Solutions
Journal

A Flameless Dragon
Charting a Clean Energy Path for China

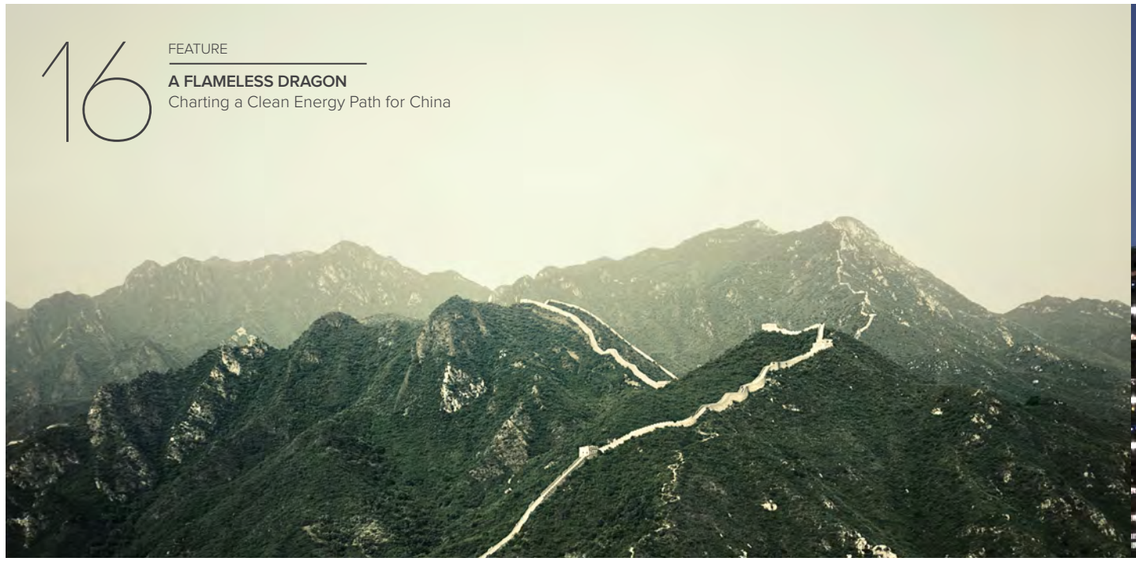
Beyond the Tip of the Energy Iceberg
Why Deep Retrofits Create More Value Than You Think

Rocky Mountain Institute®

SUMMER 2013
VOL. 6 NO. 1

Transportation Buildings Industry Electricity General Energy

SUMMER 2013/ VOL. 6 NO. 1



COLUMNS & DEPARTMENTS

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by Michael Potts

The Road to the New Energy Era

"Any trip worth taking brings on the shock of departure, where the safety, comfort, and familiarity of the current state must be disrupted to discover something new."

We can create a world that is cleaner, smarter, and safer—and can save five trillion dollars on the way. *Reinventing Fire*, published by RMI less than two years ago, laid out a specific and credible roadmap to get it done by 2050.

Here's the challenge: a starting point, end vision, and good roadmap can show generally how to get to your destination, but they don't get you there. To complete any journey, especially a bold and ambitious one like that outlined in *Reinventing Fire*, requires persistence and ingenuity in the face of long efforts and unforeseen obstacles.

Any trip worth taking brings on the shock of departure, where current safety, comfort, and familiarity must be disrupted to discover something new. The roadmap cannot contain every detail and cannot predict the political climate, the varying state of the economy, and other factors, so progress comes in fits and starts and portions of the journey sometimes take more time and effort, or detour on a different route, than originally expected.

This issue of *Solutions Journal* is a travelogue of this journey to the new energy era. RMI is working hard to help decision-makers and practitioners steer their strategies today toward this new world. To pull this off, we have recruited talented engineers, architects, scientists, and analysts who can dive into the real facts of all four energy-using sectors—transportation, buildings, industry and electricity—and can challenge business-as-usual with compelling new opportunities that drive dramatic and durable change.

At RMI, we don't lecture leaders and practitioners; rather, we engage with them to solve tough problems in new ways that unleash potential profits and shift toward a better world. These moves do not come in grand gestures; the real progress happens by tackling very specific issues with high-leverage, scalable solutions.

How do you save massive amounts of oil, for example? Our *Reinventing Fire* analysis found that the largest single lever lies in eliminating performance-degrading excess weight in vehicles. How do you eliminate this useless, oil-consumptive weight? One pivotal step: introduce stronger, lighter carbon fiber components into automobiles (page 28).

But the auto industry is huge and complex, with rigorous demands for safety, economy, cost, and customer satisfaction. Writing a white paper about the benefits of carbon fiber won't suddenly drive these massive companies to change course. Ideas are only the first step; forging workable solutions is the real challenge, and one article in this issue tells how, with your support, RMI is making good progress.

How do you empower 10,000 communities to forge their own path to the new energy era? Help one community—Fort Collins, Colo.—prove that it's possible to build a net-zero energy district, enlisting the most creative minds in the electricity industry to do so (page 10).

How do you save more than half the energy used by U.S. buildings? Prove beyond doubt that building owners and investors can create significant value from deep energy retrofits—not only from energy savings, but also from additional, and often much larger, "value beyond energy cost savings" (page 21).

And—gulp—how do you help China shift toward the clean energy era? Partner with the right players on both sides of the Pacific, including key energy leaders and agencies in the Chinese central government, to leverage the methodology and findings of *Reinventing Fire* into an entirely new roadmap for the largest energy-consuming nation in the world (page 16).

Each of these exciting efforts, like the other initiatives of RMI, represents necessary stations on our journey to the new energy era. Each is challenging and complex, involving many players, seemingly insurmountable obstacles, and years of patient but determined effort. But what else could we expect? It took us a century to build today's energy system, and we won't arrive at the new energy era quickly or easily.

Believe me, sometimes it feels as if we will never get there. But we will get there—we must. We have too much at stake, and we must complete as much of this journey as we can, so as not to leave the hard miles—or worse, a world in desperate need of repair—for future generations.

Michael Potts is president & CEO of RMI.

Potts image copyright RMI. Other images courtesy of Shutterstock.

RMI IN BRIEF

THE SUPEREFFICIENT HOUSING CHALLENGE

An estimated 12 million American households pay more than half their income for housing. Twice that many children live in low-income working families. Yet these cost-burdened families often live in the most energy-*inefficient* housing. Public housing and manufactured homes have energy costs 39 and 57 percent *higher* per square foot than the U.S. average. *Americans need affordable housing that doesn't hit them with unaffordable bills.*

RMI's Superefficient Housing Challenge, launching later this year, will show that energy-efficient, healthy, durable housing can be built cost-effectively and provide long-term low (or zero) utility bills, benefiting low-income families and the public housing agencies that help them. The effort kicks off in partnership with Colorado's Denver Housing Authority, which is currently planning over 800 new units by 2016 to address a major affordable housing shortage.

For more information, read RMI's report Superefficient Affordable Housing: Solutions to Hurdles.

REDUCING THE SOFT COSTS OF SOLAR POWER

Hardware costs for solar photovoltaic modules have dropped precipitously since 2008, including 60 percent between Q1 2011 and Q1 2013. That's good news, but in the U.S., the soft Balance of System (BoS) costs of solar—all system costs except the modules, including permitting and approvals, installation, racks, and wiring—have remained high, now constituting 60 percent of the total installed cost of a solar PV system in the U.S. In Germany, BoS costs are 75 percent lower and total installed costs about 50 percent lower.

That's why RMI—through our Simple BoS project—has teamed up with the Georgia Tech Research Institute to uncover the secrets of Germany's success. Installer surveys and time and motion studies will help reveal the factors that make German solar's soft costs so much lower, and to identify the theoretical minimum for such costs and how to chip away at the difference. Unlocking those secrets will help U.S. installers match, or perhaps even beat, Germany's low system costs, accelerating the speed and scale of distributed solar adoption.

TRANSFORMING THE ELECTRICITY SYSTEM

According to The Brattle Group, the United States' electricity system will require $1.5–$2 trillion in infrastructure upgrades by 2030, just to largely maintain the existing system. It's a century-old system based on large-scale central thermal generation and transmission (power plants fueled by coal, natural gas, and nuclear energy, connected by big, long power lines).

RMI envisages a future electricity system built on efficient use of clean, resilient, secure, largely distributed renewables, including wind and solar. Meanwhile, rapid growth in third-party distributed energy resource providers, falling costs for renewables, advanced energy efficiency, affordable electric vehicles, and other developments that span the utility and customer sides of the meter are democratizing and transforming the electricity grid.

The electricity system is at a crossroads. That's why RMI launched the Electricity Innovation Lab (e·Lab), which brings together stakeholders—utilities, third-party providers, regulators, other nonprofits, and organizations including the U.S. Navy, Microsoft, and Wal-Mart—to answer some of the most pressing questions facing our electricity future. At a charrette in May, e·Lab participants tackled topics such as a distributed energy resources tariff in Fort Collins, Colo., electricity retail price unbundling, and evolution of wholesale electricity markets.

by Amory B. Lovins

Three Major Energy Trends to Watch

Popular media and political chatter are abuzz with a cacophony of energy news and opinion. Amid the chaos, some orderly strands can be discerned. Here are three themes that merit attention:

EFFICIENCY IS ACCELERATING

Government forecasts predict U.S. energy intensity (primary energy used per dollar of real GDP) will continue to decline roughly two percent annually through 2040, but that the drop will be steepest in automobiles.

Motivated in part by more stringent fuel economy standards coming down the pipeline, lightweighting—the core of the new "platform fitness" approach, which focuses on optimizing a vehicle's structure first *before* addressing propulsion technology and fuel source—has been the industry's hottest strategic trend for several years (see "Battling America's Automotive Obesity Epidemic," page 28). In short, the auto industry is finally beginning the fundamental change we've been advocating since 1991. And as automakers and government adopt RMI's fitness-first, ultralighting-focused strategy, they're finding that making costly batteries or fuel cells *fewer* rather than cheaper can make electric cars more affordable with less time, cost, and risk. This can save severalfold more oil than the government forecasts, use 80 percent less autobody manufacturing capital, de-risk automaking, and save (in the U.S. alone) half an OPEC's worth of oil.

Meanwhile, U.S. autos' four percent average asset utilization—that is, they sit idle 96 percent of the time—is driving remarkable new carsharing and ridesharing programs, smartphone apps, and emergent automaker business models based on leasing mobility services rather than selling autos. These developments, adopting *Natural Capitalism's* powerful "solutions economy" business model, could profoundly reduce the need for autos to yield the same or better mobility and access at lower cost.

At the same time, efficient use of electricity—which is used three-fourths in buildings, one-fourth in industry—is finally starting to pull out of its decades-long doldrums. That's a big deal for saving capital and climate, because producing and delivering electricity is extraordinarily capital intensive, and classically uses two to four units of fuel at the power plant to deliver one unit of electricity. Much of RMI's work focuses on this effort, as the late Ray C. Anderson put it, to "turn stumbling blocks into stepping stones." Efforts like RMI's RetroFit initiative—whose toolkit, portfolio challenge, and training efforts are steadily gaining adherents—are key levers for scaling adoption by asset owners, financiers, tenants, designers, installers, and communities.

Initial returns are coming in. Electric intensity (electricity consumed per dollar of real GDP) fell in all but two years since 1996, drifting down by a total of 19 percent, but in 2012 alone, before correcting for weather, it fell by an unprecedented 3.7 percent. Spending on energy efficiency programs is way up and expected to keep climbing. Between 2006 and 2010, spending on utility energy efficiency programs more than doubled from $2 billion to $4.8 billion. Lawrence Berkeley National Laboratory and the American Council for an Energy-Efficient Economy forecast spending to double again by 2025, to $9.5–$10.8 billion under a medium scenario that merely maintains current energy efficiency policies. More aggressive efforts could see spending climb to $15.6–$16.8 billion. Increasingly propelled by utility- and customer-financed efficiency efforts (with utilities incented by changed rules that in 15 states for electricity and 20 for natural gas already reward utilities for cutting customers' bills rather than for selling them more energy), stagnant or declining electricity demand is emerging as the "new normal," according to The Brattle Group and Deloitte.

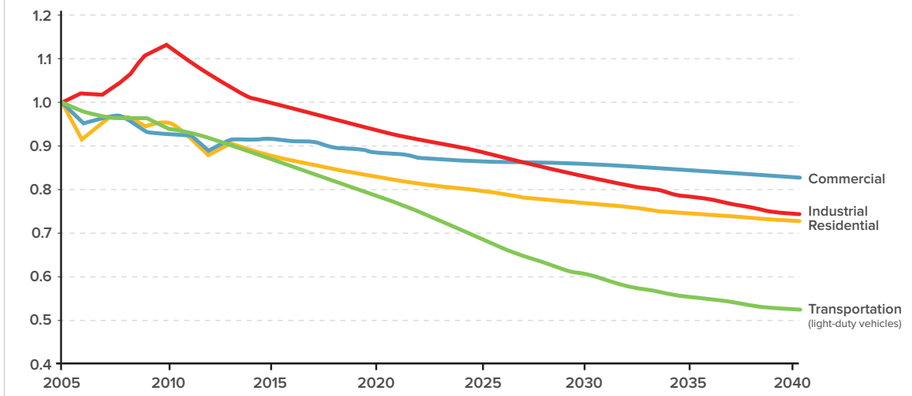
Just the new building codes that entered force in 2011–12 in half the states could about offset previously forecast electricity sales growth. And electricity demand could consistently shrink, dropping by one-fourth by 2050 despite a 2.6-fold bigger U.S. economy, if the lucrative efficiency gains described in *Reinventing Fire* were adopted over 20 years to the extent already achieved in the Pacific Northwest states.

In sum, 2050 could see tripled U.S. energy productivity, on top of the more-than-doubling already achieved since 1975. That prize is worth trillions of dollars, with handsome financial returns—plus even bigger non-energy benefits we didn't count.

RENEWABLES ARE MAKING HEADWAY, WITH MORE PROGRESS NEEDED

The business of installing solar modules is booming. Germany took it to scale, 8 GW a year, and installed more PVs in a single month in 2011 and 2012 than the U.S. added all year. That volume also cut the German installed system cost to half ours, even though we all buy the same equipment. If the U.S. did that too, it'd have *really* cheap solar power, since Germany gets about as much sun as Alaska and far less than the mainland U.S. But even so, U.S. solar prices are now low enough that photovoltaics on your roof, financed with no down payment, can beat your utility bill in over a dozen states. In fact, solar accounted for 49 percent of new electric capacity installed during Q1 2013 and *all* new utility electricity generation capacity added to the U.S. grid during this March, according to SEIA and FERC.

U.S. SECTORAL ENERGY INTENSITY INDEXES, 2005 = 1.0



Lovins image copyright RMI. Energy graph courtesy U.S. EIA.

In 2011, California utilities soliciting bids for solar power were offered enough to meet more than the state's total peak load. In 2012, the solar bids accepted by utilities undercut their cost of power from efficient new gas-fired power plants. (In June 2013, Palo Alto's new 30-year solar power contract cost just 6.9¢/kWh.) Back out the temporary 30 percent solar subsidy (generally smaller than permanent subsidies to nonrenewable competitors) and you still get a price that'll compete in a few years head-to-head with traditional generators. Indeed,

Solar accounted for 49 percent of new electric capacity installed during Q1 2013 and all new utility electricity generation capacity added to the U.S. grid during March.

it competes right now if you install as efficiently as the Germans do, or properly price carbon, or value small, fast, modular, and renewable generators' unique economic and engineering benefits.

Windpower kept struggling with Congressional stop-and-go policies, but notched up a record year of installations, with a strong 2013 unfolding thanks in part to the temporary extension of the Production Tax Credit. New windpower in the windy belt across the center of the United States sold for an average of $32/mWh, ranging from about $25 to $40, after receiving that federal subsidy. Back out the subsidy, generally smaller and more transient than those to nonrenewable competitors, and you can still beat any new central thermal power plant today. (In such places as Australia and Brazil, new wind farms are already beating new coal- and gas-fired power plants *without* any renewables subsidies or carbon pricing.) Moreover, central thermal plants are tending to get costlier, but windpower's cost keeps dropping. Again, brutal price pressure from China, which has doubled its windpower for five years running, helps sink all prices and speed global adoption.

The bottom line: windpower added 45 GW of global capacity in 2012, PVs about 32. These and other nonhydro renewables are continuing to win a quarter-trillion dollars' private investment per year globally (more than all fossil and nuclear generation got) and may hit $500 billion per year or more in the foreseeable future. This is no longer a fringe activity: it's the core of the global market and increasingly central to the United States' energy landscape. Even so, fossil fuels enjoy hundreds of billions in global investment annually and $1.9 trillion annually in subsidies, according to IMF, so the transition is far from a foregone conclusion. But the tide may be turning.

Coal lost 28 percent of its U.S. market share to gas, renewables, and efficiency just in the past seven years, 19 percent in the past two years. "Booming"

Lovins meeting with German Chancellor Angela Merkel, May 2013.

Merkel image courtesy of VDI/VDE Innovation + Technik GmbH. German farm house image courtesy of Shutterstock/Pi-Lens

natural gas, meanwhile, saw renewable energy run a close second for new installed capacity through the first half of 2012, and in the second half of the year, new installed wind capacity alone pushed natural gas into second place. In such places as California and Texas, renewables are supplying increasingly significant amounts of electricity to the grid—in California last year, the state's three largest shareholder-owned utilities generated 19.8 percent of their electricity from renewables, according to CPUC; Texas, leading the nation in installed wind capacity with nearly 13 GW by the end of 2012, generated more than 10 percent of its electricity from renewables in 2012, according to ERCOT, and in early 2013 was nearing 30 percent.

DISTRIBUTED POWER IS THE FUTURE

Momentum is shifting not just from fossil-fueled power plants to renewables but also from centralized to distributed generators. The gamechanger here is that the means of producing electricity have shifted from slow, gigantic projects—akin to building a cathedral—to scaleable, mass-produced, manufactured products. A single Chinese PV factory can make several GW of PVs *every year*, stamping them out 24/7, just like making smartphones and PCs—and we know what that does to prices. (China now has most of the world's PV-making capacity, which totals at least twice what installers could use last year. That surplus crashed the price. Surprise! Some photovoltaic manufacturers were killed by Chinese competition and these lower prices, including China's own Suntech. But China's new 35-GW PV target for 2015 will quickly absorb the surplus.)

This shift keeps renewables' prices headed relentlessly downward, and brings both the technology and its financing in reach of the masses. Denmark's 32-year shift from centralized coal-fired power plants to distributed wind and cogeneration plants (the latter largely powered by agricultural wastes) was possible partly because 86 percent of those Danish wind machines are owned by farmers and their communities. Likewise, half of Germany's renewable capacity is owned by citizens, cooperatives, and communities—vs. only about two percent in the corporate-centric U.S.

Crowdfunding, real estate investment trusts (REITs), potentially master limited partnerships (such as oil and gas drillers enjoy), commercial PACE bonds, and the explosive growth of third-party installer/owners such as SolarCity are

Distributed energy resources such as rooftop solar PV offer clean, resilient power at increasingly competitive costs.

likewise starting to revolutionize U.S. solar project financing. More broadly, innovations in financing, business models, and delivery channels are just as important and rapid as in technology, but are widely overlooked.

Distributed renewables save money, avoid price volatility and fuel insecurities, and prevent carbon emissions. But their unique strategic and marketing advantage is that if properly deployed in a largely distributed system, they can enable a resilient grid architecture (often called "netted islandable microgrids") that makes big cascading blackouts improbable by design. This approach, already adopted by the Pentagon, would make vital power supplies resilient against superstorms, solar storms, physical or cyberattack, and other risks. After Superstorm Sandy, demand for such resilience is starting to become an important market driver.

In short, a more efficient, diverse, distributed, renewable electricity system is turning the power sector upside-down. Fasten your seat belts and hang on—we're on an exciting ride to a more secure, affordable, job-rich, climate-safe, and pleasant destination than where the power industry was headed only a few short years ago. But we mustn't take that outcome for granted. We must remain committed to tenaciously busting barriers and enabling the transformation to see it through.

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

WEB EXTRA

For more information on this topic visit: rmi.org

by Eric Maurer

What's Old Is New

REINVENTING A COMMUNITY'S ENERGY FUTURE IN FORT COLLINS

Old Town Fort Collins is a historic, vibrant, pedestrian-friendly downtown at the core of the FortZED effort.

Take a journey back in time with me. Wind the clock back about fifty years and imagine strolling through the downtown of a nearby town or city. Birds are chirping. The sun is shining. You walk at a casual pace, peering into the windows of local independent restaurants, ice cream shops, and a hardware store. Smiles from the random passersby welcome you along the way.

That nostalgic vision of yesteryear is still alive in the present. These are just some of the things I saw and heard while taking a recent tour through Old Town.

Old Town is located in the downtown area of Fort Collins, a small city of about 150,000 in Northern Colorado. One million people per year visit the community, according to a 2013 report from Colorado State University, which is located in town. Another 16 million people per year also visit Fort Collins via California. How? Fort Collins is one of two U.S. communities after which Disneyland modeled its Main Street USA.

And while Old Town is capable of transporting the traveler back in time, there is something distinctly modern happening beneath its surface of brick buildings, cobblestone walkways, and canvas awnings.

BOLD VISION

Old Town is at the epicenter of an energy revolution. In 2007, UniverCity Connections, an initiative of the Community Foundation of Northern Colorado, cooked up an idea to create what it called FortZED—an effort to transform the downtown area of Fort Collins into a net-zero energy district through energy conservation, energy efficiency, renewable energy, and other smart technologies.

Definitions of a net-zero energy district vary. In the case of Fort Collins, UniverCity Connections envisioned a downtown district that becomes super-energy-efficient and draws its remaining electricity needs from a diverse set of local renewable resources, such as wind, solar PV, and biomass.

Building photo copyright RMI/Chris Rowe. Fort Collins aerial courtesy of Visit Fort Collins.

Achieving such a vision would be a pathbreaking achievement. The downtown area of Fort Collins represents 10–15 percent of the total electric demand in Fort Collins. The district covers two and a half square miles and serves about 6,000 customers, plus the main campus of Colorado State University. Fort Collins currently gets two-thirds of its electricity from coal-fired power plants, and just five percent from renewables.

EARLY PROGRESS

Even at the outset of the FortZED project, there were things to celebrate about its electricity system. Fort Collins electricity prices are 40 percent below the national average, while boasting triple the reliability as well as savings from energy efficiency comparable to some of the best programs in the country. Momentum has only been building from there.

To get things going, the initial team behind the FortZED idea formed a steering committee with heavy hitters from the city government, the city's municipal utility, and the Colorado Clean Energy Cluster, an organization made up of local cleantech companies dedicated to growing the cleantech industry across the state.

The ambitious net-zero energy goal immediately proved catalytic for the committee, helping them identify two large grants to kick-start efforts in FortZED. The first grant, from the State of Colorado, helped the city and its partners leverage $778,000 from the state to generate another $2 million in local matching funds that resulted in efficiency improvements to four large public buildings and the installation of a 54-kilowatt solar PV array on another building.

The second grant put FortZED on the fast track to meeting its long-term aspirations. The committee, working closely with the municipal utility, landed $6.3 million from the U.S. Department of Energy (DOE) and $5 million from local matches. As part of a series of DOE projects called Renewable and Distributed Systems Integration (RDSI), Fort Collins Utilities set out to use the funding to build the connective tissue that allows electric demand and supply sources in the downtown area to communicate with one another and the utility. Using this new system to activate and manage solar PV, diesel generators, gas turbines, thermal storage, and load shedding from various demands, the utility demonstrated 20 percent drops in its peak electricity demand.

The first phase of the RDSI project, completed in 2011 with reporting extending into 2012, proved hugely important for FortZED. It created the technology and communications backbone that will allow the downtown area to effectively integrate more sources of distributed electricity generation like solar PV.

But perhaps more important than the technological gains are the working relationships that developed because of RDSI. To carry out the project, the city and the utility established public-private partnerships with local technology providers and major customers. These relationships are key to the next exciting steps.

Fort Collins, with RMI's help, is creating a net-zero energy downtown district that will be super-energy-efficient and draws its electricity needs from a diverse set of local renewable resources, such as wind, solar PV, and biomass.

Fort Collins is located in sunny Northern Colorado, where the Great Plains meet the Rocky Mountains.

FORTZED BUILDS MOMENTUM

While these first two projects formed the foundation for FortZED, the steering committee recognized that the district's success ultimately demands very high levels of engagement from the community. In 2010, the committee worked with several community members and the nonprofit The Atmosphere Conservancy to create the FortZED Community Energy Challenge. The Challenge is a grassroots effort to attract community members to take a pledge to reduce energy use in their homes; the Challenge has registered over 2,100 community members to date.

Judy Dorsey, executive director of the Colorado Clean Energy Cluster and instrumental in the founding and development of FortZED, says scenario planning shows that the combination of the FortZED Energy Challenge, the building retrofits, and RDSI, coupled with existing city-wide efficiency and renewables programs, will provide approximately 15 percent of the resources to reach net zero by 2030. Admittedly, there is much left to be done.

RMI, FORT COLLINS, AND THE PATH AHEAD

Unfazed by this challenge, the FortZED team is charging ahead with the help of RMI. In November 2012, RMI's e-Lab hosted a two-day charrette in Fort Collins to help the city's leaders identify new opportunities to accelerate FortZED and the whole city's move toward a clean energy future.

The charrette resulted in two project ideas that are moving forward. In one, e-Lab is working directly with Fort Collins Utilities to explore changes in the utility's customer offerings that could induce unprecedentedly high levels of adoption for energy efficiency measures and solar PV. The potential changes being explored include innovative tariff designs, on-bill repayment of energy-related investments, and incentives that reflect the value of distributed energy resources. Together, e-Lab and Fort Collins Utilities are pioneering the development of a small-customer energy services company (ESCO) structure that could deliver integrated packages of energy efficiency services, solar PV, and other options for the customer.

In the second and complementary project, RMI is developing a detailed, Fort Collins-level *Reinventing Fire* vision to show the way forward to dramatically accelerate citywide goals to transition from fossil fuels to efficiency and renewables.

In addition, the FortZED steering committee is in the midst of creating several new projects to move the district closer to its goals. The committee is currently evaluating a wide range of potential projects for selection and planning in the next few months. The projects will touch on each of the four strategic elements of the FortZED plan: 1) reduce energy demand, 2) invest in renewable energy, 3) manage peak load, and 4) adopt smart grid technologies.

As it continues to build on its past successes with new projects, the city sees the light at the end of the tunnel. Keep your eye on what is going on in Fort Collins. If an energy revolution can happen on Main Street USA, it can happen anywhere.

For more information, read RMI's report Building the Electricity System of the Future: Fort Collins & FortZED.

Eric Maurer is a senior consultant for RMI.

At New Belgium Brewery in Fort Collins, a rooftop solar PV array—the largest privately owned array in the state when it was commissioned in 2010—generates 264,000 kWh of electricity each year.

WEB EXTRA

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

Insights

RECENT WHITE PAPERS AND REPORTS

NEW BUSINESS MODELS FOR THE DISTRIBUTION EDGE

by RMI

The declining costs and improving performance of distributed energy technologies—such as rooftop solar PV, energy efficiency, demand response, electric vehicles, and much more—are rapidly expanding the range of options for onsite generation and management of electricity, driving accelerated deployment of these technologies by customers and third-party service providers. This is leading to a fundamental shift: the electricity industry is evolving toward a constellation of interconnected business models at the "distribution edge," where retail customers interface with the electricity distribution grid. Existing electric utility business models, however, are poorly adapted to this evolving landscape. They're ill-equipped to tap the potential value of distributed resources to meet societal demands for cleaner, more resilient, and more reliable electricity supply. This paper describes how and why the forces changing the electricity system challenge existing models, and offers guiding principles and a proposed "solution set" for new business models.

Solar PV rooftop image courtesy of New Belgium Brewery.

REINVENTING EXISTING BUILDINGS: Eight Steps to Net Zero Energy

by RMI & Johnson Controls

Net-zero energy buildings fully offset their energy consumption and carbon emissions with renewable energy, preferably generated onsite. True to their name, they generate at least as much clean energy as they consume. Once considered an outlandish, far-reaching, expensive goal only available to the technically advanced, net-zero buildings are now well within the realm of possibility; they're required for all new California houses and U.S. Army installations by 2020. A study by the National Renewable Energy Laboratory found that there is the technical potential for over 47 percent of existing commercial building floorspace to achieve net-zero energy using currently known technologies and design processes. This paper, authored jointly with Johnson Controls' Institute for Building Efficiency, highlights the net-zero retrofit process.

DEEP ENERGY RETROFITS: An Emerging Opportunity

by RMI & American Institute of Architects

Architects know the profession has struggled of late. The recession has devastated architectural practices across the country; in the past three years, the employment rate among architects has declined by 28 percent. Recent graduates with degrees in architecture report the highest unemployment rate in the country at 13.9 percent. Yet crisis reveals opportunity, and architects are now leading in uncovering new sources of revenue via deep retrofits while addressing the industry's unemployment, building real estate value, lowering energy costs, and reducing environmental degradation. Energy efficiency retrofits have emerged as a robust source of economic and environmental opportunity. This paper, authored jointly with the American Institute of Architects, highlights the valuable leading role architects can play to take advantage of an emerging market opportunity with huge public and private benefits.

by Peter Bronski

Seeing the Light:

CAN AN ECO-CONSCIOUS CONSUMER OVERCOME STICKER SHOCK AND MAKE LIFE-CYCLE PURCHASING DECISIONS?

Image courtesy of Shutterstock/Chesky.

In 2012 Americans installed 49 million LEDs. A-type lamps and directional lighting made up 65 percent of energy savings, adding up to $675 million last year. That number could be $37 *billion*.

My wife, Kelli, and I try to be eco-conscious consumers. When I joined RMI as editorial director in November 2012, it only strengthened our resolve, especially when it comes to energy. We bought a house in Longmont, Colo., and to our dismay, 100 percent of its 80-plus bulbs were inefficient incandescents (also known as Edison bulbs)—they're the cheapest kind to buy and the costliest to operate.

Swapping them out for a more efficient variety was a no-brainer, but should we go with compact fluorescent lamps (CFLs) or light-emitting diodes (LEDs)? LEDs seemed the obvious choice—there's much to love about them.

Compared to incandescents, which are only about five percent efficient—converting just a small fraction of their energy to light and wasting the rest as heat—LEDs average 80 percent efficiency. Good LEDs easily outcompete even CFLs, to the tune of 100 lumens per Watt vs. 60–75 lumens per Watt for CFLs. In other words, they save tons of energy for the same amount of light output; analyses confirm we could reduce lighting energy consumption by a whopping 80 percent by switching to LEDs.

LEDs also go the distance. They can last 25,000 hours or more, compared to a scant 1,000–2,000 hours for Edison bulbs and up to 10,000 hours for CFLs, though CFLs often last a fraction of that—a McKinsey & Co. report says LEDs last three to five times longer than CFLs. Finally, LEDs put out relatively little heat, they contain no toxic mercury (as CFLs do), and they're instant-on (unlike CFLs' slow warm-up to full brightness). All of these benefits are icing on the financial cake: an LED vs. CFL cost break-even point of about six years, according to McKinsey.

Yet, despite such impressive performance, U.S. DOE forecasts only expect LEDs to surpass 25 percent installed residential lumen-hours by 2020 and 62 percent by 2030. Why such slow growth in spite of overwhelming benefits?

As Kelli and I found out, there's one major problem: cost. It's fairly common to find LEDs priced around $30 *per bulb*. For consumers accustomed to paying $1 or less for a 60-W incandescent, that's a major hurdle. Indeed, although residential LED adoption has grown more than 50-fold since 2009, LEDs still represent less than one percent of total lighting infrastructure.

When it came to LEDs, I knew the smarter long-term choice—lighting accounts for nearly one-fifth of electricity spending in the average household—but could I overcome sticker shock and become part of that growing one percent?

It would have been prohibitively expensive to swap out all the bulbs in my house at once. The most efficient bulb is the one you never turn on, so we turned our attention away from the basement, where we spend little time, and instead focused on bulbs that got the most burn time: evening exterior lights in front of the house, an entryway chandelier, and the kitchen and dining room where we spend the bulk of our time.

I then did what any (former) engineer would do: built a spreadsheet and ran the numbers to put my mind (and wallet) at ease. My calculations included a few basic assumptions, including our retail electricity rate from municipal Longmont Power & Communications (at just under 7.5 cents per kWh, we enjoy some of the cheapest electricity in the country); a subsidy taken at the checkout counter of our local home improvement store that knocked the price back from $30 to $20 per LED bulb; estimated hours per day and days per year of bulb burn time; and conservative estimates of CFL and LED lifespans, factoring in the number of CFLs I'd need to replace over the much longer lifespan of the LEDs. My results were surprisingly consistent with the McKinsey findings: just over six years to break even.

Though beyond the three-year payback acceptable to most consumers, it was good enough for us. We dropped $350 on 17 bulbs. Now we're enjoying bright, warm, instant light that's using a small fraction of the energy it did before, and for an upfront investment that will earn itself back and then start paying us with energy cost savings into the foreseeable future.

We were in good company. According to a May 2013 U.S. DOE EERE report, in 2012 Americans installed 49 million LED lamps and luminaires. A-type lamps (the standard light bulb shape we all think of) and directional lighting (like the flood and spot lights in my kitchen and dining room) made up 65 percent of energy savings, adding up to $675 million last year. That number could be $37 *billion* if all bulbs were swapped out for LEDs overnight.

There are even better times ahead. Earlier this year, manufacturer Cree—which recently doubled its market cap to $7 billion in just one year, according to *Forbes*—unveiled LED bulbs with a retail price of around $10 each. Many commentators are calling that a magic number that may help LED sales jump through the roof. Moreover, this spring, Philips announced a prototype LED boasting 200 lumens per Watt, double the energy-saving efficiency of today's LED standard. The lifespan of LED bulbs is also increasing; the U.S. DOE anticipates a crazy 75,000 hours by 2030.

We're seeing these increases in efficiency and lifespan even as costs are dropping dramatically. For A-type lamps, for example, the average price dropped from $250 per kilolumen in 2008 to $40 in 2012, while bulb efficiency increased by more than 50 percent during that same period. There's also the additional driving force of federal energy efficiency standards, which will phase out 40- and 60-Watt incandescent and other bulbs by 2014.

As LED technology continues to improve and prices drop further, we expect our whole house—like those of millions of other Americans—will switch over to LEDs. We've seen the light, and there's no turning back.

Peter Bronski is editorial director of RMI.

WEB EXTRA

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

A Flameless Dragon

CHARTING A CLEAN ENERGY PATH FOR CHINA

by Jon Creyts and Clay Stranger

In 2011, RMI published an energy roadmap for the United States called Reinventing Fire. *Its bold, integrated strategy would transition the U.S. off coal and oil energy by 2050 by aggressively deploying energy efficiency and renewables. Now RMI is embarking on an equally bold and aggressive initiative with important implications for the global energy landscape: conduct a similar analysis for China. Between October 2012 and June 2013, RMI staff—including chief scientist Amory Lovins, program director Jon Creyts, and manager Clay Stranger—traveled to Beijing four times to set up and launch the effort.*

FEBRUARY 2013, BEIJING, CHINA

It is about a kilometer walk from the Forbidden City to Beihai Park. Halfway there your throat is burning and your eyes sting. Pacing yourself as you climb the hundreds of steps to the base of the ancient white pagoda, you keep your heart rate low, not wanting to further irritate your respiratory system. The blanketing smog hangs thick, visibility is limited, and by the time you reach the pagoda's platform you can barely make out the temple gates less than 500 meters away. This winter, Beijing has seen some of the worst air quality on record; for the first time the pollution levels exceeded the 1–500 Air Quality Index, essentially breaking the scale.

The severity of the pollution, nearly all from burning coal and oil, hasn't gone unnoticed. Chinese officials, international media, and Beijing residents have all called for action. Even China's state-run media has been outspoken. During a recent peak smog event, a headline in the Party-run *China Youth Daily* read, "More suffocating than the haze is the weakness in response." Chinese officials recognize the need to act decisively. This great energy challenge the country faces offers the opportunity to shift from fossil fuel supply to an efficient and renewable future while solving for pollution, public health, and energy security. With millennia of history of global leadership, China now has the opportunity to embrace that role yet again, helping to blaze a trail to a new energy era.

PAST AND PRESENT

The past two decades have seen China rise once again to global prominence, a position it occupied for much of the last two millennia. For 18 of the last 20 centuries, China has had the world's largest economy, and from 1 AD through 1800 AD accounted for over 20 percent of global GDP. Spurred by advancements in technology, Western Europe and the Americas leaped ahead of China in the last two centuries, but China's growth has reawakened. Expanding from 4 percent of the world's GDP in the decades of Mao Zedong's rule (1949–1976) to more than 15 percent today, China has realized growth rates of 7–9 percent per annum for the past decade. It is now the second largest economy in the world, and is projected to surpass the U.S. in absolute size before 2017.

Such rapid growth, made possible through diligent planning and closely controlled resource consumption, has allowed China to lift hundreds of millions of people out of poverty over the past few decades—something never before achieved on such a scale. At the same time, China managed to cut energy intensity by more than five percent per year for 25 consecutive years through 2001. Having departed from that trajectory for much of the first decade of the 21st century while it brought online energy-intensive heavy industries, China now appears on track to resume its prior trend of annual reductions in energy intensity. An experiment in building the world's largest export engine may have run its course, and China's gaze is turning inward to correct an economy that outgoing President Hu called "unbalanced, uncoordinated, and unsustainable."

Enabled by industrialization and powered by rapid urbanization, China's growth has brought with it the risks associated with pollution and resource constraints, but has also enabled parallel rewards, including poverty alleviation and the steeply dropping costs of manufactured goods, including renewable energy technologies.

PAN-PACIFIC LEADERSHIP

The transition to an efficient and clean global energy future cannot happen without leadership from both China and the United States. Together the two nations account for about 38 percent of global energy use and 43 percent of global energy-related CO_2 emissions. China recently surpassed the U.S. to become the world's largest gross energy consumer and CO_2 emitter, although the U.S. still uses and emits more per person. As the world's largest energy consumer, China burned over four billion tons of coal in 2012—more than the rest of the world combined—providing nearly 70 percent of the nation's total primary energy. During 2001–2011, China was responsible for 55 percent of global growth in energy demand. Such staggering numbers show the size of the challenge.

Yet despite having a heavily fossilized energy sector, China is also a world leader in renewable technologies. In 2012 it was responsible for over 25 percent of the global renewable energy investment total of $269 billion. And while temporary over-supply has lately rippled through the solar power market, China's manufacturing productivity

Image courtesy of Shutterstock/oxz700.

Air pollution in Beijing has strengthened resolve for China to shift from fossil fuels to efficiency and clean renewable energy.

A solar PV array in Shanghai is a visible demonstration of China's growing embrace of renewable energy technologies.

has similarly spurred the rapid global decline in renewable prices.

In February 2013, China's National Energy Administration increased its solar supply targets from 21 GW to 35 GW total installed capacity before the end of 2015. Although ambitious, China is well positioned to realize this target given that it produces 60 GW of photovoltaic cells annually, 75 percent of the global total. Meanwhile, no other country has approached China's scaling of wind energy, doubling each year for five successive years. China now has over 60 GW of installed wind capacity and is on track to meet its 2020 goal of 100 GW. Urbanizing rapidly, China continues to build infrastructure at a breakneck pace. Some estimates indicate that China will build 50,000 skyscrapers over the next twenty years, equal to ten new Manhattans.

With the U.S. plus China consuming nearly two-fifths of the world's energy, there has never been a better moment for collaboration between the two countries in an effort to test the limits of energy efficiency and explore the maximum feasible share of renewable supply.

RMI IN CHINA: WHY NOW?

Given the resource intensity and market reach that comes from being a global manufacturing engine, China's growing attempts to shift from a fossil-based economy to one increasingly embracing efficiency and renewables are important for all. The simple truth is that any path to a new energy era must pass through China. Therefore, RMI has thought long and hard about how best to learn from the Chinese experience, and how to effectively share RMI's insights into ambitious and integrated energy systems planning with China.

As we have engaged leading Chinese experts, we have found a unique opportunity for pan-Pacific learning and partnership that is perfectly timed to meet both societies' clear and urgent needs. A joint effort has taken shape to pool collective knowledge and help build a more robust understanding of efficiency and renewables' potential for, and limits to, changing the trajectory of China's future energy use. Now is an ideal time for RMI's involvement in such an effort for four key reasons:

1. Having just undergone a leadership transition, China is ready for change. Recognizing the challenge and opportunity, China's new leadership called for "a revolution in energy production and use" at the 18th Party Congress in November 2012. Indeed, this theme featured prominently in the recent summit between Presidents Xi and Obama in Palm Springs, Calif., in June.

2. China is hitting significant resource barriers that threaten economic growth targets and undermine the country's energy systems. For example, a *Bloomberg New Energy Finance* report earlier this year noted that China's "Big Five" power utilities have more than 500 GW of thermal power plants—largely coal-fired—in water-stressed areas and face more than $20 billion in water efficiency retrofits to improve their resilience, bolstering a growing call for water-efficient renewables. Meanwhile, with plans to urbanize 250–300 million people over the next 17 years, energy efficiency will play a vital role in realizing national economic targets while delivering basic services to a vast new urban population. Facts like these further build the resolve to forge a new energy path among the nation's leaders.

3. China is at an important moment in its planning process to begin to address combined energy, environment, and security issues. It is currently crafting the aspirations for its Thirteenth Five-Year Plan to take effect in 2016. Planning is a vital element of China's centralized government, and the Five-Year Plans are a series of sweeping national macro-economic strategies, authored and implemented by the National Development and Reform Commission. Initially the plans were created to encourage growth and drive industrialization, but they are increasingly viewed as vehicles to harmonize those goals with growing social and environmental concerns. Through a unique partnership, RMI has an opportunity to position some of its ideas for consideration in the Thirteenth Five-Year Plan.

4. Previous studies have provided key insights on energy possibilities, but to date an analytically robust approach that assesses the technical feasibility and economic impact of coordinated changes across all four energy-using sectors is absent from government planning processes. There is an opportunity to create insights that are critical in the current planning process through new tools and cooperative engagement.

For these reasons, RMI has seized an opportunity to work with the Chinese government on a project that will help envision a path for China to meet its energy needs economically using the maximum feasible share of efficiency and renewables through 2050.

AN INTEGRATED APPROACH

The initiative's analysis aims to spotlight the economic, social, and environmental benefits of rapidly deploying renewables and energy efficiency technologies in China. To do so, it will focus on an economy-wide analysis of the four energy-producing and -consuming sectors of the economy: buildings, industry, transportation, and electricity.

For each sector, the team will develop and use "bottom-up" models to estimate the potential for different technologies and approaches to shift the trajectory of China against the business-as-usual scenario. Modeling will include both specific energy-saving and renewable technologies, and integrated benefits achieved by combining multiple options. Relying on our Chinese partners to inform the effort, the goal is to develop a robust, transparent, adjustable, and enduring modeling ability that will help inform government policies and China's energy future.

KNOWLEDGE TO ACTION

The intent of the project is to provide knowledge that will lead to actions—policies, technology development, and adoption approaches—that will improve China's overall energy efficiency and increase the adoption of renewables, thereby reducing expected growth in energy use, substituting supply with renewables where economic, and reducing fossil fuels' CO_2 emissions. This will be achieved through five primary outputs:

1. An executive report summarizing the key technical findings and analyzing their implications will be disseminated to key government, business, and academic thought leaders.

2. An accompanying policy report authored by the Energy Research Institute (ERI), one of the National Development and Reform Commission's think tanks, will translate technical and economic insights into specific policy recommendations for the central government.

3. Presentations to relevant Chinese leaders will ensure direct exposure to the analysis as well as to provide platforms for regular discussion of the findings.

Image courtesy of Shutterstock/ArtisticPhoto.

4. A modeling tool embedded within ERI will be used on an ongoing basis as China further refines its vision and delivery approach after the initiative has concluded.

5. An online database documenting analytic approaches, assumptions, and calculations with relevant digital content will help provide analytical transparency.

A TEAM EQUAL TO THE CHALLENGE

RMI has created a unique partnership of Chinese and American experts with the requisite experience and skills to conduct a world-class analysis.

Energy Research Institute (ERI), a primary partner, is a Chinese national research organization conducting comprehensive studies on China's energy issues that both proposes and evaluates energy policies. ERI's research focuses on the fields of energy economics, energy efficiency, climate change, and renewable energy. ERI reports to the National Development and Reform Commission, the agency responsible for national economic strategy and formulation of the Five-Year Plans.

The China Energy Group at Lawrence Berkeley National Laboratory, another primary partner, is committed to understanding the opportunities associated with meeting China's energy needs, and to exploring their implications for policy and business. With over thirty years of experience in China, the China Energy Group works collaboratively with energy researchers, suppliers, regulators, and consumers in China and elsewhere to better understand the dynamics of energy use in China, to develop and enhance the capabilities of Chinese institutions that promote energy efficiency, and to create links between Chinese and international institutions.

The most recent addition to the project team, the China Sustainable Energy Program (CSEP), is a nonprofit organization and the Energy Foundation's Beijing office. With an emphasis on both national policy and regional implementation, CSEP assists Chinese agencies, experts, and entrepreneurs in solving energy challenges. At the request of Chinese leaders, the program supports capacity-building and technology policy transfer by linking Chinese experts with best practices expertise from around the world.

Combine the expertise of our partner organizations with RMI's more than three decades of effort driving the efficient and restorative use of resources, and we have assembled a team equal to the challenge and complexity of the project.

MOVING FORWARD

The *Reinventing Fire* approach has resonated with a number of leaders in China and the Chinese government has pledged financial support for the project. ERI has assembled an impressive advisory panel, including State Councilors and Minister-level officials, to offer regular guidance throughout the research process. The panel includes several co-authors of the forthcoming Thirteenth Five-Year Plan. Direction from such a distinguished group of advisors will help ensure the credibility of the findings and will support our goal of creating results that are sufficiently plausible and compelling to be worthy of consideration in the Thirteenth Five-Year Plan.

We firmly believe that a cooperative effort between the U.S. and China has the potential to help rewrite the global energy story: shifting from dirty, depleting, and costly energy resources towards efficient use and abundant, clean supply. As the two largest economies in the world, our countries' joint leadership on energy issues is essential to drive global change. By sharing best practices and cooperatively testing the limits of efficiency technologies and business models, the change we seek can be jointly led and sped from both sides of the Pacific.

On June 19, 2013 in Beijing that journey officially began. Approximately 90 officials, corporate leaders, and academics attended the initiative's launch, including representatives from China's National Development and Reform Commission, the United States' Department of Energy, and the World Bank. There, a soaring eagle and a mighty dragon pledged a commitment to work together over the next two years to find innovative ways to quench the fires that threaten our collective progress, and explore jointly the possibility of a flameless energy future for all. RMI is proud to be a leader in the creation and pursuit of this universal vision as we take our mission to *reinvent fire* to the world.

Jon Creyts is a program director for RMI. Clay Stranger is manager of the office of the chief scientist for RMI.

WEB EXTRA

For more information on this topic visit: rmi.org

Beyond the Tip of the Energy Iceberg

WHY RETROFITS CREATE MORE VALUE THAN YOU THINK

by Scott Muldavin

Buildings in the U.S. consume a heck of a lot of energy—they use 42 percent of the nation's primary energy and 72 percent of its electricity. Much of that energy is needlessly wasted through inefficient design and operation. That's why we forecast an opportunity to reduce buildings' energy consumption by 54–69 percent over business-as-usual projections through 2050, resulting in absolute energy consumption in 2050 that would be 40–60 percent less than in 2010, *despite* a 70-percent bigger building stock.

Financial cost reductions alone make a strong argument for pursuing this future with superefficient buildings. For example, RMI's analysis found that an incremental investment of $0.5 trillion between now and 2050 could save a total of $1.9 trillion in energy costs. A joint Rockefeller Foundation / Deutsche Bank Group 2012 study similarly found energy savings worth four times their cost under an even tighter ten-year time frame: an investment of $279 billion could yield more than $1 trillion in energy cost savings.

Whether in such large-scale studies or stories about individual projects, the focus is almost always on lower energy costs. For example, when Reuters reported last year on the iconic Empire State Building's deep energy retrofit—whose energy design RMI co-led—they again focused on energy cost reductions, noting that the building had saved $2.41 million in its first full year following the completion of the retrofit, ahead of schedule en route to an anticipated $4.4 million of annual operating cost savings.

Image courtesy of Shutterstock/YanLev.

MOVING BEYOND ENERGY COST SAVINGS

A focus exclusively on saved energy costs ignores or overlooks other important values—"value beyond energy cost savings" (VBECS). Numerous studies and surveys note that, compared to market averages, energy-efficient green buildings boast reduced absenteeism, better employee health, higher occupancy rates, increased rental rates and sales prices, and decreased financial and regulatory risk.

We ignore these additional values—a robust land of opportunity that sits just below the surface, beneath the saved-energy-cost tip of the value iceberg—to our own detriment. If we are to make the nation's building stock significantly more energy efficient sooner than later, VBECS must be taken into account as an important driving force. Otherwise, deep retrofits—and the energy investment opportunities they entail—will remain under-prioritized. Value derived from saved energy cost is necessary but sometimes not sufficient to motivate investors, especially when investors' values align differently than those of building occupants.

Compared to market averages, energy-efficient green buildings boast reduced absenteeism, better employee health, higher occupancy rates, increased rental rates and sales prices, and decreased financial and regulatory risk.

Today, most building investors ignore the non-energy value created by retrofits, instead basing their decisions on simple payback—weighing upfront investments in energy efficiency against anticipated savings in energy cost—and require an average payback period of only 3.4 years. Even current industry best practice analysis (life-cycle cost analysis, or LCCA) only incorporates saved energy and operating costs, plus capital cost avoidance over the life of improvements, while still largely ignoring other values as well as risk.

DEEP RETROFIT VALUATION AND RISK

Rather than examine energy costs in isolation, our approach assesses how energy and sustainability improvements add value to all parts of a property or company. This approach is not revolutionary, but rather more comprehensive, applying industry-accepted valuation methods to the full set of retrofit value contributions, including saved energy costs, health and productivity benefits, reputation and leadership, and risk reduction.

Energy investment (and resultant property outcomes) should be treated as one of many factors that influence value, including location, tenant mix, quality of design, and more. Evaluating retrofits within the broader context of property/company value enables a logical, defensible calculation and assessment of a deep retrofit's relative contribution to value. Previous attempts to value energy retrofits have ignored retrofits' value contributions and overlooked standard approaches to valuing properties and companies.

For example, risk is one of the most important factors in any deep energy retrofit capital decision and has a direct tie to VBECS. Most commercial property valuations look at a stream of cashflows over time, with an assumed sale of the property in the future (net operating income in the last year divided by a capitalization rate). This string of cashflows is converted to a present value by applying a discount rate, which is simply the rate of return required to attract an investor to the stream of cashflows. Thus if retrofit investors think a project has high risk, they will require a high rate of return (discount rate) to attract them to invest. The higher the discount rate, the lower the value, and the less likely that a deep retrofit will be funded. This is where VBECS' integration of risk into decision-making can have a real impact.

Risk is not a soft, indirect, or non-financial consideration, but one of the most important value elements in a deep energy retrofit investment. For example, an annual $1,000 retrofit cashflow benefit with a five percent return requirement would be valued at $20,000, approximately 100 percent higher than the same $1,000 cashflow benefit valued assuming a 10 percent return requirement. Simply put, even if your VBECS analysis does nothing else but clearly identify risks and discuss how they can be managed and/or mitigated, you will have successfully applied important value concepts in a way that is not typically done well, or at all, today. If your risk assessment can reduce required returns by even a few percentage points, it makes deep retrofits possible so the dramatic gains can be realized.

ASSESSING VALUE BEYOND ENERGY COST SAVINGS

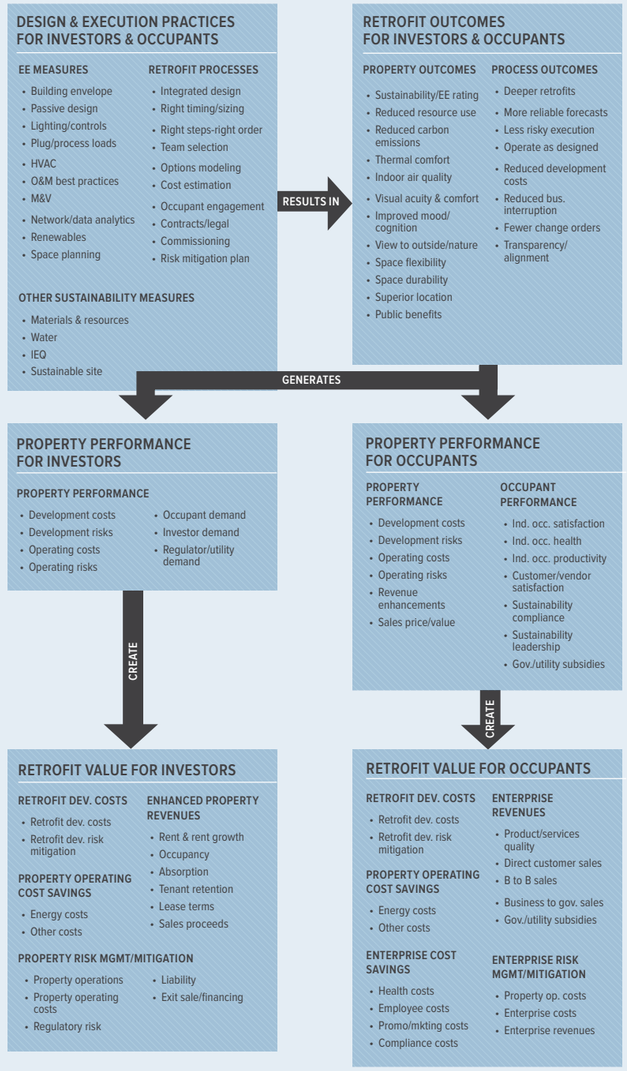
A growing body of statistical evidence suggests that green office buildings can command rent premiums of 3–6 percent and sales price premiums of 10 percent or more. The health, productivity, and recruiting advantages for occupants of energy-efficient and sustainable properties are also becoming better known. Yet authoritative guidance on how to calculate and present such value beyond energy cost savings for specific property retrofit decisions has not yet been available. RMI's VBECS project is working to fill this gap.

The project integrates sustainable building valuation and underwriting with RMI's historic strengths in identifying and deploying beyond-best-practice building technology, design, and retrofit execution. The first phase of that work, to be published later this summer, is a significant advance from earlier work because it explicitly separates occupant and investor value models (see Retrofit Value Model at right) , more directly links specific energy efficiency measures to value, and focuses on a structured process for calculating and presenting retrofit value.

RMI's Retrofit Value Models clarify how energy and sustainability improvements—as well as the processes delivering them—produce value. Retrofit value for occupants is driven by the value created in the enterprise (such as a business) occupying the property. Retrofit value for investors, on the other hand, is driven by reduced energy and other operating costs, and revenue gains from tenants who value sustainability/energy efficiency and are willing to pay for it (through higher rents, faster lease-up, higher retention, and other ways that enable the investor to monetize tenant demand).

Our retrofit models specifically address the links between specific retrofit strategies and values that derive from those strategies. Making those connections clearer is an important component of any valuation, especially one that aims to include VBECS accurately and more fully.

RMI RETROFIT VALUE MODEL



Many energy improvements have discernable impacts on staff or enterprise outcomes—beyond their energy savings—and many do not. For example, a space that is retrofitted with operable windows to provide natural ventilation can increase occupant satisfaction and performance as well as save energy for cooling. In contrast, a heat recovery system also saves cooling and

heating energy, but does not change ventilation or occupant comfort in any way. Few if any industry efforts exist to shed light on such causal relationships between retrofit measures and occupant or enterprise value.

VBECS IN PRACTICE

Evidence demonstrating retrofit value beyond energy costs savings is substantial, and examples abound:

- Major real estate investment trusts (REITs) and pharmaceutical companies have cited recruiting and retention of workers as the primary factor supporting net-zero energy buildings and high levels of sustainability.
- A major telecommunications company looking at potential investments in deep energy savings found that potential health cost savings were more than triple the energy cost savings.

Deep energy retrofits that include natural light, community areas, and other elements add value that goes well beyond saved energy costs.

- A large public pension fund decided to increase construction costs one percent to employ underfloor ventilation, based on an analysis of potential health and productivity gains of its workers in the building and potential reductions in churn (internal move) costs.
- A large government agency developed an integrated cost-benefit model to incorporate non-energy-cost benefits into its analysis of green roofs.
- A large international financial organization recently focused its VBECS retrofit analysis on risk, preparing substantial analysis of potential business interruption, cost overruns, execution timing, occupant and manager engagement, and strategies for risk mitigation.

VBECS risk analysis is also being regularly applied by occupants and investors worried about the risk of not taking action—and losing potential recruiting and retention benefits, or losing tenants, especially when the cost/hassle premiums of deep retrofits are rapidly declining.

HOW WILL VALUE KNOWLEDGE EXPAND ENERGY INVESTMENT?

While industry participants have different requirements of value knowledge, deep and broad energy investment in real estate will be limited until the value and risk of energy retrofits can be integrated into decision-making.

Many capital providers, such as pension funds, REITs, and corporations have taken the first steps—assessing energy performance, replacing inefficient lighting, and improving operations and maintenance practices. But thoughtful calculation and presentation of value is required to increase the depth and breadth of investment.

Commercial property sales and leasing brokers, architects, engineers, and nonprofit energy advocates all play a critical role in advising clients on their energy efficiency/sustainability choices in their real estate decisions. The inability to integrate value and risk into their discussions—and in the case of architects, engineers, and consultants, into their calculations and recommendations—limits both the breadth and depth of adoption.

Government agencies such as the General Services Administration and the Department of Defense have focused on the "value" and non-energy-cost benefits of sustainability investment to support their continued investment in higher levels of energy efficiency and sustainability. This trend for governments to support their investments with value arguments is expected to grow.

You might expect VBECS issues to present less opportunity for Property Assessed Clean Energy (PACE) promoters, energy service companies (ESCOs), and utility sponsors because they all base their lending and service offerings on saved energy costs alone. But you'd be wrong. In fact, value has become a central consideration in the future success of PACE and related programs.

The main issue has been demand for the programs by borrowers. The rates look good, and the longer loan terms are positive, but borrowers need to be "sold" on the potential value benefits of the investments, with a particular focus on risk mitigation and management. These same issues are also important to convince first mortgage holders to approve the secondary liens usually required or sought.

Every retrofit or renewable investment has someone (typically multiple someones) charged with taking a hard look at a project's assumptions. Due diligence analysts and underwriters do not need "empirical" or statistics-based evidence to prove every point, but they do need structured analytic valuation and risk assessment methodologies rigorously applied by professionals.

Today, most building investors ignore the non-energy value created by deep retrofits, instead basing their decisions on simple payback or life-cycle cost analysis. But accounting for value beyond energy cost savings can unlock significant investment.

Sustainability and energy efficiency have become central concerns to regulators, employees, customers, clients, boards, and other stakeholders. Maximizing recognition of value by all stakeholders requires understanding what aspects of sustainable value are most critical to different stakeholder groups and clearly communicating these values.

The real estate industry has dramatically evolved over the past 10 years to the point where many profit-minded corporations and investors are striving to be more energy efficient and sustainable. Finally, with the introduction of RMI's Retrofit Value Models and the efforts of many companies and nonprofits, these investors now have a way to turn their implicit understanding of the deep retrofit value into explicit value analysis compelling to senior decision-makers, unlocking vast capital resources to enhance the world's use of its resources. If we're going to drive much greater investment in a dramatically more energy-efficient building stock, value beyond energy cost savings must be a part of that conversation.

Scott Muldavin, CRE, FRICS is a senior advisor for RMI.

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by Ned Harvey

The Case for Giving Away IP

ENTREPRENEURIALISM & COLLABORATIVE PROBLEM SOLVING AT RMI

When *ClimateWire* profiled RMI co-founder and chief scientist Amory Lovins earlier this year, it quoted former head of the Central Intelligence Agency R. James Woolsey. "If he patented everything he's come up with," Woolsey said of Lovins, he "could be the CEO of an extraordinarily large company, but that's not Amory; that's not what he does. He plants ideas and then goes on and plants some more."

Indeed, RMI's brand of entrepreneurial, collaborative problem solving flies in the face of conventional wisdom that says you lock down your intellectual property. Instead, we give most of ours away.

Why? The answer is simple. RMI and our supporters want the insights and benefits resulting from our work to accrue to everyone, everywhere. Our solutions are for public benefit. We create intellectual property and transform it into intellectual social property—our ideas are public by design, given away by nature, with dissemination built in via our network of collaborators and other partners. We want solutions to be adopted, not shelved.

Since our founding 31 years ago, RMI has advocated that the power of innovation and entrepreneurialism can solve the nation's and the world's energy challenges. And we believe our approach can expand solutions far beyond our boundaries, letting the market for great ideas serve as the true catalyst for change in the world. This model works.

For example, with an aspiration to transform the auto industry and reduce (and eventually eliminate) its dependence on oil, RMI created in 1990–91 the innovative Hypercar concept, which won the 1993 ISATA Nissan Prize and a decade later a World Technology Award. RMI soon founded the Hypercar Center to explore the technical feasibility and commercial reality of building a hyper-efficient automobile that could revolutionize the auto industry. This vehicle was a radical idea at the time, featuring ultra-light construction with an aerodynamic body using advanced composite materials, low-drag design, and hybrid drive.

At an e-Lab charrette, RMI, utilities, regulators, corporations, and other stareholders came together to develop collaborative solutions to problems facing the electricity system.

Image copyright of RMI.

Initially we explored and validated the concept in private discussions with automakers. But when it needed to be spread more widely and pursued more aggressively, in 1993 we placed the Hypercar concept in the public domain. We wanted the ideas to proliferate in the market, and figured that, like Linux software, it would be adopted faster if it were free. The effort was well publicized to ensure anyone could learn about RMI's work and engage with our innovations. The concept incubated in and around RMI and its Hypercar Center for five years.

Then, with these ideas freely out in the public arena, RMI helped bring them to the market, spinning off Hypercar, Inc. in 1999 to further develop the Hypercar concept. By 2010, three automakers—BMW, Volkswagen, and Audi—announced volume production by 2013 of the kinds of carbon-composite electrified autos RMI has long advocated. BMW's midvolume i3 and sporty i8 are carbon fiber plug-in hybrid electric cars. VW's XL1 carbon fiber plug-in hybrid two-seater, which has been dubbed the "world's most efficient" car by some, may be the most literal realization of the original Hypercar concept, with key parameters closely matching our early-1990s analyses. Audi's production goal slipped, but its Crosslane Coupe concept—unveiled publicly last year—did show a carbon-fiber plug-in hybrid SUV rated at over 200 mpg.

Most importantly, the principles behind the Hypercar design—ultralight, ultrastrong, aerodynamic, carbon fiber construction—are increasingly becoming commonplace throughout the auto industry.

Today as RMI works to bring the *Reinventing Fire* roadmap to reality we are deeply engaged in industries ripe for change and where the proliferation of innovative ideas and business models is more important than ever. Increasingly we find ourselves as a catalyst for the promotion of collaboration and "coopetition" between innovators and incumbents alike to bust the barriers that stand in their way to a brighter energy future. With RMI playing a crucial leading role, we are once again reliant on intellectual social capital to solve the challenges before us.

RMI's ambitious Electricity Innovation Laboratory (e-Lab) is a powerful case in point. It is a model for open and collaborative innovation across the electricity sector. e-Lab is a living laboratory convened and led by RMI, where electricity industry leaders—friends, competitors, and adversaries—can safely and boldly engage to explore the challenges and opportunities facing the electricity industry, and collectively innovate and experiment to create a cleaner, more resilient, secure, and thriving energy future for us all. From new business models that help utilities, third-party service providers, and customers capture the true values and costs of distributed energy resources such as rooftop solar, to making the soft costs of solar PV lower, we are as committed as ever to collaborating with the right stakeholders and key players, to developing breakthrough solutions, and most importantly, to putting those solutions on the table for public consumption.

> We create intellectual property and transform it into intellectual social property. We want solutions to be adopted, not shelved. Our return on donors' investment accrues to society as a whole.

But we cannot succeed without the crucial generous support of our donors. In today's economy, long-time incumbents are facing threats from innovative, disruptive startups. Those startups are backed by venture capital that seeks a strong return on investment to exploit proprietary products and services.

RMI doesn't work that way. Our return on donors' investment accrues to society as a whole, not to private individuals looking to build their personal equity and reap robust financial dividends. To be sure, our work yields financial and other dividends as well—remember that *Reinventing Fire* outlines a path to a future built on clean, secure, resilient efficiency and distributed renewables, while supporting a 158-percent bigger economy at a $5 trillion savings. To get there, though, we need investors—donors—who share our vision that through intellectual *social* property—by giving away our IP—we can do the most good in the world for the most people.

Ned Harvey is COO and head of development for RMI.

by Greg Rucks

Battling America's Automotive Obesity Epidemic

Automobiles' heavy steel must be replaced by ultralight, ultrastrong carbon fiber to enable ultra efficient and electrified autos.

Succeeding in the monumental task of transitioning the entire U.S. transportation system off oil starts with a seemingly straightforward but important first step: focus on automobiles.

Americans face an obesity epidemic of staggering proportions: nearly 36 percent of U.S. adults are considered obese, according to the Centers for Disease Control and Prevention, up from 12 percent in 1990 and 23 percent in 2005. That obesity epidemic has been fueled in no small way by an addiction to liquid fuel, in particular the sugary empty calories of soda. Last year Americans' soda consumption averaged more than 467 12-ounce cans per person, according to data from *Beverage Digest*.

Our cars have followed a similar trajectory. In the past quarter century the average weight of new cars has ballooned by nearly 25 percent, growing from 3,221 pounds in 1987 to 4,009 pounds in 2010. In percentage terms, cars gained weight twice as fast as we did. And their parallel addiction to liquid fuel—oil—is enormous. Autos alone account for half of U.S. oil use, to the tune of 8.8 million barrels *per day*.

With stronger new fuel economy standards, that trend should start to slow or even reverse. But if we're serious about getting the U.S. transportation system off oil sooner than later, more drastic action is necessary.

THE COSTS OF OIL ADDICTION

America's oil dependence seemingly costs $2 billion per day, but actually costs upwards of three times that much—$6 billion per day, or a sixth of GDP. That's due to three kinds of hidden costs, each about a half-trillion dollars per year: the macroeconomic costs of oil dependence, the microeconomic costs of oil-price volatility, and the military costs of forces whose primary mission is intervention in the Persian Gulf. Yet RMI's analysis shows that transitioning America's transportation system completely off oil could save $3.8 trillion in net present value between now and 2050—or nearer $12 trillion if we counted those hidden economic and military costs.

That strong economic incentive is just the beginning. Our oil addiction's real costs to health, safety, environment, security of energy supply, global development and stability, and national reputation are extra. With atmospheric CO_2 levels over 400 ppm for the first time in human history—and enormous environmental and human health impacts from oil exploration, consumption, and emissions—ending oil addiction is imperative for reasons that extend well beyond just saving fuel costs. But how do we do that?

DRIVING CHANGE

Succeeding in the monumental task of transitioning the entire U.S. transportation system off oil starts with a seemingly straightforward but important first step: focus on automobiles. The sheer size of the U.S. automotive industry means that efficient technologies adopted for autos can quickly impact a wide swath of the market, with a strong ripple effect that propagates through the other interdependent arms of the transportation industry, including heavy trucks, airplanes, trains, and ships.

Getting cars off oil requires two fundamental shifts: 1) dramatically increase their fuel efficiency, and 2) as we're already starting to see with EVs, electrify their powertrains. Both of those shifts are ultimately dependent on an incredibly influential driving factor: vehicle weight, which causes two-thirds of autos' fuel use.

Lightweighting autos can coax maximum efficiency out of our reimagined cars of the future and enable powertrains that take full advantage of the more efficient and higher-performing characteristics of electric drive. For such revolutionary cars to achieve their fullest potential, we need to take a "clean sheet" design approach, reimagining the vehicle from scratch.

All of this depends on a key driver: advanced lightweight materials. That's because higher-performing materials enable groundbreaking designs and smaller, more efficient, and cheaper electric powertrains that deliver higher performance with fewer batteries.

Carbon fiber composites quickly emerge as the preeminent advanced lightweight material to do this. It offers unparalleled potential to produce ultralight, ultrastrong cars while maintaining or exceeding vehicle safety, robustness, and performance standards and expectations.

CARBON FIBER CHALLENGES

If carbon fiber is so great, why hasn't it been adopted already?

To some degree it has, though mainly in niche markets for high-end, small-production-run sports and luxury cars. For example, you'll find carbon fiber in the hood and roof of the BMW M3, the A-pillar of the Aston Martin Vanquish, and the floor and bulkhead panels on the 2014 C7 Corvette. Carbon fiber has also started to trickle into other makes and models. VW is developing a carbon fiber roof option (explicitly designed to shave weight and improve fuel economy) for the performance version of its Golf. And Toyota, after shutting down production on its carbon-fiber-based Lexus LFA supercar, may start incorporating carbon fiber parts into other models.

BMW's M3 (left) and Volkswagen's XL1 both incorporate carbon fiber to shave weight while maintaining strength and performance and drastically improving fuel economy.

Then there's Volkswagen's XL1, which achieves the astounding efficiency of 230 mpge through lightweight structure enabled by carbon fiber construction along with very good aerodynamics and low rolling resistance. But the initial run will produce only 250 vehicles priced at a hefty $130,000 each. BMW's i3, starting at midvolume production (rising quickly to 30,000+ vehicles per year) and priced at around $40,000 euros, better illustrates determination to bring carbon fiber electric cars into the mainstream.

These examples demonstrate the Achilles heel of carbon fiber autos to date—low- to mid-volume production at fairly high cost. Making carbon fiber structures more cost effective and widely adopted across high-volume, mainstream autos is the next challenge. That's where RMI comes in.

THE ROAD AHEAD

In November 2012, RMI hosted a three-day workshop in the Detroit area with about 45 leading experts from across the automotive carbon fiber composite value chain, industry experts, and government representatives. We convened to develop ways to break down the barriers that have stifled advancements in lightweighting autos. Overcoming those barriers would permit the widespread penetration of carbon fiber composite into mainstream vehicles.

Two related strategies soon came to the forefront: a parts campaign and an innovation hub.

Starting with a campaign for individual parts would be a high-leverage pathway to eventual high-volume production. For example, just one high-volume carbon fiber part on four mainstream vehicles would double total worldwide demand for carbon fiber, creating strong pressure to streamline processes, increase innovation, spur competition, optimize supply chains, and prompt adoption. Workshop participants identified and rigorously evaluated three promising parts that offered both a financially attractive and technically viable near-term business case: the door inner, the engine cradle, and the seat back.

Meanwhile, an innovation hub based in Detroit or elsewhere would facilitate knowledge sharing and provide access to shared test rigs and manufacturing equipment. It would foster collaboration among automakers, their supply chains, government, advanced tooling manufacturers, and industry experts. Such "coopetition" will be necessary to spur industry adoption of carbon fiber beyond small-scale, niche applications.

Now, RMI is focused full speed ahead on a discrete parts campaign to incorporate a carbon fiber composite part targeted on a circa Model Year 2018 vehicle with a production capacity in excess of 50,000 units per year. This alone will save 5.2 million gallons of fuel per year and 47,000 metric tons of annual CO_2 emissions. But more importantly, it will break open the market for automotive carbon fiber, starting the U.S.—and the world—on a more concrete path to ending our automotive obesity epidemic and thirsty addiction to oil.

For more information, read RMI's report Kickstarting the Widespread Adoption of Automotive Carbon Fiber Composites.

Greg Rucks is a senior consultant for RMI.

WEB EXTRA

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

The C7 Corvette and many other high-end sports and luxury cars make use of carbon fiber, but the technology has yet to permeate high-volume, mainstream autos.

Corvette image copyright General Motors.

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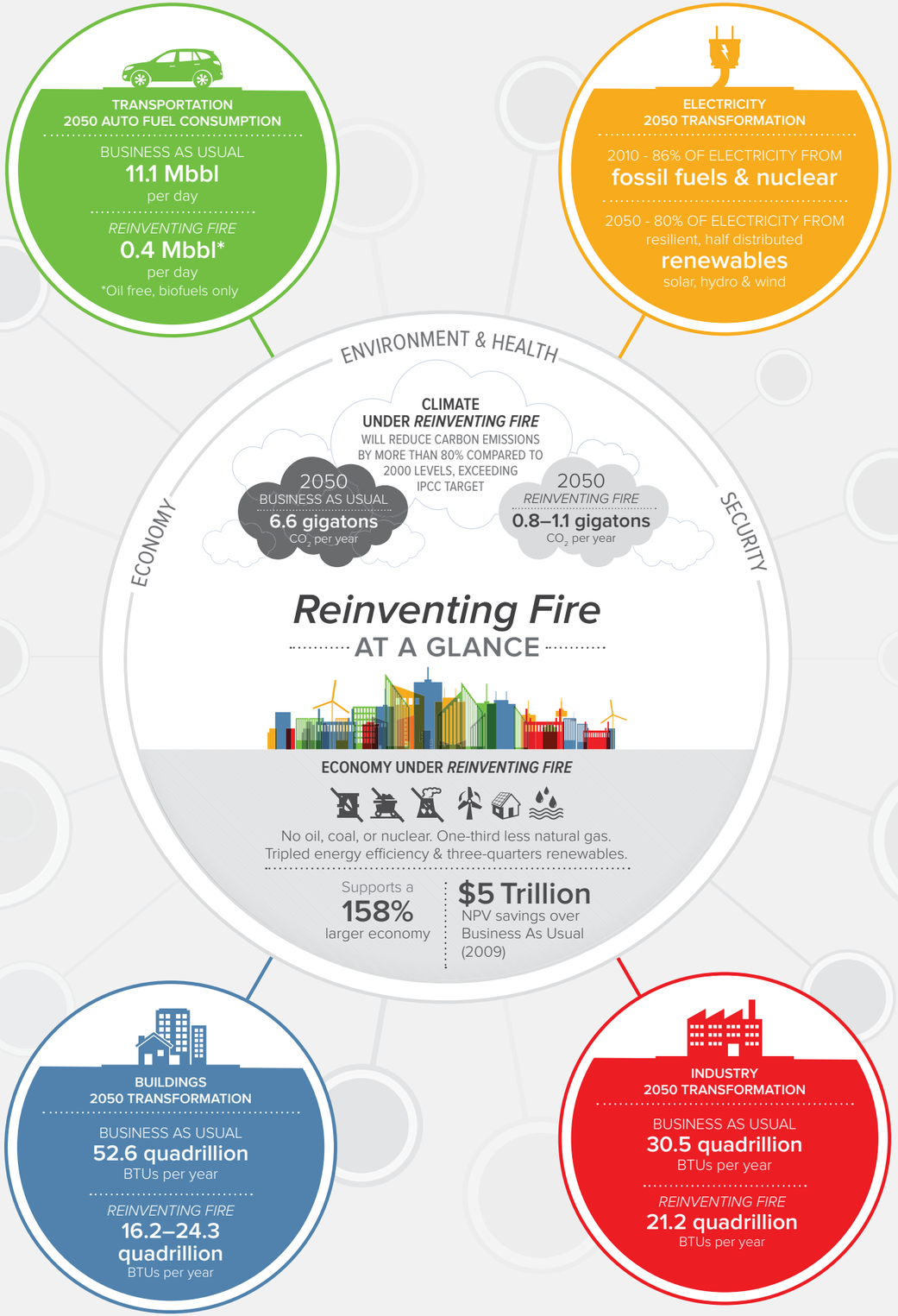

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On June 19, 2013 in Beijing, RMI and appoximately 90 officials, corporate leaders, and academics launched *Reinventing Fire: China*. Read more on page 16.

Image courtesy of ERI.

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Solutions Journal is published annually, 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.

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