THE NAVY'S ENERGY & ENVIRONMENTAL MAGAZINE

Currents

spring 2012

NAVY SURGES TOWARD Energy Independence

SUCCESSFUL BIOFUEL DEMOS FUEL THE GREAT GREEN FLEET

2012 Navy Earth Day poster inside!

Spotlight on Rocky Mountain Institute

Highlights from the 2011 Naval Energy Forum

From Wind Farms to Whales, Navy Marks Significant Milestones in Environmental Management

Co-Founder Amory Lovins Shares His Ideas for an Enduring & Resilient Department of Defense

ON 27 JANUARY 2012, Amory Lovins, co-founder of Rocky Mountain Institute (RMI), shared his ideas on an enduring and resilient Department of Defense (DoD) with Kenneth Hess from the public affairs staff at the Chief of Naval Operations Energy and Environmental Readiness Division (N45) and Bruce McCaffrey, managing editor of *Currents*.

CURRENTS: Thanks for taking the time to speak with us today, Dr. Lovins.

For readers that may be new to the energy efficiency and sustainability realm, can you give us a little snapshot of your background and expertise?

LOVINS: I'm a 64-year-old recovering physicist. I was educated at Harvard and Oxford. I dropped out of both. I'm a former Oxford don (equivalent to a faculty member). I've taught at nine universities plus a new appointment as a professor of practice at the Naval Postgraduate School. I have 11 honorary doctorates and many international awards in energy and environment. I've written 31 books and over 450 papers.

©Judy Hill Lovins

I co-founded RMI in 1982 as a vehicle for my life's work to drive the efficient and restorative use of resources.

©Judy Hill Lovins

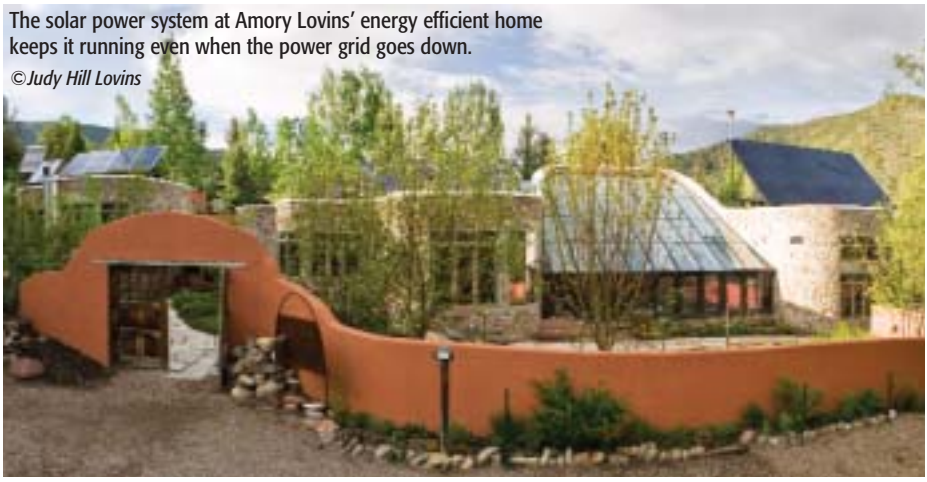
Most of my work for four decades has been as a consultant to the private sector and sometimes to governments—spanning over 50 countries—in advanced energy efficiency, energy strategy, and how energy is related to security, economy, environment, and development. I have also had the privilege to work extensively with DoD over the past few decades.

CURRENTS: Talk for a moment if you would about Rocky Mountain Institute, its origins and mission, and what led you to create that organization.

LOVINS: I co-founded RMI in 1982 as a vehicle for my life's work to drive the efficient and restorative use of resources. The Institute is an independent, entrepreneurial, nonprofit think-and-do tank. We have spun off five

for-profit and three nonprofit organizations, so we're a bit of an incubator. Our main model is to create important new intellectual capital, mainly with philanthropic support, and then apply, test, break, fix, improve, and spread those ideas through collaborations with powerful partners—usually in the private sector—who are highly motivated to solve a tough problem but feel they need our help to do so. Together we learn rapidly, solve the problem, and create teachable cases and competitive pressure for emulation. That is, we use competition to help early adopters become so conspicuously successful with radical energy resource efficiency that their rivals are forced by competitive pressure to follow suit or lose share. Of course, the mechanisms are different in the military sphere but somewhat analogous.

[We help] early adopters become so conspicuously successful with radical energy resource efficiency that their rivals are forced by competitive pressure to follow suit or lose share.



The solar power system at Amory Lovins' energy efficient home keeps it running even when the power grid goes down.
©Judy Hill Lovins

CURRENTS: Did you want to expand on the military piece of that?

LOVINS: Sure. I've worked on many national security issues over the years such as non-proliferation, critical infrastructure vulnerability, and strategic doctrine, but over the past two decades I've focused especially on two new strategic vectors—Endurance and Resilience.

Four big ideas have long driven the revolution in military affairs—speed, stealth, precision and networking. In 2001 and 2008, I was active in shaping two national Defense Science Board (DSB) task force reports that discussed two more big ideas—Endurance and Resilience.

We found that a pervasive waste of energy in the battlespace and the 99 percent dependence of fixed facilities on the highly vulnerable commercial electricity grid are hazarding mission success and incurring huge costs in blood, treasure, and lost combat effectiveness. But Endurance and Resilience can turn these handicaps into revolutionary new capabilities at similar or lower capital cost and at far lower operating cost. So it helps with DoD's budgetary pressures as well.

Let me start with the concept of Endurance. In World War II, the Allies' heavy sea forces, it has been said, "floated to victory on a sea of oil," mainly from Texas. Today's forces are about 16 times more oil-intensive, and Texas is now a net importer of oil. DoD can always get the oil it needs—albeit at a high and volatile price that buffets the budget process—but the long-uncounted cost of delivering that fuel to the battlespace is often enormously higher. It's about 20 to 36 percent of the total cost of the Afghanistan deployment, for example.

Logistics for fuel have historically used about half of DoD's personnel and a third of the budget. And the cost in blood is even higher. Over a thousand lives have been lost in convoy attacks in the past decade, mainly hauling fuel. But convoys we no longer need cannot be attacked. So saving fuel is a force protector. It's also a force multiplier that frees up fuel guards and logisticians to be trigger-pullers. It's a force enabler that radically increases range and nimbleness, and it's a key to transformational, multi-divisional realignment from tail to tooth that could save many tens of billions of dollars a year.

DoD is introducing two policy tools to make new platforms vastly more efficient, and the prime contractors are already starting to compete in this new environment. The first tool is valuing saved fuel at its fully burdened cost, delivered to the platform in theater in wartime. That's often about ten and sometimes a hundred times the undelivered cost previously assumed. I was recently speaking with one manufacturer of military airframes who gave a

three-figure dollar value per saved gallon against which they're designing their next airplane. That's going to be a very different airplane than when we thought saved fuel was going to be a few dollars a gallon. Also, DoD is adding new energy Key Performance Parameters (KPP) to prime contracts for new platforms. Those innovations will ultimately not only save most of DoD's fuel, but also catalyze leap-ahead efficiency gains in the civilian sector (which uses 50+ times more oil)—just as military science and technology investments in the Internet, Global Positioning Systems, and the jet-engine and microchip industries transformed the civilian economy.

So Endurance combines greatly improved energy efficiency in everything that uses fuel or electricity in the battlespace with autonomous energy supply that makes Endurance a lot cheaper and easier to achieve.

Now let's talk about Resilience. Right now, our land facilities rely 99 percent or so on a commercial grid that is subject to large-scale, cascading blackouts. In the 2008 DSB report entitled *More Fight—Less Fuel*, we recommended that DoD remove its fixed facilities from the commercial power grid and shift to the efficient use of electricity from diverse, dispersed and preferably renewable supplies.

The cost of delivering fuel to the battlespace…is about 20 to 36 percent of the total cost of the Afghanistan deployment.

Chief Mass Communication Specialist Kathryn Whittenberger

About 90 percent of bases on the continental United States could do that—often to their economic advantage. This shift makes it possible to reorganize the grid into a series of "islandable" microgrids that normally interchange with the commercial grid but can stand alone at need: they can isolate fractally, then reconnect seamlessly. My own house does this. I don't even know when the grid goes down. The solar power keeps it running with modest storage because I'm using electricity very efficiently.

Denmark is reorganizing its grid in this way, and every year they "stress test" it by pulling the plug on the main grid to make sure the microgrids can still run their critical loads (which they can). There are about 20 civilian microgrid experiments worldwide. Perhaps the most spectacular example is in Cuba. They applied this microgrid architecture in 2005 through 2007 to reduce their serious-blackout days per year from 224 to three to zero. And then in 2008, two hurricanes in two weeks shredded their eastern grid, yet Cuba was still able to sustain vital services. This holds important lessons.

So I think without being fond of their politics, we can still learn from Cuba's technical achievement. Efficient use, diverse distributed generators, and islandable microgrids can make bases and their surrounding communities resilient against disruption. DoD has actually launched case studies of this approach in several locations. I hope the Navy, whose [Naval Surface Warfare Center] Dahlgren experts have been critical in this effort, and the Marine Corps will sustain their leadership in shifting all of their facilities rapidly toward resilient electric systems, and there are also good initial efforts in the other Services.

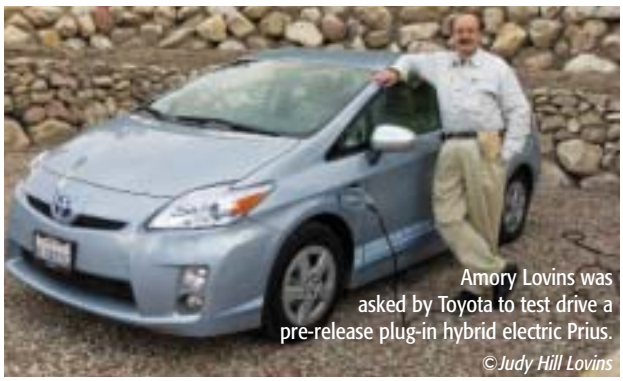
CURRENTS: What incentive do you think those airframe manufacturers have to build a more efficient aircraft? What sort of changeable incentives are they getting from either DoD, the market, or elsewhere for them to want to do that?

LOVINS: DoD is telling them that the saved fuel is worth over $100 a gallon (delivered in midair)—or their own analyses using DoD criteria are telling them that. They're starting to realize that if they don't meet their energy KPPs, there is a real risk of their contracts being

cancelled. So they're very strongly incentivized to design the aircraft for far greater efficiency. As that kind of innovation works through into the civilian sector, it helps get the nation off oil much faster by speeding the transformation of our civilian cars, trucks and planes.

Our own nation, as it comes to need no oil, may feel differently about fighting over oil.

Automobiles use three-fifths of U.S. mobility fuel; two-thirds of their energy use is caused by their weight; and saving one unit of energy at the wheels (by removing weight or drag—turning automotive obesity into fitness)—saves seven units of fuel at the tank. You can take out half to two-thirds of the weight of a car while making it safer using advanced composites that can absorb six to 12 times as much energy per kilogram as steel. And you can also improve aerodynamics, tires, accessories, and integrative design; and then downsize the power train to get the same acceleration from a lighter platform. When you put all that together and take advantage of the radically simpler manufacturing, using a fifth as much capital, the automobile's efficiency with the same or better performance, and the extra cost of the whole vehicle is approximately zero because simpler manufacturing and smaller power trains pay for the exotic materials. Such fit autos need three times fewer batteries or fuel cells, making electrification affordable and displacing the rest of the oil. Making all American autos out of carbon-fiber composites instead of heavy steel could, by 2050, displace one-and-a-half Saudi Arabias or half the total output of the Organization of the Petroleum Exporting Countries (OPEC). Those "negabarrels" under Detroit cost just $18 per barrel, and they're domestic, secure, carbon-free, and inexhaustible.



Amory Lovins was asked by Toyota to test drive a pre-release plug-in hybrid electric Prius.
©Judy Hill Lovins

The Basics About Rocky Mountain Institute

FOUNDED IN DR. LOVINS' home in Snowmass, Colorado 30 years ago, Rocky Mountain Institute (RMI) today has two offices, employs about 90 people, and has an annual operating budget of nearly $12 million. RMI's central approach uses philanthropy-funded innovation to create new solutions to old problems.

Beyond the Navy and Department of Defense work mentioned in this article, some of RMI's recent work includes:

- A project with the U.S. Department of Energy that first estimated true costs for solar energy systems, and then worked on ways to reduce those costs
- Project Get Ready–an ongoing project that aims to accelerate the adoption of electric vehicles by focusing on city readiness
- A major retrofit of the Empire State Building, resulting in energy savings of $4.4 million per year.

For more about RMI, visit http://www.rmi.org.

Think about the reductions in tensions in places from the Arctic to the Strait of Hormuz to the South China Sea in a world that uses less and ultimately no oil. Our own nation, as it comes to need no oil, may feel differently about fighting over oil. We can even envisage negamissions in the Persian Gulf—Mission Unnecessary. For warfighters, this is very good news.

CURRENTS: In your Joint Force Quarterly (Issue 57) article entitled "DoD's Energy Challenge as Strategic Opportunity" (available at www.ndu.edu/press/lib/images/jfq-57/lovins.pdf), you also encourage DoD to do a better job of articulating those incentives. You talk about the lack of cohesive strategies and policies and governing structures so that we can properly manage our energy risks.

Making all of our American autos out of carbon-fiber composites instead of heavy steel could, by 2050, displace one-and-a-half Saudi Arabias or half of the oil we import from OPEC.

LOVINS: That's true. There is a lot of work still to do. But Sharon Burke was confirmed as the head of operational energy in the Pentagon, about a year ago, and now that her office is stood up, we're starting to see good leadership in the Office of the Secretary of Defense (OSD). However, I would say that the Navy and Marine Corps in particular are well ahead of OSD in operationalizing the Endurance strategic vector. There is also excellent work going on in the Army and Air Force. The work that Colonel "Brutus" Charette and the Marine Corps are doing on Experimental Forward Operating Bases (ExFOB) is impressive and in some of their experiments now they're saving up to 90 percent of forward fuel (fuel delivered for use by the front line warfighter). (Note: The Marine Corps' ExFOB effort is identifying and evaluating energy efficient capabilities that can reduce risks to Marines and increase their combat effectiveness. Created in 2009, ExFOB brings together stakeholders from across the Marine Corps' requirements, acquisitions, and technology development communities to quickly evaluate and deploy technologies to reduce the need for "liquid logistics" today and to establish requirements for tomorrow.) If you look a little closer, the Marine Corps has found in a hot, sandy place that about 95 percent of the electricity from engine-generator sets (gensets) was going to inefficient air conditioning of uninsulated and often unoccupied tents and other structures.

The gensets and their associated wiring were only about ten percent efficient, and we're getting people blown up in convoys that fuel those gensets. You don't have to be an engineer to see what's wrong with this picture. But there is huge leverage in, as an Army Colonel remarked, "defeating Improvised Explosive Devices by not being there." This story holds true across all platforms and in all Services.

I was on a KC-130 flying between a couple of Midwestern bases a few years ago and happened to notice some heavy pieces of equipment on board that were not necessary for combat capability or airworthiness. I briefed what I'd observed the next morning to a couple of two-star Generals. Within some months, they'd come up with readily removable surplus weight in that aircraft class worth over a billion dollars in present-valued fuel savings. Then they extended to some other heavy classes of aircraft and found several billion more dollars. Nobody had been responsible or rewarded for taking out weight.

In a mid-size civilian airliner, taking a pound out of the plane is worth close to a thousand dollars in present-valued fuel savings. The military economics are a little different but not fundamentally. Throughout the Navy and Marine Corps, we are starting to see the same kind of systematic discipline in operations and design. The biggest, most fundamental advances will be in designing

new platforms. But there is still a lot we can do to run the existing ones better. In our work on USS Princeton (CG 59), for example, we suggested a new way of running their electricity-generating gas turbines that we call virtual trail shafting—analogous to the way propulsion turbines are run when you have a pair on an axial shaft. You fuel one and leave the other spinning without fuel, ready to be fueled and lit off as needed. Virtual trail shafting connects separate gas-turbine generators electrically, using a small motor to keep the unfueled backup unit spinning so the working unit can run at full load for highest efficiency. These kinds of innovations really add up. We've figured out that aboard Princeton—which was in her top quintile for class efficiency—you could save about 40 to 50 percent of the onboard hotel-load electricity. If this were true fleet-wide, you'd end up saving about a sixth of the Navy's non-aviation fuel.

An efficient warfighter is an effective warfighter.

The guided missile cruiser USS Princeton.
Photographer's Mate 2nd Class Michael J. Pusnik, Jr.

We have a lot of computing power in the fleet now that ought to be considered for more efficient design. In fact, some years ago, we were being visited here at RMI by then-Vice Admiral Denny McGinn—now a senior fellow of our Institute and leading the American Council on Renewable Energy. I had just been aboard his command ship—USS Coronado (AGF 11). All over the ship, people were using cutting torches and jackhammers to install new cooling and wiring to accommodate servers that were to provide a network-centric warfare main battle laboratory on board Coronado. So when Denny came to RMI, I showed him a little paperback-book-size Linux™ box that we had just used to replace several Wintel servers. The Linux box poked along at two or three watts and peaked at 15 watts, required no cooling, and could fit into a desk drawer. So it would save a lot of real estate as well as electricity in cooling. Denny got his Executive Officer on the phone and said, "Belay that work on Coronado, we've got a better solution."

LOVINS: Yes. I can give you another example. In 1995, I was asked to deliver a brief the Resource Requirements Review Committee, comprised of Navy admirals and Marine Corps generals, entitled "Negawatts and Hypercars:

For More Insights

FOR MORE INSIGHTS into one of many of the Navy's efforts to achieve energy efficiencies in port and at sea, read our article entitled "Pacific Fleet Targets Shipboard Power Use with Meter Technology: Continuous Monitoring Maximizes Energy Efficiency" in the fall 2011 issue of *Currents*. To browse back issues or subscribe to the magazine, visit the Department of the Navy's Energy, Environment and Climate Change web site–at greenfleet.dodlive.mil/currents-magazine. The RMI team's Princeton study is at available at www.rmi.org/Knowledge-Center/Library/S01-09_EnergyEfficiencyUSSPrinceton.

How the Resource Efficiency Revolution will Transform the Navy." The meeting was chaired by then-three-star, later four-star Admiral Joe Lopez (who began his service as an enlisted seaman). I did the first ten minutes of the brief on integrated building design, because that's the most simple and intuitive way to explain how you can achieve big savings more cheaply than small or no savings.

The admiral looks at me and says, "I suppose you know who's good at the integrated design that you're describing. Do you think you could get a group of them to sit around a table with our best designers and redesign a building we've just designed (so we'll have something to compare it to)? Then we'll build it your way and measure it. If it does what you say it will, we have $6 billion in construction that we'll do that way next year and $7 billion the year after, and we'll want you to indoctrinate our top 350 designers." I gulped and said "Yes, Sir!"

The Navy's test and acquisition programs are greatly accelerating the development of sound and affordable biofuels.

We indoctrinated the designers and the Naval Facilities Engineering Command (NAVFAC) moved out smartly. Some people did some very courageous things within the bureaucracy to make that happen. In the end, it didn't stick because the people leading it at NAVFAC were so good they got promoted up and out before these concepts had reached full acculturation. So now I think we'll do it again under the new leadership. After a year, Admiral Lopez called me back, and said, "We have eight buildings built and tested. They do what you said they would. Write me a report card. I want to know what to improve next."

I tell that story to our civilian clients—chief executives in their own large organizations—in the hopes that they'll get that good. Some of them are, but not very many. This was the beginning of my naval education in the difference between leadership and management—lessons for which I'm eternally grateful to the Navy.

CURRENTS: As a result of all this research and experimentation, do you feel like we're beginning to break down barriers to doing things a different way? Or are we still in a transition period?

LOVINS: We are definitely still in a transition period. It will take relentless patience and meticulous attention to detail to change some traditional attitudes. I appreciate the Marine and Navy leadership on those cultural changes. For so long, the attitude throughout the military was "we don't do fuel, we buy fuel." And it took a while to realize that an efficient warfighter is an effective warfighter. As this new way of thinking starts to permeate the military, we will start to change the training and educational systems, the reward systems, and the details of how we foster and sustain energy knowledge throughout the services. In that context,

MC1 Rachel McMarr

I'm delighted that, at the Cebrowski Institute at the Naval Postgraduate School, we're now designing both an energy certificate course and an energy master's course—the first in any Service to inculcate the understanding of energy and the associated organizational and cultural change vectors into the next generation of leadership.

CURRENTS: What do you think the Navy's doing right from an energy standpoint?

LOVINS: Well, we hear the most about biofuels. The Navy's test and acquisition programs are greatly accelerating the development of sound and affordable biofuels. It's all moving many years faster than it would have otherwise. But I think the underlying efficiency advance is even more significant. And the Navy's work on renewable electricity is also very important. Not just big projects like China Lake geothermal, but a lot of photo-

voltaics and other sources going in at facilities around the world. I think also the institutional changes are very important, with leaders like Vice Admiral Cullom. I'm immensely impressed with the detail and strategic astuteness with which his agenda is being implemented across the Navy and Marine Corps. I was very interested to look at the structure and rewards systems in some of the Navy's energy efficiency programs. When skippers got a share of what they saved in operational energy through smarter practices, the savings flourished. When there was no such incentive—when the ship got no direct benefit from saving energy—the savings dwindled. When the incentives came back, so did the savings. There's an important lesson here about what people pay attention to and how to focus that attention on systematic improvement.

I think military leadership will be very important in driving the civilian efficiency and renewable energy revolutions. This is not only in the obvious ways like technology development, but also social influence and leadership.

It's remarkable how naval leadership has driven the civilian transformations from sail to coal to oil to nuclear energy, and now to renewables.

Wind turbines at Naval Station Guantanamo Bay, Cuba.
Chief Mass Communication Specialist Bill Mesta

For example, we now have lots of direct digital controls in civilian life, but most of the people who built them were trained in the Navy. And indeed, if you look back at the much longer history, it's remarkable how naval leadership has driven the civilian transformations from sail to coal to oil to nuclear energy, and now to renewables.

I think that's a wonderful tradition, and I'm thrilled to be able to contribute to that ongoing naval leadership in how we use and provide energy in the civilian economy.

Reinventing Fire: Bold Business Solutions for the New Energy Era

DR. LOVINS' NEWEST (and 31st) book offers workable solutions for four energy-intensive sectors of the economy: transportation, buildings, industry, and electricity.

"Following official projections, the U.S. will have a 2.6 fold bigger economy in 2050 than in 2010," Dr. Lovins states. "We show how to run that economy with no oil, no coal, no nuclear energy–and a third less natural gas. We found that this would cost five trillion dollars less than business as usual in net present value, assuming that all externalities–all hidden costs–are worth zero. *Reinventing Fire* also claims that the proposed transition would require no new inventions, no act of Congress, and could be led by business for profit.

"We followed advice ascribed to General Eisenhower, " Lovins says. "If a problem cannot be solved, enlarge it."

Looking at energy use by sector, in other words, is ignoring the bigger picture. "We integrated all four energy-using sectors: transportation, buildings, industry and electricity, and we found that, indeed, you can more easily solve the electricity and auto problems together than separately. We also integrated four kinds of innovation–not just technology and policy, but also design and strategy–new competitive strategies, new business models. Those turn out to be even more powerful than the innovations in technology and policy–and those are certainly impressive. And all four together are much more than the sum of their parts, and offer deeply disruptive business opportunities. Entrepreneurs are starting to pick up this approach. With five trillion dollars on the table, there's plenty of incentive," he says.

For more about *Reinventing Fire: Bold Business Solutions for the New Energy Era*, visit http://www.rmi.org/rfexecutivesummary.

That being said, there are still some shortcomings in how we calculate the fully burdened cost of fuel. For example, we're counting the costs of fielded personnel for logistics and force protection, but not of the severalfold more personnel who are on rotation stateside, in training, and so on to support that fielded one-third or one-fourth of the total force structure. We should be counting the pyramid of all assets and functions that we'd no longer need if a given gallon need never again be delivered.

We are also at an early stage of extending to saved electricity the same attention that we're giving to saved fuel. So when we hear of expeditionary warfighters hugely burdened by all the batteries they need to carry, the first thing that occurs to me is, "Is their electronic equipment as efficiently designed as, say, an iPhone or a Sony consumer electronics device?" I think the answer is probably "no," because nobody told the designers how much a saved watt-hour is worth.

I am most looking forward to the thorough design reforms entering the contractor community so that they will be competing over radical energy efficiency.

In the long run, the biggest energy-saving potential is in the design of new platforms and new tactical and strategic concepts based on the radically improved capabilities of those platforms. I am most looking forward to the thorough design reforms entering the contractor community so that they will be competing over radical energy efficiency. When that competition becomes really keen, driven by the fully burdened cost of energy and energy KPPs, then the institutional change that Vice Admiral Cullom and others are driving will become permanently ingrained.

CURRENTS: What do you think needs to happen for the U.S. and the rest of the world to have the energy we need for the long term?

LOVINS: We need to use energy in an economically efficient way, and get it from diverse, distributed, and increasingly renewable sources that don't run out, cannot be cut off, and are stably priced and everlastingly available. This is a big task. That's why we called our latest book *Reinventing Fire*, because it really is that profound a change in human infrastructure. Fire made us human, fossil fuels made us modern, and now we need a new fire that makes us safe, secure, healthy and durable. We have a big task ahead for the next 40 years. It's not easy; it's only easier than not doing it.

CURRENTS: Is there anything else you'd like to say to *Currents* readers?

LOVINS: For those of you who are already in this fight, a big Bravo Zulu for who you are and what you do. For those of you who have yet to grasp the energy opportunity, it is a huge and worthy challenge, and vital to the Navy's mission. I look forward to you enlisting in the cause and being properly rewarded in your conscience and career for the results you'll achieve. As a civilian and a novice in military affairs, I'm learning something every day from your cultures. And I thank you for that, and for defending all of us who are constantly inspired by your example. ⚓