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RMI Solutions NEWSLETTER

Not a Chip Off the Old Block

With a Little Help from RMI, Texas Instruments Breaks New Ground

By Christina Page

Paul Westbrook would love to show you his house. It's a passive-solar, award-winning structure in Fairview, Tex. that uses a third of the electricity and less than a fourth of the water of conventional homes in the region. It's got super-windows, an aerobic septic treatment system, active solar water heating, a geothermal heat-pump heating system, and a pair of 1,600-gallon rainwater tanks. Its design details, favorable economics, and carefully measured performance are all posted at **www.enerjazz.com/house**.

Achieving resource efficiency and sharing information about it are two of Westbrook's talents. When he isn't showing people energy-efficient design, systems, and devices in his home, he's working hard to bring those innovations to his company—Texas Instruments, where he's the sustainable design manager.

When Westbrook encountered skepticism about the cost-effectiveness of switching from energy-hogging cathode-ray-tube computer screens to flat-screen displays, he wrote an extensive spreadsheet showing the company-wide benefits from energy and other savings. But he had loftier

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Photos pp. 1–2 courtesy Paul Westbrook, TI Worldwide Construction

Photo courtesy Judy Hill

What's Inside...

TI Makes Fab Chips. RMI Researcher/consultant Christina Page describes RMI's collaboration with Texas Instruments on a fabulous new chip fab—in Texas (p. 1).

***Oil* and Ink.** RMI's Media Director Jenny Constable takes a look at the broad coverage received by *Winning the Oil Endgame* (p. 3).

Making Waves in Boat Design. RMI Researcher/consultant Will Clift recounts how a recent RMI charrette tackled energy consumption and resource issues on a yet-to-be-built yacht (p. 5).

International Style. RMI Architect/principal Huston Eubank, AIA tells readers about his worldly adventures in green design (p. 10).

What Are You Doing? Our fall interns explain what they're up to (p. 15).

Other Voices. Ole von Uexküll explains how fossil and nuclear energy systems exacerbate the global water crisis (p. 18).

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Donor Spotlight. The National Association Of Realtors has a big new green office in Washington DC that's turning heads. NAR's Joe Maheady and Iris Amdur describe the new building and explain why NAR supports Rocky Mountain Institute (p. 24).

Texas Instruments

By driving revolutionary change and jettisoning incremental evolutionary design, the 30-percent-lower-capital-cost goal gave Westbrook and his unfunded "Fabscape" sustainability design team their opening to test the most innovative ideas.

goals in mind. When RMI's CEO Amory Lovins addressed a Sustainable Dallas event in 2001, Westbrook grabbed him to give a seminar at TI on efficient "fabs"—microchip fabrication plants. In spring 2003, Amory returned to TI; the crowd was much larger and interest was growing. To raise awareness about the opportunities for sustainability and whole-system design, Westbrook brought three TI vice presidents to his house and showed them his utility bills (just as RMI has done at its superefficient headquarters). This got their attention—and got them talking about implications for the company. "It helped demonstrate that applying good design could allow a much more efficient system with minimal capital investment," Westbrook pointed out.

A year and a half later, on 18 November 2004 in Richardson, Tex., TI broke ground on a state-of-the-art, high-efficiency, million-square-foot chip fab (including 220,000 square feet of clean room), designed in part with ideas generated during a three-day charrette[1] with Rocky Mountain Institute.

RMI has worked for chipmakers before—mainly consulting for another world leader, **STMicroelectronics** (see *RMI Solutions* Fall/Winter '03). During 1998–2000, RMI's experts surveyed eight ST fabs, finding large potential savings with fast paybacks. Sure enough, STMicroelectronics (like IBM and DuPont) has been cutting its energy use per unit of production by 6 percent every year, paying back in 2–3 years. But at TI, RMI had the prized opportunity to help design a new chip fab from scratch—bound to save more and cost less than retrofitting old ones. Normally, in the boom-and-bust chip business, redesigning the next fab is either premature or too late; there's never a good time to do it. But Westbrook astutely timed his intervention, and engaged RMI just in time to change the design mentality, both in his firm and in its equipment providers and consulting engineers.

When Texas Instruments officials first began discussing their new facility, sustainability wasn't the foremost thing on their minds. Wafer fabs are complex, extremely capital-intensive (often several billion dollars), and highly energy-intensive. Numerous layers of submicroscopic chips, with features smaller than a flu virus, are etched, sputtered, and baked onto silicon wafers by exotic high-tech "tools" inside climate-controlled "clean rooms." Chip manufacturing is extremely sensitive to disruption and contamination. Reliability is crucial—production stoppages can cost more than $1 million per day. Workers must be kept comfortable inside special smocks to keep dust and lint out of the ultra-clean air (the tiniest speck could ruin a chip whose features are less than a hundred-thousandth of an inch across). The tools' need for precisely controlled temperature and humidity can be even more critical.

To compete on cost, Texas Instruments was seriously considering building its new facility overseas. But of course fab's high cost is due not just to its specialized tools but also to the scale and complexity of the elaborate equipment that provides abundant chilled water, clean air, scrubbed exhaust, vacuum, and other "utilities." Using those services more frugally can make the fab cost less, work better, build faster, and win in the marketplace.

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The new TI wafer fab in Richardson, Tex. features an administration building in the foreground; a support link connecting to the wafer fab and administration building, and a CUP (Central Utilities Plant), attached to one end of the fab. A few of the environmental features include proper orientation (long east-west axis) for the administration building, reflective roofs, and a several-million-gallon rainwater retention/detention pond at the back of the site.

Rendering: AMA Group (www.amagroup.net)

Oil Gets Ink (and Air)

By Jenny Constable

The September 20 release of RMI's newest book, *Winning the Oil Endgame: Innovation for Profits, Jobs, and Security*, brought significant media coverage for the Institute. On release day, the online editions of the *Wall Street Journal*, *Greenwire*, *Fortune*, and *Time* covered *WTOE* (*Fortune*, *Time*, and the *WSJ* quickly ran print articles as well). *Time* called the book "one of the best analyses of energy policy yet produced." The *Christian Science Monitor*, *Energy Compass*, the *Atlanta-Journal Constitution*, and the *Aspen Daily News* also covered the book within days of its release. All told, the first week brought coverage by at least ten major news outlets around the country. Then, a 30 September column by the *Denver Post*'s respected Diane Carman highlighted *WTOE* as an antidote to America's "acute failure of imagination" in energy policy.

Google results: ("Winning the Oil Endgame")
7,560

Complete book downloads as of 31 Jan. 2005:
(www.oilendgame.com/pdfs/WtOEg_72dpi.pdf)
128,282

In October, *WTOE* was mentioned in such diverse outlets as *Renewable Energy Access*, *Wired News*, and *Oil Daily*. A 6 October report in *New Scientist* noted that the Pentagon's partial funding of *WTOE* "suggests that despite the current Administration's rhetoric that such measures are impractical, some branches of government are taking clean energy more seriously than it… seems." On 7 October, *The Economist* extolled the book's "sharp and sensible ideas."

And the coverage seems to keep rolling in.

The authors have now completed over a dozen radio interviews about the book, and editorials in the *Los Angeles Times*, the *Providence Journal*, and the *Buffalo News* promoted it. A 20 December *Wall Street Journal* op-ed by President Reagan's national security advisor, Robert C. McFarlane called it "[p]erhaps the most rigorous...analysis of what it will take to wean us from foreign oil."

Yet, the ideas presented in *WTOE* aren't revolutionary compared to the work RMI produces regularly. The Institute constantly touts efficiency as the fastest growing energy source and the cheapest new supply. So why haven't these ideas and solutions received more attention from the press?

Many at the Institute believe that's because *WTOE* responds to a specific problem: U.S. dependence on oil. *WTOE*'s focus makes it easier for journalists to see how its findings relate to issues they are covering and resources that affect their audience's pocketbooks.

"The timing of the release was excellent," said **Karen Nozik**, RMI's communications director. "It's relevant to a broad range of constituencies because virtually everyone is influenced by the role oil plays in our economy." The book targeted business and military leaders, showing them how to accomplish their goals better, while the economy struggled. High oil prices since summer kept energy in the news. And, energy independence was part of the fall political debate, so folks on both sides of the aisle were open to its recommendations.

In addition, powerful comments from experts have boosted the book's success. President Jimmy Carter wrote: "Its novel but persuasive ideas, which hold promise of revitalizing American industry and agriculture, should appeal to conservatives and liberals alike." William F. Martin, former National Security Council staff director and deputy secretary of energy called it "one of the most important energy studies in decades." Former Royal/Dutch Shell head of scenario planning Peter Schwartz, now chairman of Global Business Network, called *WTOE* "thoroughly comprehensive and imaginative"; Bill Glover, director of environmental performance strategy for Boeing Commercial Airplanes named it "a masterpiece."

All five authors have been a part of the *Winning the Oil Endgame* media campaign. Nathan Glasgow has done radio interviews with stations from Salt Lake City to Troy, N.Y.

We hope *WTOE*'s success in the media will help us learn how to better position RMI's ideas. The great systems thinker Dana Meadows once

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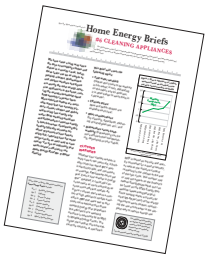
wrote, "There is only one force in the modern world that can cause the entire public to think differently. That force is the mass media."

This book has helped us make significant progress in using the media to create positive change in the world. Perhaps RMI's next publication will bring us even more coverage and help more people think differently.

Jenny Constable (jenny@rmi.org) is RMI's Media Director.

RMI *in the news*

Updated Home Energy Briefs a Hit!



RMI's recently-rereleased Home Energy Briefs seem to have become a pretty major hit—literally and figuratively. In fact, if you Google "home energy briefs" on the web, the first entry that comes up is RMI's Home Energy Briefs (out of 2,770,000 returned pages). As RMI Art Director Ben Emerson noted, "talk about savvy marketing precision!"

Also, the Briefs are now available on the National Association of Realtors website at **www.realtor.org/GAPublic.nsf/pages/energybriefs?OpenDocument**. How successful have the Briefs been? According to RMI Webmaster Bill Simon, between 29 October and 31 December 2004, the Briefs were downloaded from www.rmi.org 8,526 times.

Individually, all the Briefs seem to be popular, although Brief No. 1 (Building Envelope), seems to be the single most popular. It was downloaded a respectable eighty-seven times on 14 November.

"What a great resource they are," noted Amy Palanjian of ***Organic Style*** magazine.

Chock full of sidebars, lists, and colorful illustrations, the Briefs run between six and ten pages and tackle nine areas of interest to the typical homeowner: building envelope, lighting, space cooling, space heating, water heating, cleaning appliances, electronics, kitchen appliances, and "whole system design."

Serendipitously, one of the first people to use the Briefs was **Nancy Hirshberg**, of Stonyfield Farm, one of the sponsors of the project.

"The timing [of the Briefs completion] was particularly good for me as I've needed to do something about my windows, and a friend who is a carpenter finally has time this winter to work on it, so we took out the section on windows this weekend and used it to help make some decisions," Nancy noted in a message to RMI. "I actually brought the document with me to the lumber yard, and printed some of the links. I learned a lot. I found the links especially helpful as they provided so much detail. All of the questions that I had were answered…."

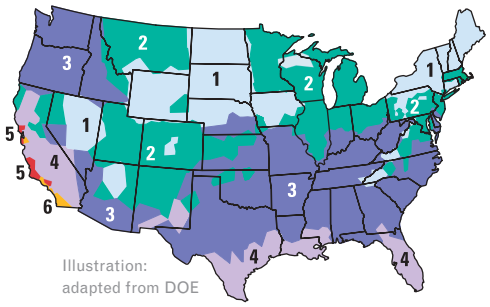


Illustration: adapted from DOE

Six zones' officially recommended cost-effective levels of insulation for new houses, counting only the value of saved energy, not of smaller or eliminated space-conditioning equipment. Corresponding R-values for ceiling, wall, floor, crawl space, slab edge, and basement are listed in Home Energy Brief No. 1, Table 1, p. 2.

Elsewhere, such organizations as **Energy Star® Homes** (www.energystarhomes.com), **Conservation Services Group** (www.csgrp.com), **The Energy Outreach Center** (www.climatesolutions.org), and **Washington State University Extension's Energy Program** (www.energyideas.org) have added links or have begun to refer people to the Briefs.

Although a limited number of hardcopies of the Briefs are available, the Institute is asking would-be readers to download their own copies from **www.rmi.org/sitepages/pid171.php#LibHshldEnEff**. These PDFs run between 148 and 260 kilobytes, and are easily downloadable via a standard dial-up telephone connection. For more information, contact **publications@rmi.org**.

Briefs Nos. 1–9 in the Home Energy series are funded by Stonyfield Farm, the Durst Organization Inc., the National Association of Realtors, and Deborah Reich.

The Good Ship *Ethereal*

By Will Clift

"Ships are the nearest things to dreams that hands have ever made."

Robert N. Rose

On a cool November evening in a small Dutch town, several Rocky Mountain Institute consultants sat in a hotel lobby, discussing the schedule for the three-day design charrette[1] that would begin the next morning. As we sat there, a tall, intense man strode briskly towards us. He greeted us and wasted no time diving into the project at hand; laptops appeared with impressive speed, a team of colleagues emerged from adjacent tables, and the lobby was quickly transformed into an impromptu design studio.

The man was **Bill Joy**, co-founder of Sun Microsystems. The team organized by Bill and RMI consisted of eleven world leaders in their fields—ranging from biological wastewater treatment to super-efficient air conditioning to advanced battery storage of electricity. Several noted naval architects also took part. The team's mission was to help Bill create a more efficient, integrated design for his new home, a 182-foot- (55.5-meter-) long expedition sailing yacht named *Ethereal*, scheduled for launch in 2008.

That our design effort began late on a Sunday evening, and that it took place in a hotel lobby instead of an elaborate drafting room, is indicative of the nature of the integrative design process. RMI places more emphasis on getting the right people together than on getting them in a particular place with specific tools. The most effective conceptual designs—the kinds that provide simple, elegant solutions—often don't require laboratories and wind tunnels, but rather open dialogue and the free exchange of ideas between people from different disciplines. This is one of the keys to integrative design.

Initially the project's relevance to RMI's mission was questioned. Should RMI commit time and other resources to advancing integrative design in a niche industry such as this—especially one accessible only to the world's wealthiest? Did the hope of innovations' trickling down to other industries provide sufficient incentive? Or did the appeal of the industry and the apparent indulgence of the boat's function conceal an opportunity to address problems that are actually enormously relevant, timely, and integral to a range of issues central to our mission? It quickly became clear that there were at least two levels on which the latter was true (see "Why the *Ethereal* Charrette?" by RMI CEO Amory B. Lovins, on p. 8).

Most directly, *Ethereal* will be both a vessel that transports people and a structure in which they live, two functions that RMI deals with daily, albeit in more traditional forms. Indeed, most systems on a luxury yacht deliver the same functionality found in commonplace vehicles and structures ashore, though with greater reliability and amenity.

On a broader level of applicability, a good yacht must also provide all the amenities found in the infrastructures of well-designed neighborhoods and cities. During the charrette Bill frequently reiterated that *Ethereal* should be thought of as self-contained, as though she were an isolated island that could travel the seas.

The boat must keep her passengers (crew and guests) safe, regardless of location and weather. She must have redundant critical systems, be resilient to breakdown, be easily fixed with spare parts on hand, and—in an emergency—provide life support for an extended period of time. Secondly, all systems must be easy to run with very little upkeep, as crew time is precious. Thirdly, *Ethereal* must provide her passengers with high-quality food and water without relying on frequent shipments from distant sources; she must be able to store or produce several weeks' worth of nourishment. Also, like a modern community of people, a yacht produces wastes,

Photos p. 5 (l–r): 1–2 courtesy Eng Lock Lee; 3–6 courtesy Judy Hill (www.judyhill.com)

Ethereal Charrette

RMI's methodology starts with the "end-uses"—in this case the services that *Ethereal* is expected to provide—and asks how they can be provided more efficiently.

organic and non-organic, that must be treated and disposed of responsibly. On a yacht the issue of trash is much harder to ignore than on land—there is no "away" to throw it; all trash must be kept on board until it can be unloaded ashore. Finally, *Ethereal* must minimize or, ideally, design out the emissions of odors, gases, and noises, which not only reduce enjoyment of a voyage, but can also pose health threats to passengers and those living near areas in which she docks. *Ethereal* must provide all of these services in a relatively tiny envelope. Imagine having a wastewater treatment plant, a desalination plant, a landfill, and a power plant all within 100 feet of your bedroom; how would you design these systems? Now add to this the constraints of preserving range, speed, handling, and beauty, plus the self-imposed goal of accomplishing all of this at comparable or lower first cost. The result is a significant and relevant design challenge.

The charrette was held at **Royal Huisman Shipyard** in Vollenhove, Holland, the yard that will build *Ethereal*. RHS is a vertically integrated shipyard. Aluminum plates, roughhewn planks of wood, and other raw materials come in one end, and finished boats come out the other, each fully detailed from fine cabinetry and electronic circuitry (*Ethereal* will have many miles of wiring and densely packed plumbing) to hull paint. She will have the latest technologies in navigation, communications, and engines, all tightly integrated into a design with sophisticated real-time monitoring. RHS, a family business founded in 1884, is a world leader in an industry known for its extreme conservatism—a mindset due as much to the industry's entrenched traditions as to the life-threatening consequences of an equipment failure at sea.

RHS has prided itself on innovating within the conservative shipbuilding industry; recently the shipyard adapted, from racing yachts, the use of composite materials such as carbon fiber in masts, booms, and other components. Even this development took time, and had its naysayers. It was clear from our first involvement that innovations proposed during this charrette would be appropriately subjected to the strictest of vetting processes, and that we would have to prove that our ideas satisfied all concerns, from durability to aesthetics, from ease of use and maintenance to capital cost.

RMI's methodology starts with the "end-uses"—in this case the services that *Ethereal* is expected to provide—and asks how they can be provided more efficiently. Only after minimizing the use of resources do we address how services are provided; doing otherwise would result in supply systems that are too big, too costly, and often too inefficient due to operation well below their full capacity. In particular, we aim not just to shrink supply systems but to get rid of them entirely, which dramatically reduces capital cost and complexity. RMI's co-founder and CEO, Amory Lovins, calls this "tunneling through the cost barrier," because it often makes very large resource savings cost *less* than small ones. This can also save space (critical on any boat), weight, and crew time.

The *Himawari* system

In a green building, a good designer makes all possible use of glare-free daylight before supplementing it with artificial light. Daylighting will be far more difficult on *Ethereal*, as living quarters are below deck, with only small portholes and hatches to afford views and admit natural light. Yet an approach derived from a Japanese invention called the *Himawari* ("sunflower") system can pipe natural light via fiber optic cable into the darkest areas of the hold. The hope is to use this piped light to grow herbs or vegetables below deck—a luxury on a voyage that lasts longer than fresh food can be preserved in a refrigerator. Daylighting can also directly enhance human health and well-being.

Photos pp. 6–7 (l–r): 1–3, 5, 7–10 courtesy Judy Hill (www.judyhill.com); 4, 6, 11 Amory B. Lovins; 12 courtesy PAX Scientific

For *Ethereal*, charrette participants found several such opportunities for "tunneling." An immediately evident example was interior lighting. Replacing standard incandescent lights (mainly tungsten-halogen) with the latest natural-color light-emitting diodes (LEDs) and other advanced technologies would save enough energy to pay for the LEDs quickly. However, some of the biggest benefits of this change are indirect. LEDs last ten to twenty times longer than their conventional equivalents, saving crew time spent on replacing bulbs. More efficient lights also release less heat into the boat's living spaces, meaning less air conditioning would be needed. This in turn would not only save energy in the air conditioner, but would also allow a smaller air conditioning system to be installed, again saving cost and space.

Water use onboard further illustrates how integrated design generates compounding benefits. A typical yacht the size of *Ethereal* would use some 8,000 liters of water per day for everything from cooking, drinking, showering, and laundry to washing the deck. All this water would be made daily by pumping ocean water through a high-pressure reverse-osmosis desalination system, which—despite being one of the most energy-efficient purification technologies available—is still energy-intensive. Charrette participants quickly eliminated 54 percent of this consumption through efficient yet equally pleasant and effective technologies in showers, laundering, and other areas, as well as by recycling some of the water used to wash the deck. These savings do not include further options, such as using the deck-wash recycling system to capture and store rainwater too. By making reasonable assumptions about technologies still under development, the group developed a yacht design that would require only 4 percent of the water that a standard yacht would use—largely by recycling water and collecting condensation. Not only would these strategies save the energy needed to desalinate the water in the first place, but they would also reduce the size and cost of water storage, purification, and energy systems.

In addition to increasing the efficiency of resource use, participants identified several waste streams that could be captured and used. For example, such yachts' engines typically discharge most of their fuel energy as waste heat into the sea or air, then use engine-generated electricity to provide thermal services such as water heating, space heating, and clothes drying. It is far more fuel-efficient to capture, store, and use the waste heat freely available from the engines; the group estimated that this could meet all thermal loads (which were already reduced through efficiency).

Today's yachts typically use a large diesel engine (so large that one must generally cut a hole in the ship to replace it) for propulsion, and run medium-sized diesel generators continuously to generate electricity. Analysis confirmed that in *Ethereal*, as in the latest military ships, turning the propeller with an electric motor instead of an engine-driven shaft, and making electricity for both propulsion and onboard loads in a shared system, would yield many advantages. These include enabling the propeller to be trailed when under sail, turning the motor into a generator. With such a system, a substantial amount of energy can be generated with only a very slight decrease in wind-provided speed that can be stored and reused later, often eliminating the need to run the diesel generators (whose waste heat, though, must then be substituted by other means).

Since *Ethereal*'s propulsion and onboard loads will both be unusually efficient, the electricity can come from three renewable sources—the sail-driven "hydropower" mentioned above, solar cells, and innovative mast-borne wind turbines—augmented by several rather small identical diesel generators. The varying loads and sources are all buffered through storage, such as lithium-ion batteries or, eventually, fuel cells generating electricity from stored hydrogen. The multiple identical engines would increase system efficiency, save valuable space, and share spare parts. The fuel tanks would shrink by one-third. And while sailing or at anchor, the renewable sources could keep the engines off and the boat silent for days at a time.

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Why the *Ethereal* Charrette?

Amory B. Lovins, CEO

People who work at Rocky Mountain Institute tend to view their work through the mirrors of global consciousness and conscience, so when word first got around our Snowmass campus that the Institute was co-organizing a design workshop for a luxury yacht, there were some grumbles. Why, some RMItes asked, would we work on such a frivolous project when there are so many more pressing issues? Indeed, one asked, "Why not just sell the yacht and give the money to the poor?"

Of course, we don't own the boat. Nor do we design things only for poor customers (as we did in 2002, at a considerable financial loss, for refugee camps). If we didn't redesign the huge industrial process plants—over $10 billion worth of them in the past five quarters—that are necessarily owned by large and wealthy corporations, or the vehicles that such firms make, we'd be punting on most of the world's waste of energy and resources. We do try to help the excellent groups that specifically help poor people around the world, and we make our intellectual capital freely available to them, but we strive to improve the *whole* world, not just the poor parts of it; and often the richest societies and institutions do the most harm.

More fundamentally, focusing just on the boat misses the point. I launched RMI's engagement in this project because its design challenges, opportunities, and learnings are so important to our mission. Here's why.

At RMI we create abundance by design (p. 14), and we learn by doing: we learn faster and create more market leverage by doing applied research, not just theory. In this case, an immensely innovative, discerning, and knowledgeable client invited us to advance the global state of the art in integrative, biomimetic design for a superefficient, clean, green microcosm that could meet human needs and wants, extremely reliably, under all conditions. That broad design problem and its universal application was what got my attention—not the specific physical form and use in which it first occurred. Four aspects of the problem seemed to me especially likely to teach us things we needed to know.

Most obviously, *Ethereal* would require us to update and refine our knowledge of the world's best technologies for providing, with the utmost in elegant frugality, practically every basic service that people need. (That this application also provides luxuries doesn't change that basic point.) And we couldn't design systems that'd work in only one place or orientation. Think of a small hotel that must work everywhere from the blazing tropics to the poles, can face in any direction, often moves in all directions (sometimes violently), must be rugged and compact, and must keep working with utter reliability for decades with only rare resupply. What a way to learn better ways to design everything—even systems for, say, villages, refugee camps, and the Navy! (The Third World is sometimes defined as "No spare parts." The details differ, of course, but many of the basic design lessons are transferable.)

Next, *Ethereal* would not just apply everything we knew about advanced resource efficiency, but also integrate it unusually tightly. For example, boats use much electricity desalting seawater, so water savings would stretch the electricity budget—but also make more of it with renewables, increase silent (fuel-free) running time, shrink engines, tanks, and emissions, and save space, capital cost, fuel, and maintenance.

Third, many of our industrial designs already integrate disparate parts of energy systems, for example by turning waste heat into needed services. Our work on superefficient vehicle design has captured remarkable benefits from snowballing savings of weight, which causes three-fourths of a car's fuel use. But we'd never before had the opportunity to focus so closely on compounding the savings of *space*—the most valuable thing on a boat, costing far more than top Hong Kong real estate. Of course our designs for efficient buildings and industrial systems tend to save space too, and unlike most designers, we assign proper value to that benefit, but it hadn't previously been a primary goal, and was something we needed to get better at.

Last but far from least, *Ethereal* would offer our best opportunity yet, working with three of the world's masters, to start applying the latest thinking in biomimicry. Such "innovation inspired by nature" seems to us one of the two great revolutions in design that can make the world profoundly better; the other is our practice of design integration for radical resource efficiency. (A third, nanotechnology, is more ambiguous.)

This unusual learning opportunity lies at the heart of RMI's mission, and it's not every day that someone offers the chance to apply it in severely practical terms. Yes, the result is likely, experts told us, to transform the luxury-yacht industry's practice and culture. That's good, but it's incidental to our deeper purpose. We accepted the *Ethereal* invitation mainly to inform our basic design agenda to make the world secure, just, prosperous, and life-sustaining. That's why we've formalized integrative design as a special area of RMI's practice (p. 14), and why our contribution to that world is so distinctive.

We plan to continue helping people to do integrative, biomimetic design that uses resources efficiently and restoratively, regardless of who those people are, where they live, whether they're rich or poor. It's the work that matters. And in time, this project could well prove to be some of the most consequential integrative design work we've done yet.

Photos: pp. 8, 9-left courtesy Eng Lock Lee, p. 9-right courtesy Judy Hill (www.judyhill.com)

A truly sustainable yacht would be made from only rapidly renewable resources. It would generate the food and energy it needs from the environment around it. It would also clean the water and air as it moves.

The charrette also gave participants the opportunity to brainstorm the use of technologies still under development that could be added to *Ethereal* at a later date to improve resource efficiency and reduce environmental impact even further. Some of the most graphically compelling examples came from the field of biomimicry, prompted by Janine Benyus's persistent question "How has nature solved our design problem?" (RMI Board member Benyus, author of *Biomimicry: Innovation Inspired by Nature*, was on the team,

as were marine naturalist Jayden Harman, founder and CEO of PAX Scientific, and Dr. John Todd, a pioneer in biological design). Could a marinized version of Lotusan® Paint—a paint that mimics the bumpy structure of the lotus leaf to make it self-cleaning in the rain—be developed and applied to decks and other surfaces? Could the hull paint repel biofoulants (living organisms that often colonize a hull, roughening its surface and slowing the boat) the way certain red algae do, by exuding traces of a chemical jammer for bacterial communications? This could save significant crew time, water, cleaning agents used for daily maintenance, overhaul cost, and marine toxicity. Furthermore, could PAX Scientific's rotor design, based on a spiral pattern found throughout nature, help *Ethereal* move more efficiently through the ocean? Could the sails capture water from moist air, as the Namibian desert beetle's wings do? Lastly, could the vapor-absorbing ability of other desert-dwelling insects be developed into a desiccant system that not only passively dries the air for comfort, but also captures and collects pure water?

There is little doubt that *Ethereal* will chart a new course in reducing the resource consumption of a boat—

luxury yacht or otherwise. As compared to standard designs now in service, the charrette helped produce an uncompromised revised design that is expected to halve overall electricity use, diesel for propulsion, trash, water usage, and noise.

That said, the limitations of today's technologies, coupled with the amenities demanded on such a vessel, constrain the level of sustainability that can be attained today. A truly sustainable yacht would be made from only rapidly renewable resources. It would generate the food and energy it needs from the environment around it. It would also clean the water and air as it moves. To approach this lofty goal today would require simplifying the yacht and moderating or sacrificing some high-end amenities. But as technology, design integration, and especially biomimicry continue their advances, we suspect these constraints will slowly disappear. During this charrette we began to glimpse the potential for future designs of beautiful simplicity; as Amory paraphrased Antoine de Saint-Exupéry, perfect simplicity is "not when there's nothing left to add, but when there's nothing left to take away."

Will Clift (wclift@rmi.org) is a researcher/consultant with RMI.

[1] **Charrette:** an intensive, transdisciplinary, round-table design workshop. It achieves many months of normal conceptual design in typically a few days. A carefully conceived but flexible process, a typical charrette alternates between plenary sessions and topical working groups (sometimes cross-pollinated by "wandering minstrels") to yield a magical level of integration. Organizing and leading charrettes is one of RMI's core skills, applied successfully to hundreds of projects across a wide range of sectors, disciplines, and scales.

A charrette is a process of discovery, unlike any conventional workshop format, and thoroughly melds the "home team" with the "visiting team" so that after the visitors have left, the "home team" can consummate the new design. The charrette is meant not only to create a design and to learn together, but also to change how the participants think. Its results are not known in advance and often appear not-quite-impossible. At times its process may seem disorderly. But as we have learned by actually doing many, design charrettes always come together in the end, and abundance by design is the result.

It's a Green Green World

An Update on GDS's International Efforts

By Huston Eubank

Over the past few years, RMI's Green Development Services group has been working on green building design in the international arena in an effort to stimulate a major worldwide transformation in the global development and construction industry. Long experience in green development—including helping to launch the **U.S. Green Building Council** (USGBC) and its **LEED**™ (Leadership in Energy and Environmental Design) green building rating program—puts RMI in a position to take a leading role in these efforts. The USGBC and its LEED program have proven extremely effective in bolstering demand for green buildings in the United States. Today GDS is helping apply both USGBC ideals and LEED-style methodologies to sustainable design principles and practices around the globe.

Specifically, RMI is supporting the ongoing development of the **World Green Building Council** (WorldGBC), a federation of emerging green building councils. The WorldGBC, in turn, supports the creation of culturally-, climatically-, and economically-appropriate rating tools, the design and construction of demonstration green development projects, and other collaborative green building efforts, in both developed and developing countries. This article describes a few recent WorldGBC activities of note.

WorldGBC International Congress

In late August 2004, I journeyed halfway around the world to Hyderabad, India to participate in the WorldGBC annual meeting, hosted by the India Green Building Council. While there I gave a presentation on natural capitalism at the IndiaGBC 2nd International Conference on Green Buildings. This epic trip was underwritten by the **United States–Asia Environmental Partnership** (US–AEP) of the U.S. Agency for International Development (U.S. AID). The agency's Exchange Program for Sustainable Growth (EPSG) is designed to allow people in Asian governments, businesses, and non-profits to exchange information and ideas with their U.S. counterparts, with the ultimate goal of greater environmental sensitivity and more professional management of their own environmental systems. The program—as its name suggests—offers many exchange opportunities, and U.S. AID is enjoying a highly effective and successful partnership with the Indian Council that the WorldGBC hopes will serve as one model for its future growth.

Joining the WorldGBC were delegates from India, Australia, Canada, Mexico, Spain, Brazil, and the United States, as well as interested participants from South Africa, Singapore, United Arab Emirates, Japan, and Taiwan. WorldGBC officers welcomed and thanked special guest **Glenn Whaley**, Director of U.S. AID's Office of Environment, Energy, and Enterprise for U.S. AID's support.

During work sessions facilitated by WorldGBC Chair **Ché Wall** and GBC-Australia Executive Director **Maria Atkinson**, the delegates developed strategic plans to help develop and support green building councils around the world. Activities that could accomplish this were numerous, but one of the most effective—it was agreed—is the development of a WorldGBC website, which was recently launched (see **www.worldgbc.org**).

An important highlight of the meeting was the venue itself, the **CII-Sohrabji Godrej Green Business Centre**, which achieved the first LEED 2.0

RMI *in the news*

RMI Bookstore Changes

If you've been thinking about buying a paper copy of ***Cleaner Energy, Greener Profits***—Dr. Joel Swisher's 2002 work on fuel cells and their benefits—too late! The 2,500-copy press run recently sold out. It is, however, still available on RMI's website, at **www.rmi.org/sitepages/pid385.php**. Also, ***Factor Four*** is no more; after some examination of the cost (to RMI) of shipping the book, sales figures, and currency of content, RMI's in-house bookstore discontinued carrying it. It is, of course, still available through Earthscan (**www.earthscan.co.uk**).

Photos courtesy IndiaGBC

Platinum designation worldwide. Out of the 150 LEED certified projects around the globe, only seven have been awarded a Platinum rating; two of these are in India (the other is the ITC Green Centre, a futuristic 181,000-square-foot office complex in Gurgaon, India that achieved a Platinum rating in November 2004). These amazing buildings are proof of the effectiveness of the partnership between U.S. AID and the Confederation of Indian Industry, which launched the IndiaGBC.

IndiaGBC hosts treated their guests to the sights, sounds, and tastes of India, including a moonlit evening of music, dancing, and dining outdoors at a fifteenth century mosque, hosted by WorldGBC Vice Chair Mr. **Parasuaramen** and his wife. In a moment reminiscent of one of John Lennon's 1969 meetings with Srila Prabhupada, **David Gottfried**, founder of the WorldGBC, sat cross-legged on the stage, delivering his keynote address while accompanied by a sitar.

China Focuses on Green Building

At the USGBC's GreenBuild 2004 conference in Portland in November, the WorldGBC board hosted a dinner for representatives from the Ministry of Construction of the People's Republic of China. In a dynamic discussion with **Vice Minister Qiu Baoxing** and other Chinese officials, the two groups explored the future of green building in China, the creation of a green building council in China, and the benefits of being a part of the WorldGBC. When asked to share his dream for the future, Minister Qiu talked about restoring the balance between humans, animals, and plants—an inspiring dream shared by everyone around the table.

The prospect of working with China to implement green rating systems and practices is very exciting. The construction market in China is the largest in the world, with over twenty billion square feet of development per year. Establishing a green building council in China will be instrumental in furthering the push for sustainable development and green buildings worldwide.

"We look forward to learning from China's cultural history, riches, and diversity," said Ché Wall, WorldGBC chair. "In return, I believe China can learn from the experience of current GBCs, such as the USGBC and IndiaGBC."

China will host the Intelligent and Green Building Conference in March 2005 (see **www.sigbac.com/en/index.aspx**).

CONTINUED ON NEXT PAGE

Above: David Gottfried, founder of the WorldGBC, delivering his keynote address at the WorldGBC annual meeting.
Below: The CII-Sohrabji Godrej Green Business Centre, in Hyderabad, India, which achieved the first LEED 2.0 Platinum designation worldwide.

Mexico, Canada, Taiwan, Australia News

Also at GreenBuild 2004, the official launch of a green building council in Mexico was announced. MexicoGBC is a member of both the WorldGBC and **iiSBE** (International Initiative for a Sustainable Built Environment; see **www.iisbe.org**). Membership in both organizations is an important aspect of the MexicoGBC because it is an excellent model for their future growth and an important collaboration between the more academic and commercial-focused segments of the construction industry. Already this model is being used to create a green building council in Brazil.

Meanwhile, north of the United States' other border, the green building movement is doing equally well. As of 1 November 2004, the CanadaGBC had grown to over 500 member companies and officially launched LEED™ Canada (with its own accreditation exam). And finally, at our Hyderabad meeting, the TaiwanGBC applied for WorldGBC membership, which has just been granted.

The TaiwanGBC has twenty-three certified and 457 registered projects under a green building rating system it established in 1999.

Closer to Home

In the first week in November, building performance experts **Bill Bordass** and **Adrian Leaman** from the UK Usable Buildings Trust (**www.usable-buildings.co.uk**) visited RMI on their way to GreenBuild. They hosted an interesting discussion on ways to improve energy performance and occupant satisfaction when designing green buildings. Their presentation focused on design and construction processes, the importance of feedback, technical performance, and making realistic assumptions about user requirements, behavior, and resources. Their work is impressive and stimulating.

In particular, Bill and Adrian described building energy certification software that they are proposing be used to enact the EU's Europrosper program. Europrosper is a 2002 EU directive mandating that information about the energy consumed by buildings and their inhabitants be available to anyone who wants it. Among other things, the directive requires energy certification (or labeling) of nearly all existing buildings in the EU. Certificates are needed when buildings are completed, renovated, sold, or rented. They must be prominently displayed and they must show energy performance, a comparison with standards or benchmarks, and recommended energy-saving measures.

Bill's software produces a building energy rating that meets all the Europrosper requirements. Three characteristics of the software are of particular interest. First, it provides

WorldGBC

Australia
Brazil
Canada
India
Japan
Mexico
Spain
Taiwan
United States

(China and United Arab Emirates are forming)

RMI *in the news*

RMI Solutions Pulls In Awards

In 2004, RMI's Communications Department won three Communicator Awards for the Institute's newsletter, *RMI Solutions*. The Department won two Awards of Distinction in both the "Newsletter" and "Writing" categories. We also received an honorable mention for interior design, thanks to the efforts of Art Director Ben Emerson. *RMI Solutions* also won an Apex Award for newsletter writing last year.

Although many people in corporate communications win these types of awards, *RMI Solutions*' winning four is gratifying.

"We strive to make the newsletter lighthearted and as easy to read as possible," said Communications Department Director **Karen Nozik**. "Our messages of efficiency, whole-system thinking, and natural capitalism can be new and complex. Generally, if something is written with simplicity and packaged well, it's more fun for a reader, and often more accessible too."

**The Green Building Council of Australia has announced it will allow free electronic access to Green Star (its environmental rating tool).
This technique for sharing information, called "open source," is rapidly becoming the global vehicle of choice for many in the sustainability community
because it has tremendous cultural and economic benefits
for both those using the content and those sharing it.**

separate ratings for the building asset (its potential) and its operational impacts, thus recognizing that the best available technology is only as good as the skill of its operators. Second is the depth of data that support the software's calculations. Thirdly, the tool works at a variety of levels of detail—from the simplest to the most complicated inputs—yet provides useful results at every level.

The Europrosper approach clearly suits the North American preference for market-driven solutions (unrated monopolies are less attractive to buyers) as well as the European inclination toward statutory direction. If implemented as the Bordass/Leaman software envisions, it appears to have excellent potential to form an effective bridge between the regulatory and the voluntary, and between expectations and outcomes. In fact, I'd argue that it has excellent potential to create real visibility for low-carbon building performance and turn it into a global business driver.

As a result of their RMI visit, I arranged for Bill to demonstrate his Europrosper prototype software to members of the U.S., Canadian, Australian, and World green building councils—who were all equally impressed—at GreenBuild. In fact, GBCAustralia immediately invited Bill to spend a month with council officials and representatives of Australian government and industry discussing Europrosper and his software's relevance in Australia.

WorldGBC Website Launch

WorldGBC has launched its new website (**www.worldgbc.org**), the first of a number of initiatives aimed at furthering the organization's goal to become the preeminent global not-for-profit organization working to make the property industry sustainable. The goal for the website is to make it the most widely used source of information, news, data, and opinion about worldwide green building practices and developments. The website promotes international sustainability events, provides a roadmap and other resources for countries aiming to set up their own councils, and includes a forum where members and non-members can offer opinions and information about the latest green building trends.

WorldGBC Invited to Join World Environment Day

In Hyderabad, WorldGBC delegates accepted an invitation from the United Nations to hold its next annual summit in San Francisco in June 2005 as part of World Environment Day (WED 2005, see **www.wed2005.org**) and the United Nation's sixtieth anniversary. The invitation comes as the UN forecasts that 2004 will be the last year in which the world's rural population is more than urban. The weeklong event will highlight green building under the theme "Green Cities—Where the Future Lives."

Plans for the weeklong event include the creation of an Urban Environmental Accord—a new framework for international environmental cooperation—by mayors and civic leaders from the world's largest cities. Through this agreement, the UN hopes to obtain their commitment to address environmental issues. WorldGBC has agreed to create and lead workshops and panel discussions at the San Francisco event.

What's Next

With the assistance of **Peg Hill** of RMI's Development Department and others, I am polishing up a proposal for funding to enable GDS to increase its focus on RMI's high-leverage international work. Part of this effort is strategizing ways to work within the European Union to bring the benefits of a unified council to Europe's multitudinous green building organizations and interests. A similar effort may be targeted at South America, where there is also growing interest in green building. As we go to press, GBCAustralia has just announced that it's granting a royalty-free license of its environmental rating tool—Green Star—to all WorldGBC members. We believe this is an important step toward a transparent, sharable, and replicable methodology for developing individual green building rating systems that could become the basis for a unified global system.

The future looks bright for the global building and development industry—green, too.

Huston Eubank, AIA, is an RMI Green Development Services principal and secretary of the WorldGBC.

Abundance by Design

Marty Pickett, Executive Director

In our recent annual report (**www.rmi.org/sitepages/pid170.php#AnnualReport**), I wrote about the strategic planning and alignment that RMI's Board, management, and staff have undertaken since last spring to ensure the viability of RMI's future. We invited four advisors, very close to RMI's work in varied ways, to help us frame the issues: **John Abele**, founder of Boston Scientific; **David Grant**, executive director of the Geraldine R. Dodge Foundation; **Hal Harvey**, founder of the Energy Foundation and program officer at the William and Flora Hewlett Foundation; and **Peter Senge**, a professor at MIT and founder of the Society for Organizational Learning. Then, in September, we held an all-day session with Board members, advisors, management, staff, and many colleagues and friends who came to share their wisdom. We are grateful to independent consultant **Michael Fischer**; **Michael Gelobter** of Redefining Progress; **Bill Joy**, co-founder of Sun Microsystems; **Roger Saillant**, CEO of Plug Power; **Chris Sawyer** of Alston & Bird; **Robert Tierney** of Pratt & Whitney; **Duncan Eggar** of British Petroleum; and **Hardin Tibbs** of Synthesys.

One of the insights that arose from our discussions is RMI's leadership in finding solutions through integrative design to foster abundance—"abundance by design." This theme resonated with everyone's thinking about RMI's mission because abundance is, obviously, the opposite of scarcity, which inherently creates insecurity and rivalry. This discussion helped us think about the areas we want to pursue to carry out RMI's mission, ways to organize our intellectual capital, and approaches to maximize RMI's core competency of integrative design.

As we now strive to implement several recommendations resulting from the recent strategic planning effort, we've first restructured our Research & Consulting department into a matrix organization to reflect our knowledge areas, not only the sectors we influence. Research & Consulting has two market-facing teams: Energy & Resources Services and Green Development Services. Both of these operate in conjunction with an overarching functional "**Integrative Design Practice.**" Although Energy & Resources Services and Green Development Services incorporate whole-system design into all of their work, the Integrative Design Practice is a group of staff members dedicated to emphasizing integrated design in all aspects of our intellectual capital while searching for new, high-leverage arenas in which to apply it. Kyle Datta, currently our Research & Consulting department's managing director, will lead the Integrative Design Practice along with CEO Amory Lovins.

As suggested by our strategic planning process, we will add significant senior thought leadership to RMI over the next several years, and are actively seeking inspirational senior professionals to help us grow. We've recently hired **Dr. David Rothstein** as the Institute's human resources director. He also brings expertise to our work with corporations from his years of consulting and teaching university courses on organizational development.

I'm very excited about opportunities in 2005 to further implement RMI's strategic plan. The additional senior thought leadership we're seeking at the Institute is our way of creating *abundance by design*, right here at home.

Editor's Notes

South Asia: A Green Building Opportunity?

Cam Burns, Editor

While many in Washington are looking at the South Asian tsunami crisis to repair the United States' globally-tarnished image, many in the sustainability community are looking for opportunities too: to build the safest and greenest buildings, to develop the healthiest communities, to grow the most healthful and benign foodstuffs, to make the most earth-friendly products.

It appears that those involved with sustainable building design are taking the first steps, with good reason. New houses—real houses—will need to be built to replace the temporary shelters that are currently going up. Hospitals, schools, government buildings, mosques, temples, and all sorts of commercial structures must be rebuilt. This is an incredible opportunity to demonstrate the value of resilient, distributed systems. These are all areas where those in the sustainability community have core competencies and primary foci.

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Editor's note: In this issue of RMI Solutions *we feature the work of our interns. Our summer 2005 internships are posted at* ***www.rmi.org/sitepages/pid164.php#Internships****.*

Piper Foster

The Internet provides indefinable limits to the reach of contact.

Seeing this, I am charting RMI's Development Department's initial phases of outreach to supporters via email, and increasing our online accessibility. My research on Internet marketing and philanthropic e-communications allayed initial concerns about compliance with anti-spam laws, maintaining the confidentiality of our contacts, and sending content of questionable worth.

We anticipate hosting an online forum regarding energy efficiency measures for the winter (parts of Colorado forecast a 20 percent increase in home heating costs!), further discussions on the ideas in ***Winning the Oil Endgame***, and other online chats. Please look forward to your invitation, and consider reserving a seat at the virtual "table." I worked with our Webmaster to revise Development's web-pages to make them more fashionable and easier to navigate (stay tuned for news of their debut).

My work on a project with the **Massachusetts Technology Collaborative** to survey foundations across the country and inquire about their capital campaign funding patterns—with an eye for inclinations toward green design—is building momentum, with full research beginning in January.

Anne Jakle

I run the Outreach desk at RMI, and field the email, phone, and mail

inquiries from people seeking knowledge relating to just about everything that RMI does (and does not) do. Much of my day is spent tracking down answers and resources in response to these numerous inquiries: How do energy-efficient refrigerators work? Will hydrogen damage the ozone layer? When will the world's oil supply run out? How does cellulosic ethanol differ from corn-based ethanol? Other regular outreach duties include writing and researching RMI's bi-monthly **Advanced Automotive News** column (**www.rmi.org/sitepages/pid388.php**), managing and distributing announcements about RMI's latest work to our Ambassadors lists, coordinating tours of our super-efficient headquarters building, and keeping the website's **Calendar of Events** (**www.rmi.org/sitepages/pid22.php**) up-to-date.

Ryan Newman

How do you convince companies to reduce energy and raw material usage?

This has been the thrust of my work as an engineer with RMI. We went to Anglo-American's papermaking facilities to find opportunities for energy savings, both by improvised design and by better monitoring equipment energy use. I also developed tools to show the benefits of savings, including a cost-benefit analysis for various energy efficiency programs, and a costing model for compressed-air usage. The best way to get companies to be *green*? Show them how it will save them some *green*. My internship was a great learning experience, and I plan to bring this ecological focus to my new job at Hewlett-Packard.

"Much of my day is spent tracking down answers and resources in response to these numerous inquiries: How do energy-efficient refrigerators work? Will hydrogen damage the ozone layer? When will the world's oil supply run out? How does cellulosic ethanol differ from corn-based ethanol?"

Anne Jakle

John Stanley

My work centers around ***Winning the Oil Endgame***, RMI's new report

explaining how the United States can wean itself from petroleum over the next few decades—while creating net jobs and wealth. The report was released shortly before I joined RMI, but I arrived just in time to help apply it. I am working with *WTOE* co-author Nathan Glasgow and principal authors in senior management to craft a comprehensive implementation plan for the report's major recommendations. Over the next few months, we will be identifying the key industries, leaders, and geographic areas that will function as leverage points to get the country moving in the right direction—away from petroleum dependence.

Staff Spotlight

Kitty Wang, RMI Research & Consulting

Kitty Wang, PE, researcher and consultant for RMI's Energy & Resources Services team and registered professional mechanical engineer, was planning to major in physics at Stanford University before going on a sophomore year camping trip to Joshua Tree, California. The desert landscape and people she met there profoundly altered her outlook, and subsequent camping trips to Yosemite Valley inspired her to change her academic focus to something related to the natural world, where she could blend her strengths in math, science, and technology. She found the perfect fit in environmental engineering.

But even in Stanford's Civil and Environmental Engineering Department, Kitty didn't discover her true life's passion until she took Stanford professor **Gil Masters**'s course "Small Scale Energy Systems." The class explored the topic of building energy systems in the home (including building orientation and envelope insulation, appliances, and air conditioning), photovoltaics, and technologies like compact florescent lamps, which at that time were becoming commonplace.

"Gil's class made me aware of the importance of energy resources that sustain us in our daily lives," said Kitty, whose curriculum had previously centered around pollution control technologies for air, soil, water, and wastewater treatment. "I realized that by showing people how to consume energy and other natural resources more efficiently, I can help prevent environmental pollution from occurring in the first place. It's much nicer than devising ways of cleaning up other people's messes after they've been made."

Kitty has done just that, working in the public, private, and non-profit sectors, and has an impressive résumé that includes work with the **American Council for an Energy-Efficient Economy** (ACEEE), **Econergy International Corporation**, and time with **Utility Engineering**, a subsidiary of **Xcel Energy**.

At Econergy International Corporation, an energy, environmental, and development consulting group, Kitty found herself working with RMI's **Dr. Joel Swisher,** PE, (then also at Econergy International), who mentored her in utility economics and the nascent market in carbon emissions trading. In addition, her work included researching the issues surrounding electricity deregulation in Colorado, and studying the impact of carbon emissions for projects financed by London's European Bank for Reconstruction and Development (EBRD).

Editor's Notes (CONT. FROM P. 14)

A typical example is **Architecture for Humanity**'s recently-initiated **Project Re:Build**, which will aim to "utilize locally based construction techniques, allowing immediate community participation, and innovative sustainable initiatives to rebuild an entire village which has been devastated by the tsunami," according to a web-posting by AFH Cofounder **Cameron Sinclair**. This project—likely to take place in the Hembanthota District of Sri Lanka—is not just about building homes; project organizers hope to get an entire community to work together to rebuild itself, with special emphasis on the public and community facilities (markets, clinics, meeting areas, etc.) and the relationships between people doing the work.

Others in the green building field are taking similar tacks. Various groups are already discussing the use of everything from non-toxic and recycled materials to using locally sourced and renewable building products to designing buildings and communities that are safer and that require minimal energy and water infrastructure.

As Rocky Mountain Institute architect and principal Huston Eubank, AIA, noted, "this is a tremendous opportunity to build good examples of green buildings—minimal infrastructure, locally sourced materials, local labor, and all the other good stuff. More importantly, we [the sustainability community] can help organize the reconstruction effort so that good green building principles are used universally. The world is ready for this kind of thinking, and out of this tragedy can arise an incredible opportunity make lives better in many, many ways."

For more on RMI's work on sustainable settlements, please visit www.rmi.org/sitepages/pid244.php.

Kitty wanted experience that better-utilized her traditional engineering training, so she moved on to Utility Engineering, a subsidiary of Xcel Energy that engineers, procures equipment for, and manages construction of power plants. The hands-on, on-the-ground project work she did at various facilities proved useful for understanding how utility companies operate and what goes into the industrial design process. At Utility Engineering, Kitty worked as a field mechanical engineer on a two-year, $200 million project to install sulfur oxide scrubbers at two coal plants, in Denver and Boulder.

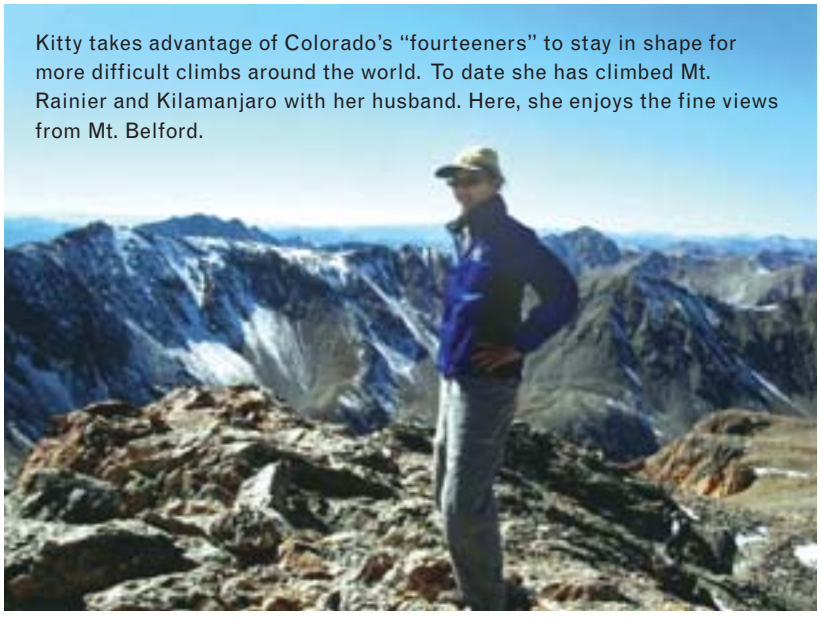
Kitty's field experience made her a valuable asset to anyone working with utilities, so it's not surprising that Swisher, who had moved to RMI, invited her to join the Institute's Energy & Resources Services team. Kitty eagerly accepted the invitation to work with an organization she'd admired since her Stanford days.

"While still a student at Stanford, I attended one of Amory's lectures about Hypercar vehicles," Kitty said.

"I realized that by showing people how to consume energy and other natural resources more efficiently, I can help prevent environmental pollution form occurring in the first place."

"It blew my mind, realizing how inefficient the existing automobile design is and the list of readily implementable solutions, including ultra-lighting and hybrid drives, that could triple and quadruple miles driven per gallon. I've always had RMI on my radar screen, and I am glad to have the opportunity to be part of it today."

At RMI, Kitty has contributed extensively to a number of projects, most significantly in her current work with three major California utilities and the California Energy Commission to evaluate a pilot program looking at residential automated demand response systems (ADRS). Her work focuses on how Web-enabled, automated technology can help homeowners reduce their major household loads, particularly air conditioning loads, during times when power plants can barely meet demand.



Kitty takes advantage of Colorado's "fourteeners" to stay in shape for more difficult climbs around the world. To date she has climbed Mt. Rainier and Kilamanjaro with her husband. Here, she enjoys the fine views from Mt. Belford.

When demand is high (in the afternoon on a hot summer day, for instance), utilities can reduce their residential customers' power draws by temporarily turning up thermostats and turning off other loads, such as pool pumps. This not only reduces power demand; it also saves consumers from paying high prices for electricity. In California, the demand response pilot is based on price signals, and customers can pre-program and personalize their thermostat responses and pool-pump operating schedules according to different electricity price signals in real time. The pilot project tested the system in 175 homes in Pacific Gas and Electric (PG&E), Southern California Edison (SCE), and San Diego Gas and Electric (SDG&E) service territories. It's hoped to emulate the success of a similar pilot conducted by Nevada Power, which found that direct signals to homes during times of peak load yielded energy savings of about two to three kilowatts (kW) per home (an average home consumes about three to five peak kilowatts; large homes can consume five to eight kilowatts).

Kitty also recently oversaw the writing of RMI's updated **Home Energy Briefs** (free to download at **www.rmi.org/sitepages/pid171.php #LibHshldEnEff**), a series of nine publications that provide energy- and money-saving tips for homeowners (see p. 3 for more information).

In addition to her dynamic professional life, Kitty somehow finds time to pursue her outdoor passions, and is never happier than when rock climbing, mountain biking, cross-country skiing, and downhill skiing. She often adventures with her husband Mark to Colorado's 14,000 foot peaks.

—Anne Jakle

Energy and Water

Water and energy are two of the most important topics on the international environment and development agenda. Unfortunately, though, international aid and development agencies and programs often treat the two as isolated issues. Here, Ole von Uexküll explains how fossil and nuclear energy systems exacerbate the global water crisis, while many renewable energy technologies alleviate it, and that world water woes cannot be solved until we make a complete shift to renewables.

By Ole von Uexküll

In 2001, the Executive Director of UNEP, Klaus Töpfer, opened the International Conference on Freshwater in Bonn with the words: "Indeed, there are only two issues that are so intensively interrelated and important for development and they are water and energy." While water and energy have, each in its own right, become well-established as top development priorities, this interrelation between the two fields is very rarely mentioned.

Since the beginning of the 1990s, a series of international conferences has been held on the use of our global water resources. Their recommendations rank from the recognition of water as an economic good over rather vague development jargon ("new partnerships, identifying best practice, increased efficiency, improved management") to the "Millennium Development Goal" of halving the number of people without access to safe drinking water by the year 2015. However, none of the conferences conclude that energy questions are linked to water problems—except for questions of hydro-power, where the connection is obvious. Not even the 2002 World Summit on Sustainable Development in Johannesburg, which recognized energy and water separately as top development priorities, established the link. A look at the scope of the global water and the global energy crises and their connected problems and connected solutions shows that the two issues are, in fact, far more related than only via hydro-power.

The Global Water Crisis

Water has always been Earth's most valuable resource. All ecosystems and every field of human activity depend on water. In contrast to other resources, there is no substitute for water in most of its applications. The availability of this clear gold has determined the fate of empires, and wars have been fought over its access.* Only 2.5 percent of the world's water is fresh, and only a tiny fraction of this is accessible for human use. In principle, this should be a self-generating resource, but today many aquifers are tapped at a rate exceeding their natural regeneration capacity and many rivers are polluted. At the same time, the water retention capacity of the landscape is constantly decreasing because natural vegetation is cleared and soil surfaces are sealed. As a consequence, the amount of freshwater available for human use is dramatically decreasing in many regions. Currently, at least one billion people have no access to safe drinking water.

* Editor's Note: Our esteemed colleague Dr. Peter Gleick maintains a water-conflict chronology at www.worldwater.org/conflict.htm.

The Global Energy Crisis

The world energy system depends largely on finite fossil and nuclear energy sources, which require long and complex resource chains—from mining and extraction to transportation and processing to conversion to energy in the power plant and disposal of waste (Scheer 2002). Along these chains the energy system causes adverse socio-economic and environmental problems such as armed conflict, economic inequality and dependencies, the poisoning of the environment, and global climate change. Particulate emissions from the burning of fossil fuels annually cause roughly 800,000 casualties worldwide, corresponding to a 1.4 percent share of global mortality (World Health Organization 2002), and nuclear radiation is still causing much suffering around Chernobyl and elsewhere. It is evident that if the poor countries of the South were to copy the energy consumption patterns of the North, there would be a global ecological collapse.

Connected Problems

Our present energy system consumes and pollutes water along its entire resource chain. For oil extraction, water is pumped into the wells to increase the pressure. Refining consumes additional water. Coal production and transportation, gas processing and transmission, and the nuclear fuel cycle also consume large amounts of water. At the same time, water is polluted by oil spills and tanker wrecks, and contaminated by radioactive emissions from reprocessing plants. Table 1 shows the water consumption of different electricity production technologies. Thermoelectric power generation, with its large evaporation losses,

We cannot solve the global water crisis without stopping the present energy system's free ride on our water resources.

The Lost Cup (or the Most Inefficient Way to Boil Water)

When boiling water for tea, you should take the water off the stove as soon as it boils, so that no water is lost. But is there really no water lost? If the water is boiled with electricity from a fossil or nuclear power plant, one has to consider the following calculation:

The specific heat of water: **4.2 kJ/(K×kg)**

Temperature difference from 20°C to 100°C: **80 K**

Let's assume we boil 1 liter, so the mass is **1 kg**

Water consumption of a nuclear/fossil power plant (Table 1): **ca. 2 L/kWh**

Boiling 1 liter of water requires ca. 0.1 kWh electric power (4.2 kJ/(K×kg) × 80 K × 1 kg × 0.000278 kWh/kJ = 0.093 kWh). Generating this power evaporates 200 mL of water at the power plant (0.1 kWh × 2 L/kWh = 200 ml).

Result:
When our tea water starts boiling,* one cup of water has already evaporated without our even noticing it.

consumes most water. In the United States in 1995, thermoelectric power generation accounted for 39 percent of total annual water withdrawal and 3.3 percent of annual consumptive water use, which is more than any other industry (U.S. Geological Survey 1998). (Because of massive irrigation, industrial water consumption is still outnumbered by the agricultural sector with 85 percent.) The numbers in Table 1 reveal the inefficiency of common energy-water operations, for example boiling water to make a cup of tea (see boxed text above).

How much the water evaporation of power plants disrupts the natural water balance depends on the climate of the region and the source of the cooling water. Most power plants use freshwater, although the use of seawater would not compete with human water needs. In arid regions, where freshwater availability is a limiting factor for agriculture, industry, and human health, a competing power plant has disastrous consequences. To make things worse, the burning of fossil fuels prevents rainfall. A study of satellite data in the journal *Science* (Rosenfeld 2000) shows that particulate matter from urban or industrial sources like fossil power plants can completely shut off precipitation from clouds. The likely explanation is that the small particulates act as cloud condensation nuclei forming many small droplets that inefficiently merge into raindrops. Besides local climate effects, the burning of fossil fuels is changing the global climate. It is widely expected among climate experts that climate change will bring about an increase in extreme weather conditions (i.e., more heavy rains as well as more droughts). This can cause dramatic changes in the water balance of whole regions, which so far are poorly understood and highly unpredictable. During the August 2003 drought in Europe, many nuclear power plants had to reduce energy production or even shut down because rivers simply did not carry enough water to ensure their cooling. Obviously, droughts can also hit hydro-power, an energy source that many countries are highly dependent on, very hard.

* Editor's Note: If the whole liter actually boiled away, that would use an additional 0.63 kWh of "latent" heat, consuming ~1.3 more L at the power station—a good reason to turn off the heat as soon as boiling begins!

Connected Solutions

To solve the world energy crisis, a complete transition to **renewable energy sources** (RES) is inevitable and technically possible, as has been shown by many projections and feasibility studies (see Scheer 2002 and references therein, as well as studies at **www.eurosolar.org**). Table 1 shows that two of the most important technologies for solving the world energy crisis—PV and wind power—consume practically no water during operation. The same is true for small hydro power plants. In light of the global water crisis, it is astonishing that this fact is not regularly brought forward in favor of RES as opposed to nuclear and fossil energy sources.

Table 1: Consumptive Water Use for Electricity Production

Energy technology	Consumptive use (m^3 per 10^3 kWh(e))
Conventional coal combustion	
Once-through cooling	1.2
Cooling towers	2.6
Oil and natural gas combustion	
Once-through cooling	1.1
Cooling towers	2.6
Nuclear generation (LWR)	
Cooling towers	3.2
Renewable energy systems	
Photovoltaics: residential	a
Photovoltaics: central utility	0.1[b]
Solar thermal: Luz system	4.0
Wind power	a

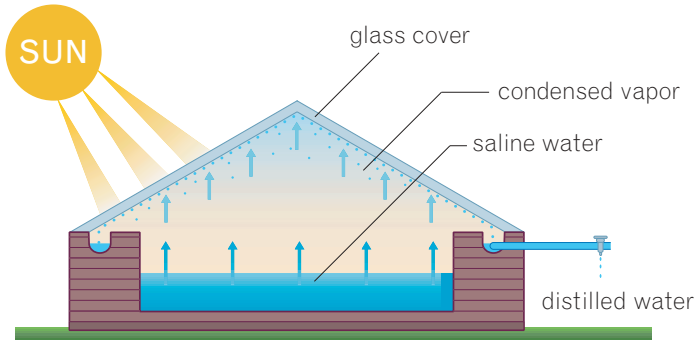
a = Negligible.

b = Maximum water use for array washing and potable water needs.

Source: excerpted from Gleick 1994

Equally important—and equally ignored—is the fact that renewables offer a means to produce the energy necessary for extracting and transporting water in off-grid areas, especially in developing countries. It is more than doubtful that the Millennium Development Goal of halving the number of people without access to safe drinking water can be achieved as long as the international community goes on ignoring the crucial role of renewable technologies in this endeavor. In a brief on the agricultural applications of solar energy, the U.S. Dept. of Energy's Office of Energy Efficiency and Renewable Energy (2002) concludes: "Photovoltaic (PV) water pumping systems may be the most cost-effective water pumping option in locations where there is no existing power line. When properly sized and installed, PV water pumps are very reliable and require little maintenance." This has been proven by many successful installations around the world. For countries in arid coastal regions or regions with brackish groundwater, like many small islands, desalination is increasingly becoming an issue that links—for better or for worse—water and energy issues. The different desalination techniques (reverse osmosis, electrodialysis, vapor compression, multiple effect or multistage flash distillation) all require considerable amounts of energy. China has already offered to help Morocco with the construction of a small nuclear power plant, which should provide the necessary energy for desalinating seawater and greening the desert. Instead of abusing the water argument for advocating new fossil and nuclear power plants, countries in arid regions could utilize renewable energy, which offers a far larger capacity for desalinization. In coastal regions, solar thermal power plants could use seawater for cooling and desalinate it as a by-process in the generation of clean electricity.

Figure 1: Solar Still

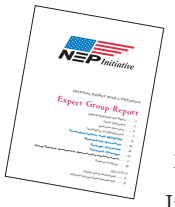


Solar stills can differ in size and shape. Using the sun's radiation, they effectively remove many impurities such as salts and microorganisms.

Editor's Note: A coastal greenhouse can simultaneously distill seawater, grow crops, and provide cooling.

New & noteworthy

National Commission on Energy Policy Reaches Broad Agreement on Policy Package



In early 2002, while energy bill negotiations were stalled in Congress, RMI and the Consensus Building Institute of Cambridge, Mass. brought together a panel of senior-level energy experts to formulate widely acceptable objectives, principles, and content for U.S. energy policy. The project was called the **National Energy Policy Initiative** (**www.nepinitiative.org**), and its work won praise from both sides of the aisle. This quick, low-budget experiment tested and proved the hypothesis that focusing on hidden but widely shared points of consensus could make areas of disagreement superfluous and could craft a comprehensive, integrated, visionary, yet practical policy framework.

In mid-2002, the **Hewlett Foundation** sponsored the creation of the **National Commission on Energy Policy** (**www.energycommission.org**) to "address major long-term U.S. energy challenges." NCEP was also made up of bipartisan energy experts from industry, government, academia, labor, and consumer groups. The group released its consensus in December 2004, with recommendations to improve energy security, mitigate climate risks, increase energy efficiency, supplement U.S. energy supply, and develop new technology. Early NCEP design was informed by the NEP Initiative, but NCEP involved tough negotiations among strong advocates of divergent views within a relatively conventional policy context—a different but still useful approach. RMI's *Winning the Oil Endgame* (p. 3) apparently came too late to influence NCEP's findings, but should help to enrich discussion of them.

Even more important is decentralized, autonomous desalination on a small scale. A 1998 U.S. DOE National Renewable Energy Laboratory survey of the possible combinations between different renewable technologies (PV, wind, and solar thermal) and different desalination technologies showed that reverse osmosis and electrodialysis have been applied successfully in combination with both PV and wind (Corbus 1998). For households without access to potable water, a simple solar still (Figure 1) can easily produce the water needed for drinking and cooking. Alternatively, PV-powered systems can purify and disinfect water by means of UV radiation or microfiltration. Additionally, there is tremendous potential in the combination of wastewater treatment and energy production. Biomass removed in the treatment process can be turned into biogas for energy production by means of a digester. Integrated biological wastewater treatment systems can even produce biomass because they use aquatic plants to filter and purify the water and to sequester nutrients. Researchers at the Indian Institute of Science in Bangalore have demonstrated the viability of using these aquatic plants for biogas production. Similar research is being carried out at the University of Florida Center for Aquatic and Invasive Plants, and in other countries.

Conclusions

These are only a few examples of the interconnectedness between the energy and water crises. There are myriad other links, like the lowering of regional water tables by coal mines and the killing of fish and aquatic biota by the cooling systems of thermoelectric power plants. These connections all point to the fact that we cannot solve the global water crisis without halting the present energy system's free ride on our water resources. This requires a drastic change of the energy system, a complete transition from nuclear and fossil energy sources to renewable energies. To create a mutually supportive relationship between energy production and water use, there is an urgent need for research and development of integrated water/energy solutions—like better techniques for the coupling of wastewater treatment and energy production. Desalination and water purification with renewables must be promoted because the growing scarcity of water will otherwise pave the way for nuclear and fossil energy in many developing countries. In international policy, we can no longer afford the mental blocks regarding the connection between these two top development priorities. The **United Nations Commission on Sustainable Development** (CSD), which is planning to hold a review and a policy session on water in 2005 and on energy in 2006 and 2007, should merge these efforts into a concerted water-energy session. The distance between energy and water issues is a result of the current overspecialization of environmental policy. Decision-makers become experts for certain sub-areas, but lose sight of the bigger picture. The same is true for environmental scientists and NGOs. This bureaucratic categorization contradicts basic ecological insights about the interrelatedness of nature. It is high time that national and international decision-makers overcame their over-specialization and looked at the inter-relationships. Energy and water are the sources of life on our planet, the king and queen among the great services nature provides us. Without respecting this relationship, we will solve neither our water nor our energy problems.

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About the Author

Ole von Uexküll studied in Lund (Sweden) and Berlin (Germany) and holds Masters' degrees in environmental science and European Studies. He has worked on sustainable energy issues with RMI, the German Parliament, and UNEP's Division of Technology, Industry, and Economics in Paris. He has visited and evaluated environment, energy, and development projects in twenty countries around the world. Uexküll is now working with the Stockholm-based Right Livelihood Award Foundation. This article originally appeared in the March/April 2004 edition of REFocus.

Sue Woolsey

One thing RMI looks for when it invites individuals to join its governing Board of Directors is diversity: wide-ranging experience across many boundaries. Sue Woolsey, then, is an excellent addition.

Sue is probably best known as the former chief operating officer of the **National Academies of Science** and for her work reshaping the Academies, but her experience in government, institutional, academic, private sector, and non-profit entities is vast and deep. She jokingly calls her career "checkered," but as any RMI supporter knows, a diverse background is key to the transdisciplinary approaches the Institute brings to myriad challenges.

It's also no surprise then that one of Sue's biggest interests is organizational change. As a Board member, she is a great position to both share information about how and why organizations can be influenced to change, but also how the organizations doing the influencing (e.g., RMI) can best go about it. She joined RMI's Board of Directors in early 2004 and she believes the principles that RMI has developed need to be fed into all types of organizations, from social groups to government institutions.

"It's the counterintuitive understanding that you can do well by doing good," she said. "That has to be gotten out to more people. And it's not just in energy and green buildings; it's in any one of these things that RMI works on (business, water efficiency, economic renewal, etc.). The fact that if you think something through well enough you can do things more efficiently, more cheaply, and make it better for everyone is a powerful notion. Cutting across this presumed tension between efficiency and environmental awareness and [the] bottom line is very important work."

Sue was born in San Francisco and grew up in Carmel and Oakland. She did her undergraduate studies at Stanford University (where she met future husband Jim), and then went east, to the Boston area, where she earned a master's degree and a Ph.D. in clinical and social psychology at Harvard University.

Sue and husband James (then midway through his active duty in the Army) then moved to Washington DC, where she taught at Federal City College (now the University of the District of Columbia) and helped set up its psychology department. After a brief stint in Europe, Sue's big career change—which was also a change in organizational type, from academia to government—came in 1970 when she landed the job of deputy assistant secretary in the Department of Health, Education, and Welfare under then-Secretary Eliot Richardson.

In 1975 she gave birth to the first of three sons. When her second son arrived, she decided to change careers again, and moved to the Urban Institute to run a small research group that worked on social issues and on "how to tell whether policy changes actually work."

"At that time, anybody who talked about that stuff only talked about economics," she said. "Since I was a psychologist, I wanted to talk about organizational change and behavioral change and so on."

Cave snorkeling
in the Sea of Cortes 2002.
From left Jim, Sue, Russ Stevenson (friend).

"It's the counterintuitive understanding that you can do well by doing good that has to be gotten out to more people. The fact that if you think something through well enough you can do things more efficiently, more cheaply, and make it better for everyone is a powerful notion. Cutting across this presumed tension between efficiency and environmental awareness and [the] bottom line is very important work."

When Jimmy Carter was elected president, Sue was invited to join the transition team for the U.S. Office of Management and Budget (OMB), where she served as associate director. That led, in 1980, to a position writing editorials for the *Washington Post*, followed by a position with Coopers and Lybrand, where she remained for nine years. In 1989, she took a job with the National Academies of Science, where she ultimately ended up as chief operating officer and helped "reengineer" the Academies.

These days Sue spends a small amount of time as a consultant, but most of her time is spent working as a board member for various public and private organizations, including the boards of the German Marshall Fund, Van Kampen Mutual Funds, Colorado College, Neurogen Corporation, Intelligent Medical Devices LLC, and the Institute for Defense Analyses—as well as Rocky Mountain Institute.

Her relationship with RMI stems from the early Carter Administration, when "Amory Lovins was the exciting guy on energy policy," she said. Jim Woolsey, then a former Under Secretary of the navy, and Admiral Thomas Moorer, who'd been President Nixon's Chairman of the Joint Chiefs of Staff, wrote the forward to *Brittle Power* (www.rmi.org/sitepages/pid1011.php), RMI cofounders Amory and Hunter Lovins's seminal 1981 Pentagon study on the fragility of American energy infrastructure. Later, Jim became President Carter's Director of Central Intelligence.

"I still think the whole *Brittle Power* idea is a really important one," said Sue. "We really ought to get off this huge grid system and develop small, self-sufficient, mutually supportive electricity systems. I've thought that for years."

Like many associated with RMI, Sue grew up enjoying the great outdoors as often as possible—in her case, hiking and camping throughout the mountains of California. "I guess I really learned that you're not at home unless you're out in the woods," she said. "In the east, where there aren't many mountains to speak of, I do a lot of sailing, but once a year I have to get my mountain 'fix' and either come here [Snowmass] or go to the Sierra Nevada." She also does a lot of adventure travel with her family.

Serving on the RMI Board helps her get her mountain fix a couple of times a year while at the same time rewarding her ideals about civil service and helping RMI think about how to change some very big, very entrenched organizations and industries.

"I think it's a great honor because I've always admired the work and it's exciting to be a part of it."

—Cameron M. Burns

Woolsey family (counterclockwise from top Rob, Jim, Sue, Ben, Dan).

NATIONAL ASSOCIATION OF REALTORS®

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In the sustainability business, leverage is key.

If you're a small organization trying to have a global impact, you tend to join up with all the like-minded souls as you can find—hence RMI's new relationship with the National Association of Realtors.

Based in Chicago, the National Association of Realtors (NAR) is America's largest trade association, and it represents more than a million individuals involved in all aspects of the residential and commercial real estate industries. As the NAR's mission statement says, its members strive "to be the collective force influencing and shaping the real estate industry."

The intersection between the NAR and RMI is an obvious one: green building.

"Realtors are concerned and active members of their communities," said Joe Maheady, NAR's Senior Environment Policy Representative. "Realtors care about a healthy quality of life as well as a vibrant economy, and they are willing to do their part to maintain that important balance."

Maheady, an attorney and policy analyst, represents the NAR in Washington DC, and it was through his support of RMI that the entire organization became involved about a year ago. NAR contributed to the support of revamping RMI's Home Energy Briefs last summer, a chore that was completed in the fall (they are now online at **www.rmi.org/sitepages/pid171.php#LibHshldEnEff**).

"[It's because of RMI's] focus on market-based solutions to energy issues," Maheady noted, that drew NAR's support in the first place.

NAR and RMI recently gained another piece of common ground: a building designed to showcase energy and resource efficiency. In spring 2004, the NAR completed its new Washington DC headquarters, located just a few blocks from the Capitol; it is likely to achieve a LEED Certified or Silver rating.

"NAR wanted to set an example for its members to illustrate that green building makes good business sense and that green buildings make good neighbors," said Iris Amdur, a principal with GreenShape LLC, a Washington DC-based green building consultancy that worked on the project. "The new green building allows the Realtors to teach their members and the community at large about the reduced impact of green buildings on the environment while benefiting from operational cost savings and productivity gains."

Besides the fact that it's a gorgeous building (the *Washington Post*'s Ben Forgey called it "an astonishing new landmark"), there are some good reasons the new NAR building is considered one of the finest projects of its kind.

First of all, it's built on the site of an old gas station, a so-called "brownfield" site, one damaged as a result of decades' worth of oil and gasoline seepage. Most developers consider the reuse of badly damaged property the most noble activity any developer can undertake.

Second, the futuristic looking building—with its slim, tapered shape—is designed to let in as much daylight as possible, but also, in tandem with the glass curtain walls and an efficient HVAC system, to cut heating and cooling bills. As one DC columnist noted: "Depending on your perspective, the $46 million edifice looks like a gigantic slice of key lime pie or a blue-green battleship that has the Capitol dome in its wake."

"The most striking aspect of the building is the daylight and views," said Amdur. "Because of the narrow footprint and floor-to-ceiling glass, every single person in the building has access to natural daylight and a spectacular view. In one direction is a panoramic view of the Capitol building and in the other an expansive view into the city. The fixture-based daylight 'harvesting' sensors allow each light fixture to

Photos courtesy
Allan B. Sledge, NAR

dim according to the amount of available natural daylight while maintaining the desired level of ambient light. The light-colored finishes add to the airy feeling of the space while helping to increase the daylighting performance. After just two weeks of being in the new building, the Realtors' staff has already commented on how much calmer they feel in their new building. And the Realtors are achieving a 30 percent savings in energy costs, much of this due to the high-performance low-e glass and the reduced lighting load."

The building isn't just about daylighting.

Rainwater is captured for reuse in irrigating the landscape. Native and adaptive plantings further reduce the amount of water required for irrigation and the building's HVAC equipment does not contain chlorofluorocarbons (CFCs). Materials were selected based on their recycled content and low content of volatile organic compounds (VOCs), and more than 80 percent of the materials for the building were manufactured within 500 miles of the project site. The building even has water-free urinals.

"The water-free urinals presented a bit of a challenge," said Amdur. "Initially NAR resisted being the first in the District of Columbia to use an unfamiliar technology. After the Realtors decided to pursue use of the water-free urinals, the DC code officials denied the request for a code variance that would allow their use.

A meeting was scheduled with the head of the DC Office of Regulatory Affairs to explain the technology behind the water-free urinals and the benefits of water savings and sewage volume reduction. We provided extensive documentation, which included independent test results as well as draft language indicating anticipated changes to the International Plumbing Code in which the water-free urinals will be included. The Realtors, who had initially been somewhat hesitant about the new technology, celebrated the victory when the code variance was finally approved."

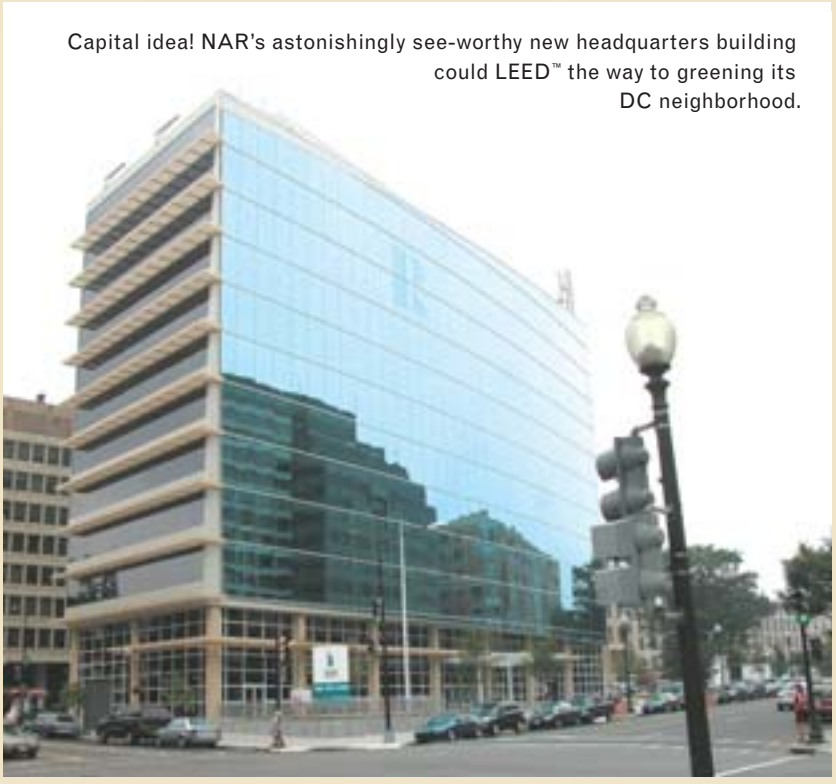
That this building will be the nation's capital's first Certified LEED building is rather astonishing. According to Amdur, there are several significant projects underway in the District, but no new project thus far has achieved a LEED rating; the NAR building is expected to be the first.

NAR is America's largest trade association, and it represents more than a million individuals involved in all aspects of the residential and commercial real estate industries. As the NAR's mission statement says, its members strive "to be the collective force influencing and shaping the real estate industry."

NAR's new Washington headquarters isn't just about lower operating costs and lower energy usage. As Maheady said, the new building also serves "to show our commitment to the environment and our support for constructing buildings as sustainably as possible."

Indeed, the new building is like a great big sign—near the Capitol—pointing to the future of real estate. Clearly, the National Association of Realtors is not a bad partner for RMI to have.

—Cameron M. Burns



Capital idea! NAR's astonishingly see-worthy new headquarters building could LEED™ the way to greening its DC neighborhood.

Duly Noted

Dale Levy, Development Director

At the end of each calendar year, many RMI supporters are incredibly generous and give us gifts ranging from cash to appreciated stock to real estate—even modest pledges of monthly support. We at RMI are honored and humbled by the wonderful written expressions of belief in our projects and mission that accompany all of these generous gifts.

"RMI is one of the only organizations that comes up with real solutions for change in the future based on profit and enlightened self-interest, rather than regulation and preaching."

Kerwin Schaefer

Here are a few examples from our mailbag within the past month:

- **Kerwin Schaefer** of New Bern, N.C. wrote: "Wish I could send more! RMI is one of the only organizations that comes up with real solutions for change in the future based on profit and enlightened self-interest, rather than regulation and preaching. This makes it far more realistic as a spurt towards the sustainable economy we need. Keep the ideas coming!"

- **Eric Doub** of **Ecofutures Building, Inc.**, in Boulder, Colo. wrote, on his latest business reply envelope: "My career path was shaped, at age eighteen in 1981, by first reading a Richard Barnet article in *The New Yorker*, and then by reading *Soft Energy Paths* (by Amory Lovins). It was all uphill from there! This spring I helped launch the Boulder Green Building Guild. And Ecofutures, my twenty-person ecobuilding company, had gross revenues last year of $2.5 million, and I simply divert a large portion of these revenues from green remodeling and building clients in the Boulder area to causes I care about—and RMI is naturally at the top of the list."

- **H. Virginia Thompson**, of Eagar, Ariz. said: "I'm so proud to be able to add my tiny bit to your efforts. I've admired your successes toward better energy sources and many other things over the years. It is the most important contribution I've ever made—now narrowed down to only two."

- **Erika Leaf**, of Eugene, Ore. sent us the following: "I am instructing Schwab to transfer eighty shares... to the RMI Schwab account. It is worth approximately $2,000. Thank you for the wonderful work you folks do. Keep it up!"

- The Denver Architectural firm **Hoover Desmond** also sent a note: "Our tradition of giving on behalf of our clients and friends continues this year with donations to the Kempe Children's Foundation and Rocky Mountain Institute."

- **Kathleen** and **Jon Scott** of Altamont, N.Y. wrote: "*Winning the Oil Endgame* is great! Keep up the good work! Our [Toyota] *Prius* arrives tomorrow!"

- **Penelope Kreinberg**, of Portland, Ore. noted the following: "Because we believe in the value of the work of RMI and the benefit it brings to this world, we at the Kreinberg Foundation would like to contribute to your efforts as part of our giving plan for 2004. Please use this to further your very valuable work."

We appreciate all the financial help RMI supporters give the Institute, but, more importantly, we appreciate your feedback. Please keep it coming.

Our sincere appreciation is offered to these friends who have contributed to RMI between 16 August 2004 and 31 December 2004. Numbers in parentheses indicate multiple donations. Please let us know if your name has been omitted or misspelled so it can be corrected in the next issue.

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The National Solutions Council (NSC) provides opportunities for intellectual stimulation and dialogue around RMI's work, opportunities for its members to network with intellectual colleagues and peers, introduces and promotes RMI's work to others on a national and international level, and broadens the base of financial support for RMI's programs.

Members of the National Solutions Council are:

- invited to participate in various discussions with RMI staff and/or Board of Directors about global issues in which RMI has an influential role, including one of the Board's Blue Sky Sessions;
- special invitees to RMIQs (RMI's Quest for Solutions presentations) and other RMI events;
- sponsors of regional RMIQ lectures or series; and
- recipients of advance notification of key upcoming RMI publications.

The NSC held its first gathering in June 2003, and extends an invitation to all RMI donors of $1,500+ annually to join the NSC. Watch your mailbox for upcoming NSC events.

For more information about the Council, please contact Development at (970) 927-7201 or develop@rmi.org.

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For more information, contact Development Director Dale Levy (970) 927-7217 or dalelevy@rmi.org) or Finance Director Steve Swanson (970) 927-7349 or sswanson@rmi.org).

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CONTINUED FROM P. 2

In 2003, Chris Lotspeich, who'd led much of RMI's ST work, nicely summarized the challenges of chip fabs:

> Fabs have extensive heating, ventilating, and air conditioning (HVAC) systems with high-performance filters to maintain clean rooms' temperature and humidity precisely while filtering airborne particles. Fans, pumps, furnaces, and chillers deliver conditioned air and cooling water into the clean room via ducts and pipes. Depending on their size, fabs use anywhere from 3 to as much as 30 megawatts of power.[2] HVAC systems consume 30–50 percent of a fab's electricity; tools use another 40 percent or so. Energy accounts for [only a few]… percent of a chip's cost, yet electricity can be the largest single [non-labor] operating expense for a chipmaker, totaling millions of dollars annually at a single fab. Moreover, energy-saving measures can improve key operating parameters (yield, setup time, flexibility), and in new plants can save capital and construction time—critical factors in competitiveness.
>
> Despite great innovation, semiconductor manufacturing fosters a risk-averse corporate culture due to exacting process requirements, safety risks, the high cost of downtime, and brutal competition in a fast-moving market. Meeting production and time-to-market targets requires extraordinary control over thousands of variables. When something works, it is copied exactly. Firms also "copy exactly" previous fabs when building new ones. This saves some time and initial cost, yet retards improvements outside the clean room, including energy efficiency features—thus raising operating costs. It's somewhat ironic that cutting-edge technologies are made in buildings designed decades ago, and thus those buildings now offer significant energy-and money-saving potential.

Photos pp. 33, 35 courtesy Paul Westbrook, TI Worldwide Construction

Additionally, a huge modern fab complex can easily go through 2–3 million gallons of water per day, a quarter of it for cooling.

Now came the hard part: TI's engineers and designers were told to cut the building and utilities cost by 30 percent over the previous project. "The cost challenge could have been a show-stopper," Westbrook said, "but turned out to be a benefit. We literally had to go back to the drawing board on many items. It gave us a chance to analyze old assumptions and challenge some conventional wisdom. RMI CEO Amory Lovins calls it 'good old Victorian engineering'"—the art of wringing multiple benefits from single expenditures.

By driving revolutionary change and jettisoning incremental evolutionary design, the 30-percent-lower-capital-cost goal gave Westbrook and his unfunded "Fabscape" sustainability design team their opening to test the most innovative ideas. Starting in 2002, the team met every two weeks and generated a flurry of state-of-the-art concepts.

Their growing stack of white papers soon made a compelling case for a freewheeling-but-disciplined design process to distill out something useable. So in December 2003, a team of RMI consultants came to help TI bubble up and boil down hundreds of nifty notions into twelve "Big Honkin' Ideas"—concepts that could fundamentally change how TI designed and built a fab and how TI worked with its industrial partners.

A wafer fab is full of exquisitely complex tools made by arcanely specialized suppliers. Energy efficiency is rarely a consideration when specifying tools. Because process and reliability requirements rule, the customer seldom asks for efficiency, and the toolmaker, who won't pay the utility bills, simply isn't used to providing it. It's not that they can't; rather, they've never been asked.

Yet the cumulative effect of *all* the power consumed by *all* the fab's tools and equipment led the charrette participants to trace how each watt of energy consumed by each tool ends up as heat that must be removed, making the cooling equipment bigger and power-hungry—at a total present-valued cost around $7 per watt! So the biggest win wouldn't be simply making the cooling equipment more efficient, but making it smaller and simpler by buying efficient tools that would give off less heat in the first place. Equipment would be sized by measurement, not guesswork: as RMI designers say (borrowing from GM), "In God we trust; all others bring data."

Savings quickly started to breed and multiply. Nearly doubled-efficiency vacuum pumps, cut to idle speed when waiting for wafers, saved 300 tons of chiller capacity and 7 percent of the plant's total electricity. Vacuum-pump vendors, initially startled by requests for extra efficiency, soon saw the business logic. Optimizing temperature and pressure drops saved a fifth of internally cooled tools' cooling-water flow. Smarter exhaust systems saved 100,000 cubic feet per minute

The TI participants' diverse enthusiasms quickly focused on winning a high LEED™ (Leadership in Energy and Environmental Design) rating—a systematic way, evolved with RMI's help, to score points for elements of good design.

(cfm) of exhaust and its replacement (conditioned fresh air)—each worth a present value of $62. Internally cooled tools with heat exchangers designed to lose less pressure and temperature cascaded into a 3,000-gallon-per-minute reduction in the size of the central process cooling water system, saving both capital and operating cost.

As post-workshop design progressed, it became increasingly apparent that smarter tools and their smaller, more efficient supporting systems would cascade energy and water savings. The results included a split chiller plant that cools water to two different temperatures for different purposes (further innovation might even eliminate one of the two sections in the next fab); highly efficient fan filter units for air recirculation; prechilling incoming hot air with outgoing cool air; big pipes and small pumps to cut friction and capital cost; natural daylighting and highly efficient lighting fixtures in the office area; solar water heating; a reflective roof; and extensive water recycling and reuse (reclamation will save nearly a million gallons of city water per day). Recovering heat previously thrown away, and using high-pressure water spray rather than steam for humidification, reduced six boilers to just one plus a backup—both of which will be off most of the year—cutting emissions of nitrogen oxides by 60 percent.

Although the facility will have to be up and running before anyone can know for sure, Westbrook predicts that the new facility will cut energy use by 20 percent and water use by 35 percent compared with TI's previous wafer fab. The savings come about half each from better tools and their direct support equipment and from smaller, more frugal utilities and building systems.

"Whole-systems tool design" wasn't the only breakthrough idea that emerged from the workshop. For example, TI decided to test lighter-weight smocks for clean room workers. Particle tests revealed that eliminating facemasks shouldn't harm product quality, and could make workers more comfortable with less chilling.

Some of the design features explored at the workshop were standard components of green design for non-industrial buildings, and offered tremendous financial benefit. Each waterless urinal, for example, will save 40,000 gallons of water a year, plus the capital cost of flush valves and water pipes not installed—helpful to a water-intensive industry in an arid climate. Energy modeling software such as **eQUEST3** let the designers test immediately how their ideas would change performance: for example, rotating the administration building 30° could save about $30,000 annually in space cooling.

The participants' diverse enthusiasms quickly focused on winning a high **LEED**™ (Leadership in Energy and Environmental Design) rating—a systematic way, evolved with RMI's help, to score points for elements of good design. As Westbrook noted, "The competitive nature of people is a strong force and can be harnessed for good. We like to save energy and reduce emissions—we love it when we score a point for doing so."

RMI *in the news*

Oil Endgame's Foreign Relations

Photo courtesy Judy Hill

On 3 December 2004, Amory Lovins was the featured guest at a luncheon at the **Council on Foreign Relations** (CFR) in New York City to answer questions about *Winning the Oil Endgame*. **David Victor**, director of the Energy and Sustainable Development Program at Stanford University's Center for Environmental Science and Policy, and an adjunct senior fellow with CFR, presided over the session. Victor called Lovins's history as a contrarian "a good reminder that we can think outside the box about our energy future."

The distinguished audience of approximately seventy included representatives from the investment banking industry as well as international bodies, such as the U.N. Development Programme. The lively group asked questions about everything from lightweighting cars to the next steps in implementing the plan in Detroit. The session was part of RMI's project to promote the book to those who can adopt its recommendations in their work.

To read the full transcript of the session, visit **www.cfr.org/pub7553/amory_b_lovins_david_g_victor/rethinking_energy_security_mobilizing_american_innovation.php**.

Compost filled tubes filter site runoff during the construction project, then are reused as landscape material at project completion.

The LEED focus seems to be working well for TI. The company will invest $2–3 million in LEED-related items—mostly efficiency gains that would have been incorporated anyway. That investment will return an estimated $750,000 in operating cost just in the first year, and at full buildout, should save more than $3 million *every year*.

It'll be exciting to see what comes from those three days in Texas. So far, RMI's retrofit efforts with ST Microelectronics, wrote Lotspeich, have "identified potential HVAC energy savings of 30–50 percent, plus other efficiency opportunities. Collectively these retrofits had payback periods of less than two years." But designing a new fab offers far greater scope for doing it right the first time: low-friction pipes and ducts, controls that run motors at the speed instantaneously required, even free cooling by exploiting cool or dry outside air. Such a system at ST's fab near Milan "costs 80 percent less to operate than conventional cooling, saving $500,000 annually with a payback of one to three years, depending on the weather."

In the end, such bottom-line benefits led TI to adopt most of the Fabscape team's dozen Big Honkin' Ideas (though some await further testing and analysis). All the energy and water savings changed the net capital cost by roughly zero—at most one percent extra, but quite possibly a decrease. Total capital cost per square foot, as required, came in at 30 percent below normal, blowing away industry norms and keeping the new fab in the United States.

On 15 March 2005, sponsored by leading chipmaker **Applied Materials**, Amory Lovins will describe TI's breakthrough to the China Semicon exposition in Shanghai. His goal: to foster still further design improvements in China, which has smart engineers and abundant pollution, scarce power and water, and an urge to leapfrog the West. Such competition is good for the world, and further opportunities remain to be exploited. Could the next fab be designed even better, to save 50 percent of its energy? Seventy percent? Eighty percent? Let's find out. As such radical savings emerge from the next generations of tool and system design, they may work even better and cost even less. With dedicated innovators like Paul Westbrook and his remarkable team, we're off to the races—helping one of the world's fastest-growing and most advanced industries to reduce all forms of waste to zero.

Christina Page (cpage@rmi.org) is a researcher/consultant with RMI.

[1] **Charrette**: a very intensive, highly integrative, transdisciplinary, roundtable workshop that brings together stakeholders and experts at the very outset of a design or problem-solving process. It yields an ambitious design product, typically conceptual with some extension into early schematic design. (See also footnote 1, p. 9.)

[2] These rough estimates come from several sources in the industry.

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