

# Innovative Energy

REVIEW

A Journal of the  
Colorado Cleantech  
Industries Association

## Partnerships Matter

How strategic partnerships  
are working wonders for  
Colorado's energy industry  
P.7



*Greg Fischer, Denver Water, and Jocelyn Hittle, CSU*

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## What is Craftsmanship<sup>SM</sup>?

To be crafted is to meet exacting standards.

It's the human touch that combines art and science to create something unique.

We tend to think about craftsmanship in terms of physical things: fine wine, classic cars, custom furniture and iconic structures.

But what about the underwriting of insurance to craft protection for your unique and valuable things? And the service behind that coverage when you need it most – like claims and loss prevention?

For your business.

Your employees.

Your home.

The people you love.

Things that need a particular kind of protection and service.

The kind Chubb provides.

Not just coverage. Craftsmanship.<sup>SM</sup>

Not just insured.

Chubb. Insured.<sup>SM</sup>

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*Photo: Jonathan Castner*



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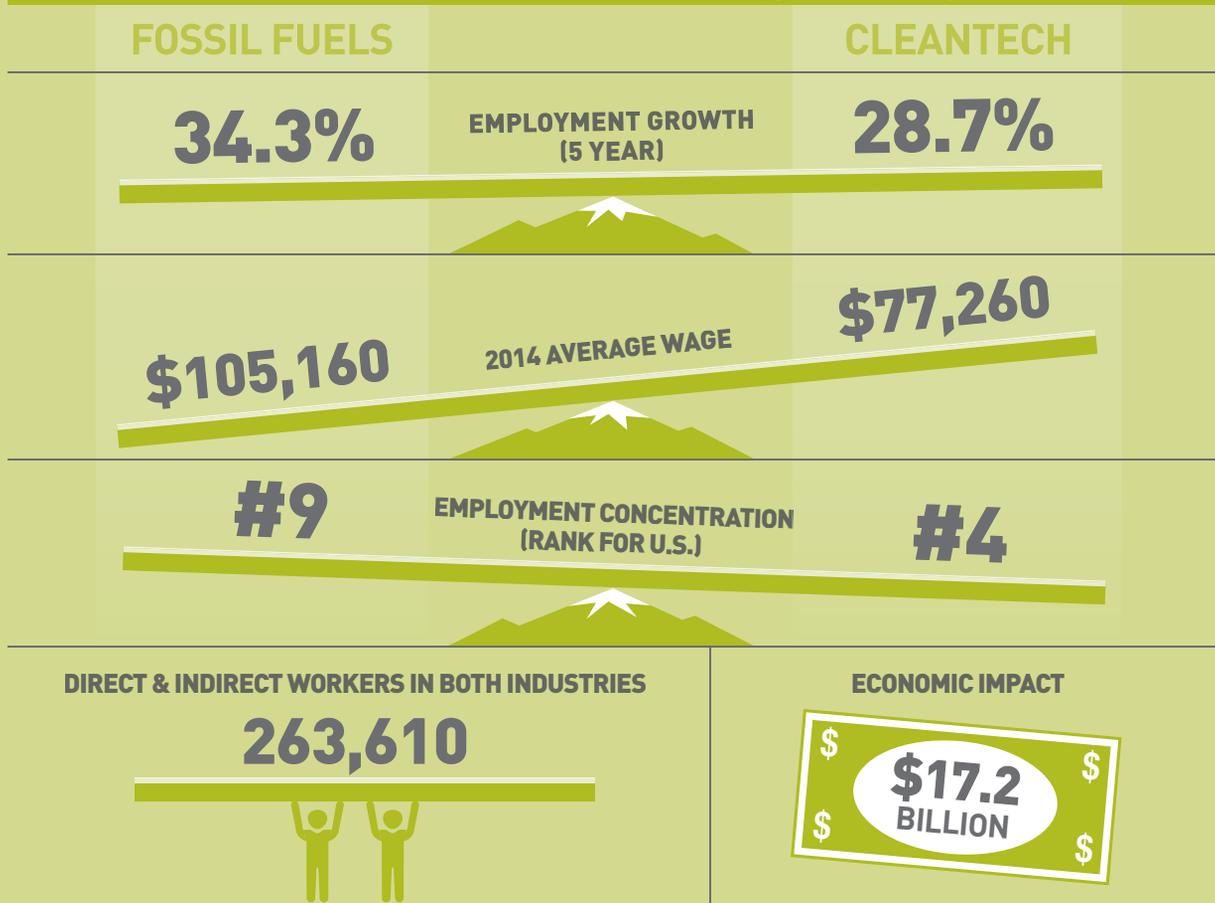
*By Stacy Bare*  
Partnerships are everywhere...  
Good thing

# COLORADO

## The Balanced Energy Capital of the West

The integration of renewable energy and the state's rich energy resource base puts Colorado at the forefront of energy development for the nation.

### Colorado's Balanced Energy Industry



### Energy by the Numbers

127.3M  
BARRELS



of crude oil produced in Colorado in 2015, a new state record and a 35% increase over 2014



#1

Colorado is the No. 1 state for wind-energy manufacturing

Brain  
power



fuels innovation in Colorado's energy industry - we have the nation's 2nd-most highly educated workforce.

#BalancedEnergy



COLORADO  
ENERGY  
COALITION

[www.metrodenver.org/CEC](http://www.metrodenver.org/CEC)

Dedicated to supporting and promoting all energy sectors: fossil fuels, cleantech, efficiency, and conservation.

# From the Chairman

## CCIA Serves as Pivotal Partner for Access to Strategic Markets and Companies

IN ITS EIGHT-YEAR HISTORY, Colorado Cleantech Industries Association (CCIA) has been one of the critical contributors to the dramatic economic expansion of cleantech and energy industries in the state of Colorado. Our programs have encompassed a focus on people, policy, community, and access to capital, enabling some of the strongest success stories of companies in these sectors. Navigating through the economic shifts in these industries and their related capital markets, CCIA endeavors to continually adapt its programs to deliver optimal value supporting the growth and success of its members.

Studying the economic landscape in the past several years, we've seen a dominant number of cleantech and energy technology innovations unable to provide projected returns to venture capital investors. Many of the innovations in this sector fall into advanced materials, chemicals, and processes, where the challenges of scaling from lab science to factory production can be daunting both technically and financially. As such, there's been a significant dropoff in the aggregate venture capital investment into these sectors.

Hence, as CCIA's board chairman, I frequently hear the need for connecting and integrating clean and energy technologies with strategic investors, markets, and buyers in an effort to address this substantial reduction in available capital. I now believe it's a key role for CCIA to assist in these market and investment connections.

In many instances, the association fulfills this need by making individual, specific introductions for its member companies based on the robust relationships CCIA owns in the extractive, energy, real estate, architecture, manufacturing, and food processing industries, to name a few. While valuable, this method of helping companies find markets and customers is simply not scalable.

However, what has proven scalable, are recent CCIA programs that partner with companies in strategic markets looking to expand and streamline their opportunity for ac-



**Ed Williams**  
*Chairman,  
Colorado Cleantech  
Industries Association*



cess to advanced energy technology solutions. For the past three years, CCIA has successfully launched programs to meet this need.

Take a look at CCIA's Oil & Gas Cleantech Challenge (OGCC). The OGCC is an annual six-month program, or process, led by CCIA that targets companies in the strategic industry of upstream oil and natural gas exploration and production. In partnership with some of the largest companies in the field, CCIA collaboratively identifies the critical technology limitations that pose barriers in their ability to meet regulatory requirements and realize savings to the bottom line.

These companies then rely on CCIA to represent their interests to the cleantech and energy industries, enabling the creation and distribution of an aggregated list of technology needs. CCIA subsequently curates a national pool of technology solution developers, shared with the strategic partners, who then down-select the companies that appear to best meet their technology requirements.

Over the past three years, this OGCC process has introduced close to 80 national and international cleantech companies to interested strategic partners and investors. The program consequently enables a very efficient alignment of strategic companies and markets with technology solution developers, an extremely valuable way to mutually help these companies grow and expand.

CCIA will be bringing the OGCC model to other industries, including mining, advanced materials, and smart cities, as we explore ways to provide additional scalable processes for cleantech companies to efficiently access strategic markets and partners.

CCIA's board and staff strive to deliver valuable programs that drive expansion of a cleaner, cheaper, more efficient, and secure energy economy and are your unique partner in Colorado to do so. □



# Partnerships Matter





Having the **wrong** business partner can break a company.

• • •

Finding the **right** one can allow you to change the world.

EVERY CLEAN TECHNOLOGY COMPANY IN COLORADO is on the hunt for the most effective and efficient partner.

The right project partner, the right funding partner, the right piloting partner, the right development partner, the right customer partner, the right manufacturing partner. The list goes on and on.

Sound familiar? Colorado's cleantech companies aren't the only ones with this concern.

According to the Global Cleantech Risk Survey conducted by the Chubb Group of Insurance Companies and Cleantech Group, "establishing new business relationships" was both a short- and long-term priority for the 300 global cleantech CEOs surveyed in the 2015 report.

That's why CCIA elected to focus the 2016-2017 Innovative Energy Review on partnerships.

So much more can be accomplished with the right partner.

It's not only the private sector that prioritizes new, successful business relationships, but nonprofit, public-private, and public-public partnerships are also key to creating an environment that enables organizations to meet

their goals through innovation and out of the box thinking.

By being open to new win-win partnerships and savvy about how to find and vet potential partners, Colorado's cleantech companies and organizations are leading examples for others to follow. Introductions, meeting new people, and building relationships outside of our comfort zone is how the most effective partnerships are created. Trust has a lot to do with it, too.

One such unique partnership is between Denver Water, the largest public water utility in Colorado, and Colorado State University (CSU). The two entities came together to forge a new initiative that will lead to breakthroughs in water conservation, quality, and management.

We hope you enjoy reading about Colorado's effective and unique partnerships unfolding across the state, throughout the country and globally, that positively impact our planet and our lives. □



**Chris Shapard**  
*Executive Director*  
*Colorado Cleantech Industries Association*



*Denver Water  
Operations Complex  
Redevelopment*



# Denver Water, National Western Center Bring Water Use into the 21st Century

*By Chris Meehan*

The redevelopment is guided by a **“One Water”** philosophy by “using the most appropriate source water for each water use.”

SOME OF THE MOST MEASURED AND TREASURED WATER IN THE WORLD is here in Colorado. It’s also home to some of the most innovative thinking and action on water.

Two Denver projects are rethinking water use: the redevelopment of Denver Water’s headquarters and the establishment of the CSU Water Resources Center at the National Western Center.

## Denver Water Operations Complex Redevelopment

Denver Water has a long history of conserving water. In fact, the utility coined the term, “xeriscape,” to encourage low-water landscaping in 1981. It also manages the state’s largest water conservation program. Now, as Denver Water overhauls its headquarters, it is putting its money where its mouth is and incorporating cutting-edge uses of water and water-saving technologies.

As part of the \$195 million redevelopment of the utility’s 35-acre operations complex in central Denver, the complex is being designed with LEED certification in mind, and will showcase net-zero energy demonstrations and concepts for managing all water sources, says Travis Thompson, spokesperson for Denver Water. “The redeveloped complex may provide an education center for those interested in learning more about water and its efficient use,” he adds.

In developing its plans to remodel the headquarters, the utility partnered with numerous players including Mortenson, which serves as the general contractor carrying out architect RNL Design’s plans, and Trammell Crow Company, which is serving as the project’s owner’s representative.

“Because many of the new technologies and ideas will require regulatory changes, Denver Water will also be partnering with regulatory agencies to secure proper approval,” Thompson says.

The redevelopment is guided by a “One Water” philosophy by “using the most appropriate source water for each water use,” he adds. “The One Water concept aims to reduce as much as possible water demand and discharges to the environment and to recover, recycle and reuse appropriate water sources for non-drinking water purposes. Denver Water is also working with Colorado State University (CSU) to develop a site at the National Western Center to test and demonstrate these concepts to foster innovation in the water industry.”

The One Water concept will use both old and new water-conservation technologies. It will incorporate green infrastructure to absorb and filter excess stormwater, high-efficiency plumbing fixtures, and water-wise landscaping. The utility has plans to capture rainwater for irrigation on the site so it can demonstrate water conservation techniques.

The utility also is looking at “the concept of an eco-machine in the administration building, which would be like a mini-water treatment plant underground — using biological processes,” Thompson says. The water used in the administration building would be collected and recycled.

“After the first use, the water would then be purified through an ecological process that uses living organisms, including plants in the lobby of the building,” explains Thompson. “The purified water would then be used again. The recycled water from the eco machine would be used to serve non-potable demands



*47th Avenue Festival Street and Elyria Plaza at the front door to the new Trade Show/Exhibition Hall-looking Northwest during a future National Western Stock Show.*

such as in the building’s toilets and onsite landscape irrigation. Some of these intended uses will require modifications to existing regulations.”

The redevelopment project also encompasses water-based geothermal heating and cooling in the new administration building. “After the water is piped through the building to heat it or cool it, depending on the weather, the water would be sent back to the larger pipeline for use by customers,” Thompson says.

## National Western Center

With CSU’s well-earned status as an academic hub for agriculture, it’s no surprise that it’s a longstanding partner of the National Western Stock Show. With the redevelopment and expansion of the National Western Complex to become the National Western Center, this part of the City is working to realize a new vision of serving and leveraging the state’s agri-industries in the 21st century.

As part of the pivot, CSU and the other National Western Center partners are working with Denver Water to develop the CSU water Resources Center. While still in planning, the center will bring together various water sectors to develop water-oriented technology, support research, business incubation, K-12 education, and community programs.

“The Colorado State University Water Resources Center at the National Western Center will honor our history of agriculture and the partnership that CSU and the

National Western Stock Show have had for more than 100 years,” says Jocelyn Hittle, director of Denver program development for CSU. “We are in the process of identifying additional partners from various sectors for the collaborative components of the Water Resources Center.”

Hittle notes that the Center will explore water’s connections to the food system, the environment and society, and also will explain water quality and management, history, and policy while matching the source of water to its end use. “CSU is committed to highlighting state-of-the-art practices in water conservation at the Water Resources Center, allowing it to be an educational showcase of best practices in responsible water use, while also being a fun and educational place to be,” she explains.

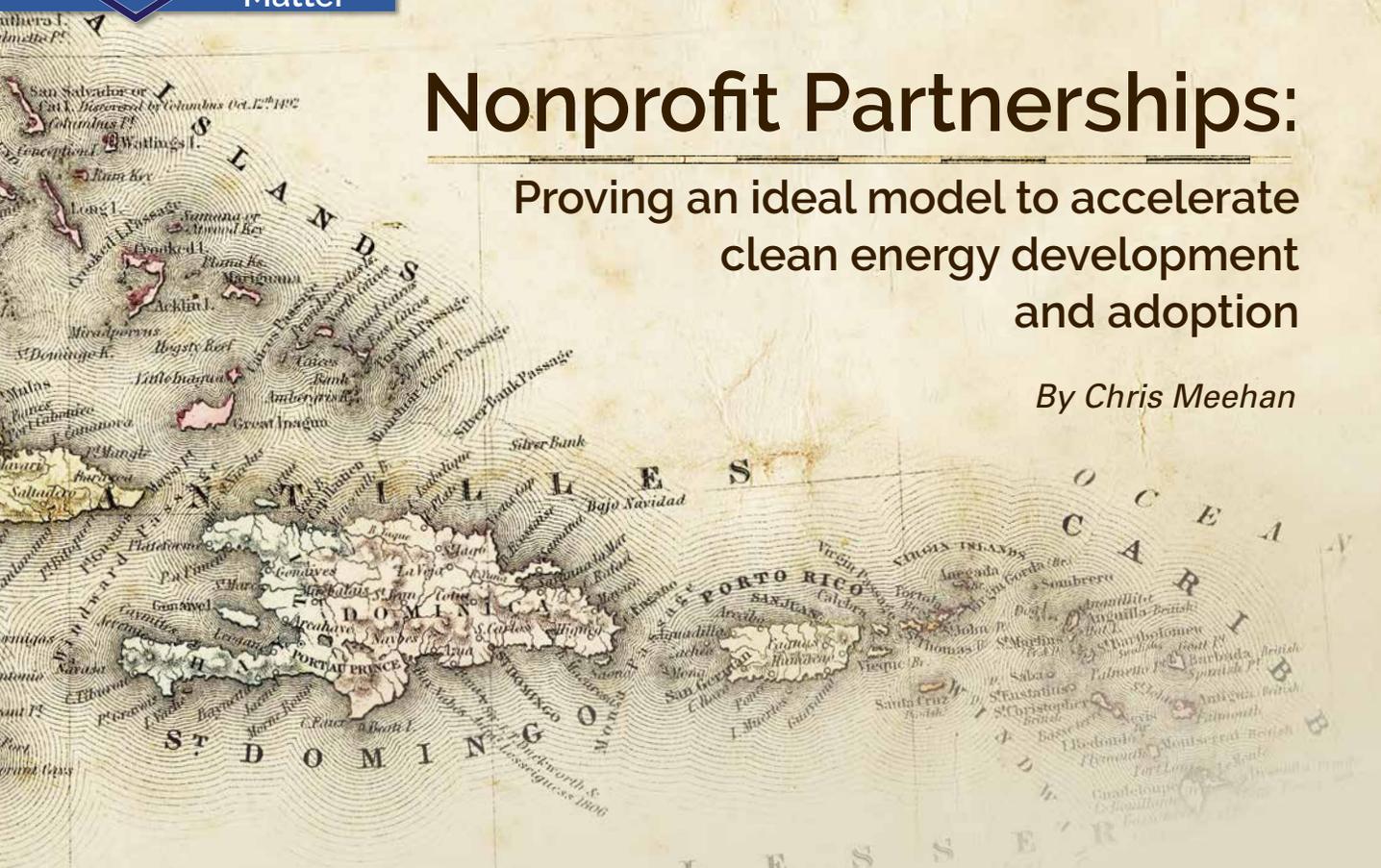
“We’re excited about this partnership because it combines academic and industry expertise to create a first-of-its-kind approach to water innovation,” said Greg Fisher, Denver Water’s manager of demand planning and National Western Center project liaison.

“This partnership creates collaboration around water quality, conservation, reuse/recycling, treatment, and more, and is a cooperative public/private/utility endeavor that is unique in the nation,” says Hittle. “It will be a cutting-edge innovation space to take on the important water issues of the next 100 years.” □

# Nonprofit Partnerships:

## Proving an ideal model to accelerate clean energy development and adoption

By Chris Meehan



TO MOVE THE NEEDLE on fossil fuel dependence and catalyzing cleantech innovation, collaboration is critical.

Nonprofits like the Colorado Cleantech Industries Association (CCIA), Cleantech Open, and the Rocky Mountain Institute (RMI) are working together to bring cutting-edge science to the forefront, grow the economically sensible adoption of renewable energy, and prepare today's students for active roles in a cleantech-driven world. Partnerships are at the forefront of these efforts.

### Ten Islands Challenge

In 2014, Boulder-based Rocky Mountain Institute (RMI) launched the Ten Islands Challenge to move Caribbean nations from dependence on fossil fuels to renewable generation. While many countries are part of a larger infrastructure network, islands and island nations are at a disadvantage. Many have relied on diesel to generate electricity and adding in solar, wind, geothermal, and other power sources has been prohibitively expensive.

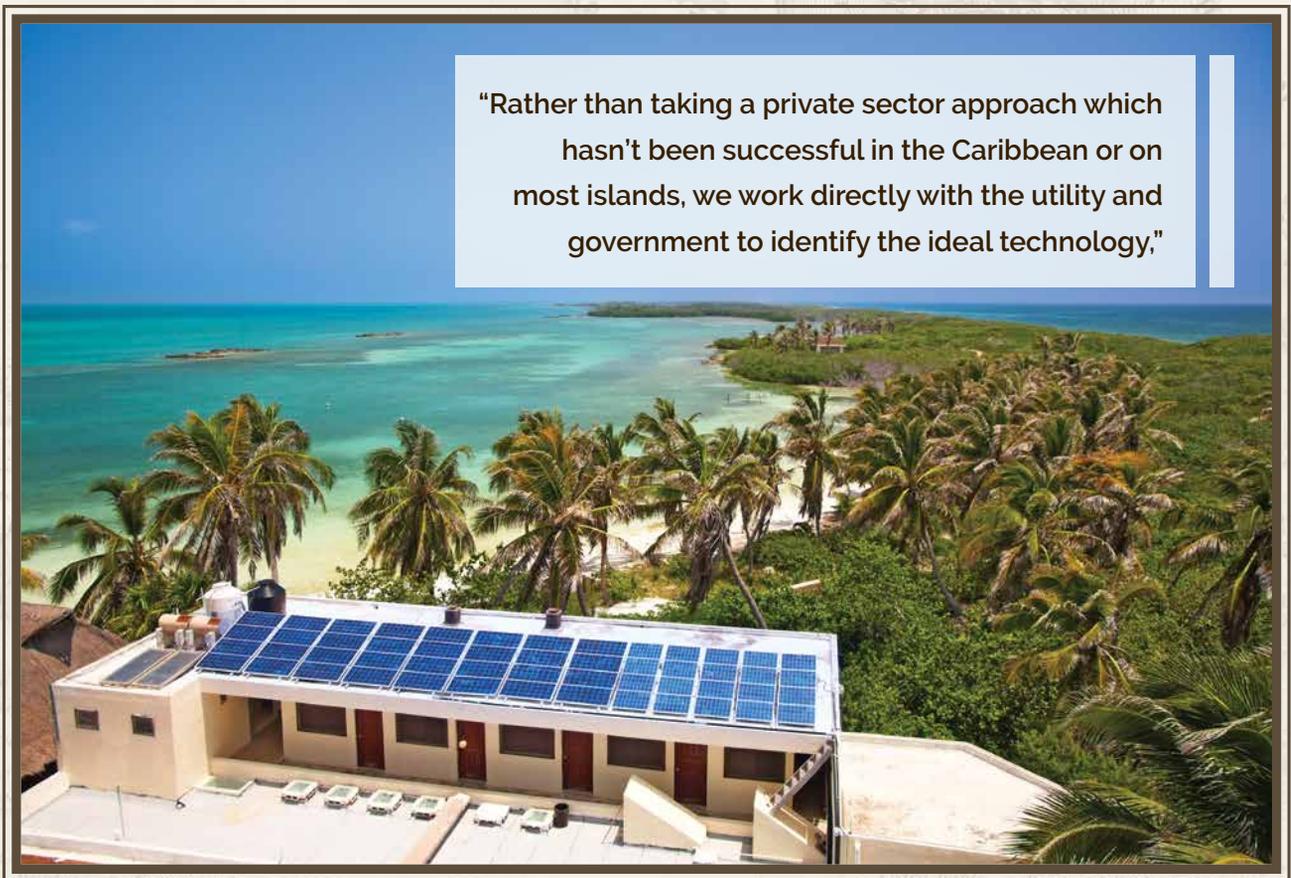
Since the launch, RMI and Carbon War Room merged and the Clinton Climate Initiative has joined the effort,

providing additional resources and funding opportunities and expanding the challenge into the Islands Energy Program, explains Justin Locke, the program's director.

"Although they're all similar, there are key differences in each island that we're working in that impact the investment," Locke says. "These are very detailed strategies that look at the size of each investment, the type of technology, whether the utility would own the asset, and an EPC would be contracted to do the construction and engineering or going out through an independent power producer in the market."

Locke says the work looks at how renewable energy can embrace utility-scale development as well as distributed residential and commercial projects and energy-efficiency initiatives. "It communicates to the market that these are the investments we're going to bring to the market over the next eight to 10 years, so it helps to stabilize the market and people know what's going to come through the pipeline," he explains.

"Rather than taking a private-sector approach, which hasn't been successful in the Caribbean or on most islands, we work directly with the utility and govern-



“Rather than taking a private sector approach which hasn’t been successful in the Caribbean or on most islands, we work directly with the utility and government to identify the ideal technology,”

ment to identify the ideal technology,” Locke adds. Then through a competitive procurement process, a request for proposal (RFP) is issued and project developers are identified.

The partners are now working to get multiple islands up and running with renewable energy, including a three-megawatt solar project on St. Lucia. “That contract should be signed pretty shortly and those three megawatts should be up and running by the end of the year,” Locke asserts. “We also have another three megawatts of geothermal under construction on Montserrat and we hope to have 7.5 megawatts of utility-scale distributed solar underway in Aruba soon.”

While each island has specific needs, there are commonalities in structuring deals. That’s why another key partner in the Islands Energy Program is CARILEC, an association of Caribbean utilities. “We’ve created an online platform where utilities can exchange information with each other to further stabilize the market,” Locke says. As the island utilities gain experience with renewables, they can share that information with other utilities. “It’s important for them to learn from each

other to being on new renewables.”

The partnership with CARILEC is also helping create standardized templates for procurement documents and more. “Those would be publicly accessible in an online repository to help stabilize the market and create some standardization across these markets even though the regulatory statutes are highly different across each of these countries.”

Caribbean utilities are currently most comfortable with adding in one- to four-megawatt renewable energy projects — about 5 to 8 percent of peak load, Locke says. They can still feel comfortable managing the intermittency at that level.

While these first projects don’t incorporate energy storage, which can offset the effects of intermittent energy from solar or wind, Locke says the utilities are very interested in energy storage. “We plan to offer storage in the future,” he adds.

With success, the Island Energy Program and its approach are garnering even more recognition, accord-

ing to Locke. “Recently we’ve been approached by the Green Climate Fund to submit a proposal, which would look to scale our program globally,” he says.

## Cleantech Open

While RMI and its partners are working on practical solutions today, other nonprofits are helping catalyze tomorrow’s solutions. Colorado Cleantech Industries Association (CCIA) recently solidified its partnership with the Rocky Mountain Cleantech Open (CTO), a global accelerator for early-stage companies with a growing Rocky Mountain presence.

“For CTO, we see our partnership with CCIA as a way to connect industry expertise with entrepreneurship development. When you add in the value of the labs and universities, you start to understand why Boulder-Denver, and more generally Colorado, is being recognized nationally as a top-ten hub for cleantech,” explains Brian Oehler, Cleantech Open state director of Colorado.

The startups enter CTO’s program with a bright idea, and when they complete the accelerator program, they are well-positioned to continue on with partner organizations such as Innosphere, the Center for Renewable Energy and Economic Development (CREED) and Cleantech Community (CTC). As CCIA and CTO expand their partnership they offer a unified front to help encourage even more growth in cleantech and entrepreneurship throughout Colorado.

## Teacher Training with Industry Partners

CCIA has another forward-looking partnership with the Colorado BioScience Association Institute (CBSA Institute) and its Research Experience for Teachers (RET) program. “They take high-school science teachers and have them work at bioscience companies for a month in the summertime,” explains CCIA executive director Chris Shapard. “This year, they expanded into another

sector, and it was cleantech. Two of our member companies participated in the program.”

The Institute’s RET program provides teachers with practical knowledge and hands-on experience to enhance their content understanding, classroom practice and bridge to the real-world skills students will need. Throughout the program, teachers spend about 130

hours with an innovative STEM company working on real-world projects and 30 plus hours in teacher professional development. The goal is to help build long-term collaborative partnerships between teachers, industry leaders, and the local university research community by involving the teachers in STEM-based, industry-relevant projects and helping them increase student engagement and interest in STEM careers. After two years

of successfully running the RET program, school district partners asked CBSA if they could expand the STEM reach beyond bioscience. A natural partnership opportunity with CCIA presented itself and school districts were thrilled to hear that the program would expand into the cleantech space with CCIA.

Through expansion of the program, local cleantech companies including battery maker SolidPower and non-chlorine pool treatment company Clear Comfort took on teachers as temporary employees this summer.

“It’s a great application not only for the past, but also for the future, because you’re engaging kids as well as teachers, even though the kids aren’t directly involved in the intern program,” Shapard says. “The teachers are really amazed by the results of making a real-world connections and can share that excitement with their students.”

Nonprofits are often small. They are typically underfunded and understaffed. But don’t tell them that. Working together, they punch above their weight and prove that partnerships spur creativity, opportunity, and a solutions-minded approach to market needs. □



# Colorado Universities Partner to Bring **Tomorrow's** Cleantech to **Today's** World

When it comes to solving the world's problems, they're fertile ground for breakthroughs. They also have unique spaces where companies and organizations can partner to incubate new technologies or help get an idea off to a great start. At least three of Colorado's leading education institutions are creating unique partnerships to help advance cleantech to the next level.

The Colorado School of Mines partnered with Vartega Carbon Fiber Recycling, a startup aimed at creating a low-cost, low-energy intensive and modular approach to providing reusable recycled carbon fiber. It's one of the most in-demand industrial materials today, wanted for its versatility, strength, and weight. For instance, Boeing Dreamliners incorporate roughly 23 tons of carbon fiber, and a 135-foot wind-turbine blade can have seven tons of carbon fiber. The uses are much more diverse — even fishing poles and prosthetics use carbon fiber — but the high demand keeps it expensive.

"Carbon-fiber recycling requires a fraction of the energy needed to make virgin carbon fiber and this results in a material that has very similar properties to virgin carbon

fiber with a considerable economic benefit," says Jordan Harris, Vartega senior process engineer.

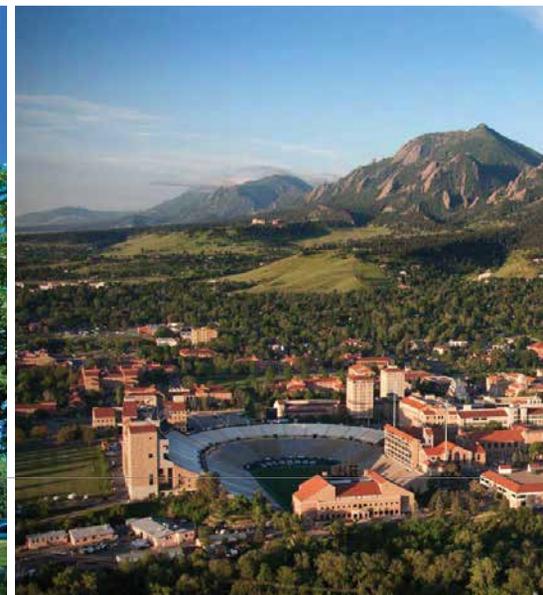
The company uses solvolysis, a chemical reaction that results in new compounds. In this case, it yields carbon fiber, resin, and recycled process fluids. "One advantage of our process is that we can recover the fibers in their original form factor without degrading their mechanical properties," explains Harris, noting that the process helps manufacturers to avoid disposal fees. "This allows for closed-loop recycling where we supply fibers back to the companies who provided us with their scrap."



The Colorado School of Mines gives Vartega access to facilities and equipment, allowing employees to better understand the technologies the company is using and improve its processing techniques, Harris says. "The knowledge and expertise of the

Mines team has been an invaluable resource."

The company is now raising funds through public and private sources to build a pilot system, which it hopes to launch in early 2017 and to show to potential customers.



# Colleges and universities produce tomorrow's best and brightest: industry leaders, pioneering scientists, and innovative engineers.

*By Chris Meehan*

It will be able to recycle 100 tons of carbon fiber annually. "Commercial opportunities are developing and our timing positions us well for a strong position in the market," Harris explains.

Colorado State University also partners with companies to develop cleantech solutions, and the school is also working with several developing nations, including Rwanda; only about 20 percent of the nation is electrified and roughly 3,000 villages have no electricity. To bring the life-changing promise of electricity to these rural spaces, CSU launched the Smart Village Microgrid project.

"CSU's approach is a tight integration between the electrification and specific economic development initiatives," explains Alison Anson, a graduate teaching assistant in the CSU Department of Sociology. "We are interested in economic development catalyzed by access to energy."

The systems, Anson says, will help current energy demands, powering radios and smartphones and providing

electric lighting to replace candles or lanterns fueled by dirty, dangerous kerosene.

"We expect rapid growth in this category — small refrigerators, fans," she adds. "A key here is that electricity is the same or less cost, produces less health impact, and is easier to use."

The electricity from the grid can also support local enterprise, everything from cutting hair to milling grain and drying or refrigerating crops and food. "These loads keep money in the village, and therefore provide a big impetus for economic growth," explains Anson, noting that the systems also will support "anchor tenants" like schools and health clinics. "These loads help lift the power demand and reduce the unit cost of energy."

Rwanda has aggressive air quality and carbon goals and fossil fuels are very expensive, says project leader Dan Zimmerle, senior research associate at CSU's Energy

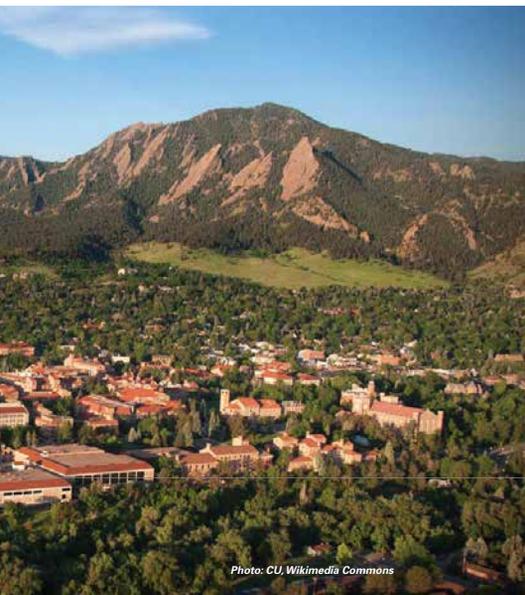


Photo: CU, Wikimedia Commons

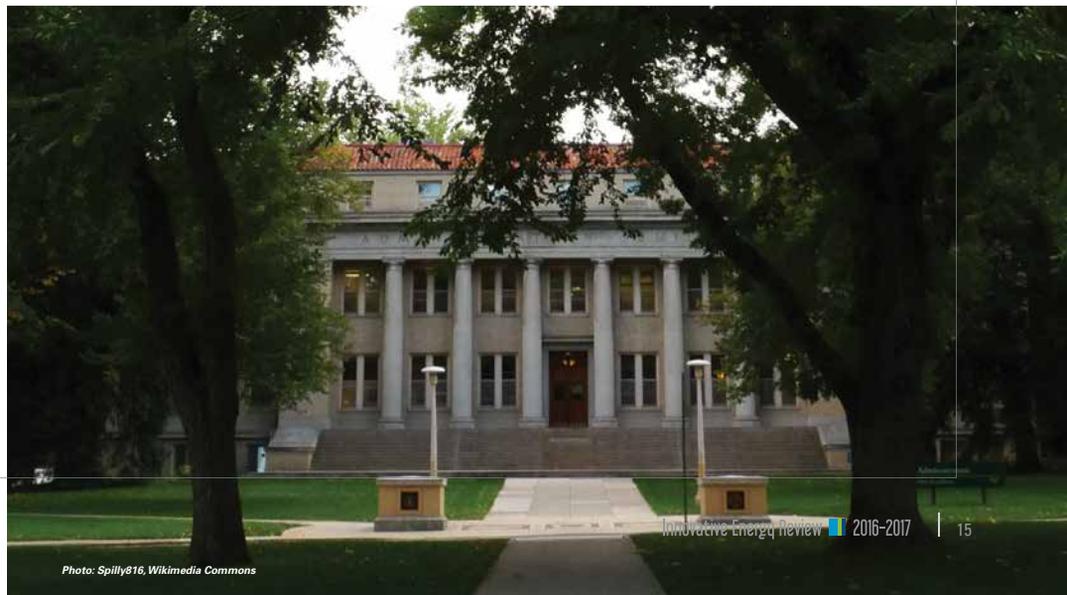


Photo: Spilly816, Wikimedia Commons



Institute. To power the systems, he says, the plan is to first use solar power.

“The cost and operational complexity of photovoltaics have dropped dramatically in recent years, making it attractive for remote operations,” Zimmerle says. “Unlike wind or hydropower, PV is also relatively site-independent.”

Looking ahead, the project team will also consider engines, hydropower, and wind generation. “Hybrid systems are typically more cost-efficient than sole-source systems,” Zimmerle explains.

The team plans to deliver its first microgrids to Rwanda in 2017. Currently, the team is still designing the grid and working with suppliers. “Often we attempt to leverage existing relations with partners, but are open to any new opportunities for acquiring equipment,” Zimmerle says. “Recently, we have been working with a handful of companies we know are in the right space and have expressed an interest, including Schneider, SparkMeter, and KeySight.”

Next steps will include developing the business plan. “Ideally, villagers will utilize pre-pay or pay-as-you-go metering that allows them to pay for energy with their mobile phone and a meter connected to their home” says Zimmerle. “This type of meter is very common in the developing world and even in parts of Europe or Asia.”



CU Boulder recently created a unique partnership incubator when it launched the Sustainability Innovation Lab at Colorado (SILC). “Research universities are such a reservoir of important information,” says Ben Webster, managing director of SILC. “The trouble is there is not a good bridge

between the academic community and the entrepreneurial community.”

It follows that SILC aims to link academia with those in policy, non-governmental organizations (NGOs), and the

private sector. It can also coordinate and apply for grants that otherwise might be inaccessible.

“The center itself is a physical space that acts as a conduit to other parts of the campus,” Webster says. “On the flip side, we wanted a place where organizations are so faculty, researchers, and students can engage with them.”

Though SILC isn’t an academic program, an undergraduate environmental leadership class will serve as a student introduction to SILC. Likewise, CU’s Masters of the Environment program will have interactions with SILC. “We are one of a handful of centers not associated with an academic unit,” says Webster. “We can easily engage with lots of parts of campus as opposed to another center, which might be in a given college and which is going to be beholden to that college.”

Already the nascent center, which operates under the Office of the Vice Chancellor for Research at CU, has signed up tenants that reflect its ambitions, among them CU spinoff Resilient Analytics, which came to SILC through the Colorado Cleantech Industries Association (CCIA), Webster says. The company provides tools and information for infrastructure entities, such as harbors, to prepare for climate change.

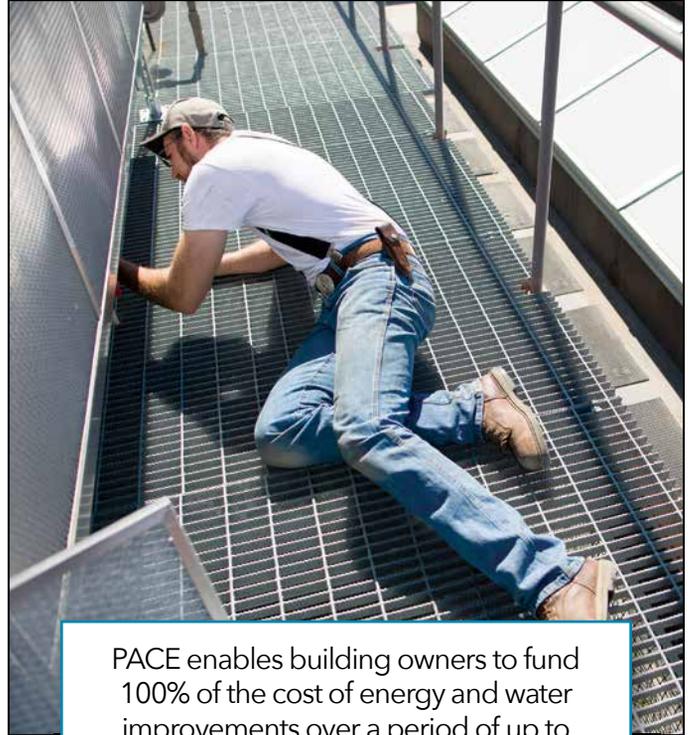
Another tenant for the center is Future Earth, which Webster characterizes as a new international research secretariat. “It’s focused on the human, biological, and physical elements of climate change,” he says. The NGO has a decentralized headquarters structure with hubs in Tokyo, Montreal, Paris, and Stockholm. “The U.S. hub is funded through the National Science Foundation. The funding flows through SILC and that is housed at CU Boulder.”

Webster says SILC is unique in academia. “We have not encountered any other coworking, colocation-type spaces like this anywhere else in the country,” he notes. “There are plenty of examples of private-sector entities renting labs, but the idea of having intentionally created space designed to facilitate interaction between a university, its students, and organizations in a given area, we have yet to encounter another like this. It’s very much a learning process.” □

# Commercial building energy improvements – C-PACE financing



Colorado C-PACE can pay for new heating and cooling systems, lighting improvements, solar panels, water pumps, insulation, and more for a variety of commercial properties.



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PACE is an innovative public-private partnership that allows property owners the opportunity to obtain low-cost, long-term, private-sector financing for energy and water improvements. Go to [copace.com](http://copace.com) to learn more.



**COLORADO**  
Energy Office



# Financing Building Upgrades Through Public-Private Partnership

*By Jeffrey King*

COLORADO RANKS AMONG THE TOP 10 STATES for clean energy technology markets. Two key indicators that affect Colorado's ranking are financial and human capital. These assets contribute to Colorado's ability to find innovative solutions to some of the state's most challenging areas in clean energy, such as energy financing. One solution is the use of public-private partnerships to address market challenges. Colorado Commercial Property Assessed Clean Energy (Colorado C-PACE) is an example of a strategic public-private partnership that addresses energy financing barriers, including a shortage of financing options and lack of affordable capital.



**A public-private program that offers commercial property owners a unique way to finance 100 percent of energy and water improvements to their properties.**

PACE, as a public-private partnership, can produce financing structures that are more favorable and tailored to clean energy projects. Within such partnerships, a government entity generally provides a portion of risk mitigation to stimulate private sector investment. Within the context of PACE, this risk mitigation is provided through one of the core mechanics of the program, namely the assessment that is placed on the property through the county tax system and used to subsequently repay the loan that funds the improvements. In this way, PACE represents a successful model of how government can partner with the private sector to advance economic development and energy efficiency goals in a local jurisdiction.

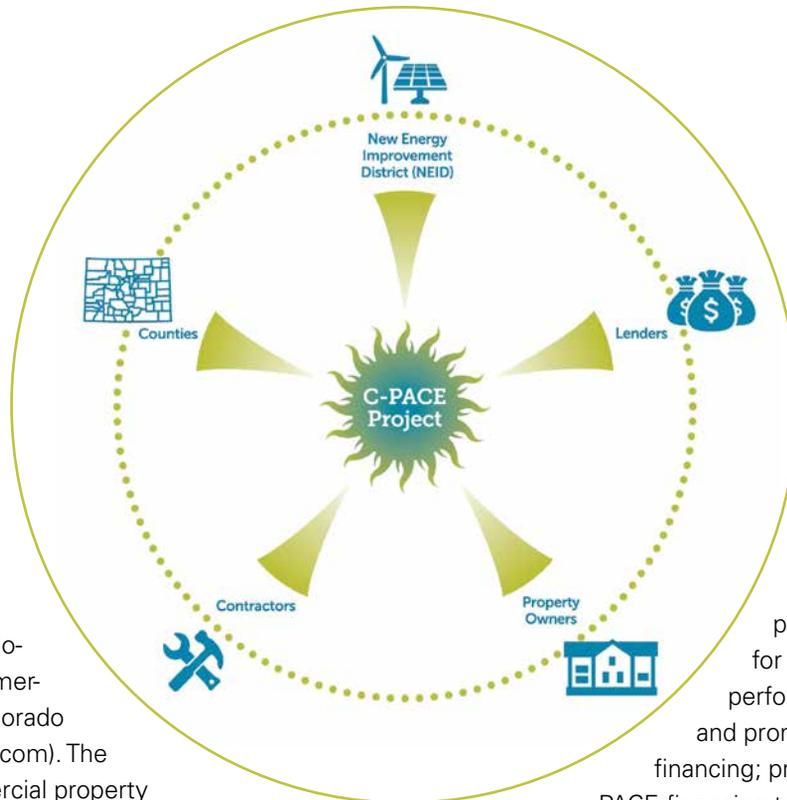
## What is Colorado C-PACE?

In December 2015, Colorado launched its commercial PACE program, Colorado C-PACE ([www.copace.com](http://www.copace.com)). The program offers commercial property owners a unique way to finance 100 percent of energy and water improvements to their properties. Owners repay the cost of eligible improvements through an assessment on their property tax bills. Since PACE allows for financing terms up to 20 years, owners are able to spread out the costs of energy upgrades, allowing for cash flow positive projects with no upfront capital outlays. Colorado C-PACE can pay for new heating and cooling systems, lighting improvements, solar panels, water pumps, insulation, and more for a variety of commercial properties.

## Colorado C-PACE as a Public-Private Partnership

PACE is an innovative public-private partnership that allows property owners the opportunity to obtain low-cost, long-term, private-sector financing for energy improvements. The success of PACE is in its ability to leverage multiple parties' attributes from the public and private sectors to coalesce around a single project to provide the construction, engineering, financing, and repayment of the energy improvement measures.

Each Colorado C-PACE partner plays a specific role: the New Energy Improvement District (the district) oversees PACE programs throughout the state; counties voluntarily



opt into the statewide district and serve as a collecting and recording entity; lenders provide private sector financing for the projects; contractors perform the building upgrades and promote the benefits of PACE financing; property owners pursue PACE financing to upgrade their buildings.

The steps of a PACE transaction highlight how the partnerships brings a project to fruition. First, a Board of County Commissioners adopts a resolution for the county to opt into the PACE program, allowing commercial business owners in that county the option to apply to the district to receive financing from private lenders for eligible energy and water improvements. The business owner then submits the project to the district. If the district deems the project eligible, the program administrator and the district work with the applicant to obtain mortgage holder consent, meaning the mortgage holder agrees to having the PACE lien in a superior position. Consent is required to move forward with a PACE assessment.

If consent is provided, a special assessment is recorded within the county land records and the contractor can begin work on the project. The district provides each participating county a certified assessment that includes the PACE assessment amount to be placed on the property tax bills for each participating property. The property owner will pay property taxes to the county treasurer in the same manner as they were paid before, except that there will be an additional line item for the PACE assessment. The county treasurer remits the PACE special assessments to the district, which, in turn, remits those payments back to the private lenders who provided the original PACE financing.



To date, several counties have opted into Colorado C-PACE, with Boulder and Adams counties among the first to do so.



**C-PACE Participation**  
■ Participating  
■ In-discussion Counties

### C-PACE Partners

Colorado counties are the most essential partners for the Colorado C-PACE program’s success. The county is the gatekeeper for the activation of PACE programs within its jurisdiction. It also serves as the entity that collects and remits the financing repayments. Once a county chooses to opt into the statewide district, commercial properties within that county are able to take advantage of PACE financing. Working with the counties to help them opt into the PACE program is an essential element of the partnership.

Since partnership with the counties is necessary to opt into the program, it has been vital to understand the needs and processes of county tax collection systems. The district has been working closely with individual counties across the state to ensure that the flow and mechanics of the Colorado C-PACE program closely align

with county tax collection and assessment recording processes. The expertise the counties have brought to shape the program flow has been critical.

To date, several counties have opted into Colorado C-PACE, with Boulder and Adams counties among the first to do so. In the coming months, several more counties are expected to participate in the program, opening the door for Colorado to become a leader in the national market for commercial PACE projects.

A second key partner in the equation is the lender. Qualified capital providers finance PACE projects through the open, competitive financing model of the Colorado C-PACE program—a unique characteristic of the Colorado program. This design allows lenders—including local banks, regional banks, national banks, specialty lenders,

and others—to participate in the program by investing in property improvement projects throughout the state. PACE financing provides an opportunity for capital providers to expand their lending services by offering them the assurance of a secure investment that leverages the public sector’s assessment and collection infrastructure.

Along with the county partnership, the program wouldn’t be successful without skilled contractors and developers to perform the energy and water upgrades and ensure that property owners realize the projected savings and efficiency. Colorado is fortunate to have a knowledgeable and forward-looking contractor community that understands the benefits of PACE financing. To support their efforts in highlighting the program benefits to business owners, the district and its program administrator have provided contractor trainings throughout the state and will continue to do so as PACE coverage expands to an increasing number of counties.

The final party to this public-private partnership is the property owners who pursue PACE financing to reduce

operating costs, improve their building stock, generate additional cash flow, and/or meet commitments to reduce energy usage and emissions. Immediately following the launch of Colorado C-PACE, local property owners began applying to the program, and have been working with the district and its program administrator to move projects toward completion.

Colorado’s commercial PACE program embodies the public-private partnership framework and the benefits that it can bring to local communities. By leveraging key resources and working collaboratively, Colorado C-PACE has been able to jumpstart a financing program that will benefit Coloradans across the state. □

### Jeffrey King

*As the Business Development Manager within the Finance and Operations department of the Colorado Energy Office, Jeffrey King works to identify and address energy finance barriers by researching, developing, deploying, and promoting financing solutions. He also works extensively with Colorado-based startups, serving as an energy finance resource.*



*Photo courtesy of Namaste Solar*

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# LAB-CORPS

Connecting Top Lab Researchers with Entrepreneurial Training and the Marketplace

By Shelly Curtiss



“I now have a much deeper understanding of the brilliant people and depth of technologies within DOE labs.”

*Lab-Corps mentor*

## Entrepreneurial bootcamp for national laboratory scientists.

### Really?

That was the prevailing response to the idea for Lab-Corps when the program was introduced. But that reaction has since changed.

The challenge to develop Lab-Corps, an entrepreneurial bootcamp based on the National Science Foundation’s successful I-Corps program, was put forth by the U.S. Department of Energy (DOE) in late 2014. The Golden-based National Renewable Energy Laboratory (NREL) and national laboratories across the U.S. responded immediately.

### The Challenge:

DOE’s National Laboratory researchers are some of the greatest technical minds in the world, working on some of the most exciting science and technology challenges of our time. But within the laboratory culture, researchers are often so focused on their specific scientific challenge, they may not be aware of how their work relates to the needs of industry and the marketplace.

### The Solution:

Through Lab-Corps, we created a two-month training curriculum that invites researchers to analyze and explore how their ideas can best meet market needs and

be successfully commercialized. The program provides a set of training methods that equip scientists with a better understanding of the commercialization process, industry needs and the importance of “getting out of the building” to talk with potential partners.

### Getting out of the building

Lab-Corps empowers researchers and scientists with the tools, resources, and relationships necessary to commercialize their innovations. And in Lab-Corps, just as it is in I-Corps, it’s all about the team. Participating national laboratories assemble and support teams comprised of a Principal Investigator, an Entrepreneurial Lead, and an Industry Mentor. The team is tasked with devoting at least 50 percent of their time in the quest to uncover potential licensing, development, or commercialization opportunities for their technology.

This quest is driven by a team of highly qualified instructors pushing the teams to “get out of the building” and meet with up to 75 potential “customers.” This customer-centric focus pushes teams to (among other things) develop a value proposition, understand the needs of potential partners, and understand their ecosystem, all with an eye towards determining potential commercial pathways for their work.



Throughout the program, researchers are encouraged to reach out to industry and focus on research informed by real-world challenges and opportunities. Colorado Cleantech Industries Association (CCIA) is a key partner in the program that is involved in program management, delivery, and industry engagement. By tapping Colorado's extensive energy ecosystem, CCIA has created "Industry Night" — an opportunity for Lab-Corps teams to engage in 20-minute speed meetings with industry experts from across the energy landscape. Participants in Industry Night have included Rocky Mountain Institute, Agrobotix, The 3D Printing Store, Hitachi, American Energy Assets, Rachio, Colorado School of Mines, and numerous individuals.

## Network of Partners Make Lab-Corps Possible

Lab-Corps owes its early success to the backbone of partners supporting its efforts across the country. Without a doubt, the expertise and dedication of the teaching team is one of the most critical aspects of the program. By bringing voices from across the country to instruct for the program, participants benefit from the successes, failures and real-world experiences brought to bear by the teaching team.

Partners such as Jean Redfield, CEO of Michigan-based NextEnergy, have been key in the development of the curriculum and tone of the program. Colorado-based energy pros such as Sandy Butterfield, Robert Clarke, Doug Henston, Tom Teynor, Ed Williams, and Trevor Zimmerman have mentored teams and led program instruction, reinforcing the strength of Colorado's energy community in lending a hand to build out the Lab-Corps program. Mentors are key to the success of each team as they provide a backbone of business experience and help in closing the knowledge gap between researchers and the marketplace.

**"If I were a venture capitalist, I would require all of my companies to go through a program like this."**

*~ Industry mentor*

Also central to program development was the groundwork laid by the National Science Foundation's (NSF) I-Corps program. Silicon Valley-based entrepreneur Steve Blank developed the LeanLaunchpad methodology in the 1990s to encapsulate strategies and techniques leveraged by countless entrepreneurs to achieve commercial

“Lab-Corps increased our confidence in the technical direction we want to go, and made me a better scientist with a better view of the problems.”

*Lab-Corps graduate*

“It made us aware of other applications [of our technology] we had never thought of.”

*Lab-Corps graduate*

“I always thought business was the easy part.”

*Lab-Corps graduate*

success. Working with Blank, the NSF adopted this curriculum for the I-Corps program and, in turn, NSF partnered with DOE in expansion of the program into the Lab-Corps curriculum delivered today. Over the course of two intensive months, each team participates in a variety of interactive workshops and market discovery activities designed to advance their entrepreneurial knowledge and map out potential paths toward commercialization.

### Prototypes, funding, and transformation

To date, nearly 40 teams have completed Lab-Corps and recent participants are already making progress toward commercialization. Multiple graduates are exploring startup possibilities, and some laboratories are even re-examining mothballed entrepreneurial-leave programs to encourage further researcher-to-industry engagement efforts. Teams have received R&D 100 Award nominations, been featured in Popular Science, and one team placed as a finalist in the Chicago Clean Energy Trust Competition.

Prototypes have been completed and nearly \$7 million in follow-on funding has been raised from a wide variety of sources to allow teams to continue their research and commercialization efforts. Cooperative research and de-

velopment agreements with major international companies are also underway for a number of teams. Whether researchers spin out new businesses or return to the lab with a new appreciation for market needs, Lab-Corps is beginning to transform the national lab culture into one that is increasingly more commercially aware and impactful. □

“I’ve spent 29 years in the lab and I thought I was close to industry. I learned more in the last six weeks than in those 29 years.”

*~ Lab-Corps graduate*



**Shelly Curtiss**

*Deputy Director*

*Colorado Cleantech Industries Association*

## Solar Grid Studies in Hawaii:

# A Glimpse of the Future for U.S. Utilities

By Ben Kroposki

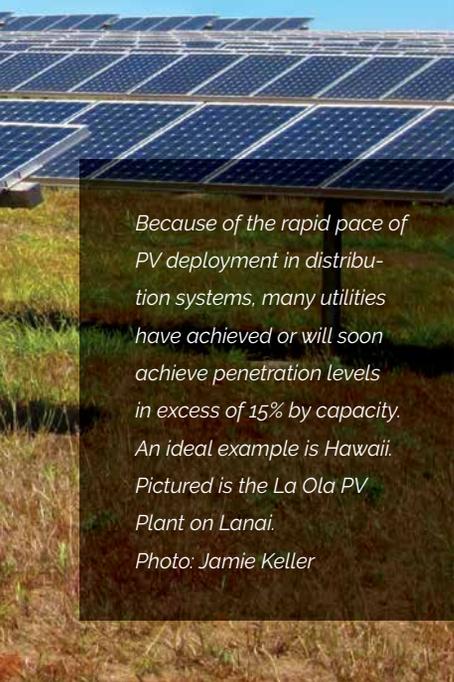


**This is a tumultuous time for electric utilities, as many are struggling with concerns about increasing numbers of solar power systems installed at homes and businesses, usually connected to “feeder lines” of the power distribution systems that snake through people’s neighborhoods.**

For utilities concerned about the growing popularity of solar photovoltaic (PV) power, there’s a place that provides a glimpse of the future: Hawaii. Customers of the three Hawaiian Electric Companies (HECO)—Hawaiian Electric, Maui Electric, and Hawaii Electric Light—have about 20 times more solar power systems connected to the grid than their counterparts on the U.S. mainland, on average. About 12% of HECO customers have rooftop solar systems, compared to a U.S. national average of just 0.5%, according to the Solar Electric Power Association.

In Colorado, about 1.5% of customers have rooftop solar systems, placing the state further along than most, but still far behind Hawaii, so Colorado is one of the many states looking to Hawaii as a model of the future. But Colorado is also home to the U.S. De-

By Ben Kroposki



*Because of the rapid pace of PV deployment in distribution systems, many utilities have achieved or will soon achieve penetration levels in excess of 15% by capacity. An ideal example is Hawaii. Pictured is the La Ola PV Plant on Lanai.*  
Photo: Jamie Keller

partment of Energy's National Renewable Energy Laboratory (NREL), where top-notch engineers and scientists are working diligently to modernize today's power grid, which was not designed to accommodate distributed power sources like rooftop solar systems.

One of NREL's newest facilities is the Energy Systems Integration Facility (ESIF), a building

specifically designed to address such questions as how to integrate high amounts of renewable energy onto the grid. NREL was asked by one of its partners—SolarCity Corporation—to examine what higher penetrations of PV means in Hawaii. The work included a collaboration with HECO.

It's clear that homeowners on the Islands want to tap into their region's abundant solar resource to generate electricity, in part because of the sky-high energy costs in Hawaii. However, some feeder lines had reached a limit for solar power under an industry-standard rule of thumb followed by HECO: the maximum solar generation capacity on any line couldn't exceed 120% of the minimum daytime load on that line to avoid any voltage control issues. This left 2,700 customers out in the cold, wanting to install solar power but not able to.

SolarCity Corporation partnered with NREL to address the operational issues associated with large amounts of distributed solar energy on electric grids.

"Some utilities have concerns about distributed PV causing power to flow 'backwards' at times of low load and high solar irradiance," said NREL Engineer Andy Hoke. "In Hawaii, that happens every day on many feeders, and that in itself is not necessarily a problem. But as the amount of power backfeeding the substation becomes large, some real concerns can arise."

If a distribution feeder that is backfeeding power into the grid disconnects from the rest of the grid (for example when a tree branch touches a power line and causes a grid circuit breaker to trip), all the solar power is redirected into the local loads, causing a brief transient overvoltage. If the overvoltage, referred to as a load-rejection overvoltage, is high enough and persists long enough, it can damage loads or distribution equipment. To better assess the validity of this concern, SolarCity Corporation partnered with the NREL to address the operational issues associated with large amounts of distributed solar energy on electric grids.

## Smart Inverters to the Rescue

The research team chose to see how "smart" inverters could help address the voltage control issue. Inverters are electronic devices that convert the direct-current (DC) power supplied by solar panels into the alternating current (AC) used by the power grid. However, most inverters sold to homes and businesses today could be considered to be "dumb" inverters: they supply AC at the right voltage and frequency in synchronization with the distribution grid, but they are otherwise passive. They measure voltage and frequency and disconnect from the grid during disturbances, such as faults and



*LEFT: This home in Kaupuni Village, on the island of Oahu incorporates, energy efficiency and renewable energy technologies to achieve net-zero energy consumption. Photo: Kenneth Kelly / NREL*

*RIGHT: Ranching the Sun project in Hawaii generates 175 kW of photovoltaic power and 50 kW of wind power. Photo: SunPower*



power outages. But at high levels of penetration, they can all disconnect simultaneously from the grid and exacerbate grid disturbances.

In contrast, smart inverters include advanced functionalities that allow them to provide support to the grid during off-normal conditions, rather than simply withdrawing from the fray. Smart inverters often include communication technologies that allow some utility control of their operation, but such controls aren't necessary to achieve benefits for the utilities. Rather, the inverter must be set up to automatically respond correctly to grid disturbances, which can happen in a fraction of a second. For instance, smart inverters often include a form of "low-voltage ride-through," in which the inverter maintains its connection to the grid when it first detects a low-voltage condition, thereby helping to maintain voltage on the grid.

The question for the research team was whether smart inverters could avoid a transient overvoltage or not. Together, the partners in this research project employed the ESIF to explore the ramifications of higher penetration of solar power on the grid.

For utilities that want to do testing of operational grid issues without affecting their grid, the ESIF's laboratories are the perfect venue. Megawatt-scale power hardware-in-the-loop testing allows engineers to analyze the behavior of electricity generation and distribution devices while connected to a testing system that emulates the characteristics of a power system. It literally allows an inverter, operating at full power, to interact with a software simulation of a power grid.

## Simulating Reality with Computers and Power Equipment

Engineers at the ESIF followed a test plan developed by the Forum on Inverter Grid Interconnection Issues, a group that includes representatives from inverter manufacturers, solar power providers, utilities, research labs, and consulting firms. This collaboration among stakeholders helped ensure that all parties would accept the validity of the test results.

The experiments carried out in the ESIF found that the load-rejection overvoltages were significantly less

*This home in Kaupuni Village, on the island of Oahu incorporates, energy efficiency and renewable energy technologies to achieve net-zero energy consumption.*

*Photo: Adam Warren / NREL*



severe than had been feared. The maximum overvoltage measured in any test never exceeded twice the nominal level, and typical overvoltage levels were significantly lower. Furthermore, the durations of overvoltage were only on the order of microseconds to milliseconds, which represent an acceptably short time duration. The results allayed HECO's worst fears and may also calm the numerous other utilities concerned about transient overvoltages.

"The results from NREL testing were instrumental in HECO's decision to raise its limit of PV capacity on each line from the old rule-of-thumb limit of 120% of minimum daytime load to 250%, therefore more than doubling the amount of solar power allowed on each distribution line," said NREL Principal Engineer Sudipta Chakraborty, the principal investigator for the SolarCity project.

ESIF experiments also examined the impact of inverter ground faults, in which a single phase of the inverter output shorts to ground. For synchronous generators, such faults can cause sustained, high overvoltages. However, the ESIF tests demonstrated that current-controlled inverters do not cause ground-fault overvoltages in the same way that synchronous machines can. The results are

expected to be broadly applicable to all current-controlled inverters, regardless of size.

As a result of the experiments, HECO committed to clear its backlog of applications, and since then, more than 15,000 applications have been approved to install or interconnect. If all of these systems are interconnected, HECO will have more than 77,000 rooftop solar customers.

But that actually raises a separate concern: inverters are designed to disconnect from the grid when the grid goes down, avoiding the creation of a self-energized "island" of power that could cause safety issues for utility crews working to recover from the outage. This "anti-islanding" feature depends on each inverter autonomously detecting the loss of power, but this situation gets complicated if a large amount of distributed generation is keeping the feeder line energized.

To address that issue, NREL and SolarCity devised a series of tests to examine the impacts of both grid support functions (like low-voltage ride-throughs) and multi-inverter islands on anti-islanding effectiveness. Tests with individual inverters found that voltage and frequency ride-



throughs prolong the existence of a power island, but not long enough to exceed the international standards of 2 seconds duration. The anti-islanding tests also examined scenarios with multiple inverters connected to many different points on the grid and found that the maximum power island duration was only 0.632 seconds. While this so-called “solar subdivision” scenario has been examined to some extent through simulation, this was the first known work to test it using hardware inverters.

## Allowing Greater Distributed Solar Capacity

Hawaii is no longer alone when it comes to adding higher penetration of interconnected solar generation. Other utilities are experiencing increasing customer requests for the interconnection of distributed solar or wind. Those utilities are also looking to NREL for research studies to guide their decision making.

NREL’s future work will look at how greater solar penetration could actually benefit the grid by enhancing reliability. For example, smart inverters could help utility operators provide optimized voltage support along

specific segments of distribution circuits, for instance, at a data center location with high power-quality requirements. Other work will focus on the impact of remotely cutting back the generation of solar power during certain periods, and on using energy storage to handle excess generation of solar electricity.

“The results of our studies provide valuable quantitative insight for utilities facing increased PV penetration on their grids,” concluded Chakraborty. “They can have greater assurance that more solar can be added without detrimental impacts, while maintaining safe, reliable electricity to customers.” □

### Ben Kroposki

*Dr. Ben Kroposki is the Director of the Power Systems Engineering Center at NREL, where he leads NREL’s strategic research in the design, planning, and operations of electrical power systems.*



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# Smart City Challenges & Opportunities

By Eric Woods

## Around the world. . .

cities are a focal point for some of the most profound economic, environmental, social, and technological issues facing the world today. Cities are playing a leading role in the mitigation of climate change and are increasingly focused on improving global adaptability to its consequences. The smart city is a simple label for the complex forces shaping urban life in the 21st century. It is a framing device for many of society's most important conversations about globalization, technology, and the environment.

Navigant Research defines a smart city as the integration of technology into a strategic approach to sustainability, citizen well-being, and economic development. These policy objectives are being met through innovation across all aspects of city infrastructure and operations, including the energy and water sectors, urban mobility, smart buildings, and improvements to government services.

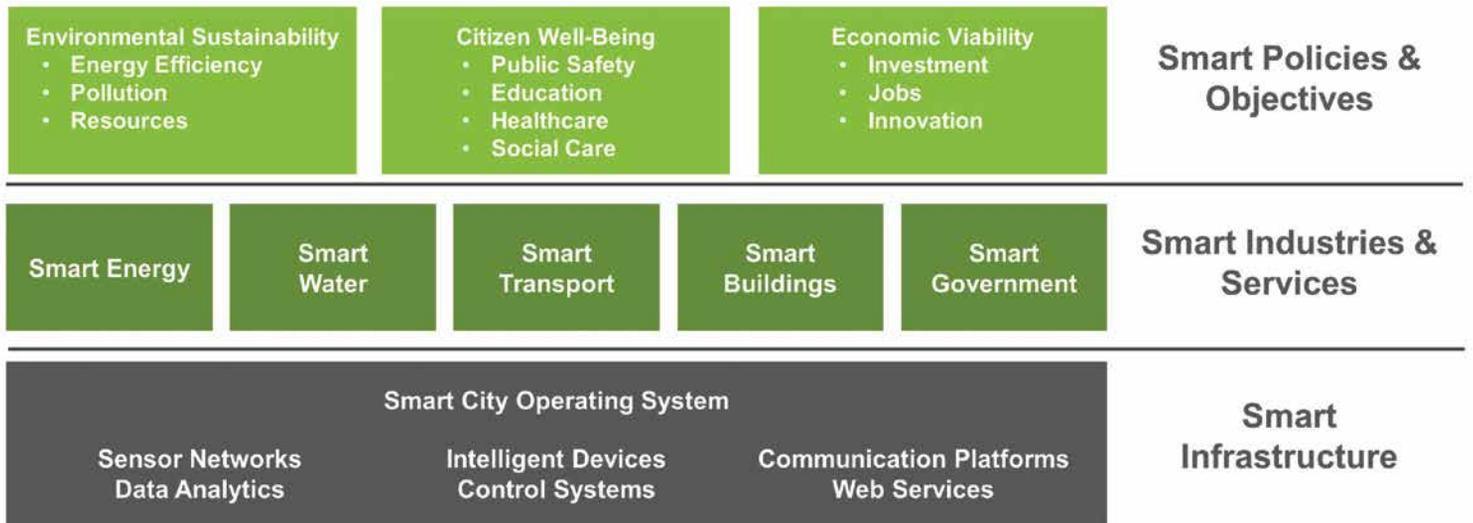
### A Market Opportunity

Smart city developments present considerable opportunities for the cleantech sector. Navigant Research expects the global smart city technology market to grow from

\$36.8 billion in annual revenue in 2016 to \$88.7 billion by 2025 at a compound annual growth rate (CAGR) of 10.3%. Cumulative 2016-2025 revenue is expected to reach \$606.4 billion. The North American smart city market alone is forecast to grow from annual revenue of \$10.9 billion in 2016 to \$23.1 billion by 2025 at a CAGR of 8.8%.

The North American smart city market has received a significant boost as federal, state, and municipal governments have all increased their focus on the importance of city development as part of broader economic, technical, and sustainability policies. In areas such as renewable energy, smart grids, water infrastructure, building efficiency, and new transportation systems, US cities are taking a leadership role in driving innovation and investment. National programs such as the federal government's Smart Cities Initiative and the US Department of Transportation's (DOT's) Smart City Challenge are helping cities develop strategies and implement ambitious projects.

In Colorado, the cities of Denver, Boulder, and Fort Collins have instigated a number of projects that fit into the



scope of smart city innovation. Denver was also one of the seven finalist cities in the DOT's Smart City Challenge, losing out to Columbus, Ohio for the \$50 million prize to support transportation innovation projects. However, the announcement of a major partnership between the City of Denver and Japanese manufacturing giant Panasonic in January 2016 has put Colorado on the map of global smart city projects. The proposed creation of a greenfield community southwest of the Denver International Airport called Peña Station NEXT has the potential to make the city a showcase for urban innovation.

## Accelerating Smart City Innovation

The most successful cities are combining an understanding of the potential of new technologies and a detailed understanding of how they fit local priorities and needs. In particular, five key themes are common across the leading cities:

### 1. Leadership and Vision.

Strong leadership from the city council and executives is vital to developing a coherent and sustainable smart city strategy. The leading cities have not only produced a guiding vision for a smart or future city, they are also embedding these ideas into their programs for service improvement and capital investment. There is strong leadership from the top

and clear accountability for delivering the plan.

### 2. A Focus on Local Priorities and Strengths.

Each city has its own priorities in terms of social, environmental, and infrastructure challenges, but each also has distinct strengths in terms of skills and resources. Successful smart city programs build on those assets to develop a distinct smart city vision that is aligned with local needs and goals.

### 3. Engagement with Communities.

Cities need to work with local communities in all aspects of their smart city programs, from initial strategy to project design, deployment, and data collection. A smart city strategy that does not engage with local communities has little chance of long-term success.

### 4. Building Partnerships.

Smart city solutions can only be delivered through a network of partnerships. The leading cities are notable for their ability to bring together public sector agencies, the private sector, and academia.

## 5. Understand the Data Revolution.

Smart cities are looking at how they can better use data to improve services and boost innovation. The rapid growth in the number of sensors and other intelligent devices deployed across the city landscape is creating an immense amount of new data that cities need to manage and learn to exploit to the benefit of all.

As cities address these issues, the momentum behind the smart city market continues to grow. There are undoubtedly significant limitations on the ability of a simple two-word label to cover the complexities of global urban development, but that simplicity allows the smart city to act as a signpost to some of the most exciting and pressing developments in society and technology. □

### About the Author



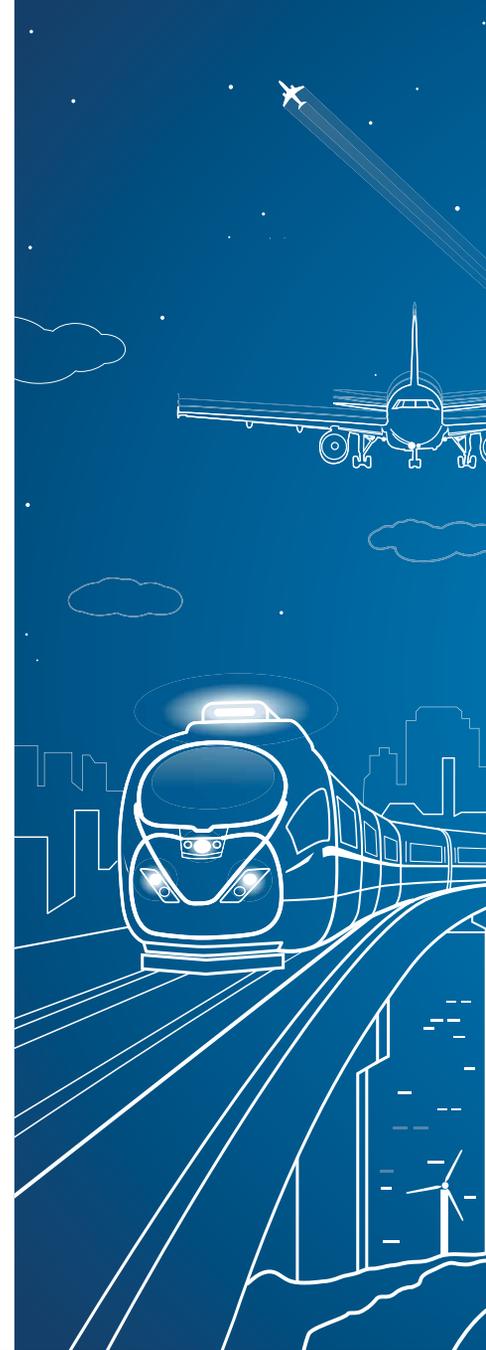
#### Eric Woods

*is a research director leading Navigant Research's coverage of smart cities. He has written numerous reports on smart city markets and technologies and has more than 20 years of experience as an analyst and consultant on new technology trends.*



#### About Navigant Research

*Navigant Research, the dedicated research arm of Navigant, provides market research and benchmarking services for rapidly changing industries. Additional information about Navigant Research can be found at [navigantresearch.com](http://navigantresearch.com).*



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## COMMUNITY CATALYST:

# The Energy Fellows Institute

### Innovation starts with an idea.

Maybe it's your idea, maybe you met someone inspiring at a networking event, or a technology created by a laboratory researcher caught your attention. Perhaps you're already working in the energy arena or you're an experienced executive from another industry looking for a new challenge.



By *Mary Austin*  
EFI Program  
Director at CClA

Your next step likely involves some continuing education, a deep dive into clean technology.

### Enter the Energy Fellows Institute.

Founded in 2012 through the partnership of Colorado Cleantech Industries Association (CCIA), National Renewable Energy Laboratory (NREL), and Advanced Energy Economy, the Energy Fellows Institute (EFI) combines cleantech education with the real-world experiences of entrepreneurs who are in the energy trenches.

The program incorporates roundtables led by industry experts, site tours, lab visits, and case studies. Fellows are immersed in industry categories including energy generation and delivery, storage, transportation, building efficiency, water, and natural gas. Within these sectors, the Fellows learn about markets, business models, and policy issues while gaining access to a network of experts and resources critical for success in this growing industry.

Each spring, the Institute welcome applications from across the country and up to 10 participants are selected to join the program. To date, 33 Fellows have completed the program and over 150 speakers have volunteered their time in support of the Institute.



"It's really about bringing the full Front Range together," says CClA executive director Chris Shapard. Keeping the program purposefully small is critical, she adds, as it promotes conversation, not one-way lectures.

At its core, the Energy Fellows Institute owes a lot of its success to its broad partnership base. All speakers and industry advisors are volunteers. Partners provide training, community leaders open their doors to the program and its participants - all in support of developing a stronger energy community.

"It was built by the community," says CClA deputy director Shelly Curtiss. The industry and community-based model "is really important and that's what we're most proud of."

Through this network, the Institute advances its Fellows into the region's growing energy ecosystem. The Fellows who have come through this program represent all walks of expertise. But they all have in common an entrepreneurial spirit, a passion for innovation and the courage to make a difference in the energy industry.

I'm impressed with their dedication to this industry and confident that the state's energy ecosystem is stronger for their participation. □

Learn more about the Energy Fellows Institute at [www.energyfellows.com](http://www.energyfellows.com).

"The Energy Fellows program through CCIA was extremely valuable and provided me with an immersion into the current developments of the global cleantech world while giving me an opportunity to meet with companies and leaders making impacts locally. I see benefits professionally and personally by being part of the Energy Fellows program."

CRAIG SWIATEK

Portfolio Development Manager  
Johns Manville



"Through the Fellows program, I was introduced to a group of scientists at the National Center for Atmospheric Research. I licensed NCAR's connected-car technology and developed a company plan concurrent with the Fellows program. Now, three years later, WeatherCloud continues with its mission to make roads safer and make the transportation grid more efficient."

DUER REEVES

Senior Vice President  
WeatherCloud



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# The Grids of the Future are Happening

Led by Unique Partnerships & Projects

*By Chris Meehan*

Like the highways that crisscross the nation, electrical grids are in flux in the U.S.

The backbones of both the power and transportation grids were built in a somewhat hodgepodge fashion in the 20th century to meet immediate needs. Small electric grids with localized generation gave way to giant transmission lines and central electric generation, and small winding roads gave way to the sprawling interstate system that spans the United States.

In the 21st century, both are showing signs of age, wheezing fumes as they're stretched beyond their original capacity, and both now require significant upgrades to accommodate transportation of electrons and vehicles.

Thankfully those issues are being addressed today in Colorado and beyond. Where manual and mechanical solutions once dominated, software and new hardware are creating more reliable and efficient solutions. Some, like microgrid technologies being studied by Xcel Energy's Public Service Company of Colorado — the state's largest electric utility — are actually making the grid more local.



Meanwhile, Denver is looking at giant infrastructure changes, one of which could bury part of I-70 a la Boston's Big Dig. Most changes would be more granular, such as programs to fight pollution by reducing idling times and increasing the number of electric vehicles in the region, and other projects that will require a network of partnerships as large as the systems they're impacting.

## An Evolving Grid

The Colorado Cleantech Industries Association (CCIA) is a valuable partner with players like the City and County of Denver, Xcel, and national labs, as well as startups that are thinking ahead to make sure the grids of tomorrow are more stable, secure, and flexible than ever before.

Sometimes, things don't work out as hoped. In 2015, for instance, Denver participated in the U.S. Department of Transportation's Smart Cities Challenge — and lost to Columbus, Ohio. The Challenge would have opened up a total of \$40 million in federal funding to update the city's transportation infrastructure, but participating in the challenge opened up big opportunities, contends Tyler Svitak, the City and County of Denver's energy and transportation administrator.

“...the grid of the future is going to be more distributed and they will need the technologies to continue making electricity consistent, secure and safe.”

“The Challenge was an opportunity to dream big — to think above and beyond normal budget constraints, knowledge barriers, and technological hurdles to identify a concrete path forward with a focus on innovative technologies, vehicle electrification and the need to better connect lower-income neighborhoods,” he explains.

“We proposed deploying over 500 electric vehicles in a variety of applications, including taxis, transportation network companies like Uber and Lyft, RTD transit buses, city fleet vehicles, and other high-mileage, visible fleets that would electrify the greatest number of miles and educate the public,” Svitak says of the proposal.

Denver is still eligible for a second phase of the Smart Cities Challenge, so hope for some federal funding is not yet lost. Having those industry and community partnerships could be key to winning the second pot of \$40 million.

Svitak identifies another upside to the first loss: “Now that we have a plan in hand, along with the industry and community partnerships, we are working hard to identify 2017 budget priorities and outside funding opportunities that will allow us to turn the plan into action.”

### Innovative Clean Technology Program

To develop Colorado’s energy grid of the future, Xcel has worked with the Colorado Public Utilities Commission to create the Innovative Clean Technology (ICT) program to test emerging clean energy technologies.

“Xcel is very interested in seeing what new technologies are out there,” according to CCIA executive director Chris

Shapard. “They know the grid of the future is going to be more distributed and they will need the technologies to continue making electricity consistent, secure and safe. You need tech for that...and CCIA is a trusted partner to consistently introduce the utility to new solutions.” “Companies in the micro-grid and battery space are hot right now,” Shapard notes, “and Colorado has an abundance of them including smaller tech companies Solid Power Battery, HOMER Energy, SilLion, and Pneumaticoat and utility-scale companies RES Americas, Enbala Power Networks and Tendril.”

Indeed, when Xcel created ICT in 2009, it became the first utility in the nation to pilot a parabolic concentrating solar power system with a coal-fired power plant to reduce consumption of coal at the site.

It’s since announced two pilots involving energy storage: a commercial-sized system with a 1.3-megawatt solar panel canopy at Denver International Airport (DIA) and a two-megawatt lithium battery system. Xcel will contribute \$6.7 million to the first project, DIA will contribute \$2.5 million, and Panasonic will add \$1.1 million; the system will act as a microgrid and provide backup power to the site and local grid during emergencies. The other project will install batteries at select homes in Denver’s Stapleton neighborhood.

“Our goal is to use these demonstration projects as a foundation for how to efficiently manage renewable energy on our Colorado system, and to continue to provide our customers with insight into the energy choices they want and value,” says David Eves, president of Xcel Energy in Colorado.

The new projects build on Xcel’s other pilots like the Smart-GridCity project in Boulder that tested smart meters. “It was

## “Our goal is to use these demonstration projects as a foundation for how to efficiently manage renewable energy on our Colorado system”

designed to help us learn how these types of technologies could be implemented efficiently and to a larger customer base in the future,” says Michelle Aguayo, Xcel spokesperson.

Data from the SmartGridCity project, for instance, was useful in determining reliability improvements, fuel savings, and integrating local power generation sources. Xcel and partners like Panasonic will now use the same approach using that information to inform future projects for the utility.

As more electric vehicles enter the region, transportation and electrical infrastructure are coming into a convergence where the electric grid will have to be even more dynamic to accept distributed generation like

rooftop solar and discharge large volumes of energy to charge vehicles quickly.

Denver’s Svitak says the city aims “to provide smart, convenient charging infrastructure throughout the city to alleviate range concerns,” noting the proposal anticipated that as many as 30,000 electric vehicles could be on the grid and providing transportation in Denver by 2020.

The projects Xcel is working on will help prepare for that, but CCIA is partnering with companies and startups looking beyond 2020. Through existing programs like Lab-Corps, Energy Fellows, Cleantech Open and the upcoming Power Sector Challenge, CCIA is working to support early stage projects and startups, sustain existing grid programs and scout for new technologies. □

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# Making Supply Chains More Resilient

By Martin Kunz



TODAY'S GLOBAL SUPPLY CHAINS assist clean technology companies sourcing components and raw materials worldwide, and involve more partnership – collaboration, sharing data – than ever before.

These supply chains are critical to a company's market success, but they are only as strong as their weakest link. For instance, economic conditions in a country can affect the financial stability of a key supplier. An earthquake, severe flooding or a fire can shut down an important facility for an indefinite basis. Labor issues and civil commotion can result in unexpected shipment delays. And these problems are just scratching the surface of potential pitfalls.

When suppliers fail to provide needed components and materials on schedule, the resulting bottlenecks can impede the orderly flow of goods to markets, causing customer frustration. Potential reputational damage may result or a delay could lead to a breach of a company's contract leading to a costly lawsuit. Competitors can take advantage of these stumbles to increase their market share. These substantial financial exposures require a greater understanding of the underlying problems to manage these risks more effectively.

In 2015, Chubb conducted a survey of 300 clean tech executives to learn more about their supply chains. While more than half (56%) of the respondents have multiple sources of supply or suppliers, only 15% conduct periodic financial reviews of their suppliers and just 11% ensure their suppliers have business interruption plans in place. More needs to be done to ensure greater resilience.

## Bombarded By Risk

Many clean tech companies' supply chains also are under duress from cyber attacks, political unrest, transportation snafus, and a supplier's financial instability. A sole source supplier—a provider of a particular component that no other company produces—multiplies the impact of these risks.

Equally challenging is the breadth and depth of many companies' supply chains. Each supplier often has its own suppliers, which have their suppliers, and so on. The metaphor of a chain falls short in describing these supply tiers. A better description would be a supply chain network, given the complex entanglements in play.

When a provider in this network is unable to deliver a raw material or component on schedule, the dominoes may fall. A case in point is the massive flooding that occurred in Thailand in 2011. Thailand is a major source of hard disc drives used by global electronics manufacturers and automobile makers. The disaster severely curtailed the flow of hard drives, causing hundreds of millions of dollars in business interruption losses for the industries.

The devastating earthquake, tsunami and nuclear disaster in Japan the same year caused additional disruptions for the global electronics industry. Ninety percent of the world's supply of bismaleimide-triazine, a resin used in semiconductor packages, was suddenly unavailable.

Clean tech companies and their respective tiers of suppliers are also reliant on resins and other raw materials to accommodate their production needs. Losing one supplier in a region due to a weather-related issue may be considered a medium-scale disaster, but losing multiple suppliers in a region can be catastrophic.

## Taking Action

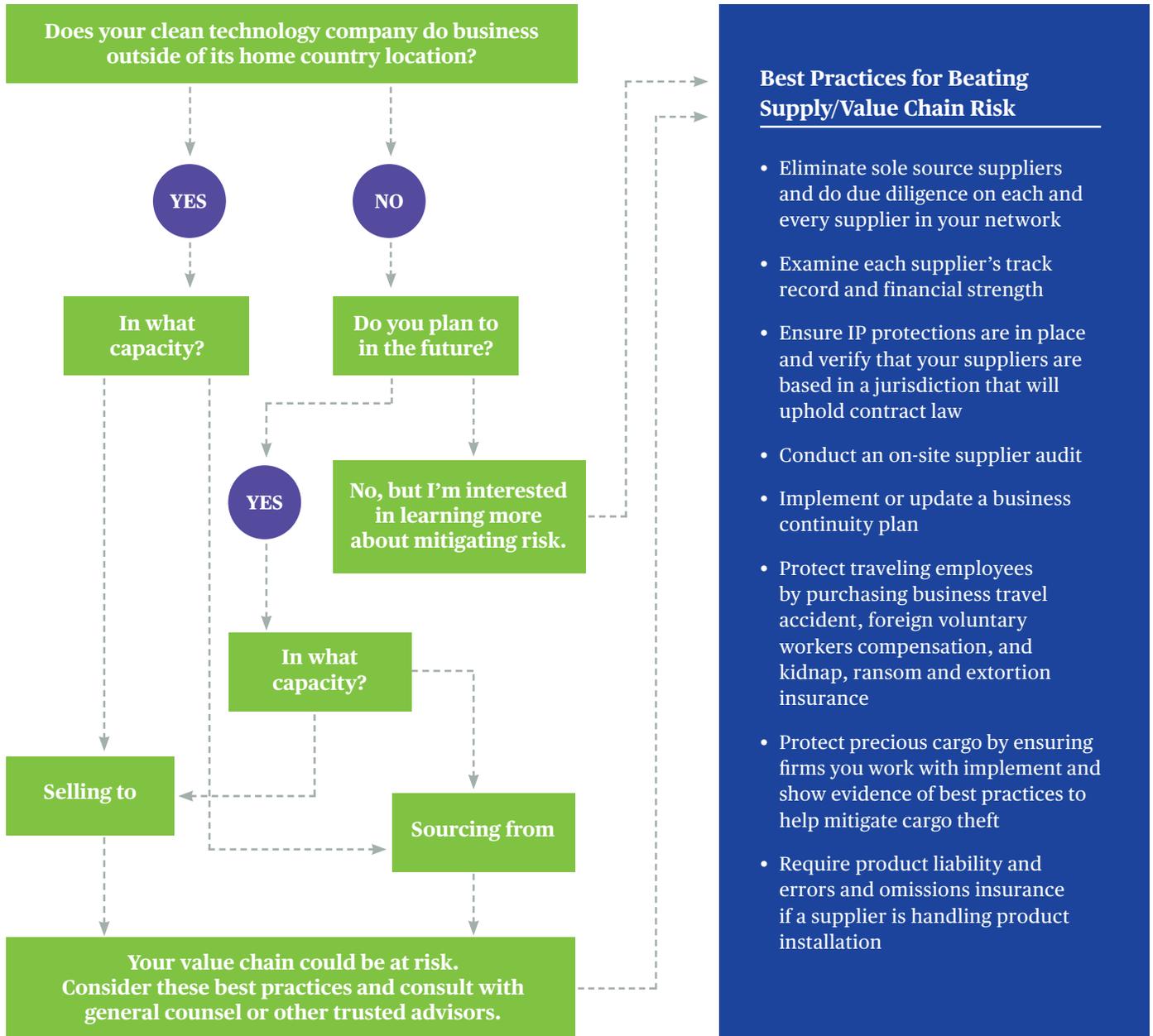
What can a company do to limit the potential for such grim consequences? The first step is to recognize that key suppliers are partners and then elevate supply chain resiliency as a strategic imperative—putting in place a management structure to identify, assess, quantify, mitigate and insure the various risks across the enterprise.

# Clean Technology

## Mitigating Risk to the Supply and Value Chain

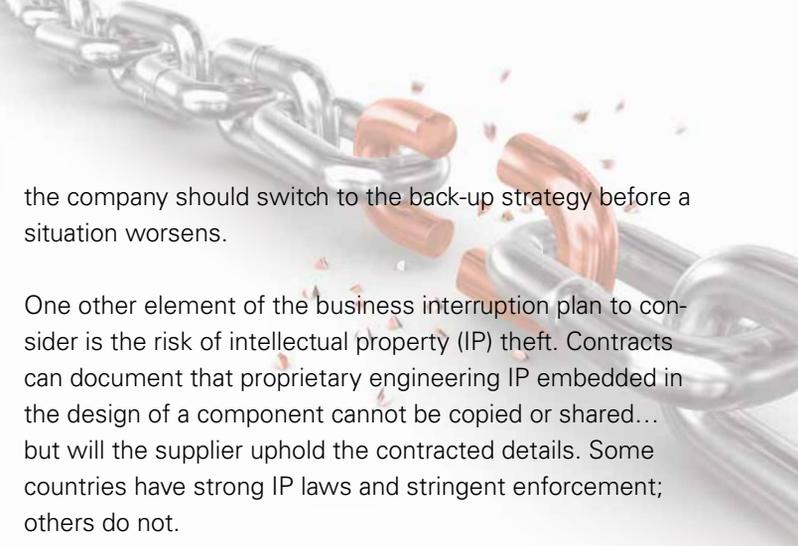
### Chart Your Course for a Safe Journey

Evaluating your supply and value chain risk is critical to improving your company’s long-term outlook for a healthy bottom line.



#### Best Practices for Beating Supply/Value Chain Risk

- Eliminate sole source suppliers and do due diligence on each and every supplier in your network
- Examine each supplier’s track record and financial strength
- Ensure IP protections are in place and verify that your suppliers are based in a jurisdiction that will uphold contract law
- Conduct an on-site supplier audit
- Implement or update a business continuity plan
- Protect traveling employees by purchasing business travel accident, foreign voluntary workers compensation, and kidnap, ransom and extortion insurance
- Protect precious cargo by ensuring firms you work with implement and show evidence of best practices to help mitigate cargo theft
- Require product liability and errors and omissions insurance if a supplier is handling product installation



In building this structure, assemble key people from within the business to form a supply chain risk management group that meets on a regular basis to discuss challenges, opportunities and goals. Members should be composed of individuals across the enterprise including production, product development, sourcing, corporate risk management, IT, and finance. Companies may also include outside parties on the team, such as a consulting firm or insurance agent specializing in supply chain risk management..

Once the group is formed, a first task is to list all the company's suppliers including the components or materials they provide and their suppliers, as well as the storage facilities and transportation routes. Plot all this data on a digital map, hyperlinking a list of the location-specific vulnerabilities of each supplier. For instance, a third tier supplier to a key supplier may be in a region prone to political unrest and labor strife while another supplier elsewhere in the network may be susceptible to earthquakes.

For each of these points, develop a backup plan if something goes awry. For instance, consider other components that could be used if the primary one is unavailable. Have an alternate plan for routing goods if a particular mode of transportation—rail, air, ship, or truck—is curtailed.

On the supply chain map, designate specific regions of the world that are critical to the company's efficient flow of goods and keep track of news in each region.. Real-time information is critical to decision-making and determining if

the company should switch to the back-up strategy before a situation worsens.

One other element of the business interruption plan to consider is the risk of intellectual property (IP) theft. Contracts can document that proprietary engineering IP embedded in the design of a component cannot be copied or shared... but will the supplier uphold the contracted details. Some countries have strong IP laws and stringent enforcement; others do not.

To mitigate the risk, find out if the supplier is based in a jurisdiction with weak IP laws. If this is the case, then consider completing the assembly of select components in-house.

The final element in a strong risk management program is insurance coverage to help transfer the risk of a business disruption. Unfortunately, Chubb's survey indicates that only 11% of clean tech companies purchase this vital product. Despite best efforts, even the most resilient supply chain will unravel on occasion. Insurance is a good solution to ensure capital as needed to preserve the orderly flow of commerce. □

### **Martin Kunz**

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THE VOICE OF EXPERIENCE

# The Value of Partnerships

By Stacy Bare

A photograph of two hikers on a rocky mountain peak. One hiker is standing on a higher rock, reaching down to help another hiker who is climbing up. The background shows a clear blue sky and distant mountains.

Partnerships in life have a big impact. You can't do it alone, and you can never really plan for just how amazing — or how horrible — it can all turn out. But if you focus on the good and give a hand as often as you can, those hands you grasped will come back to lift you up many times over.

Sometimes it's a long term formalized partnership, and sometimes it's an informal connection that lasts for a few weeks but moves you up and over an obstacle or turns a barrier into a key piece of your infrastructure. Sometimes the partnerships last too long or end poorly — but even those have a benefit and provide important lessons.

When I look back on the last 10 years of my life, there are a few easily discernible dividing lines that demarcated success and failure. Overwhelmingly, the successes in my life involved partnerships. The failures are defined by the times I was jealous or fearful of the success of potential partners, who I instead saw as competitors. On other occasions, I simply had mismatched expectations of a partner.

My most successful partnerships were often the most unexpected. For example:

- ▶ My partner on a design project in graduate school who shared a posting for a job in Boulder, Colorado, that he thought I should apply for because the job had something to do with veterans, and we were both veterans. (Veterans of the Taiwanese Army and the U.S. Army, working side by side!)



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▶ The man who hired me in Boulder and gave me my first start after the Army and graduate school. He would become my most trusted mentor. He knew from the get-go that it might not be the best fit, but wanted me to stick around to discover who I might become if I had some time in the mountains.

▶ The old friend from Iraq who took me climbing on the First Flatiron when I instead wanted to take my own life.

▶ The guy who put together a panel on environmental activism and invited me to speak — and would go on to introduce me to a filmmaker who believed in my story and helped me find my voice and launch a company.

▶ The graphic designer who designed the logo for that company, who one year later would coach me through the challenges of getting clean and sober.

▶ The competitor in social entrepreneurship who shared that first film with a writer who nominated me for National Geographic's Adventurer of the Year.

▶ Representatives from the brand who liked what they saw from Nat-Geo and brought me on their team.

▶ The international superstar climber who I met through the job I landed as a result of the success of my first company. And the support the brand gave — a platform to begin chasing down the dream of healing and homecoming I had as soon as I came home from war.

▶ My life partner, who I met looking for a room to rent for that first job in Boulder and keeps believing in me even when I can't.

I am who I am not just because of all the people who believed in me and allowed me to believe in them. I am who I am because we all found a way to work and strive together. As partners.



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