Solutions
Journal

Distributed Defectors
Solar-plus-battery systems upset the balance of grid-sourced electricity

BMW's Carbon Fiber i3
Meet the world's first composite-intensive mainstream electric vehicle

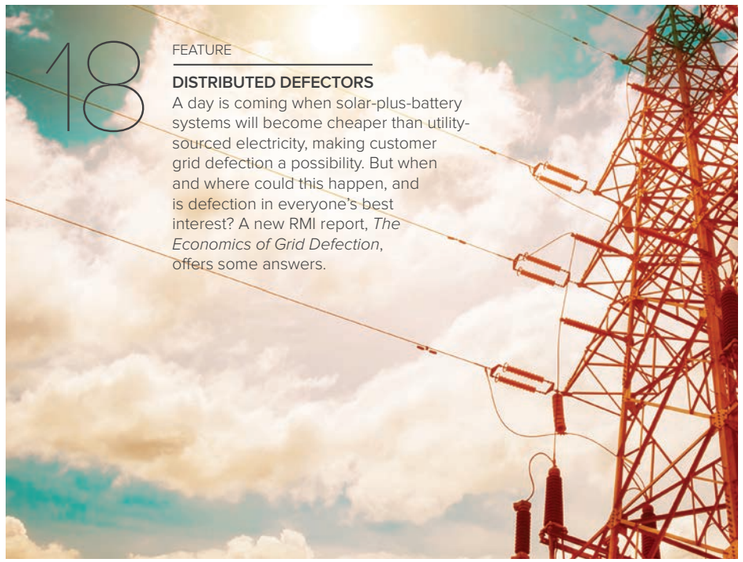
2025 Goals
RMI scales up, drives impact, and gets accountable

Rocky Mountain Institute

WINTER 2014
VOL. 7 NO. 1

Transportation Buildings Industry Electricity General Energy

WINTER 2014 / VOL. 7 NO. 1



COLUMNS & DEPARTMENTS

Our Printing and Paper
This issue of *Solutions Journal* is printed on elemental chlorine-free paper. Specifically, it is #2 FSC-certified CPC Matte Book and FSC-certified CPC Matte Cover, Sappi Papers in Minnesota, sourced from SFI-certified pulp. Using certified paper products promotes environmentally appropriate and economically viable management of the world's forests.

Staff
Publisher – Rocky Mountain Institute
Editorial Director – Peter Bronski
Writer/Editor – Laurie Guevara-Stone
Art Director – Romy Purshouse
Designer – Chris Rowe

by Jules Kortenhorst

Reinventing RMI

SCALING UP, DRIVING IMPACT, AND GETTING ACCOUNTABLE

Image copyright RMI.

For more than 30 years, RMI has championed the shift from fossil fuels to efficiency and renewables, both in the United States and abroad. We have made progress in influencing thought leaders and key players, generating breakthrough insights, and piloting and scaling solutions. But more of that important work remains to do. The pace at which we transform global energy use to create a clean, prosperous, and secure future needs to be significantly faster than it has been. Equally important, this is a global challenge, so we need to make our impact on a global scale, beyond the borders of the United States where RMI was born.

We recently went through a strategy exercise to refocus RMI on driving even greater impact. That impact comes with great benefits. It unlocks trillions of dollars of economic value. It bolsters the security and resilience of our energy systems. And it creates a greener, cleaner world for you and me and our children to live in. But these linked goals, from our economy to our security to the environment, are now increasingly threatened by climate change. We must take action, and we must do it now.

RMI has a concrete vision for what a clean, prosperous, and secure future looks like. We call that vision Reinventing Fire—a fundamental transformation in global energy use from fossil fuels to advanced efficiency and renewables. If we can succeed in this transformation—and we must—we can tackle climate change and achieve the economic, security, and environmental benefits we all hold dear in our hearts and minds.

Turning Reinventing Fire from vision into reality—by 2050, if not sooner—is a big goal. That's why our recent strategy process defined ambitious and impactful 2025 program goals to drive change, as well as near-term milestones that each guide our next steps.

Those goals and milestones (about which you can read on page 28) are measurable, because more than ever before, RMI is ready to be accountable, to ourselves and to you. Making societal change happen, especially in an area as challenging as global energy use, is hard and complex work with lots of uncertainty. But we at RMI stand behind our commitment to deliver impact. Thus we are increasing investments in our programs in buildings, electricity, and communities in the U.S. And we are also putting a very significant effort into working with China. Meanwhile—building on RMI's historic strengths—we are exploring new opportunities in transportation, industry, and more.

This issue of *Solutions Journal* highlights some of the ways we are aiming to achieve that greater impact. You will read: How we're bringing our Reinventing Fire vision not only to places like Fort Collins (Colorado), Arizona State University, and Minnesota, but also to all of China. How we are accelerating the adoption of clean solar energy by streamlining the permitting process in communities and showing how utilities, customers, and energy developers can leverage solar power and battery storage systems to create an optimized, reliable, clean, decentralized grid. How automakers like BMW are embracing ultralight materials and electrification, and how RMI is working with the auto industry to take such shifts mainstream. And how we are driving greater investment in commercial buildings' energy efficiency by helping investors count the full value of deep retrofits.

Such exciting and important work is only just the beginning. To deliver our promised impact, we need to increase the scope, scale, and speed at which we work. RMI must widen our global reach, accelerate the pace of our programs, and forge more and stronger partnerships. And we need to make RMI bigger…to grow our talented, dedicated staff; to expand our influence; to make a greater impact much sooner. For that we will also continue to need your help and support.

We cannot afford to wait; we need to do this now. When I think of the legacy we are leaving for my four kids and their entire generation, I realize the urgency of the challenge we have before us. At the same time I am excited that RMI is ready and able to step up to that challenge, scale up our programs, and help bring forth a clean, prosperous, and secure energy future.

ROCKY MOUNTAIN INSTITUTE AWARDED GENEROUS FUNDING FROM DUTCH POSTCODE LOTTERY

RMI is excited to announce it has been renewed as a beneficiary of the Dutch Postcode Lottery and was awarded $1.2 million at the Lottery's Goed Geld Gala in Amsterdam in early February. The second largest charitable funder in the world, the Postcode Lottery gave a record €302 million to 101 charities around the world. Archbishop Desmond Tutu gave an inspiring speech at the event.

RMI is honored to be a partner of the Postcode Lottery, along with many other worthy charities, including Peace Parks, World Wildlife Fund, Carbon War Room, The Climate Group, and the Clinton Foundation. RMI has received over $7 million in funding from the Postcode Lottery over the past six years.

BE PART OF THE SOLUTION

Philanthropic support makes RMI's work possible. Join us by **making a donation today** to help create a clean, prosperous, and secure energy future.

Give an unrestricted gift or target your gift to support an RMI project that addresses your passion.

WWW.RMI.ORG/DONATE

"OUR DONORS ARE MAKING IT POSSIBLE"
—AMORY LOVINS

by Amory Lovins

Ramping Up Renewable Electricity

AS GRID OPERATORS COMBINE VARIOUS TECHNIQUES, HIGH-PERCENTAGE RENEWABLES PROVE THEY CAN PROVIDE RELIABLE POWER

Many people in the electricity industry long thought that the two renewable sources of electricity that vary widely over time—windpower and solar photovoltaics (PVs)—could provide only a few percent of total generation without endangering reliability. Those who still believe this now face increasingly severe reality tests.

As we'll see, Germany and other countries are successfully powering their grids with astonishingly high fractions of renewable generation by combining five techniques: a) leveraging diverse generation sources across interconnected regional and national grids, b) improving renewables' forecasting and predictability, c) integrating dispatchable renewables, d) adding distributed storage, and e) leveraging demand response.

GENERATION DIVERSITY AND INTERCONNECTED GRIDS

In Germany, renewables contributed 23 percent of total electricity generation for 2012. In Denmark, renewables produced an even more impressive 41 percent—windpower alone produced 33 percent for all of 2013 and 54.8 percent for December. These two countries had Europe's most reliable electricity, about ten times more reliable than America's.

Both countries swap electricity with neighbors on two or more sides, helping to balance windfarms' and PVs' variable output. Denmark, for example, exports windpower when the country's turbines are generating a surplus, and imports hydropower from the Scandinavian grid when it needs to. But such interconnections may be less important than many think.

Out on the edge of the European grid, Spain generated 49 percent renewable electricity in the first half of 2013, and Portugal, interconnected only with Spain, an astonishing 70 percent (respectively 29 and 30 percent excluding hydropower). For all of 2013, Spain's electrical generation was 32 percent renewable (30 without hydro), Portugal's 47 (44). Similarly, Scotland, a net exporter linked only to England and Wales, generated electricity 40 percent renewably (36 without hydro).

For brief periods, the first four of these high-renewables countries have respectively achieved 70, 136, 61, and 100 percent renewable generation, just as Xcel Energy in Colorado briefly surpassed 60 percent from windpower last year.

IMPROVED FORECASTING AND PREDICTABILITY

Modern PVs and windpower are among the most reliable known generating technologies (typically 98–99 percent technically available), but their output varies strongly with time and weather. Fortunately, one generator doesn't serve one load; all generators together serve the grid, which melds them to serve all loads. Thus the giant German utility RWE, working with Siemens, "synthesizes" steady output from a diverse portfolio of varying renewables.

Such stable and reliable power comes from choreographing many shifting resources, so variable outputs must be accurately forecast. Though still improving, forecasting is already so good that PV and windpower are often more predictable than electricity demand. For example, throughout a stormy winter month, the French grid operator reported actual national windpower generation very close to its forecast one day ahead (see graph below). The small remaining errors disappeared in the hours before actual dispatch.

INTEGRATING DISPATCHABLE RENEWABLES

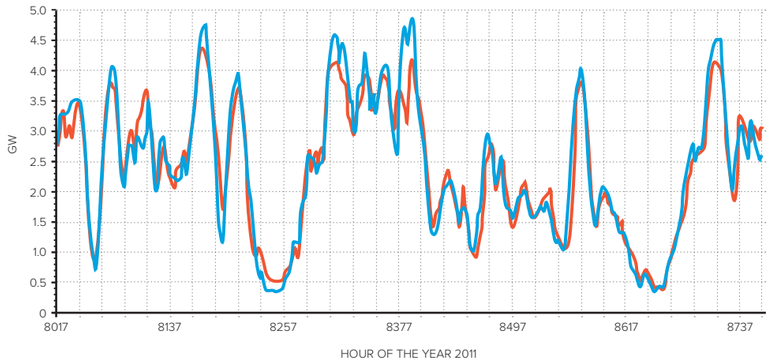
Modern grid operators are also melding an even broader slate of resources. They start with wind and PV power, diversified by location (so they don't all see the same weather at the same time) and by type (so they don't all react in the same way). Operators next add the other, "dispatchable," kinds of renewables that can operate whenever they're needed and in good working order: big and small hydropower, several emerging kinds of marine energy, solar-thermal-electric plants whose stored heat can stretch their operation into or through the night, geothermal, and burning biomass, biogas, or wastes (often in combined-heat-and-power plants of various sizes, including "green gas" or natural gas in fuel cells, or cogeneration from waste heat).

ADDING DISTRIBUTED STORAGE

Another key flexibility resource is distributed electricity storage—as heat (such as ice-storage air conditioning) or as electricity (such as smart charging of electric vehicles or battery backups for solar PV systems). With smarter grids, car charging can be bidirectional, drawing some peak power back from the car when it's exceptionally valuable—of course, without compromising driving. Tesla, other automakers, and several solar developers are developing such capabilities. Tesla,

Hourly Actual vs. Forecasted Wind Generation

France, December 2011



Source: Bernard Chabot, 10 April 2013, Fig. 7, www.renewablesinternational.net/wind-power-statistics-by-the-hour/150/505/61845/, data from French TSO RTE

Image courtesy of Shutterstock.

now the world's largest battery manufacturer, is also piggybacking on its world-class battery and inverter production for cars to offer very efficient, reliable, and economical distributed storage modules for buildings and factories. And firms like Sunverge, SolarCity, Solar Grid Storage, Stem, and a growing list of others are starting to (or already) offer distributed storage to complement solar PV.

LEVERAGING DEMAND RESPONSE

Operators can also integrate with "demand response," which controls or influences when customers use electricity for particular tasks. Your utility may pay you to allow your electric water heater to be turned off occasionally for a quarter-hour; you'll never notice such "load management." Many building services and industrial processes can use smart controls unobtrusively to make demand surprisingly flexible to make the grid agile. Modern telecommunications, distributed control intelligence, transparent pricing (especially if it reflects real-time production and delivery costs), and integration with efficient energy use combine to make demand response a bigger and more versatile resource than had long been thought.

New forms of demand response are continually emerging. For example, my electric car charger adjusts its charge rate between zero and 7 kW every second according to the frequency of the grid. Such "fast regulation" is worth enough (if the grid paid me for it as FERC says it should) for me to make a few bucks' profit every night by charging my car.

ADDING IT ALL UP

All this is a big slate of options. But what if it's not enough? The next and costlier options would include bulk electricity storage (via compressed air in underground caverns, pumped hydroelectric storage, hydrogen, or conventional or flow batteries). But the five European countries mentioned earlier have needed no new storage or backup capacity. Indeed, emerging evidence seems consistent with my longstanding hypothesis that a largely or wholly renewable power system may need less storage and backup than utilities have already bought to manage the intermittence of their big coal and nuclear plants. For example, many utility analyses find major windpower installations need only about five percent or less in "balancing reserves," while big thermal power stations require three times that reserve.

As more countries build more renewables, any limits of this strategy will increasingly be tested. So far, practice is confirming analysis. The National Renewable Energy Laboratory's 2011 REFS study showed how to run an 80–90 percent renewable U.S. grid in 2050 with only 136 GW (about 10 percent of the total renewable capacity) of added bulk storage. RMI's 80-percent-renewable Transform scenario in *Reinventing Fire* added less bulk storage—67 GW (6.3 percent)—mainly because its renewables were half-distributed.

The more we let all options compete—demand-side resources can now bid into power auctions in about three-fifths of the U.S.—the more we can discover in the marketplace how far customer-centric, distributed supply- and demand-side resources can deliver reliable and resilient electrical services at least cost. But already, it's clear that the long-claimed low limits to renewable power supply were imaginary.

With only about six percent of the world's electricity now coming from non-hydro renewables, we're a long way globally from the average renewable fractions now achieved in five European countries and two U.S. states. But every year, these sources are getting a quarter-trillion dollars of private investment worldwide and adding over 80 GW, both promising trends. Global clean-energy investment fell 11 percent in nominal terms during 2013, but in 2012, despite a similar 10 percent nominal investment drop, capacity additions rose 6 percent because costs fell even faster. Soon we'll know whether the same recurred in 2013.

After all, half the world's new generating capacity added each year starting in 2008 has been renewable; solar cells are scaling faster than cellphones, probably surpassing windpower's 2013 additions; and Bloomberg New Energy Finance expects solar power to compete with retail grid power in three-fourths of world markets in another year or two. The first part of the renewable power revolution—scaling production—is already well underway. Next comes the interesting part: ensuring that all the moving parts mesh properly.

Amory B. Lovins is the cofounder, chief scientist, and chairman emeritus of RMI.

RMI in Brief

NEWS FROM AROUND THE INSTITUTE

PROJECT GET READY

Launched in early 2009, RMI's Project Get Ready (PGR) worked with over 25 cities and 40 strategic partners to develop and disseminate best practices for electric vehicle integration and adoption. PGR's accomplishments included the oft-cited *EV City Casebook*, which details the policies, incentive programs, and customer behaviors of 16 pioneering cities and regions around the world. Now, RMI is shifting gears from PGR to the Autocomposites Commercialization Launchpad to kickstart the mainstream adoption of lightweight-yet-ultrastrong carbon fiber to dramatically increase automotive fuel economy and enable affordable electrification with fewer batteries.

SUPEREFFICIENT HOUSING INITIATIVE

RMI's Superefficient Housing Initiative (SHI) addressed an important issue: the disproportionally high utility bills that burden low-income American families and the housing agencies and organizations that support them. Our 2013 report *Superefficient Affordable Housing: Solutions to Hurdles* identified barriers to making affordable housing more energy efficient and proposed a series of solutions, while our collaboration with Denver Housing Authority and other partners sought to make healthy, cost-effective low-income housing that saves at least 60 percent of energy costs a reality. We maintain an advisory role to many of these groups, even as we focus our efforts on other important parts of the building sector.

ENERGY EFFICIENCY AT THE EXCHANGE

The Exchange, the Department of Defense's oldest and largest retailer, operates retail and convenience stores, gas stations, restaurants, theaters, and other businesses on military installations in 50 states, 5 U.S. territories, and more than 30 countries. RMI partnered with the Exchange to improve energy efficiency dramatically across its main stores and food courts, focusing on a subset of 24 malls that represent 35 percent of the Exchange's total domestic mall square footage and 38 percent of the company's domestic mall energy consumption. Following analysis at military bases in Colorado and Kentucky to identify oppertunities, Exchange CEO Tom Shull has earmarked $30 million for energy efficiency retrofits to help reach this goal.

SHAPING A NEW ENERGY FUTURE IN MINNESOTA

The State of Minnesota plans to reduce carbon emissions 80 percent from 2005 levels by 2050 and for its largest utility to source 31.5 percent of electricity from renewables by 2020. Yet, Minnesota still spends $13 billion annually to import natural gas, oil, and coal. So what might a clean energy future look like for Minnesota? RMI is working with the state to answer that question. In October 2013, RMI and Minnesota's Department of Commerce (MN DoC) hosted a stakeholder session, followed by an RMI-led report the MN DoC submitted to the state's Legislative Energy Commission in January. The next step—should the legislature opt to pursue it—would be a Reinventing Fire-like energy future study.

ACCELERATING EFFICIENCY, SOLAR, AND NET ZERO IN FORT COLLINS

RMI continues its work with e-Lab and the City of Fort Collins, CO, to accelerate the city's ambitious energy and climate goals and develop on-the-ground solutions to reach those goals. Our analysis and report to the city, *Stepping Up*, found Fort Collins could reduce its energy-related carbon emissions 80 percent by 2030, two decades ahead of its existing 2050 greenhouse gas reduction target, with a net benefit totaling $261 million compared to business as usual. Meanwhile, our ongoing work with Fort Collins Utilities is developing a set of initiatives that can be piloted in FortZED, the city's downtown net-zero-energy district, to drive increased energy efficiency in buildings and greater adoption of solar PV and other distributed resources.

by Marty Pickett

JOHN DENVER ASPENGLOW FUND HELPS LIGHT RMI'S WAY

From "Sunshine on My Shoulders" to "Rocky Mountain High," John Denver's songs are loved by millions. But another legacy remains: his passion for the environment and humanity.

In the late 1970s, John and his friend Tom Crum started an environmental and humanitarian organization called the Windstar Foundation in Old Snowmass near Aspen, Colorado. Its annual Choices for the Future Symposium was a summer highlight for years; experts gathered to inspire and conspire for a better world. In 1982, Amory Lovins cofounded his energy think-and-do tank, Rocky Mountain Institute, ten minutes' walk away.

Left to right: Annie Denver, RMI's Marty Pickett, and the Aspenglow Fund's Karmen Dopslaff

When RMI grew beyond the walls of the Lovins home/office, it leased additional space in the Windstar Foundation's 1950s farmhouse. When those 957 mostly wild acres, owned by Windstar and the National Wildlife Federation (NWF), faced sale for development, RMI purchased NWF's interest and, with the Windstar Foundation, created the Windstar Land Conservancy to hold and restore the property, including a conservation easement that forever preserves 927 acres from development.

With John's untimely death in 1997, the Windstar Foundation struggled. By 2012, Windstar dissolved and RMI made plans to move. The property was sold and proceeds were shared equally between RMI and the John Denver Aspenglow Fund of the Aspen Community Foundation. The fund is led by former directors of Windstar with long-time friends Tom Crum, Joe Henry, and Annie Denver.

Karmen Dopslaff, former Windstar Foundation president and long-time friend of John and Annie, led this transition, wanting to make the best decisions for the future and John's legacy. For example, the larger-than-life statue of John that fans long admired is now at the Colorado Music Hall of Fame at Red Rocks Amphitheater in Denver, one of John's favorite performance venues, where it can delight far more visitors.

Karmen and her team have also made some extraordinary grants from the Aspenglow Fund that will allow many organizations to make a lasting impact in the world. Support ranges from helping less fortunate preschool children improve their cognitive and social skills, to environmental education, to providing support to families in John's parents' home state of Oklahoma affected by natural disasters.

It is not too much to say that all these projects are embodied in the lyrics of John's song "It's About Time":

It's about time we begin it, to turn the world around.
It's about time we start to make it, the dream we've always known.
It's about time we start to live it, the family of man.
It's about time, it's about changes and it's about time.

This same generosity resulted in the lead foundation grant for RMI's initiative Reinventing Fire: China. The generous $1 million gift was presented to RMI in August 2013 soon after the effort launched in Beijing. John would be pleased: he was especially beloved in China, where he'd often go to villages where nobody spoke English, only to find the kids singing his songs in English.

Marty Pickett is a managing director at RMI.

by Clay Stranger

MOMENTUM BUILDS IN CHINA

In November 2013, Rocky Mountain Institute joined partners Lawrence Berkeley National Laboratory, Energy Research Institute, and Energy Foundation China in Beijing to participate in China's Senior Policy Advisory Council Dialogue. The theme of this year's summit was Reinventing Fire: Contributing to China's Energy Production and Consumption Revolution.

Reinventing Fire's top billing at the event was evidence of the Chinese government's National Development and Reform Commission's growing embrace of this two-year project launched in June 2013. The effort is testing the maximum possible share of energy efficiency and renewable energy that could support the Chinese economy through 2050, while gauging its economic and emissions implications.

After being briefed on the project, distinguished Chinese policymakers had the opportunity to discuss its goals, implications, and opportunities. One official reinforced her hope that Reinventing Fire: China would provide insights and inputs to the energy chapters of the upcoming 13th Five-Year Plan. Addressing a room full of his peers, another senior official commented, "It is an imperative for us to reinvent fire, pursuing energy efficiency and clean energy to support blue skies and fresh air for the future of China."

Those blue skies and fresh air are front-of-mind for many in China, including the nation's leaders. Recent peak smog events have crippled northern Chinese cities, and the economic and social costs of heavily polluted air have captured global attention. In northern China alone, air pollution has cost the country an estimated 2.5 billion years of life expectancy to date. In response, China's State Council recently released a ten-point plan aimed at reducing emissions and improving regional air quality. The plan emphasizes improved air quality monitoring, energy efficiency, accelerated renewable deployment, and shrinking coal's share of total energy to less than 65 percent by 2017. The plan also targets reducing PM2.5 emissions (a dangerous form of particulate matter air pollution) 25 percent in Beijing-Tianjin-Hebei, 20 percent in the Yangtze River Delta, and 15 percent in the Pearl River Delta by 2017.

In addition to State Council's plan, the 3rd Plenum of the 18th Party Congress recently announced that the market will start to play an enhanced and decisive role in resource and energy planning. This explicit new approach from the Chinese government lays a strong foundation for Reinventing Fire: China to build on.

China stands at an energy crossroads. It paradoxically leads the world in CO_2 emissions, oil imports, and coal consumption on one hand, and energy-productivity gains and renewables investment, manufacturing, and capacity (hydro and non-hydro) on the other. This giant, ancient, complex country is a nexus of enormous challenges and equally impressive solutions unfolding with astounding speed. Decisions made and directions chosen over the next several years will have tremendous implications for the future of China and the world.

Clay Stranger is project manager for Reinventing Fire: China at RMI.

China image courtesy of Shutterstock. Aspenglow image courtesy of Marty Pickett.

WEB EXTRA

For more information, read "A Flameless Dragon: Charting A Clean Energy Path for China" in the summer 2013 issue.

by Todd Neff

Streamlining Solar

TO TACKLE PV'S "SOFT" COSTS, IT TAKES A SOLAR-FRIENDLY COMMUNITY

Between 2008 and 2012 the installed cost of a residential rooftop solar PV system in the U.S. declined by 37 percent. That sounds like good news, and it is, but more than 80 percent of that cost decline was due to module prices. Balance-of-system costs remain high, so solar can—and needs—to do better. That's why the U.S. Department of Energy's SunShot Initiative is targeting $1.50 per installed watt for residential systems by 2020, compared to nearly $5/W today.

For prices to fall another 70 percent by the decade's end, the U.S. will need to learn from the examples of places such as Germany. In that cloudy, northern European country, residential solar PV systems cost a mere fraction (45 percent) of what they do stateside, and have the SunShot target well in their sights, with costs already down to $2.25/W. It's not the hardware, whose cost is relatively constant across countries. It's the process. The total cost of any PV installation includes not just the hardware, such as the panels themselves, but also "soft" costs, such as installation labor; permitting, inspection, and interconnection (PII); and customer acquisition.

Thanks to steep declines in module prices, such soft costs now make up more than 60 percent of the total price of a solar PV installation. It's in those arenas where countries such as Germany shine, and where the U.S. can make real progress, according to a December 2013 Rocky Mountain Institute report with Georgia Tech Research Institute (GTRI), *Reducing Solar PV Soft Costs: A Focus on Installation Labor.* Installation labor costs in Germany, for example, are just two-fifths what they are in the U.S., and for PII costs, an astounding one-sixth.

Whether for a customer directly or via a third-party solar developer, PII can be a big deal, and streamlining the PII process can reduce aggravating hassle, speed installation times, and save cost. And so in early 2012, the Colorado Solar Energy Industries Association (COSEIA) and Rocky Mountain Institute launched an effort to rein in soft costs. With help from a $491,000 grant from the U.S. Department of Energy's Rooftop Solar Challenge program, Solar Friendly Communities (SFC) was born. The aim was to cut permitting, inspection, and interconnection costs 25 percent through a combination of policy changes and online tools. Solar Friendly Communities' success in Colorado now has its creators looking to take the program national.

"It really is a true partnership between industry and local government, designed to make it faster, easier, and more affordable to go solar," says Rebecca Cantwell, COSEIA's senior program director. It was a grassroots approach, adds Jesse Morris, a Rocky Mountain Institute senior associate who worked on the program's technical design.

RMI and the Colorado Solar Energy Industries Association, with support from the U.S. Department of Energy, launched Solar Friendly Communities with a goal to cut permitting, inspection, and interconnection costs 25 percent.

First, the team talked with about two dozen solar installers from across Colorado's Front Range—a north-south corridor along the foothills of the Rocky Mountains that includes Colorado Springs, Denver, Boulder, and Fort Collins—to understand installers' pain points. They heard about challenges in finding specifics on a given municipality's requirements for solar; the differing paperwork demanded by different towns, cities, and counties; multiple inspections; and vast differences in permitting costs.

"When you think about it, if you're a solar installer working in the area, you're holding business and contractor licenses in at least 12 jurisdictions across the Front Range," says Whitney Painter, co-owner of Golden, Colo.-based Buglet Solar.

RMI and COSEIA took these and other concerns to local governments, Morris says. They spoke with everyone from building officials to sustainability officers, from city council members to plan checkers. The team asked a simple question: How can we make this easier from your perspective?

The Solar Friendly Communities team conducted workshops with municipalities and solar installers, and Morris and RMI colleagues developed a 12-step program, each step representing a solar best practice, ranging from posting requirements on a single government Web page to adopting standard permit forms to requiring just a single inspection. Each step was assigned a point value. Participating governments could pick and choose, earning points to achieve bronze, silver, gold, or platinum status. The result, Cantwell says, is "a program based on national best practices but rooted in reality. It's a menu of options and not mandates."

More than a dozen Colorado communities have signed on so far, from Carbondale (pop. 6,500) to Denver (pop. 635,000). Aurora, the state's third-largest city, was already meeting many criteria, according to Karen Hancock, Aurora's environmental program supervisor. Missing was a Web page listing or linking to all the requirements for rooftop solar, she said. By January 2013,

Images courtesy of Shutterstock.

auroragov.org/solar was live and Aurora had earned silver status, complete with a city council visit and a plaque. The recognition, Cantwell says, is a bigger carrot than one might expect: "No one ever gives a code official a pat on the back." In Aurora's case, the designation helps businesses and residents realize the city is a strong supporter of solar, Hancock says. "And yes, I love that plaque," she adds.

In addition, towns achieving the "medal" status often put up a sign as you enter town, similar to the road signage that often highlights Tree City USA and Bicycle Friendly Community status. For example, as you travel on Carbondale's main thoroughfare, Route 133, you'll see road signs for Carbondale's proud status as both a silver-level Solar Friendly Community and a Bicycle Friendly Community greeting you as you enter town.

Installers have been happy with the results, too—no small thing, since third-party-owned and -installed arrangements accounted for 90 percent of new installs in Colorado in 2012—to the point that 16 Colorado solar companies are offering $500 discounts to customers living in SFC jurisdictions. Painter of Buglet Solar, which is offering the discount, says there's been a "marked difference" in working with SFC communities "It's not just about lower costs, but smoother process," she says.

Not only are there more consistent PII requirements among SFC jurisdictions, but there's also more uniform knowledge of solar-related best practices within a given municipality, Painter says.

"There's been a shift from the counter all the way back to the reviewer as far as having a global understanding," she says. At the job site, SFC-related best practices such as tight inspection windows make a big difference for installers, she adds. "In some jurisdictions not working with the program, you'll have to wait around for a whole day for an inspector to show up for a rough inspection."

All told, a community participating in SFC can shave "many hours to a couple of days" off an installation, she says, which means that much less time a homeowner has to deal with "people crawling around on the roof."

Participating communities are also promoting the discount program and its installers, which helps drive business and cut customer-acquisition costs, according to Morris. "We're a small business—it is helpful to us," Painter adds.

Two years after it began, the program has gained momentum with growth. With its foundation in place, COSEIA and the Colorado Nonprofit Development Center have created a new nonprofit home for Solar Friendly Communities, Go Solar Colorado, to raise funds and take it national.

"We think it has tremendous potential and have heard interest in adopting the program from all over the country," says Cantwell.

Todd Neff is a freelance writer who specializes in covering energy and climate.

WEB EXTRA

For more information on this topic visit: solarcommunities.org and gosolarcolorado.org

Image courtesy of Shutterstock.

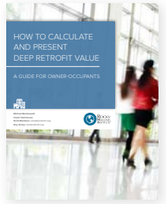
Insights

RECENT WHITE PAPERS AND REPORTS

ADVANCING MILITARY MICROGRIDS

by RMI & NAVFAC Southwest

The U.S. Navy is leading the way in the technical and economic testing of microgrid technology as it looks for new ways to bolster the energy security of Navy and Marine Corps bases—a broad Department of Defense agenda in which RMI's played an important role for three decades. But as those bases, especially in the Southwest, begin to experiment with the technology, they face several major questions around microgrid design, evaluation, economics, and operation. This report discusses the findings of a two-day workshop with RMI and the Naval Facilities Engineering Command Southwest. Drawing on key stakeholders and experts from inside and outside the Navy, the report provides a set of recommended priority action areas for the Navy—or any customer closely looking at microgrid-enabled resilience or renewable energy.



HOW TO CALCULATE AND PRESENT DEEP RETROFIT VALUE

by RMI

Deep retrofits—energy efficiency retrofits that reduce a building's consumption 50 percent or more—significantly cut energy bills. But they also yield many other benefits: improved employee productivity, retention, and health; lower maintenance costs; increased occupancy; bolstered reputation; reduced risk; and higher lease-up and sales rates. Accurately calculating and presenting these additional forms of value to decision makers is a critical tool for driving greater investment in deep retrofits. This paper details both the evidence for that additional value and practical information for how to calculate and present it.

REDUCING SOLAR PV SOFT COSTS: A FOCUS ON INSTALLATION LABOR

by RMI & Georgia Tech Research Institute

Distributed solar energy is a key enabler of an affordable, resilient, secure, and low-carbon electricity future. Thanks to steep declines in module prices, over 60 percent of the cost of a residential rooftop solar PV system is now attributable to soft costs, including installation. In Germany, such costs are a fraction of what they are in the U.S. Together, RMI and researchers from Georgia Tech Research Institute set out to determine why. This paper discusses the results of time and motion studies conducted in both countries, as well as best practices and other opportunities U.S. installers can implement to approach German rates of installation cost per watt.

BUILDING ENERGY MODELING FOR OWNERS AND MANAGERS

by RMI

Building energy modeling (BEM) is the practice of using computer-based simulation software to perform a detailed analysis of a building's energy use and energy-using systems. BEM for new construction or retrofit building projects can reduce operational costs, reduce project first costs, and improve occupant satisfaction. This guide helps building owners and managers to define and procure modeling services in commercial new construction, renovation, or operation improvement projects. The topics and examples focus on issues most relevant to owners and managers, including the value of modeling, types of services, and solicitation.

These reports, and more, are available online at http://www.rmi.org.

by Jesse Morris

Pedal Pusher

CAN ONE RMI STAFFER HELP HIS MOUNTAIN TOWN EMBRACE BIKE SHARING?

Image copyright RMI/Romy Purshouse.

Standing behind an information table at my local farmer's market last summer, a second-home owner from Texas who lives part time in Aspen, Colorado, asked me, "Is this part of that big, communist, United Nations scheme to get me out of my car?"

I was there at the market to educate people as a board member of We-Cycle, the world's first rural bike-sharing program, located in Aspen, where I live. It currently offers 13 conveniently located stations around town with a total of 100 bikes. As the Texan went on, it was clear I had more educating to do: "I mean, those Europeans and liberals down in Boulder can let these bike-share things take up as much parking as they want, but I don't want them ruinin' my town."

"Actually," I responded, "there's some serious evidence out there showing how increased bike traffic boosts local U.S. economies from Chattanooga to Minneapolis. And I don't know about this UN thing, but our program isn't asking you to do anything. It's just trying to give folks like yourself a new, low-cost, hassle-free way to see our town." It would also help to address Aspen's dual challenges of traffic congestion and transportation-related emissions that harm local air quality in the valley and contribute to climate change worldwide.

My challenge from the Texan highlighted a more fundamental and difficult reality I'd been discovering. No matter how good the economics are, how many health benefits there might be, or how compelling a future vision is, it's really, really hard to get people out of their cars. No wonder transportation uses almost one-third of all U.S. energy—mostly to move you and me, mainly in two-ton cars and light trucks.

There are two main ways to tackle transportation-related fossil fuel use. The first gets most of the mainstream press' attention: make cars and trucks more efficient and run them on different fuels, including electricity. The second method, less-discussed but potentially very powerful, is simpler and therefore harder to imagine: design transportation systems and the places we live so people don't need to use personal vehicles to get from point A to point B in the first place. That's where bike sharing comes in.

But as I discovered with the skeptical Texan, words would usually only get me so far. Instead, the best way to convince people was to physically walk them through the user experience. Slide the bike-share key in, adjust the seat height, and start pedaling; use an app on your mobile phone to make sure there's room at the next station, re-rack the bike, and your ride is complete. And did I mention that it's cheaper than driving your car, gets you some exercise, and lets you take in your beautiful surroundings without a sheet of auto-glass between you and the view?

I remained undeterred. I'm an avid cyclist, and in addition to speaking with folks one on one, I rode We-Cycle all over town, encouraged visiting friends to hop on the bandwagon, and worked hard to bring in new donors and generate buy-in throughout the community. But convincing one person at a time that We-Cycle is a good idea only got us so far. In addition, we needed the local government's support for We-Cycle to succeed. And in our efforts to court local government support of the program, I was struck by another difficult truth.

At RMI, we tend to support and encourage state- or local-level policymaking, since passing policies to support the Reinventing Fire vision is easier at state and municipal levels than it is in Washington. But as I discovered, going the local route is no ride in the park either.

Aspen, a progressive and wellfunded city government, was not interested in providing significant levels of funding to We-Cycle, even though cities like Aspen both face congestion issues and invest heavily in transportation infrastructure. It can be a tough sell to get local governments to invest in new technologies and approaches with the potential to enable a more efficient and low-carbon future—something that we at RMI ask individuals, businesses, and governments to consider almost daily. My latest local government interaction has highlighted how I, as a general communicator and RMI staffer, need to do some soul-searching and figure out how to better engage local government officials, especially if I expect Reinventing Fire to succeed without the need for federal-level policy change (though we'll happily accept supportive national policies too).

I don't have all of the answers to these challenges, but I do know this: We-Cycle had a great first year of operation with more than 10,000 rides logged—not bad for a town with a permanent population below 7,000.

My experience with We-Cycle has been both enlightening and incredibly frustrating. It's shown me just how difficult it is to get individuals to change their transportation habits, and it has also made trying to get folks to adopt solar energy (one of my day-to-day responsibilities at RMI) look somewhat easier by comparison.

No matter how good the economics are, how many health benefits there might be, or how compelling a future vision is, it's really, really hard to get people out of their cars. No wonder transportation uses almost one-third of all U.S. energy—mostly to move you and me, mainly in two-ton cars and light trucks.

Nonetheless, I plan on continuing to try and bring the Reinventing Fire message home and live it in my daily life, not just professionally at RMI, but personally. I've invested in Solar Mosaic (an investing platform that allows folks like me who don't own their rooftop to invest in and make a return on green energy), helped my local homeowners' association get high-efficiency natural gas boilers, taught high-school students about the economic case for energy efficiency, and advised local towns on renewable energy procurement strategies. And I drive a bright orange Prius…when I'm not on my bicycle.

As for We-Cycle, it's shuttered for the winter season while Aspenites hit the ski slopes. But it'll be back this spring, and I'll be there once again, getting more people out of their cars and onto a bike.

Jesse Morris is a senior associate for RMI.

WEB EXTRA

For more information on this topic visit: rmi.org/transportation

Distributed Defectors

by Peter Bronski

A DAY IS COMING WHEN SOLAR-PLUS-BATTERY SYSTEMS WILL BECOME CHEAPER THAN UTILITY-SOURCED ELECTRICITY, MAKING CUSTOMER GRID DEFECTION A POSSIBILITY. BUT WHEN AND WHERE COULD THIS HAPPEN, AND IS DEFECTION IN EVERYONE'S BEST INTEREST? A NEW RMI REPORT, *THE ECONOMICS OF GRID DEFECTION*, OFFERS SOME ANSWERS.

When the state of Hawaii and the U.S. Department of Energy launched the Hawaii Clean Energy Initiative in 2008—an effort for which RMI provided detailed and comprehensive policy recommendations to the state—their goal was simple: transition the island state off the imported oil that supplies 90 percent of its energy at an annual cost of $5–7 billion. An associated roadmap plans to achieve 70 percent clean energy by 2030—30 percent through energy efficiency measures, the remaining 40 percent through renewables.

But how to get there from here? The National Renewable Energy Laboratory's June 2013 *Hawaii Solar Integration Study* found that renewables—especially wind and solar, with an emphasis on solar—could provide 20 percent or more of

Image courtesy of SolarCity.

Hawaii's electricity needs without requiring major system changes. But that'd be only halfway to the stated 40-percent-renewables goal.

Amazingly, NREL's 20-percent-penetration day may already be here. As of Q3 2013, Hawaii again ranked among the top ten states for both new and cumulative installed PV capacity, according to the Solar Energy Industries Association (SEIA). The Hawaiian Electric Company (HECO) supplies power to 95 percent of the state's population. HECO's system maps show that many of the grid's circuits on islands such as Oahu and Maui already have so much distributed generation (DG), primarily rooftop solar, that their output exceeds 100 percent of daytime minimum load. In fact, the most DG-congested circuits are now even reaching 15 percent peak load (some circuits hit an astounding 50–75 percent or more), approaching or surpassing the levels at which the NREL study suggests grid operators need to start thinking harder about how to add more solar without compromising system performance.

The result—for now—is potential frustration for customers rushing to put solar on their roofs, in part to escape (or at least take a bite out of) residential electricity prices averaging 36 cents per kWh—the most of any U.S. state and triple the national average.

Some customers are being told they can't put solar on their roofs *and* connect to the grid—at least not yet. HECO says it must first conduct feasibility studies to figure out how to accommodate more solar on the grid safely, without destabilizing the system. Such studies could take two years or more, raising the ire of some solar advocates.

Despite this friction, there are signs HECO remains a solar-friendly utility. Late last year HECO relaxed its qualifying standard for simplified interconnection, so more customers can install grid-connected PV systems without a detailed and time-consuming interconnection study. Also, though updated rankings aren't yet available for 2013, in 2012 HECO ranked in the top 10 and top 4 utilities nationwide, from among more than 260, for newly installed solar PV capacity and new solar capacity per customer, respectively.

Even so, some new solar PV customers are being told to wait—and many don't want to.

A December 2013 *Bloomberg* story, for example, highlighted an Oahu homeowner who spent $35,000 on a 5.9-kW PV system, only to be told he couldn't connect it to the grid. He's not alone. Some observers estimate hundreds, if not thousands, of customers find themselves in similar situations.

RISE OF THE DISTRIBUTED DEFECTORS

Customers impatient to wait for HECO to complete its study are left with a difficult decision: abandon their solar PV plans and continue paying expensive retail prices for grid electricity, or defect from the grid entirely.

The latter is exactly what happened in the case of a Maui Builders and Maui Solar Energy Systems residential client. "We were going to install a grid backup system, this way we could size the battery bank in a more optimistic fashion," Maui Builders and Maui Solar president John Bews explains, "but the local utility balked." So Bews and his crew took the entire house off the grid.

Such a customer grid defection will increasingly become a possibility—even a probability—and not just in Hawaii where conditions are ripe, but in other geographies throughout the United States, from Los Angeles, California, to Westchester County, New York, as the levelized cost of energy for solar-plus-battery systems reaches or undercuts economic parity with grid-sourced electricity at comparable reliability.

Utilities have known this day is coming. A January 2013 Edison Electric Institute report, *Disruptive Challenges*, put the issue front and center. Other reports and studies from the likes of NREL and Lawrence Berkeley National Laboratory have looked at the issue as well. But no one has more specifically analyzed where and when grid parity will happen—until now.

GRID CONNECTION BECOMES OPTIONAL

To answer such a fundamental and important question, Rocky Mountain Institute partnered with HOMER Energy, an NREL spinoff with microgrid simulation software that supported the analysis, and CohnReznick Think Energy, which advises large energy buyers on renewable energy systems.

"For a long time, the mentality in the energy industry has been that battery storage will become economic right around the same time we figure out cold fusion," says Leia Guccione, senior associate in RMI's electricity practice. In other words, parity won't happen anytime soon. But that antiquated outlook is proving wrong.

According to SEIA, in the past two years (Q3 2011 to Q3 2013) the average installed cost of a completed U.S. solar PV system has fallen 33 percent, from $4.50 to $3 per watt. And further cost drops are clearly in the cards, in part because of RMI's solar balance-of-systems work (see "Streamlining Solar," page 12). The result is solar installations "at rates we've never seen before," says Guccione. Indeed, 2013 proved the first year in which solar PV beat wind for new capacity additions globally, according to Bloomberg New Energy Finance projections late last year.

Regionally expensive retail electricity prices, resiliency and backup power interests, desire for self-sufficiency and energy independence, and climate concerns and demand for low-carbon energy are driving early adopters toward solar-plus-battery systems.

The rest of the story is in continuing sharp falls in battery storage prices, coupled with rapidly expanding market size, largely via growth in electric vehicles. "This has been the year of awakening on storage broadly," says RMI managing director Jon Creyts. Guccione adds: "The inevitability of combining these two—solar plus storage—is now starting to reach a critical threshold."

THE INFLUENCE OF MOTIVATION AND GEOGRAPHY

That inevitability is already becoming a reality among some early adopters. Their motives vary, from islands where an economic case is already evident, to interests in resiliency and backup power, to desire for self-sufficiency and energy independence, to climate concerns and a desire for a low- or zero-carbon energy footprint.

Recent fights over the evolution of net metering are also driving the issue, with customers looking at storage behind the meter as a viable option to take the grid and the utility out of the equation. RMI electricity principal Dan Seif explains: "If you can't sell [surplus power] back to the grid or if the payback is very poor—as in some revised net metering scenarios—then you have more reason to go toward storage."

Such motivation is also there for commercial customers with steep demand charges. Say a customer normally draws 50 kW of power, but has spikes to 100 kW. The customer pays (heftily) for the size of that spike, which solar-plus-battery systems can knock down. "You get a lot of bang for your battery buck that way," says Seif.

But beyond early adopters, the day is coming—and sooner rather than later—when solar-plus-storage systems will become cheaper than the macro-grid. That's the real step-change.

RMI's February 2014 report, *The Economics of Grid Defection: When and where distributed solar generation plus storage competes with traditional utility service*, analyzed residential and commercial scenarios in five locations (Hawaii, California, New York, Texas, and Kentucky) that represent a range of utility markets, retail electricity prices, and solar PV penetration levels, all against both conservative and more aggressive solar-plus-battery cost projections.

The resounding conclusion is that grid parity for solar-plus-storage systems is coming in the foreseeable future. It's already here in Hawaii for commercial customers, and it'll be here in the next 5 to 20 years, including some residential market segments, across many other scenarios, including in NY and CA.

This is, in short, a big deal. Though industry estimates have solar PV alone reaching grid parity even sooner across a much broader swath of the market, PV-only systems fundamentally remain grid dependent, since for the vast majority of customers solar produces a surplus of energy during the day and a total deficit at night. (This dependency is at the heart of debates about revising net-metering policies and value-of-solar tariffs.) Solar-plus-battery systems, on the other hand, allow customers to completely sever ties with their utility, if they choose.

ENTER THE UTILITY DEATH SPIRAL?

"This study confirmed what we thought we knew," says Mark Crowdis, president of CohnReznick Think Energy. "PV systems plus storage are going to move more and more mainstream in the U.S. market over time." John Richardson, an analyst at CohnReznick, adds: "The results showed that these systems could become viable much faster than utilities or consumers thought." That's important. Why? The infamous utility death spiral.

The utility death spiral describes a scenario in which growing numbers of customers defect from the grid. This leaves fewer remaining customers to pay off utility debt, so retail prices rise, making it even more attractive for more customers to defect.

"If the price of solar-plus-storage solutions is competitive with retail electricity rates and the reliability is there, the load loss and defection will put immense strain on the traditional utility business model," says Creyts at RMI. "Our research shows that with current cost trends much of the country will hit that point over the next 30 years, which is the traditional recovery period for utility investments made today."

The implications of this are not lost on utilities. Hanan Eisenman is the communications manager for San Diego Gas & Electric (SDG&E), a progressive Southern California utility that offers fast-tracked solar PV interconnection and which added 11,000 rooftop solar installations to its grid just last year. "Distributed energy technologies are certainly driving changes in the utility business model and the kind of rate design that will be needed to support wider-scale deployment of distributed energy resources in the future," he says.

STAYING WITH THE GRID FOR MAX BENEFIT AT LEAST COST

Defecting from the grid entirely actually doesn't yield an optimal energy solution in many situations.

"You don't want to defect because the greatest value comes from staying connected," explains RMI's Guccione. "When you're off the grid, you need to invest in redundancy and into oversizing the system, so you end up taking a 'penalty' that ranges from 10 to 50 percent of the cost of the system, just for being off grid. You can reduce your annual operating cost by staying grid connected, where you can more optimally size your system and participate in markets, accessing new value streams."

The current electricity system has similar issues with overbuild too, where the system has more capacity than it needs at any one point in time. Having smaller, modular resources as part of the supply base can help maintain a better balance between supply and demand as customers' needs shift, so solar-plus-storage offers potential benefits to the grid as much as the grid offers benefits to solar-plus-storage systems.

"The death spiral is not in anyone's interests, really. It's bad for society as a whole," adds Peter Lilienthall, CEO of HOMER Energy. "We've got this infrastructure in place. Even if it's used in a different way than we have in the past, or it's used less to some extent, it's still valuable."

But while it may not be in everyone's best interests to defect, it's still a very real possibility. "For customers, this is going to become a real option. For utilities, this is going to happen," says Guccione. "Once you invent something, you can't uninvent it. This technology will be adopted, and utilities need to prepare for a future where it does happen."

"Currently, these systems are not being deployed as 'cut-the-cord' technologies [in our region] and are functioning as connected aspects of the grid," says SDG&E's Eisenman. "However, this may change as this technology becomes more available for customers in the near future, and it does represent an evolution of customer-sited options."

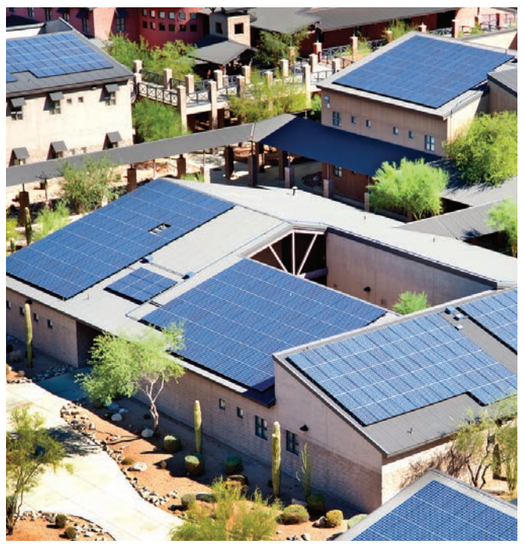
THE YIN AND YANG OF RISK AND OPPORTUNITY

The grid defection risk and utility death spiral notwithstanding, should utilities see solar-plus-battery systems as an existential threat? Maybe.

"Utilities should definitely feel threatened," explains Creyts. "But it's a threat that should be looked at as an *opportunity*. Storage is not a threat to the grid; it's a *value* to the grid. Utilities should be looking to evolve their business models." CohnReznick's Crowdis agrees: "Utilities should be looking at this as a huge opportunity, rather than running their business-as-usual models without seeing these developments as anything more than an irritant."

Utilities like SDG&E agree. "[We] believe these systems have the potential to deliver multiple benefits when integrated with the grid, including enhancing reliability, supporting self-sustaining microgrids, integrating electric vehicles, and smoothing the supply from intermittent renewable generation sources," says Eisenman. In fact, SDG&E has already installed more than a dozen lithium-ion battery systems of its own on the grid, ranging in size from a few kilowatts to half a megawatt of power capacity, and plans to add even more to the grid in keeping with California's recent energy storage mandate.

Image courtesy of SolarCity.



Solar-plus-battery systems offer other opportunities, too, including reserve capacity, peak shaving, demand charge reductions, and ancillary services such as voltage control and frequency regulation. And having such microgrids transact with the grid—either under current regulations or under a reformed regulatory scenario that allows fairer, more equitable, and widespread participation in electricity markets by all stakeholders—can allow everyone (utilities, customers, third-party developers) to derive the most benefit at least cost from the system.

RMI's been working on such utility business-model issues for years, even decades, through projects in its collaborative Electricity Innovation Lab (e-Lab), in papers such as *New Business Models for the Distribution Edge*, via DOE-supported work on innovative solar business models, through direct work with utilities and state regulatory commissions, and more, including a forthcoming report on alternative business models that would better leverage the value solar-plus-battery systems can provide.

"At RMI we talk about how we don't want energy *per se*; rather, we want the things energy provides: hot showers and cold beers," concludes Guccione. "Consumers value having their lights on, having reliable electric power for their electronic devices; commercial customers want to run their businesses. If there's a better way to do that with less energy and at lower cost—such as by integrating distributed solar-plus-storage systems onto the greater grid—that's what customers really value." Amory Lovins adds: "And if this comes with islandable microgrid architecture that lets the customers get their vital services even when the big grid fails, that value greatly increases."

"The answer, in my mind," says Maui Solar's Bews, "is battery storage on grid-interactive homes." Time will tell if that comes to pass.

Peter Bronski is the editorial director of RMI.

RMI's Economics of Grid Defection work was possible, in part, through the generous support of Fred and Alice Stanback and the Rudy & Alice Ramsey Foundation.

WEB EXTRA

For more information on this topic visit: rmi.org/electricity

BMW's Big Bet on Carbon Fiber

by Wendee Nicole

WITH THE NEW i3, THE WORLD MEETS THE FIRST COMPOSITE-INTENSIVE MAINSTREAM EV

On the streets of Barcelona, green car expert Jim Motavalli finally got to take the new BMW i3 for a ride. Author of *High Voltage: The Fast Track to Plug In the Auto Industry*, Motavalli was attending the annual EVS-27 International Electric Vehicle Symposium & Exhibition, where enthusiasts test drove the highly anticipated electric car. The i3 didn't disappoint. "It's very quick off the line, very quiet, very good handling," says Motavalli. As you'd expect from the engineers at the 'fun to drive' European automaker, he continues, the i3 is undoubtedly "a performance car."

BMW has completely reinvented the way to manufacture a car with the i3, crafting the world's first production car—not just electric vehicle (EV)—with an all-carbon-fiber passenger compartment. Six times stronger than commonly used steel and 30 percent lighter than increasingly popular aluminum, carbon fiber has historically been too expensive for bulk use, yet it holds great promise for making gasoline-powered autos radically more fuel efficient and opening the door for their cost-effective electrification, getting cars off oil completely.

But delivering on carbon fiber's sustainability promise—crucial to delivering on the BMW i series' promise of carbon-emissions-free transportation—required making not just the material work, but also the energy and financials.

Doing *that* ultimately led BMW to establish a carbon-fiber production facility in Moses Lake, Washington, where the automaker could use 100 percent renewable, climate-friendly hydropower for one-fifth the European price. (The i3 completes its production at two facilities in Germany—Landshut and Leipzig.)

THE PATH TO THE COMPOSITE-INTENSIVE CAR

The road to Moses Lake began earlier, with BMW's strong climate-motivated commitment to sustainability, prodded by increasingly stringent European and American fleet fuel economy regulations. "As an overall fleet of models worldwide, we want to reduce CO_2 emissions dramatically," says Oliver Walter, Head of BMW i3 Products and Launch Management Worldwide. "[That] will not be possible with only V8 and 6-cylinder engines."

There was also the issue of growing consumer demand for EVs, which BMW watched carefully before boldly merging into the market with the i3. "We don't want to wait until everybody bypasses us," Walter explains. "We want to be the driving force behind it." After BMW tested e-mobility with two electric vehicles built on traditional car platforms—the MiniE, followed by the ActiveE—the German automaker was ready for full-scale production of an electric car.

The i3 is the result of that effort. "We call [the i3] the battery electric vehicle 2.0 because it's not a conversion anymore; it's 100 percent designed for electromobility," says Walter, noting that many other recently released EVs, such as the popular Nissan LEAF, were built on the guts of a gas-powered counterpart; not so for the i3, which was designed and built from the ground up with electric drive in mind. "With [our other cars] it's an evolution direction, whereas with the i brand we go into the *revolutionary* direction," he says.

FROM CONCEPT TO REALITY

"We chose carbon fiber because for us it's the only lightweight material you can use in the automotive industry without any concessions to safety," says Manuel Sattig, BMW i series Project Manager. That said, it takes the right set of benefits—strength and safety gains, weight savings and efficiency improvements—for pricey carbon fiber to pay off. And so traditionally, smaller amounts of the material have been incorporated into parts on low-volume premium cars, like the Lamborghini, Porsche Spyder, and Chevrolet Corvette.

The i3, on the other hand, was carbon fiber for the masses. "When looking at carbon fiber, we had to take two separate actions: bring down the cost of the material and bring down the production cycle times for the material," Sattig explains. Harkening to the days when Ford manufactured its own steel for the Model T, BMW decided to produce carbon fiber itself—unusual in today's auto industry—in a joint venture with SGL Carbon SE.

"We set up a production chain going from the sourcing of the precursor material to the production of the carbon fiber itself and then the production of fabrics," says Sattig. At Moses Lake, ultra-thin filaments go through a series of heating and cooling ovens, where they gradually turn into a molecular chain link of carbon crystals, weighing half what they did at the start. These filaments are sprayed with epoxy and shipped to Germany where they get woven into flexible mats. Eventually, robots mold these fabrics into the pieces needed for the i3—130 in all, compared to around 400 for a steel-bodied car. Having a carbon-fiber passenger cell also eliminates the need for many bolts and screws, further reducing the car's weight. While bolts are needed elsewhere in the vehicle's body, "the whole car underwent a specific weight diet," says Sattig. "We looked at every screw, every bolt, every piece."

BMW calls this carbon-fiber skeleton the Life module. Meanwhile, an aluminum Drive module—the electric powertrain, plus crash-critical and other components—is built in parallel, and the two halves of the i3 come together at the end in Leipzig. This parallel process enables the speedy production BMW needs for the quasi-mainstream i3. In fact, BMW cut its self-reported production times on the i3 in half compared to its non-carbon-fiber, gas-powered 3 series.

That said, BMW has been tight-lipped about its actual annual production volume the i3 is initially ramping up to. Industry media have estimated 30,000 units per year, with the option of rapid expansion if demand warrants. That's a common mid-volume level, but short of the 50,000-or-more units necessary to truly reach high-volume production. The world's best-selling models are made at the biggest factories in hundreds of thousands per year.

PROOF IN THE PERFORMANCE

"Not only is carbon fiber new to the car, but the whole idea of a completely new architecture, a new production concept, a completely new drivetrain," says Sattig. "It's been a lot of hard work." That hard work has paid off in an exciting new vehicle.

Superficially, the i3 has four seats and a usable trunk space of around 200 liters, plus extra cargo space if the rear seats are folded down. But what's really notable are the performance specs. Because of the i3's carbon-fiber skeleton, the car weighs 600 to 1,200 pounds less than electric cars converted from a gas-powered vehicle frame, says Sattig, resulting in some peppy weight-loss-induced numbers. Compared to the Nissan LEAF, the i3's most relevant point of comparison, the i3 boasts a significantly more powerful engine that does 0 to 60 mph several seconds faster *plus* a one-third-longer range … all with a *smaller* battery pack (no small matter, given currently high battery costs). That's the power of designing an auto from the ground up around carbon fiber. We can likely expect even further gains as automotive designers ascend the learning curve for carbon-fiber-intensive vehicles.

"I got to throw it around," Motavalli says of his test drive, taking corners and driving fast, like the typical European driver. "It feels very fast and very sporty. It was a lot of fun to drive." RMI's Amory Lovins, after a recent test drive in Munich, concurs. "It in no way compromises the sportiness at the heart of BMW's brand," he says. "Two decades ago, I felt BMW was one of two automakers worldwide most likely to combine the engineering and strategic qualities needed to leapfrog to carbon-fiber electric cars. I'm thrilled they've now done it, and eager to see how it evolves next."

THE ROAD AHEAD

With the November 2013 European release of the i3 still fresh in everyone's minds—not to mention its 2014 release in the U.S. and East Asia—it's too soon to say where BMW will go with the i3 from here. But you can be sure there's more carbon fiber in the automaker's future, from the forthcoming i8 to some of its more traditional fueled models that will benefit from the i3's lessons.

There's also the bigger question of carbon fiber's place in the automotive industry and BMW's investment in the technology just may be the stamp of approval carbon fiber needs. "If such a huge company makes such a transformative change in the way it designs its vehicles, that testifies to how promising carbon fiber technology can be for the automotive industry," says Greg Rucks, a manager for Rocky Mountain Institute's transportation practice.

Images copyright BMW AG.

CATERING TO CUSTOMERS

It will take more than an automaker such as BMW investing in carbon fiber for the technology to become truly widespread in cars, however. There's still the issue of customer demand and adoption, not just of EVs, but of carbon-fiber-intensive autos.

"As long as the vehicles are as safe and functional as today's vehicles, most consumers won't care what material their vehicle is made of," says Rucks. "They will, however, notice the benefits of carbon fiber construction even if most are unaware of the material itself: greater fuel efficiency, quicker acceleration, and better safety ratings."

Those benefits are great, and BMW is further making sure that customers' transition from gas-powered autos to carbon-fiber-based electric vehicles like the i3 is as comfortable and seamless as possible, while alleviating common concerns such as range anxiety. For BMW, this is about more than making and selling cars. BMW i series customers get a shiny new performance car, yes, but they also get a holistic suite of mobility services. In tandem with the i3, BMW designed what it calls its 360 Electric Mobility Program. "Our focus is to break down those barriers to EV adoption so we can get the customers to understand that driving electric is an achievable means of transportation," says Robert Healey, BMW North America's EV Infrastructure Manager.

Connected vehicle technology estimates driving range, can shift into modes such as Eco Pro to conserve energy, and can help navigate to public charging stations, among other features. An i Remote smartphone app puts such data in the palm of drivers' hands when they're not behind the wheel. BMW offers gas-powered loaners for longer trips than the i3's range. The automaker facilitates installation of a Bosch level 2 in-home charger (for homeowners) or connecting with EV-friendly garage owners (for urban residents without their own parking space). BMW likewise gets new i3 owners signed up for access to Chargepoint's nationwide network of public charging stations, and offers a 10 percent discount with SolarCity for a residential solar PV installation for customers who want to charge their EV with rooftop renewable energy.

With a premier brand like BMW behind such a revolutionary vehicle, driving one can feel exhilarating. "We have tremendous admiration for what they've done," says Rucks. "It's a gratifying

leap towards the types of vehicle we envision for the future of the transportation industry." That future includes truly high-volume-production carbon-fiber-intensive autos. With the i3, it's one step closer to reality.

Wendee Nicole is a freelance writer whose work has appeared in Scientific American and Nature.

AUTOCOMPOSITES COMMERCIALIZIATION LAUNCHPAD

The Autocomposites Commercialization Launchpad (ACL) was created by RMI and industry partner Munro & Associates to advance the design, production, testing, and implementation of lightweight carbon fiber composite parts on mainstream vehicles by model year 2018. Eight major U.S. supply-chain companies are already signed on. The ACL's goal is to achieve high-speed production volume of at least 50,000 units per year, a target not yet achieved with carbon fiber composites in any industry anywhere in the world. By securing the first rope across the chasm between pilot-scale and commercial production, the ACL aims to enable a full-fledged bridge to the revolutionary ultralight vehicles at the heart of achieving an oil- and carbon-emissions-free transportation system by 2050.

WEB EXTRA

For more information on this topic visit: rmi.org/transportation

Taking a Stand

RMI UNVEILS BOLD GOALS TO DRIVE IMPACT, COMMITS TO SPEED, SCALE, AND ACCOUNTABILITY

Transforming global energy use to create a clean, prosperous, and secure energy future is an ambitious, vital undertaking—and our sole focus. It demands all our determination and expertise. To succeed, we must rapidly scale our impact—to "reinvent fire"—making the shift from fossil fuels to energy efficiency and renewables by 2050, if not sooner. We must move decisively. That's why we've established bold goals to achieve by 2025, with near-term milestones and actions to chart our progress and hold ourselves accountable. We welcome you on the journey with us. This is, in part, how we'll do it … over the next 1–2 years and beyond.

SOURCE U.S. ELECTRICITY RENEWABLY

The Impact

By 2025, we'll cut U.S. electricity use by 18 percent and nearly double renewables' share of generation from 16 to 30 percent compared to business as usual.

How We'll Do It

We will accelerate the transition from fossil fuels to renewables by fostering rapid evolution of the electricity system pushed by disruptive innovation. With regulators, utilities, and others we'll align incentives and create a fair electricity market to support a distributed energy future. Meanwhile, we'll implement strategies and business models for customer-sited technologies such as rooftop solar, so they cost less than incumbent central power supply.

What's Next

- Develop rate structures that reflect the benefits and costs of distributed energy resources and demonstrate them with at least one utility or regulatory commission
- Launch six Electricity Innovation Lab (e-Lab) projects, including collaborations with specific utilities and communities, to highlight the feasibility of high percentages of community-based renewables
- Create a solar development excellence center to lower the soft costs that now make up ~60 percent of solar PV installation costs
- Make low-cost solar financing a reality for far more customers by standardizing commercial PV credit screens, incorporating PV into real estate finance, and opening up finance to underserved markets
- Speed innovation and pioneer new approaches to optimized solar PV and other distributed energy applications, with at least 10,000 on- and off-grid installations each via collaborators

MAKE U.S. BUILDINGS SUPEREFFICIENT

The Impact

By 2025, we'll make one billion square feet of commercial building space 35 percent more efficient, influence the deep energy retrofit (>50 percent efficiency improvement) of billions more, and grow the buildings efficiency market from less than $10 billion per year to more than $25 billion.

How We'll Do It

We'll target four of the largest, most influential segments of the buildings market—major corporations, the General Services Administration, the Department of Defense, and activist cities—for deep and portfolio-wide retrofits. And we'll stimulate private capital investment in deep energy retrofits by getting owners and investors to consider more than energy cost savings alone and integrate the full set of deep retrofit values (DRV) into their decision making.

What's Next

- Building on our success taking the United States' biggest real estate manager, the General Services Administration, from 18 to 39 percent average retrofit energy efficiency improvement, bring the GSA further toward 50 percent efficiency gains on future retrofits
- Drive change in the owner-occupant sector, which accounts for 50 percent of all commercial buildings, including by training at least 10 top corporations how to incorporate DRV into real estate investment decision making and making DRV a required component of two real estate finance certification programs
- Get 20 or more leading real estate companies and 10 or more leading practitioners to adopt portfolio-wide energy strategies and perform deep energy retrofits on individual buildings
- Team with a major city (potentially Chicago) to drive breadth and depth of retrofits on major buildings, which represent half of total urban building energy use

03

TRANSFORM COMMUNITIES' ENERGY SYSTEMS

The Impact

By 2025, we will directly support communities representing 10 million people to plan and execute towards a clean, prosperous, and secure energy future; enable communities representing 40 million more people to do the same with RMI-developed tools and approaches; and see 700 university campuses substantially reduce their carbon footprint.

How We'll Do It

We'll improve neighborhoods, accelerate economic development, reduce traffic, improve building stock, and create a more resilient energy supply in communities by applying Reinventing Fire's cross-sector approach. And we will get over 100 large universities to reduce their carbon emissions by 50 percent, inspire 600 others to 25 percent reductions, and get 10 million students, faculty, and staff to cut their carbon footprint by at least 10 percent.

What's Next

- Obtain 60-percent-or-better carbon emission reduction commitments from four communities representing a total of at least one million people, and take active steps along an implementation pathway
- Develop a widely available package of tools and processes to make our approach to community energy system transformation replicable and scalable
- Partner with at least six university "leaders" to provide guidance, tools, processes, and know-how to get 100 other universities to commit to reduce their carbon emissions 50 percent
- Get Arizona State University, the nation's largest university, to adopt and act upon an action plan to achieve its climate neutrality target

04

REINVENT FIRE IN CHINA AND BEYOND

The Impact

By 2025, we'll ensure that a Reinventing Fire-like vision is adopted in countries totaling at least half the global population, with a goal of a 70 percent carbon emissions reduction over 2050 business as usual, starting with China, the world's largest carbon emitter.

How We'll Do It

We have already embarked on work with the Chinese central government and influential partners—Energy Research Institute, China Energy Group at Lawrence Berkeley National Laboratory, and Energy Foundation's China Sustainable Energy Group—to deliver a compelling alternative development path for the country.

What's Next

- Publish a technical report with the Chinese National Development and Reform Commission characterizing the maximum potential for energy efficiency and renewables to meet economic, environmental, and energy security needs
- Make policy recommendations that identify the key adjustments that enable China to capture the full potential of energy efficiency and renewable energy and which inform China's 13th Five-Year Plan
- Begin implementation of the Reinventing Fire plan alongside Chinese partners, pursuing key opportunities in the transportation, buildings, and industrial sectors
- Catalyze an automotive leapfrog, in which China's rapidly growing auto sector foregoes oil and incremental fuel economy improvements in favor of radical progress to electric vehicles

GERMINATING SEEDS OF CHANGE

Our targeted impacts in electricity, buildings, communities, and China form the core of RMI's commitments, but we don't stop there. To truly reinvent fire, we also must address transportation, industry, and product efficiency. That's where seeds come in—a set of early-stage projects with high potential for impact. They are exploratory in nature, akin to venture capital investing. We expect some to fail, but we also anticipate some will be incredibly successful.

Transforming Transportation: Vehicle Design and Use

To get the world off fossil fuels we must tackle oil, and for that, we need to transform transportation. To win the oil endgame, we plan to focus on the global auto industry and bring electrified and lightweight automobiles to a large production scale in both the U.S. and China (see Autocomposites Commercialization Launchpad, page 27). By 2025, we want to see one million cars with substantial carbon fiber parts in the U.S., and at least five million light, electrified mass-market city cars in China.

Making Islands Sustainable

In conjunction with the Carbon War Room, we plan to work with ten island nations to help them build resilient and sustainable energy systems, including taking one Caribbean island to 100 percent renewable energy within a decade. These islands will serve as templates of success impelling other islands to commit to transformation and engaging larger countries to act.

Getting Large Companies to Procure Renewable Energy

The commercial and industrial (C&I) sectors are responsible for about half of all primary energy use. We plan to get large C&I companies—including at least five Fortune 500 companies—to procure renewable energy by creating a renewables attainment resource center and scalable renewable supply solutions.

Increasing Product Efficiency

The products that plug into our walls consume more than 40 percent of the electricity consumed in U.S. buildings. We plan to cut the consumption of those energy-consuming products by one-third in U.S. homes and offices, demonstrating the value proposition to retailers and providing consumers with desirable efficient products.

Factor Ten Engineering

Our Factor Ten Engineering (10xE) initiative will help engineers, architects, and their clients apply RMI's whole-system design principles to achieve radical energy and resource efficiency in manufacturing processes, buildings, and vehicles, often at lower cost. We also intend to build this game changer into design pedagogy.

DRIVING IMPACT

These ambitious goals are designed to tackle the world's toughest energy challenges. From the U.S. to China to the rest of the world, we'll drastically cut carbon emissions to tackle climate change, unlock enormous economic opportunity, and make our energy systems clean, prosperous, and secure. This is our promise to ourselves, to you, and to the world. And as RMI's CEO Jules Kortenhorst explains in his introductory letter to this issue (page 4), "We at RMI stand behind our commitment to deliver impact."

China and seed images courtesy of Shutterstock. Community image courtesy of Visit Fort Collins by Ryan Burke.

WEB EXTRA

For more information on this topic visit: rmi.org

by Laurie Guevara-Stone

The High-Renewables Pathway

CARIBBEAN ISLANDS ARE ON THE ROAD TO A CLEAN ENERGY FUTURE

When it comes to the Caribbean islands, monikers like "tropical paradise" get thrown around a lot, and for good measure—warm water and air, sandy beaches, spectacular snorkeling and scuba diving, fresh seafood, a relaxed vibe. Full-time residents, though, know another reality: extremely costly retail electricity, dependence on fossil fuel imports, and vulnerability to climate change and the sea-level rise and increasingly severe tropical storms associated with it. It's these challenges—coupled with the Caribbean's abundant renewable resources, especially solar and wind—that make the region ripe for leading the way toward a clean energy future.

DEPENDENCE ON FOSSIL FUEL IMPORTS

Islands' smallness often means limited local fuel resources and, as a result, dependence on fuel imports. Since they may have no pipeline access for gas, and are too small to burn coal cost effectively, most islands burn costly liquid fuels, such as diesel or fuel oil. Those expensive imports take an economic toll. Oil imports cost up to 12 percent of GDP in Antigua and Barbuda, 13 percent in Grenada, and 14 percent in the Bahamas (the U.S. is currently at 1.3 percent). At the United Nations Sustainable Energy for All Conference, Barbados Prime Minister Freundel Stuart emphasized the negative effects these high prices have for island economies. "At the regional level we realize that high oil prices have severely affected Caribbean competitiveness, with a negative fiscal and macro-economic impact on our fragile economies."

In 2002, RMI's Amory Lovins addressed the Bahamas' Prime Minister and Cabinet at the pioneering renewably-powered campus of The Island School in impoverished South Eleuthera. At that time, the deeply indebted, government-owned Bahamas Electricity Corporation was sending 11 percent of GDP, or about a half-billion dollars a year, abroad for fuel and capital. That's the same fraction of GDP as today's earnings from financial services, the nation's second-biggest sector. The biggest, now about 60 percent of GDP and half the jobs, is tourism. Back in 2002, Lovins estimated that roughly a fourth of total tourist revenue was needed just to provide the nation's electricity. Oh, and did we mention that BEC lost money on every kWh it sold? It could probably have cut those losses by giving away efficient showerheads and light bulbs.

"Islands are challenged by the need to depend almost solely on costly fossil fuel imports to provide their energy supply," says RMI principal Karen Crofton. "Thus, islands are truly searching for a comprehensive solution that provides both a clean and secure energy future." For example, about 98 percent of St. Lucia's energy is imported oil, so in 2010, the government crafted a National Energy Policy to "create an enabling environment, both regulatory and institutional, for the introduction of indigenous renewable energy to the national energy mix, thus achieving greater energy security and independence."

Islands in the U.S. Virgin Islands are following St. Lucia's lead. In 2010, the USVI Water and Power Authority burned 2.6 million barrels of oil to generate electricity. The USVI, almost 100 percent reliant on imported oil for electricity and transportation, now has a target to reduce its fossil fuel dependence 60 percent from business-as-usual forecasts by 2025, largely via energy efficiency and renewable energy.

EXPENSIVE ELECTRICITY

All of that imported fossil fuel doesn't come cheaply. Due to the islands' cherished remoteness, fuel must be imported long distances, so most residents pay extremely high energy costs. While the cost of electricity in the continental United States averages $0.12 per kWh, in Hawaii it averages over $0.36, and in the U.S. Virgin Islands it's an astronomical $0.48–0.50.

Renewables easily compete with those high prices. A National Renewable Energy Laboratory study found the levelized cost of energy (LCOE) for windpower in the USVI would be in the range of just $0.07 to $0.30 per kWh. And recent installed projects on Aruba and Jamaica are getting windpower at an LCOE of $0.10–0.20 per kWh.

Those prices are one reason the Caribbean island of Anguilla has decided to switch to renewables. In 2012, electricity prices on the island, which relies completely on diesel, spiked to $0.63 per kilowatt-hour. With many families unable to pay their monthly bills, the Anguilla Electricity Company cut power to so many homes that the island seemed plunged into darkness. Now, an Anguilla Renewable Energy Office is spearheading a 10-year plan to make Anguilla energy-independent "built upon a solid and ever growing foundation of our own free, abundant, clean, and renewable energy resources—the wind and the sun," according to the island territory's official energy policy through 2020.

Images courtesy of Shutterstock.

RESILIENCE AND CLIMATE CHANGE VULNERABILITY

Adding insult to injury, burning the fossil fuels on which the islands depend is not only crippling their economies but threatening their very existence via climate change, including rising sea levels, saltwater infiltration into groundwater, and increasingly severe tropical storms.

While most islands aren't large enough to have a big direct impact on climate change, collectively they can demonstrate to the world that energy transformation is possible through repeatable, scalable projects. Which is exactly why the small island of Tokelau in the South Pacific, a colony of New Zealand, has gone 100 percent renewable with one megawatt of PV. At the Durban Climate Conference, Foua Toloa, then head of Tokelau's government, stated, "We stand to lose the most of any country in the world due to climate change… so leading the way by making the highest per person investment [in renewable energy] in the world is a message to the world to do something."

EMBRACING ABUNDANT LOCAL RENEWABLES

What the Caribbean lacks in local, affordable fossil fuels it more than makes up for in renewables. From the abundant sunshine that draws tourists to its islands' beaches to the famous trade winds, there is no lack of reliable sources of renewable energy. An NREL study of a potential wind site on St. Thomas (USVI), for example, found abundant opportunities for wind resources class 4 and above, the typical standard for wind of utility-scale quality. A recent report commissioned by the Inter-American Development Bank showed that Latin America and the Caribbean have enough renewable energy potential to cover their projected 2050 electricity needs 22 times over.

Having the resources is one thing, but taking advantage of them is quite another. "Although many SIDS [small island developing states] are energy deficient in conventional energy, limitless potential for renewable energy and energy efficiency resides in our countries," said Barbados Prime Minister Freundel Stuart. "The fundamental issue thus is how do we, as small island developing states with inherent structural problems and limited resources, convert this renewable energy potential into a tangible product that is accessible, affordable and adaptable?"

This is where the international partnership for Energy Development in Island Nations (EDIN) comes in. EDIN, founded by NREL, is a partnership of Iceland, New Zealand, and the United States. EDIN supports islands by helping them find the technology, financing, and policy solutions that allow them to tap into their renewable energy resources and also deploy energy efficiency measures. Besides helping the USVI with their energy goals, EDIN is currently working with Dominica and the Pacific Islands to reduce their dependence on imported fossil fuels.

"The comparatively small project sizes on islands can often hinder obtaining sufficient financing and competitive bids for project execution. However, by collaborating on solutions islands can still leverage the power of scale," notes RMI's Crofton.

PARTNERING WITH CARBON WAR ROOM

In early February, billionaire Sir Richard Branson announced that NRG Energy would build a microgrid combining solar, wind, storage, and other technologies to power his Necker Island in the BVI. The announcement came at Creating Climate Wealth (CCW), an event held on Necker and Moskito islands off the coast of Virgin Gorda. CCW kicked off the next phase of the Ten Island Challenge, an effort in which RMI is now partnering with the Carbon War Room to work with Caribbean islands to transition off fossil fuels onto renewable energy. The CCW workshop brought together more than 100 attendees from government, corporate, nonprofit, and international aid institutions.

Aruba was the first island to join Branson's Ten Island Challenge, pre-dating the February 2014 summit. Aruba's goal is to transition to 100 percent renewables by 2020. Currently a 10-turbine wind farm rated at 30 megawatts meets 20 percent of Aruba's electricity needs, and a second wind farm is in progress. "As an island, Aruba is particularly vulnerable to rapid changes in the price of fuel oil," according to Aruba Prime Minister Mike Eman. "So it makes great economic and security sense for us to rely to a greater degree on renewable energy and have more control over our destiny." Other islands in the Ten Island Challenge include the British Virgin Islands, St. Lucia, and Grenada.

In the wake of the CCW summit, a total of nine island ministers committed to move forward with project-based activity focused on transforming the energy sector in the Caribbean. RMI, for its part, will continue to support the efforts of Carbon War Room's Ten Island Challenge and others to attain a carbon-free Caribbean whose energy system is affordable, resilient, and environmentally sound.

"[Bringing] renewable energy to the region is the only assurance we have of preserving the Caribbean's beauty and prosperity for generations to come," wrote Branson during the event. By switching to renewable energy, islands reduce their reliance on imported fuels, keep money in the local economy, provide residents and guests with reliable power, and lower their carbon emissions—a win for the Caribbean … and the world.

Laurie Guevara-Stone is a writer/editor for RMI.

Extremely costly retail electricity, dependence on fossil fuel imports, and vulnerability to climate change—coupled with the Caribbean's abundant renewable resources, especially solar and wind—make the region ripe for leading the way toward a clean energy future.

Image courtesy of Shutterstock.

WEB EXTRA

For more information on this topic visit: rmi.org

by James Newcomb and Robert "Hutch" Hutchinson

It Takes a Village

MOVING BEYOND NET-ZERO BUILDINGS TO NET-ZERO DISTRICTS AND COMMUNITIES

In the past few years, net-zero buildings—those that produce as much (or more) clean energy on site as they use annually—have been gaining momentum. Once considered a crazy idea, they're now coming of age as a realistic goal for a building. More than 400 such buildings are documented globally, with about one-fourth in the U.S. and Canada. This growing number is encouraging, yet for comparison, there are more buildings on the Cornell University campus alone than there are net-zero buildings worldwide. (RMI is currently developing plans for just such a building for its own use, high in Colorado's mountains, and Amory Lovins expects his own house, which included RMI's headquarters for its first 18 years, to go net zero as well.)

LESSONS FROM SINGULAR BUILDINGS

Shooting for net-zero status—whether it's a realistically achievable goal or not—can galvanize creativity around a commendable, big, aggressive target. Recent projects illustrate five more key lessons for successfully reaching net-zero status for a building:

1. Double down on efficiency and plan for solar: In July 2013 the Packard Foundation announced results from the first year of operation of its headquarters building in Los Altos, CA. Extensive energy efficiency efforts reduced consumption to 46 percent *below* California's strict Title 24 standards, at 351 MWh for the year. That allowed solar PV to shine and take the building right through the net-zero ceiling, producing 418 MWh.

2. Learn, then repeat, repeat, repeat: The first try is invariably more costly than it need be, so finding a way to repeat very similar efforts many times creates huge scaling opportunities. Walgreens, the largest drug store chain in the nation, opened its first net-zero retail store in Evanston, IL, in November 2013. In addition to myriad energy efficiency gains, the store features two wind turbines, 850 solar panels, and a geothermal heat pump system. Thomas Connolly, Walgreens vice president of facilities development, said, "We are investing in a net-zero energy store so we can bring what we learn to our other new and existing stores."

3. Climate is not necessarily a barrier: Habitat for Humanity opened a new net-zero home in Minneapolis's cold climate in December 2013. The building's superinsulated building shell, triple-glazed windows, and R-100 ceiling insulation minimize energy use, while solar thermal and photovoltaic systems will provide more energy than the home consumes. Commercial housing developers like Shea Homes and De Young Properties have recently announced new offerings in multiple climate zones to test buyers' interest.

4. Might makes right: Though most completed net-zero buildings are small (as are most new buildings of any kind), the success of net-zero buildings like the Bullitt Foundation's new 52,000-square-foot building in Seattle, WA, and NREL's recently completed 220,000-square-foot office building in Golden, CO, illustrates that a bigger building has more, not fewer, options for achieving net-zero status.

5. Pesky plug loads: Designing and building a potentially net-zero building is one thing, but a remaining challenge is the humans inside and their tendency to plug in gadgets, ranging from computer servers to coffee pots to computers and smartphones. The Packard Foundation building's 67 MWh/y surplus was more than created by the nearly 90 MWh/y saved by RMI Senior Fellow Peter Rumsey's push on plug loads, saving 58 percent of their energy compared to a normal Energy Star list but at no extra cost.

NET-ZERO LAW AND ORDER

With net-zero buildings now a reality, building codes, standards, and certifications are evolving as well. The federal government has remained a leader in this space, with Executive Order 13514, signed in October 2009, requiring all new federal buildings entering the planning process in or after 2020 to be net zero by 2030. The Byron Rodgers Federal Building in Denver, CO, is on its way to that status. And the U.S. Army Corps of Engineers has been piloting net-zero buildings since 2011. It aims by 2030 to spread net-zero-energy, -water, and -waste designs to its installations worldwide, with important projects underway from Fort Bliss, TX, to the U.S. Military Academy at West Point, NY.

Meanwhile, California's revisions to Title 24 building standards establish ambitious new performance goals, requiring all new residential construction to be net-zero energy by 2020, and new commercial buildings by 2030. In addition, Governor Jerry Brown's new executive order requires state agencies to take measures towards achieving net-zero energy for 50 percent of the total floorspace of existing state buildings by 2025.

Another milestone was the Living Building Challenge's 2012 introduction of a rigorous net-zero energy building certification standard.

CALCULATING NET ZERO AND LEVERAGING THE GRID

No key U.S. net-zero buildings could be net zero without the electric grid—utilities accept surplus solar power from these buildings during the day and provide them with power at night or on cloudy days. Net-zero buildings don't typically operate fully off-grid, though many isolated older buildings have done so at extra cost with batteries.

Thus, net-zero and nearly-net-zero buildings present a challenge for utilities and regulators responsible for designing electricity rates. Under existing rate designs, net-zero buildings may pay nothing, or very little, for the services that electric utilities provide balancing the load. This is partly why California's public utilities commission defined net-zero energy to mean that the *net societal value* of grid electricity consumed vs. on-site renewable energy generated is positive (as determined by some complex accounting).

Elsewhere, utilities and regulators in multiple jurisdictions around the country are also looking at how electricity prices can better reflect the cost of serving net-zero customers and provide incentives for net-zero-energy buildings to minimize potential costs to the grid. Eventually, this may include charging customers for how heavily they use the grid's services at critical times, rather than just charging them for the amount of energy they use in a given period. Such changes could realign the incentives for net-zero design toward flattening their loads through better management of when energy is used, or perhaps through on-site storage.

TAPPING THE POWER OF COMM≠≠≠UNITIES

Going net zero one building at a time is a commendable goal, but as we've already begun to discuss, not without challenges, including accounting, the role of the utility, the potential for

Image courtesy of Shutterstock.

overbuild (sizing a single building's renewable generation to cover its peak load), and practical challenges unique to particular buildings.

Enter the biggest growing trend for net-zero energy planning and design: net-zero districts, campuses, and even entire communities.

Applying net-zero energy at a district or community level has several advantages. For instance, multi-building systems offer opportunities for taking advantage of diverse load shapes, heat requirements, and opportunities for renewable energy production. Just as automakers can meld many models' fuel economies into a fleet average, so too can net-zero districts and communities achieve net-zero status in aggregate even though some individual buildings may do better or worse.

So far, the nation's largest planned community designed to reach net-zero energy is West Village, a mixed-use campus neighborhood at the University of California, Davis. It's designed to ultimately house 3,000 students along with 500 staff and faculty families. The first phase is complete and has been occupied for more than a year, achieving 87 percent electrical self-sufficiency. Higher-than-expected demand from plug loads in some of the apartments, together with glitches in heat-pump water heater operations, accounted for the shortfall in meeting the net-zero goal in the first year, but West Village's managers are confident that they will do it. Even the results to date are inspirational.

Such larger-scale net-zero efforts are taking place at RMI as well. Our collaboration with energy service company Ameresco and Arizona State University is aiming to propel the nation's largest university to a net-zero carbon footprint—a tougher standard than net-zero energy—by 2025. It's the most aggressive large campus project in the country. Meanwhile, the city of Fort Collins, Colorado, also with help from RMI, has undertaken the development of FortZED, a zero-energy district encompassing much of the city's downtown business district and the Colorado State University campus.

MAKING NET-ZERO COMMUNITIES A REALITY

While the promise of net-zero communities is alluring, challenges remain. It may be easier in theory to design a net-zero district or community than to try to meet such a standard for each building individually, but it's not always possible. Existing electric utility regulations, for example, typically forbid neighbors from exchanging energy among themselves, blocking integrated community microgrid solutions that could offer a net-zero pathway.

Yet RMI's Electricity Innovation Lab (e-Lab) is working on that problem and others. In the end, opening the door to net-zero-energy communities could be a powerful way to enable the transition to a cleaner and more secure energy future.

James Newcomb and Robert "Hutch" Hutchinson are managing directors at RMI.

Image courtesy of SolarCity.

WEB EXTRA

For more information on this topic visit: rmi.org/buildings

Deep Retrofit Value

GOING BEYOND ENERGY SAVINGS

Investment in the construction of new green buildings and deep energy retrofits of existing buildings has traditionally been based on energy costs alone. But high-performance buildings generate far more value. Accounting for that value beyond energy savings in sustainable building projects can help drive far greater investment in energy efficiency.

For more information, download RMI's How To Calculate and Present Deep Retrofit Value: http://www.rmi.org/retrofit_depot_deepretrofitvalue

2317 Snowmass Creek Road
Snowmass, Colorado 81654
(970) 927-3851

Creating a clean, prosperous, and secure energy future™

About *Solutions Journal*
Solutions Journal is published, both in print and electronically, by Rocky Mountain Institute. Back issues of *Solutions Journal* and all RMI publications are available online at http://www.rmi.org.

About Rocky Mountain Institute
Rocky Mountain Institute (RMI) is an independent, nonpartisan, 501(c)(3) nonprofit organization. We drive the efficient and restorative use of resources to create a world thriving, verdant, and secure, for all, for ever.

Contact Us
2317 Snowmass Creek Road
Snowmass, Colorado 81654
(970) 927-3851

1820 Folsom Street
Boulder, Colorado 80302
(303) 245-1003

solutionsjournal@rmi.org | http://www.rmi.org