Innovation with Impact: The Synergy of Science and Applied R&D
A Results-Driven Model for Accelerating New Clean Energy Technology
(Script as prepared)

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I trust you all recognize how relevant energy is to our future. For those of us in the energy field, I would say the work we all are doing is nothing less than pivotal. We are, in fact, at the epicenter of national challenges / national solutions!

Think about it. Middle East turmoil dominates the headlines … and every day the business channels speculate on how each unfolding development will impact a nation that imports nearly 70 percent of its oil: much of it from countries who do not share our economic interests.

Oil prices themselves have risen to more than $110 a barrel, and we're all talking about how energy prices threaten a still-fragile economic recovery.

A disastrous earthquake and a resulting tsunami have wreaked havoc on a nation with the world's third largest economy and one of our largest trading partners. But the story of damage to that nation's energy infrastructure, its nuclear power plants, and the threat to the environment and public health, is overshadowing news of the earthquake itself.

And according to polling, the environmental, economic and political ramifications of an accident at another energy facility – the Gulf oil spill – was the biggest story for all of last year.

For better or worse, energy issues dominate the day's news, and our public dialogue in the United States, and around the world. And it seems the more we focus on energy, we as a nation are coming to understand that we need to fundamentally alter where we get, and how we use, energy.

Transformation

- Need energy system transformation
  - Won't be easy
  - Will take persistence, policy, and priority

And, above all, it will take VISION (with conviction!) of a new energy future

- The VISION needs to include
  - Energy security
  - Economic competitiveness
  - Environmental impacts

} all three

And we'll need a lot of fresh innovation, and entirely new options for clean energy technology, if we are to surmount our myriad energy challenges.

But while there's growing acknowledgement that our energy habits have to change, there's much less agreement about how. The question is: How will we be able to achieve the kind of transformative energy innovation we so obviously, and some would argue, desperately, need?

We have over the years seen progress in developing new energy technology, but too often, advances in energy technology haven't really kept pace with our economic needs, with our national security interests, with our lifestyle imperatives, or with our environmental responsibilities. And, probably most importantly, with an insatiable global demand!

By The Numbers

So, to highlight just how much progress there's been (and to satisfy the skeptics that don't believe renewable are real today), let me give you a few numbers.

In 2010, renewable energy was a $243B market, up from $150B in 2009. This includes China ($55B), Germany ($43B), and the U.S. ($35B).

Installed Global Renewable Energy Capacity in 2010 was 388 GW (includes small hydro) and 980 GW of large hydro. This is about 18.5% of global electricity generation.

At the end of 2010, wind power had increased to 194 GW, up from 17 GW in 2000.

Solar electric was up from 1.9 GW in 2000 to 41 GW at the end of 2010.

In 2009, solar heat accounted for 180 GW_{th}
Of 30 GW_{th}, 80% was in China and 15% was in the EU.

The U.S. is 6th in the world with 3.1 GW of solar PV installed. Germany has 18 GW! In 1995, PV manufacturing was 43%. In 2009, it was less than 6%!

In 2000, there were 3 LEED-certified buildings. In 2010? 8,100 LEED-certified buildings.

But, there are some disturbing trends, as well.

Renewable energy is losing ground relative to global demand. In 1990, renewable energy totaled 19.5% electricity generation; in 2010, it was down to 18.5%! 47% of that demand has been supplied by coal!

That needs to change.

What this is really about is acceleration!

Innovation

And, where I could spend all of my time with you talking about the National energy debate and the lack of an energy policy, and there is plenty to talk about there, today I want to focus on – what I trust we can all agree on is an important part of the solution – and that is innovation!

As someone who's devoted his career to energy R&D, I can tell you that if we are going to be successful, the traditional way we go about energy R&D also needs to change.

For too long we've looked at each step of the innovation process – science, applied research, commercialization, and so on – as different and independent functions … each with their own language, purposes and reward structures.

There have been some great discoveries, with great potential, to be sure. But the benefits from those great ideas are frequently too slow in coming. Or they never mature enough to be deployed at a scale that allows them to really make a difference.

Given the energy challenges we now find before us, we can no longer afford to waste time, or waste promising ideas. We clearly need a unified approach to innovation -- innovation with impact, if you will.

So, let me brag a bit…

The scientists and engineers at my research facility, the U.S. Department of Energy's National Renewable Energy Laboratory, have taken this on as our overarching mission. Fortunately, the history of our Laboratory is ideally suited to this challenge. Over NREL's three decades as the only National Laboratory dedicated solely to renewable energy and energy efficiency, we have conducted the basic science, the R&D and the technology application for solar, biofuels, wind power -- all the major renewable energy systems. In addition, we have conducted the science and technology development for energy efficiency in transportation and the built environment.

And more recently, as clean energy technology has assumed a more central and vital role in our nation's future, we increasingly have taken an active role in working with industry, on commercialization and deployment as well.

As this work has progressed, we've realized that the conventional research model itself may be one of the most significant barriers we faced in getting effective technology into the market.

It's still common today to see each step in technology development as successive and linear: You start with basic science, then move through applied research, then testing and validation, and finally, commercialization and deployment.

In the real world, however, we've found that the technology development process is not linear at all. Science remains fundamental, but it needs to be informed by real-world energy needs, and market realities and business models as well. And, innovation needs to be the driving force at every stage of this process.

The unified, full spectrum research model we've undertaken doesn't just do the science, publish the paper, and then hang a patent on the wall to wait and see if someone, someday, does something with it. We want to become actively engaged not just with the science, but with getting the best innovations to a place where they can be commercialized by the private sector. I like to emphasize that at the core of our mission is to help reduce the investment risk that allows the private sector to take technologies to market.

This means, where needed, we will continue to work on any remaining R&D enablers necessary to see the new technology become a viable product in a competitive market that can truly benefit the nation by helping to meet our pressing energy challenges.

Let me provide some examples of how this full-spectrum approach to research produces results that either would have never occurred, or would have taken years or decades longer.

Solar Photovoltaics (PV) – National Center for Photovoltaics

As home to the National Center for Photovoltaics, NREL has worked on solar PV technology from the infancy of the PV industry. NREL, in fact, was first named the Solar Energy Research Institute when it was first founded in 1977. Over the years, NREL has been a part of virtually every meaningful advance in PV technology, and we've worked directly with virtually every significant player in the solar power field.

That hands-on, direct impact is quite evident in one of the most promising new solar photovoltaic energy technologies, the so-called thin-film technologies known by their elemental materials mix such as cadmium telluride and copper indium gallium diselenide or CIGS. Thin film technologies today are the fastest growing segment of the solar power market. They're seen by many as the best hope to drastically reduce the cost of solar energy, in large part because thin film means very little photovoltaic material is required.

NREL first began working on cadmium-telluride technology when we partnered with researchers at Colorado State University in 1993. Our early science explored the nature of the material, to understand its characteristics and how it could be most effectively formed on a PV panel. Once we understood the potential of cadmium-telluride, we've largely turned our attention to improving the quality of the material as it's deposited on the panel.

That led us to creating a device that achieved the world record in efficiency for cadmium telluride. That device produced 16.7 percent of the sun's energy into electricity – an efficiency significantly higher than the first thin film cells. We also helped improve the material's durability under long-term use, and we've applied for and received three distinct patents for cadmium telluride PV modules along the way.

Today, I'm pleased to report, all those years of effort by NREL, by our university collaborators, and by our private industry partners, is having a significant impact. In addition to First Solar being the largest solar cell manufacturer in the world, there are no less than 15 U.S. CdTe manufacturing companies. One such company, a local start-up, Abound Solar, has constructed a 126,000-square-foot manufacturing plant in Fort Collins, Colorado.

Abound says its new high-speed, large-capacity manufacturing facility will produce modules at well below a $1 a watt. That's not just a huge milestone for the company, and its growing staff of employees and its investors, there are commensurate benefits for the state and national economy as well.

It's also an important step on the road to reaching a key national energy goal – that of producing clean, abundant solar power as cheaply as conventionally produced power on the grid.

And even as commercial production surges ahead, NREL and the Department of Energy solar program continue to play a role so that this break-through technology can realize its potential. We didn't stop at creating the technology itself. The manufacturing techniques that Abound Solar is using to produce solar panels with the new technology were perfected with support from the DOE-NREL PV Technology Incubator Program.

We've also dedicated a section of our solar Process Development and Integration Laboratory to exploring advances in cadmium telluride materials and production.

This laboratory at NREL, which is the most modern solar R&D facility in the world, continues to pursue valuable new insights into semiconductor physics, into creating better, more efficient and less costly materials, into novel new device structures, and into improving manufacturing processes.

Since end results matter most, each one of these steps has been a necessary precursor to all of them finding their way into a commercial product. All this work is continuing through partnerships with universities and industry, with formal research and development contracts, as well as informal information sharing.

All told, NREL's National Center for Photovoltaics has been working with some 75 PV companies. They include Ampulse, a rising up-start – a venture-capital supported firm with a new thin-film technology that could drastically reduce costs and improve PV efficiencies. And they extend all the way to First Solar, the largest PV manufacturer in the United States, which has a decade-long history of working with NREL.

It's all part of not only doing the science, but making sure the science yields tangible benefits – benefits for taxpayers, benefits for consumers, benefits for our economy and environment … benefits for the entire nation.

Biofuels – AFUF, BSCL, IBRF

Another example of this top-to-bottom R&D emersion is our work in next generation biofuels technology. In recent years, as the ethanol industry has grown to produce billions of gallons of fuel from corn, our Laboratory has been focused on new technology that will allow us to make ethanol from non-food feedstocks, like trees, or agricultural residues, or waste products. This cellulosic ethanol technology is destined to revolutionize the way we power our transportation systems, reduce our reliance on imported oil, and provide many environmental and economic benefits over conventional fuels. It is also destined to replace petroleum as feedstock for plastics and synthetics.

Here again, our researchers are helping the nation meet its clean energy goals by not only doing the basic science, but carrying that science through to fruition, so it contributes new understanding, new technologies, new commercial opportunities, and new energy solutions for the country.

And again, we began with cutting edge science to better understand the resource.

Making fuel from the cellulose of a plant is possible, but it's much more complex and, and thus, much more challenging than making fuel from a grain, or a starch, like corn.

So we built an entire laboratory dedicated to exploring the intricacies of cellulose, and how it changes its composition on its way to becoming ethanol, right down to the molecular level. Applying modern computational capabilities allows us to better understand the fundamental properties of biomass materials. Our Biomass Surface Characterization Laboratory uses state-of-the-art instruments like scanning electron microsopes, and the latest laser devices to probe plant material, and the plant-to-fuel conversion process.

The insights we gleaned have helped us refine the process for turning non-food plant material into fuel, using both biochemical, and thermochemical conversion processes. Our work in the biochemical pathway led us to team up with industry leaders Novazymes and Genencor to

develop cheaper and more efficient enzymes to break down cellulose into its usable components.

This public-private partnership was so effective it ended up achieving twice its stated goal. Bottom line: We now have enzymes that are more efficient in breaking cellulose down into fermentable sugars, yet they're 20-times cheaper than those available previously.

On the thermochemical side, our work has helped us envision how a fully functional biorefinery would operate. The goal here is a refinery that would use non-food plant material to not only produce fuel, but also chemical feedstocks and the building blocks for plastics and other synthetic materials – all the products that typically are derived from a conventional petroleum refinery today.

Last year we more than tripled the size of our existing biofuels Process Development Unit pilot plant. Construction of this new Integrated Biorefinery Research Facility allows us to conduct research on multiple feedstocks – like switch grass, corn stover or wood chips – all at the same time. This will enable us to speed up our R&D progress, work simultaneously with more than one commercial entity, and to achieve our program goals sooner.

All of this work has contributed to reducing the modeled cost of cellulosic ethanol from more than $6.50 a gallon, to less than $2 a gallon. And it's helping keep the Department of Energy's national research program on track to meet its goals of making cellulosic ethanol cost-competitive with corn ethanol, and then gasoline, all within the next few years.

And remember, this next-generation ethanol technology has many environmental and carbon-reduction advantages over corn ethanol, and even more advantages over petroleum-based fuels.

Strategic Energy Analysis

In some cases we've found added value in supporting the deployment of new technology in novel ways. We are using our advanced strategic energy analysis capabilities and modeling techniques to show how new clean energy technologies like wind, solar and geothermal can efficiently be deployed onto the electrical grid – at the higher and higher levels of penetration foreseen for the future.

Finance – Commercialization and Deployment

And our efforts reap the benefits of innovation doesn't stop at Laboratory itself. Because financing is an essential component of the technology development process, we launched the NREL Industry Growth Forum. The Industry Growth Forum is the nation's leading program for getting energy technology entrepreneurs together with venture capital firms, to spur investment in clean energy start-ups. Since it began in 1995, participating companies have raised more than $3.4 billion in new capital – the lifeblood they need to bring their technology to market.

Full Spectrum Role

We've shown that this start-to-finish, full spectrum, unified approach to R&D has proven to be the most successful strategy in overcoming the many inherent obstacles to creating major innovation in the nation's energy systems.

Despite this, there is misunderstanding – and perhaps some resistance – toward these new approaches to the traditional pure-science research model. Some reject anything that would compromise full focus and dedication to orthodox science.

There are those also who understand the value of government sponsored research, but contend all government involvement should end once a project leaves the laboratory. In this view, the argument goes the government should be "picking winners and losers," and industry alone should shoulder the burden, and risk, of getting new technology to market.

Though keeping the federal research role well within legal, ethical and common-sense boundaries is essential, the real public benefits we've derived from an applied science, collaborative public-private, unified approach to R&D are undeniable.

Energy Sector is Different

Frankly, our experience has shown energy technology development is different from other fields of R&D. The fact is, energy industries have never invested in the kind of innovation that has always driven, say, the electronics, IT, or pharmaceutical industries. Energy has largely remained a least-cost commodity, where technological improvement either happens slowly, or not at all.

R&D investment by energy industries comprises less than one percent of sales revenues, compared to 10 percent or more for other industries.

At the same time, energy in many ways lies outside the boundaries of what we normally think of as a free-market system. Internationally, consider the giant oil cartels, huge sovereign funds, and a long history of political manipulation around energy resource development. On the home front, electric generation and distribution are highly regulated at the local, state and federal levels.

Given these realities, it's no surprise that simple free market economics haven't produced the energy innovation we need.

And when you consider the unquestionably vital role energy plays in our economy and in our modern lives, you understand why we believe a new model of federal R&D is needed to bring about the energy innovation we so clearly need for our future. The good news is that we can use smart R&D to bring us the innovation we need in the energy sector.

The bad news is that we may be on the verge of making the same mistake we have in the past – a mistake that has cost us dearly in terms of having the clean energy technology we need.

Budgets for R&D

Cuts have been proposed to the R&D programs of the Department of Energy that would devastate wind, solar, biofuels, geothermal, hydrogen, transportation energy efficiency, buildings technology and a host of other promising new technology development programs.

We all need be serious about confronting deficit spending. But cuts that would decimate years of productive research are themselves not prudent. They would be wasteful, because they could set back by years, if not decades, the time when we get to reap the very real benefits of the energy research investments we've already made.

The critical issue before the nation looms as large now as ever: Can we afford to abandon our drive for new, cost effective, clean energy technologies at a time when oil prices have climbed precipitously to $100+ a barrel?

At a time when imported oil accounts for nearly 70 percent of U.S. consumption? At a time when many of the nations on which we depend for oil are reeling under unprecedented political instability and uncertainty?

All of this points to a single overarching question: That is, do we as a nation need the benefits of new energy technology in the near term? Today, tomorrow, or in the next few years? The answer, I would say unequivocally, is that we most certainly do.

Benefit of Applied Energy Science

Indeed, our nation will benefit tremendously if we can move the technologies that have already been developed, do the necessary remaining work it takes to conceptualize those technologies into products and systems, and make certain that those technologies result in commercialized products that can be brought to the marketplace. In fact, there is no shortage of good ideas!

In very real terms, what applied energy science does is reduce the acceptable risk of investing in new technology. So that companies and the venture capital community can have the confidence they need to adequately invest in those new technologies.

The value of this work clearly resonates with the business leaders and investors who have staked their futures on bringing new clean energy technology to the marketplace. Today, our Laboratory is working with more than 350 separate companies, from established industry mainstays, to entrepreneurial start-ups.

Our clean energy R&D portfolio holds the very promise of our energy future, including new technology for cellulosic ethanol, biodiesel, fuels produced from algae, renewably produced hydrogen, solar, wind and geothermal power, new battery and other energy storage systems, and of course, energy efficiency technologies as well.

The companies commercializing each of these technologies work with us because they know what applied energy science through public-private partnerships has accomplished in the past. If you consider the real price for a unit of energy produced, solar, wind, bio-fuel and other renewables today cost anywhere from 70 to 90 percent less than they did when the federal research effort began and our Laboratory was founded in the late 1970s.

And more than three decades later, our work remains very relevant to the issues that confront our nation today.

Closing

If you believe the economic recession and the need for job creation are the most pressing issues we have, then clean energy R&D should be a priority. If you're seeking ways to increase our nation's economic competitiveness, then clean energy research should be on top of your list as well.

If you are looking to strengthen U.S. energy independence, and reduce our reliance on imported oil, and achieve commensurate benefits to national security and improved balance of trade, then here again clean energy research is one of the best policy options we have available to us.

In conclusion, if our nation is to have the energy options we need, we will require major new innovation, achieved through applied energy science working in multiple technology pathways.

Federally sponsored research, often in tandem with industry, can bridge the gap between good ideas and marketable products … so those innovative products arrive with a high probability of commercial success. And in doing so, it offers our best chance for solving our nation's energy problems as well.

Thank you …