The Megapixel Kilowatt-Hour:
21st Century Electricity Pricing

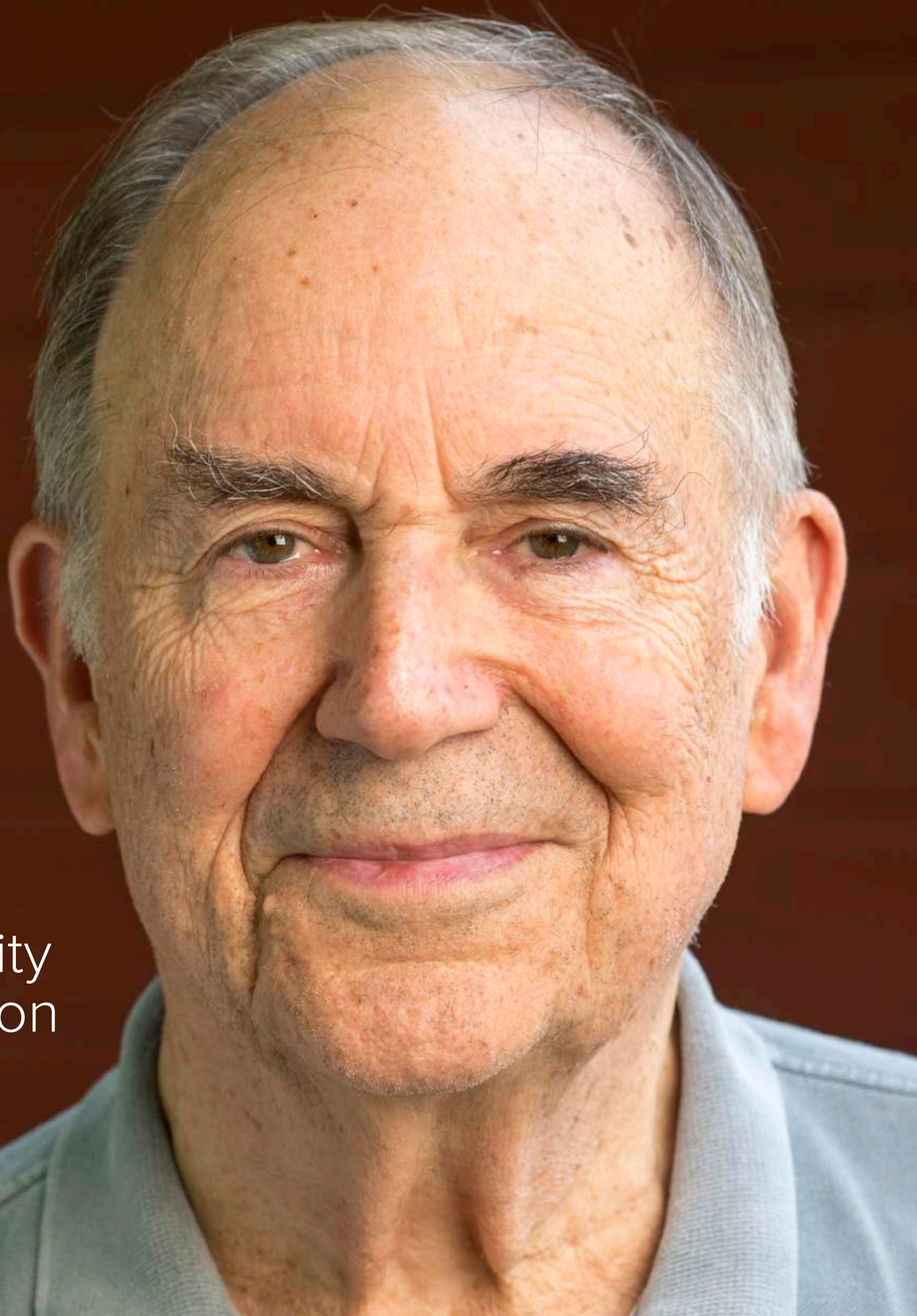
Making Efficiency Mainstream:
5 Top Real Estate Execs Weigh In

The Hypercar Lives:
Meet VW's XL1

Rocky Mountain Institute®

Solutions Journal

SUMMER 2014
VOL. 7 NO. 2



Boston Scientific's **John Abele** on Community Transformation

SUMMER 2014 / VOL. 7 NO. 2

COLUMNS & DEPARTMENTS

Transportation Buildings Industry Electricity General Energy

Electricity and buildings images courtesy of Shutterstock. XL1 image copyright Volkswagen of America.

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
Designer – Teressa Luedtke

by Jules Kortenhorst

The Energy Revolution is *Here*

We live in an exciting time. Yes, glaciers are melting, sea levels are rising, and in my new home in the Western United States, earlier snowmelts, longer summers, and hotter temperatures have made wildfires 400 percent more frequent. And yet, there are encouraging signs we are in the midst of an energy revolution that is sure to transform our climate, our economy, and our lives for the better.

Three trends in particular offer strong evidence: 1) the rapid and accelerating pace of renewable technology development, as shown by patent filings and product offerings, 2) the continued declining costs for those technologies, which makes them ever more economically competitive, and 3) the way that solutions are all combusting—so to speak—together through combinations that leverage the fuller potential of solutions, such as the combination of solar PV and battery storage.

ACCELERATING RENEWABLE TECHNOLOGY DEVELOPMENT

A 2013 study by MIT and Santa Fe Institute researchers found that between 1970 and 2009 energy-related filings accounted for a growing share of new patents, with renewable energy patents responsible for a dramatic increase in new energy patents overall. In the U.S., renewable energy patents increased from fewer than 200 annually prior to 2000 to more than 1,000 by 2009. Fossil-fuel patents, meanwhile, increased from about 100 per year to 300 over the same period. Since 2004, growth in solar and wind patents has been especially fierce, reaching respective 13 percent and 19 percent annual growth rates that match or exceed those of technologies such as semiconductors and digital communications, according to researchers.

And though global investment in clean energy fell for the second straight year, from a record high of $318 billion in 2011 to $254 billion in 2013, renewable-energy costs fell even more, so global capacity additions actually rose over the same two years. Other indicators remain strongly positive: for example, the NEX index—

which tracks clean energy companies worldwide—grew by 50 percent (far outperforming the general market), and equity raisings by quoted clean energy companies more than doubled, according to Bloomberg New Energy Finance (BNEF). For all clean-energy new build, BNEF forecasts 37 percent higher capacity additions in 2015 than in 2013 based on projects currently in the pipeline.

DECLINING COSTS

The cost for renewable technologies, meanwhile, is coming down rapidly. The cost of electricity from onshore wind facilities, after a decade of higher prices, is back to near historic lows and the *unsubsidized* levelized cost of energy for the most cost-effective new wind projects beats all forms of generation, fossil-fueled or otherwise, except efficiency. Solar PV modules have dropped in price by about 80 percent since 2008, with total installed cost for systems falling about 40 percent over that same period. And the cost of LED lights has fallen by more than 85 percent over the past five years, and battery storage costs have dropped by more than 40 percent.

Those cost declines, meanwhile, are spurring greater and greater adoption, driving costs even lower through scale and competition. In the decade from 2004 through 2013, global electricity generation from wind and solar PV grew 853 percent to 753 TWh, including 1,200-plus-percent growth in the U.S. Electric vehicle sales are scaling twice as fast as hybrid cars did at the same point in their respective histories since market introduction. And corporations are investing heavily in renewables. Global companies like IKEA, Google, Apple, Facebook, Salesforce, and Walmart have committed to 100 percent renewable power. Apple is operating the largest privately owned solar installation in the U.S. at one of its data centers. Facebook is building a wind farm to power one of its data centers with 100 percent wind energy. And Walmart is covering rooftop after rooftop of its stores with solar panels.

SYNERGISTIC SOLUTIONS

The most exciting thing, though, isn't the rapid pace of renewable technology development or the equally rapid decline in those technologies' costs or any other individual factor. It's the way myriad technologies and trends are converging to transform global energy use. For example, electric vehicles and their battery technology—and companies such as SolarCity and Tesla—are for the first time truly bridging the divide between the electricity and transportation sectors. Lithium-ion battery developments and price declines driven by the automotive sector are crossing over into stationary residential applications; clean solar power is providing an alternative to fossil fuels for cars that once burned only gasoline or diesel; and vehicle-to-grid technologies are offering firming capacity for variable renewables and ancillary grid services such as frequency regulation.

Nowhere do we perhaps see this synergistic effect more than with the combination of rooftop solar and battery storage. RMI's February 2014 *Economics of Grid Defection* report highlighted this disruptive opportunity resulting from the effectiveness of combining these two technologies. Earlier this summer, Barclays—in part citing RMI's analysis—downgraded the entire U.S. electricity sector, noting these burgeoning renewable technologies' combined risks for traditional utility business models.

A 2013 Department of Energy report analyzing the growth in solar, wind, electric vehicles, and LED lighting stated, "The trends in each sector show that the historic shift to a cleaner, more domestic, and more secure energy future is not some far away goal. We are living it, and it is gaining force." We hope you will join us in this exciting time, to be part of this historic shift, and help accelerate this critical transition. People say that an energy revolution is coming. We at RMI say the energy revolution is *here*.

by Amory Lovins

Energy Efficiency: The Secret Revolution

Michael Liebreich, chairman of Bloomberg New Energy Finance's advisory board, notes that the U.S. fracking revolution and the consequent 2004–13 rise in domestic oil output displaced oil imports equivalent to 10 percent of domestic consumption—while two little-noticed demand-side trends, less driving and more-efficient vehicles, saved *18 percent*, nearly twice as much. Drilling's impressive achievements were almost lapped by demand-side shifts. Yet hose saved barrels were nearly invisible because we can't see energy we don't use or buy.

Similarly, co2scorecard.org showed that in 2012, lower U.S. electric intensity—using less electricity to produce a dollar of real GDP—displaced nearly twice as much domestically burned coal as expanded natural gas use did. In that year, weather-adjusted electric intensity fell by an unprecedented 3.4 percent, saving 145 TWh (billion kilowatt-hours). In other words, saved electricity was six times the same year's 24-TWh rise in non-hydro renewable generation.

Moreover, natural gas additions didn't deliver some key benefits claimed for them. Price-driven switching of electric generation from coal to gas accounted for only about a tenth of the 2006–11 drop in U.S. carbon emissions. Moreover, much displaced coal was dumped into foreign markets, offsetting 173 percent of domestic carbon savings with overseas emissions. Separately, gas power's "collateral damage"—displacement of carbon-free generation—plus a conservative estimate of gas leakage meant that U.S. coal-to-gas switching has not yet reduced U.S. carbon emissions at all.

These examples reveal a yawning gap in our understanding and discussion of energy, due to gross inequality not in achievements but in microphones. With all due respect to the American Council for an Energy-Efficient Economy and the Alliance to Save Energy, energy savings lack an amplifier powerful enough to make their important signals audible over the supply-side hype, so efficiency continues to be underestimated or ignored. This omission makes governments and firms misallocate even more financial, physical, and political capital to costlier, slower, and less effective supply expansions. Reduced energy intensity could fuel about three times as much recent global economic growth as increased supply, but the supply industries own more like 99 percent of the message.

The International Energy Agency's pioneering *Energy Efficiency Market Report 2013* estimated that in 2011, the world invested up to $300 billion in energy efficiency, about as much as in fossil-fueled power generation. Yet this investment was probably understated, it had never before been estimated, its savings still aren't well measured, and vastly more efficiency remains available and worth buying.

Increased efficiency matters: lower consumption due to 1974–2010 drops in energy intensity was the largest single energy resource across the 11 IEA member countries' aggregate total final consumption—bigger than either oil or the *combined* contributions of gas, electricity, and coal. Had those 11 countries produced their 2010 GDP at their 1974 delivered energy intensities, they'd have used 65 percent more energy than they did. Reduced intensity has fueled half the world's growth in energy services since 1970—as much as all supply expansions. Who knew?

To be sure, not all the decreased intensity is due to more efficient lights, motors, appliances, building envelopes, vehicles, or industrial processes. Such technical improvements, says the same IEA report, caused about half of 1990–2010 intensity drops in the U.S., U.K., and the average IEA country. The rest came from changes in economic structure, such as producing more financial services and less steel, and a tiny bit came from behavior shifts. Thus the IEA ascribes nearly all of Spain's 1990–2010 drop in energy intensity to changes in its economic structure, but four-fifths of Germany's savings to greater technical efficiency. While American, German, and British energy intensity all fell by similar amounts during 1990–2012, *technical* efficiency improved much more in Germany.

Energy intensity sounds like a clear and simple metric, but actually it's fuzzed by different countries' size, economic structures, climates, behaviors, efficiencies, and definitions (such as whether one counts fuel used by international plane and ship travel). Even within a single country, intensity can fluctuate due to weather—the cold winter of 2013 raised it in the U.S.—and business cycles, because the least-efficient factories shut down first in a recession, exaggerating intensity drops, then return to service in a recovery, reducing them.

Such distortions can be avoided by comparing *physical* intensities, such as the energy or electricity used per square meter of floorspace per degree-day, or per unit of lighting service, or to produce a ton of cement or carry a ton-mile of truck freight. Unlike fuzzy GDP, such denominators are real, measurable, comparable, and meaningful.

But even though the primary or delivered energy used per unit of GDP is only a crude yardstick to be applied with caution, it's still a handy way to illustrate how energy savings can surprise—as we've already seen—in both size and cause. After the second oil shock in 1979, the U.S. cut energy use 10 percent in four years while GDP rose 11 percent. That saving, equivalent to a supply expansion of 11.8 quadrillion BTU per year, was 44 percent greater than the 2009–13 rise in oil and gas output.

U.S. Energy Intensity - Forecasts vs. Actual

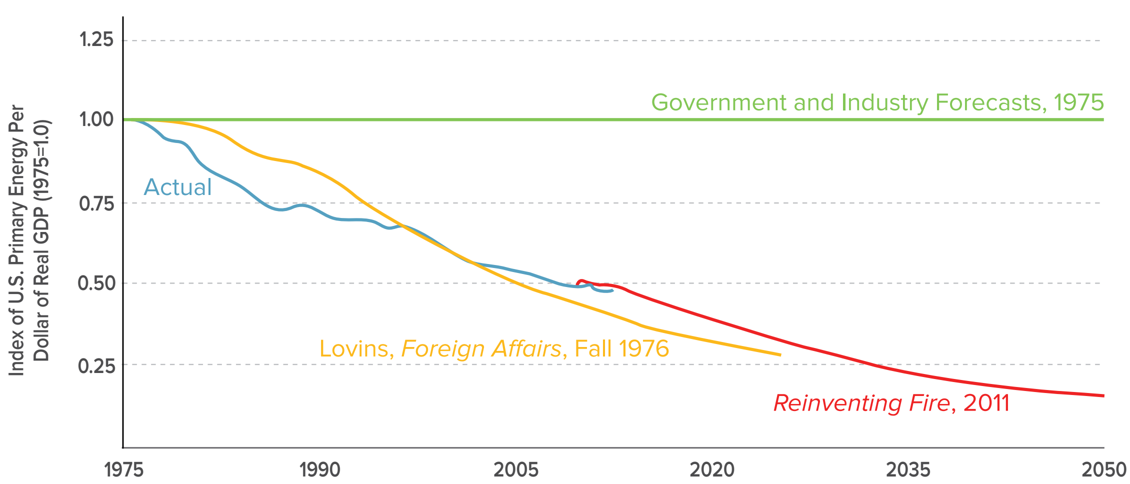


Image courtesy of Judy Hill Lovins.

In 1975, government and industry insisted the primary energy needed to make a dollar of real GDP could never go down: trying to break this supposed link would send us, we were told, back to caves and candles. I heretically suggested in a 1976 *Foreign Affairs* article that U.S. energy intensity could fall by two-thirds over the next 50 years. As the graph shows (see previous page), we've already cut energy intensity by more than half in 38 years. We're using less than half the energy (and emitting less than half the carbon) we would be if today's economy had 1975 energy intensities. But that's only a fraction of the savings now available and worthwhile.

RMI's *Reinventing Fire* showed that another two-thirds saving, tripling energy productivity, could be led by business for profit. Moreover, combining that tripled efficiency with a shift from one-tenth to three-fourths renewable supply (including 80 percent renewables for a half-distributed and highly resilient electricity system) could cost $5 trillion *less* in net present value (2009 $) than business-as-usual, conservatively counting all hidden or external costs at zero. Those efficiency-tripling improvements can use new technologies, designs, and financing, marketing, and delivery channels to achieve twice the total energy savings, at about a third the cost, that my 1976 *Foreign Affairs* article foresaw. The low-hanging efficiency fruit keeps growing faster than it's harvested.

Energy efficiency improves quality of life, delivering better services—comfort, mobility, visibility, information processing, cooking, smelting, whatever—with less energy, less money, and smarter technologies. Ever-better technology and design keep its scope growing and its cost falling, with no end in sight. So while the Carbon Tracker Initiative's *Unburnable Carbon* report emphasizes the size and cost of the world's fossil fuel reserves we can't burn for climatic reasons, a separate "carbon bubble" is unrelated to climate: fuels uncompetitive with the ever bigger and cheaper reserve of unbought zero-carbon "negawatts" (saved watts). Fuel sales are probably at greater risk from efficiency's competition than from regulators' mandates.

How low can we go in the efficiency limbo? Nobody knows—but we're far from any practical limit, and the frontiers keep expanding. Every gain in smart thermostats and superwindows, in LEDs and motors, in process equipment and computers, locks in more "negawatts" that further reduce our energy intensity.

Those energy savings bring a clean, prosperous, secure energy future steadily closer. They're not costly but profitable. Getting started takes intent focus on energy intensity—the biggest, cheapest, fastest, safest, least noticed, least understood, and still most underbought way to deliver the reliable energy services we need.

Amory B. Lovins is cofounder, chief scientist, and chairman emeritus of RMI. A version of this article previously appeared on Forbes.com.

by Laurie Guevara-Stone

RMI in Brief

NEWS FROM AROUND THE INSTITUTE

RMI WINS BLOOMBERG NEW ENERGY FINANCE AWARD

RMI's Business Renewables Center (BRC)—a program to significantly scale investment by Fortune 500 companies into sourcing renewable energy—was one of six winners at the Bloomberg New Energy Finance Summit's Finance for Resilience ("FiRe") event. FiRe identifies the best proposals to spur increased investment in renewables and scale them as quickly as possible. BRC will offer corporate decision makers one-stop shopping for renewables deal-making education, such as boot camps for senior executives, information resources including how-to guides and case studies, and transaction services and affordable access to top-tier experts. We expect the Center to promote more than $15 billion in new annual renewables investment by 2019.

REDUCING BATTERY BALANCE OF SYSTEM COSTS

Similar to our previous and ongoing solar balance of system (BoS) work, which looked beyond the solar panel in order to reduce the "soft costs" of solar PV systems, our newly launched battery BoS work (B-BoS) will explore how to lower the cost of battery storage installations by looking beyond the batteries themselves. Although battery costs are coming down and expected to continue their decline, reaching industry-established price targets won't happen if non-battery costs—such as permitting, power electronics, battery housing, and installation labor—do not also come down. Our B-BoS work will help make distributed battery energy storage systems more cost-effective faster and in more places, unlocking their potential—among other flexibility solutions—to empower customers, balance variable renewables, and provide a variety of values to the grid.

Image courtesy of Shutterstock.

EXCITING STEPS FOR REINVENTING FIRE: CHINA

In May, experts from RMI, China Energy Group at Lawrence Berkeley National Laboratory, and the Energy Research Institute of China met in Beijing for a series of feedback workshops with industry experts, including representatives from the Chinese Academy of Buildings Research, the Chinese Electric Power Research Institute, the Chinese Transportation Institute, and industry trade groups for metals, cement, chemicals, and building materials. Next we'll brief the National Development and Reform Commission on our findings for consideration in China's 13th Five-Year Plan and hold an "ultra-lightweighting" vehicle workshop with the Chinese Academy of Sciences and the Ministry of Science and Technology in the autumn focused on light- and medium-duty trucks and passenger vehicles. One of the project's senior advisors said that Reinventing Fire: China represents "the most successful U.S.-China energy collaboration he has yet seen."

DOCUMENTING RENEWABLES' GROWTH

RMI's micropower database documents global installed electric capacity and actual generation of all renewable energy systems (except large hydro) plus cogeneration. These modular, mass-produced generating technologies already create a quarter of the world's electricity today. The database, now newly updated through 2013, presents a clear, rigorous, and independent assessment of global renewables growth. The information is based on equipment counts reported by suppliers and operators, and includes both annual capacity additions and output and cumulative installed capacity.

To download the update, visit:
http://www.rmi.org/micropower-database

by John Abele
As told to Peter Bronski

The Strategic Philanthropist

BOSTON SCIENTIFIC CO-FOUNDER JOHN ABELE TALKS ABOUT WHY HE SUPPORTS RMI IN ITS EFFORTS TO TRANSFORM FORT COLLINS' ENERGY SYSTEM

Abele is a strategic philanthropist who demands benchmark and real-world results.

As the cofounder of Boston Scientific, John Abele helped build a $7 billion worldwide company that pioneered new medical devices and techniques, opening up the field of "less-invasive medicine" and saving countless patients' lives in the process. It's an approach he calls "for-profit philanthropy, " explaining that he "happens to have been involved in a for-profit company whose total mission was basically improving the quality of healthcare and reducing its cost."

From his support for the next generation of engineers, to biomass, to energy-efficient LED ventures, to the nearly-10,000-panel solar array on his farm, Abele's philanthropy and investments have been no less strategic. He's a savvy supporter of many environmental and social causes who demands benchmarks and real-world results.

That call for setting targets and delivering promised impact has played an important role in the evolution of RMI. A supporter since 2003 and board member since 2008—along with his daughter, Jeneye, president and CEO of the Abele family's Argosy Foundation and an RMI supporter since 2007—he's seen RMI grow and mature, for the first time establishing and publicly committing to bold goals and commitments to impact.

We spoke with Abele to talk about why he's believed in RMI for more than a decade, the challenges of community energy system transformation, and why he's so excited about RMI's work in the city of Fort Collins, Colorado. There we're helping the city realize its vision for a net-zero-energy district (FortZED) that generates as much clean energy locally as it uses and showed the city how it could accelerate its 80-percent emissions reduction climate target two decades from 2050 to 2030.

ON SOCIAL CHALLENGES

The whole concept of a large net-zero energy project has been floating out there for a while, including in Fort Collins, Colorado. But defining a goal is one thing—that's the easy part. How you get there is another.

It's primarily a social challenge of avoiding the tragedy of the commons. How do you get many different interest groups to give up something in the short term for everyone to gain a lot collectively in the long term? It's especially difficult getting everyone on board when you're trying to bring many parties together, some of whom don't inherently trust one another. It is a very complex problem that can look simple from the outside.

ON COLLABORATION AND WHY RMI

There will always be skeptics. One of the tasks is winning them over one by one. It all comes down to building trust in the process. If you want me on the landing, include me on the takeoff. Helping build that trust is one of RMI's strong suits. We convene people and create an environment in which collaboration is supported. You're trying to build a sense of trust among people by building confidence in the process.

RMI also thinks long term when others don't. How do you get everyone on board in a place like Fort Collins when you don't know how you're going to get there? RMI can be an honest broker in helping the community clarify goals, identify barriers, and strategize a practical plan to achieve those goals.

ON CREATING MODELS OF SUCCESS

Our national government, as we're acutely aware, is stalemated and almost proud of it. Meanwhile, cities are taking on—and they have for some time—the whole issue of energy use. The symbolism of a reasonably good-sized community like Fort Collins pulling this off with RMI's help is huge, especially if you can do it thoughtfully, in a way that keeps people on board. That gets me excited as a donor: the extent to which we can learn from this process and make it valuable for others.

ON RAISING ALL BOATS

It's not uncommon to see nonprofit and for-profit organizations come together on social challenges such as this. You might have an institute that advances the field with research that it shares broadly, protecting the commons by making information and even services available that expand everyone's horizons. This raises all boats.

Tesla is a good example, with the company's announcement of making its patents available to competitors. That might sound like giving things away, but it comes from enlightened self-interest. If we want more charging stations and cheaper batteries to grow the electric vehicle market, Tesla can't do that alone. It wants—and needs—outside help. In my mind, that's a great way to behave.

It comes down, as Amory and RMI love to say, to systems thinking, systems design, and looking at the big picture. That is the fascinating thing about RMI … the way it works across for-profit and nonprofit collaborators and applies systems thinking. Whether it's Walmart or the military, if they want more-efficient trucks that creates enough demand that you can build an entire industry around it, and everyone else benefits, too.

ON FORT COLLINS AND THE FUTURE

The same can be true in Fort Collins. The Fort Collins process is really a learning laboratory, one where sharing data will be critical, including admitting mistakes and understanding how to prevent them next time. Some people don't like to hear it expressed that way, but I'd argue that it's an honor. It's a great privilege to be a very early leader. Every resident can add value and have a sense of pride and ownership in the result.

Efforts that have broad community participation are more likely to last. Everybody has to buy into the change: residents, businesses, local politicians. You can't force that change from the outside, it must come from within the community and RMI has to know just how lightly or heavily to help that process. Along the way we've got to figure out solutions, but that's what RMI is good at.

WEB EXTRA

For more information on this topic visit: rmi.org

By Victor Olgyay

An Efficient, Sunny Family Retreat

RMI'S VICTOR OLGYAY TURNED HIS FAMILY'S 1950s RANCH INTO A COMFORTABLE, EFFICIENT HOME INFUSED WITH SOLAR-SMART DESIGN.

Solar thermal collectors on the lower roof and a solar PV array on the higher roof supply the home's hot water and electricity.

Humans are adaptable creatures. We'll stubbornly walk with a stone in our shoe, but are happier when we remove it. That certainly should be true with our homes. Rather than change ourselves to fit the home we get, we can adapt our homes to fit us better. Like a shoe, they can stretch to provide comfort, rather than force our feet to fit.

In 2004 my wife, Kristy, and I had our second daughter and bought a small 1950s ranch conveniently located in central Boulder, Colorado. We could walk to work, and our lot has a beautiful, mature hackberry tree on which we hung a swing. The house was cozy and as we lived in it, we gradually made it more so. We insulated and weatherstripped it. We planted a vegetable garden. We spent a couple hundred dollars on natural gas per year, and got itty-bitty annual electricity rebate checks from Xcel, our utility, thanks to a 4-kW solar PV system we put on the roof. The house felt like a good fit.

But as our children grew, we found our family needed more space. So in 2011, we took the plunge and renovated the house. We added a 900-square-foot second floor, nearly doubling the square footage from 1,200 to 2,100.

Since we were tearing up the place, it was an ideal time to do a few other performance upgrades. We switched out the existing double-pane, low-e windows (with terrible frames) for quad-pane, fiberglass-frame windows with an overall unit average of R9. We decreased our home's north-facing glass and increased it on the sunny south side. We calculated the overhangs to provide passive solar heating in the winter and shading in the summer. All the new windows are casements or awnings so they lock airtight when we want them to, and catch the wind when open for increased ventilation.

The average American home consumes ~10,800 kWh of electricity per year; between July last summer and June this summer, we consumed just 96 from our utility.

And we did a million other things. We reused as much of the old roof framing as possible, framing the upstairs walls with the 2x8 rafters, stuffing them with cellulose, and wrapping the whole house with two inches of rigid insulation to eliminate thermal bridges. The roof is framed with R40 SIPs. We used an ENERGY Star-rated light-colored roofing material, and local beetle-kill pine for all the soffits and trim.

So the house performs well, using about one-tenth the energy of a typical efficient house. But most importantly, once again it's a comfortable fit. It's 95 degrees Fahrenheit outside in Boulder as I write these words in midsummer, and inside the house it is 76 … and we have no AC. We open the windows at night and close them during the day.

Yet the true comfort is in how we use the house, and how it supports our lives. Our kids love the balcony over the living room; they can spy on the adults or fly airplanes down on unsuspecting targets. The community spaces—living room, play room, deck—gather us as a family, while private spaces let us take quiet time. The 1-watt LED lights built into the stair risers cast an amber glow on the adjacent wall, safely and satisfyingly identifying the steps. Their warm, low-color temperature and low light levels have the least amount of impact on sleep cycles and the body's melatonin production, allowing people to traverse at night with out triggering their brains to wake up any more than necessary. And the west side of the house, nestled under the shade of the big hackberry tree, is lousy for solar collection, but a great place to plant a green roof. With a view of the Rocky Mountains' foothills, our kids think it's the best room in the house. Architecture must support life first.

The rest of the roof, it collects rain and sun. We pulled off the existing 4-kW PV system during the renovation and reinstalled it after. We are still effectively net zero for electricity—the average American home consumes ~10,800 kWh of electricity per year; between July last summer and June this summer, we consumed just 96 from our utility. And because our house is significantly more airtight than it used to be, we decided to get rid of all combustion within the building envelope. No fireplace, no gas water heater, no carbon monoxide. We have an inexpensive electric water heater as back up, but most of our domestic hot water comes from the sun. We added a solar thermal system with three collectors yielding 90 kBtu/day average—enough for all our needs in the winter and more than enough in the summer, so we store the extra heat in our hot tub. Indulgent, but it makes our night.

Right-sized overhangs on the south side of the house keep the summer sun out of windows with passive solar design.

We still have much to do to make the house more efficient, including replacing our 15-year-old refrigerator and dishwasher. But in the meantime, we have fruit trees and a garden, and a home that's comfortable, efficient, and connected to nature. Our little 6,000-square-foot landscape is diversifying, encouraging more pollinators to visit, birds to spread seeds, and other ecosystem services to flourish. As a family we are adapting to environmental concerns, and slowly working to improve our individual and collective lives. Our home needs to fit us, and by doing so, it also better fits the planet.

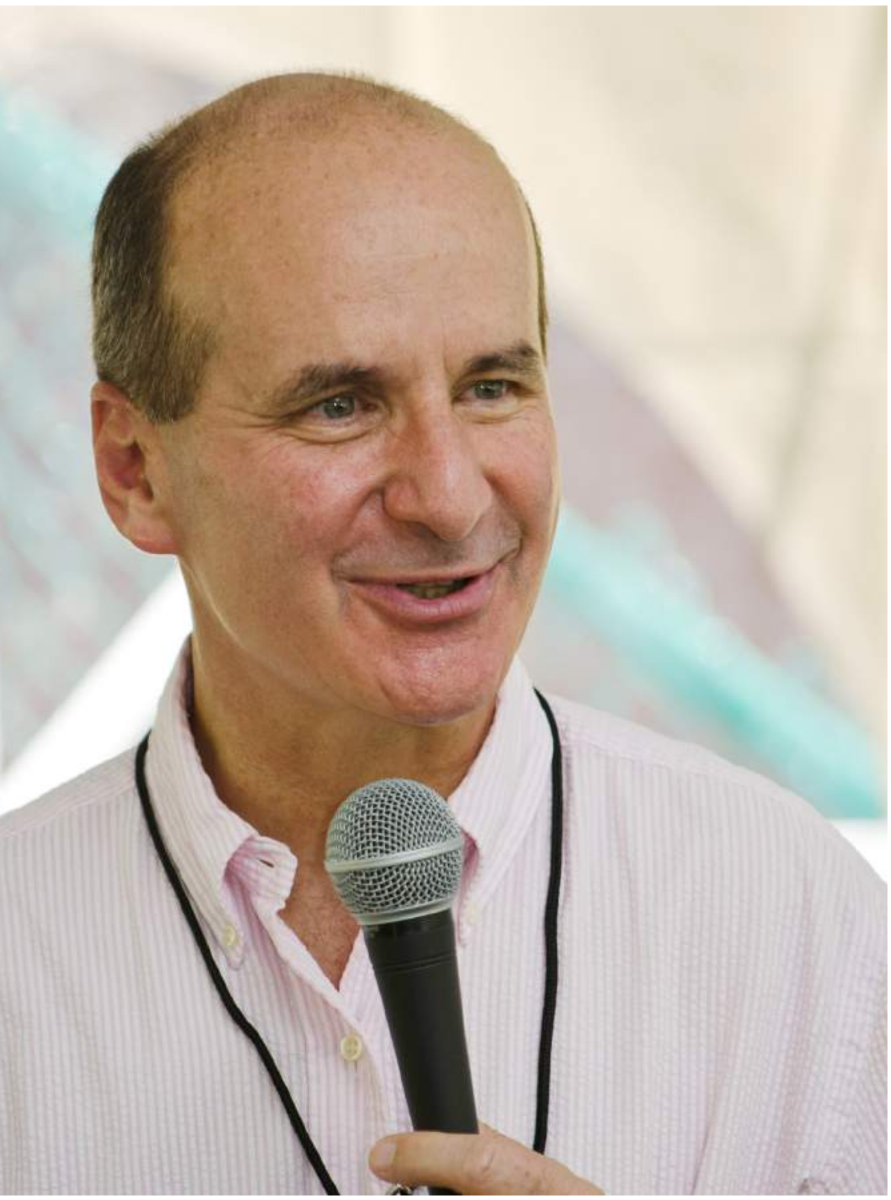
Victor Olgyay, AIA is a bioclimatic architect and a principal in RMI's buildings practice.

WEB EXTRA

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

On Low-Carbon Economies

FORMER COSTA RICAN PRESIDENT AND CARBON WAR ROOM HEAD JOSÉ MARÍA FIGUERES ON ISLANDS, CARBON, AND GLOBAL ENERGY USE



As the head of Sir Richard Branson's Carbon War Room, Figueres champions market-based energy solutions that drive gigaton-scale impact.

In 1994 at age 39, José María Figueres was elected president of Costa Rica, becoming the youngest president of a Central American country during modern times. A graduate of the United States Military Academy at West Point and Harvard University's John F. Kennedy School of Government, his administration focused on sustainable development. Since then, he has served as the chair of a United Nations taskforce, CEO of the World Economic Forum and then Concordia 21, and most recently president of Sir Richard Branson's nonprofit Carbon War Room. Fresh off travel through parts of Asia with RMI chief scientist Amory Lovins, we asked Figueres about the importance of working with islands, creating low-carbon economies, and how to accelerate transforming global energy use.

Rocky Mountain Institute: Like RMI CEO Jules Kortenhorst, your background spans business and government. Looking at today's energy and climate challenges, why are market-based solutions—even if bolstered by supportive governmental policies—so important for driving change?

José María Figueres: About 40 percent of global carbon emissions can be profitably avoided today within existing international agreements and national regulations by applying already-proven technologies. RMI and CWR are leaders in helping businesses realize this terrific market opportunity. As we get more capital to flow into financing the transition toward clean energy and lower carbon emissions, we can provide profitable example for others to follow and broaden understanding about these issues at the same time.

RMI: Looking at RMI and Carbon War Room's collaborative work together in the Caribbean, including the Creating Climate Wealth summit earlier this year, why is focusing on *islands so important, given their small contribution to climate change yet great vulnerability in the face of it?*

JMF: Working with islands to shift their energy base from fossil fuels to renewables is important for at least three reasons. First, it helps improve the quality of life for island residents, who are burdened with some of the highest electricity prices in the world. Second, such a transition creates jobs, investment possibilities, and entrepreneurial opportunities that render these islands—normally dependent on tourism for the overwhelming bulk of their economies—more competitive. And third, our work with islands can yield shining examples of a successful transition to lower-carbon, clean-energy economies using existing technologies. This will hopefully inspire others to follow in their footsteps, and not only on literal islands. After all, islands need not be surrounded by water. They can be an off-grid mine, a rural community, an isolated military installation, and much more.

RMI: What do you see as the most significant barriers that stand in the way of transforming global energy use? With renewables making an increasingly compelling economic case—garnering billions of dollars of global investment, while their costs keep declining, making that investment go further—how can we accelerate their adoption and topple incumbent fossil fuels?

JMF: There is nothing harder than changing cultural attitudes. Most of the world grew up on fossil fuels without thinking of their unintended consequences: increasing carbon emissions driving climate change. Now we must change our habits and practices, and do so within a ten- to fifteen-year window to avoid temperature changes from escalating beyond two degrees Celsius. This requires broadening our understanding with respect to the business opportunities it entails, strong leadership to change present business models, and public-private partnerships to make progress in the short time we have to act.

RMI and Carbon War Room are working together to help Caribbean islands transition to low-carbon, clean-energy economies.

Figueres image courtesy of Carbon War Room. Caribbean island image courtesy of Shutterstock.

RMI: Costa Rica, already known as an ecotourism hot spot and global leader in environmental stewardship, has set a goal to become carbon neutral by 2021. Your energy mix is already almost entirely renewable (mostly hydro plus some geothermal and wind), with an impressively small amount of fossil fuels. As the country embraces diversification with other renewables, such as solar in the Guanacaste region, what lessons can the rest of the world learn from your successes and challenges?

JMF: The first lesson is that renewables are profitable. Powered by renewables Costa Rica has successfully diversified its economy, with a very pronounced and competitive export-oriented bias. Secondly, we are living proof it can be done even among developing nations with scarcer economic resources than the developed world. Thirdly, our experience shows that systemic thinking in addressing these challenges is much better than a "silo" focus.

RMI: With China and the U.S. dominating global oil imports, fossil fuel consumption (especially coal), and carbon emissions, how do smaller countries such as Costa Rica and the Caribbean's island-nations perceive their place in that landscape?

JMF: Smaller nations face both a great challenge and a great opportunity. The challenge—and it's not an easy one to come to terms with—is that even if we do everything we can in the smaller nations and reduce our carbon footprint to zero, the world still needs China, the U.S., Brazil, India, and other large players to do more and move faster. The opportunity, though, is for smaller nations to set an example in the transition to low-carbon economies, which hopefully inspires others to follow. Then, the issue becomes one of scaling solutions, rather than proving them in the first place. Smaller nations can become early-adopters proving the case that paves the way for other major world energy powers to follow.

WEB EXTRA

For more information on this topic visit: rmi.org

By Todd Neff with Peter Bronski

Meet the Megapixel Kilowatt-Hour

FOR DECADES, CUSTOMERS HAVE PAID A FLAT, BUNDLED PER-kWh PRICE FOR ELECTRICITY. BUT A CHANGE TOWARD HIGHER-RESOLUTION PRICING COULD ACCELERATE AND OPTIMIZE DEPLOYMENT OF ROOFTOP SOLAR, ELECTRIC VEHICLES, AND OTHER DISTRIBUTED RESOURCES IN WAYS THAT CREATE GREATER VALUE FOR ALL, SAYS A NEW e⁻Lab REPORT.


T T H O U R S
Rr
WATTHOUR METER

June 3, 2014 was a sunny day in Denver. At 7:30 a.m., two hours after sunrise, the 13 solar panels on the east-facing aspect of my roof—installed by Sunrun in June 2010—were kicking out 1,575 watts. It was 67 degrees outside at the time. At 6:30 p.m., two hours before sunset in the west, the AC units on my neighborhood's houses were cranking in the 90-degree heat, spiking electricity demand from Xcel Energy, my local utility. My PV system's 64 watts of output, meanwhile, would have just managed to light an old-fashioned incandescent reading lamp.

It's there, amidst the 1.6 kW of morning output and 0.06 kW of afternoon output, that the panels on my roof help explain how electricity retail pricing models that grew and sustained a national electric-power infrastructure emanating from big, centralized power plants are poised to break down in a world of increasingly decentralized, customer-sited, renewable energy production.

Xcel charges residential customers an inclining block rate during the summer season. I pay 10.4 cents per kilowatt-hour for the first 500-kWh block and 15.6 cents per kWh after that. But these prices are only a rough approximation of Xcel's actual costs to produce and deliver electricity, and their bundled nature means they average lots of cost components behind a flat per-kWh rate: generation, transmission, and distribution infrastructure investment; fuel and other costs to operate the system; voltage and frequency regulation to keep the power grid humming at 120 V 60 Hz; corporate overhead costs; and much more. But at any point during the day or night—and in different locations throughout the distribution grid—Xcel's cost to deliver electrons (and the relative value my roof's PV system likewise offers) will deviate from the average. These deviations are an untapped source of opportunity for deployment of economic, low-carbon distributed resources.

For example, at 7:30 a.m. on that 67-degree June morning, the cost of supplying electricity is very low. But to feed all those air conditioners' ravenous appetites at 6:30 p.m. on a 90-degree summer evening, Xcel would have spent much more to deliver a given kWh of electricity, meeting that demand by calling on its more expensive and less-efficient natural gas peaking plants and independent power producers with the highest marginal costs.

On June 3, and on many other days, my roof overproduced in the morning, when Xcel didn't particularly need the electricity, and the house drew from the grid in the afternoon and evening to feed the AC beast when electricity was most expensive. But given that Denver can cloud up in the afternoon, to maximize the total amount of output from my system Sunrun had the panels installed only on the east side of my east-west facing roof. However, its 39-degree slope means that production bombs down a cliff mid-afternoon, just when the demands on Xcel's system start to skyrocket in the summer. Yet every kWh I produce or consume is credited at the same retail rate.

Thus the 1.6 kW my system pumped out in the morning had great value for me but relatively little for Xcel and the grid, while the 0.06 kW that trickled from my panels in the late afternoon did little to offset my air conditioner's demand at a time when Xcel was marshaling pricey generation

sources to meet a spiking load that would have been better served by comparatively cheap residential solar. "What you've got is a system that helps you individually and is not aligned with what society and the grid really need," says Owen Smith, a principal in RMI's electricity practice.

Jim Avery, senior vice president of power supply for progressive California utility and e-Lab member SDG&E, agrees. "If a solar customer tilts their panels 10 degrees further west, those panels will produce less energy but they'll do it at a time of day when it's more valuable," he explains. But without better price signals, such as time-of-day pricing that makes a solar kWh generated during afternoon peak more valuable than one generated in the morning—or even price signals in the first place—customers "are incented to do the wrong thing," Avery says. Today's rate designs, in other words, are an overly simple legacy of an earlier approach to how to provide and price energy. As consumer adoption of distributed resources increases, electricity prices will need to become more sophisticated and highly differentiated, reflecting various sources of costs and value in the electricity system. Eventually, prices will need to reflect two-way exchanges of value between customers and the grid. And a new e-Lab report, *Rate Design for the Distribution Edge*, offers some answers for how to achieve this transition.

THE GROWING NEED FOR HIGH-RESOLUTION RATE STRUCTURES

For the many decades over which utilities reliably and affordably produced electricity exclusively in big central plants, this approach worked fine because things did, in fact, average out. Flat per-kWh rates or inclining block rates (i.e., a lower per-kWh price for the first monthly chunk of consumption, then a higher price for the next chunk of consumption as an incentive for conservation and efficiency) once ruled the day.

But rooftop solar, smart thermostats, electric vehicles, batteries, efficiency, demand response, and other distributed energy resources (DERs) are changing that. Increasingly individualized electricity customers need more and better utility pricing options, so that customers, third-party resource developers, and utilities alike can invest in a 21st century grid that will deliver maximum benefit for all. Developing those options—akin to shifting from low-resolution to high-resolution images that have more and more information embedded in the big picture of kilowatt-hours generated, delivered, and consumed—has to start with adding sophistication and detail, even if the big picture looks largely the same for customers who don't "zoom in" close enough to see or appreciate the megapixel difference.

RMI's James Newcomb, a managing director of the electricity practice, and SDG&E's Avery agree: this seemingly simple, yet surprisingly complex, shift from block rates to more sophisticated pricing will be the most fundamental change in a century of utility business models. But that shift has tremendous potential to eventually enlist millions of electricity "prosumers" in helping to balance a dynamically changing electricity system, while making the grid more secure, adaptive, and self-healing. Some of this has already happened for big commercial and industrial customers whose bills already reflect far more detail than the average residential customer like you and me. Such high-resolution pricing—and the DER adoption it could enable—can unlock great value for residential and small commercial customers, utilities, and society.

For example, in Southern California peak demand hits the electric grid from late afternoon into early evening, when people return home from work, turn on their air conditioning, cook dinner, and settle in to watch a night of television. Avery calls these customers "energy hogs"—they're a good approximation of the kind of customer that has no incentive to change under "old" block, bundled prices. SDG&E has to plan for and size its infrastructure capacity not only to deliver the necessary electricity to customers like these but also to meet the size of the spike during peak demand. "Utilities design and build their whole system for the highest-demand hour of the year," explains RMI's Smith. "Yet prevailing rate structures—except, to some limited degree, those utilities that offer time-of-use pricing—don't give customers any indication that those peak periods drive a substantial portion of system costs." Adds Avery: "Customers have a perverse incentive to save energy but not capacity. *When* they use energy is critically important to the grid."

Now consider another type of customer: an energy-savvy one with an electric vehicle they charge overnight, one that precools their house prior to system peak, one with west-facing solar panels on the roof, one with an efficient home and maybe a smart thermostat that communicates with the grid. A customer like that will use the same or less

Image courtesy of Shutterstock.

Developing options—akin to shifting from low-resolution to high-resolution images that have more and more information embedded in the big picture of kilowatt-hours—starts with adding sophistication and detail, even if the big picture looks largely the same for customers who don't "zoom in" close enough to see or appreciate the megapixel difference.

energy than the earlier example, but importantly they also will have shifted that same load to other times of the day and night. "We have to build our electricity system to serve the energy hogs," says Avery. "But in reality, we'd need a much smaller system to serve [energy-savvy customers]."

A more modest grid with a smoother, less "peaky" load curve is good for everyone. For one, it uses assets more efficiently. Utilities like SDG&E essentially size the capacity of their system to meet peak demand, but a growing contrast between the amplitude of that peak spike and customers' overall energy needs means that much expensive grid infrastructure basically sits idle a good portion of the time. To wit, SDG&E's load factor—more or less the degree of utilization of its assets—has steadily been going down. Meanwhile, accelerating customer adoption of clean distributed energy resources such as rooftop solar helps to reduce the carbon intensity of electricity generation. For example, SDG&E's grid mix has gone from less than 0.5 percent renewables a decade ago to 23 percent for 2013. Better price signals—enabled by more sophisticated electricity prices—can unlock far greater gains. "Distributed energy resource adoption is growing rapidly," Smith says. "Better price signals can better direct that investment, so that instead of haphazard adoption—with solar panels showing up on the east-facing aspects of roofs—we can build a more optimal overall system that lowers cost, improves reliability, and decreases carbon intensity through clean, distributed renewables."

WHAT COULD A MEGAPIXEL KILOWATT-HOUR LOOK LIKE?

The grid is no longer a one-way street from power plant to customer. DERs make the grid a two-way exchange, and we need rate structures to reflect that. But how? *Rate Design for the Distribution Edge* advocates increasing rate sophistication in three arenas, differentiating: a) by the time of day or night at which a kWh is produced or consumed, b) according to the geographical location in the distribution grid where that production or consumption takes place, and c) through an approach known as attribute-based pricing that unbundles the various components that make up a kilowatt-hour.

While the most extreme form of such changes aren't realistic in the foreseeable future, many valuable shifts could take place now or soon. Expanded time-of-use pricing could honor the system's demand curve over the course of day and night, charging more during high-demand periods and less off peak. Demand charges, a form of attribute-based pricing, could put a price on the size and steepness of a customer's spike, incenting them to smooth out their curve by consuming at other times, such as through energy management software. And utility price signals could give credit to customers with DERs that help to alleviate "hot spots" in the grid where the electric distribution system is getting too congested.

In my case, Xcel might pay less for my morning electrons, but then pay handsomely for my shaving of peak demand in the late afternoon. Panels would appear on western-facing aspects of roofs. A given system might generate more or less, but it would generate more wisely. Longer-term, attribute-based pricing would nudge utilities into considering DER's not as rounding errors around the fringes, but as central elements of long-term resource plans, Smith and colleagues say. These incentives and disincentives would change behaviors and change the grid for the better.

You can see a window into that better future if you know where to look. In Texas, for example, utility Austin Energy conducted a pilot program called Rush Hour Rewards, using Nest thermostats to create a residential demand response program that could give economic signals for customers (financial savings!) to shift their load and reduce peak demand on the grid. The result? An astounding 50-plus-percent decrease in air conditioner run time during peak demand.

Win-win outcomes like that are just the tip of the iceberg. Google and others see great business opportunities—both for themselves as commercial customers and also as enablers of residential consumers. A future of attribute-based pricing can usher in an entirely new era for the electric grid.

ARE CONSUMERS READY FOR HIGH-RESOLUTION RATES?

For customers used to a simple utility bill and a straightforward, flat per-kWh electricity price, a jump directly to fully unbundled attribute-based pricing could be an abrupt—and complex—bill to swallow. That's why Smith and his coauthors on the new report, Matt Lehrman and Devi Glick, describe a deliberate, gradual transition that slowly shifts the default pricing option toward greater sophistication over time, allowing options for even more sophistication for those that need it, and preserving simpler options for those that want it. Smith and colleagues recognize this won't be an overnight revolution, but contend that significant portions of the country—especially those areas that have deployed advanced metering—can make substantial progress within just a few years.

Plus, SDG&E's Avery argues that today's utility customers are much more energy aware and savvy than customers of even a decade or two ago. "People talk about the notion that the customer will never understand, never embrace, this sort of complexity," he says. "But the fact is that an unbundling of charges exists already in so much of our lives today: airline tickets, cell phones. It's customary, especially for the younger generation, to look at the services they're paying for and evaluate the best option. I have two girls; they're part of a new generation who want to use energy wisely.

Even so, that doesn't mean unnecessary rate sophistication. Software, technology, and other solutions can maintain necessary behind-the-scenes complexity for grid operators while keeping a simplified experience for customers. For example, a smartphone app connected to an electric vehicle can "know" to start and stop charging the car when electricity prices rise or fall above and below predetermined thresholds.

There is tremendous latent potential sitting out there in the grid, just waiting to be tapped—by residential customers, third-party providers, utilities. But for now, that potential is masked behind the blunt instrument that is block pricing. Adding higher resolution to electricity pricing—by honoring the time- and location-based aspects of electricity generation and consumption, and through unbundling the kWh package via attribute-based pricing—can unlock that potential.

But will utilities and regulators move? "Unfortunately, we're an industry that tends to react to problems instead of proactively addressing them," Avery says. "Utilities need to prepare for the future. We should not be thinking of the way we did business in the past. You need to provide options for customers—by unbundling utility services—so they can buy the product they need." The new *Rate Design for the Distribution Edge* e-Lab report and the work of e-Lab's members are taking important steps in that direction.

Getting there from here won't necessarily be easy. "Regulators will need vision, courage, and persistence to make this transition," says RMI's Newcomb. "But it's essential work to transform the electricity system to a more distributed model."

For those in the business, it's an exciting time. "Unbundled pricing is the key pathway to unlocking new value pools for service providers, which now include not just the utilities but DER-enabled customers and third-party providers," says Newcomb. "Industries have inflection points of dramatic change. For the electricity industry, this is it."

Todd Neff is a freelance writer who specializes in covering energy and climate. Peter Bronski is the editorial director of RMI and contributed reporting to this story.

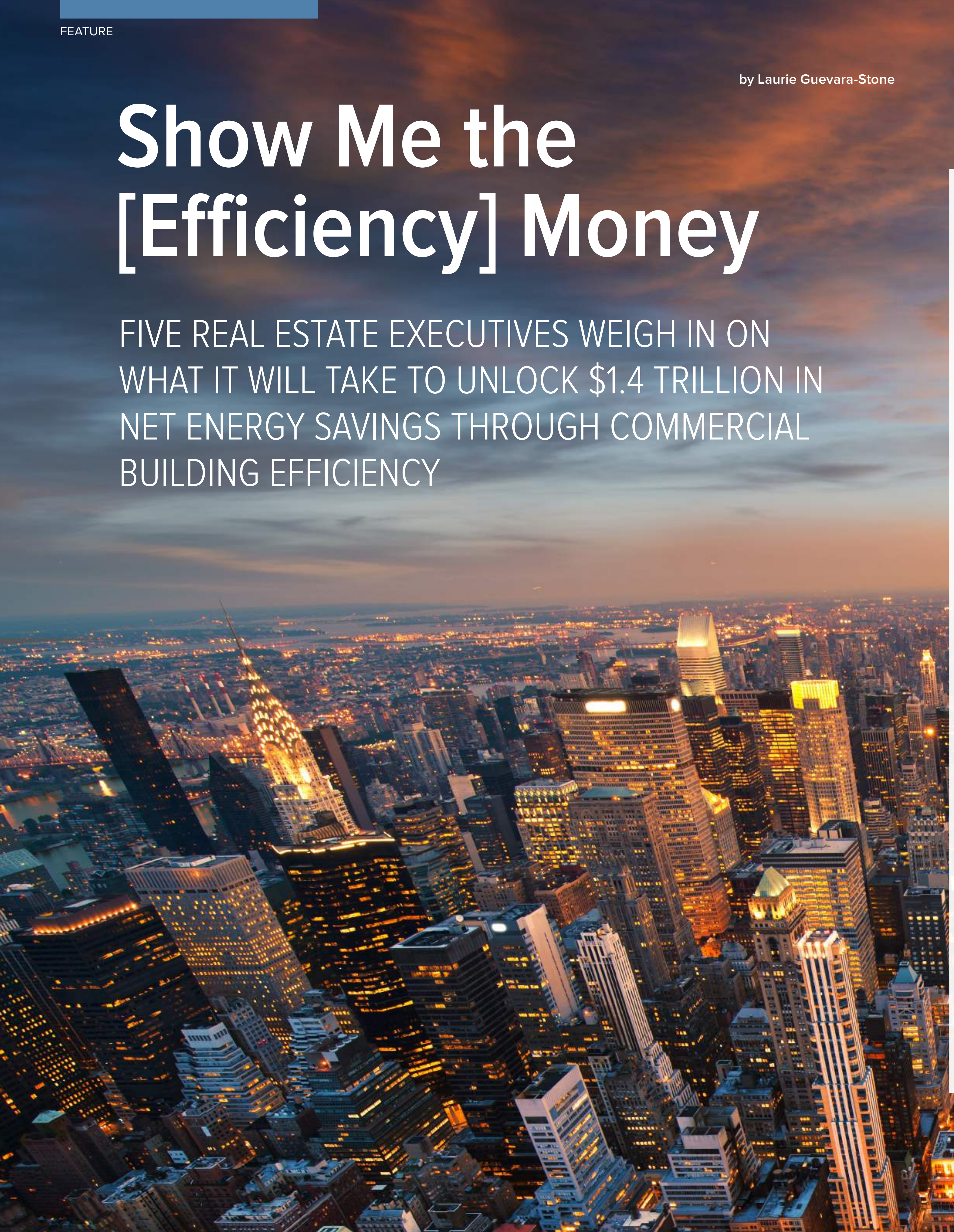
WEB EXTRA

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

by Laurie Guevara-Stone

Show Me the [Efficiency] Money

FIVE REAL ESTATE EXECUTIVES WEIGH IN ON WHAT IT WILL TAKE TO UNLOCK $1.4 TRILLION IN NET ENERGY SAVINGS THROUGH COMMERCIAL BUILDING EFFICIENCY



RMI's *Reinventing Fire* analysis shows how to tap into $1.9 trillion in saved energy costs in U.S. buildings through 2050, from an incremental investment of $0.5 trillion (both in present-valued 2009 $). En route, we plan to make one billion square feet of commercial space at least 35 percent more efficient and grow the buildings-efficiency market from less than $10 billion to more than $25 billion per year by 2025.

But what will it take to get there from here? We asked five top real estate executives two questions:

1. In your opinion, what needs to happen for energy efficiency to become mainstream in U.S. commercial buildings?

2. And how can we get to deeper levels of energy efficiency in markets where commercial buildings have already grabbed the low-hanging efficiency fruit?

This is what they said.

CLAY NESLER

VICE PRESIDENT, GLOBAL ENERGY AND SUSTAINABILITY, JOHNSON CONTROLS

There are two important factors to address: timing and financing.

As RMI has written about in the past, it's very hard to get commercial building owners to invest in efficiency improvements out of cycle. These interventions need to be done during critical times in a building's life cycle, such as when it's being acquired, undergoing renovations, or being refinanced.

An opportunity for investor-owned buildings is to identify energy-efficiency opportunities during the purchase due diligence period. Many portfolio asset managers take a year or more after acquisition to perform an energy audit and develop a business case for energy-efficiency improvements. At this point, with only a few years left in the portfolio, only improvements with very short payback periods are considered. There are a number of new virtual audit tools that use advanced analytics to identify energy-efficiency improvement opportunities and produce a preliminary business case, even before the building is acquired.

The other critical factor for commercial energy-efficiency projects is financing models. Commercial buildings are usually owned by limited liability corporations (LLCs) that have difficulty securing credit. Many have lease structures that do not properly align the financial investments and returns between the building owners and tenants. We are big fans of financing structures like property assessed clean energy (PACE) financing that tie the funding to the property instead of the building owner, allowing loans to be transferred to new owners. PACE also allows costs and savings to be passed on to tenants in an equitable way, even with traditional leases.

Another key driver is the trend towards energy-efficient tenant spaces. We are working with the Natural Resources Defense Council (NRDC) on a project to demonstrate the attractive business case and energy savings opportunities for high-performance tenant spaces, especially when built out in high-performance buildings.

Buildings image courtesy of Shutterstock. Nesler image courtesy of the subject.

ANGELA CAIN

CEO, CORENET GLOBAL

Building owners and tenants need to see and experience the financial rewards of energy efficiency. Once a building owner sees that converting to energy-efficient lighting reduces utility bills, and that demand-side power management also yields significant savings, the movement will become mainstream. I think this is already happening.

According to the Association of Energy Services Professionals, the large-scale commercial and industrial building sector is poised for the greatest amount of growth in energy efficiency, compared to small buildings and residential. The Building Technologies Office of the EPA has several programs under way and is working well with the commercial sector in enhancing efficiency. And utilities all over the world have incentive-based programs for businesses as well as homeowners. At CoreNet Global, we are encouraging all of our members to institute energy-efficiency programs.

The guide to energy-efficient retrofits that CoreNet Global is developing with RMI is a great example of how to get to even deeper levels of efficiency. I think for building owners to go beyond the "low-hanging efficiency fruit," they must employ the technologies and make the investments into converting older buildings. This too will become mainstream, but it will take time. Today, even though it's mandated by federal law, we wouldn't think twice about making sure that either an old or new building is ADA compliant. The same mindset will establish itself with respect to energy efficiency.

The key again is to make it a revenue issue. We've made great progress as an industry with sustainable building design, of which we are extremely proud. But energy efficiency, more than being a best practice for the sake of the environment and the power grid, really does generate measurable financial gains. Once companies see this, the movement will become mainstream.

DAVID DEVOS

VP, GLOBAL DIRECTOR OF SUSTAINABILITY, PRUDENTIAL

The big driver is to understand the financial advantages of energy efficiency, which can only happen with benchmarking. In order to put together a pro forma or financial analysis of energy efficiency, we need to know where we are today and where we need to go tomorrow. We just finished benchmarking 780 of our buildings in 17 countries. That process is critical to evaluating the financial opportunity of energy-efficiency measures.

It's also important to try to stay ahead of the regulatory concerns and risks. Reporting requirements are growing rapidly, making it easier to collect data and benchmark. For example, we received energy data from 60 industrial properties, compared to zero beforehand, after the passing of California's Mandatory Energy Benchmarking and Disclosure Bill (AB 1103). The challenge is the variety of regulations that are out there. Each state is different. A national standard or protocol would be extremely helpful for portfolio owners.

The real issue is to make it easy for the average building operator to understand energy efficiency's financial benefits. Certain things, like a lighting retrofit, are straightforward, but when you get into deeper retrofits the calculations are much tougher. The real estate industry doesn't often factor in the "softer" benefits of efficiency—whether productivity, health, or tenant satisfaction. They drive building value but are extremely difficult to calculate. We know that by investing in energy efficiency we will have other financial gains, but the hard part is quantifying them.

The bottom line for us is our fiduciary responsibility. If we're investing on behalf of people's retirement money, we have to show that the bottom line will be better. So our first target is to improve the financial performance of buildings. But I'm confident that if we improve the energy efficiency of buildings, we are not only gaining environmental benefits, but improving the financial bottom line as well.

ANTHONY MALKIN

CHAIRMAN, CEO, AND PRESIDENT, EMPIRE STATE REALTY TRUST

The biggest driver to scale efficiency is to work with tenants. Unlike whole-building retrofits, people are building out tenant space all the time. And in a typical urban office building, the tenants use 60 percent or more of the building's energy. This brings us to the hurdle of the split incentive. Landlords wonder why they should spend money on things in which the tenant will profit. We have addressed this in our high-performance tenant demonstration project. We work with the same process that we use for whole office buildings, and we make that applicable to individual office spaces. This way we can demonstrate to tenants that they can get the same investment and return by designing their spaces to be efficient.

However, in order for tenants' spaces to be efficient, they need a central building energy management system. Buildings without a central energy management system will be at a disadvantage when it comes to making the determination for the tenants to invest. This is a big incentive for building owners to invest in central building energy management systems. It puts the actual incentives for efficiency investment in individual offices in the tenant's hands, and the investment incentives for the whole building in the landlord's hands.

The most important way to drive energy efficiency is to show the numbers work. When you can point to proven replicable models with economically justified energy savings, others will follow. When you can document investment and return, and get the word out that investment in efficiency yields returns, more people will buy into it. So the key driver is setting up a replicable program, executing, documenting, monitoring, verifying, and educating people when they go to spend money, on a better way to spend money based on economic returns.

RAME HEMSTREET

DIRECTOR OF ENERGY, KAISER PEMANENTE

Here in California energy efficiency is mainstream in commercial buildings. Not only is it required by the building code, but also most large real estate owners, ourselves included, recognize we improve our bottom line by paying for energy efficiency.

One of the most important things to do in existing buildings is retrocommissioning, and then constant commissioning from that point on, which is becoming cost effective due to the IT revolution. We integrate all our building management systems and create a constant commissioning program. If anything goes out of parameters it's immediately recognized and reacted to, rather than having to wait for a utility bill. Once you have that capability, you discover all sorts of things about your buildings you didn't know before. That's the easy part. The hard part is establishing the capability and protocols of how to react to different situations.

In new construction we are pursuing a number of measures to make our hospitals 20–50 percent more efficient than the norm. For instance, we are utilizing active chilled beams and trigeneration (combined cooling, heat, and power, or CCHP) in our newest hospital, currently under construction, and we require LEED Gold certification for all new facilities. We are also exploring the potential for natural ventilation to improve both energy efficiency and indoor air quality.

There are two ways to get more portfolio owners to perform constant commissioning of their buildings. One is through the regulatory process. In California the code moves us in that direction: we will get to net-zero energy for commercial buildings by 2030. The other way is to present case studies that prove there is a return on investment. Investing in constant commissioning and energy-efficiency measures has an excellent return.

WEB EXTRA

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

By Peter Bronski

The Hypercar Lives: Meet VW's XL1


XL1

RMI FOLLOWERS AND AUTO BUFFS OFTEN ASK, 'WHAT HAPPENED TO THE HYPERCAR?' WITH THE RELEASE OF VW'S IMPRESSIVELY FUEL-EFFICIENT AND STRIKINGLY SIMILAR XL1, THE WORLD NOW HAS AN ANSWER.

When VW released the European fuel economy ratings for its new, limited-production XL1 passenger car last summer, you could almost hear the automotive world's collective jaw drop. The XL1 came in at a staggering 313 miles per Imperial gallon of diesel. That's the efficiency equivalent of more than 230 miles per U.S. gallon of gasoline. At a time when the 2014 model of the most popular-selling vehicle in the United States for more than three decades—Ford's F-150 pickup truck—gets an EPA-rated 23 mpg highway, and the average for all model year 2013 light-duty vehicles sold in the U.S. was just 24.6 mpg, VW had moved the decimal point an entire place to the right.

ENGINEERING LEADERSHIP AND PLATFORM FITNESS

The XL1 is named for its engineering goal: develop a production car that can drive 100 kilometers on 1 liter of fuel (235 miles per U.S. gallon). That was the charge in 1999 to VW engineers by the company's visionary then-chairman, Ferdinand Piëch, who is Ferdinand Porsche's grandson and chair of VW's supervisory board today. "We built the Bugatti and now the XL1," says Mark Gillies, manager of product and technology communications for VW of America. "Both use extreme technology to achieve almost opposite ends of the [performance] spectrum."

The XL1's tiny 2.6-gallon diesel-fuel tank can fuel average driving for more than 310 miles, thanks to a combination of strategies that RMI collectively calls platform fitness. That's the key to the Hypercar concept developed by RMI chief scientist Amory Lovins in 1991 and evolved by RMI's Hypercar Center through the 1990s. Hypercars integrate ultralight weight, superior aerodynamics, low-rolling-resistance tires, and a downsized and superefficient electrified powertrain. For example, VW's XL1 weighs just 1,750 pounds. How? "We used mixed lightweight materials to bring out their best performance in their respective places in the vehicle," explains Dr. Volker Kaese, VW's project manager for the XL1. High-temperature-tolerant steel is used in the powertrain. Lighter, more flexible aluminum forms the chassis and crash zones. Polycarbonate side panels save weight and allow sleeker shapes. And the passenger cell is a carbon-fiber monocoque.

Then there's the XL1's astonishing aerodynamic drag coefficient. Lower is better, and the XL1's 0.189 is the best ever in a production car. By comparison, a sleek and streamlined 2014 Corvette Stingray has a drag coefficient of 0.29 and Ford's popular F-150 is around 0.40. The XL1 shaves drag everywhere it can, covering the rear wheels and replacing protruding side-view mirrors with low-profile, rear-facing cameras displayed on a dashboard screen.

Even before the first XL1 rolled off the production line, some were quick to point out the striking parallels between the Hypercar concept specs of the early 1990s and the real-world specs of today's production XL1. "The XL1 is a hypercar in the way that might make Amory Lovins smile," wrote High Gear Media's Bengt Halvorson, in a piece that ran in the *Washington Post*. "That's a nod to one of the creators of the original 1990s Hypercar project from Rocky Mountain Institute." Similarly, automotive writer David Herron in *Torque News* noted, "the VW XL1 is the embodiment of the hypercar concept developed by Amory Lovins years ago."

Besides Lovins himself, no one knows this better than Michael Brylawski. Currently the founder and CEO of Vision Fleet Capital, which works on clean vehicle adoption, he cofounded RMI's sustainable transportation practice and later led strategy for RMI spinoffs Hypercar, Inc., its successor Fiberforge Corporation, and Bright Automotive. "When I saw the XL1 from VW, the specs looked quite similar to where Amory was predicting well over 20 years ago that vehicle design could go," he explains. "The XL1 is the purest form of the

Hypercar [on the market today]. The similarities are exceptional."

FROM HYPERCAR CONCEPT TO VW REALITY

RMI's Hypercar started in 1990 with a $50,000 seed grant from the Nathan Cummings Foundation to "get Amory to think about cars." The resulting paper, "Advanced Light Vehicle Concepts," shocked the National Research Council's auto-efficiency symposium, says Lovins. Don Runkle, then GM's head of advanced engineering, took Lovins to lunch, and on a handshake, launched a fruitful two-year process of mutual education.

To say that Lovins, RMI, and Hypercar made a splash in the auto world would be an understatement. The British magazine *Car* named Lovins the 22nd most powerful person in the global automotive industry (and the only outsider). The Hypercar concept won the ISATA Nissan Prize and a World Technology Award—followed by another to Hypercar, Inc. a decade later. In 1993, after two years' validation with the industry, RMI put the Hypercar concept into the public domain so nobody could patent it and to encourage competition leveraging its ideas, while RMI's for-profit spinoffs sought to commercialize technologies outside automakers' comfort zone and raise the competitive pressure.

By the first half of the 2000s, you could read about the Hypercar everywhere from *Automobile* magazine to the *Wall Street Journal* to *Environmental Health Perspectives*. But a true Hypercar had yet to leap from the drawing board to the streets. "The roadmap was right, but the distance underestimated," Brylawski says today.

Indeed, many of Lovins's predictions have come to pass. Two decades ago he claimed regenerative braking could yield 70 percent efficiency when automakers questioned exceeding 30. Today's electric vehicles, including the Chevy Volt and Tesla Model S, respectively get 70+ and 80 percent. Meanwhile, the XL1's specs are an eerily close match with Lovins's early Hypercar predictions for achievable rolling resistance, aerodynamic drag, and more. (Unfortunately, estimates of fuel economy can't be directly compared between the Hypercar and XL1 due to differences in their number of seats, U.S. vs. European test cycles, and changes in modeling and test cycle protocols, but both are far into triple digits.)

So if the Hypercar concept is now emergent reality, why aren't more Hypercars on the road? "There's a lot of hard work that goes between the idea and the execution," says Brylawski. And *that's* where VW's XL1 is really notable. It combines an electrified hybrid powertrain, lightweight carbon fiber and other materials, and low aerodynamic drag and rolling resistance, bringing the Hypercar and other 1990s concepts like it—such as GM's 1991 Ultralite—from drawing board to driver's seat. Lovins, for his part, is thrilled—he would love to be VW's first U.S. XL1 customer, he says.

Covering the rear wheels and eliminating protruding side-view mirrors contributed to the XL1's astonishing aerodynamics.

THE FUEL-EFFICIENT ROAD AHEAD

For all the similarities between Hypercar and XL1, there is at least one major point of departure: cost. The Hypercar was always meant to be competitively priced, but with a sticker price of $150,000, VW's XL1 certainly is not. Its production run is just 250 copies—a niche, novelty vehicle for aficionados. "It's something of a one-off," says VW's Gillies. "The market is effectively limited for [such an expensive] small economy car."

But a high-volume car was never VW's goal. The XL1 was a proof of concept, says Gillies, to "show the production feasibility; that VW has the vision and drive to get it through to production. It's one thing to do a concept, but another to show you could actually build the thing." Its innovations will doubtless inform other models.

A diesel-electric hybrid powertrain, combined with a mixed-material approach that shaves weight without sacrificing performance, enables XL1's impressive fuel economy.

Despite XL1's eye-popping mpg rating, VW might have left some efficiency on the table. Lovins notes that Toyota's 2007 1/X concept car, also a plug-in hybrid, had four seats and the interior volume of a Prius, but weighed only 926 pounds, so even a production-ready version would probably weigh less than the two-seat XL1. "We're seeing a lot of partially executed solutions," says Jerry Weiland, the GM veteran who leads RMI's transportation practice. "Different automakers have done bits and pieces [of the Hypercar concept], but no one has put the whole thing together."

Equally surprisingly, the XL1 may actually take efficiency *further* than needed. RMI senior associate Jonathan Walker explains: "VW had a different goal than we do. Their goal was to make a 235-mpg car. In my opinion, you don't need that," he says. "RMI's goal is get off carbon and oil. A 100 mpg car gets you there." RMI's *Reinventing Fire* analysis, he notes, can fuel its efficient vehicles, some at just half XL1's efficiency, with any mixture of electricity, hydrogen, and advanced biofuels but no oil. "The added capital and cost of going for XL1 levels of efficiency is not worth it," Walker says. "You start getting diminishing returns." In other words, more modest but still radically improved fuel efficiency can yield an affordable Hypercar that doesn't carry an XL1 price tag.

RUNKLE'S THEORY OF ECONOMIC GRAVITY

"Amory gets full credit for putting these concepts on the table more than 20 years ago," says Weiland. "But by now, the automakers have developed and productionized what they saw fit. If they're not doing something, there's probably a somewhat rational reason." One of those reasons is federal fuel economy standards. Until recently, U.S. consumers haven't been especially concerned about mpg in their car-buying decisions, so automakers have mostly done just enough to meet corporate average fuel economy (CAFE) requirements.

As Walker notes, those requirements, recently stiffened to 54.5 mpg for an automaker's fleet by 2025, still might not move the needle. Many automakers can make more money paying modest penalties and selling gas-guzzlers than they can complying. Also, more-efficient hybrids and electric vehicles help automakers' fleets meet the CAFE average standard while still including inefficient SUVs and pickup trucks.

But if CAFE standards are insufficient, that puts the ball squarely back in the court of economics. And Don Runkle has something to say about that.

Runkle is now executive chairman of EcoMotors, a firm pioneering superefficient internal combustion engines (which Lovins thinks could weigh far less than the XL1's diesel-electric hybrid). Before EcoMotors, Runkle spent 30 years with GM, leading the Ultralite and other early-1990s Hypercar-esque concepts. "I was always involved in some attempt at extraordinary performance levels," he says. "Sometimes it was outright speed or acceleration or fuel efficiency. You're pushing the envelope. In terms of high performance—whether it's acceleration or top speed—you're always trying to make sure you had the structural integrity you needed at the lowest mass you could handle"—simultaneously boosting efficiency.

Like the Hypercar, his Ultralite team similarly pursued lightweighting, rolling resistance, aerodynamics, and a downsized powertrain to develop a sporty, 100-mpg, four-seat concept car. At some point, though, Runkle argues that eking out more mpg comes at a cost. If cost is no object, almost any level of performance—fuel economy or otherwise—is possible. But cost *is* an object. He calls it his theory of economic gravity.

"In a nutshell, it's not hard to get high fuel economy. That's a matter of physics," he explains. "What's hard is to get a technology that saves more than it costs. That's economic gravity, where there's a natural incentive." Automakers more or less all have a spreadsheet, Runkle says, showing incremental efficiency gain vs. cost for a big portfolio of technology options—electric steering, lightweighting with carbon fiber, LED lights, lower-friction tires. Engineers start with the cheapest options and work their way down the list until they've met legal mpg requirements, he says.

"It's always good to do the Hypercars, the Ultralites," says Runkle. "They push the envelope. They help clarify the problem and show the promise. Then you can focus more on trying to solve the cost issues."

A HYPERCAR FOR THE MASSES

There is, of course, a very RMI way around the a la carte approach of Runkle's spreadsheet: whole-systems thinking. "That's the challenge if you're only looking at single components versus a systems approach," says Brylawski. "It's challenging running a multi-billion-dollar, multi-million-unit auto company without some specializing," Brylawski continues. "That's a barrier to more holistic approaches" like VW's XL1 and BMW's i3, not to mention RMI's Revolution concept, an SUV successor to the Hypercar.

"What Amory and RMI showed [with Hypercar] is that change is hard but you can end up in a better place. But why change unless you have to?" That's the rub. Inertia is strong. "The extreme retooling required, metaphorical and literal, hasn't been compelling enough for automakers," argues Brylawski. "Not until recently have you had a global regulatory and fuel price environment that makes it worthwhile"—and the threat, proven by Tesla, of outcompeting incumbents by making better autos.

Now, with automakers like VW leading the charge, and with manufacturing methods like RMI's Fiberforge spinoff (whose technology was sold last year to German Tier One pressmaker Dieffenbacher), that could be changing. "Fast forward to today," Brylawski points out. "BMW has a car made largely from carbon fiber. Toyota has a fuel cell car coming out. VW's XL1 gets hundreds of miles per gallon. We're seeing a whole host of interesting solutions that read pretty closely out of Amory and RMI's playbook from the early 1990s."

Moreover, from VW's Jetta to Toyota's Prius, automakers are offering multiple efficient and electrified powertrain options: TDI clean diesel, hybrid, plug-in hybrid electric, all-electric, and extended-range electrics like the Chevy Volt. "It comes back to platform physics. That makes sense to do first," continues Brylawski. "The combination of platform fitness and electrification is like peanut butter and chocolate creating a Reese's cup. It's Amory's holistic view, and that's where VW and BMW are ahead of the curve."

"I think XL1 will stimulate both VW and its competitors—as will BMW's i3 and i8—to develop families of diverse vehicles that increasingly converge with our original Hypercar goals," says Lovins, reflecting on the Hypercar's influence. "Our early-1990s expectations are now matched by reality in such key areas as mass, drag, tire rolling resistance, braking energy regeneration, and—even exceeding my early hopes—the weight, cost, and performance of electric powertrains. Such advanced vehicles are not only for the select, higher-price markets in which they're initially being introduced in Germany, but also ultimately for mass markets."

"It takes a long time, but once you get these things into the market, things start to accrete," concludes Brylawski. "The Prius outsells every SUV in America. Back in 2000 that was unimaginable." We're already, in fact, seeing signs of further traction. Earlier this year BMW increased production on its i3 by 43 percent to meet higher-than-expected consumer demand, and is on track for total annual sales, at U.S. prices starting around $40,000, to be nearly double initial forecasts.

From VW's pioneering XL1 to BMW's i3 to even the aluminum-infused, lighter-weight-but-still-built-Ford-tough F-150, Hypercar's innovative concepts live on.

Peter Bronski is the editorial director of RMI.

WEB EXTRA

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

by Charles C. Poling

Houston, We Have A Solution

e-Lab ACCELERATOR IS HELPING HOUZE MAKE AFFORDABLE, ZERO-ENERGY HOMES A REALITY

One of HOUZE's first zero-energy homes in Houston's Independence Heights neighborhood.

As a global oil and gas capital, Houston, Texas might seem an unlikely place to launch a revolution in community-level, distributed energy independence—but not to David Goswick and his company, HOUZE Advanced Building Science. The developer began overturning the conventional grid-consumer paradigm one house at a time in 2012, when he built five affordable Arts & Crafts style zero-energy homes in a neglected neighborhood. Now, with the help of RMI's e-Lab Accelerator, Goswick wants to up the ante by extending the zero-energy concept from individual houses to the whole neighborhood of Houston's historic Independence Heights, an African-American and predominantly low-income community with an outdated housing stock. More than $150 million in federal funding has helped it and other Houston neighborhoods rebuild in the wake of damage from Hurricane Ike, but there's more to do and HOUZE wants to go further.

Such aging, low-income housing has notoriously poor energy efficiency, using significantly more energy per square foot than your average American home. As a result, low-income households are burdened with spending a disproportionately large part of their income on energy—as much as triple—straining already tight finances. To lighten that burden, Goswick envisions a microgrid incorporating renewable power sources like solar photovoltaics (and, to date, some natural gas fuel cells).

As with all grand visions, the devil is in the details. The initiative will involve a host of stakeholders, from community leaders to bankers to the local electric utility. Goswick knew he needed help. That's why he turned to e-Lab Accelerator.

In RMI's multi-year Electricity Innovation Lab (e-Lab), experts and decision makers in the electricity sector collaborate on developing innovative ways to overcome myriad challenging barriers stifling change in the U.S. electricity system—and which can't be surmounted by any one stakeholder alone. Accelerator took the e-Lab core team and an expanded faculty of experts—"world-class thought leaders and industry titans," in the words of RMI's Leia Guccione, a manager with RMI's electricity and industrial practices—and brought 13 diverse project teams, including the Independence Heights Zero Energy Initiative, to Colorado's Rocky Mountains earlier this year to make rapid and targeted progress with e-Lab's help. That's priceless counsel that otherwise would be very pricey consulting.

Accelerator also gave teams a chance to network with one another and share best practices, thus creating a support system that lasts beyond the workshop. Goswick said he found himself rising early and staying up late so he could visit with participants from other teams and e-Lab faculty: "Having access to people who shape industry and movements is just incredible."

Karen Crofton, a principal with RMI's industrial practice, facilitated the workshop sessions for the Independence Heights team. It included team leader Goswick; Tanya Debose, executive director of the Independence Heights Redevelopment Council; Paul Campbell and Emily Van Court of BASF; Benjamin King of Bosch Siemens Home Appliances; and fellow Houstonian Jason Scarbrough of Choice! Energy Services. Their objective was to develop a plan to transform underserved, low-income neighborhoods—and communities with simply old building stocks—into affordable zero-energy districts.

So why Independence Heights? "We thought, we could do this at the high end of the market, which was the obvious thing to do," Goswick says. "Or we could do the hard stuff first in underserved communities"—because if it can be done in such a tough place, it can be done anywhere.

As a group they reviewed the progress to date in Independence Heights, assessed needs for expanding the initiative, considered the market for zero-energy homes, and looked at scaling the HOUZE business model for implementation in communities and cities across America.

After developing their understanding of the challenges facing them, the team capped their work at Accelerator by creating a template for "putting the pedal to the metal" as they move forward with the Independence Heights initiative, Goswick says, and explore replicating it elsewhere. They came away with objectives, strategies, tactics, target audiences, and the resources required to create a zero-energy neighborhood. The plan includes a process to select locations for future zero-energy communities and a method for identifying everyone who should be involved or could be affected by such an initiative. On another front, the team plans to form a zero-energy consortium, or hub, to act as a clearinghouse for information and technical support.

A recently completed net-zero home shows what the future will look like for the run-down shack in the background, one of the next the HOUZE team is tackling.

Such an ambitious, far-reaching initiative requires community buy-in, new collaborations, and new ways of thinking. "It's about reinventing the electricity system," Goswick says. "Probably the most powerful takeaway from e-Lab was this sense that something will happen no matter what. Do you want to be a part of it or just impacted by it?" With Accelerator's help, Goswick, HOUZE, and the rest of the Independence Heights team are leaning in to make it happen.

Charles C. Poling is a New Mexico-based freelance writer whose architecture writing has appeared in *Dwell*, *New Mexico Magazine*, and others.

WEB EXTRA

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

Images courtesy of Austin Goswick.

by Titiaan Palazzi

Powering Portugal

HOW THE IBERIAN COUNTRY WENT FROM FOSSIL-FUELED ELECTRICITY TO A LION'S SHARE OF RENEWABLES

Portugal—a republic just shy of 11 million citizens—is best known for its cobblestone villages, port wine, and stunning beaches. Yet in the past decade an exciting transformation has swept the country, earning it recognition for another reason: making the switch from fossil-fueled electricity to predominantly renewables. In 2006, fossil fuels generated two-thirds of Portugal's electricity. Seven years later, in the first quarter of 2013, renewables instead generated nearly two-thirds of electricity, and for all of 2013, 58 percent. Why and how Portugal made this remarkable switch, and how the Portuguese grid successfully handled large amounts of peaky, variable wind power, is a lesson for other nations.

THE MOTIVATION TO MIGRATE ITS ENERGY SYSTEM

As late as 2006, Portugal depended on imports of oil, coal, and natural gas to generate two-thirds of its electricity. At the beginning of the decade, in 2001, this cost Portugal more than €5 billion. Portugal thus had a strong incentive to reduce its dependence on expensive imports through domestic, non-fossil-fuel sources.

In 1988 Portugal became one of the first European countries to implement a feed-in tariff (FIT), focused on cogeneration and renewables, including wind. The FIT was later expanded in 1995, but it took a second policy driver for non-hydro renewables to really take off.

In 2001, the European Commission established a goal of 22 percent of gross electricity consumption from renewables by 2010. The Portuguese government committed to generate 39 percent of electricity from renewables by then, third only to the targets of hydro-rich Austria (78 percent) and Sweden (60 percent). En route, Portugal nearly doubled its renewable electricity generation capacity—mostly with new wind installations—from 4,600 MW in 2001 to 8,800 MW in 2010. In fact, renewables for the first time surpassed fossil fuels as Portugal's primary power generation source, with non-hydro

In the span of less than a decade, Portugal's electricity system transitioned from fossil fuels to predominantly renewables, powerd largely by growth in wind farms.

renewables growing 800 percent. That same year (2010), Portugal adopted an even more ambitious National Renewable Energy Action Plan that further accelerated renewables' rise, targeting 60 percent of electricity from renewables by 2020.

ON WITH THE WIND

Meanwhile, in 2005, the government began to restructure and privatize formerly integrated state energy utilities, creating utility Energias de Portugal and grid operator Redes Energéticas Nacionais. In parallel, Portugal's new government commissioned 1,800 MW of new wind power capacity through a public tender (the ENEOP cluster), investing €290 million in the winning consortia and more than doubling Portugal's 2005 installed wind capacity.

From 2001 to 2013, average FITs for wind were $103 per MWh, guaranteed to developers for 20 years. In a country with abundant wind, these favorable financial incentives led to 500 percent growth in installed wind capacity between 2005 and 2013, from 1 GW to 5 GW. Though some have said Portugal's FITs are too high, those FITs have proven an affordable way to shift the country's energy economy away from the €5 billion per year it previously paid for imported fossil fuels: in 2010, the Portuguese government spent about $880 million on wind FITs that brought in almost 10 TWh of renewable, wind-powered electricity generation, roughly one-fifth of all Portuguese generation.

By the end of 2011, Portugal ranked tenth worldwide in absolute wind power capacity and second in percentage of electricity consumption generated from wind (behind only Denmark). As in Denmark and similarly wind-rich Spain, the surge in wind turbine installations led to the birth of a new Portuguese industry: by 2020, electricity generation from renewable sources will account for an estimated 35,000 new jobs.

VARIABLE RENEWABLES KEEP PORTUGAL POWERED RELIABLY

Portugal's only grid interconnection is with Spain. This contrasts with Denmark, whose 31 percent wind power share of electricity consumption in 2013 benefitted from balancing hydro interconnections with neighboring Norway as well as Germany and Sweden. Yet Portugal's isolated geography has not led to problems with grid reliability. Despite a steep increase in electricity coming from variable, peaky wind and hydropower, grid interruptions have decreased in the last decade: 42 interruptions were noted in 2003, compared to only 5 in 2012. It seems that, even without bulk storage, the Portuguese grid is thriving.

The first quarter of 2013 was exceptionally wet and windy. In this period, hydro generated 40 percent of all electricity consumed, wind added another 28 percent, and other renewables such as biomass combustion and solar PV added a final 6 percent, totaling a renewable electricity supply of a very impressive 74 percent. (In one extreme week from March 27 to April 2, coal and natural gas supplied only 4.2 percent of Portuguese electricity consumption, and in a similar peak in 2011, renewables' share briefly hit 100 percent.) For the first half of 2013, 70 percent of Portugal's consumed electricity was renewable, and for all of 2013, 58 percent. That was the highest in Europe outside countries exceptionally rich in hydropower (like Norway and Sweden) and/or geothermal (Iceland).

As Portugal looks to its future, it's showing that sustained and reliable renewable power contributions of 50 percent and even 70 percent are not just possible, they're becoming a reality.

Titiaan Palazzi is special aide in RMI's office of the chief scientist. Ivonne Peña, a Ph.D. candidate in energy systems at Carnegie Mellon University and Portugal's Instituto Superior Técnico, provided valuable insights.

Portuguese electricity demand by generation source

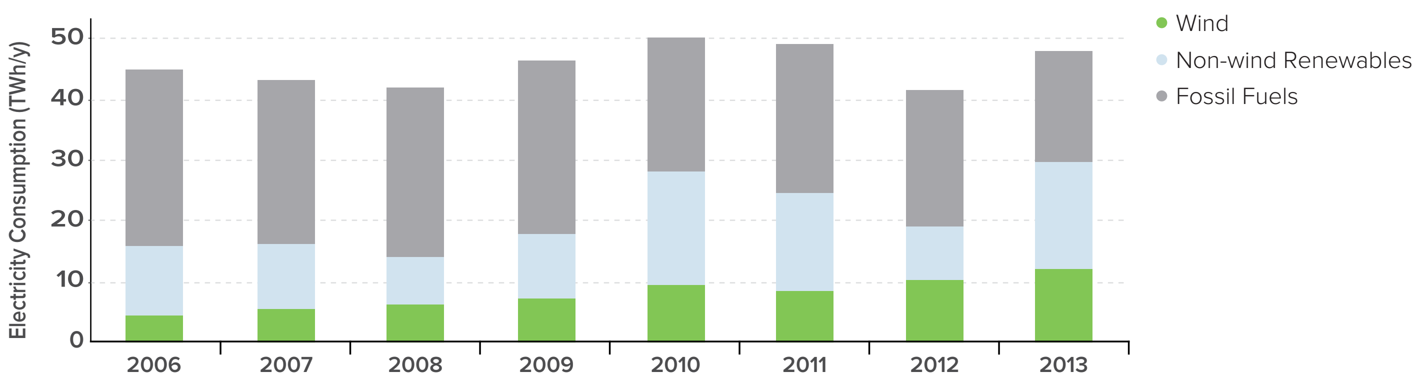


Image courtesy of Shutterstock.

by Jennie Lay

Solar Gets a Credit Check

WITH TRUSOLAR, RMI AND PARTNERS MAKE THE "FICO SCORE OF SOLAR" READY FOR SHOW TIME

Imagine a mortgage market where 90 percent of eligible homeowners couldn't get access to a loan because banks had no idea how creditworthy each applicant was. Before the days of the FICO score, that was the reality. Today, we are in the same situation for commercial-scale solar. Businesses can't get access to capital from lenders, and as a result, the majority of potential projects ultimately fall through for lack of financing. Only the biggest firms able to undertake the robust due diligence investors demand have successfully navigated that project graveyard, which is why of the nation's ~18,000 employers with 500 or more employees, just 0.001 percent are responsible for 13 percent of the commercial solar PV capacity cumulatively installed in the U.S. through mid-2013.

When truSolar launches this summer, there will finally be an accessible standardized test to assess the merits of pending commercial solar projects. Whether it's a school or an office suite aspiring to add commercial-scale solar, truSolar unveils a framework designed to make solar projects better, and therefore easier (and cheaper) to finance.

Paradoxically, residential solar is booming, surpassing newly installed commercial solar capacity during Q1 2014 for the first time in over a decade. And utility-scale solar maintains its historically strong share of new installs. Yet commercial-scale solar (500 kW to 10 MW projects) has been stuck in slower growth, despite the fact that these projects should—and often do—have more favorable economics. Finding scalable and efficient financing remains the biggest hurdle. truSolar has emerged in response, creating a set of standards for commercial projects, offering a familiar look and feel that developers on the one hand and banks and other financiers on the other can rely upon.

Akin to the FICO score for residential mortgage creditworthiness, truSolar is a proxy designed specifically for commercial solar projects. truSolar's working group is acutely aware of lenders' need to understand the relative risk associated with a given project's combination of physical system hardware, offtaker credit, regulatory environment, and more. The truSolar score is

The goal of truSolar's credit screen is to unlock a trillion dollar market by enabling easier access to cheaper capital for commercial solar projects.

intended to become a way to pull all that together into a FICO-like package.

Distributed Sun CEO Chase Weir said his company realized this problem back in 2011. Conversion ratios were terrible—as few as 10 percent of deals were getting financed. Even though deals differed, they needed to start reviewing them similarly. "In this young industry you realize how many things they get right, but some things go wrong, like a contract that's not bankable, terms that couldn't be met…there had to be a better process to find those fatal flaws earlier," Weir said. He realized these were the biggest impediments to getting deals done—and how big a task it would be to standardize lenders' risk-assessment process.

Until now, there hasn't been a common way to assess the risks of commercial projects even though the commercial segment is ideal for solar, says James Mandel, a manager in RMI's electricity practice. Roofs tend to be big and flat. The scale is larger. It fundamentally lowers operating costs and price-volatility risks for businesses. Properly wired, it can give them resilient electricity even if the grid is down. And commercial real estate is an active market. "People are pretty comfortable investing in building small and medium-sized office spaces and warehouses, so why shouldn't they be interested in investing in solar if it makes those buildings cheaper to operate?" Mandel asks.

They haven't because there wasn't a good way to assess risks. truSolar will change that, becoming an industry standard for credit evaluation in commercial solar that bears the expectation of creating more access to cheaper capital and getting more deals approved.

SETTING A STANDARD

For two years, the truSolar working group RMI convened has been evaluating a broad array of risks and creating a way to model them. Ultimately, their conclusions will help both financiers and developers assess risk. Today's working group is made up of 12 diverse market leaders—including RMI, DuPont, Mosaic, Assurant, Panel Claw, and others—who have created a framework to determine what a good project looks like and assess every aspect that might affect its creditworthiness.

An important early decision was whether to create a proprietary or an open standard. The working group bet on promoting large-scale adoption of the truSolar standard as quickly as possible. truSolar evolved as an open standard with access for everyone, but the working group balanced proprietary concerns with a purely open angle to come up with a mixed approach.

How "open" actually works has been a complex discussion. "You want to make it high quality. In order to make it high quality, you have to get data from people. In order to get people to give up data, they've got to know it's safe. But at the same time, if it's expensive to participate in or takes a lot of resources, it becomes as expensive as business as usual," explains RMI's managing director of development Ned Harvey, who forged the relationship with Distributed Sun CEO Chase Weir early to create the truSolar working group. "We decided to make the framework, the data set, and the key indicators all open, and then people can use that and build out proprietary tools," Harvey says.

A beta test ran through June. It shadowed 14 Distributed Sun projects that were moving through their typical chain of review, with hopes of gleaning insight about new or streamlined elements the truSolar score might bring to the table. Test projects were updated with real data and are being peer reviewed prior to truSolar's launch.

LAUNCHING TRUSOLAR

As truSolar evolves as an independent nonprofit and the assessment program rolls out later this summer, RMI is leading the effort to develop processes and protocols to administer truSolar evaluations. RMI will staff the accreditation body, while a board comprising the 12 working group members is tasked with ensuring standards stay strong.

Ultimately, a nonprofit truSolar will steward the risk screen. An annual peer review will let industry explore the process and provide advice and data to improve it. Unlike FICO, a private company that guards its scoring protocol and took more than 30 years to get market acceptance as a standard, open-source truSolar is hoping to take the fast track to market adoption. "We're trying to create something that becomes an industry standard much quicker. We don't think we have 30 years to wait for a private company to build the trust in the capital markets," Mandel says.

Eventually, "you will find components or sub-components of systems or project approaches that are so standardized that they can get certified

Image courtesy of Shutterstock.

truSolar aims to become an industry standard for credit evaluation in commercial solar that bears the expectation of creating more access to cheaper capital and getting more deals approved.

as truSolar, and that will become the Good Housekeeping seal of approval," Harvey says. As truSolar's open standards come into play, users' interactions will improve it over time. It has been created as a dynamic tool for industry.

Whether truSolar will be a game changer in the quality and reliability of commercial solar systems (since low-quality, poorly-installed systems would score poorly) remains to be seen. "The benefit that the risk screen brings to the industry is consistency and repeatability in the way PV products are examined. Whenever you bring consistency and repeatability and put it into practice, it has the effect of driving quality, safety, and reliability," says UL business development manager Scott Jezwinski, another truSolar working group member.

Attorney Charlotte Kim, a partner with Wilson Sonsini Goodrich & Rosati, a firm that provides legal advice for technology and has played an advisory role to the truSolar working group, said clients could benefit daily from truSolar. "Negotiating these contracts and doing it in a cost-effective way is a difficult balance, especially at the smaller end," she says. Attorneys see the same contractual issues come up repeatedly.

truSolar doesn't replace the contracts, but it is can be helpful for investors and developers to evaluate these documents earlier in the life cycle of a project.

truSolar creates a common framework for talking about risk and understanding where risk lies, as well as a common understanding of what "good" looks like. This should be appealing to banks, pension funds, tax investors, and especially the small regional and community banks that are the traditional financiers of small business in their areas. While they provide much of the financing for local commercial retail development, at least 90 percent have not participated in solar projects because they haven't had the resources for deep project finance analysis.

In the end, the ultimate goal of a mechanism like truSolar is securitization of solar portfolios that effectively evaluate and balance risk, creating a significant asset class out of commercial-scale solar. Weir says truSolar will democratize the path to commercial solar financing, raise the bar on products in a multi-billion-dollar industry, and unlock the potential of what could be a trillion dollar market.

Weir compares truSolar's effort to the collaborative creation of CDMA protocols for cell phones, when competitors understood that growing markets were to everyone's benefit. With truSolar, he says, commercial-scale solar gains a Rosetta stone: "If you don't standardize, you can't professionalize. People need to agree on the rules. The value is in the cost savings that it unlocks immediately because you're making the project more affordable, and helping the capital markets remove basis points."

Jennie Lay is a freelance writer and editor whose work has appeared in *High Country News*, *Bulletin of the Atomic Scientists*, *Wilderness*, *Yoga Journal*, and elsewhere.

Image courtesy of SolarCity.

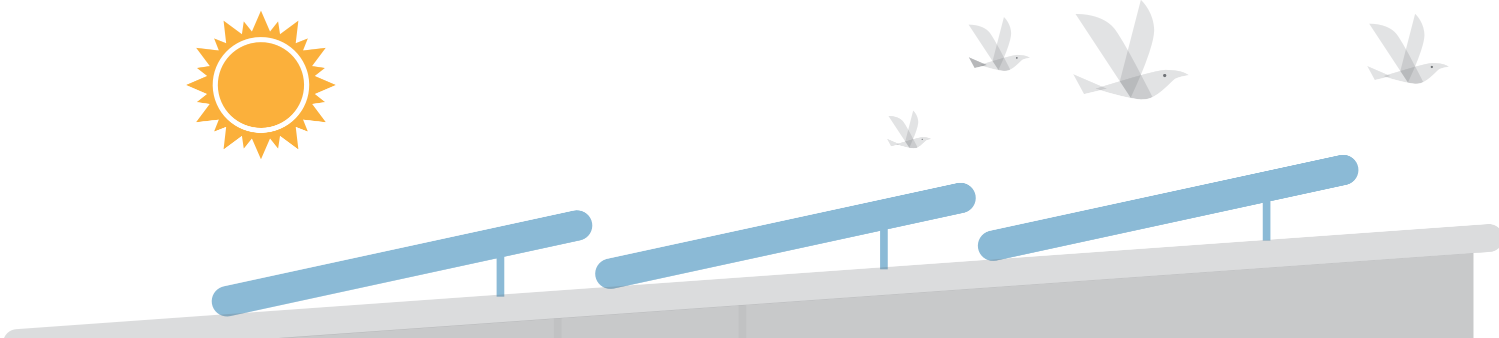
WEB EXTRA

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

SOLAR FINANCING

OPTIONS FOR HOMEOWNERS

So you want to go solar? Homeowners have a variety of options for how to finance a PV system. Available options will vary by region, but here's what you need to know about your spectrum of choices.



FINANCE CATEGORY	THIRD PARTY		UTILITY	PERSONAL			
FINANCING OPTION	**PPA** Power purchase agreement	**LEASE**	**ON-BILL**	**CASH**	**LOAN**	**MORTGAGE**	**PACE** Property assessed clean energy
WHAT IS IT?	A third party owns and maintains the system. You pay for the energy it produces, and don't pay if it doesn't produce.	A third party owns and maintains the system. You pay a monthly fee to lease it, regardless of system output.	Your utility finances the system. You pay it off in installments on your monthly electricity bill.	You buy the system outright with upfront, on-hand funds.	You purchase the system through money borrowed via a bank, credit union, or home equity loan.	You fold the cost of the system into your home's mortgage.	Your city or county government finances the system. You pay it off in installments through your property taxes.
WHAT'S MY MONTHLY PAYMENT?	$109.11	$109.11	$129.15	$0.00	$90.90	$80.85	$121.90
WHAT ELSE SHOULD I KNOW?	With no-money-down offers, you start saving on day one since third-party options typically beat utility electricity prices. At the end of term, you can renew your agreement or buy the system at fair market value.		Only some utilities offer it. Often generates immediate positive cashflow and can be transferred to future homeowners if you sell your house.	You're responsible for the substantial upfront cost of the system and any ongoing maintenance. But also eligible for federal, state, and local rebates and/or incentives.	Loan interest could be tax deductible. You own the system, so you maintain it. Appraisal of system's value varies, including potentially $0, if selling your home.	Places a lien on your home and only certain banks offer it, but can be tied into your home's mortgage and thus transferred if you sell your house.	Places a lien on your home and only some local governments offer it, but is tied to the home and thus transfers if you sell your house. Designed to generate immediate positive cashflow.

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.

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

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

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