [cmu.edu/homepage/society/2012/fall/mobile-solutions.shtml](http://cmu.edu/homepage/society/2012/fall/mobile-solutions.shtml)

### SPARKMETER ⚡

#### SPARKMETER

**Key Researchers:** Anthony Rowe and Dan Schnitzer

SparkMeter electricity meters enable grid operators to implement pre-payment as well as real-time monitoring and control. By improving cost recovery, these electric grids become more reliable for lower-income households throughout the world whose only alternatives are expensive, inefficient and dangerous fuels like kerosene and candles. Notable achievement:

- SparkMeter supports connections in 15 countries, with more added daily

More information at: [sparkmeter.io](http://sparkmeter.io)

## Residential Environmental Monitoring



#### MELLONHEAD LABS

**Key Researcher:** CREATE LAB

MellonHead Labs is a CMU spin-off commercializing the CATTfish and FlaminGO water sensors developed in the CREATE Lab at CMU. These sensors 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.

More information at: [cattfish.com](http://cattfish.com)



#### SPECK

**Key Researcher:** Illah Nourbakhsh

The Speck airborne particle counting device was developed in the CREATE Lab at Carnegie Mellon. It monitors fine particle concentration levels in homes and displays the data in an understandable way. This knowledge empowers people susceptible to asthma or other conditions to reduce particulate exposure by opening or closing windows, altering activities or taking action such as using HEPA air filters. Notable work:

- Citizen groups have used Speck to monitor particulates emitted by coke batteries or by natural gas production
- Currently being commercialized by CMU spin-off company Airviz
- Recently obtained an investment from InfoSys

More information at: [specksensor.com](http://specksensor.com)



# Transit Energy Management

## Traffic Management



### RAPID FLOW TECHNOLOGIES

**Key Researchers:** Greg Barlow and Stephen Smith

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. Notable achievements:

- A Pittsburgh demonstration project on nine intersections reduced travel time by 26 percent
- Technology is now implemented in 47 Pittsburgh intersections
- The spin-off is developing a ubiquitous Bluetooth AVI sensor network technology for ITS performance modeling and other applications through a Small Business Innovation Research (SBIR) grant from the U.S. Department of Transportation
- Recipient of the *Pittsburgh Business Times* 2017 Innovation Award

More information at: [rapidflowtech.com](http://rapidflowtech.com)



### VIRTUAL TRAFFIC LIGHTS

**Key Researcher:** Ozan Tonguz

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.

More information at: [virtualtrafficlights.com](http://virtualtrafficlights.com)

## Light Duty Vehicle Management



### HYLIION

**Key Researcher:** Thomas Healy

Hyliion is engineering a revolution in the trucking industry by enabling immediate electric hybridization of Class 8 trucks. The Hyliion intelligent electric powertrain relieves the diesel engine to reduce fuel consumption and CO2 emissions. The Hyliion system is the only Class 8 hybrid solution on the market and delivers a positive cash flow the first month it is deployed. The 6x4HE Intelligent Electric Drive Axle System is available for installation today and is being adopted by industry leading fleets. Notable benefits:

- Reduces energy consumption by over 30 percent
- Return on investment in less than one year
- Award winning system: Winner of the prestigious 2018 Jim Winsor Memorial Technical Achievement Award and DOE student business competition in 2015

More information at: [hyliion.com](http://hyliion.com)



## OTTOMATIKA

**Key Researcher:** Raj Rajkumar

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. Notable achievements:

- Partnered with General Motors
- Additional support from the U.S. Department of Transportation and the National Science Foundation
- Acquired by Delphi Automotive PLC in 2015 and spun out as Aptiv in 2017
- Ottomatika-powered Delphi self-driving vehicles received a Best of CES (International Computer Electronics Show) 2015 award from *Mashable*

More information at:

[cmu.edu/news/stories/archives/2015/august/spinoff-acquired.html](http://cmu.edu/news/stories/archives/2015/august/spinoff-acquired.html)

## Fuel Generation



### BIOHYBRID SOLUTIONS

**Key Researchers:** Kris Matyjaszewski, Alan Russell and Antonina Simakova

BioHybrid Solutions commercializes polymer-based protein engineering technology based on the 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.

Notable achievements:

- Named one of 40 “Best University Startups” by the National Council of Entrepreneurial Tech Transfer
- Awarded DOE SBIR grant

More information at [biohybridsolutions.com](http://biohybridsolutions.com)

## Public Transportation



### ROADBOTICS

**Key Researcher:** Christoph Mertz

RoadBotics uses computer vision and machine learning to analyze and map road conditions and irregularities, as a tool for decision-makers. The technology:

- Detects and assesses severity of potholes
- Detects snow conditions on roads
- Detects road signage conditions and visibility
- Mounts on the windshield of a car or plow
- Analyzes and maps data

More information at: [roadbotics.com](http://roadbotics.com)

## ■ Transit Energy Management



### TIRAMISU TRANSIT

**Key Researcher:** Anthony Tomasic

This CMU spin-off has developed a crowd-powered transit bus information system that gives information on bus schedules, seat availability and problematic situations. It encourages use of public transportation, thus reducing energy consumption by motor vehicles used typically as an alternative, as well as overall congestion by vehicles on the road. Notable features:

- Useful for riders in wheelchairs and those with visual disabilities
- Available on iTunes and Android Market for bus systems in Pittsburgh and New York City
- Funded by SBIR grants

More information at: [tiramisutransit.com](http://tiramisutransit.com)

## Industry Vehicles



### CARBON FREIGHT

**Key Researchers:** John Dieser and Glen Philen

Carbon Freight builds durable, lighter-weight shipping pallets that reduce the amount of energy consumed for freight transportation. Notable features:

- Reduces number of trips by shipping more pallets per mile
- Increases miles per gallon by reducing weight of transported goods
- Part of the National Science Foundation I-Corps program

More information at: [carbonfreight.com](http://carbonfreight.com)

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