

IN²

SMART CITIES CONNECTED COMMUNITIES

A Report from the Wells Fargo Innovation Incubator (IN²) Summit
August 16, 2017



Founded by:



EXECUTIVE SUMMARY

More than half of the world's population currently lives in urban areas, and that figure is expected to grow by another 2.5 billion people by 2050. This densification has profound implications on such vectors as energy usage, food and water consumption, conflict, quality of life and carbon emissions, among numerous other factors. Cities currently occupy only two percent of the world's land mass but are the source of more than two-thirds of global greenhouse gases. The challenges associated with the breadth and depth of population density creates intense strain on local infrastructures and natural resources, yet gives rise to numerous opportunities to both develop and implement disruptive technologies to meet the changing needs of urban areas.

In August 2017, the Wells Fargo Innovation Incubator (IN²) convened a Summit and brought together more than 150 stakeholders from across the country to discuss innovation in residential buildings, transportation, agriculture and food systems, and water use as the keystone for building smart and connected communities. IN² is a unique technology incubator and platform funded by the Wells Fargo Foundation and co-administered by the U.S. Department of Energy's National Renewable Energy Laboratory (NREL). Companies selected to participate in the IN² program receive funding and access to NREL's world-class research facilities and expertise to prove, optimize and test their technology at scale. Founded in 2014 with an initial focus on supporting innovations in the commercial buildings space, its current mission is to create a collaborative ecosystem that enables smart and connected communities of the future.

The 2017 IN² Summit addressed three mutually dependent subjects relevant to the creation and advancement of smart and connected communities: residential buildings; transportation; and the nexus of food, water and energy. The discussions generated great insights into the future of smart communities and revealed several prevalent themes that guided conversation. A fuller accounting of these dialogues are contained in the body of this white paper.

As discussed in this white paper, the crossover and challenges presented between agriculture and food, energy, and water provides tremendous opportunities and potential for impact for the IN² program expansion. As such, we will be continuing to engage our key stakeholders and subject matter experts to further investigate how the IN² model can best be leveraged in this technology vertical. A resulting outcome will be the release of a roadmap and announcement of subthemes IN² will focus on in this space. We will share this document with the greater ecosystem once finalized in late Spring.



RESIDENTIAL BUILDINGS



**FOOD, WATER, ENERGY
NEXUS**



TRANSPORTATION

A fuller accounting of these dialogues are contained in the body of this white paper. For more information on the IN² ecosystem and IN² portfolio companies, please visit www.in2ecosystem.com.

Origin of the IN² Program

The Wells Fargo Innovation Incubator (IN²) is a unique technology incubator and platform funded by the Wells Fargo Foundation and co-administered by the National Renewable Energy Laboratory (NREL). Launched in 2014, IN² was developed to speed the path to market for early-stage, clean-technology entrepreneurs. Its initial focus was to support scalable solutions to reduce the energy impact of commercial buildings. Companies selected for participation in the program receive up to \$250,000 in non-dilutive funding from Wells Fargo, technical support and validation from experts at NREL's facilities in Golden, and may have the opportunity to beta test at a Wells Fargo facility or with a strategic program partner.

Wells Fargo supports smart and connected communities that can safely meet the emerging needs of citizens while minimizing or mitigating the environmental impacts that come with rapid and sustained growth. Through the establishment of a series of corporate sustainability goals — including 35 percent reduction in absolute greenhouse gas emissions, 40 percent increase in energy efficiency and purchase of renewable energy to power 100 percent of operations by 2017, for example — Wells Fargo announced its Environmental Affairs Commitment, whereby it would spend \$100 million by 2020 to achieve these ambitious targets.

To help realize these targets, Wells Fargo partnered with NREL to develop IN². NREL is the only Department of Energy (DOE) laboratory focused solely on the research, development, and commercialization of renewable energy and energy-efficient technologies. As the foundational partner, NREL provides leadership in developing clean-energy technologies and solutions and is responsible for the administration of funds and carrying out due diligence as leaders of the strong network of partners executing the IN² vision.

Companies selected to participate in the IN² program receive access to NREL's world-class research facilities and expertise to prove, optimize and test their technology at scale. Validations achieved through intensive data collection and rigorous analysis of technology performance at NREL help promising early-stage technologies and companies quantify and reduce risk in their products. Select companies are also offered an opportunity to beta test innovations in a commercially relevant environment as part of the IN² program. This platform helps to reduce technology risk and makes investment realizable at an accelerated rate based on results of the demonstration. Through this unique incubator approach, IN² participants receive resources, expertise and a fast track for market adoption, which creates opportunities for collaboration with Wells Fargo.

The Wells Fargo Foundation awarded IN² with an additional \$20 million in 2017 in order to expand its focus and to grow its ability to provide non-dilutive funding to support innovations in clean technology. The funding will enable IN² to help its companies overcome the technical and market “valleys of death” by providing validation, expertise, capital and networking opportunities. These funds are also used to support the ecosystem as a whole through awarding funding to channel partners.

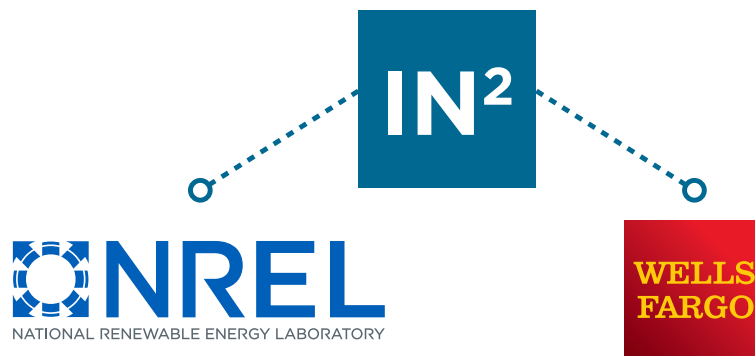
While commercial buildings will remain the cornerstone of the program, particularly since Wells Fargo has set a goal of having 35 percent of its properties LEED-certified by 2020, IN² is now expanding to support a broader set of innovations that can foster smart and connected communities. IN² has prioritized stakeholder outreach, with the intention of continuing to provide a platform for innovations that are driving the energy ecosystem. IN² will soon publish its strategic vision for enabling step change technological advances in the verticals of residential buildings, sustainable mobility and the food-energy-water nexus.

Expanding the Focus to Smart and Connected Communities

The IN² definition of smart and connected communities applies to communities of all types and sizes, from college campuses to neighborhoods and any other group of people unified in addressing challenges at a local level. Smart and connected communities will require cross-cutting efforts in a wide range of technical disciplines as energy use and pollution are inexorably bound to infrastructure, commerce, personal and commercial mobility, and the production and treatment of food and water. Underpinning these modalities is a vision of equity to ensure that the benefits of these emerging technologies provide real benefits across socio-economic status and geographies.

By convening subject matter experts and stakeholders from across the country, IN² is linking international issues with local perspectives in order to create a global community that can achieve synergies, transfer and share knowledge and create an enabling environment for contributing to the sustainability of all communities.

IN²'s focus on scaling commercial buildings technologies has demonstrated proof of concept for early-stage entrepreneurship, particularly when paired with NREL's experience with commercializing new energy technologies and with Wells Fargo's national footprint. Together, these factors converge in creating an ecosystem where novel ideas can truly be brought to fruition for the benefit of a greater community. Extending this strategy to a holistic approach to community development is only one part of Wells Fargo and NREL's commitment to reducing environmental impacts and supporting resilient communities.



Informing the Path Forward: Highlights from the 2017 Summit

In August 2017, IN² convened a Summit of 150 stakeholders to discuss innovation in residential buildings, transportation, and water use as the keystone for building smart and connected communities. This high-level Summit included renowned subject matter experts, investors, channel partners and recognized industry leaders. Cohorts were established on the basis of these three verticals, and together articulated the greatest technical challenges and opportunities. The highlights of these discussions are provided below.

“Business is the only mechanism on the planet today powerful enough to produce the changes necessary to reverse global environments and social degradation.”

- Paul Hawken, keynote speaker at the IN² Summit



Challenges and Barriers to Innovation in Residential Buildings

IN²'s experience with commercial buildings lends itself well to work in the residential building sphere as many of the buildings technologies supported by the first three rounds of the IN² program are directly translatable to residential homes. With more than 2 million new residential homes built and 27 million retrofitted in the U.S. every year, small improvements in home energy efficiency create an opportunity to achieve substantial impacts if widely enacted¹. Subject matter experts and stakeholders discussing residential buildings identified a long list of challenges associated with developing new energy technology for homes, including energy spent in HVAC operation, inefficient water use, the high price and low energy-carrying capacity of current energy storage systems, dynamic energy pricing, the intermittent nature of renewable energy supplies, the complication of integrating internet-enabled sensors with control systems and associated cybersecurity threats, meeting peak demand surges in water and power consumption, the long life spans of old buildings and antiquated appliances, and a general lack of consumer and builder awareness of factors supporting sustainability and energy use.

Opportunities for Innovation in Residential Buildings

- Capturing waste heat and improving insulation;
- Grey water reuse and storm water collection to reduce waste and inefficiency;
- Designing and manufacturing improved batteries and resilient microgrids to increase capacitance and reduce interruptions;
- Developing new financial and operational transaction models like blockchain for decentralized energy exchange;
- Peak pricing to transform consumer behavior; and
- Reimagining residential spaces for designs that are smaller and use rooftop space for the generation of electricity or gardens.



Challenges and Barriers to Innovation in Transportation

Each day, American workers log nearly 4 trillion miles on roadways, and every day 91 percent of Americans commute to work in personal vehicles² with an average fuel economy of fewer than 25 miles per gallon³. Use of personal vehicles and the shipping of goods were responsible for consuming more than 25 percent of the energy used in the U.S. in 2016⁴, making transportation the second-largest source of greenhouse gas emissions.

The discussion groups recognized manifold technical challenges that the transportation sector faces, including the high cost and rigidity in service delivery of public transportation systems. The topic of autonomous vehicles generated concerns about cybersecurity, the impact of automation on employment, and incomplete data on consumer behavior, traffic patterns and accessibility. The growth of the aviation sector and its dependence on liquid fuels was also discussed as a unique problem.

Opportunities for Innovation in Transportation

- Electrical vehicle charging infrastructure;
- New revenue streams from ride sharing;
- Enabling multi-modal transportation systems;
- Aggregation of transportation system schedules and one payment method;
- Facilitating two-way communication between passengers and transporters to

- optimize efficiencies;
- Sensor and data reliability;
- Congestion in the air with the advent of e-commerce;
- Automated delivery of goods and services;
- Smart parking; replacement for on-street parking – inevitable direction where cities are going;
- Fleet optimization, including structured leasing option;
- Facilitated car sharing assuming communal ownership;
- Optimization and congestion based dynamic tolls; and
- Need to improve energy storage for electrical vehicles.



Challenges and Opportunities in the Food-Water-Energy Nexus

Food production in the United States accounts for more than 10 percent of the total consumption used in the U.S.⁵, and 143 billion gallons of fresh water — or nearly 45 percent of the total water withdraws in the country — are used every day in energy generation. In addition to the emissions associated with moving food from seed to table and the water requirements for power generation, discussion at the IN² Summit included the need to increase food production for a growing population while simultaneously facing shortages of water, phosphate and protein. These challenges are exacerbated by a lack of infrastructure in remote agricultural production locations, the life-cycle effects of fertilizers, the amount of time required for seed-based agricultural advances to enter mainstream food production, and the risk-adverse nature of highly regulated agricultural businesses and public utilities.

Opportunities for Innovation in the Food-Water-Energy Nexus

- Use of agronomy and molecular biology techniques to generate more robust crops;
- Reducing food waste by increasing access to preservation technologies and improving storage/refrigeration;
- Reinforcing markets for non-centralized and urban agriculture;
- Easing water shortages through desalination, water reuse and waste to energy projects;
- Desalinization;
- Reducing water use in agriculture production and food processing;
- Greater weather prediction and anticipation techniques;
- Atmospheric water generation;
- Urban agriculture/farming; vertical farming decreases water usage and transportation energy use, more energy to grow;
- Solar on reservoirs
- Precision agriculture: membrane system that can recycle water
- Water reclamation technologies, water from supermarket displays can be recaptured and used with evaporative cooling systems to provide AC
- Fire-fighting that doesn't require water use; and
- The energy intensity of accessing food and water was a key discussion point and provides opportunities for innovation.

NEXT STEPS

IN² can play a critical role in fostering synergies that will benefit sustainable, clean, and accessible communities, and it will focus on verticals related to energy efficiency vis-a-vis commercial and residential buildings, transportation, food production and water use. The direction of the next round of funding will be determined by matching the most impactful challenges and opportunities illuminated at the IN² Summit with the research capabilities available at NREL. During the coming months, IN² will deliver a road map for execution of Wells Fargo's strategic vision and present a funding opportunity specifically targeting technical challenges outlined at the IN² Summit.

ABOUT WELLS FARGO

Wells Fargo & Company (NYSE: WFC) is a diversified, community-based financial services company with \$1.9 trillion in assets. Wells Fargo's vision is to satisfy our customers' financial needs and help them succeed financially. Founded in 1852 and headquartered in San Francisco, Wells Fargo provides banking, insurance, investments, mortgage, and consumer and commercial finance through more than 8,400 locations, 13,000 ATMs, the internet (wellsfargo.com) and mobile banking, and has offices in 42 countries and territories to support customers who conduct business in the global economy. With approximately 268,000 team members, Wells Fargo serves one in three households in the United States. Wells Fargo & Company was ranked No. 25 on Fortune's 2017 rankings of America's largest corporations. The Chronicle of Philanthropy ranked Wells Fargo No. 3 on its most recent list of the top corporate cash philanthropists. In 2016, Wells Fargo donated \$281.3 million to 14,900 nonprofits and Wells Fargo team members volunteered 1.73 million hours with 50,000 nonprofits. Wells Fargo's corporate social responsibility efforts are focused on three priorities: economic empowerment in underserved communities, environmental sustainability, and advancing diversity and social inclusion. News, insights and perspectives from Wells Fargo are also available at Wells Fargo Stories.

ABOUT NREL

NREL is the U.S. Department of Energy's primary national laboratory for renewable energy and energy efficiency research and development. NREL is operated for the Energy Department by The Alliance for Sustainable Energy, LLC.

¹Energy Use in the U.S. Food System, USDA Economic Research Report Number 93, March 2010. Retrieved from http://web.mit.edu/dusp/dusp_extension_unsec/reports/polenske_ag_energy.pdf

²The Role of Fossil Fuels in the U.S. Food System and the American Diet, USDA Economic Research Report Number 224, January 2017. Retrieved from <https://www.ers.usda.gov/publications/pub-details/?pubid=82193>

³Monthly New Residential Construction, July 2017. U.S. Census Bureau and the U.S. Department and Urban Development. Retrieved from <https://www.census.gov/construction/nrc/pdf/newresconst.pdf>

⁴Use of Energy in the United States Explained, Energy Use for Transportation, U.S. Energy Information Administration. Retrieved from https://www.eia.gov/energyexplained/?page=us_energy_transportation

⁵Use of Energy in the United States Explained, Energy Use for Transportation, U.S. Energy Information Administration. Retrieved from https://www.eia.gov/energyexplained/?page=us_energy_transportation

COMPANIES PARTICIPATING IN THE IN² PROGRAM CURRENTLY INCLUDE:



HVAC Systems

Thermal conditioning for buildings or equipment, including water heating and appliances.

7AC Technologies

7AC Technologies' liquid desiccant air conditioning system reduces typical HVAC electricity and water consumption by as much as 40%.

ThermoLift

ThermoLift's natural gas-driven heat pump combines heating, cooling and hot water supply — reducing primary building energy use by as much as 50%.

Software Motor Corporation (SMC)

SMC is building the world's highest efficiency Internet-enabled motor for HVAC applications.



Smart Glass

Dynamic glass for energy savings and human comfort.

VG SmartGlass

VG SmartGlass develops a polarizing film-based shading solution with the potential to control both heat and glare with a simple design and low cost.

Polyceed

Polyceed is developing a low-cost controllable material for dynamic windows that requires no external wiring.

Heliotrope

Heliotrope is developing a neutral-colored dynamic glass solution with a target of achieving cost neutrality with conventional window solutions.



Energy Analysis

Technology for conducting energy audits and determining energy efficiency.

Whisker Labs

Whisker Labs' peel and stick submetering technology enables cost-effective insight into whole-building energy performance.

simuwatt

simuwatt is a web and tablet-based application for conducting rapid energy audits and analysis.

Maalka

Maalka enables cities and organizations to set cost-effective EE investment strategies and leverage powerful real-time Measurement and Verification to track the impacts of these investments across large portfolios of buildings.



Data Infrastructure

Energy efficient data infrastructure and computing.

LiquidCool Solutions

LiquidCool Solutions' total immersion electronics cooling technology for computer servers offers 40% energy savings relative to air-cooled systems.



Energy Storage

Battery systems that store energy efficiently and respond to energy demands.

Energy Storage Systems

Energy Storage Systems' all-iron redox flow battery has the potential for safe and cost-effective energy storage at 30% of current costs.

NETenergy

NETenergy's thermal battery for HVAC systems enables up to a 30% reduction in typical cooling energy costs by shifting peak demand.



Energy Management

Typically hardware technologies, actively manage resources or enable resources to communicate with one another.

Go Electric

Go Electric provides a microgrid and demand response power system that can enable up to a 50% reduction in typical building energy costs.

Geli

Geli provides a software platform to design, automate, and manage energy storage systems.

EdgePower

EdgePower sells and deploys building energy management controls hardware and software.

Transformative Wave

Transformative Wave is developing a battery storage retrofit kit for commercial buildings that optimizes on-going revenue with 15-30% energy savings and 20-40% peak demand reduction.

J2 Innovations

J2 Innovations empowers companies with a building automation and operating system for connecting and controlling devices.

PowerFlex

PowerFlex's adaptive EV charging technology provides a target charging capacity at 40% lower infrastructure and operating costs and reduces carbon footprint.

Ibis Networks

Ibis Networks addresses plug load management with its patented IntelliNetwork system, enabling customers to save up to 40% of energy cost on managed equipment.



Water

Systems to increase the conservation of water and reduce energy use related to the production and use of water.

APANA

APANA builds cloud-based analytic solutions to scan, pinpoint, and guide resolution of water waste by instantly alerting frontline staff with actionable guidance.

IN² CHANNEL PARTNERS

ACRE

New York, NY

Austin Technology Incubator at UT-Austin

Austin, TX

Caltech, Flow Program

Los Angeles, CA

Carnegie Mellon

Pittsburgh, PA

Case Western

Cleveland, OH

Clean Energy Trust

Chicago, IL

Cleantech Group

New York, NY

Cleantech Open

Redwood City, CA

Coachella Valley Economic Partnership

Indio, CA

CSU Powerhouse

Fort Collins, CO

Cyclotron Road

Berkeley, CA

Elemental Exceleator

Hawaii

Greentown Labs

Boston, MA

Imagine H2O, Inc.

San Francisco, CA

Innosphere

Ft. Collins, CO

Los Angeles Cleantech Incubator

Los Angeles, CA

Mass Challenge

Boston, MA

MIT Energy Club

Boston, MA

NECEC

Boston, MA

NextEnergy Center

Detroit, MI

Northwestern University

Evanston, IL

Oregon BEST

Portland, OR

Portland State University Foundation

Portland, OR

Prospect SV

San Jose, CA

Purdue University

West Lafayette, IN

Rice University

Houston, TX

Stanford University's TomKat Center for Sustainable Energy

Stanford, CA

Sustainable Startups

Salt Lake City, UT

Telluride Venture Accelerator

Telluride, CO

Texas A&M Engineering Experiment Station Clean Energy Incubator

College Station, TX

Texas State University

San Marcos, TX

The Water Council

Milwaukee, WI

UC Berkeley

Berkeley, CA

UC Davis EEC

Davis, CA

UC Irvine

Irvine, CA

UC San Diego

San Diego, CA

UNC Charlotte

Charlotte, NC

University of Colorado - Boulder (CU)

Boulder, CO

University of Denver (DU)

Denver, CO

University of Michigan

Ann Arbor, MI

University of Texas at Austin, McCombs School of Business

Austin, TX

University of Washington

Seattle, WA

University of Wisconsin

Madison, WI