Clean Energy Is Real … and More Imperative Than Ever

The profound implications of the Gulf oil spill offer still more proof that our nation must forge a new energy future – one that should be, and can be, both environmentally and economically sustainable

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Gulf Oil Spill has Sparked Debate

As the director of the nation's principal research center for renewable energy and energy efficiency, I started getting questions as soon as the first news broke about the explosion and fire on the Gulf oil rig, which we now understand has resulted in perhaps the worst environmental catastrophe in our nation's history.

In the weeks since, and even now, I'm still hearing the same question. The exact words may vary, but it all comes back to a single, frustrating conundrum: *The problems created by our "addiction to oil" are only getting worse. But realistically, is there anything we can do to break that dependency?*

There are some who say the historical choices we've made create a challenge too enormous to effectively confront. In this view, there's not much we can do to change our oil-dependent ways, even if we decided to do so.

Others, quite frankly, paint a too-rosy picture of a world where we just turn off the oil spigot, and move to some single favored cure-all, which somehow magically solves our energy problems.

My experience tells me that neither of those assessments is right, nor for that matter, very helpful.

No One Solution

My many years in the energy research field tell me that the answer is that we need to move boldly on a deliberate path on each of our most viable clean energy options. We need to do this with a focused near-term and long-term research and development effort. That R&D effort must include consistent and sustained policies that accelerate these new technologies into everyday use, to benefit the nation, and at the same time enhance our energy security.

This answer recognizes an important precept – **there is no one "silver bullet."** Instead, our path should be to push forward with multiple clean energy resources and technologies, putting each to their highest and best use.

Can Renewable Energy Contribute?

Of course, there will be those who will argue that energy alternatives don't work. Or we can't afford them. There's an easy answer for that. The truth is we already are producing more renewable energy today than the energy

content from all U.S. offshore oil production. According to the 2009 EIA Energy Outlook, in 2008 non-hydro renewable energy – wind, solar, geothermal, and biomass – supplied 4.9 quadrillion BTUs in the U.S. in the form of electricity and liquid fuels/fuel blends. If we add renewable hydroelectric power, we obtained 6.2 quadrillion BTUs of clean, renewable energy annually. In comparison, the energy content of the 683 million barrels of offshore oil we produce is approximately 3.96 quadrillion BTUs. With renewable energy already contributing more to the nation's overall energy needs as offshore oil, it's clear that renewable technologies and resources no longer live solely in the future; they have proven themselves as viable, and substantial, today.

<u>But, Energy Transformation Requires "Systems Perspective"</u>

The attention being directed at the Gulf oil spill is obviously well warranted; it deserves the strongest national response we can muster. But it's instructive to step back for moment and look at the broader energy picture as well.

Unfortunately, today we continue to struggle with the worst economic climate since the Great Depression. We also have a number of mounting national security challenges. Our petroleum addiction is part and parcel of these problems as well. Whether it's a serious trade deficit resulting from oil imports, or the financial support oil imports provide to hostile regimes, energy is central to our economic and national security interests.

It's becoming clear that the **trio of crises** – the environmental, economic, and national security predicaments we face – are not distinct. They're **intertwined**. Each is related directly to how we generate and use energy. It will be difficult to solve any one of these issues without seriously tackling a fundamental problem: our dependence on oil for transportation.

What is demanded, then, is a dramatic leap forward in innovation; a national and, in fact, international scientific research and development effort around clean energy technology – mounted on an unprecedented scale. But even this not enough. To accomplish our clean energy and climate change mitigation goals, we need to move beyond what I frankly see as our outmoded ways of developing and deploying new technologies. We need a complete makeover in the way we move new technologies out of the laboratory, adapt them to create new, marketable energy systems, and deploy them at the speed and scale needed to truly make a difference.

Changing Our View

This transformation will, among other things, require nothing less than a radically different way of thinking about energy. Energy resources have historically been viewed as a least-cost commodity, without regard to their economic, environmental, and security impacts.

The imperative today then is to re-envision energy as a high-tech, high-growth industry, one which can drive our economy. I think there are important parallels to be drawn from the deregulation of the Bell system (of

which I am a product), that spawned a new vibrant and dynamic telecom market that, to this day, continues to drive innovation.

The environmental, security and economic benefits of renewables, and the fact that renewables are distributed, lead me to believe these technologies will ultimately be our best choice for the future. But, as we transition to a clean energy future, there will still be a useful role for coal and biomass to liquids, oil shale, tar sands, and natural gas transportation fuels all with appropriately managed carbon emissions. I expect new nuclear power also will have a role in electrical generation. Again, we need all the new and next generation energy technologies we can develop to reduce our reliance on imported petroleum.

Despite what some may claim, we do have a number of promising technology options for both significantly improving energy efficiency and for producing new, environmentally beneficial fuel alternatives. Working together, fuel efficiency and fuel switching can displace significant amounts of the petroleum we rely on today.

Transitioning portions of our vehicle fleet from gasoline to electric power should be an ongoing priority. Hybrids which efficiently use gasoline and electricity already are commonplace on our roads. The first commercially available plug-in hybrids will be introduced this year. Electric-only vehicles are establishing their own market niche as well.

A key benefit of electrifying our transportation network is that it will allow us to use the most environmentally sustainable renewable energy systems. If

we produce electricity from solar or wind power, and we use that electricity to power our cars and trucks, we essentially have an abundant and accessible supply of clean, renewable wind and solar fuels to meet our transportation needs. That, in the long view, should be one of our key goals.

At 35,000 Megawatts installed capacity, the United States has become the world's largest producer of wind power, and we now have over 1 Gigawatt of solar photovoltaic systems, and both keep growing at 30% to 40% per year. However, we still have a long way to go to capitalize on the full advantages of wind and solar resources as they only comprise just over 1% of our electricity generation. But it's important to note, just as our energy problems are intertwined, our energy solutions are intertwined as well.

Moving more renewable wind and solar power onto the electrical grid won't immediately displace large amounts of oil, because little of our electrical power comes from oil. Longer term, however, make no mistake: powering electric vehicles with electricity from wind and solar generation can contribute in substantial ways to reducing our dependence on oil.

Recent Studies Indicate the Promise of Solar and Wind for Electricity Generation

There is reason for optimism on the solar power and wind energy fronts as well. Several recently conducted comprehensive analyses on wind and solar alone indicate that we can realistically expect to supply 20% to 30% of our electricity from wind and to supply 10% to 20% of our electricity from

solar. In the scenarios analyzed, no major technical breakthroughs are required, but we do need to change the way we manage our system and, in the case of solar, continued cost reductions are still required.

Transitioning Transport Will Be Hard

Still, making the transition from a transportation sector almost entirely dependent on liquid fuels will be difficult. Electrification of our passenger and commercial vehicle fleet is but one fuel-switching option. And I am quick to remind people that simply swapping brown hydrocarbon molecules for green electrons alone is insufficient and, unless other things change, really not very economical.

Other important clean-fuel pathways involve using various biomass resources to create alternative, carbon-based liquid fuels, and the Department of Energy is today doing the R&D to unlock the potential of this important resource. These technologies build on the existing corn-based ethanol industry, but instead the new technologies use plant material and agricultural wastes that aren't related to food crops. These next-generation biofuels include cellulosic ethanol, bio-diesel, algae and other biobased hydrocarbon fuels. Additionally, we should not overlook the role that natural gas and hydrogen can play in meeting our transportation needs.

Importance of R&D

Indeed, we are fortunate to have a number of viable, clean energy options before us. But new innovation is required. The benefits of energy

efficiency, biofuels, wind and solar and other emerging clean energy technologies like hydrogen and fuel cell technology, and enhanced geothermal, simply will not come soon enough without a far greater commitment to energy research and development.

As a member of the National Science Board, last year I served as co-chair of a major examination of our nation's energy needs. We called on some of the best and brightest energy experts to provide us their recommendations. While the findings are far-reaching, one overarching conclusion emerged: **moving rapidly to a sustainable energy future** – one that's clean, reliable and affordable – **must be a national priority**.

One root cause of our energy crisis, which we found time and time again in our National Science Board review, was that public and private budgets for energy R&D have been wildly inconsistent. This has led to frustrating stops and starts, and, over the decades, plenty of lost opportunity.

The 30-plus year history of the federal research facility which I am honored to lead, unfortunately, bears testimony to this.

The budget for the National Renewable Energy Laboratory in Colorado has gone up and down with the volatility of oil prices. When oil prices have been at their highs, we as a nation have cared about finding alternative energy technologies. As prices slid off their peaks, we returned to our unsustainable oil consumption habits. Progress on new energy technologies lost momentum in the face of policy neglect and diminished support.

Our National Science Board review concluded that the record of federal support for energy R&D has been gravely insufficient to the task. Today, we are paying for that deficit in a myriad of ways. It's a safe bet that we would already be enjoying the benefits from cheaper and more efficient clean energy technologies – those new energy systems we are working on today, which will reach the market in five to ten years hence – if only we had supported advanced energy research in a coherent fashion over the past several decades.

The shortfall in support for clean energy research has been also true in private R&D efforts. One study found that U.S. energy companies could increase their R&D spending by a factor of ten, and still remain below the average relative R&D spending for U.S. industries generally.

Economic studies have shown that for a variety of reasons increased federal research support almost invariably stimulates increased research by private corporations in corresponding fields. The inescapable reality is that our energy situation is much worse today because we, as a nation, have failed to invest consistently in energy R&D. This is not a mistake we can continue to afford to make.

There's another fact here that should not be overlooked. When we take stock of the resources that *have* gone into federal renewable energy research, we can see they have provided a very strong return on taxpayer dollars. Since our Laboratory began as the Solar Energy Research Institute in 1977, the work accomplished at our facility and at other labs

around the country has significantly improved the market-readiness of renewable energy technologies.

Looking at the real price for a unit of energy produced, solar, wind, biofuels and other renewables today cost anywhere from 10% to 30% of what they did when the federal research effort began in the late 1970s. If we consider the many economic development and educational benefits additionally derived from these efforts, the federal investment in energy R&D has paid for itself many times over. Unfortunately, that benefit has mostly accrued to the international market players that have created today's renewable energy industry globally. Only 10% of the market is in the U.S.

Importance of Technology Transfer

So, research is important. But our national commitment cannot stop there! Once we have firmly established a newly invigorated, clean energy research and development effort, we need to adopt new, innovative ways of moving the most viable of the resulting new technologies into commercialization. Then, markets can determine the appropriate mix of environmentally and economically sound alternatives.

But I want to impress upon you that our frustration of little progress in energy is due to the fact that the energy sector is uniquely different from other sectors of the economy. And the government has two key roles to play. First, government must create incentives and policies to shape markets if we are to encourage investment and thereby innovation in the private sector to move clean energy technologies into the marketplace.

Second, the government must accelerate the adoption of new technologies at speed and scale through the full spectrum of the innovation cycle including science, market-relevant research, systems integration, testing and validation, commercialization and deployment, all done in partnership with the private sector. Only then can we achieve success of the clean energy mission.

We are fortunate that President Obama and Energy Secretary Chu have made clean energy a priority of this administration. The significant energy efficiency and renewable energy provisions in the American Recovery and Re-investment Act and other clean energy legislation passed by Congress have provided us with a good start out of the gate. But, given the magnitude and time frame of the job ahead, this can only be viewed as something akin to seed funding for a new technology venture.

The findings of our National Science Board Task Force suggest that even the enhanced levels of support for clean energy technology in place today will still leave us far short of achieving even the clean energy goals that are already set in federal policy – let alone the more ambitious goals many are advocating for the future.

Moreover, our collective experience suggests we need to adopt an entirely new model for federal research and development in energy. Our regulated and highly inelastic energy market simply has too many barriers.

What is needed, then, is to extend what has been the traditional role of federal R&D. If we are to achieve the quick and deep market penetration

we need for clean energy, new technologies must be supported through the R&D pipeline, then they need to be shepherded into the marketplace – through demonstration to commercialization and deployment.

I can tell you we are making great progress toward this end. In the case of my laboratory, NREL, the extensive interactions we've had with the private sector over the years are now rapidly evolving and expanding further still. Now, more than ever, we are devoting ourselves not only to the priorities of research, but also to ensuring the benefits of that research are fully – and expeditiously – reaching industry, to produce products that benefit the nation as a whole. The lesson is that federal research institutions need to get beyond the classic R&D model and think about the full-cycle market implications of their work.

Increased collaboration must be another imperative. We will succeed with the urgency required only if we work together, as part of the broader energy research community, tapping interdisciplinary expertise across public and private sectors around the U.S. and around the world.

A new emphasis on advanced energy sciences is in our national interest, and will provide great national benefits. Our country's leaders have long known the link between science and economic competitiveness. Our scientists and engineers now must be challenged, and given the opportunity, to solve our economic, climate, environmental and security challenges as well.

Returning to the question at hand – can these alternative technologies truly make a difference? Here again, there is plenty of real-world evidence to suggest that clean energy technology is a proven commodity.

Take the good people of Greensburg, Kansas. After a tornado packing 200 mile-per-hour winds killed 11 residents and leveled much of their community, the city leaders decided they would rebuild their town using the most energy efficient and clean energy technologies available. Engineers from NREL have been working hand-in-hand with officials in Greensburg now for more than three years. The results are impressive: The new homes built in Greensburg are fully 40% more efficient than the houses they replaced. A community wind farm generates enough electricity to power their own town, and they plan to sell the local utility enough excess electricity to power three additional towns their size.

Or, consider the U.S. Department of Defense. NREL is working with energy planners in the Defense Department on ways to save energy and rely more on renewable energy resources. Together, we've developed solutions that improve energy security through sustainability to not only move the military to greater reliance on solar, wind and other renewables, but we are doing so in ways that save money, and crucially for our armed forces, in ways that actually enhance mission readiness and effectiveness.

We can reflect on the impressive work now underway in the State of Hawaii. Government and utility officials are working with NREL analysts to completely refashion where energy is obtained, and how it is used across the state. That effort may be instructive for all of us, because the island

state is even more vulnerable than the rest of the nation. Some 90% of Hawaii's energy currently comes from imported oil. The Hawaii Clean Energy Initiative is a serious, pull-no-punches response to the state's petroleum predicament. The emerging public-private partnership that is pushing the Initiative forward is moving dramatically away from oil, and calling for 70% of the state's energy needs to be met through energy efficiency and renewable energy by the year 2030. These are just a few of many watershed developments on the clean energy front.

Finally, I'd be remiss if I didn't brag about our lab's campus. The National Renewable Energy Laboratory is, in fact, a living laboratory of the future. We believe that as the national spokespeople for renewable energy that it is incumbent on us to "walk the talk" and show the way. Just yesterday, I participated in an open house of our newest signature facility, the Research Support Facility. This building embodies the systems level approach to energy efficiency and sustainable renewable energy generation. It is, in fact, the world's most efficient building of its size and on an annual basis it is designed to generate as much energy as it consumes – effectively a net zero energy building. And, the best part is that it was built at a cost equal to what a government building costs if it is built to existing code. At our lab, the future is now and we are pleased to be part of demonstrating the art of the possible.

In conclusion, I believe that in the future, the U.S. energy landscape, must be, and will be, vastly different than it is today. To get there, we will need innovation through expanded research and development on multiple technology pathways. This long-term clean energy R&D portfolio must

include cellulosic ethanol, biodiesel, fuels produced from algae, renewably produced hydrogen, solar, wind and geothermal power, smart grid technologies, new battery and other energy storage systems, and, of course, energy efficiency technologies as well.

So, as I add to the national debate, I feel strongly that rather than discussing the sacrifices and costs of getting there, what we really need is a comprehensive, forward-thinking, sustainable energy plan, one with aggressive goals, and a focused commitment to achieve those goals. The real answer lies in transforming our entire energy infrastructure toward a full range of sustainable energy sources – driven by innovation, private-sector investment and a supportive national energy policy. My guess is it won't be much of a sacrifice at all – and may just invigorate our economy!

Thank you …