

Compete: Energy

Regional Energy Summit Series

Western Energy Summit Accelerating Energy Innovation: Spurring the Development and Commercialization of New Energy Technologies

July 30, 2009



Compete.

Council on
Competitiveness

Energy Security, Innovation & Sustainability Initiative

In 2007, the Council on Competitiveness launched the Energy Security, Innovation & Sustainability (ESIS) Initiative to explore the linkages between the United States' need for greater energy security, the global imperative for environmental sustainability and U.S. economic competitiveness. Through a series of Progressive Dialogues, the ESIS Initiative brought together high-level experts from industry, labor, academe and the policy community to form conclusions and ideas on how to create the enabling conditions will stimulate and accelerate private sector innovation and investment in sustainable energy solutions. Leveraging the insights generated at the Dialogues and the wisdom of the ESIS Initiative Steering Committee, the Council crafted *Prioritize: A 100-Day Energy Action Plan for the 44th President of the United States*. The Council on Competitiveness leadership released *Prioritize* at the National Press Club on September 9, 2008, and it has since had a significant impact in shaping U.S. energy policy and priorities.

In an effort to broaden understanding of the drivers for innovation and investment in sustainable energy solutions, the Council has held a series of four regionally-based energy summits around the United States during the first half of 2009. The Western Energy Summit was the fourth of this series.

Following are highlights and key points captured from the Western Energy Summit at the NASA Ames Research Center in Moffett Field, California, on July 30, 2009.

The Council would like to express its gratitude to: S. Pete Worden, director of NASA Ames Research Center; Mark Yudof, president of the University of California; George Miller, director of Lawrence Livermore National Laboratory; Paul Alivisatos, interim director of Lawrence Berkeley National Laboratory; and Thomas Baruch, founder and managing director of CMEA Capital for co-sponsoring the Western Energy Summit; Shirley Ann Jackson, president of Rensselaer Polytechnic Institute, vice chairman of the Council and co-chair of the Council's ESIS Initiative, for her leadership and vision in conceptualizing the Regional Energy Summit Series; Gary Martin, director, New Ventures and Communications at the NASA Ames Research Center; Bruce Darling, executive vice president at the University of California System; Tomás Díaz de la Rubia, chief research and development officer at Lawrence Livermore National Laboratory; James E. McMahon, head of the Energy Analysis Department at Lawrence Berkeley National Laboratory; Rachael Sheinbein, senior associate at CMEA Capital; and the NASA Ames, University of California, Lawrence Livermore, Lawrence Berkeley, and CMEA Capital teams for their strong support in planning and executing this event.

**Compete: Energy
Regional Energy Summit Series**

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Energy Security, Innovation & Sustainability Initiative Regional Energy Summit Series

●
February 13, 2009
Houston, TX

Clarence P. Cazalot Jr., president and CEO of Marathon Oil Corporation, hosted a regional summit on the path to achieving sustainable energy supplies and the impact of the economic stimulus package on U.S. energy security. This meeting was held in concert with *CERAWeek 2009*, the annual conference that brings executives from around the world together to discuss global energy issues.

●
April 15, 2009
New Brunswick, NJ

Ralph Izzo, chairman, president and CEO of Public Service Enterprise Group; and Richard L. McCormick, president of Rutgers, The State University of New Jersey, co-hosted a regional summit on ways to promote energy efficiency in the utility industry and lessons for the nation that can be learned from the rollout of the Regional Greenhouse Gas Initiative (RGGI).

●
May 13–14, 2009
Chicago, IL

James Owens, chairman and CEO of Caterpillar Inc.; Robert Zimmer, president of The University of Chicago; and Eric Isaacs, director of Argonne National Laboratory, co-hosted a regional summit focused on using the Midwest's unique energy resources and infrastructure to reduce greenhouse gas emissions and improve our nation's energy security.

Compete: Energy

The National Energy Summit & International Dialogue

July 30, 2009
Mountain View, CA

S. Pete Worden, director of NASA Ames Research Center; Mark Yudof, president of the University of California; George Miller, director of Lawrence Livermore National Laboratory; Paul Alivisatos, interim director of Lawrence Berkeley National Laboratory; and Thomas Baruch, founder and managing director of CMEA Capital; co-hosted a regional summit on lessons that can be learned from the successes of California and other western states as front-runners in the development and deployment of sustainable energy technologies.

September 23–24, 2009
Washington, D.C.

The Council will convene its top experts in the energy field and representatives from countries around the world to address the interconnected challenges of energy security, innovation and sustainability. The Council's agenda for change will be rooted in a new relationship between the public and private sectors to deal with a defining challenge of the millennium.



Western Energy Summit Participants List

LEADERSHIP ROUNDTABLE PARTICIPANTS

Thomas R. Baruch

Founder and Managing Director
CMEA Capital

George Blumenthal

Chancellor
University of California, Santa Cruz

C. Wm. Booher, Jr.

Executive Vice President and
Chief Operating Officer
Council on Competitiveness

Lucien Y. Bronicki

Chairman and Chief Technology Officer
Ormat Technologies, Inc.

Steve Cardona

Chief Executive Officer / Managing Partner
Orange County Green Fund

Mike Chrisman

Secretary
California Natural Resources Agency

John Denniston

Partner
Kleiner Perkins Caufield & Byers

Harrison Dillon

President and Chief Technology Officer
Solazyme, Inc.

Robert E. Estill

Vice President, Strategic Planning & Portfolio Management
Marathon Oil Corporation

Marc Edward Gottschalk

Partner
Wilson Sonsini Goodrich & Rosati

Jim Hawley

Senior Vice President, General Counsel & Acting Chief
Executive Officer
TechNet

Alan Hecht

Director, Sustainable Development, Office of Research and
Development
U.S. Environmental Protection Agency

Paul Kimball

President
Sagebrush Capital

Michael Kluse

Director
Pacific Northwest National Laboratory

Steven E. Koonin (Keynote Speaker)

Under Secretary for Science
U.S. Department of Energy

Dave Lazovsky

Founder, President and Chief Executive Officer
Intermolecular, Inc.

George H. Miller

Director
Lawrence Livermore National Laboratory

Arun Majumdar

Director
Environmental Energy, Technologies Division, Lawrence
Berkeley National Laboratory

James Newcomb

Leader, Market and Policy Impact Analysis
National Renewable Energy Laboratory

David Rodgers

Director, Strategic Planning and Analysis
Office of Energy Efficiency and Renewable Energy,
U.S. Department of Energy

John P. Sellidoff

President and Chief Executive Officer
Legrand North America

Alan Shaw

President and Chief Executive Officer
Codexis, Inc.

Les Shephard

Vice President for Energy, Resources and Nonproliferation
Sandia National Laboratories

Harry Sim

Founder and Chief Executive Officer
Cypress Envisystems

Tyler Suiters (Moderator)

Chief Correspondent
Clean Skies News

Richard Swanson

President and Chief Technical Officer
SunPower Corporation

Larry Vanderhoef

Chancellor
University of California, Davis

S. Pete Worden

Director
NASA Ames Research Center

Mark Yudof

President
University of California

EXPERTS WORKSHOP SESSION I—RESEARCH AND DEVELOPMENT IN SUSTAINABLE ENERGY SOLUTIONS

Harry Atwater

Howard Hughes Professor and Professor of Applied
Physics and Materials Science
California Institute of Technology

C. Wm. Booher, Jr.

Executive Vice President and Chief Operating Officer
Council on Competitiveness

Steve Cardona

Chief Executive Officer / Managing Partner
Orange County Green Fund

J. Michael Davis

Associate Laboratory Director, Energy and Environment
Directorate
Pacific Northwest National Laboratory

Julio Friedmann

Leader, Carbon Management Program
Lawrence Livermore National Laboratory

Alan Hecht

Director, Sustainable Development
Office of Research and Development, U.S. Environmental
Protection Agency

Barbara Heydorn

Director, Center for Excellence in Energy
SRI International

John Hogan

Physical Scientist and Consulting Professor
NASA Ames Research Center

Martha Krebs

Executive Director for Energy and Environmental Research
Development
University of California, Davis

Jane Long

Fellow, Center for Global Strategic Research and Principal
Associate Director at Large
Lawrence Livermore National Laboratory

Terry Michalske

Director, Energy Innovation Initiatives
Sandia National Laboratories

James Newcomb

Leader, Market and Policy Impact Analysis
National Renewable Energy Laboratory

Bruce Pasternack (Moderator)

Venture Partner
CMEA Capital

Joshua Raffaelli

Associate
Draper Fisher Jurvetson

Susan Rochford

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David Rodgers

Director, Strategic Planning and Analysis
Office of Energy Efficiency and Renewable Energy,
U.S. Department of Energy

Stephen Selkowitz

Department Head, Building Technologies Department
Lawrence Berkeley National Laboratory

Carl Wood

National Director, Government and Regulatory Affairs
Utility Workers Union of America, AFL-CIO

**EXPERTS WORKSHOP SESSION II-
DEPLOYING SUSTAINABLE ENERGY
SOLUTIONS AT SCALE****Arun Banskota**

Vice President, Business Development
First Solar, Inc.

Josh Becker

General Partner and Co-founder
New Cycle Capital

Marty Brown

Director, Global Energy & Climate Change Program
Pfizer Inc

Steve Cardona

Chief Executive Officer / Managing Partner
Orange County Green Fund

Matthew Frome

Director, Business Development
Solazyme, Inc.

Robert E. Estill

Vice President, Strategic Planning & Portfolio Management
Marathon Oil Corporation

Christine Gulbranson

Director, Advancing Innovation
Ewing Marion Kauffman Foundation

Maurice Gunderson

Senior Partner
CMEA Capital

Thomas C. Halbouty

Vice President and Chief Information Officer
Pioneer Natural Resources Company

Alan Hecht

Director, Sustainable Development
Office of Research and Development
U.S. Environmental Protection Agency

Ted Howes

Sustainability Lead
IDEO

Glen A. Lewis

Energy and Supply Chain Management Advisor, California
Institute of Food & Agriculture Research, University of
California, Davis

James E. McMahon

Head, Energy Analysis Department
Lawrence Berkeley National Laboratory

James Newcomb

Leader, Market and Policy Impact Analysis
National Renewable Energy Laboratory

Bruce Pasternack (Moderator)

Venture Partner
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Christopher Perkins

Chief Executive Officer
Unimodal Systems

Dean Pournaras

Vice President, Marketing,
WattStopper / Legrand

Susan Rochford,

Vice President, Energy and Sustainability Initiatives
Council on Competitiveness

David Rodgers

Director, Strategic Planning and Analysis
Office of Energy Efficiency and Renewable Energy, U.S.
Department of Energy

Carl Wood

National Director, Government and Regulatory Affairs
Utility Workers Union of America, AFL-CIO

Executive Summary

Participants discussed the lessons that could be learned from California's experience as a front-runner in sustainable energy technology development and deployment, as well as the relative roles of the private and public sectors in addressing the conjoined challenges of energy security and sustainability.

A distinguished assembly of corporate chief executives, university presidents, national lab directors and energy experts met on July 30, 2009, at the NASA Ames Research Center in Silicon Valley, for the last in a series of four regionally-based energy Summits held by the Council on Competitiveness under the auspices of the Environmental Security, Innovation & Sustainability Initiative. The Western Summit was co-hosted by the NASA Ames Research Center, CMEA Capital, the University of California, Lawrence Livermore National Laboratory and Lawrence Berkeley National Laboratory.

During his opening remarks, NASA Ames Research Center Director S. Pete Worden set the tone by framing the nation's space program as a catalyst for planetary environmental awareness, and by sharing some of NASA Ames' successes in developing clean energy technologies. Dr. Steven E. Koonin, Under Secretary for Science in the U.S. Department of Energy, gave the keynote address, emphasizing the unique scale of the energy security and sustainability challenge, and the importance of reinvigorating the nation's basic science and energy programs.

Apropos of the location, much of the Summit's plenary discussion focused on technology research and development. Participants generally agreed on the existence of a de facto division of labor among universities, national labs and the private sector,

with the universities focused on basic research, national labs specializing in technology development and private sector firms engaged in applied research projects with relatively short-time horizons. All agreed that government funding was essential for long-term and high-risk projects, and there was a strong consensus in favor of creating institutions that would provide "connective tissue" for researchers working on similar projects at different institutions, such as the Bay Area's Joint BioEnergy Institute. Similarly, participants expressed support for increased public-private research partnerships and the need for greater international collaboration.

There was also considerable discussion of the underappreciated complexity of the joint energy security and sustainability challenge. A number of participants took issue with the "moon shot" and "Manhattan Project" metaphors commonly invoked when discussing the urgent need for solutions. As each pointed out in different ways, the Apollo Program and the Manhattan Project were well-financed government programs designed to produce a handful of technologies for non-commercial use, and for which there were no incumbent competitors. New energy technologies, on the other hand, must compete in the commercial marketplace on price and performance against mature incumbents that operate on a massive scale with an equally massive supportive infrastructure.

In line with this assessment, a number of participants sounded a call for realism when it came to the commercial development of sustainable technologies. Many—including top executives from a few local startups—emphasized the need for robust business models for new market entrants, such as



Western Energy Summit attendees listen to a diverse panel of experts discuss the development of innovative energy technology.

a focus on technologies that are compatible with existing infrastructure or technologies that have multiple commercial applications. Many participants also acknowledged that most clean energy production technologies will require government support as technologies scale up and mature, or until externalities like carbon emissions are fully factored into energy prices. Accordingly, they recommended seeking a sound alignment of federal R&D spending, regulatory and other energy policies, and the capital requirements of private sector investors.

Looking at California's experience, there was at least one clear example where technology, policy and capital successfully aligned: the state's effort to allow utilities to profit from energy-efficiency

activities. But participants pointed out a number of missed opportunities as well, such as the failure to put stronger energy-efficiency codes into place prior to the state's recently completed construction boom. With the issue of policy alignment clearly in mind, a number of participants also spoke to the importance of public education on energy issues—not simply to improve consumer behavior, but to build public support for otherwise politically unpalatable choices.

Western Energy Summit Highlights

Setting the Stage

C. Wm. Booher, Jr.

Council on Competitiveness

The Council's ESIS Initiative began nearly two years ago—after the culmination of our National Innovation Initiative—when we recognized the important role that energy issues were likely to play on American prosperity and the global economy in the 21st century. Today, we are going to discuss ways to improve the energy technology innovation ecosystem all along the research, development and deployment continuum. The goal of this event will be to provide recommendations both for spurring the development of technologies that address the nation's energy and environmental challenges, and for capturing all the associated economic benefits that these innovations can bring to the United States.

Your insights will feed into the Council on Competitiveness National Energy Summit and International Dialogue on September 23 and 24—convening over 250 CEOs, university presidents, government leaders, and labor leaders to catalyze the market, policy and other actions that will be necessary to build a strong, sustainable and competitive energy and climate change agenda for America.

S. Pete Worden

NASA Ames Research Center

During the Apollo 8 mission, Astronaut Bill Anders looked at the Earthrise over the moon and said that, while we came all this way to explore the moon, the most important thing is that we discovered the Earth.

NASA since then has really taken that message to heart. Efficiency, sustainability and renewable energy have been critical elements to all of our human and

robotic explorations—for example, the two rovers we have on Mars: Spirit and Opportunity. They have been there for over five years. They need only an average of 100 watts of energy to keep going. This is an incredible example of power management and integrated renewable systems working in a pretty harsh environment.

We live off the grid when we go to space. We have, I think, today, a full complement of astronauts on board at our International Space Station. They live and work in one of the most sustainable habitats on or off Earth. It costs about \$10,000 a pound to take hardware to space, so we do not have a lot of spares.

In aeronautics, NASA has a long history of technology development for sustainable aircraft systems. Those of you who flew into San Francisco International for this Summit may have come in a “continuous descent landing pattern” that considerably reduces both noise and fuel consumption. This innovation, the development of this pattern, was a NASA-led effort, with many others, to help increase the efficiency of our transport system.

Today, airplanes only produce about 3 or 4 percent of the world's greenhouse gas emissions. However, if the rest of the world starts to travel as much as the people in this room, that will rise to about 50 percent. So we have embarked on a major initiative in NASA to develop low-carbon transport systems.

We are also bringing NASA down to Earth—constructing what we call the first lunar building on Earth using NASA technology to build a 40,000 square foot facility that will be among the greenest in the federal government, exceeding LEED Platinum certification.



Bill Booher, Council on Competitiveness; Tyler Suiters, Clean Skies Network, LLC; and Pete Worden, NASA Ames Research Center.

Tyler Suiters

Clean Skies TV

We are clearly at an intersection between our need for energy and the needs of the environment—never more so than now, as Washington and would-be Washingtonians make the rest of the American public aware. On the campaign trail, President Obama was quick to point out that we use 25 percent of the world's oil and possess only 3 percent of the world's oil reserves. But even the headline of clean energy, which tests extremely well with voters, has its challenges. If you look at the wind sector, out of the top ten wind turbine manufacturers in the world, the United States has exactly one. If you turn to the solar sector, we are falling behind in terms of photovoltaic manufacturing. Some have said that we need to turn our focus to the next generation of solar technology in order to catch up. We have already been surpassed for this generation.

Since Clean Skies News is based in Washington, I thought it might be fitting to begin with a political quote of sorts. Paraphrasing House Majority Leader Steny Hoyer, I hope America will be selling clean technology to China and India—and not the other way around. I believe that is why we are here: to find the answers to make America the world leader in clean energy technology.

Executing an Energy Systems Transformation

David E. Rodgers

U.S. Department of Energy

It is very easy to compare ourselves to others around the world and come out with a negative point of view, “Oh, the poor United States of America. We lost our mojo. We cannot really pull things together, and everybody else has beaten us.” I believe that just the reverse is true.

Folks around the world are looking to the United States—including our national laboratories and our universities—as leaders of the green energy revolution. The technologies that are now so popular in Europe to reduce carbon emissions were invented in the United States. The technologies that, in fact, China may use to out-compete us in silicon solar panels and battery technologies, were invented here.

We have the capacity to move forward. We have the capacity to lead. In order for the United States to lead, we have to do the things that will put us on track to meet the President’s goal for 80 percent reduction of carbon emissions by 2050.

Arun Majumdar

Lawrence Berkeley National Laboratory

We need an industrial revolution in energy technologies. Although we cannot compete with the rest of the world in terms of numbers of people, we can certainly compete in ideas and innovation. The magnitude of the energy technology challenges we confront over the next 10 to 20 years—whether renewable, energy efficiency or carbon capture and storage—are analogous to the invention and discoveries of the airplane, the transistor and the Internet.



Alan D. Hecht, U.S. Environmental Protection Agency.

Alan D. Hecht

U.S. Environmental Protection Agency

Over four decades, successive administrations have emphasized the need for sustainability and secure sources of energy to little avail. It is extremely important to understand why. Three key elements—science and technology, regulation and policy, and green business strategy—must converge.

Robert Estill

Marathon Oil Corporation

Working together is going to be the key for all of us. In terms of this recession and what is going on with energy prices, when energy prices are low, there is no incentive to develop some of these new technologies because the economic return is not there. So government help is necessary in creating a range of incentives.

The Trillion Dollar Question: Financing Energy Innovation

Alan Shaw

Codexis, Inc.

Recent estimates of the cost of getting next generation biofuels to market—just in order to just satisfy the renewable fuels standard—are somewhere between \$50 and \$100 billion. That is a huge amount of capital investment. The capital intensive requirements for clean tech will kill off many innovative companies long before they get a chance to go to market. We are seeing that happening literally as we speak.

So what do we do to protect innovation? I think companies need to look toward consolidation. Sustainability can mean many things in this sector, but businesses themselves needed to be sustainable. We cannot look for a hand out. If the business model does not make sense, the products probably will not get to market.

I also see the role of big oil becoming increasingly important in this sector. Exxon's recent \$600 million investment in bio-based fuels is a step in that direction. The problem is that we are currently going through a kind of musical chairs game in which there are not that many chairs to begin with; and, when those chairs are gone, there will be nowhere left to sit.

I think we have also got to look to the government. Typically, that is the last place I would look. By the time the money come out, it could be too late for a lot of innovative companies. Getting a grant does not always equate to getting a check. It would help to speed up disbursements.

But we need ultimately to look to industry—the big, well-funded oil majors and the large industrial conglomerates—to save this sector and take it to where it should be in solving some of the world's biggest problems.

Thomas R. Baruch

CMEA Capital

We are not going to solve these problems simply by running the printing presses in Washington. We absolutely need to have enlightened economic policies. We need to have tax policies that encourage innovation rather than discourage innovation. Investment in technology alone cannot solve the problem. You need to combine it with enlightened policies that encourage entrepreneurs to take risks and the creation of incentives in order for the markets to furnish the capital required to do what we have to do. I think it is absolutely critical that we do not kill the goose that lays the golden egg.

Venture capital is one asset class that has contributed greatly to the technology and product innovation that has occurred over the past 50 years. Just in terms of order of magnitude, in 2008, venture capital funded companies accounted for \$2.9 trillion of revenues in our economy and over 12 million jobs. The leverage that has been obtained from relatively small investments is huge.

Paul G. Kimball

Sagebrush Capital Holdings, LLC

The concept of raising taxes to pay for future energy infrastructure has been so widely rejected that it has held back a thoughtful discussion of how to solve this problem. We want clean energy, and we want to be able to reduce reliance on foreign sources of energy—pretty simple things. But if you cannot raise taxes or apply some sort of an energy tax, then all of a sudden, the capital requirements of solving those two questions are impossible to square.

George H. Miller

Lawrence Livermore National Laboratory

I think one of the fundamental issues that the country has to come to grips with is: what is the role of government in developing these technologies? As a backdrop, when there were long gas lines in the



Paul G. Kimball, Sagebrush Capital Holdings, LLC.

1970's, our laboratory had probably 30 percent of its science and technology devoted to energy technology sequestration of carbon and underground cold gasification material science. We have essentially lost 30 years because the government, when the gas lines shortened, decided not to invest. So the real issue is the power of the national laboratory system to develop the truly revolutionary technologies that require sustained investments over decades.

Steve Cardona

Orange County Green Fund

I think we are facing a very unique situation right now. There has always been something in the intellectual property, IPO, or commercialization ecosystem called the Valley of Death. Many of us received initial grants from the government but relied on angel and seed capital to become venture capital-ready. For the most part, that has dried up because the folks who have high net worth, who traditionally played that role, have been bludgeoned in both the real estate and stock markets. So the Valley of Death is wider and deeper than it has ever



George H. Miller, Lawrence Livermore National Laboratory.

been. Despite all the monies that the Department of Energy and the government are putting into research, the technologies will languish if there is not a bridge to from research grants to venture capital.

Dave Lazovsky

Intermolecular, Inc.

What is fundamental for companies that are just starting up is to move as quickly as possible to sustainable profitability and to eliminate reliance on outside funding agencies, be they government or venture capital. The key is biting off chunks that are realistic and achievable in terms of driving grounded business models, moving to a structure that is cash-flow positive, and effectively setting your own destiny—not relying on others. That is obviously very challenging. But with the right technology and the right team, and with a clear understanding of the application space that the company is targeting, it can be achieved and should be a priority for any early stage company.

Luncheon Keynote

Energy Innovation in America

Steven E. Koonin

Under Secretary for Science, U.S. Department of Energy

Circumstances today demand radical innovation in this country's energy system. We are importing more than 60 percent of our crude oil: draining our economy of \$600 million each day, and rendering us subject to the actions and fortunes of governments in distant lands. Continuing the conventional burning of fossil fuels imperils the globe by increasing the atmospheric concentration of greenhouse gases.

The Obama Administration has set concrete goals for responding to these challenges. Within a decade, we seek to reduce oil consumption by some 3.5 million barrels a day or about 40 percent of what passenger transport consumes. We seek to reduce greenhouse gas emissions by some 20 percent in 2022, relative to 2005, and by about 80 percent by mid-century.

How can we bring about the required revolution in our energy system? What technologies do we need, and what institutions will best facilitate their development? What policies will be required to hasten the development and deployment of those technologies? What will be the costs? How long will it take, and how can we meet those goals while creating jobs and fostering prosperity?

By now, it is well understood that the commonly invoked silver bullet in energy technologies is just wrong. Our nation has limited resources—whether it is financial, human capital or tolerance for change—and has limited time in which to address the dual challenges of energy security and emissions. And while there is no silver bullet, neither can we let 1000 flowers bloom indiscriminately. We have to assess technologies according to their ability to scale, their economics, their readiness and their technical headroom.



That does not mean we cannot pursue research and development for technologies for the longer term. But we do need to distinguish carefully between what is ready for prime time now and what might be ready in the future. The deployment of ineffective, feel-good technologies is doubly bad in that it creates the illusion of doing something even as it diverts resources from more effective measures.

Our two energy challenges are quite de-coupled. Energy security is almost exclusively about oil for transport, while the bulk of greenhouse gas emissions arise from fossil fuel use for heat and power. It is convenient to talk about those two separately.

Let me start with transportation and energy security. Liquid hydrocarbons are important for transport not because of government regulation but because of their high energy density. It's almost two orders of magnitude more than the best batteries anybody is talking about right now. So, liquid hydrocarbons

are unlikely to disappear from transport anytime soon. Fortunately, engine efficiency can be improved dramatically at low cost using existing technologies like homogeneous charge compression ignition, variable valve timings, selective cylinder deactivation, light weighting. Increasing the CAFE standards will drive the development and deployment of those technologies during the next decade.

To supply energy for transport, biofuels—particularly those from lignocellulose and perhaps algae and thermo-chemical processes—can plausibly be brought to economic cost and commercial scale. That will reduce transportation’s greenhouse footprint and enhance energy security through a diversification of sources. Beyond those steps, there will be electrification of the drive train from mild to full to plug-in hybrids and perhaps, eventually, to all electric vehicles. The pace for that will be driven by advances in electrical storage technologies and reductions in their cost. That is rather difficult to predict.

On the stationary side, about 40 percent of the nation’s energy is consumed in buildings for heat, light or ventilation. Again, there are already many technologies to enable more efficient use of that energy. The cool roofs much in the news are just one example. But the nation is not deploying efficiency measures aggressively—the barriers to this are economic and social.

Urban energy systems are another potential big win. Today, half of the world’s population lives in big cities. By 2030, 70 percent of the population will be similarly situated. Building or retro-fitting cities with careful attention to building design, the integration of residential, commercial and industrial spaces, and transport systems for people, goods and information could, in principle, significantly reduce energy use.

On the stationary supply side, coal provides much of U.S. global and electrical power. It is available. It is where the demand centers are. It is easy to use, and it is inexpensive. It is, therefore, not going

to disappear anytime soon even if it is the most carbon-laden of fossil fuels. If we are going to reduce significantly CO₂ emissions from coal-fired power, we need to demonstrate and deploy at commercial scale carbon capture and storage, both pre and post-combustion. That technology is more than a notion, as all of the above ground elements have been demonstrated but not yet integrated on a commercial scale. The integrity of the below-ground containment is plausible but also remains to be demonstrated. When mature, the technology is expected to have a cost comparable to that of nuclear power.

Natural gas is a better fossil fuel than coal for power. It emits about half the CO₂ per kilowatt hour produced. Fortunately, new, sub-surface access technologies have vastly expanded U.S. natural gas reserves by a factor of four or more. So in my mind, substitution of gas for coal seems a viable and material option.

Hydro-electric power, I was surprised to learn in the last month or two, is also effective for low-emission production, and there are tens of gigawatts of small and medium hydro-power capacity that could be installed in the United States.

Wind power is quite a mature technology that is competitive with fossil fuels at good sites on shore. It is being deployed rapidly and currently constitutes about two percent of US electrical generation—not capacity, but actual kilowatt hours produced. When I started giving talks on energy, the number was about 0.8 percent. It is going up significantly. The number 20 percent was quoted recently as perhaps an intermediate stop to which we can imagine wind power growing, and I would subscribe to that number. It is difficult to see how we could get higher than 20 percent.

Fission currently supplies about 20 percent of the nation’s electricity but has not grown at all in the past two decades. To my mind, it is a proven technology

that produces material amounts of emissions-free power, at competitive economics. If the world is going to address CO₂ emissions seriously, nuclear will almost certainly be a part of the picture. It is not yet without its drawbacks—safety, waste management, non-proliferation concerns—these are all real issues, but I think renewed attention to them on both a national and international scale should reduce concern significantly.

Beyond the near-term menu, there are power technologies that are still maturing in cost and scale. Photovoltaics and enhanced geo-thermal systems are particularly relevant to northern California. Another is concentrated solar thermal power, which is perhaps on the cusp of wide scale deployment.

An important part of our electrical power future is the so-called smart grid. Right now, the power grid that has grown up over almost a century is a patchwork of technologies and regulation. Its modernization is sorely needed to better manage demand, to reduce transmission and distribution losses, to integrate a growing fraction of intermittent renewables, and to enhance reliability and security.

We, who aspire to revolutionize the energy system, have to realize that it is in several ways fundamentally different from other realms that have seen great innovation in the past few decades—IT and biotech, for example. The good news is that the energy use changes in response to technology, economics and policy. The bad news is that it changes slowly on decade-long scales—very different from the few years that characterize Moore's Law.

Energy is perhaps uniquely distinguished by a large and costly infrastructure. A single power plant or one offshore oil field can be a multi-billion dollar investment. There are large amounts of material (coal production is on the order of giga-tons per year around the world) and large numbers of units (150 million passenger cars in the United States,

250 million road vehicles in total). This scale requires large amounts of capital and/or the ability to leverage existing infrastructure.

The second feature of this energy system is its ubiquity—energy-enabling heat, light and mobility is so ubiquitous that we hardly give it a thought. But that very ubiquity generates direct interest from many different players—industry, consumers, governments, NGOs. As those interests are not often aligned, change occurs slowly.

The third feature is one of longevity. The lifetimes of large equipment—from a century for buildings, 50 years for power plants, 20 years for automobiles—make it difficult to effect rapid changes.

Just to give you one example: hybrid vehicles. The Prius was introduced about seven years ago. I think there are right now less than a million Priuses in the world altogether. There are a billion vehicles in the world right now. Change takes a long time.

The need for inter-operability also inhibits change. For example, my former employer, BP, cannot make arbitrary changes in the fuels that it sells because they have to work in all vehicles. Consider that while the carbon problem has decadal to millennial time scales, the infrastructure lifetime is measured in decades. The political cycle is a few years. The business cycle is a quarter of a year, and the news cycle is a day or even less. Society is not very experienced, or, in my opinion, well-suited to managing problems that have this kind of duration.

Finally, the fourth feature of energy that makes it different is one of incumbency. From a consumer point of view, there are already perfectly good ways of providing heat, light and power. Any new technologies that get introduced which will not provide qualitatively new services have to compete on cost and against existing interests.

The idea that we can recreate a Manhattan Project to solve the energy and climate grand challenges is entirely specious. The Manhattan Project was set up to produce a few gadgets for a single customer. It did not have to compete with an existing capability, was carried out in secret and had an almost unconstrained budget. The moon shot had more or less a similar set of caveats.

What lessons do we draw from that discussion? First, there is the lesson that transformation is going to take a long time. For that reason, consistency of purpose, policy, and funding are very important. Second, if we are going to accelerate changes in the energy system, we must better couple basic research with development, demonstration, and deployment. Third, because scale requires large capital and access to existing infrastructures, big corporations will necessarily be involved. Finally, technology alone is not enough. Economic, political and social dimensions are at least as important.

So who is going to do all of this transforming, and how will they work together? To discuss that, I think you really need to understand the differing roles of the various actors—the universities, the national labs, the private sector, and the state and federal governments.

We largely look to the universities for new basic knowledge in science and technology and for training next generation of researchers. However, in my mind, universities have other important roles. They help educate the citizenry. They can be trusted voices in energy matters, both to the public and to the Congress. Perhaps uniquely, they can be centers for the kind of multi-disciplinary thinking that energy transformation requires. It is also worth noting that it is no accident that the great centers of innovation in this country—here in Silicon Valley; Cambridge, Massachusetts; San Diego; and, Austin—have grown up around some of its great universities.

The national laboratories are unique U.S. assets. They can focus research on missions and projects in ways that are not well-suited to universities, and they can construct and operate unique major facilities such as those close by to us. The national labs were born of the nuclear weapons program and have grown since to span basic research, applied research and national security.

Turning now to the for-profit sector, that group of organizations exists to make money. Period. To do otherwise would be irresponsible to the share-holders. Corporations are superb optimizers given the rules of the playing field. This playing field, of course, is set by consumer demand and modulated by government policies and economics. That modulation of the playing field is the most important thing that governments can do to stimulate energy transformation.

Consistent and significant carbon prices, renewable or low-carbon power portfolio standards, and oil production tax regimes are all examples of how governments can determine what the energy future will look like. Beyond setting the rules, the government should support basic science, the development of human capital, and the development and demonstration of pre-competitiveness technologies.

However, it is important to realize that government capital is pretty feeble. For example, BP capital spending a year ago was \$20 billion in one year. That is just about two-thirds of the total budget in the Department of Energy.

In sum, all of the players have current conceptions of their roles that are hard to change, but indeed must change if energy innovation is to proceed at the pace to which we aspire.

Roles and Responsibilities

The Executive Branch: Catalyze Transformation

Steve Koonin

U.S. Department of Energy

The government's role is to set the playing field through regulation, through economics, through the tone of the discussion, and to catalyze with the relatively feeble funds that it has. Twenty-eighty billion dollars in the Department of Energy sounds like a lot of money, but on the scale of what business spends on energy, it is small potatoes. The government really needs to catalyze through technology funding, through human capital, through bringing together partnerships.

Congress: Focus on Goals not Routes

Harrison Dillon

Solazyme, Inc.

Too many times, entrepreneurs are actually blocked from doing something very innovative because the policy from Washington, D.C., is to focus on the route rather than the goal.

For example, if you can take a pile of saw dust, which is made out of cellulose, you can use some technologies to turn it into ethanol. You can use others to turn it into crude oil. You can use others to turn it into, say, other hydrocarbon fuels. What is the right thing to do with that pile of cellulose? The rule of thumb should be: Let us turn that into the best fuel, at the lowest cost, that has the highest energy density, and that is compatible with the existing infrastructure.

Universities: Create the Foundations

George Blumenthal

University of California, Santa Cruz

The role of the university is to do basic research and to educate. We have seen an evolution in terms of basic research. Two to three decades ago, a great



George Blumenthal, University of California, Santa Cruz

deal of basic research was performed in industry laboratories. Bell Labs was one of the great centers of innovative research. But industry has moved into more applied research and left open ground for universities. This is an evolution that we must understand and make use of as we address these grand challenges. The university's second major mission is education—an educated and technically-capable workforce is a critical ingredient in innovation and economic competitiveness.

National Laboratories: Poised to Deploy

George Miller

Lawrence Livermore National Laboratory

The national laboratories have an incredible ability to go from fundamental basic science to a deployed idea very quickly. I think that is what their strength is, and as we have said before, they do it with teams—not only teams of scientists and chemists and physicists and computational scientists, but also engineers and technicians. That is, in fact, truly our unique set of capabilities.



Thomas R. Baruch, CMEA Capital

The Private Sector: Pursue Sound Business Models

Thomas R. Baruch
CMEA Capital

There are better and worse strategies to pursue when it comes to the commercialization of new technologies. For instance, it is absolutely critical to have a sustainable and highly differentiated platform—technologies that can leverage material sciences in a very disruptive way. Without a sustainable differentiated platform, it is impossible for companies to attract the capital they require.

Here in Silicon Valley, we are extremely fortunate to have available to us entrepreneurs who understand the value of highly differentiated platforms. We have almost a bottomless reservoir of highly-skilled, outstanding entrepreneurs—several of whom are with us at this Summit. We just need to continue to be disciplined in the way we approach investments.

Solutions

Partner Globally

Michael Kluse

Pacific Northwest National Laboratory

We have to recognize how complex the challenges are that we face in energy and the fact that these challenges have been long in the making. We have to recognize that, as a country, we cannot solve these problems alone. We have to reach out to our world partners and engage the global R&D community to assemble the needed multi-disciplinary teams and novel public-private partnerships. In particular, I think there is a huge opportunity with respect to China. The whole idea is to bring together the best minds and talents to address these challenges. We must employ collaborative technologies to work across organizational lines and national boundaries.

Educate Policymakers and the Public

Steve Koonin

U.S. Department of Energy

My solution is education about energy. There are so many misconceptions, even among policymakers. We need to educate the policy makers and educate the public to achieve a common recognition of the problems. Without that, making progress is much more difficult.

Richard Swanson

SunPower Corporation

Energy is a funny concept. The public is not very aware of what energy is. We understand the other physical concepts like space and time and weight, but what is energy? I think people viscerally know the difference between gallons of gasoline and miles per gallon, but they do not know the difference between kilowatts and kilowatt hours—and this lack of public understanding trickles up through the entire system. We owe it to the world to start educating people on what energy is, what the issues are, and how we as a global community need to go forward.



Lucien Bronicki, Ormat Technologies, Inc.

Lucien Bronicki

Ormat Technologies, Inc.

A very interesting idea for the mid-term is internships in industry, particularly in power plants. Ormat Technologies has an internship program with the University of Nevada in geothermal power plants. It provides an opportunity for the students, before they pursue a master's degree, to get hands-on experience and hone their problem-solving skills. Incentives for these kinds of internships could be an important tool in getting students ready to work in industry.

Build Connective Tissue

Michael Kluse

Pacific Northwest National Laboratory

I would agree there is tremendous technological capacity. What we need is that connective tissue to bring the best minds and ideas together, and focus them on the various elements of the energy challenge. In fact, the notion of the innovation hubs has begun to evolve around this concept. It has already created a level of dialogue among the national labs that I do not think would have otherwise happened.



James Newcomb, National Renewable Energy Laboratory.

James Newcomb

National Renewable Energy Laboratory

In many ways, the Manhattan Project is exactly the wrong metaphor for clean energy challenges. In that case, the process was government-driven, highly secretive and very closed. The forces that drive innovation in Silicon Valley are exactly the opposite: a combination of technologies, across a very wide spectrum, in a networked environment.

Create Outcome-Based Models

Les E. Shephard

Sandia National Laboratories

The Joint Bioenergy Institute started a couple of years ago through the Office of Science. It is one example of an outcome-focused model. The concept was to bring the very best ideas, capabilities, and intellect from across the region to work on biofuels development. The goal was large-scale deployment and commercialization of lignocellulosic technologies over some specified period of time. The Institute's governing structure looked much like a start-up company—enabling it to look at technology very quickly, and to make

decisions in an accelerated way about which technologies could make significant or sizeable impact—and which could not.

Ensure Infrastructure Compatibility

Harrison Dillon

Solazyme, Inc.

Compatibility with the existing infrastructure is something that needs to be at the forefront of every aspect of energy solutions from laboratory research to small-scale pilots to commercialization. You can succeed in every aspect of technology development, including achieving a competitive price, and still utterly fail because the technology does not fit into the existing infrastructure and there is no funding for a duplicate one. Hydrogen is an example of this.

Align Incentives

Arun Majumdar

Lawrence Berkeley National Laboratory

I think if you look across the whole landscape of energy and alignment, there are many places where the incentives are misaligned. One example is energy efficiency for buildings. That is why you do not see many of the things that could happen. One of the brilliant strokes of innovation policy in California was to enable the utilities to make money by selling less energy. Every dollar invested by the utilities in efficiency measures has generated more than two dollars in savings for customers, while giving utilities an incentive to boost energy efficiency.



Martha Krebs, University of California, Davis and Les E. Shephard, Sandia National Laboratories.

Lessons from California

Martha Krebs

University of California, Davis

I think the most significant difference between California and the federal government in the energy technology space is that California has had a consistent energy policy for the last 35 years, particularly when it comes to energy efficiency. The state de-coupled gross energy sales from utility profits in the 1970s; and, this has enabled utilities to put energy-efficiency incentive programs in place with their customers and allowed them to get a fair rate of return on that investment.

The legislature also empowered the California Energy Commission to put in building and appliance energy performance standards, which are renewed and upgraded every three years. It is very, very different from what has taken place at the federal level.



Marc Edward Gottschalk, Wilson Sonsini Goodrich & Rosati.

Marc Edward Gottschalk

Wilson Sonsini Goodrich & Rosati

We established the Clean Tech Open in 2006, and we have had approximately 200 companies come through as finalists. The companies have raised over \$130 million in venture capital support, and many of the success stories started with an entrepreneur or a scientist who had an idea, who was sitting on the couch, had no idea how he was going to take this idea forward. They came to us. We put them through a training program—our boot camp—on how you start a business, and then we were able to bring in the resources of the national labs, the Department of Energy and our sponsors in the venture capital world.

It has been a very successful model. We have since rolled it out in the in the Pacific Northwest and in the Rocky Mountain region, and we do think it has been very effective in catalyzing the commercial development of a number of innovative technologies.

Mike Chrisman

California Natural Resources Agency

Here in California we have managed to keep per-capital electricity use flat over the last thirty years, even as the population has grown from about 22 million to about 38 million. And it is because of energy efficiency regulations and power plant requirements put in place during the 1970s—standards that have driven technology. In retrospect, then, California has shown that a properly structured regulatory system can make a difference.

Carl Wood

Utility Workers Union of America, AFL-CIO

While there have been many successes, there have also been missed opportunities. One is in the deployment of solar thermal water heating. This is about as low-tech as you can possibly get. It is a technology that has been in existence for a century. You can always improve technologies. But this one is quite ready to go and it has been deployed in this state, around the country and in different parts of the world over many years. And it is proven. If it were deployed in the area where I live in southern California, it could obviate the need for about 40 percent of the natural gas use in the region.

The economics of it are extremely persuasive because the initial capital investment gets paid back in a very short period of time. All that is needed is a public policy that makes initial capital investment available to homeowners—perhaps encumbering the utility bill as a means to securitize the investment. It seems to me it is a no-brainer, but somehow—and I have had discussions about this when I was an Energy Commissioner—although people nodded and agreed with me, the idea never seemed to capture anyone's imagination.



Mike Chrisman, California Natural Resources Agency, and John Denniston, Kleiner Perkins Caufield & Byers.



Thomas R. Baruch, CMEA Capital, and Robert E. Estill, Marathon Oil Corporation.

Another, probably bigger area which the region and the nation are just beginning to address is weatherization and building codes. California does more than any other state in terms of low-income home weatherization, but it really is not enough. And we missed the opportunity of a lifetime during the recent housing boom because we did not have in place strong enough energy efficiency standards for homes. If the strong codes had been in place, we would have a housing stock that was world class.



Jonathan Trent, NASA Ames Research Center; Christopher Perkins, Unimodal, Inc.; Ted Howes, IDEO; James E. McMahon, Lawrence Berkeley National Laboratory; Susan Rochford, Council on Competitiveness; and Bruce Pasternack, CMEA Capital.

About the Council on Competitiveness

WHO WE ARE

The Council's mission is to set an action agenda to drive U.S. competitiveness, productivity and leadership in world markets to raise the standard of living of all Americans.

The Council on Competitiveness is the only group of corporate CEOs, university presidents and labor leaders committed to ensuring the future prosperity of all Americans and enhanced U.S. competitiveness in the global economy through the creation of high-value economic activity in the United States.

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HOW WE OPERATE

The key to U.S. prosperity in a global economy is to develop the most innovative workforce, educational system and businesses that will maintain the United States' position as the global economic leader.

The Council achieves its mission by:

- Identifying and understanding emerging challenges to competitiveness
- Generating new policy ideas and concepts to shape the competitiveness debate
- Forging public and private partnerships to drive consensus
- Galvanizing stakeholders to translate policy into action and change

FOR MORE INFORMATION

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The Council on Competitiveness launched the Energy Security, Innovation & Sustainability (ESIS) Initiative in July 2007 with the firm belief that the crucial role of the private sector demand in driving the way America produces and uses energy has gone largely unrecognized in prior policy initiatives. The ESIS Initiative, which was called for in the Council's 2004 seminal report *Innovate America*, is led by a CEO-level steering committee comprised of approximately 40 chief executives from U.S. industry, academia, government laboratories and organized labor. The distinguished steering committee is led by James W. Owens, chairman and CEO of Caterpillar Inc.; Shirley Ann Jackson, president of Rensselaer Polytechnic Institute; and D. Michael Langford, national president of the Utility Workers Union of America, AFL-CIO. The goal of the Initiative is to enhance U.S. competitiveness and energy security by developing a public-private action agenda to drive private sector demand for sustainable energy solutions and create new markets, industries and jobs. It is underwritten by the U.S. Department of Energy and has benefited from the guidance of more than 200 executive-level energy experts.

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