1825

S. HRG. 110–664

EFFICIENCY: THE HIDDEN SECRET TO SOLVING OUR ENERGY CRISIS

HEARING

BEFORE THE

JOINT ECONOMIC COMMITTEE CONGRESS OF THE UNITED STATES

ONE HUNDRED TENTH CONGRESS

SECOND SESSION

JULY 30, 2008

Printed for the use of the Joint Economic Committee

U.S. GOVERNMENT PRINTING OFFICE

45–011 WASHINGTON : 2008

For sale by the Superintendent of Documents, U.S. Government Printing Office
Internet: bookstore.gpo.gov Phone: toll free (866) 512–1800; DC area (202) 512–1800
Fax: (202) 512–2104 Mail: Stop IDCC, Washington, DC 20402–0001

JOINT ECONOMIC COMMITTEE

[Created pursuant to Sec. 5(a) of Public Law 304, 79th Congress]

SENATE

CHARLES E. SCHUMER, New York, *Chairman*
EDWARD M. KENNEDY, Massachusetts
JEFF BINGAMAN, New Mexico
AMY KLOBUCHAR, Minnesota
ROBERT P. CASEY, JR., Pennsylvania
JIM WEBB, Virginia
SAM BROWNBACK, Kansas
JOHN E. SUNUNU, New Hampshire
JIM DEMINT, South Carolina
ROBERT F. BENNETT, Utah

HOUSE OF REPRESENTATIVES

CAROLYN B. MALONEY, New York, *Vice Chair*
MAURICE D. HINCHEY, New York
BARON P. HILL, Indiana
LORETTA SANCHEZ, California
ELIJAH E. CUMMINGS, Maryland
LLOYD DOGGETT, Texas
JIM SAXTON, New Jersey, *Ranking Minority*
KEVIN BRADY, Texas
PHIL ENGLISH, Pennsylvania
RON PAUL, Texas

MICHAEL LASKAWY, *Executive Director*
CHRISTOPHER J. FRENZE, *Republican Staff Director*

CONTENTS

EFFICIENCY: THE HIDDEN SECRET TO SOLVING OUR ENERGY CRISIS

WEDNESDAY, JANUARY 30, 2008

CONGRESS OF THE UNITED STATES,
JOINT ECONOMIC COMMITTEE,
Washington, DC.

The committee met at 10:00 a.m., in room 106 of the Dirksen Senate Office Building, the Honorable Charles E. Schumer (chairman) presiding.

Senators present: Bingaman, Klobuchar and Brownback.

Representatives present: Maloney and Hinchey.

Staff present: Christina Baumgardner, Tamara Fucile, Nan Gibson, Colleen Healy, Israel Klein, Michael Laskawy, Ted Boll, Chris Frenze, Tyler Kurtz, Gordon Brady, Robert O'Quinn, Jeff Schlagenhauf and Jeff Wrase.

OPENING STATEMENT OF HON. CHARLES E. SCHUMER, CHAIRMAN, A U.S. SENATOR FROM NEW YORK

Chairman Schumer. The hearing will come to order, and I want to apologize to my colleagues, the witnesses, and the audience. I had a bill on the Floor, and I had to speak on it at 10:00, so I apologize for being late.

I want to thank everybody for coming to our Joint Economic Committee hearing on energy efficiency. I want to welcome my colleagues and the Chairman of our Energy Committee, Senator Bingaman, who has shown great interest in this issue, as in all of the energy issues.

Now, of course, everywhere we go—Legion Halls, parades, weddings—the high price of gasoline is one of the very first things people bring up. In a few short months, families from New York to Washington State, will also be struggling to pay their winter heating bills, so it's no wonder that Congress has held 60 hearings on energy policy so far this year, 20 alone in July.

Americans across the country are being squeezed. Middle class families are paying $2,000 more in gasoline costs alone—double what they spent in 2001.

We had a Committee hearing last month to examine whether these high prices were a temporary bubble or a new reality for our economy. At that late June hearing, oil topped $134 a barrel; it's now $122 a barrel. If there's no oil bubble or if prices temporarily decline, as they have, and we put off doing the necessary things we have to do, like investing in efficiency programs and alternative fuels, we'll be even further behind than we are now from breaking our foreign oil dependence.

So, it's clear that demand for energy, especially in rapidly-developing, large countries, like China and India, is on the rise, so the reality is, we need to look beyond quick fixes that will do little for consumers and less to address this energy crisis.

In the long term, we must address the demand side of the energy equation. And while I have supported some targeted drilling in the Gulf of Mexico, I don't believe we can drill our way out of this crisis, and neither do the American people.

According to a recent poll, 76 percent of Americans said we should focus on investing in new energy technologies, renewable fuels, and more efficient vehicles, rather than expanding oil exploration and drilling.

One of the good things that came out of the oil shock of the '70s was the dramatic push for energy conservation. Why don't we do more of that now?

California made tremendous efforts under Governor Jerry Brown, during that time, to reduce consumption, and they are now well below the national average in energy usage per capita. Let me repeat that: California, home of the car, is below average in terms of energy consumption, and that's simply because they did smart conservation measures 30 years ago.

One environmentalist said, "Alternative fuels are the sizzle, but conservation and efficiency is the steak." We're here to have a nice steak dinner at this hearing.

But to some, conservation has the connotation of discomfort—using an extra blanket in the winter, easing up on the air conditioning in the summer—but as our witnesses will discuss, energy efficiency is actually doing more with less.

We'll learn about the most recent state to implement landmark energy efficiency and alternative energy programs, from the Massachusetts Secretary of Energy, Ian Bowles.

But what should we be doing in Washington to address this problem? We should be requiring utilities to achieve 10-percent energy savings each year, by helping their customers with energy efficiency programs, improving energy efficiency in their own distribution systems, or through credit trading.

We need to require states to update their commercial and residential building codes to achieve a 30-percent energy savings by 2015, and 50 percent by 2022, based on the 2006 building code standards. That's an idea that offers big bang for the buck, because buildings consume a great deal of our energy and are very inefficient.

By most statistics, heating and cooling buildings consumes more energy than the gasoline with which we drive our cars, so we're ignoring this whole area, and it's important.

I want to thank Senator Bingaman. In our Democratic energy proposal, some of the things that I've been talking about with building efficiency, he added into his comprehensive plan.

Finally, we should be giving states like Massachusetts the ability to set higher appliance standards, with the proper approval from the Department of Energy, to help the Federal Government and big manufacturers stay ahead of the technology curve.

Another idea that Dan Reicher addresses prominently in his testimony and is long overdue, a reinvigorated and beefed up weather-

ization program to help millions of Americans consume less energy, stay warmer in the winter and cooler in the summer.

Given the recent inability of the Senate to increase funding for the Low-Income Home Energy Assistance Program that we all call LIHEAP, in what is predicted to be a terrible winter heating season, I'm worried that families in New York and around the country will be choosing between heat and food, or between heat and healthcare.

This common-sense investment in reducing energy consumption is an energy hat trick. It helps families to make ends meet, improves our energy security, and strengthens our economy.

The bottom line is, if you don't encourage energy efficiency, if you don't invest in alternative energy, and if you don't tell the big oil companies that they can no longer run energy policy in America, we will not succeed, plain and simple.

Our witnesses today are experts in doing more with less, which is why they will get only 5 minutes to make their opening statements.

[Laughter.]

But also because we have—and even I took 5 minutes and 22 seconds, and I'm not known for brevity.

[The prepared statement of the Honorable Charles E. Schumer appears in the Submissions for the Record on page 26.]

Chairman Schumer. Congresswoman Maloney.

OPENING STATEMENT OF HON. CAROLYN B. MALONEY, VICE CHAIR, A U.S. REPRESENTATIVE FROM NEW YORK

Vice Chair Maloney. Thank you, Chairman Schumer, for holding this hearing to examine the role that efficiency measures can play in our energy strategy.

Three years ago, the Republican-controlled Congress passed energy legislation they said would bring down the cost of gasoline and end our dependence on foreign oil. Instead, the price of gasoline has nearly doubled since then.

Whether it's paying over $4 per gallon for gas or milk, due to soaring fuel costs, Americans are paying a hefty price for the failure of this Administration to pursue a sensible energy strategy over the past seven years of this Administration.

We cannot drill our way out of the problem. Meeting the energy needs of our nation will require a comprehensive strategy for achieving greater efficiency and investing more in renewable fuels.

The Democratic-led Congress has already enacted into law, the first new Fuel Efficiency Standards in over three decades and made an historic commitment to biofuels grown here at home, both of which are reducing consumption and saving families money.

We are building on these steps by encouraging the use of mass transit, and expanding tax incentives for renewable energy to spur American innovation and business investment and create green jobs.

Record energy prices are forcing all of us to rethink the way we live and commute, and companies are also rethinking the way they do business. In short, we all need to think outside the oil barrel.

Today we will hear about the many ways in which families, businesses, and government can work together to achieve greater en-

ergy efficiencies, which Mr. Reicher has noted is perhaps the fastest, cleanest, and cheapest way of addressing our energy challenges.

More flexible workplace policies can also play an important role. A recent survey by the Society of Human Resources Management found that 26 percent of businesses are offering flexible schedules to help employees cope with high gas prices.

Across the nation, local governments are altering work schedules to save energy and cut costs. Utah's Republican Governor, John Huntsman, recently announced that most state employees will be moving to a mandatory four-day work week, to reduce the state's energy consumption, while also providing workers with greater flexibility.

A bill I have coauthored with Senator Kennedy, the Working Families Flexibility Act, would help working families across the country by putting a process in place for employees to request a change in their work schedules, and providing job protection when making that request.

More and more businesses are finding that flexible work schedules and other family-friendly programs are good for the bottom line in terms of reducing turnover and increasing productivity.

What's also coming to light are the ways in which these policies can help companies and families reduce consumption, cut energy costs, and ease traffic congestion.

Our nation's continued prosperity depends on meeting the challenges of our energy needs and bringing relief to American families. Chairman Schumer, again, I thank you for holding this hearing and I look forward to our panelists' testimony. Thank you.

[The prepared statement of the Honorable Carolyn Maloney appears in the Submissions for the Record on page 29.]

Chairman Schumer. Thank you, Vice Chair Maloney. Senator Brownback.

OPENING STATEMENT OF HON. SAM BROWNBACK, A U.S. SENATOR FROM KANSAS

Senator Brownback. Thank you, Mr. Chairman, thank you for holding the hearing, thank you, witnesses, for being here, and I look forward to the testimony.

Mr. Chairman, there is much we can do to improve efficiency, and, doing so, is certainly one part of the equation, using less, but we must address the supply side of the equation, as well. And since this is the Joint Economic Committee, I think it's interesting and appropriate to look at some of the economics of this, as well.

As a nation, we produce barely half the amount of crude oil and about the same amount of natural gas as we did in 1970. Roughly, we consume 25 percent of the world's oil and produce about three percent of it.

According to BEA, in the first quarter of 2008, our imports of petroleum products amounted to $451 billion, on an annualized basis. Tomorrow, when BEA releases its first look at the second quarter GDP, I suspect we'll see an even higher number.

I mention this in terms of GDP, because imports are a subtraction from GDP, and lower GDP, meaning fewer jobs, lower government revenues, and a larger trade deficit. In the first five months

of this calendar year, had we imported one million barrels less, just one million barrels of oil less per day, our trade deficit would have been $14 billion lower over those five months, and our government deficit would have been lower, substantially, as well.

The policy that the other side of the aisle is defending with such zeal, by failing to promote the discovery and drilling and production of additional domestic oil supplies, is sending money and jobs outside the United States by the truckload.

This is wrong and must be stopped. That is what I and my colleagues on this side of the aisle have been fighting so hard for over on the Senate floor. It's time we took action and gave the American people some needed and real relief, and it's time we started acting like the Senate and start voting on these issues.

Let's have some votes on these, and let's move forward with also addressing the supply side and the economic side of this equation.

I want to close by noting that drilling is not the entire answer to the entire question. We need a broad-based approach that continues to encourage the development and use of alternative sources of energy like biofuels, wind, solar, and so on, and using less. But we also have to produce more.

We should require that an increasing share of the vehicles sold in the United States be flexfuel, or alternative fuel vehicles that can run on ethanol, methanol, or gasoline, and any combination.

A tripartisan group of Senators has put forward a bill, and filed an amendment on the Energy Bill as well. But we must also maximize in an environmentally sensitive manner our existing resources so we are not sending all of those petroleum dollars overseas.

To do less would be irresponsible. My colleagues on the other side of the aisle need to recognize quickly that both sides of the equation—supply and demand—must be addressed.

Thank you, Mr. Chairman.

[The prepared statement of Senator Sam Brownback appears in the Submissions for the Record on page 31.]

Chairman Schumer. Thank you, Senator Brownback.

We are now going to go to our witnesses. Because we have votes coming up we are going to try to move the hearing along. It is such an important hearing, and I hope people, my colleagues, will hear about this because it is one of the sort of, as we called the hearing, The Hidden Secret To Solving Our Energy Crisis.

That is only a little hyperbolic. It is still hidden, and it will not solve the energy crisis, but it will do a lot more than a lot of other things. So now let me introduce our witnesses and ask them each to—you can each put your entire statements in the record—to try and keep within that five-minute limit.

Ian Bowles is Secretary of the Executive Office of Environmental Affairs in Massachusetts. He oversees the Commonwealth's six environmental natural resource and energy regulatory agencies, and has nearly 20 years of both public and private-sector experience in the energy and environmental sectors. He served in the Clinton Administration as Associate Director of the White House Council on Environmental Quality.

Dan Reicher is Director of Climate Change and Energy Initiatives for Google.org, the arm of Google devoted to making invest-

ments and advancing policy in the areas of climate change and energy, global development, and global health. He, too, has 20 years of experience in business, government, and nongovernment organizations. When I heard Mr. Reicher lecture on energy efficiency, it sort of blew me away and I have been dedicated to that issue ever since hearing him speak several years ago.

Jonathan Koomey is Professor at Stanford University. He is a project scientist at the Lawrence Berkeley National Laboratory, a consulting professor at Stanford University. For more than 11 years he led the National Laboratories End-Use Forecasting Group which analyzes markets for efficient products and technologies for improving the energy and environmental aspect of these products, and is author or co-author of 8 books and 150 articles.

And Mark P. Mills of ICU Technology is the co-founder and Chairman of that company. He is also a founding partner of Digital Power Capital, served as a technology advisor for Bank of America Securities, and is a co-author of the Huber-Mills Digital Power Report. Under President Reagan he served as staff consultant to the White House Science Office.

Secretary Bowles, your entire statement will be read in the record. You may begin.

STATEMENT OF THE HONORABLE IAN BOWLES, SECRETARY OF ENERGY AND ENVIRONMENTAL AFFAIRS, COMMONWEALTH OF MASSACHUSETTS, BOSTON, MASSACHUSETTS

Mr. Bowles. Thank you, Mr. Chairman, and other Members of the Committee. I am delighted to be here.

My main message to you all is that we have, broadly speaking, built an inefficient delivery system for energy in the United States and we have rewarded utilities predominantly for selling power and not necessarily for meeting the load of their consumer in the least-cost type of way.

We have done a number of things in Massachusetts to address that, and I will give a summary of those and then be happy to take your questions.

Massachusetts has long been a leader in this area. We, like our neighbors in New York and in Connecticut, do not have much in the way of indigenous fossil supply. So for us we have high transportation costs and inherently higher energy costs in our region. That has made some of our efficiency investments relatively cheaper as compared to the price of power than some of our other states.

We are just behind New York and Connecticut as the third most energy efficient state in terms of the economic productivity we get out from each energy unit that is consumed.

We today face the challenge of greenhouse gas emissions, record high fuel prices, and other factors that make now the right time for us to be investing more in energy efficiency. Governor Patrick, I think, has also seen the economic opportunity in clean energy technology and made it a major part of his economic strategy to good effect in Massachusetts.

Historically we have had utility-operated energy efficiency programs that helped consumers with retrofitting their appliances, helped in replacing other equipment that is oftentimes heavy energy users, but historically this has been capped.

We have said you have a certain amount of money each year that you can spend on efficiency that the ratepayers provided, but we have never had a true market where energy efficiency could compete with power generation to figure out who can meet the needs of our consumers in the cheapest way. So it is very simple and a very American concept of having a true energy market where we are trying to figure out what is the least-cost way for our consumers to be able to meet their energy needs.

So some sweeping energy legislation that the Governor signed recently really uncaps sufficiency and puts in place a system, in wonkie terms called "least-cost procurement," where essentially we require the utilities to go out and buy energy efficiency that is cheaper than the marginal cost of buying power.

It is a relatively simple idea that says: Focus on the least-cost solutions.

Our Public Utility Commission has also just issued a broad rate decoupling order that essentially breaks the disincentive the utilities have had. If they get rewarded and their revenues are tied to how much power they sell, their incentive is obviously not to have people use less of it because they get less revenue.

Essentially rate decoupling turns that on its head and said you, the utilities, and our deregulated power market don't own any power generation. They should not have any financial interest in how much they are selling through their wires. They are just in the wires' business.

So essentially rate decoupling severs that link and puts them into the efficiency business. I think it is a very sensible policy driven by cost imperatives.

We have done a variety of other things in Massachusetts that are relevant to these matters. A new building code. Several of the other New England States have done this, and others. We require now greenhouse gas analysis in the context of state environmental review, our version of NEPA in the state, and we require our major developers to go through and analyze their greenhouse gas emissions and look at opportunities to avoid, minimize, and mitigate those emissions in their projects.

We have a far-reaching executive order requiring that any new state buildings be lead-certified plus 20 percent better in terms of energy efficiency, and have been working away in that regard.

In terms of federal policy that is relevant, I would echo the Chairman's remarks about appliance standards. We in New England are I think shortly going to apply for a waiver on furnace efficiency, something provided for in your statute. This is an area to my mind of real federal leadership.

Setting a broad carbon policy for the Nation to my mind would be very helpful. We in Massachusetts, and many other states, have been building systems like the Regional Greenhouse Gas Initiative, but I think we all understand we need a common currency for pricing carbon across our economy. So we encourage you in that area.

Model building codes are really focusing on end-use energy efficiency in buildings.

And then there is an obvious federal role in the technology piece as well, here, and major economic opportunity for the Nation.

Acknowledging the comments made by Senator Brownback, I am happy to talk some about how supply matters in Massachusetts as well. My main point for you all is that there are cheap efficiencies that we should be getting simply by aligning the incentives on our utilities in a smart way that focuses on cost.

Thank you all very much.

[The prepared statement of Ian Bowles appears in the Submissions for the Record on page 33.]

Chairman Schumer. Thank you, Secretary Bowles.

Mr. Reicher.

STATEMENT OF THE HONORABLE DAN REICHER, DIRECTOR, CLIMATE AND ENERGY INITIATIVES, GOOGLE.ORG, MOUNTAIN VIEW, CALIFORNIA

Mr. Reicher. Mr. Chairman, Vice Chair, Ranking Members, thank you for the opportunity to testify.

Chairman Schumer. If you could turn on your mike, please, sir?

Mr. Reicher. Thank you for the opportunity to testify.

To meet the critical challenges of the 21st Century, climate change, energy security, and economic development, we need a bold new vision for how America generates and uses electricity.

The core of that vision must be an electricity system that is clean, efficient, reliable, and secure; one that enables hundreds of thousands of megawatts of green power, millions of plug-in vehicles, and tens of millions of energy-smart homes and businesses.

Dramatically increased energy efficiency is fundamental. By many measures, it is our fastest, cheapest, and cleanest opportunity to address our energy challenges, the real low-hanging fruit in our economy.

From cars and homes to factories and offices we know how to cost-effectively deliver vast quantities of energy savings today.

In the 1970s and 1980s we were asked to do less with less, to lower the thermostat, turn off the lights, don a sweater, and leave the car in the garage. Energy efficiency takes a different approach, offering the opportunity to do more with less, to use energy more productively.

As one energy expert colorfully puts it, all people want is cold beer and hot showers. We are interested in the results of energy use, not the energy itself. How much energy we use to cool the beer and heat the water is a choice we make.

According to a 2007 study by McKinsey, efficiency opportunities could keep global energy demand growth at less than one percent per year, or less than half of what is projected to 2020. This would cut global demand by the equivalent of 64 million barrels of oil per day, or almost 150 percent of today's energy U.S. energy consumption.

A new McKinsey study makes clear the attractive benefits of investments in efficiency. Additional global investment of $170 billion annually for the next 13 years would be sufficient to cut projected global demand by at least half.

These investments would have an annual average rate of return of 17 percent and would generate annual energy savings ramping up to $900 billion per year by 2020. And they would deliver up to

half of the reduction in global greenhouse gases required to cap long-term atmospheric concentrations.

Capturing this vast potential, however, will require a significant policy push. Aggressive federal policy can increase investment in energy efficiency.

In my written testimony I outline a number of promising approaches. Let me briefly highlight four:

First is automobile fuel efficiency. Congress's recent boost in CAFE is a good step, but we can do better. Existing technologies, hybrid electric drives, drive-train improvements, lightweight materials, can today get us to roughly double the mileage of our current passenger fleet.

An exciting technological development is the recent emergency of plug-in hybrids which connect to the electric grid for recharging. Charged at night, they can use lower-cost and cleaner off-peak electricity. Plugged in during the day, they can send power back to the grid to meet peak demand.

Google.org has converted several regular hybrids to plug-ins. In a recent test, our plug-ins achieved as much as 93 miles per gallon on average for all trips, and 115 miles per gallon for city trips.

In June we cohosted a conference with Brookings to explore how government can help accelerate their commercialization. At a minimum we need to increase funding for federal R&D, invest in the electricity infrastructure to support hybrid plug-ins, modernize our regulatory system to permit real-time pricing of power, and provide incentives such as federal tax credits.

The second important federal policy is an energy efficiency resource standard. The EERS sets efficiency resource targets for electricity and gas suppliers over a given period of time, building on policies in nine states.

Texas utilities, for example, now meet a specified percentage of their load growth needs through efficiency programs. The EERS is a compelling complement to a national renewable portfolio standard.

Last year the House adopted a combined RPS/EERS that allowed up to 4 percent of a 15 percent national renewable mandate to be met through energy efficiency. Congress should give strong consideration to this combined approach.

Mr. Chairman, the third policy I want to highlight is low-income home weatherization. Across the Nation low-income families this winter will increasingly face the choice between heating and eating.

Congress continues to debate the traditional fix, LIHEAP, an absolutely critical but in no way sufficient answer to this problem. What we need is home weatherization. By upgrading a home's furnace, sealing leaky ducts, fixing windows, and adding insulation, we can cut energy bills by 20 to 40 percent in winter and summer and save even more with efficient appliances and lighting.

Unfortunately, our national policies have failed to recognize the benefits of low-income weatherization. While the Nation has weatherized about 6 million low-income homes since 1976, more than 28 million remain eligible. Congress should make a national commitment to weatherize at least 1 million low-income homes each year for the next decade.

The price tag for retrofitting 10 million low-income homes is relatively modest, about $2 billion annually, with the added benefit of major greenhouse gas reductions and jobs.

Finally, government-backed financial mechanisms could significantly increase the deployment of clean energy technologies, including energy efficiency. Senator Bingaman's recent bill would encourage banks to make loans for clean-energy projects by providing a secondary market for their loans.

Senator Domenici's bill creates a clean-energy investment bank with authority to invest in eligible clean-energy projects using a variety of financial tools.

In a recent hearing, I urged both Senators to integrate the best of their bills to take clean energy to scale.

In conclusion, the Federal Government has a significant role to play in increasing investment in energy efficiency. By adopting a forward-thinking set of policies, Congress can stimulate significant near-term investment in energy efficiency with major economic, environmental, and security benefits.

Thank you.

[The prepared statement of Dan Reicher appears in the Submissions for the Record on page 48.]

Chairman Schumer. Thank you, Mr. Reicher.

Dr. Koomey.

STATEMENT OF DR. JONATHAN KOOMEY, PROFESSOR, STANFORD UNIVERSITY, STANFORD, CALIFORNIA

Dr. Koomey. Thank you, Mr. Chairman, and to the other members of the Committee for the opportunity to share my views with you today. To keep the lawyers happy I have to say that this testimony represents my professional opinion, not that of the Department of Energy or the Lawrence Berkeley National Laboratory.

So as Dan mentioned, one of the most important lessons of the past few decades in energy policy is that improving energy efficiency is the fastest, cheapest, cleanest way to address the problems of energy security and climate risks.

Energy supply technologies will also no doubt play an important role in dealing with these problems, but the history is clear. Energy efficiency is the most abundant and least expensive of all the options was have.

So how can we best capture that resource? Now some have called for an Apollo Project for energy technologies, but I think a better analogy would be the broader U.S. response after the Soviet Union launched Sputnik.

That means broad societal mobilization, massive investments in science and engineering education, substantial increases in basic and applied research and development, and implementation efforts on the scale of the Apollo Project.

Now for energy efficiency that means more energy efficiency standards, that means Energy Star labeling, utility programs, revenue-neutral fee baits, tax credits, prizes like the automotive X Prize, business plan competitions like the California Clean Tech Open, institutional commitments to efficiency goals as Dan mentioned, institutional procurement of efficient products; more fund-

ing for education and training; and big increases in energy R&D funding, which has fallen to historical lows since the 1970s.

But we need more than just technological innovation. People and institutions also need to evolve to meet the new challenges with the overarching goal of breaking down barriers to efficiency and making the more efficient choice always the more profitable choice.

So I am going to give you an example from some recent work I have been doing in data centers. These are the high density computing facilities that power the internet and that help virtually all modern companies to operate efficiently.

What you find in these facilities is that typically the people who buy the computers have one budget and the people who buy the electricity and supply the cooling to the computers have a separate budget.

And so the people who buy the computers do not have an incentive to spend even an additional dollar for a more efficient server because the savings accrue and the savings are substantial—typically $5 or $10 for every $1 spent on a server for efficiency—the savings are substantial, and yet they accrue in someone else's budget.

So the IT folks just will not buy a more efficient server. So that is an example—I have others that we can talk about in the question period—that is an example of the kind of institutional issues that are surmountable, but we need to figure out how to solve these problems more effectively and more broadly. Keep in mind that these are the most mission-critical, the most sophisticated, the most carefully designed facilities in business today. And even in these facilities we see these kind of misplaced incentives.

That to me means that it is likely these misplaced incentives are pervasive throughout the economy.

Great challenge also means great opportunity. The U.S. has the chance to set a new course, one that combines economic benefits with improvements in environmental quality. Now is the time, with oil prices near record highs, and the climate crisis bearing relentlessly down upon us, to make that new future a reality.

My testimony, submitted for the record, describes some specific ideas for how to take up that challenge. Thank you again for the opportunity to present today.

[The prepared statement of Dr. Jonathan Koomey appears in the Submissions for the Record on page 60.]

Chairman Schumer. Thank you, Dr. Koomey.

Mr. Mills.

STATEMENT OF MARK P. MILLS, PARTNER, DIGITAL POWER CAPITAL (AN AFFILIATE OF WEXFORD CAPITAL L.L.C.), ARLINGTON, VIRGINIA

Mr. Mills. Thank you, Mr. Chairman, members of the Committee, for the opportunity to present some thoughts, high-level thoughts in my case, on the role of energy efficiency in the U.S. economy.

I think history will record that we are today on the cusp of an energy revolution, one involving efficiency, with implications as deep and far-reaching as the industrial and the electric revolutions of the previous two centuries.

Each of these previous pivots in history was similarly anchored in profound changes in the efficiency with which we could use basic resources, and energy resources in particular.

The emerging efficiency revolution derives directly from our Nation's collective investment of trillions of dollars in the intellectual capital and infrastructure of the Silicon and digital economy. It is not a single device or program or a solution, but the emergency of an entirely new structural approach to energy efficiency—what I would call a hybrid energy economy.

The nature and implications of this paradigm shift are epitomized by the hybrid electric car which some of the other witnesses have talked about.

Conventional cars waste gasoline. Stop and go, coasting, running, unnecessary stops, and generally operating an engine suboptimally.

You could do manually much of what a hybrid car does automatically, though it would be rather annoying. You would turn the engine off every time you do not need it. At every stop, when you are braking, when you are coasting. You restart it to accelerate, or cruise.

This kind of behavior would increase urban fuel economy 10 to 50 percent, or you could hybridize the car, which is to wrap the engine, and the drive shaft with sensors, power electronics, electric motors, batteries, microprocessors, software, and high-speed communications, in short all of the stuff of the digital economy, and then you let all that digital stuff seamlessly and invisibly juggle the on/off and optimally operate the constellation of energy-consuming components in real time, reacting to dynamic conditions in ways you could never accomplish manually.

Nearly everything in our economy operates like today's cars—suboptimally. Building and running things in the physical world is difficult to do optimally. Cars in fact are the simplest things to fix in this regard, much simpler than factories, offices, and homes.

Yet, the latter collectively consumes 70 percent of all of our energy suboptimally. The technologies that enable a hybrid economy arrive first to serve the information markets—the data, voice, video. They came first, to put it simplistically, because data doesn't weigh anything. So pure information devices just need milliwatts or watts.

To move tons of stuff, and people, and materials, you need kilowatts and terawatts. This is a much more difficult task and took longer to do.

The emerging hybrid economy takes America to the next quantum leap beyond automation, or supply chain management, or such things as telecommuting and e-commerce. All those energy saving systems are of course important, but they are just building blocks to the deeper hybrid economy phenomena that I am describing.

Over the past 50 years the 20th Century's technology has doubled the overall efficiency of the U.S. economy. This has allowed the GDP to increase six-fold with a comparatively modest two-and-a-half-fold increase in our energy consumption.

The hybrid economy can do this and much more in the future. One thing to keep in mind is that radical improvements in energy efficiency produce unexpected and, by and large, beneficial outcomes.

I mean, Energy efficiency—two specific examples from one of our witnesses today of course is what made Google possible, one made Apple possible. Operating at the energy efficiency of the first computer as a single Google Data Center would consume the entire electricity supply of New York City.

At the efficiency of early radios, iPhones would be the size of trunks and served by cell towers the size of the Washington Monument.

Instead, today we have staggering improvements in computing and information energy efficiency and there are consequently thousands of data centers and billions of computers and cell phones. Both have become ubiquitous industries of their own with vast, sprawling, and productive infrastructures.

There is every reason to believe that more of the same of this is in store with the next wave of efficient technologies emerging in what I would call the hybrid energy economy.

But much of it is unpredictable in both direction and form. It is because efficiency, like its economic cousin labor productivity, arises primarily from technology progress that the challenge—this is an old challenge for the Congress and for States—the challenge is to find ways to incentivize and accelerate innovative technology.

How do we encourage markets to adopt near-term innovation and invest in enabling long-term infrastructure? I would suggest in both cases money is the most powerful tool.

In the short term, high-cost energy does accelerate near-term capital investment in more efficient technologies. In the long term, however, this is where federal funding has a central role in basic R&D that is essential to fuel the next cycle of innovation, and frankly to educate the emerging class of energy innovators.

Thank you, Mr. Chairman, members of the Committee, for the opportunity to present these thoughts.

[The prepared statement of Mr. Mills appears in the Submissions for the Record on page 82.]

Chairman Schumer. Thank you, Mr. Mills.

I want to thank all four of our witnesses for excellent testimony. I am going to yield my time to Chairman Bingaman to ask questions, and then I will have to step out for a minute and Vice Chair Maloney will continue the hearing. I will be back to ask questions at the end rather than at the beginning. Thank you.

Chairman Bingaman.

Senator Bingaman. Thank you very much, Mr. Chairman, for having this hearing, and thanks to all the excellent witnesses.

One of the obvious points I guess for people who have looked at this efficiency issue is that we need to get the right information to the people who are making decisions at every stage, or in every part of our economy in order to get maximum efficiency in the system.

We have a proposal in an amendment that I have offered related to energy on the speculation bill that is currently pending in the Senate to establish a requirement that all vehicles beginning in 2012 have a fuel economy monitoring device put on them, similar to what you see when you drive a Prius.

A very similar concept is the smart metering idea with regard to electricity that allows people to know how much electricity they are using at any particular time.

I guess, Dr. Koomey, let me start with you. Another example of one of the issues you were pointing to there about the incentives being in the wrong place, the people deciding which computer to buy didn't have any incentive to buy an energy-efficient computer. Another example which is pretty clear is the Coca-Cola and the various companies that put in these vending machines in federal buildings, or any building, who have very little interest in how much energy they use because there is no savings to them, obviously. They just plug it into the wall and the landlord pays the bill.

Do you have any additional insights you could give us as to how we get this information to people in a way that allows them to make the right decision, Dr. Koomey?

Dr. Koomey. Thank you, Senator. You raised one of my favorite examples in the vending machine. Another example is the cable box. The cable company buys the cable box and you pay the electric bill to warm your cat and do other important tasks.

So the question you ask relates to information. My initial response is: Information is important when the people who are able to make the decision can take that information and use the skills that they have to come to the right decision.

But in many cases these choices are small choices. So the choice of how much electricity your cable box uses, that is a difficult thing for an ordinary person to investigate. So we have to think a little bit about the transaction costs associated with getting people to do the calculation.

Maybe it does not make sense to have the customer do the calculation. Maybe it makes sense to have an Energy Star label where EPA and the Department of Energy did the calculation once already, and then all the customer needs to do is find the Energy Star label. Or to have an energy efficiency standard, again.

So I think information is very important, but in some cases I want to emphasize that sometimes the transaction costs aren't worth it for individuals to do these kinds of calculations. There are other tools we can bring to bear to solve the problem.

Senator Bingaman. You also had a comment in your written testimony about how we ought to consider directing FERC to tell us how to go about promoting standardized electronic formats for utility rates. Could you elaborate on that a little bit?

Dr. Koomey. So one of the problems that big companies face is that they have facilities in many different states. And the utility rates for companies particularly are very complicated. So there's Demand Charges, and Electric Charges, and they vary by time of day. Unfortunately, most of these rates are only published on paper nowadays.

So it is very hard for a company to do the comparisons they need to do to choose to use energy efficiently. The proposal I made in the testimony was to standardize those formats for the electronic rates, and have that standardization help companies like Google design web tools to help these big companies, as well as small consumers, to compare rates and make the most efficient choice for them.

So this is again use of information technology, as Mr. Mills pointed out, use of information technology to do our energy sums more carefully and come to the more efficient conclusion at the end of the day.

Senator Bingaman. Secretary Bowles, did you try to address any of these issues in the recent legislation you adopted in Massachusetts?

Mr. Bowles. Senator, we did to a degree. Just for your backdrop, we have in Massachusetts a very high penetration of real-time meter and real-time pricing of power in the industrial and commercial areas where peak power is ten times or more, sometimes much more than that, more expensive than baseload power. And so companies can get tremendous economics by moving their load around and avoiding the peak hours.

They do that, and they have responded well. What we have not seen in our deregulated power market in New England is really penetration into the retail level. Whereas we have consumers who have figured out cell phones—you know, we need to buy 500 minutes to 1000—we do not have those products available in the retail market, in part because the competitive energy suppliers just have not seen enough profit potential in that area to really get into that market.

So one of the barriers is cheap real-time meters. I think that is an area where the Federal Government could intervene, to my mind, helpfully.

In direct answer to your question, yes, the Legislature created a pilot program that will get at some of this. Our utilities, many of them, have somewhat smart meters for the purposes of service efficiency, but they aren't in the dynamic pricing business yet.

So the energy legislation takes a step in that regard, but it has not been one of the lowest hanging fruit for us as yet in terms of cost.

Senator Bingaman. Thank you very much, Mr. Chairman.

Mr. Hinchey [presiding]. Senator Bingaman, thank you. Senator Brownback.

Senator Brownback. Thank you very much, Mr. Chairman, appreciate that.

What is the Automotive X Prize, Dr. Koomey, that you were talking about?

Dr. Koomey. So the original X Prize was for space travel.

Senator Brownback. Right.

Dr. Koomey. It was a prize of I think $100 million for the first——

Senator Brownback. It was $10 million to get up to space twice within two weeks.

Dr. Koomey. Okay. So the Automotive X Prize is a similar sort of idea. So it's a large amount of money that is given for automobiles that reach a certain efficiency target. So it's not standard——

Senator Brownback. It has not been set yet? It is something that you're advocating for?

Dr. Koomey. No, it's something that—the same group that did the X Prize for Space is also doing this for Automotive——

Senator Brownback. And do you have specifics on this?

Dr. Koomey. I do not know the details on this, but the general idea is that having these kinds of prizes stimulates innovation because it gets many different teams of engineers to focus on solving the problem.

Senator Brownback. I agree. I agree. It is just that is the first I had heard about it, so I was curious about the specifics on it and I wanted to see if we could do more with that. Because I find a lot of people, as I am out traveling around or doing town hall meetings, everybody is talking about what they are doing.

I was talking about a bio diesel the other day on the phone at the airport and a guy behind me is listening and said, hey, I have got a conversion system to take old vegetable oil. I'm doing this. And I was on a town hall meeting last night and this guy called in and he said: You know, if you guys would just license us to drive golf carts around our little town here, I am already plugging it in. You know, if we can get up to—it goes everywhere I need to go.

And I thought, well, that is kind of an interesting idea in a small-town setting. I hope somebody is thinking about doing that. It is just interesting, the innovation that you are seeing and that the high prices do stimulate to take place.

This would be I think a good one. I am hoping in the future we are going to have a plug-in hybrid flexfuel vehicle that will be the standard model. So you plug it in, do 20 or 30 miles on electricity; it switches over to hybrid, it can do flexfuel, it can run on ethanol, methanol, gasoline, or any combination thereof, and that is existing technology that we could do and really stretch a gallon of gasoline a long ways.

Mr. Mills, I guess that is really along your line of a hybrid energy economy, which I find very exciting. From a State like mine with a lot of wind sources, a lot of agricultural sources, we look at this as okay now this is a chance that we can really produce in this economy.

Let me ask you, though. You seem to premise your basis on the key here is to create an investment strategy to do this. Am I catching that right, or not?

Mr. Mills. The key is to understand how we can accelerate capital turnover to new technologies. In a sense it is an investment strategy. Businesses will buy more efficient equipment when it is in their interest because most of them, in my experience, are aware of what it costs them to do things, and particularly these days where they are buying electricity or oil.

But equipment has sunk costs. It still works well. There's no capital in it if it's fully depreciated. So having a decision internally to move to the next generation of technology, whether you are a manufacturing plant, a commercial building, is generally literally an investment decision for the operator.

Senator Brownback. We stimulate that here from tax policy, tax credits——

Mr. Mills. Accelerated depreciation.

Senator Brownback [continuing]. Subsidization, accelerated depreciation, research R&D would be the primary route forward?

Mr. Mills. The latter would help long-term technology. I think one area where probably the whole panel agrees is it is important

to stimulate long-term R&D, which is predominantly a federal role typically in the long-term science engineering.

But that does not do much for us today, obviously, to get businesses to change their behavior. Like consumers, you have to decide to buy a new car. The car you have may be fully paid for, and you have got zero capital, additional capital cost in that even though it is inefficient.

Senator Brownback. That is where I think we ought to go. I read a paper on this one time and it talked about the three waves of, really, environmental concern, the first wave being conservation, the second wave being regulation, and the third wave being an investment strategy.

It sure strikes me that that is the way we could all agree upon to move on forward with, is that you incentivize the investment in this. It makes sense for the economy. It makes sense for the ecology. And it is primarily focused on the energy end of the equation, which I think would be critical.

One final question, if I could get it in here, is there is a lot of talk about diffusing energy sourcing. So you have energy, instead of from big power plants, but in addition to big power plants you go to diffusing the energy.

What do you think of that (a);(b) if you can do it quickly, how would you incentivize that?

Mr. Mills. Usually for price mechanisms—you're talking about distributed energy where there are lots of small power plants? We make lots of small power plants already. That's our cars. We make millions and millions of them a year. They are power plants. They can make electricity.

The distributed energy market is bigger globally in developing economies largely because they do not have the economies of scale that we have.

On average it is cheaper to make energy centrally, but in a high-cost environment there are a lot of folks who will look at distributed generation. Rooftop solar can make more sense than utility solar because you are paying for high cost at the point of use as opposed to competing with a very cheap power at the point of generation.

So there is certainly room for it. In fact I think we will have not much choice as a matter of fact.

Mr. Hinchey. Mr. Bowles.

Mr. Bowles. I just wanted to comment on your question, Senator Brownback, about distributed power. It goes back to the rate structure point I was making, again that in our system prior to rate decoupling the utilities had had every reason not to want to have that distributed power because their revenue is tied to the power that flows through their wire to your home.

So if you did a big solar array, then they just lose money. So that is part of the point of, to my mind, the simple things we can do to have the utilities be in the wires business and indifferent to whether or not you do solar in your home, or someone does a combined heat and power unit in a commercial development. I think that is an important part of the puzzle.

Senator Brownback. Thank you, Chairman.

Mr. Hinchey. Senator Klobuchar.

Senator Klobuchar. Thank you very much, Mr. Chairman. Thank you to our witnesses. I am sorry I was late. We were trying to get those energy tax extenders done, as well as some other things in the transportation area.

I think you all know I come from the State of Minnesota where we believe in science and the potential for new technology. We have brought the world everything from the Post-It Note to the Pacemaker.

We are also very advanced in what we are doing with energy. We have one of the most aggressive energy portfolio, renewable energy portfolio standards in the country with the 25 percent goal with renewable electricity by 2025.

We also have some interesting things with Best Buy and Super Value and some of our other major companies that are working in the energy area.

My question first is this idea of the energy efficiency in the homes. I have noticed, especially Mr. Reicher, if you could answer this first, that there is just much more interest in our state now. It is no longer Jimmy Carter going on the TV in a sweater talking about, in a glum face, what is going to happen.

We have a number of loan programs in our state. We have one for up to $10,000 you can get a loan to update your homes. But there is really a low usage rate of this program because people have to initiate it on their own.

Could you talk a little bit about incentives, and anyone else can join in, for home owners to make improvements and how we could better get them involved in this? Because I see this as part of the key. It is no longer just an environmental issue; to them it is an economic issue. And if they could get those meters on their washers and dryers and figure out how to do it so they could get the information, I think we would be a lot better off.

Mr. Reicher. It is a great opportunity. Home energy use, building energy use, is a very significant percentage of our overall energy use, and we have great opportunities to reduce it dramatically.

Obviously we have financial incentives right now with higher energy prices, but that does not get us all that we need. I think there is a variety of things.

First we have to give people better information. This once a month paper energy bill we get from our utility just does not do it. Most people do not understand it. They do not know how to——

Senator Klobuchar. Like me.

[Laughter.]

Mr. Reicher. Yes.

Senator Klobuchar. Okay.

Mr. Reicher. And so that is the place to start, is just giving people better information. And that starts with a home energy audit, which is available increasingly from utilities and from other providers.

You can go in and get a very good baseline assessment of what is going on in your house. We even have advanced technologies now to do that. You can use something called a Blower Door Test which pressurizes the house and, with an infrared monitor, you can find everything down to the size of a pin hole in terms of leaks.

With that you really understand where to go. So that is the first thing is just setting a baseline so people understand.

Giving them access to real-time information about their energy use. As we say, let's give them a speedometer, not an odometer. Let's give them actual real-time usage as you have increasingly in automobiles. If we had that for our homes, if you knew at any given moment that your child was up there in the second-floor bedroom and somehow lots of things were on that did not need to be on, you could make some adjustments.

Even better——

Senator Klobuchar. So how much would it cost to buy these things? Would regular people be able to buy them? Would we sell them at places like Best Buy? Or would the government give some kind of deal to get them so that we could get people going on this? That is what I am trying to figure out.

Mr. Reicher. Yes, there are lots of approaches, but one of the most significant—and I think one that has potentially the greatest impact—are what we call smart meters. You replace your simple dome electric and gas meters with something that has two-way information, can talk to the utility, can send information to the consumer on a real-time basis that you get in your laptop.

We have many utilities now in the United States which have committed to putting in smart meters. Southern California Edison is going to be installing over 5 million. And that is the sort of thing that really gets people going.

In terms of Federal incentives, tax credits both to industry and utilities and to homeowners for installing this kind of equipment could help a great deal.

Real-time pricing, so that there is some incentive for example to wash your clothes and dry them at night instead of during the day. A choice, not a mandate but a choice, because you knew if you did it would be 50 percent less.

Air conditioners that can actually talk to the utility on their own. So at any given point you have made a deal with the utility that you are willing to have your air conditioner cycled off for 5 or 10 minutes at a time when the temperature hits X degrees, and you get an extra $25 off your electricity bill as a result of that.

So there are all sorts of things that can be done that start with technology, that move from there to federal and state support. The good news is, this is not rocket science any longer. We have these technologies available.

Senator Klobuchar. Secretary Bowles.

Mr. Bowles. Yes. I would agree with your comment very much. We in Massachusetts now, the Governor has been talking about energy audits, we now have such a backlog of them that we are not even scheduling them now until November. That is a phenomenon where we have only given a certain amount of energy efficiency funding to the utilities to spend until it is gone.

What we have done in restructuring the energy market in Massachusetts is basically said to the utilities: You can spend any money on these efficiency investments, including energy audits, insulation, weather stripping, appliance subsidies, things like that, until the point that the next investment is more expensive than power generation.

So as long as it is cheaper than buying the next kilowatt hour of power, you can make those investments. And any state can do that. A number of states have. It is, again in wonkie terms, called "least-cost procurement," but it is basically the idea of buying the cheapest energy resource.

So state utility commissions can do that. Legislatures can do that. That is the biggest thing structurally we can do to really create an energy efficiency marketplace that again competes on costs. We are not taking about any crazy expensive things, we are talking about things that are cheaper than power generation.

With the costs of commodities, natural gas going up so much, there is a lot more cheap efficiency out there. So at the end of the wires as a consumer what that means is you have more people showing up on your doorstep saying, you know, do you have a 20-year-old refrigerator in your basement that is still plugged in? Twenty percent of your load could be just that old refrigerator you forgot about a decade ago. If you unplug it, it would probably be cheaper for all of us if we just bought you a small new refrigerator and took that damn thing away. But there is a variety of things we have not done because we have not given the utilities really the incentive to focus on saving money.

Senator Klobuchar. Okay.

Chairman Schumer [presiding]. Congressman Hinchey.

Mr. Hinchey. Thank you very much, Mr. Chairman.

Thank you, gentlemen, very much, for this opportunity to listen to you and to learn a number of very important things. We are grateful to you for being here.

The idea of energy efficiency I think is very critical. Last year the Congress finally passed an energy efficiency bill which upgraded the CAFE standards, the automobile fuel efficiency standards, upgraded them to 34 or 35 miles a gallon by the year 2020. This was the first time that that was done in 32 years. That standard was good, but it seems to many of us that a lot more could be done. A number of us have introduced another bill last year, which would jack up these CAFE standards to at least 40 miles a gallon by the year 2016, which is I think very easily achievable.

I would just like to hear your comments on that. What do you think that we could do in terms of CAFE standards, automobile efficiency, miles to a gallon, how much? How quickly do you think that we could accomplish that kind of efficiency?

Mr. Reicher. Congressman Hinchey, I think there is a great deal that can be done. The great news is that the automobile companies themselves I think are much more convinced about that than they have been in the past.

I mentioned in my testimony that at Google we actually converted several Toyota Priuses and Ford Escapes to be plug-in vehicles, and we tested those with professional drivers following Federal data on how consumers actually drive. The Ford Escape plug-ins got 50 miles per gallon. The plug-in Priuses got over 90 miles per gallon.

So we know how to do this. This is technology that is available. So I think it would be fair to revisit the CAFE law and consider increasing those requirements.

In conjunction with that, I do think we need to also provide some help with some of the infrastructure that our utilities are going to need, for example, if we are going to move to plug-in hybrids. Because I think that is a big opportunity. So I would encourage you to take a look at that, as well.

Mr. Hinchey. Thank you. Dr. Koomey.

Dr. Koomey. Congressman, thanks for your question.

One of the issues that I think people need to think about when they are examining the car efficiency question is the mass of the vehicle. We have designed vehicles more or less in the same way for a long time using materials that have changed somewhat over the last 20 years, but there are a lot of new materials that we now know are more energy absorbing, lighter, and allow vehicles to still be a good size but much lighter and therefore more efficient.

So part of the thinking around this, I agree with Dan that we need to re-examine where those CAFE standards should go, but part of that evaluation I think should be kind of whole system redesign using current materials, current information technologies, not assuming the way we have always designed cars is the way they need to be designed going forward.

Mr. Hinchey. Mr. Mills.

Mr. Mills. Congressman, I just first want to thank you. Your brother has taught a couple of my sons at school locally, and they——

Mr. Hinchey. He is a great math teacher.

Mr. Mills. He is a great math teacher.

Mr. Hinchey. Thank you.

Mr. Mills. The automotive industry is fascinating. As I think everybody knows, they have figured out that they might have to build different kinds of cars in this price climate. I think the automotive industry believes the price climate is in this range for awhile.

I just want to answer briefly the question about timing that you had asked. There are today dozens of car models that get between 30 and 40 miles per gallon, so consumers have the ability to buy high efficiency cars today.

It is not like auto makers have not figured out how to make them. They do exist. In fact, demand for used Honda Civics, I was reading recently in The Wall Street Journal, are priced at the same price as new Honda Civics because they are north of 30 miles per gallon on the highway, and you can almost have yourself paid to buy a Silverado taken off the lot at some GM dealers.

So some of the market response is already taking place. A couple of witnesses have noted the auto industry has figured this out, and in fact ironically enough there is some remarkable leadership going on in the R&D labs at the auto industry in my experience through the investment work that I do.

I would not call it stealth work; they just are not getting that much credit for it, frankly, from studying changes in car architecture, or car design, not just hybrids and plug-in hybrids.

When I first wrote about plug-in hybrids a few years ago in a Forbes article, the fact-checker called all the major auto makers and they all said universally to the fact-checker at Forbes that I was wrong; I was nuts; they were not going to make them; they were not in the plans.

I think at that time it was not so much they had their head in the sand. I happen to know from my own intel, if you like, that they were doing that. They just did not want to signal where they were in the path in a few cases, particularly in Toyota's case. They are very secretive about these radical changes they make in car design.

Mr. Hinchey. Secretary Bowles.

Mr. Bowles. Congressman, I would just say, to endorse what the others have said about revisiting CAFE. I think it makes sense for the United States.

The one other element I just would throw into the mix is we in California and in 14 States have been pursuing a waiver from the EPA for the CAL LEV standard, which would allow us as states to decide on one other standard that we could pursue more aggressively, and I think that is another step that Congress could step in and override, in my view, the recalcitrance from the EPA in terms of letting states go further when they are ready to, and recognizing it is only one other standard. We are not talking about a myriad of standards. So that is another thing that Congress could do if they did not want to touch CAFE right now.

Chairman Schumer. Thank you, Congressman Hinchey. And I want to thank all of the witnesses once again.

First to Mr. Reicher. I am very interested in the low income home weatherization program. I am going to put in some legislation to move it up.

Can you talk a little bit more about the program? Why is it so uniquely positioned to help reduce energy consumption as well as U.S. emissions? What can we in Congress do to ensure the remaining $28 million homes eligible for assistance receive the weatherization support they need?

There is such bang for the buck, and frankly as you said it is a permanent solution, whereas LIHEAP is a year-to-year solution.

Mr. Reicher. Mr. Chairman, it is a great program that has received very little attention.

Chairman Schumer. Why, do you think?

Mr. Reicher. We have not focused on energy efficiency as——

Chairman Schumer. At all.

Mr. Reicher [continuing]. At all. And when we have gotten into trouble in terms of higher energy prices, the general reaction in Congress has been, let's put more money into the Low Income Home Energy Assistance Program, LIHEAP, which is an important program. It does buy down people's energy bills.

But that is a one-time buy-down. To be candid, it really gets to a very, very small percentage of the need both in terms of eligible families and how much it actually helps them.

The great thing about weatherization as a complement to LIHEAP is that it continues to return savings year after year after year. Twenty to forty percent improvement in energy bills, not even taking into account what you can do if you also improve some of the electricity using appliances in the home.

The great news is, there is an established base of home weatherization providers all around the United States, scores of them. They have been added since the 1970s. They have done roughly 6 million homes. There is a very established process for doing it that

starts with the Home Energy Audit. There's a standardized set of tools you use for that, a standardized set of approaches you take to making the changes in the home.

What is exciting now, though, is that there is increasingly the opportunity to not just have this be federally funded but there may well be ways to aggregate hundreds or thousands of homes into a financeable package. I mentioned that in my testimony.

Chairman Schumer. Right.

Mr. Reicher. Imagine being able to not only have federal dollars going into this, but also get the private sector to start investing in these kinds of upgrades.

The problem today is we are only weatherizing on the order of 100- or 200,000 homes a year. The Energy Department has actually proposed this year to zero out the weatherization budget, as you know.

Chairman Schumer. Yes. That is hard to believe, given everything that has happened.

Mr. Reicher. We should be going the opposite direction. A million homes a year for the next ten years we would at least get to a third of what we could do. The job creation is extraordinary. The climate change impacts are extraordinary. We would even moderate the price of natural gas.

Chairman Schumer. How long does it—if you weatherize a home in year one, how long does it stay weatherized? Forever? Or do some things deteriorate?

Mr. Reicher. Well the savings are over many, many years.

Chairman Schumer. Right. But would you have to re-weatherize it 20 years from now?

Mr. Reicher. Certain things will still be in effect. You know, good insulation can last longer than that. Good windows can last longer than that. Other things, you might have to go back but normal home maintenance would get you there. But those first 10, 20, 25 years you really see major savings.

Chairman Schumer. Yep. Mr. Mills, do you disagree with anything Mr. Reicher said about weatherization? Not about in general, but just on weatherization?

Mr. Mills. Well, no. I mean, weatherization of homes and buildings is important. I think that the only thing that I would be nervous about is the financing structure, just because it is difficult in practical systems. This has been done before in many states, to weatherize low-income homes. And utilities in a variety of states have moved, gas utilities in particular, to put programs in place.

It turns out, just my experience working with the utilities over the years, that the old expression the devil is in the details, it is very difficult to implement these things.

To the point earlier about Minnesota has programs that have not been taken advantage of, it is hard to incent people to do these things. And it is hard to force them to do these things. So it tends to go slower than people expect.

Chairman Schumer. Right. That is probably true. But my guess is there are millions more who would do it in a New York minute.

Mr. Mills. I think that my view would be, of the New York Minute, would be with New York prices it would be a New York second.

Chairman Schumer. Exactly.

Mr. Mills. I think the big, big push will be because prices are so high. One winter at $4 or $5 a gallon heating oil, people get religion very fast.

Chairman Schumer. Right. Just a quick question to, let me ask Dr. Koomey, Secretary Bowles. My time is running out and we have a vote, so we are going to have to be quick.

It is hard to give a quick answer, but if you could do one thing, if we, the Senate, the House, the President, could do one thing to encourage efficiency right now to help us save money, reduce oil consumption, reduce prices, what would you choose?

Secretary Bowles. But you've got to answer quickly.

Mr. Bowles. I'll give you a two part. For this winter, which will be very cold and we need weatherization, LIHEAP very badly because people are going to die from this cold winter——

Chairman Schumer. Right.

Mr. Bowles [continuing]. I would do a lot of subsidization of insulation and weather stripping. That is the biggest short-term thing.

Long term, I would give the states irresistible incentives to totally restructure their electricity market as we have done and California has done.

Chairman Schumer. Right. Dr. Koomey.

Dr. Koomey. I would help the states to adopt decoupling and profit incentives for energy efficiency because when you make it profitable for companies to pursue efficiency, they go after it.

Chairman Schumer. Yes. Your ideas are very interesting, and you are harnessing the free market to do some good. Now there are, I do not know if you would call them externalities, but imperfections in the free market that do not allow it to happen.

If there were perfect knowledge, the little example you gave of the IT buyer not caring about efficiency would not matter—I don't know if it is perfect knowledge. I do not know what you call it. Yes, it is, perfect knowledge of the CEO at the top of the company.

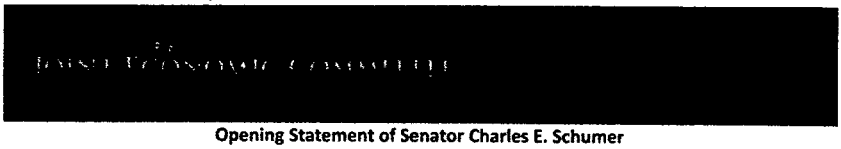
Dr. Koomey. And also misplaced incentives.

Chairman Schumer. Right. I want to thank our witnesses. I know this hearing was a little brief because of the votes and unfortunate scheduling, but it was a great hearing. This is to me one of the great frustrations: Energy efficiency is the steak. It does not get the attention it deserves, and our job here will be to try to move some of these pieces forward. So thank all four of you.

The hearing is adjourned.

[Whereupon, at 11:30 a.m., Wednesday, July 30, 2008, the hearing was adjourned.]

Submissions for the Record



Opening Statement of Senator Charles E. Schumer
Chairman, Joint Economic Committee
Hearing: "Efficiency: The Hidden Secret to Solving Our Energy Crisis
July 30, 2008
(as prepared for delivery)

Good morning and thank you for coming to our Joint Economic Committee hearing on energy efficiency – which is what I call the hidden secret to solving this serious energy crisis Americans are facing.

Everywhere we go – legion halls, parades, weddings – the high price of gasoline is one of the very first things people bring up. But in just a few short months, families from New York to Washington State will also be struggling to pay their winter heating bills. It is no wonder that Congress has held over **60** hearings on energy policy so far this year – and **20** in July alone.

Americans from coast to coast are being squeezed. We had a hearing last week to examine the Middle Class Squeeze in more depth. Elizabeth Warren from Harvard told our committee that the average family is earning over a $1,000 less than they did in 2001 and they're paying from $4,500-7,000 more in energy, health care, housing, college tuition, and child care costs. That's bad news for families and for our country's economic health, which is driven by the hard work of middle class families.

Americans from coast to coast are being squeezed. Warren estimates that middle class families are paying over $2,000 more in gasoline costs alone -- DOUBLE what they spent in 2001.

This is terrible news, in particular, for millions of families in the lower income brackets. Gasoline bills alone ate up 10 percent of their paychecks in 2006 – when a gallon of gas was "only" $2.50.

For all of the talk about how American families have benefited from the Bush tax cuts, and for all of the emphasis that some of my colleagues are placing on making those tax cuts permanent, the simple, undeniable, you-can-look-it-up, no-spin truth is that the average American family is paying far more in higher gas prices this year than they received in Bush tax cuts.

We had a committee hearing last month to examine whether these high oil prices were a temporary bubble or a painful, new reality for our economy. At that late June hearing, oil topped $134 a barrel -- it is now a paltry $122 a barrel. If there is *no* oil bubble, *or* if prices temporarily decline, as they have recently, and we put off doing the necessary things we have to do – like investing in efficiency programs and alternative fuels– we'll be even further behind than we are now from breaking our foreign oil dependence.

It is clear that demand for energy – oil, gas, electricity -- is on the rise – especially in rapidly developing, large countries like China and India. **So the reality is that we need to look beyond quick fixes that will do little for consumers and do less to address this energy crisis. In the long-term, we *must* address the demand side of the energy equation.**

With 7 years under their belt, this White House has taken zero pro-active steps to reduce our dependence on foreign oil or push other serious energy efficiency programs. If it wasn't for the Democratic Congress passing a long-overdue, small increase in fuel efficiency standards for cars, President Bush would leave the White House with a spotless record – committing no sins against Big Oil or OPEC.

With almost 70 percent of all of the oil we consume going into our gas tanks, it is a crime that the White House and the Republican Congress since 1995 have opposed increasing fuel economy standards for so many years.

While I have supported some targeted drilling in the Gulf of Mexico, I don't believe that we can drill our way out of this energy crisis – neither do the American people. According to a recent poll, 76% of Americans said that we should focus on investing in new energy technologies, renewable fuels, and more efficient vehicles rather than expanding oil exploration and drilling.

One good thing that came out of the oil shock in the 1970's was the push for dramatic energy conservation. Why don't we do more of it now? California made tremendous efforts under Governor Jerry Brown during that time to reduce consumption and now they are well below the national average in energy usage per capita. **One environmentalist said, alternative fuels are the sizzle, but conservation and efficiency is the steak.**

But to some conservation has the connotation of discomfort – using an extra blanket in the winter or easing up on the air conditioning in the summer. But as our witnesses will discuss, energy efficiency is actually doing more with less. We'll learn about the most recent state to implement landmark energy efficiency and alternative energy programs from the Massachusetts Secretary of Energy and Environmental Affairs, Ian Bowles.

But what should we be doing in *Washington* to address this problem?

We should be **requiring utilities to achieve 10% energy savings each year** by helping their customers with energy efficiency programs, improving energy efficiency in their own distribution systems, or through credit trading.

We need to **require states to update their commercial and residential buildings codes to achieve a 30% energy savings by 2015 and 50% energy savings by 2022**, based on 2006 buildings code standards. That's an idea that offers big bang for the buck because buildings consume a great deal of our energy and are very inefficient.

Finally, we should be **giving states like Massachusetts the ability to set higher appliance standards**, with the proper approval from the Department of Energy, to help the federal government and big manufacturers stay ahead of the technology curve.

Another idea that Dan Reicher addresses prominently in his testimony may be long overdue -- **a reinvigorated and beefed up weatherization program to help millions of Americans consume less energy, stay warmer in the winter and cooler in the summer.**

Given the recent inability of the Senate to increase funding for the low income home energy assistance program (LIHEAP) and what is predicted to be a terrible winter heating season, I'm worried that families in New York and around the country will be choosing between heat and food or between heat and health care. **This kind of common sense investment in reducing our energy consumption is an energy hat trick – it helps families who are making ends meet, improves our energy security, and strengthens our economy.**

The bottom line is that if you don't encourage efficiency, if you don't invest in alternative energy, and if you don't tell the big oil companies they can no longer run energy policy in America, we will not succeed, plain and simple. Our witnesses today are experts in doing more with less – which is why they only will get five minutes to make their opening statements.

Witnesses:

Ian Bowles, Secretary of Energy and Environmental Affairs, Commonwealth of Massachusetts
Dan Reicher, Director of Climate Change and Energy Initiatives, Google
Dr. Jonathan Koomey, Professor, Stanford University
Mark P. Mills, Co-Founder, Chairman ICx Technologies, Inc.

# # #

JOINT ECONOMIC COMMITTEE
SENATOR CHARLES E. SCHUMER, CHAIRMAN
REPRESENTATIVE CAROLYN B. MALONEY, VICE CHAIR

Statement of Carolyn Maloney, Vice Chair
Joint Economic Committee Hearing
July 30, 2008

Good morning. I would like to thank Chairman Schumer for holding this hearing to examine the role that efficiency measures can play in our energy strategy.

Three years ago, the Republican-controlled Congress passed energy legislation they said would bring down the cost of gasoline and end our dependence on foreign oil. Instead, the price of gasoline has nearly doubled since then.

Whether it's paying over $4 for a gallon for gas or milk, due to soaring fuel costs, Americans are paying a hefty price for the Bush Administration's failure to pursue a sensible energy strategy over the past seven years. We cannot drill our way out of this problem, as the Administration and my colleagues on the other side of the aisle would have us believe.

Meeting the energy needs of our nation will require a comprehensive strategy for achieving greater efficiency and investing more in renewable fuels. The Democratic-led Congress has already enacted into law the first new fuel efficiency standards in over three decades and made an historic commitment to biofuels grown here at home, both of which are reducing consumption and saving families money.

We are building on these steps by encouraging the use of mass transit and expanding tax incentives for renewable energy to spur American innovation and business investment, and create green jobs.

Record energy prices are forcing us all to rethink the way we live and commute, and companies are also rethinking the way they do business. In short, we all need to think outside of the oil barrel. Today we will hear about the many ways in which families, businesses, and government can work together to achieve greater energy efficiencies, which Mr. Reicher has noted is perhaps the fastest, cleanest, and cheapest way of addressing our energy challenges.

More flexible workplace policies can also play an important role. A recent survey by the Society for Human Resource Management found that 26 percent of businesses are offering flexible schedules to help employees cope with high gas prices.

Across the nation, local governments are altering work schedules to save energy and cut costs. Utah's Republican Gov. John Huntsman recently announced that most state employees will be moving to a mandatory four-day work week to reduce the state's energy consumption, while also providing workers with greater flexibility.

-more-

A bill I have co-sponsored with Senators Kennedy and Obama, the Working Families' Flexibility Act (H.R. 4301), would help working families across the country by putting a process in place for employees to request a change in their work schedules and providing job protection when making the request.

More and more, businesses are finding that flexible work schedules and other family-friendly programs are good for the bottom line, in terms of reducing turnover and increasing productivity. What's also coming to light are the ways in which these policies can help companies and families reduce consumption, cut energy costs, and ease traffic congestion.

Our nation's continued prosperity depends on meeting the challenge of our energy needs and bringing relief to American families.

Mr. Chairman, thank you for holding this hearing and I look forward to the testimony today.

###

JOINT ECONOMIC COMMITTEE

Senator Sam Brownback, Senior Republican Senator

Opening Statement of Senator Sam Brownback
"Efficiency: The Hidden Secret to Solving Our Energy Crisis"
July 30, 2008

Mr. Chairman, I want to thank you for scheduling today's hearing. I hope this will give us the opportunity to focus needed attention on the important role energy efficiency can play in helping to address the energy challenge our nation confronts. I must admit, however, that I am a bit perplexed by the title of today's hearing – "Efficiency: The Hidden Secret to Solving our Energy Crisis."

I am perplexed about the hearing title on a couple of levels. First, the title reaffirms the fact that the majority in this body remains in denial, believing that our Nation's energy crisis can be addressed by some single silver bullet, in this case, a hidden secret, on the demand side of the equation. Mr. Chairman, when is the majority in both Houses of Congress going to acknowledge the fact that this crisis cannot be addressed simply on the demand side of the equation?

Yes, reducing demand through efficiency and technology is an important part of any meaningful and comprehensive strategy to address this crisis. However, another aspect that is also lost in the hearing title is any recognition of the fact that many of the demand reduction strategies propounded by the other side are heavily dependent on higher taxes – direct or indirect – and/or steep increases in energy prices to create incentives to save energy.

Secondly, Mr. Chairman, the discovery that "efficiency" is somehow a "hidden secret" is almost as absurd as the notion that the potential health risks associated with smoking represents a breakthrough in modern scientific thinking. In fact, improving efficiency is not a new or a novel concept.

I would commend to the Committee's attention the July 2006 "National Action Plan for Energy Efficiency." This plan was "developed by more than 50 leading organizations in pursuit of energy savings and environmental benefits through electric and natural gas energy efficiency." That national action plan lays out five broad recommendations:

- Recognize energy efficiency as a high-priority energy resource.
- Make a strong, long-term commitment to implement cost-effective energy efficiency as a resource.
- Broadly communicate the benefits of and opportunities for energy efficiency.

- Promote sufficient, timely, and stable program funding to deliver energy efficiency where cost-effective.
- Modify policies to align utility incentives with the delivery of cost-effective energy efficiency and modify ratemaking practices to promote energy efficiency investments.

The report goes into great detail about the role of efficiency in meeting the demand for energy. It focuses on the efforts of a number of states to improve energy efficiency. But the report also draws attention to a number of disturbing aspects of the debate. For instance, on an inflation adjusted basis, investment in efficiency declined by 25% between 1992 and 2000. Fortunately, by 2003 the trend reversed itself and increased 15% from the 2000 levels.

Mr. Chairman, there is much we can do to improve efficiency – and doing so is one part of the equation. But we must address the supply side of the equation as well. As a nation, we produce barely half the amount of crude oil and about the same amount of natural gas as we did in 1970. According to BEA, in the first quarter of 2008, our imports of petroleum products amounted to $451 billion on an annualized basis. Tomorrow, when BEA releases its first look at second quarter GDP, I suspect we will see an even higher number.

I mention this in terms of GDP, because imports are a subtraction from GDP. And lower GDP means fewer jobs, lower government revenues and a larger deficit. In the first five months of this calendar year, had we imported one million barrels of oil less per day, our trade deficit would have been $14 billion lower over those five months.

The policy that the other side of the aisle is defending with such zeal by failing to promote the discovery and drilling of additional domestic oil supplies is sending money and jobs outside the United States by the truckload. This is wrong and must be stopped. That is what I and my colleagues on this side of the aisle have been fighting so hard for over on the Senate floor. It's time we took action and gave the American people some needed and real relief.

Let me close by noting that drilling is not the entire answer to the entire question. We need a broad based approach that continues to encourage the development and use of alternative sources of energy like bio-fuels, wind, solar and so on. We should require that an increasing share of the vehicles sold in the United States be flex fuel or alternative fuel vehicles. But we must also maximize, in an environmentally sensitive manner, our existing resources. To do less would be irresponsible. I hope my colleagues on the other side of the aisle will quickly recognize that both sides of the equation, supply and demand, must be addressed.

Testimony of Ian Bowles
Secretary of Energy and Environmental Affairs
Commonwealth of Massachusetts
Joint Economic Committee
U.S. Congress
July 30, 2008

Thank you, Chairman Schumer, Vice Chairman Maloney, and members of the committee, for the opportunity to testify today and for your leadership in addressing an issue that is central to the nation's future. We are proud of the progress the Commonwealth of Massachusetts has made toward reducing our dependence on foreign oil, tackling the climate challenge, and especially strengthening our economy, all through energy efficiency. I am glad to share our experience with you, lay out our goals for the future, and make some modest but deeply felt recommendations for state policy.

Massachusetts has long been a national leader in energy efficiency, but the value of investing in energy saving measures is apparent now more than ever. All energy users – homeowners and renters, commercial enterprises, manufacturers, institutions, cities and towns – are feeling the pinch of rising fuel prices, and are struggling to adjust to the stresses created by today's global energy markets. At the same time, all of us are coming to realize the stake we have in tackling the threat of global climate change. For reasons economic as well as environmental, we need to find ways to meet our energy needs while burning less fossil fuel.

This imperative is nothing new to us in Massachusetts. With no oil, coal, or natural gas of our own and located literally at the end of the energy pipeline, Massachusetts has always had high energy costs. It has long made economic sense to use the energy we pay for as efficiently as possible. Our experience over the years has taught us that energy efficiency and conservation are by far the cheapest, as well as cleanest, ways to meet our energy needs, but even we have not taken maximum advantage of that lesson. Now, as we face record high fuel prices, driven by global demand that is more likely to grow than shrink, the time has come to put conservation and efficiency at the heart of our energy policy. We are doing so in Massachusetts, with support across the political spectrum and from business groups as well as environmental advocates.

We are also seizing energy efficiency, along with renewable energy, as an economic opportunity. Clean energy technology – the development and commercialization of innovations ranging from super-efficient lighting and motors to cellulosic biofuels made from non-food crops and plug-in hybrid cars that get 150 miles per gallon of gasoline – is a young but growing industry in Massachusetts, with more than 14,000 employees already and soon to be the 10th largest industry sector in the state. Backed by the intellectual resources of our great private and public universities and the second-highest investment of venture capital in the country, clean energy technology is an industry of the future for Massachusetts. As Governor Patrick often says, if we get this right, the world will be our customer. The same could be said of the United States as a whole.

I. Past Energy Efficiency Programs: Highly Cost-Effective, But Constrained

Massachusetts has a history of success delivering energy efficiency to residential, commercial and industrial customers. Through programs established by both state mandates and the cooperation of the state, utilities, and various stakeholders beginning in the 1980s, we have long had residential energy auditors, insulation contractors, and plumbers fanning out across the state making our aging housing stock more energy efficient. And for decades we have had engineers examining our commercial office buildings, city halls, hospitals, and industrial facilities replacing outdated lighting, motors, refrigeration equipment, and more.

The programs have been built on a basic model, though with many variations:

- get energy use data;
- prioritize high value efficiency opportunities (where the cost of a measure will be offset by significant short and long term bill savings); and
- provide rebates or incentives to encourage energy users to take action to save energy.

The measures covered by the programs have varied over time, but include steps as simple as caulking and weather-stripping leaky doors and windows, and as complex and expensive as switching out a 50-year-old boiler for a brand new energy-efficient one. (In some places we are now piloting super-efficient micro-combined heat and power systems that can provide both electricity and heat.) Often, commercial and industrial customers will get a comprehensive energy audit from experienced engineers that will provide a list of more than a dozen energy efficiency measures that will reduce energy expenses, cut pollution, and improve aging capital.

These programs have been highly cost effective, delivering great benefits to the Commonwealth. These include energy bill savings through direct reductions in energy bills for homes and businesses that have made efficiency upgrades. But the benefits go farther than that. Energy efficiency reduces demand for electricity from the regional electricity grid, which means that all these measures significantly reduce pollution from power plants. Moreover, demand savings are especially valuable in places (like parts of New England) where peak electricity use bumps up against limits of supply. These reductions in capacity are valuable financially, because they reduce wholesale electricity prices and avoid the need for expensive peaking power plants. These and other factors combine to reduce energy costs for all users.

Moreover, energy efficiency programs have local economic development effects. Dollars that consumers and business owners don't spend on energy are available to be spent productively in many other ways. Importantly, the dollars spent on these energy efficiency measures are dollars spent improving Massachusetts homes and businesses, through work done by local contractors, with employees from the Commonwealth and surrounding states, rather than sent out of state to pay for coal, oil, or natural gas.

The tables below summarize the impacts of the Commonwealth's energy efficiency programs. Table 1 describes the impacts of the existing electric energy efficiency programs in the years 2003-2005.

Table 1
Participants and Annual Bill Savings, 2002-2005.
Program Summary 2003-2005

Residential	1,520,391	$158	$35	$319
Low Income	429,525	$48	$12	$133
Small Commercial & Industrial	10,075	$49	$10	$132
Medium Commercial & Industrial	6,342	$96	$18	$258
Large Commercial & Industrial	1,913	$143	$25	$387
Total	1,959,246	$504	$100	$1,229

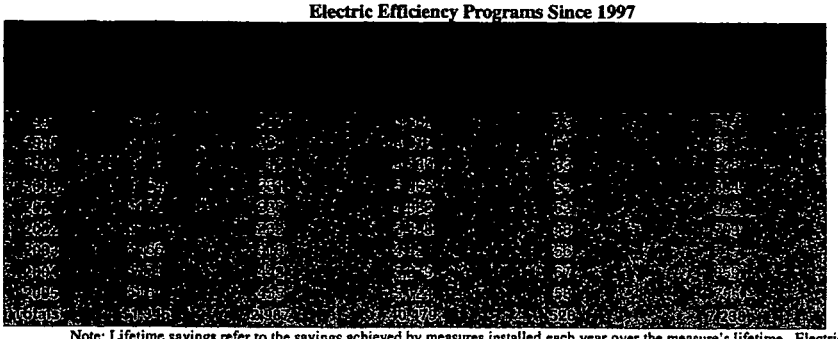
Note: Some customers participate in more than one program but are counted as a new participant each time.

Overall, there were almost 2 million participants in utility energy efficiency programs, the great majority of them residential purchasers of compact fluorescent light bulbs (CFLs). Massachusetts, in cooperation with other New England utilities and major retail outlets, subsidizes compact fluorescents at the wholesale level, bringing the price in stores down to $1-$2 per bulb. Customers are not burdened with cumbersome rebate and coupon requirements and have enthusiastically purchased CFLs, making Massachusetts the highest CFL purchaser per capita in the nation.

The largest reservoir of energy savings is found among commercial and industrial customers. Massachusetts energy efficiency programs actively pursue these savings, with programs designed to make participation as easy as possible. Programs have been designed so that business paybacks on their investments in energy efficiency fall within 18 months to two years.

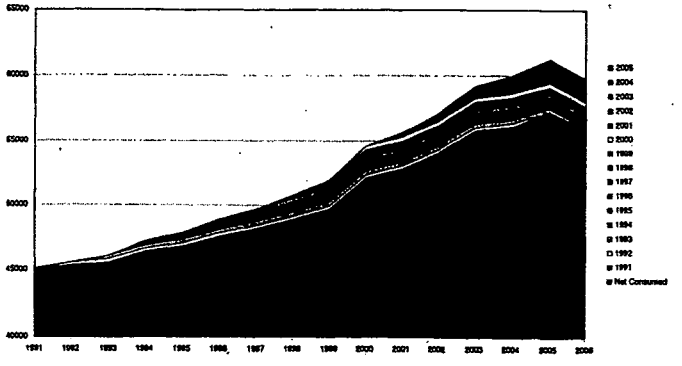
Table 2 below describes the impacts of energy efficiency programs since Massachusetts passed the Electric Utility Restructuring Act in 1997. That act established a System Benefits Charge, initially set at 3 mils for every kilowatt hour sold in the state, currently set at 2.5 mils ($0.0025). The table shows the savings achieved in each year on both annual and lifetime bases. The expenditures include both the SBC incentives and customer copayments. In addition to energy saved, the programs have also reduced peak demand through investments in air conditioning, commercial lighting, efficient motors and control systems. These investments in demand reductions will grow substantially, as long as they cost less than additional power generation, under the Green Communities Act, further reducing the need to construct additional peak demand generation and saving money for consumers.

Table 2
Electric Efficiency Programs Since 1997

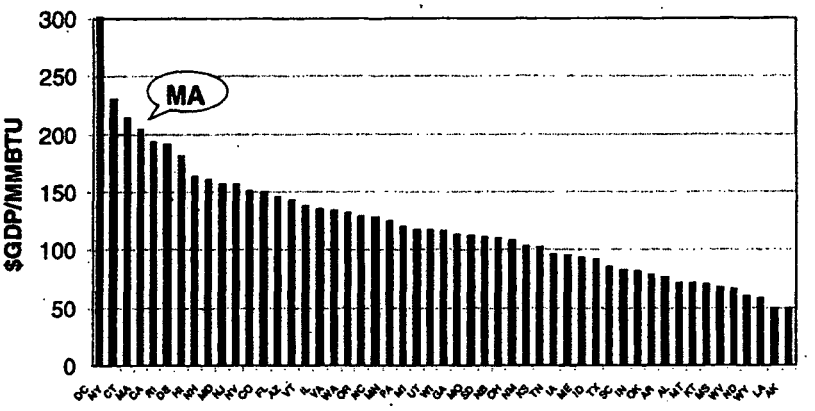


Note: Lifetime savings refer to the savings achieved by measures installed each year over the measure's lifetime. Electric efficiency measures average 13 year lifespan.
* Expenditures include SBC funds plus participant measure cost share.

These savings accumulate dramatically. The chart below shows the "ribbons" of savings derived from each year's energy efficiency programs and their lasting effect in the electricity system. In 2006, energy efficiency provided approximately 4 million MWh worth of electricity.



Focus on energy efficiency has made Massachusetts one of the most energy-efficient economies in the nation. Our gross domestic product per MMBtu is well above the national average, and behind only two states (each of which also has extensive energy efficiency programs, and one of which is the great state of New York) and the District of Columbia.



All of this shows the tremendous benefits of energy efficiency. But many technical and economic analyses indicate that there is far more potential to save energy than we have realized. We have only been scratching the surface. Since their creation in 1997, our energy efficiency programs have been capped by the amount of funding provided by the System Benefit Charge, no matter how many more savings were available. Program administrators have been allocated a fixed budget each year, and cannot exceed it. In some instances, programs run out of money and close up shop by as early as April, while in others; demand has been carefully managed by waiting lists for services.

In contrast, there has been discussion in recent weeks about solving our energy problems by drilling deeper in the search for oil. Where we should be drilling deeper is energy efficiency. Tapping into more energy saving opportunities in our homes and businesses will be far more productive and far more beneficial to the Commonwealth and the nation than any other energy strategy, and should be our first priority.

In Massachusetts, we chose to remove the caps and break down the barriers for energy efficiency, unleashing conservation as a resource to harness market forces and grow to meet energy demand.

II. The Green Communities Act: Expanding Efficiency and Renewable Energy

On July 2, Governor Deval Patrick signed into law the Green Communities Act, a comprehensive energy reform law developed in close collaboration with House Speaker Sal DiMasi and Senate President Therese Murray (see Appendix for statute summary). The new law dramatically expands energy efficiency's role in the Massachusetts economy, and sets as a goal reduction of energy consumption across the Commonwealth by 10 percent in less than a decade.

Under the new law, the state will make energy efficiency programs compete on price with traditional energy supply. Utility companies (NSTAR, National Grid, Western Mass. Electric, etc.) will be required to purchase all available energy efficiency improvements that cost less than it does to generate power to meet the same energy need, ultimately saving money on consumers' electricity bills. And it will be done not as an add-on to utility bills, but as an integral part of the way utility companies meet their customers' energy needs.

When each electric distribution utility looks at how much electricity it needs to buy from power generators in our competitive wholesale market to meet the demands of its customers, it will be required first to identify all the cost-effective opportunities available to save electricity. That means replacing lighting, air conditioning, and industrial equipment with more efficient models.

Utility companies will offer rebates and other incentives for customers to upgrade lighting, air conditioning, and industrial equipment to more efficient models, whenever those incentives cost less than generating the additional electricity it would take to power their older, less-efficient equipment. Each utility will be required to submit a three-year efficiency investment plan, subject to review by a new Energy Efficiency Advisory Council and approval by the Department of Public Utilities.

Existing efficiency programs have shown savings at 3 cents per kilowatt-hour versus 9 cents for power generation, which leads us to expect that there is much more efficiency to be obtained at a cost lower than generation. Customers who take advantage of these incentives will save money as they reduce how much energy they use and pay for. And all customers will save money from lowering the overall demand for electricity.

Greater energy efficiency overall reduces total electricity system costs because, on the wholesale power market, the price of electricity is set by the highest-cost generator operating at the moment, with peak-hour demand, when the most expensive plants are running, pushing the price to astronomical levels (up to $1,000/MWh on the hottest day of the year). Energy efficiency lowers overall demand and therefore the clearing price of electricity every hour.

Lower demand peaks also reduce the need for costly new power plants that run only to meet the highest load levels of the year. Recently, ISO-New England, the regional grid

operator, held the first auction in its Forward Capacity Market, which is intended to ensure that the region has enough generating capacity to meet future needs. Two-thirds of awards were won by demand-reduction resources, rather than generating resources.

All this gives us great confidence that there is tremendous potential to save money for residential and business consumers and reduce the use of imported fossil fuels by means of the expanded energy efficiency programs created by the Green Communities Act.

The law also promotes energy efficiency in other ways. It requires the state Board of Building Regulations and Standards to adopt, as its minimum standard, the latest edition of the International Energy Conservation Code as part of the state Building Code. As the IECC is updated every three years, this requirement will keep Massachusetts building standards at the highest levels of energy efficiency.

Finally, the Green Communities Act gives legislative approval to the Commonwealth's participation in the Regional Greenhouse Gas Initiative (RGGI). Substantially all of the emissions allowances issued by Massachusetts under the program will be auctioned – in accordance with the policy announced by Governor Patrick in January 2007 – allowing the proceeds to be spent on a variety of public benefits, with at least 80 percent of the proceeds to be invested in energy conservation and demand reduction. I recently (January 23, 2008) described the rationale and goals of this auction process in testimony before Chairman Markey's Select Committee on Energy Independence and Global Warming.

Renewable energy is another focus of the Green Communities Act, for its environmental and also energy independence benefits: Massachusetts has no fossil fuels of its own, but plenty of wind, solar, and biomass resources.

The law promotes renewable energy in a number of ways. It doubles the rate of increase in the Renewable Portfolio Standard, from 0.5 percent per year to 1 percent per year, with no cap. As a result, utilities and other electricity suppliers will be required to obtain renewable power equal to 4 percent of sales in 2009, and rising to 15 percent in 2020, 25 percent in 2030, etc.

The law also requires utility companies to enter into 10- to 15-year contracts with renewable energy developers, which will provide price certainty for wind power in the future and thereby help developers obtain financing for their projects. The agreements will target Massachusetts-based projects.

In addition, the law makes it possible for homeowners, businesses and cities and towns that own wind turbines and solar power installations to sell their excess electricity into the grid ("net-metering") at favorable rates, for installations of up to 2 megawatts (up from 60 kilowatts currently).

The measure authorizes utility companies to own solar electric power they put on their customers' roofs or in freestanding installations – a practice that was previously

prohibited under the electricity restructuring of 1997 – up to 50 MW for each of the state's four distribution utilities after two years. If utilities take full advantage of this new opportunity, it will help Massachusetts meet Governor Patrick's goal of installing 250 megawatts of solar power statewide by 2017.

The Green Communities Act also creates a Green Communities program to offer benefits to municipalities that make a commitment to efficiency and renewable energy. The state's Department of Energy Resources will provide technical and financial assistance to municipalities for energy efficiency and renewable energy efforts, with $10 million in funding from a variety of sources, including emissions allowance trading programs, utility efficiency charges, alternative compliance payments generated by the Renewable Portfolio Standard, and the Renewable Energy Trust Fund.

III. Other Administration Initiatives: Boosting Efficiency in All Sectors

The Commonwealth under Governor Patrick's leadership has taken a number of other steps to boost energy efficiency, starting with the creation of the first Cabinet-level agency in the country that combines all energy and environmental policy and regulation. Under the Executive Office of Energy and Environmental Affairs, the six environmental and energy regulatory agencies (including the public utility commission) are able to coordinate their efforts to reduce energy costs and usage, curb greenhouse gas emissions, and tap the economic potential of the rapidly growing clean energy technology sector in Massachusetts.

Our Department of Public Utilities recently issued an order "decoupling" utility revenue from sales volume – a process designed to eliminate the economic incentive for utilities to maximize power consumption and equivocate about conservation. This reform will make the distribution utilities full partners in promoting energy efficiency for their customers, and fulfilling the efficiency promise of the Green Communities Act.

In March, Governor Patrick announced a bold Zero Net Energy goal for buildings in the Commonwealth. The Governor has established a Task Force whose work will enable the state to begin construction of the first state-owned zero net energy building by 2010; point the way toward broad marketability of zero net energy residential and commercial buildings by 2020; and establish standards for statewide adoption of zero net energy buildings for new construction by 2030. Aggressive pursuit of zero net energy buildings will improve application of existing technologies while also spurring development of innovative technologies, as well as design and operating practices, to make buildings super efficient.

Last year, Massachusetts became the first state in the nation to incorporate greenhouse gas emissions into the state environmental review process, a policy that is leading to greater private investment in green buildings. Through the environmental review process, major new real estate projects will be required to analyze how they can maximize energy savings through better design and construction.

The Governor has also issued Executive Order 484, entitled "Leading by Example," which requires all state agencies to reduce energy use at state-owned buildings 20 percent by 2012 and 35 percent by 2020. The Executive Order also requires all new construction and major renovation projects to meet the Massachusetts LEED Plus standard, which is based on LEED but sets a higher bar for energy efficiency.

IV. Role for Federal Policy

In many instances, achieving substantial energy efficiency improvements must begin from the unique circumstances of each state, taking into account age of building stock, industry concentrations, climate, and other factors. But federal policy can nurture and accelerate these efforts tremendously. A combination of strong state and federal policy can unleash energy efficiency tremendously, offering savings, energy independence, and greenhouse gas emissions reduction across the land – and launching a new and vital industry that is central to our future.

We are already beginning to see glimpses of the new energy opportunities on the horizon, as Massachusetts and California set bold goals to get to Zero Net Energy homes and commercial construction in coming years, and California begins to reshape residential and small commercial heating and cooling industries to be dramatically more efficient.

Working together, the states and the federal government could put energy efficiency at the heart of our energy policy, enabling us to maximize energy savings at a time of record fuel prices; tackle the challenge of climate change; and become more energy independent. In several areas key to achieving greater energy efficiency – including utility regulations, building codes, and land use and development – the states have particular expertise and/or authority, and the federal government should look for ways to support and encourage state leadership. In several other areas, Congress has the opportunity to establish national policies that will drive significant energy savings – climate policy, vehicle fuel efficiency, national building codes, and appliance standards.

We strongly support aggressive fuel economy standards for vehicles, and are pleased that Congress has recently acted to update the Corporate Average Fuel Economy (CAFE) standards. On the other hand, we are dismayed that the Bush Administration has denied California's waiver under the Clean Air Act to impose greenhouse gas emissions limits on cars and light trucks, which Massachusetts and several other states are poised to adopt as well. While not an efficiency measure per se, California's emissions standards would require greater and faster vehicle improvements than CAFE, and our states should be allowed to put these requirements into effect.

We encourage the federal government to quickly adopt more stringent appliance and equipment efficiency standards. When the federal government establishes appliance and equipment standards, they are setting the minimum energy efficiency of the products we buy and use every day. Higher energy efficiency standards save money for energy users,

protect the environment, and boost the economy by driving innovation. They hasten adoption of energy-saving technology in products, often with improved performance. Existing standards have saved more energy than we would have gotten from dozens of power plants, and the potential savings from new, higher standards could do far more.

Massachusetts supports swift and aggressive federal energy standards for small motors, battery chargers, commercial refrigeration and the dozens of other products currently under review by the U.S. Department of Energy. In particular, we call for the federal government to adopt the one-watt standby initiative to require all appliances to consume no more than one watt per hour when not in use. Research from Lawrence Berkley Labs suggests that "vampire" or "phantom" load in homes accounts for 10 percent of residential electricity consumption for no useful purpose.

Carbon policies such as cap and trade mechanisms for particular sectors, as in the case of the Regional Greenhouse Gas Initiative (RGGI), or economy-wide caps adopted or under consideration in a number of states, will also drive major investments in energy efficiency. We support swift adoption of a federal carbon cap designed to reduce all U.S. emissions 80 percent by 2050, as is generally accepted within the scientific community as necessary for avoiding the worst impacts of climate change, with interim targets that can be revised as science dictates. Any federal carbon policy should auction allowances, and direct a major share of the auction toward the state level, where utilities, building codes, and zoning offer the best opportunities to capture energy savings; preserve the right of states to implement more stringent greenhouse gas limits if they so choose; support early acting states or corporations; send clear market signals; and invest in efficiency and renewable energy nationwide.

While we know that the untapped potential for energy efficiency using today's technologies is enormous, we also know that the future potential can be even larger. Refrigerators today use roughly half of the electricity they used 15 years ago, due to technological developments. Such developments are occurring all the time, due to market forces as well as government energy efficiency policies. In Massachusetts, we believe there is an important role for research and development to push technologies further so as to ensure that efficiency opportunities will continue to expand in the future. The federal government must play a critical role in supporting R&D efforts – leading to benefits that will be enjoyed nationwide."

There are several other steps the federal government should take that would significantly boost energy efficiency. Establishing a national energy efficiency resource standard, or energy savings targets for electric and gas utilities, would drive significant investment in this sector. Establishing a financing mechanism for energy efficiency improvements, along the lines of the HEAT Loan program we have operated in Massachusetts, would enable middle-income families to take greater advantage of energy savings opportunities, as would extending existing energy efficiency tax incentives. It would also be worth expanding the existing oil heat research program to include energy efficiency for oil-heated homes.

V. Low-Income Households and the Winter 2008-09 Heating Crisis

Energy efficiency must be a crucial component of our short- and long-term energy strategies, and the Commonwealth of Massachusetts is making it the centerpiece of our state's response to the current rise in energy prices. Of particular concern is the anticipated impact of sharply higher fuel prices for home heating this coming winter. At $4.71 a gallon, the price of home heating oil is now more than double what it was three years ago. An average household that spent $1,800 to heat its home with oil in the winter of 2005-06 could spend in excess of $3,750 next winter.

We are already working with utility program administrators and regulators to expand home weatherization and insulation programs this summer and fall in order to help as many people as possible stay warm this winter. But state efficiency resources are only one part of the solution for the home heating crisis we see unfolding this winter.

As the governors of all six New England states said in a July 9th letter to House and Senate leadership, never before in modern history has New England faced the prospect of so many residents being unable to heat their homes as it will this winter. We are deeply concerned that many low-income families, especially those with young children and senior citizens in the household, will risk serious illness or even death this winter without a significant increase in funding for the federal Low-Income Home Energy Assistance Program (LIHEAP). Pipes will burst, driving families out of their homes, and desperate people will resort to unsafe alternatives to traditional heating methods, raising concerns about fire safety.

Because of sharp increases in energy costs, the purchasing power of LIHEAP funds, already inadequate, has fallen dramatically. LIHEAP funding for New England states needs to be increased to $1 billion this year. In addition, the federally funded Weatherization Program is critical to improving the efficiency of heating for low-income households, stretching LIHEAP dollars as far as they can go. Funding for the Weatherization Program should also be significantly increased.

VI. Conclusion

In Massachusetts, as in the nation, we are facing the greatest energy challenge since the discovery of fossil fuels, and it is all about reducing our dependence on those very fuels – for the sake of our economy, and for the sake of our environment, now and for future generations.

President Bush has spoken of our dependence on oil as an "addiction." If he is right, it now seems that we have hit rock bottom. The high prices of fossil fuels threaten to cripple our nation's economy, and the emissions produced by using them for energy threaten to change our climate irreversibly, with disastrous consequences. It is time for an intervention.

Energy efficiency is that intervention. It promises not only a way to reduce our cravings for fossil fuels, but also an opportunity to harness our country's capacity for innovation and entrepreneurship to create new technologies that solve our energy problems and grow our economy. We in Massachusetts are doing what we can to pursue this path to recovery. I encourage you in Congress to put the nation on this path as well.

Appendix A. Summary of the Green Communities Act

Energy Conference Report – Summary of Major Provisions

DOER Reorganization: Establishes the Department of Energy Resources (DOER) within the Executive Office of Energy and Environmental Affairs. The newly created Department, which replaces the Division of Energy Resources, will have three divisions: Division of Energy Efficiency, Division of Renewable and Alternative Energy Development, and Division of Green Communities.

Green Communities: The Division of Green Communities is directed to establish the "Green Communities" program to provide technical and financial assistance to municipalities to implement energy efficiency and renewable activities. Funding of $10 million for the Green Communities program is made available through 1) RGGI and NOx allowance trading programs; 2) efficiency funding from the electric utility System Benefit Charge; 3) alternative compliance payments generated through the Renewable Portfolio Standard; and 4) the Massachusetts Renewable Energy Trust Fund. To qualify as a Green Community, a municipality would have to meet various requirements as to siting and permitting of renewable or alternative energy generating facilities and various energy efficiency measures.

Mass. Renewable Energy Trust: Establishes a nine-member governing board (chaired by the Commissioner of DOER) that is charged with creating a detailed five-year strategic plan and annual operating plan for the use of the Massachusetts Renewable Energy Trust Funds. The governing board would include secretaries of energy and environmental affairs, housing and economic development, and administration and finance; one member of the Mass. Technology Collaborative board of directors; and four members with specified expertise appointed by the Governor.

RGGI: Directs DEP and DOER to adopt rules and regulations to establish a carbon dioxide cap and trade program, on the basis of which Massachusetts will participate in the Regional Greenhouse Gas Initiative (RGGI). States that substantially all of the RGGI allowances issued under the program will be auctioned. Bill creates a RGGI Auction Trust Fund to recover the proceeds from the allowance auction under the program. The proceeds from the fund are directed for:

1. Reimbursing a municipality in which the property tax receipts are reduced as a result of RGGI mandates;
2. Funding the Green Communities program;
3. Providing zero interest loans to municipalities for energy efficiency projects; and
4. Promoting energy efficiency, conservation, and demand response.

Efficiency Competes with Supply: Legislation requires that the Commonwealth's gas and electric needs will be met first through cost-effective energy efficiency and demand reduction resources. Requires that every three years, distribution companies will prepare efficiency investment plans to be approved by the Department of Public Utilities. Each plan shall provide for the acquisition of all available efficiency and demand resources

that are cost effective or less expensive than supply. These plans will be subject to vetting through the Energy Efficiency Advisory Council, a new entity appointed and convened by the DPU and chaired by the Commissioner of the Department of Energy Resources.

Long Term Contracts for Renewables: Creates a renewable energy long term contracts pilot program (capped at 3% of the electric load) for Massachusetts projects. For a period of five years starting in 2008, each electric distribution company must solicit proposals from renewable energy developers twice during the period. If the distribution company receives reasonable, cost-effective proposals for long-term (10 to 15 years) contracts from developers of renewable energy generation facilities, it must enter into such contracts. This provision creates a new financial incentive for renewable energy.

Utility Ownership of Solar Power Generation: Allows electric companies and distribution companies to own or operate generation facilities for solar power up to 25 MW for the first year and 50 MW the second and thereafter. Requires utilities to file with DPU, which must assess the program by 2012, after which the program sunsets.

International Energy Conservation Code: Requires State Board of Building Regulations and Standards to adopt as a minimum standard, within one year of its being updated, the latest edition of the International Energy Conservation Code as part of the State Building Code. (The IECC is updated every three years.)

Net Metering: Encourages small, behind-the-meter wind and solar generation not greater than 2 MW by paying the owners of the renewable generation for the excess electricity they generate at favorable rates; allows for energy credits for generation to be transferred to different electric accounts within the utility's service area, and for "neighborhood" net metering, through which credits for renewable generation are shared among neighboring households.

Renewable Energy Portfolio Standard. Increases the requirement on utilities and other electricity suppliers to procure a certain percentage of power from new renewable sources by an additional 1 percent of sales per year, rising from 4 percent in 2009 to 15 percent in 2020, 25 percent in 2030, etc. In addition, a certain percentage (to be determined by DOER) of renewable energy will have to be obtained from new on-site generation (such as wind turbines, solar installations, biomass generators installed principally to meet the electricity needs of a home, business, or institution) less than 2 MW in size. The legislation also creates a Class II of renewable energy resources subject to minimum mandatory procurement, with the Department of Energy Resources specifying the level of the requirement. Class II includes generating sources that began commercial operation prior to Dec. 31, 1997 from a variety of renewable energy sources, including solar, wind, ocean; fuel cells; landfill gas; small hydroelectric facilities that meet certain standards; waste-to-energy; low-emission biomass; and geothermal. Waste-to-energy facilities are considered Class II renewable sources only if they are located in Massachusetts and operate or contract for recycling programs, with at least 50 per cent of any revenue from Renewable Energy Certificates allocated to recycling.

Alternative Energy Portfolio Standard: Creates a new alternative portfolio standard that includes gasification, flywheel storage, plasma gasification, combined heat and power, any facility that substitutes its fossil fuel source with an equal or greater amount of alternative paper-derived fuel source approved by DEP, energy efficient steam technology, or any other technology approved by DOER. This section requires that coal gasification technology must have the ability to permanently capture and sequester carbon and that DOER shall set emission performance standards and the required procurement level.

Siting Commission: Establishes an Energy Facilities Siting Commission to examine opportunities to maximize the development of clean and renewable generating facilities in the Commonwealth.

Steam: Gives DPU oversight of steam distribution companies. Authorizes the DPU to assess steam distribution companies and requires annual reports by the companies on intrastate operating revenues.

Municipal Light Companies: Allows communities with municipal light departments the option of contributing into and accessing benefits from the Renewable Energy Trust Fund.

State Building Construction: Requires DCAM to mandate that new construction or renovations of over $25,000 of facilities owned or operated by the Commonwealth utilize energy efficiency, water conservation, or renewable technologies utilizing listed criteria. Also creates a simplified process for state agencies, building authorities, and municipalities to contract for small energy efficiency and solar PV projects.

DPU Utility Oversight: Authorizes the Department of Public Utilities oversight over "holding companies" in sales/mergers – correcting a legal shortcoming that did not provide for state review of the National Grid-Keyspan merger.

Google

Testimony of Dan W. Reicher
Director, Climate Change and Energy Initiatives, Google.org

Before the Joint Economic Committee
Hearing on "Efficiency: The Hidden Secret to Solving Our Energy Crisis"
July 30, 2008

Mr. Chairman, Ms. Vice-Chair, Ranking Members and Members of the Committee, my name is Dan Reicher, and I am pleased to share my perspective on the opportunities and challenges of energy efficiency. I serve as Director of Climate Change and Energy Initiatives for Google.org, a unit of Google which has been capitalized with more than $1 billion of Google stock to make investments and advance policy in the areas of climate change and energy, global poverty and global health. At Google we have been working to lower the cost and increase the deployment of renewable energy, and to accelerate the deployment of plug-in vehicles. We have also been working to increase our use of clean power and energy efficiency at Google data centers and offices in the U.S. and other countries. Together with other technology companies and organizations, Google launched the Climate Savers Computing Initiative last year to reduce the power consumption of computers and servers.

Prior to my position with Google, I was President and Co-Founder of New Energy Capital, a private equity firm investing in clean energy projects. New Energy Capital has made equity investments and secured debt financing for ethanol and biodiesel projects, cogeneration facilities, and a biomass power plant. Prior to this position, I was Executive Vice President of Northern Power Systems, one of the nation's oldest renewable energy companies. Northern Power has built almost one thousand energy projects around the world and has also developed path-breaking energy technology.

Prior to my roles in the private sector, I served in the Clinton Administration as Assistant Secretary of Energy for Energy Efficiency and Renewable Energy, the Acting Assistant Secretary of Energy for Policy, and Department of Energy (DOE) Chief of Staff and Deputy Chief of Staff.

My message today is simple: to meet the critical challenges of the 21st Century – climate change, energy security, and economic development – we need a bold new vision for how America generates and uses electricity. The core of that vision must be a 21st Century electricity system that is clean, efficient, reliable and secure. Such a system must:

- Drive the development and optimization of renewable energy generation and related transmission;

- Encourage utilities to reduce peak loads, institute real-time pricing, and advance demand-side management;

- Empower and incentivize businesses and consumers to monitor and reduce their own energy use; and

- Enable the electrification of vehicles - including vehicle-to-grid capabilities - without a major increase in new generation.

Energy efficiency is fundamental to the changes we must make in our energy system. By many measures, it is our fastest, cheapest and cleanest opportunity to address our energy challenges – the real low-hanging fruit in the U.S. and global economy. From cars and homes to factories and offices, we know how to cost effectively deliver vast quantities of energy savings today. And the exciting fact is that this low hanging fruit grows back. The air conditioner we replace today with a more efficient model, we will be able to replace again with one that uses even less energy and "talks" to the electric grid to better manage peak electricity demand. Similarly, we can trade our inefficient SUV today for a more efficient full-featured hybrid gas-electric model. And down the road we will replace the hybrid with an even more efficient model that plugs into the electric grid.

We have made an important transition in this country away from a focus on "energy conservation" and toward the more recent concept of "energy efficiency" (or "energy productivity"). In the era of energy conservation in the 1970's and 1980's, we were asked to "do less with less" – to lower the thermostat, turn off the lights, don a sweater and leave the car in the garage. Energy efficiency takes a different approach, offering the opportunity to "do more with less". As McKinsey and Company stated in a 2007 report, "By looking merely in terms of shrinking demand, we are in danger of denying opportunities to consumers – particularly those in developing economies who are an increasingly dominant force in global energy-demand growth. Rather than seeking to reduce end-user demand – and thus the level of comfort, convenience and economic welfare demanded by consumers – we should focus on using the benefits of energy most productively." As energy guru Amory Lovins puts it: "All people want is cold beer and hot showers. We are interested in the results of energy use, not the energy itself. How much energy we use to cool the beer and heat the water is a choice we make."

The increasing interplay between energy hardware and information software – and the corresponding rise of the Internet and the connectivity it brings – adds to the potential to make and to use energy more productively. From smart meters and smart appliances to smart homes and a smart grid, we are poised to significantly advance our ability to monitor and manage energy. As one commentator recently put it, we are "moving from odometers to speedometers," from an after-the-fact record of our energy use to real-time metering and intelligent response.

The main finding of the 2007 McKinsey report is that while energy demand will continue to grow, "there are sufficiently economically viable opportunities for energy-productivity improvements that could keep global energy-demand growth at less than 1% per annum – or less than half of the 2.2% average growth to 2020 anticipated in our base-case scenario." This would

cut global energy demand by the equivalent of 64 million barrels of oil per day, or almost 150 percent of today's entire U.S. energy consumption.

As McKinsey recognizes, we can gain energy-productivity improvements either from reducing the energy inputs required to produce the same level of energy, or from increasing the quality or quantity of economic outputs. The report concludes that globally the largest untapped potential for cost-effective energy productivity gains (>10% Internal Rate of Return) lies in the residential sector (e.g. better building shells and more efficient water heating and lighting), power generation sector (e.g. more efficient power plants and electricity distribution) and industrial sector (e.g. less energy-intensive oil refineries and steel plants).

However, McKinsey also rightly recognizes that capturing this vast potential will require a significant policy push. The inefficiencies working against energy productivity include market-distorting subsidies, information gaps, and agency issues. Acknowledging that "the small share of energy costs for most businesses and consumers reduces end-use response to energy-price signals," McKinsey recommends that "shifting global energy demand from its current rapid growth trajectory will require the removal of existing policy distortions; improving the transparency in the usage of energy; and the selective deployment of energy policies, such as standards."

As we consider this policy dimension, we also need to consider how to harness an important and encouraging new trend – the unprecedented flow of private capital into clean energy in the past few years from major banks, pension funds, insurance companies and venture capital firms. Much of this increasing investment in technologies and projects has been on the supply side involving key technologies like solar, wind, and biofuels. Less investment has found its way to commercializing or deploying energy efficiency technologies despite their cost-effectiveness and reliability. Aggressive federal policy can make a major difference in the deployment of energy efficiency by increasing the attractiveness of investment, from early stage venture capital investment in the development of high risk technology to the financing of large-scale projects.

A new McKinsey study from February of this year makes clear the attractive economics and climate benefits of investments in energy efficiency. McKinsey concludes that additional investments of $170 billion annually for the next thirteen years would be sufficient to capture the energy productivity opportunity identified in the 2007 report – i.e. cutting projected global energy demand to 2020 by at least half. While this sounds daunting, according to McKinsey, these investments – made in the industrial, commercial, residential, and transportation sectors – would have an average annual internal rate of return (IRR) of 17% and would collectively generate annual energy savings ramping up to $900 billion by 2020. Importantly, McKinsey also concluded that these investments could deliver up to half of the abatement of global greenhouse gases required to cap the long-term concentration in the atmosphere to 450 to 550 parts per million. And according to McKinsey, we would also avoid investment in energy generation infrastructure that would otherwise be required to keep pace with accelerating demand. The International Energy Agency estimates that on average an additional $1 spent on more efficient electrical equipment, appliances, and buildings avoids more than $2 in investment in electricity supply. The report quotes Chevron CEO David O'Reilly who recently said that energy efficiency is the cheapest form of new energy we have.

I should emphasize that by moderating demand growth through energy efficiency, and at the same time increasing clean generation using renewable sources, we can slow and begin to decrease carbon emissions while we work to adopt and implement a comprehensive approach to addressing climate change and our nation's energy security. The Administration and Congress should pay careful attention to this complementary strategy involving both energy efficiency and renewable energy as an important down payment on reducing carbon emissions, while advancing the more complex agenda involved in enacting and implementing an economy-wide climate and energy security policies.

Federal Policies to Increase Investment in Energy Efficiency

The federal government has the power to stimulate vastly more private sector investment in energy efficiency and thereby dramatically increase U.S. competitiveness, improve national security, and confront climate change. There is a broad range of federal policies that can increase investment in energy efficiency including standards, tax credits, R&D funding, procurement and financial support mechanisms. Below I outline a number of the most promising approaches.

Automobile Fuel Efficiency – The Role for Plug-in Vehicles

Since its adoption in 1975, the Corporate Average Fuel Economy requirement (CAFE) has cut U.S. oil consumption by over 1 billion barrels each year. Even with this progress, passenger vehicles today consume approximately 40% of the petroleum in the United States – with the transportation sector projected to generate 89% of the growth in petroleum demand through 2020. In late 2007, federal energy legislation requires that automakers boost fleet-wide gas mileage to 35 mpg by the year 2020 for all passenger automobiles, including light trucks.

This increase in CAFE standards is a definite step forward, but we can do even better. Existing technologies – hybrid electric automobiles, drive train improvements, lighter weight materials – can today get us to roughly double the mileage of our current passenger fleet. Perhaps the most exciting technological development has been the recent emergence of plug-in hybrids – a technology that will enable us to exceed any fuel economy proposals under consideration at this time. Plug-in hybrids have a more powerful battery than traditional hybrids and are designed to be connected to the electric grid for recharging. This allows the vehicle to cut gasoline use and, if charged at night, use lower cost and cleaner off-peak electricity. These cars could also benefit electric utilities when plugged in during the day by sending power back to the grid to meet peak power needs, thereby supplanting some of the most costly and often most polluting power generation. According to some analysts, this benefit could be worth hundreds or even thousands of dollars per year per car, a value that could exceed the incremental cost of the vehicle's more powerful battery.

By increasing vehicle use of electricity over liquid fuels, we should have an easier time improving the environmental profile of our automotive fleet. In addition, plug-in hybrid vehicles enabled to run on biofuels can further reduce greenhouse gas emissions and oil consumption. The bottom line is that plug-in hybrids – and down the road all electric vehicles – have the

potential to dramatically reduce America's oil dependence, improve our national security, and help fight global warming.

Google.org's RechargeIT initiative is working to accelerate the commercialization of plug-in vehicles and the widespread adoption of vehicle-to-grid (V2G) technology. We have created our own demonstration plug-in fleet at Google, involving converted Ford Escapes and Toyota Priuses, and made more than $1 million in grants to support the adoption of plug-ins. Last week we announced the initial round of several investments in companies whose innovative approach, team, and technologies will enable widespread commercialization of plug-ins.

Our RechargeIT initiative recently conducted a driving experiment with plug-ins from our fleet to see how well they performed against standard cars. Using a variety of vehicles, professional drivers, and driving routes representing typical trips for U.S. drivers, we conducted a series of controlled tests over seven weeks. Our plug-ins achieved as much as 93 mpg on average for all trips and 115 mpg for city trips. See www.rechargeit.org for more details.

Public policy will also play a crucial role in driving innovation and commercializing new plug-in technologies. In June we co-hosted a conference with the Brookings Institution to showcase plug-ins and explore the role that government can play in accelerating their commercialization. Members of Congress, auto and utility executives, and technology experts discussed the promise of plug-ins and the need for government leadership. We hope that discussions at the conference – along with a serious of policy papers we commissioned with Brookings that will be released later this year – will lead to specific and actionable policy solutions. At a minimum, we believe the following measures are needed:

- **Funding for federal research and development** - Federal R&D support is key to driving development of new technologies. We must further develop power management devices, grid integration technologies, and better batteries to increase the range and efficiency of plug-in vehicles. The federal government can play a critical role in helping to accelerate the necessary R&D efforts.

- **Investment in infrastructure** - Putting millions of plug-in cars and trucks on the road will require deployment of recharging stations and new power management hardware and software. The U.S. government should start investing in and incentivizing the infrastructure necessary to support this transformation.

- **Financial incentives to spur adoption** - Federal tax credits jump-started the mass market for hybrid technology. A comparable set of incentives for initial marketability of plug-in vehicles could similarly boost the momentum and mass market availability of plug-ins.

- **Federal procurement** - The federal government should procure large numbers of plug-in vehicles for the federal fleet and develop related charging infrastructure.

- **Modernized regulatory system** - Reform of current utility rate design in many states will permit real-time pricing of electric power, which will assist consumers in choosing to

recharge during off-peak periods.

- **Uniform data protocols** - The U.S. government should foster national uniform data collection and publication protocols for electric vehicles and V2G, including miles per gallon, standards, tailpipe emissions and carbon reductions.

Energy Efficiency Resource Standard (EERS)

Congress should establish a mechanism called the Energy Efficiency Resource Standard (EERS) that would set efficiency resource targets for electricity and gas suppliers over a given period of time. It builds on policies now in place in nine states – California, Texas, Vermont, Connecticut, Nevada, Hawaii, Pennsylvania, Colorado, and most recently, Massachusetts – designed to cut the growth in electricity demand through energy efficiency. The Texas and Vermont policies have been implemented for several years and have been very successful. Texas utilities, for example, are required to meet 10% of their load growth needs through efficiency programs. Utilities are easily exceeding this target. Vermont created an energy efficiency utility that has helped the state in recent years meet more than two thirds of load growth (typically 1.5 to 2% per year) through energy efficiency and the state is on a path to avoid all load growth in the near future.

Under the proposed federal EERS, suppliers would obtain energy savings from customer facilities and distributed generation installations in amounts equal to at least 0.75% of base year energy sales for electricity and 0.50% for natural gas. This requirement would be phased in over three years and would cumulate during the compliance period of 2008-2020. The requirement would apply to retail suppliers (local distribution utilities or competitive energy suppliers) who sell annually at least 800,000 megawatt hours of electricity or 1 billion cubic feet of natural gas.

Eligible energy savings measures include efficiency improvements to new or existing customer facilities, distributed energy technologies including fuel cells and combined heat and power systems, and recycled energy from a variety of defined commercial and industrial energy applications. Savings are determined using evaluation protocols that can be defined by DOE, with state protocols available that the Department can build on.

Suppliers may obtain and trade credits for energy savings under procedures to be defined by DOE. This will enable suppliers with energy savings beyond the requirements of the standard to sell them to suppliers unable to obtain sufficient savings from their customers within a given compliance period.

Integrated EERS and RPS

The EERS is a compelling complement to a national Renewable Portfolio Standard. EERS moderates demand growth so that RPS targets can actually reduce fossil fuel consumption. The RPS provision the Senate supported in 2005 calls for 10% of U.S. electricity generation to be generated from non-hydro renewable energy sources in 2020. However, the Energy Information Administration forecasts electricity demand to grow more than 22% by 2020. So bringing down demand growth is crucial to reducing overall fossil energy consumption and carbon emissions. The EERS proposal, as analyzed by the American Council for an Energy Efficient Economy,

would reduce 2020 peak electricity demand by about 10% or about 133,000 MW – equivalent to almost 450 power plants at 300 MW each. This would bring demand growth down to a level where a 10% RPS could meet all new electricity generation needs. ACEEE also estimates that by 2020, this provision will reduce natural gas needs by about 2 billion cubic feet, reduce CO_2 emissions by more than 340 million metric tonnes, and result in cumulative net savings to electricity and natural gas consumers of about $29 billion. Moving to a 15% or 20% RPS level, as proposed in bills in 2007, would further accelerate the move to a less carbon-intensive electricity system.

These two policies, EERS and RPS, figure prominently in a 2007 report that explores the synergies between energy efficiency and renewable energy. It was prepared by the American Council for an Energy Efficient Economy and the American Council on Renewable Energy and supported by the Rockefeller Brothers Fund. Calling energy efficiency and renewable energy the "twin pillars" of sustainable energy policy, the report emphasizes that both resources must be developed aggressively if we are to stabilize and reduce carbon dioxide emissions in our lifetimes.

Energy efficiency and renewable energy offer a highly complementary approach to managing the challenges of the U.S. power sector in the coming decades. Efficiency is essential to slowing energy demand growth so that rising clean energy supplies can make deep cuts in fossil fuel use. If energy use grows too fast, renewable energy development will chase a receding target. Likewise, unless clean energy supplies are deployed rapidly, slowing demand growth will only begin to reduce total emissions; reducing the carbon content of energy sources is also needed.

By moderating demand growth through an EERS and increasing clean generation through an RPS, we can slow and begin to decrease carbon emissions in the utility sector, while we work to adopt and implement a comprehensive cap-and-trade system. Policymakers should give strong consideration to this EERS-RPS approach as a straightforward down payment on reducing carbon emissions, while deliberating the more complex issues entailed in enacting and implementing an economy-wide climate policy.

Appliance Efficiency Standards

One of the nation's least-heralded energy success stories involves federal appliance efficiency standards. In the last 15 years, Congress and the Department of Energy have set new standards for a number of products. Refrigerators sold since 2001 in the U.S. use just one-third the energy of comparable models sold in 1980. Home air conditioners are nearly twice as efficient as those sold in 1980.

Standards in place today will save American families and businesses about $200 billion cumulatively by 2020, cutting electricity demand and carbon emissions substantially. The standards for the sixteen products in the Energy Policy Act of 2005 will save another $50 billion, and will cut carbon emissions by another 16 million tons in 2020.

Unfortunately, DOE has issued only three new appliance efficiency standards in recent years. In the settlement of litigation brought by states and environmental groups, DOE agreed in 2006 to a

schedule for issuing all 22 overdue standards by 2011. Congress should ensure that DOE has the funds to conduct the necessary analysis, that the Department stays on schedule, and that it adopts rigorous final standards. Indeed, recent standards are not models of great rigor: the standard for furnaces can be met by virtually all existing products on the market; the one for boilers rejected a tougher joint proposal by manufacturers and advocacy groups; and the one for distribution transformers rejected a significantly more stringent recommendation from the electric utility industry itself.

Tax Credits for Efficient Buildings

The Energy Policy Act of 2005 (EPACT) provided important tax incentives for efficient buildings and equipment, in addition to significant support for renewable energy and other advanced energy technologies. Most of the energy efficiency incentives, however, expired at the end of 2007. Legislation introduced by Senators Snowe and Feinstein, called the EXTEND Act (S. 822), would have extended and expanded these building-related incentives. These provisions, however, were not ultimately adopted in 2007 federal energy legislation. In February 2008, the House passed $18.1 billion in renewable energy tax incentives (H.R. 5351), including an extension of the tax credits for energy-efficient home improvements. The Senate has also taken up tax credit extensions. These tax credit packages, however, are still pending.

Commercial buildings and large residential subdivisions have lead times for planning and construction of several years, so many businesses will refrain from making investments to qualify for tax incentives if the duration of the incentive is only two years. The EXTEND Act provides four years of assured incentives for most situations and some additional time for projects with particularly long lead times, such as commercial buildings.

Significantly, the EXTEND Act also phases out incentives based on the cost incurred in saving or producing energy and replaces them with incentives based on the actual performance (measured by on-site ratings for whole buildings and factory ratings for products like air conditioners, furnaces, and water heaters.) The legislation provides a new home retrofit tax incentive for ambitious levels of energy savings that are verified by a third-party rater.

The bill is intended to transition from the EPACT 2005 retrofit incentives, which are based partially on cost and partially on performance, to a new system that provides greater financial incentives based on performance. These larger incentives should not cost the Treasury more because the ambitious requirement of a minimum 20% savings will effectively eliminate free-ridership, which is the problem that caused the current EPACT incentives to be scored as high as they were.

The Snowe-Feinstein bill also extends the applicability of the EPACT incentives so that the entire commercial and residential building sectors are covered. The current EPACT incentives for new homes are limited to owner-occupied properties or high rise buildings. The Snowe-Feinstein bill extends these provisions to rental property and offers incentives whether the owner is an individual taxpayer or a corporation. This extension does not increase costs significantly, but it does provide greater fairness and clearer market signals to builders and equipment manufacturers.

GDS Associates estimates that if the EXTEND Act had been adopted, the two-year EPACT incentives plus the additional EXTEND incentives, over the 2006-2020 timeframe, would have reduced U.S. natural gas use by about 4.65 trillion cubic feet (almost enough to serve California and New York for a year), decrease consumer energy bills by about $93 billion, and avoid 657 million metric tons of carbon dioxide (equivalent to 142 million passenger cars not being driven for one year). GDS also estimates that EXTEND would have reduced peak electric demand by about 15,500 megawatts by 2020 (equivalent to 52 power plants of 300 MW each).

Low Income Home Weatherization

Across the nation, poor families increasingly face the choice between heating and eating as prices for natural gas, heating oil, propane and electricity have risen and millions of Americans have found themselves spending more than one-quarter of their income to run their furnaces, air conditioners and keep the lights on. In a survey of low income families – before the energy price spike in 2005-2006 as well as more recent ones – 32% went without medical or dental care, 24% failed to make a rent or mortgage payment, and 22% went without food for at least one day due to energy bills.

Congress continues to debate the traditional fix for this problem: additional funding for the Low Income Home Energy Assistance Program (LIHEAP). LIHEAP is essentially a one-shot buy-down of energy bills that covers a modest percentage of eligible families – an absolutely critical but in no way sufficient answer to our nation's energy predicament. Together, federal and state fuel assistance funds provided less than 10% of the total energy costs for low income households in 2006 and even less today.

A long-term answer for low-income families is home weatherization. By upgrading a home's furnace, sealing leaky ducts, fixing windows, and adding insulation we can cut energy bills by 20-40% – and the substantial savings accrue with summer air conditioning as well as winter heating. And by adding energy efficient appliances and lighting the savings are even greater. Replacing a 1970's refrigerator with a new energy efficient model will cut an average home electricity bill by 10-15%. Weatherizing low-income homes also improves comfort, reduces illness and creates jobs.

Unfortunately, the benefits of low-income weatherization are not reflected in our national policies. There was about $245 million in the 2006 Department of Energy weatherization budget, enough for only about 100,000 U.S. homes. DOE proposed reductions in subsequent years and actually called for zeroing out weatherization in the 2009 budget. And while the nation has weatherized about 6 million low-income homes since 1976, more than 28 million remain eligible.

Congress should make a national commitment to weatherize at least one million low-income homes each year for the next decade. This approach would go a long way toward helping the most vulnerable among us. The price tag for retrofitting 10 million low-income homes is relatively modest – about $2 billion annually when fully implemented.

With such a commitment there would be other benefits that directly address our current energy and environmental challenges. Stresses we are seeing today on the U.S. energy system – from blackouts to natural gas shortages – will be improved with every additional home weatherized. For example, weatherizing all the low-income homes that heat with natural gas would cut residential U.S. use of this fuel by about 5%, dampen its price volatility and reduce the call on federal fuel assistance funds.

The advanced technologies pioneered in the federal low income weatherization program can also be readily applied to the U.S. housing stock at large – with even greater energy savings. One technology developed in the Department of Energy weatherization program uses a pressurization device and a simple infrared sensor to pinpoint leaks down to the size of a nail hole for about $100 per home. With this information insulation can be installed in the right places with the least amount of waste.

As we cut energy demand we also cut air pollution. An Ohio study showed that weatherizing 12,000 homes not only cut the average consumer bill by several hundred dollars each year but also avoided annual emissions of 100,000 pounds of sulfur dioxide as well as 24,000 tons of carbon dioxide. As Congress considers changes to the Clean Air Act we ought to create an effective way to encourage investment in weatherization and other "downstream" pollution reduction opportunities. This could leverage substantial additional private sector capital for low-income weatherization and avoid the need for new power plants.

For example, one approach would:

- Aggregate thousands of homes eligible for weatherization in a locality;
- Establish a base-line of energy use as well as associated greenhouse gas and other emissions across the portfolio of homes;
- Install advanced metering to monitor post-investment savings as well as provide utility load control;
- Secure federal and state funding as well as carbon off-set, pollution credits, and utility capacity payments;
- Leverage private sector investment in the aggregated portfolio through a "shared savings" approach or other financial mechanism; and
- Benchmark the investment to enhance replication.

There may also be an opportunity to provide an extra incentive or credit in the Energy Efficiency Resource Standard for investment by an electricity or gas supplier in low income home weatherization.

Federal R&D Funding

Research and development is essential to supplying the "technology pipeline" we need to provide this Century's clean energy and energy independence solutions. Unfortunately, R&D on energy efficiency, as well as other energy technologies, has been falling and did not return to FY2002 levels until FY2008. Total federal spending remains far below the peak of investment that occurred in the 1970s. And the private sector has not yet picked up the slack; efficiency funding in the electricity and gas industries has fallen even faster than federal investment. Some states, like California, Iowa, Wisconsin, and New York, are trying to make a real difference, but their work is no substitute for federal support. Congress should ensure that adequate funds are appropriated to advance critical clean energy and energy independence R&D.

Government-Backed Financial Mechanisms

There are a variety of government-backed financial mechanisms that could be of significant help in dramatically increasing the deployment of clean energy technologies, including energy efficiency. Senator Bingaman recently introduced S. 3233 which would increase the willingness of banks to make loans for clean energy projects by providing a secondary market for their loans through the 21st Century Energy Deployment Corporation. And in March Senator Domenici introduced S. 2730, the Clean Energy Investment Bank Act of 2008, creating a federal investment bank to make investments in eligible clean energy projects using a variety of tools including loans, loan guarantees, purchase of equity shares, and participation in royalties, earnings and profits. The bank builds from the loan guarantee program authorized by Congress in EPACT 2005, which DOE administers but has yet to back any loans.

At a recent hearing before the Senate Committee on Energy and Natural Resources, I testified in support of Senate efforts to greatly increase the debt capital available for clean energy projects, particularly for early higher risk commercialization projects that often have trouble raising capital and frequently perish in what has come to be known as the "Valley of Death". I urged Senators Bingaman and Domenici to integrate the best aspects of their two bills and thereby provide important mechanisms that will stimulate the massive private sector investment required to take clean energy technologies to scale. We also supported efforts in Senator Bingaman's bill to develop debt instruments that aggregate smaller clean energy technology deployment projects. This could be particularly helpful to an array of energy efficiency projects which tend to be smaller but often share enough characteristics to be aggregated into larger financeable packages.

State Building Codes

California has demonstrated the significant efficiency gains that can be achieved through state building codes that are well designed and implemented. Title 24 of the California Code has been the national model, helping the state avoid thousands of megawatts of new generation capacity. Despite this impressive track record in California, many states have inadequate state building codes or none at all.

Section 128 of the 2005 Energy Policy Act authorizes $25 million per year for FY2006-FY2010 ($125 million total) for states that have adopted, and are implementing, both residential and commercial building energy-efficiency codes that meet or exceed specific standards. For states where there is no statewide code, the money will be allocated to local governments that have

implemented codes that meet the above standards. Unfortunately, the funding authorized in the 2005 EPACT for state building codes was never appropriated by Congress and therefore this important incentive for adoption of state building codes has not been implemented. Congress should appropriate the funds authorized in the 2005 EPACT.

Utility Revenue Decoupling

The National Action Plan for Energy Efficiency (http://www.epa.gov/cleanrgy/actionplan/eeactionplan.htm) provides joint recommendations from federal agencies, states, the utility industry and environmental groups regarding energy efficiency. One area of focus in the report is the concept of "revenue decoupling". This approach, first instituted in California and most recently ordered in Massachusetts, decouples sales from profits, so that electric and gas utilities do not have a disincentive to promote energy efficiency. The current "throughput" incentive (the more electricity or gas a utility sells, the more it earns) is a significant impediment to energy efficiency. As state utility commissions work to advance decoupling, Congress and the Administration (especially FERC and DOE) should consider further incentives to promote energy efficiency. One important federal role would be to promote "best practices" and provide technical assistance to interested parties to facilitate energy efficiency.

Conclusion

The federal government has a significant role to play in increasing investment in energy efficiency. By adopting a set of policies similar to those outlined above, the federal government can stimulate significant near-term investment in energy efficiency with substantial reductions in energy use and major economic, environmental and security benefits.

Thank you for the opportunity to testify today. I look forward to answering any questions to assist this Committee in its important examination of energy efficiency.

Testimony of Jonathan Koomey, Ph.D.

Project Scientist, Lawrence Berkeley National Laboratory and

Consulting Professor, Stanford University

Before the Joint Economic Committee of the United States Congress

For a hearing on

Efficiency: The Hidden Secret to Solving Our Energy Crisis

106 Dirksen Senate Office Building

Washington, DC 20510

July 30, 2008

SUMMARY

This testimony responds to an invitation from the Joint Economic Committee of the U.S. Congress to explore the potential contribution of cost-effective energy efficiency investments to solving the current energy crisis.

This hearing comes at a propitious time. By July 2008, the acquisition cost of imported crude oil to the U.S. had increased eleven-fold in inflation-adjusted terms from its most recent low in December 1999 (based on Energy Information Administration data), and other energy prices have been increasing as well. We depend increasingly on oil imports from unstable parts of the world, and the world's fossil fuel consumption is (with more than 90% probability) warming the globe (according to the latest reports from the Intergovernmental Panel on Climate Change). Various analysts and political leaders have advocated increasing the supply of energy through expanded offshore oil drilling, more construction of power plants, and increased production of alternative fuels, some of which surely is necessary to meet the joint challenges of oil dependency and climate change. But there has been remarkably little focus (relative to the vast potential) on America's secret energy surplus, "energy production" from innovation in the efficient end-use of energy.

In the three decades since the energy crises of the 1970s we've learned a great deal about the potential for energy efficiency and the means to deliver it cost effectively and reliably. Back then, many analysts still held to the now discredited "ironclad link" between energy use and economic activity, which implied that any reduction in energy use would make our society less wealthy. Now we know that there are many different ways to produce a dollar of GDP using current technologies, some energy efficient and others not. We know that the available efficiency resources are enormous and largely untapped. We know that markets, while generally the best way to provide goods and services, can fail in ways that can be fixed by clever policy choices and business incentives, resulting in lower energy use and a total cost to society (including the implementation costs of those efficiency policies and programs) that is less than that of preserving the status quo. We also know that making efficiency profitable for business is one of the fastest ways to make it happen, although sometimes incentives, government mandates, and other programs are required. Finally, we know that increasing energy efficiency is a question of innovation, not just in technology but also in institutional arrangements and incentives, and if we're fast and smart about it, that innovation can result in direct economic savings to our economy and products and services that we can sell overseas, generating even more economic activity right here in the U.S.

INTRODUCTION

My name is Jonathan Koomey. I'm a project scientist with Lawrence Berkeley National Laboratory and a Consulting Professor at Stanford University. This testimony represents my own professional opinion and in no way represents the views or positions of Lawrence Berkeley National Laboratory, the Department of Energy, or Stanford University.

Given the title of this hearing and recent events, I take it as a given that we are experiencing an energy crisis. The question is: what can and should we do to address this crisis?

What I'd like to make clear today is that energy efficiency is an essential part of the solution. It is the fastest, cheapest, cleanest way to address the problems of oil dependency and climate change.

Since the energy crises of the 1970s we have learned a great deal about the potential for energy efficiency and the means to deliver it cost effectively and reliably:

First, energy efficiency is the key to growing our economy while using less energy in the process.

Second, the available efficiency resources are enormous and largely untapped.

Third, while markets are generally the best way to provide goods and services, they can fail in ways that result in the waste of (or the inefficient use of) our energy resources. Clever policies and programs can fix these failures and reduce energy use at a cost that is less than that of doing nothing.

Fourth, making efficiency profitable for business is one of the fastest ways to improve energy efficiency, although sometimes incentives, government mandates, and other programs are required.

Finally, improving the efficiency of energy use depends on innovation, not just in technology but also in institutional arrangements and incentives. If we're fast and smart about it, that innovation can result in products and services that generate increased economic activity right here in the U.S.

In short, we can use our country's ability to innovate to substitute for using and importing energy resources – an effort that will leave our economy and the environment richer in the end.

BACKGROUND AND EXPERIENCE

I led the energy forecasting group at Lawrence Berkeley National Laboratory for more than eleven years (from 1991 to 2002) and I've been working on evaluating alternative energy futures for more than two decades. I was a central participant in five of the most

important and comprehensive energy policy studies to be conducted during the past twenty years:

1) The *Energy Policy in the Greenhouse* study of European options for reducing carbon emissions, conducted by the International Project for Sustainable Energy Paths for the Dutch Ministry of Environment, with books and reports released over the period 1989 through 2001 (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11).

2) A detailed multi-year analysis of the economics of reducing carbon emissions in the New England electric utility sector, conducted by Lawrence Berkeley National Laboratory and completed in 1992 (12, 13).

3) The first "Five labs" study completed in 1997, conducted by five Department of Energy National Laboratories (Argonne National Laboratory, National Renewable Energy Laboratory, Lawrence Berkeley National Laboratory, Oak Ridge National Laboratory, and Pacific Northwest National Laboratory). This study focused on options for reducing U.S. carbon emissions (14, 15, 16).

4) The second "Five labs" analysis, completed in 2000-2001, known as the "Clean Energy Futures" Study, which still stands as the most detailed, authoritative, and comprehensive scenario analysis ever undertaken of U.S. energy futures (17, 18, 19, 20, 21, 22, 23, 24).

5) The "Winning the Oil Endgame" study conducted by Rocky Mountain Institute and released in September 2004. This study focused on options for reducing and eventually eliminating oil dependence in the U.S. (25)

Energy efficiency played a central role in all of these studies, as did energy supply technologies. We'll need both if we're to reduce oil dependency and greenhouse gas emissions significantly.

WHAT DO WE MEAN BY EFFICIENCY?

People don't care about energy use, they care about the services that energy delivers, like warm rooms, cold drinks, and well-lit garages. Efficiency means delivering the same services using less energy. Cost-effective efficiency means that the total societal cost for delivering those services with the efficient technology installed (including all capital, operating, pollution, and program implementation costs) will be less than that for keeping things the way they are now.

Cost effective from society's perspective is not the same thing as cost effective from the individual's perspective. The transaction costs and information costs associated with a consumer buying an efficient product instead of an inefficient one are real societal costs. But just because consumers face those costs doesn't mean those costs can't be reduced or eliminated by policy action. For example, the Energy Star label, which is awarded by the U.S. Environmental Protection Agency and U.S. Department of Energy to products that will both save money and reduce pollution, is a voluntary collaboration between government and industry <http://www.energystar.gov>. That label helps consumers, who

no longer need to do any calculations to figure out which products are worth buying—they just look for the label. And minimum efficiency standards overcome the transaction costs issue by simply eliminating the inefficient products from the market, doing so in a way that does not apparently reduce features or affect costs significantly, at least for refrigerators, one of the earliest products to be regulated in this fashion (26).

As long as programs are based on rigorous cost/benefit analyses (as these are) then society will become more efficient as a result, both in energy and economic terms. And that is the goal of increasing efficiency—to improve societal well being while also improving environmental quality.

HOW COME PEOPLE DON'T BUY EFFICIENCY ANYWAY?

An economist and an engineer are walking down the street. The engineer sees a $20 bill and says "Look, a $20 bill!" The economist says "That's impossible. If a $20 bill had been on the street, somebody would have picked it up already." That joke more or less frames the historical debate on this topic.

People have known for a long time that consumers and institutions don't invest in efficiency options that seem to be cost effective, creating what is known in the literature as "the efficiency gap" or "the efficiency paradox" (2, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45). This issue has in the past been portrayed as a conflict solely between engineers and economists, with the engineers arguing for the existence of cost effective efficiency based on their experience with technologies in the field, and the economists arguing against it based on economic theory. That characterization is no longer accurate. The conflict is really among economists (with the engineers supplying supporting data and evidence), with many economists now realizing that the simple models on which their initial skepticism is based do not accurately characterize the phenomena they claim to describe.

Some of the most interesting recent work in economics has focused on transaction costs, information costs, information asymmetries, misplaced incentives, cognitive failures, differential risk aversion, principal-agent problems, path dependence, and increasing returns to scale (2, 39, 40, 46, 47, 48, 49). These issues dominate people's choices about energy efficiency, and they are in many cases amenable to policy action, which in my view is where the answer to the paradox lies.

So that $20 bill on the sidewalk might be better characterized as 2000 pennies, as Florentin Krause points out. And the policy instruments like Energy Star labeling are equivalent to giving the engineer better glasses to help her to see the pennies and a broom and dustpan to help her sweep them up. But just how many pennies are there, and what will it take to put them in the bank?

THE SIZE AND COST OF THE AVAILABLE RESOURCE

It is no longer credible to claim, based on economic theory, that there is no cost effective efficiency to be tapped. The real questions are "Just how much efficiency can be cost-effectively captured, and how much will it cost?" These questions are ultimately

empirical ones that can only be answered precisely by actually attempting to implement efficiency and evaluating the results, but the findings from analytical and evaluation studies of previous programs are encouraging.

In a world in which perfect markets prevail, the business-as-usual or base-case forecast includes all cost-effective efficiency improvements. If there are market imperfections that inhibit the adoption of energy efficiency (as there often are), then an additional potential for savings may exist. This potential can be characterized in a "technical" or "techno-economic" fashion. The techno-economic potential gives the costs and savings possible if all possible and cost-effective options are implemented starting immediately, gradually replacing existing equipment through the end of the analysis period (50). It captures the dynamics of stock turnover and generates reasonable upper bound efficiency potential estimates for end-uses where the technologies and dynamics are well understood.

Estimating such potentials requires detailed knowledge of how energy is used in particular end uses, as well as the cost and effectiveness of different technologies to reduce that energy use. The techno-economic potential is characterized by calculating a cost of conserved energy (CCE, in cents per kWh of electricity, dollars per barrel of crude oil, or dollars per gallon of gasoline) and an energy savings for each measure, relative to the base case.

In the real world, policies and programs are imperfect, so the techno-economic potential must be adjusted downwards to reflect those constraints (51). We then estimate what is termed an "achievable potential" that captures some fraction of the savings from the techno-economic potential. This "achievable fraction" is a function of the aggressiveness of policies and the time horizon of the analysis. For a longer time horizon, more equipment is retired naturally and more of the efficient devices can then be installed, thus increasing the potential savings.

There are few recent studies of the potential for efficiency in the U.S., but assessments of efficiency potentials have been conducted for more than three decades (7, 12, 14, 17, 25, 50, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66) They generally find significant cost-effective efficiency potentials in a wide variety of end-uses, although they differ on methods and exact results.

A recent analysis by McKinsey and Company (67) draws from previous energy research to focus on the potential for reducing greenhouse gas emissions in the U.S. This study estimated a significant contribution to emissions reductions from efficiency, but the report itself does not allow easy estimation of the technical details associated with those efficiency potentials.

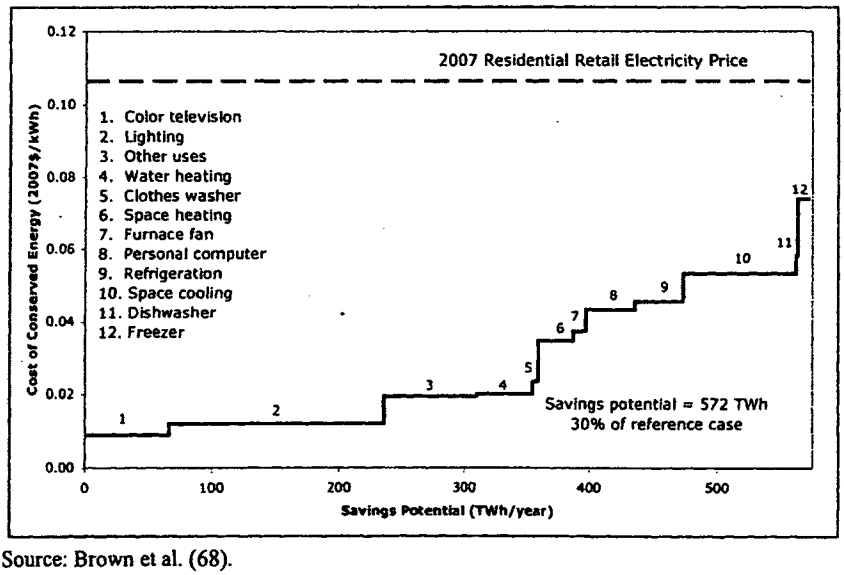
The most detailed study of efficiency potentials for buildings in the past decade was the Clean Energy Futures study (20), which estimated technical and achievable efficiency improvements by 2020. Brown et al. (68) used the CEF analysis and some simple assumptions to estimate techno-economic potential savings to 2030 relative to the Energy Information Administration's *Annual Energy Outlook 2007* (69). The Brown et al. study

found that the techno-economic potential was about one third of the base case electricity use for both residential and commercial buildings in 2030.

How much of that techno-economic potential could reasonably be captured by 2030? The original CEF study made explicit assumptions about the adoption rates for specific policies, programs, and technologies. In the CEF moderate case (which assumes only modest changes in policies and incremental improvements in technology) the achievable savings were a little more than one third of the techno-economic potential savings by the end of the analysis period, yielding a total achievable savings of about 10% relative to the base case by the end of the analysis period. In the advanced case (which included more and more aggressive programs, policies, and technologies), the achievable savings reached about half of the techno-economic potential savings by the end of the analysis period, representing a total achievable savings of about 15% of the baseline at the end of 20 years. Given a longer time horizon, much more of the techno-economic potential could be captured (and the techno-economic potential could actually increase as innovation improves the capabilities and reduces the costs of efficiency technologies).

Brown et al. (68) also assessed the economics of the efficiency investments from 2010 to 2030, based on the CEF analysis. The benefit/cost ratio for these efficiency options is about 3.5, meaning that every dollar spent on efficiency returns 3.5 dollars of savings to the economy. On average, these investments would pay for themselves in 2.5 years.

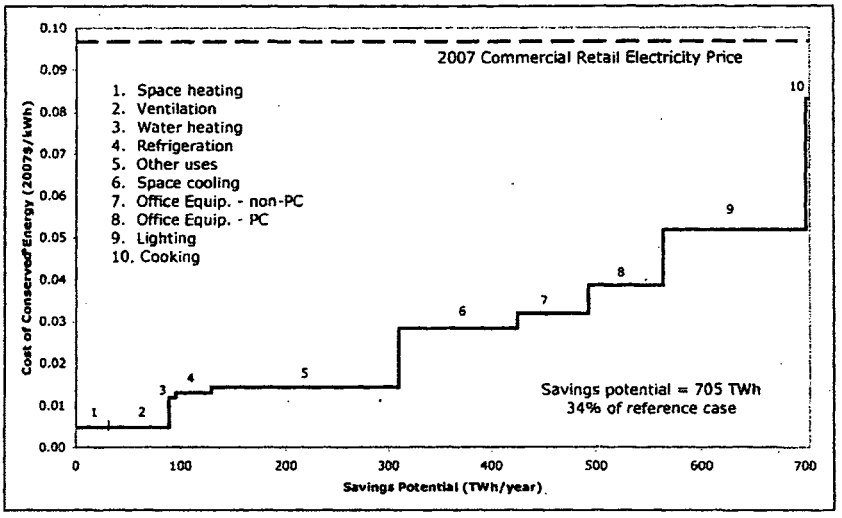
Figure 1: Residential Techno-economic Savings Potential for Electricity, 2030



Source: Brown et al. (68).

6

Figure 2: Commercial Techno-economic Savings Potential for Electricity, 2030



Source: Brown et al. (68)

The most detailed recent assessment of efficiency improvements affecting oil use is contained in Lovins et al.(25). This study estimated potential savings in U.S. oil use for two cases. The first case was termed "conventional wisdom", representing the potential savings from incremental changes using "off the shelf" technologies for all types of oil using equipment. The second was termed "state-of-the-art", which assumed "clean slate, whole systems redesign" of automobiles, trucks, planes, and other vehicles, using technologies that had been at a minimum demonstrated in prototypes by around the year 2004 (and accounting for the time needed to design and build production vehicles based on those prototypes). The conventional wisdom case showed techno-economic potential savings of about 25% compared to the 2025 baseline oil use in the Energy Information Administration's Annual Energy Outlook 2004, at a cost of conserved energy of about $6/barrel of crude oil. The state-of-the-art case showed techno-economic potential savings of about 50% compared to the base case forecast, at an average cost of conserved energy of about $12/barrel of crude oil.

At the time the "Oil Endgame" analysis was published the Energy Information Administration predicted crude oil prices in 2025 of $26/barrel in year 2000 dollars. Now, of course, that prediction looks low, and the EIA has adjusted its forecast to about $48/barrel of crude oil (2000 dollars). In either case, energy efficiency is a terrific bargain, saving society a great deal of money while also reducing oil dependence and emissions of greenhouse gases.

The historical policy experience in California (70) and the U.S. (71, 72, 73, 74) yields similar results, as does the program evaluation literature. Program evaluations are

conducted by electric utilities to understand the impacts and costs of their efficiency programs (75). Two exemplary reviews of such studies in the mid-1990s found that commercial sector utility efficiency programs were generally quite cost effective when evaluated from society's perspective (76, 77). Another analysis of commercial lighting addressed challenges to such evaluation results from the economics community and concluded that the societal cost-benefit analysis for the efficiency programs evaluated had indeed been conducted correctly (78). More recent evaluation work for California is available at <http://www.calmac.org>.

The most important point to take from these studies is that there are many untapped options available to improve efficiency of energy use, and that this energy efficiency costs a lot less than buying energy, be it oil, electricity, or natural gas. Procuring efficiency also avoids the costs and risks of oil dependency, local air pollution, and climate change in the bargain, and is faster to implement than most supply side options. The exact size of the efficiency resource is ultimately a function of how much we invest in research and development and how successful our policies and programs are at breaking down barriers to cost effective efficiency, but we know there's a lot of efficiency that's ours for the taking. So what do we need to do to capture it?

CAPTURING COST-EFFECTIVE EFFICIENCY

There are many summaries of the policies and programs needed to capture efficiency, but two of the most comprehensive ones are *Scenarios for a Clean Energy Future* (17, 18) and *Winning the Oil Endgame* (25). The *National Action Plan for Energy Efficiency* (79) gives broad recommendations for successful energy efficiency implementation, and Skip Laitner of the American Council for an Energy Efficient Economy gave some very specific recommendations recently in testimony before the U.S. Senate Committee on Natural Resources (80). There are many other reports with similar lists and I won't describe their recommendations in detail, but I summarize them here. They include both energy pricing policies (in the form of emissions trading or carbon taxes) and non-price policies, including increased effort on labels like Energy Star, minimum efficiency standards, incentives to consumers for the purchase of efficient products (positive, negative, or revenue-neutral feebates), incentives to utilities for promoting efficiency, demonstration projects for innovative technologies, prizes for achieving efficiency goals, business plan competitions for promoting startup companies, government and business procurement of efficient products, and greater research and development spending, which has fallen to historic lows from the late 1970s (81).

Pricing policies are useful in promoting supply side fuel switching, but are much less so for efficiency. A simple calculation demonstrates why. A carbon tax of $50/metric tonne of carbon (which is the level considered in the Clean Energy Futures study that led to very substantial changes in electricity supply side investments) would raise gasoline prices by about 12 cents per gallon, barely enough to notice in a world of $4/gallon gasoline. And 30-40% of building sector energy use in developed nations is afflicted by the so-called principal-agent problem, where the person buying and operating the equipment is not the same one who pays the energy bills, making those users impervious to price signals (48, 49).

So getting prices right is not enough. To achieve large efficiency improvements–that is, to stop installing wasteful designs of buildings, equipment, appliances and lighting–we'll also need non-price policies as described above, and other innovations, as described below.

WHAT KINDS OF INNOVATIONS ARE NEEDED?

The central organizing principle for research, development and incentive policies should be what Amory Lovins of Rocky Mountain Institute (RMI) calls "clean slate, whole system redesign". Instead of promoting incremental efficiency improvements, as is so often done, institutions should redesign energy intensive products from the ground up. Most technologies are the result of an evolutionary path that is heavily dependent on history. Instead, the focus should be on delivering the services that people demand with products that are just better in every way (not just more efficient, but also more desirable for their other attributes).

And innovation needs to come to institutions as well as technologies, to harness the power of business in the pursuit of efficiency. One reason why Energy Star is so successful is because the program helps make efficiency profitable—it gives companies that produce efficient products a marketing advantage over those producing the less efficient devices.

Modern companies are brilliant at replicating a proven business model on a large scale, which is one example of what economists call "increasing returns to scale" (82). Imagine if a large retailer (like Costco or Walmart) decided that they would only stock Energy Star products from now on (for those products for which a label is available). This action would create a large market for efficient products, making them widely available and turning them from niche products to those with large market share. It would put pressure on the producers of those products to reduce their prices, which would be justified because of the larger production scale that orders of that size would enable. And the markups that companies up and down the value chain formerly applied to these niche products would shift overnight to markups appropriate to products that are widely used, further lowering the price to consumers. That example shows the power of increasing returns if properly applied. We're only at the beginning of understanding and using this concept to our advantage in promoting efficiency.

Two other important institutional innovations relate to electric utility profits, which for 45 states and the District of Columbia are directly tied to electricity sales: every kilowatt-hour of electricity saved means a reduction in profits for the utility. According to the Natural Resources Defense Council, only five states as of July 2008 (CA, DE ID, MD, NY) have adopted legislation to decouple electricity sales from profits. And only five states (CA, ID, MN, WA, WI) have implemented profit incentives for efficiency investments by utilities. We know from the history in California that utilities are enthusiastic and productive efficiency investors when they make money at it. These two institutional innovations (decoupling and profit incentives for utilities) should go nationwide.

Information technology (IT) is one of our most powerful allies in the quest for efficiency (83). IT helps because moving bits is much less energy intensive than moving atoms, because it allows us to collect more and better data, and because it, more than any other technology, allows us to tap into increasing returns to scale.

Amory Lovins of Rocky Mountain Institute says "Move the electrons, leave the heavy nuclei at home". So instead of traveling to Bangalore for a planning meeting, an engineer can use modern "telepresence" technology to meet with his colleagues virtually, saving a great deal of energy, but also avoiding the wasted time, money, and human cost of international travel (84). If you've seen such a system recently (as I have), you know just how far this technology has come since the early days of video conferencing. Significant energy savings accrue because the nucleus of atoms is thousands of times more massive than the electrons carrying the information over the network.

IT also lets us collect more data and better data, which helps us make better decisions. In data centers, the high density computing facilities upon which all companies now rely, the advent of cheaper sensors and ever more powerful computing is helping people manage their costs and energy use more effectively than ever before. And more accurate data allows companies to more effectively identify and eliminate misplaced incentives that inhibit efficiency (85), because the consequences of such institutional problems become manifest more quickly.

Since the 1990s, commercial enterprises have developed and utilized computer analysis tools to manage a wide variety of risks. In contrast, investments in energy efficiency are not typically evaluated in a risk analysis, but treated much more conservatively, usually by using a simple payback analysis. Those enterprises that explicitly analyze the opportunities for energy efficiency and implement cost-effective options will benefit their bottom line (86).

IT also helps users manage data more effectively, particularly when data are released in a standardized format. For example, electric utility rates, which are now almost exclusively printed on paper, are difficult to manage for large companies with facilities in many states. The rates are complicated and they vary state-by-state and over time in unpredictable ways. If the federal government were to promote the development of a standardized electronic format for utility rates it would allow greater efficiencies in the design and energy management of facilities owned by multi-state and multi-national companies. The Lawrence Berkeley National Laboratory tariff analysis project made a first pass at creating a database of such tariffs manually <http://tariffs.lbl.gov/>, but that's a far cry from having such data released and updated automatically by each utility. A nice side effect of such standardization would be that web-based energy analysis tools could more easily evaluate utility bills for residential and smaller commercial customers as well.

One of the main reasons companies are now so good at replicating business practices is because of the scalability of IT infrastructure. There are terrific returns to scale with these systems, and once a new business model has proven itself in one store, a large company can very easily roll it out to all its other stores in a matter of days (82). The

power of this technology puts increased economic and resource efficiency within our grasp, and we can improve efficiency much more rapidly now than we could in the past.

RECOMMENDATIONS

Some have called for an Apollo project to attack the current energy crisis (87), but I think a better analogy would be what happened after the Russians launched Sputnik (88). The U.S. invested massively in science and engineering education, in technology, and in research and development, across the board. The whole society was mobilized to meet the challenge, and the Apollo project was just one manifestation of that effort. Meeting the current energy challenge will require mobilizing our entire society again, this time to promote energy innovation.

Congress can aid that effort in several ways.

First, I suggest that the National Academies and the National Science Foundation be commissioned to evaluate

(1) the need for additional research and development (R&D) and the effectiveness of the current R&D portfolio across the entire federal government, with particular emphasis on the potential for clean-slate whole-systems redesign as a central organizing principle for these efforts.

(2) the need for increased funding for science and engineering education from kindergarten through post graduate work

(3) the current portfolio of energy efficiency standards, focusing particularly on standards that have been passed by the state of California that have not yet been passed by the federal government, on end-uses where significant cost-effective energy efficiency potential remains (89), and in enduses that are affected most strongly by the principal-agent (landlord/tenant) problem (49).

(4) the use of prizes (like the X-prize for space travel) to promote breakthrough innovations in energy efficiency and alternative fuels

(5) the use of revenue neutral "feebates" for promoting efficiency in light vehicles, given that this policy has the potential to promote efficiency and increase the profitability of domestic automobile companies (25).

(6) the use of new information technologies (such as improved video conferencing, electronic tolls for roadways, radio frequency identification (RFID), and wireless sensor networks) to improve the overall resource and energy efficiency of technological systems both within and outside the federal government..

Second, the U.S. Department of Energy and the Federal Energy Regulatory Commission should be asked to assess the benefits and costs of promoting standardized electronic formats for utility rates.

Finally, the relevant agencies in the Federal government should collaborate with the utility industry and the National Association of Regulatory Utility Commissioners to promote the adoption of decoupling of utility profits from electricity sales and the

implementation of direct profit incentives for utility investments, both of which have been successful in California in making utilities enthusiastic advocates for energy efficiency. Adopting those institutional innovations in the states that do not now have them is one of the largest single steps we as a society could take to promote energy efficiency on a large scale.

CONCLUSIONS

Efficiency is the cheapest, cleanest, and fastest source of new energy "supply"—it can both save money and improve environmental quality. This insight is not a new one, but the U.S. has been reluctant to fully embrace it. There have been some notable historical successes with CAFE standards for automobiles, minimum efficiency standards for appliances, Energy Star labeling, and utility efficiency programs, but we have not yet tried a "full court press" for energy efficiency. The name of the game is innovation in technologies, policies and behaviors, and we as a society need to make that innovation occur more rapidly, more broadly, and more effectively than it ever has before.

Our choices today affect the choices we will have tomorrow. Continuing to install inefficient products will strand investment and delay the transition to using – and marketing to the world – efficient alternatives. If we choose to invest in research, development, demonstration and implementation we can have a much more efficient future than we would have otherwise, with co-benefits in energy security, economics and the environment. This future is within our grasp—we just need to reach for it.

REFERENCES

1. Krause, Florentin, Wilfred Bach, and Jon Koomey. 1989. *From Warming Fate to Warming Limit: Benchmarks to a Global Climate Convention.* El Cerrito, CA: International Project for Sustainable Energy Paths.

2. Krause, Florentin, Eric Haites, Richard Howarth, and Jonathan Koomey. 1993. *Cutting Carbon Emissions–Burden or Benefit? The Economics of Energy-Tax and Non-Price Policies.* El Cerrito, CA: International Project for Sustainable Energy Paths.

3. Krause, Florentin, Wilfred Bach, and Jonathan Koomey. 1992. *Energy Policy in the Greenhouse.* NY, NY: John Wiley and Sons.

4. Krause, Florentin, Jonathan Koomey, David Olivier, Pierre Radanne, and Mycle Schneider. 1994. *Nuclear Power: The Cost and Potential of Low-Carbon Resource Options in Western Europe.* El Cerrito, CA: International Project for Sustainable Energy Paths.

5. Krause, Florentin, Jonathan Koomey, Hans Becht, David Olivier, Giuseppe Onufrio, and Pierre Radanne. 1994. *Fossil Generation: The Cost and Potential of Low-Carbon Resource Options in Western Europe.* El Cerrito, CA: International Project for Sustainable Energy Paths.

6. Krause, Florentin, Jonathan G. Koomey, and David Olivier. 1995. *Renewable Power: The Cost and Potential of Low-Carbon Resource Options in Western Europe.* El Cerrito, CA: International Project for Sustainable Energy Paths.

7. Krause, Florentin, David Olivier, and Jonathan Koomey. 1995. *Negawatt Power: The Cost and Potential of Low-Carbon Resource Options in Western Europe.* El Cerrito, CA: International Project for Sustainable Energy Paths.

8. Krause, Florentin, and Jonathan Koomey. 1998. *Low Carbon Comfort: The Costs and Potentials of Energy Efficiency in EU Buildings (Final Report).* El Cerrito, CA: International Project for Sustainable Energy Paths. January.

9. Krause, Florentin, Jonathan Koomey, and David Olivier. 1999. *Cutting Carbon Emissions While Making Money: Climate Saving Energy Strategies for the European Union (Executive Summary for Volume II, Part 2 of Energy Policy in the Greenhouse).* El Cerrito, CA: International Project for Sustainable Energy Paths. October.

10. Krause, Florentin, and Jonathan Koomey. 1996. "The cost of cutting carbon emissions -- a case study of Western Europe." *Energy Conversion and Management.* vol. 37, no. 6-8. 8 June 1996. pp. 973-978.

11. Krause, Florentin, Paul Baer, and Stephen DeCanio. 2001. *Cutting Carbon Emissions at a Profit: Opportunities for the U.S.* El Cerrito, CA: International Project for Sustainable Energy Paths. May.

12. Krause, Florentin, John F. Busch, and Jonathan G. Koomey. 1992. *Incorporating Global Warming Risks in Power Sector Planning: A Case Study of the New England Region.* Lawrence Berkeley Laboratory. LBL-30797 (vols I and II). November.

13. Krause, Florentin, John F. Busch, and Jonathan G. Koomey. 1993. "Carbon Reduction Costs in New England's Power Sector." *Contemporary Policy Issues.* vol. XI, no. 2. April. pp. 100-112.

14. Interlaboratory Working Group. 1997. *Scenarios of U.S. Carbon Reductions: Potential Impacts of Energy-Efficient and Low-Carbon Technologies by 2010 and Beyond.* Oak Ridge, TN and Berkeley, CA: Oak Ridge National Laboratory and Lawrence Berkeley National Laboratory. ORNL/CON-444 and LBNL-40533. September. (http://enduse.lbl.gov/Projects/5Lab.html)

15. Koomey, Jonathan G., Nathan C. Martin, Marilyn Brown, Lynn K. Price, and Mark D. Levine. 1998. "Costs of reducing carbon emissions: U.S. building sector scenarios." *Energy Policy.* vol. 26, no. 5. April. pp. 433-440 (also LBNL-40829).

16. Brown, Marilyn A., Mark D. Levine, Joseph P. Romm, Arthur H. Rosenfeld, and Jonathan G. Koomey. 1998. "Engineering-Economic Studies of Energy Technologies to Reduce Greenhouse Gas Emissions: Opportunities and

Challenges." In *Annual Review of Energy and the Environment 1998*. Edited by J. M. Hollander. Palo Alto, CA: Annual Reviews, Inc.

17. Interlaboratory Working Group on Energy-Efficient and Clean-Energy Technologies. 2000. *Scenarios for a Clean Energy Future*. Oak Ridge, TN and Berkeley, CA: Oak Ridge National Laboratory and Lawrence Berkeley National Laboratory. ORNL/CON-476 and LBNL-44029. November. (http://www.ornl.gov/sci/eere/cef/)

18. Brown, Marilyn A., Mark D. Levine, Walter Short, and Jonathan G. Koomey. 2001. "Scenarios for a Clean Energy Future." *Energy Policy (Also LBNL-48031)*. vol. 29, no. 14. November. pp. 1179-1196.

19. Gumerman, Etan, Jonathan G. Koomey, and Marilyn A. Brown. 2001. "A Sensitivity Analysis of the Clean Energy Future Study's Economic and Carbon Savings Results." *Energy Policy (also LBNL-47357)*. vol. 29, no. 14. November. pp. 1313-1324.

20. Koomey, Jonathan G., Carrie A. Webber, Celina S. Atkinson, and Andrew Nicholls. 2001. "Addressing Energy-Related Challenges for the U.S. Buildings Sector: Results from the Clean Energy Futures Study." *Energy Policy (also LBNL-47356)*. vol. 29, no. 14. November. pp. 1209-1222.

21. Hadley, Stan W., and Walter Short. 2001. "Electricity sector analysis in the clean energy futures study." *Energy Policy*. vol. 29, no. 14. November. pp. 1285-1298.

22. Worrell, Ernst, and Lynn K. Price. 2001. "Policy Scenarios for Energy Efficiency Improvements in Industry." *Energy Policy*. vol. 29, no. 14. November. pp. 1223-1242.

23. Greene, David L., and Steve E. Plotkin. 2001. "Energy futures for the U.S. transport sector." *Energy Policy*. vol. 29, no. 14. November. pp. 1255-1270.

24. Lemar Jr., Paul L. 2001. "The potential impact of policies to promote combined heat and power in U.S. industry." *Energy Policy*. vol. 29, no. 14. November. pp. 1243-1254.

25. Lovins, Amory B., E. Kyle Datta, Odd-Even Bustnes, Jonathan G. Koomey, and Nathan J. Glasgow. 2004. *Winning the Oil Endgame: Innovation for Profits, Jobs, and Security*. Old Snowmass, Colorado: Rocky Mountain Institute. September. (http://www.oilendgame.com)

26. Greening, Lorna A., Alan H. Sanstad, and James E. McMahon. 1997. "Effects of Appliance Standards on Product Price and Attributes: An Hedonic Pricing Model." *The Journal of Regulatory Economics*. vol. 11, no. 2, March. pp. 181-194.

27. Howarth, Richard B., and Bo Andersson. 1993. "Market Barriers to Energy

Efficiency." *Energy Economics*. vol. 15, no. 4. October. pp. 262-272.

28. Koomey, Jonathan, and Alan H. Sanstad. 1994. "Technical Evidence for Assessing the Performance of Markets Affecting Energy Efficiency." *Energy Policy*. vol. 22, no. 10. October. pp. 826-832.

29. Levine, Mark D., Jonathan G. Koomey, James E. McMahon, Alan H. Sanstad, and Eric Hirst. 1995. "Energy Efficiency Policy and Market Failures." In *Annual Review of Energy and the Environment 1995*. Edited by J. M. Hollander. Palo Alto, CA: Annual Reviews, Inc.

30. Sanstad, Alan H., and Richard Howarth. 1994. "'Normal' Markets, Market Imperfections, and Energy Efficiency." *Energy Policy*. vol. 22, no. 10. October. pp. 826-832.

31. Sanstad, Alan H., Carl Blumstein, and Steven E. Stoft. 1995. "How High are Option Values in Energy-Efficiency Investments?" *Energy Policy*. vol. 23, no. 9. September. pp. 739-744.

32. Howarth, Richard B., and Alan H. Sanstad. 1995. "Discount Rates and Energy Efficiency." *Contemporary Economic Policy*. vol. 13, no. 3. pp. 101.

33. DeCanio, Stephen. 1993. "Barriers within firms to energy-efficient investments." *Energy Policy*. vol. 21, no. 9. pp. 906-914.

34. Koomey, Jonathan, Alan H. Sanstad, and Leslie J. Shown. 1996. "Energy-Efficient Lighting: Market Data, Market Imperfections, and Policy Success." *Contemporary Economic Policy*. vol. XIV, no. 3. July (Also LBL-37702.REV). pp. 98-111.

35. DeCanio, Stephen J. 1998. "The efficiency paradox: bureaucratic and organizational barriers to profitable energy-saving investments." *Energy Policy*. vol. 26, no. 5. April. pp. 441-454.

36. DeCanio, Stephen J., and W. E. Watkins. 1998. "Investment in Energy Efficiency: Do the Characteristics of Firms Matter?" *Review of Economics and Statistics*. vol. 80, no. 1. February. pp. 95-107.

37. DeCanio, Stephen J. 1997. "Economic Modeling and the False Tradeoff between Environmental Protection and Economic Growth." *Contemporary Economic Policy*. vol. 15, no. 4. October. pp. 10-27.

38. Haddad, Brent M., Richard B. Howarth, and Bruce Patton. 2000. "The Economics of Energy Efficiency: Insights from Voluntary Participation Programs." *Energy Policy*. vol. 28, no. 6/7. pp. 477-486.

39. DeCanio, Stephen J. 2003. *Economic Models of Climate Change: A Critique*. Basingstoke, UK: Palgrave-Macmillan.

40. Koomey, Jonathan. 1990. *Energy Efficiency Choices in New Office Buildings: An Investigation of Market Failures and Corrective Policies.* PhD Thesis, Energy and Resources Group, University of California, Berkeley. (Download from http://enduse.lbl.gov/Projects/EfficiencyGap.html)

41. Jaffe, Adam B., and Robert N. Stavins. 1994. "Energy-Efficiency Investments and Public Policy." vol. 15, no. 2. pp. 43.

42. Oster, S.M., and J.M. Quigley. 1977. "Regulatory Barriers to the Diffusion of Conservation: Some Evidence From Building Codes." vol. 8, no. 2. pp. 361-77.

43. Lovins, Amory B. 1992. *Energy-Efficient Buildings: Institutional Barriers and Opportunities.* E-Source. Strategic Issues Paper. December.

44. Golove, William H., and Joseph H. Eto. 1996. *Market barriers to energy efficiency: A critical reappraisal of the rationale for public policies to promote energy efficiency.* Berkeley, CA: Lawrence Berkeley Laboratory. LBL-38059. March.

45. Brown, Marilyn A. 2001. "Market Barriers to Energy Efficiency." *Energy Policy.* vol. 29, no. 14. November. pp. 1197-1208.

46. Barker, Terry. 2008. *The Economics of Avoiding Dangerous Climate Change.* Norwich, UK: Tyndall Center. Working Paper 117, also submitted as the springboard editorial for the journal Climatic Change's issue on the Stern Review. June.

47. Arthur, W. Brian. 1990. "Positive Feedbacks in the Economy." In *Scientific American.* February. pp. 92-99.

48. Murtishaw, Scott, and Jayant Sathaye. 2006. *Quantifying the Effect of the Principal-Agent Problem on U.S. Residential Energy Use.* Berkeley, CA: Lawrence Berkeley National Laboratory. LBNL-59773rev. August 12.

49. IEA. 2007. *Mind the Gap: Quantifying Principal-Agent Problems in Energy Efficiency.* Paris, France: International Energy Agency.

50. Koomey, Jonathan G., Celina Atkinson, Alan Meier, James E. McMahon, Stan Boghosian, Barbara Atkinson, Isaac Turiel, Mark D. Levine, Bruce Nordman, and Peter Chan. 1991. *The Potential for Electricity Efficiency Improvements in the U.S. Residential Sector.* Lawrence Berkeley Laboratory. LBL-30477. July.

51. Brown, Richard E. 1993. *Estimates of the Achievable Potential for Electricity Efficiency in U.S. Residences.* M.S. Thesis, Energy and Resources Group, University of California, Berkeley.

52. AIP. 1975. "Efficient Use of Energy: Part 1 – A Physics Perspective." In *AIP Conference Proceedings No. 25.* Edited by W. Carnahan, K. W. Ford, A.

Prosperetti, G. I. Rochlin, A. H. Rosenfeld, M. Ross, J. Rothberg, G. Seidel and R. H. Socolow. American Institute of Physics.

53. SERI, Solar Energy Research Institute. 1981. *A New Prosperity: The SERI Solar/Conservation Study*. Andover, MA: Brick House Press.

54. Meier, Alan. 1982. *Supply Curves of Conserved Energy*. PhD Thesis, Energy and Resources Group, University of California, Berkeley.

55. Meier, Alan, Jan Wright, and Arthur H. Rosenfeld. 1983. *Supplying Energy Through Greater Efficiency*. Berkeley, CA: University of California Press.

56. Krause, Florentin, John Brown, Deborah Connell, Peter DuPont, Kathy Greely, Margaret Meal, Alan Meier, Evan Mills, and Bruce Nordman. 1988. *Analysis of Michigan's Demand-Side Electric Resources in the Residential Sector*. Lawrence Berkeley Laboratory. LBL-23025 (Vol. I-Executive Summary); LBL-23026 (Vol. II-Methodology and Results); LBL-23027 (Vol. III-End-use studies). April.

57. Rosenfeld, Arthur, Celina Atkinson, Jonathan Koomey, Alan Meier, Robert Mowris, and Lynn Price. 1993. "Conserved Energy Supply Curves." *Contemporary Policy Issues*. vol. XI, no. 1. January (also LBL-31700). pp. 45-68.

58. Lovins, Amory B. 1979. *Soft Energy Paths: Toward a Durable Peace*. New York, NY: Harper Colophon Books.

59. Von Weizsacker, Ernst, Amory B. Lovins, and L. Hunter Lovins. 1997. *Factor Four: Doubling Wealth, Halving Resource Use*. London: Earthscan Publications Ltd.

60. Lovins, A.B., H. Lovins, F. Krause, and W. Bach. 1981. *Least-cost energy: Solving the CO2 problem*. Andover:

61. National Research Council. 1992. *Automotive Fuel Economy: How Far Should We Go?* National Academy Press.

62. National Research Council. 2003. *Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards*. Committee on the Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards Board on Energy and Environmental Systems Division on Engineering and Physical Sciences Transportation Research Board, National Research Council, National Academy Press.

63. Rufo, Michael, and Fred Coito. 2002. *California's Secret Energy Surplus: the Potential for Energy Efficiency*. San Francisco, CA: The Energy Foundation and The Hewlett Foundation. (http://www.ef.org/energyseries_secret.cfm)

64. Atkinson, Barbara, Celina Atkinson, Jonathan Koomey, Alan Meier, Stan Boghosian, and James E. McMahon. 1991. *Supply Curve of Conserved Carbon:*

Emissions Reduction Potential Through Electricity Conservation in U.S. Residential Buildings. Proceedings of the Conference on DSM and the Global Environment. Arlington, VA: Synergic Resources Corp. April 22-23, 1991.

65. Hanson, Donald, and John A. "Skip" Laitner. 2004. "An integrated Analysis of policies that increase investments in advanced energy-efficient/low-carbon technologies." *Energy Economics*. vol. 26, no. 4. July. pp. 739-755.

66. Ehrhardt-Martinez, Karen, and John A. "Skip" Laitner. 2008. *The Size of the U.S. Energy Efficiency Market: Generating a More Complete Picture*. Washington, DC: American Council for an Energy Efficient Economy. E083. May.

67. Creyts, Jon, Anton Derkach, Scott Nyquist, Ken Ostrowski, and Jack Stephenson. 2007. *Reducing U.S. Greenhouse Gas Emissions: How Much at What Cost?* U.S. Greenhouse Gas Abatement Mapping Initiative, McKinsey & Company and the Conference Board. December.

68. Brown, Rich, Sam Borgeson, Jonathan Koomey, and Peter Biermayer. 2008. *U.S. Building-Sector Energy Efficiency Potential*. Berkeley, CA: Lawrence Berkeley National Laboratory. REVIEW DRAFT. June.

69. US DOE. 2007. *Assumptions to the Annual Energy Outlook 2007, with Projections to 2030*. Washington, DC: Energy Information Administration, U.S. Department of Energy. DOE/EIA-0554(2007). March. (http://www.eia.doe.gov/oiaf/aeo/assumption/)

70. CEC. 2007. *2007 Integrated Energy Policy Report*. Sacramento, CA: California Energy Commission. CEC-100-2007-008-CMF.

71. Koomey, Jonathan G., Susan A. Mahler, Carrie A. Webber, and James E. McMahon. 1999. "Projected Regional Impacts of Appliance Efficiency Standards for the U.S. Residential sector." *Energy: the International Journal*. vol. 24, no. 1. January. pp. 69-84.

72. Webber, Carrie A., Richard E. Brown, Akshay Mahajan, and Jonathan G. Koomey. 2002. *Savings Estimates for the ENERGY STAR Voluntary Labeling Program: 2001 Status Report*. Berkeley, CA: Lawrence Berkeley National Laboratory. LBNL-48496. February.

73. Brown, Richard, Carrie Webber, and Jonathan Koomey. 2002. "Status and Future Directions of the ENERGY STAR Program." *Energy--The International Journal (also LBNL-45952)*. vol. 27, no. 5. May. pp. 505-520.

74. Levine, Mark D., and Paul P. Craig. 1985. "A Decade of United States Energy Policy." In *Annual Review of Energy 1985*. Edited by J. M. Hollander. Palo Alto, CA: Annual Reviews, Inc. 557-587 pp.

75. Nadel, Steven. 1992. "Utility Demand-Side Management Experience and

Potential -- a Critical Review." *Annual Review of Energy and Environment.* vol. 17, pp. 507-35.

76. Eto, Joe, Edward Vine, Leslie Shown, Richard Sonnenblick, and Chris Payne. 1994. *The Cost and Performance of Utility Commercial Lighting Programs.* Lawrence Berkeley Laboratory. LBL-34967. May.

77. Eto, Joseph H., Suzi Kito, Leslie Shown, and Richard Sonnenblick. 1995. *Where did the money go? The cost and performance of the largest commercial sector DSM programs.* Berkeley, CA: Lawrence Berkeley Laboratory. LBL-38201. December.

78. Levine, Mark D., and Richard Sonnenblick. 1994. "On the assessment of utility demand-side management programs." *Energy Policy.* vol. 22, no. 10. pp. 848-856.

79. Smith, Marsha, and James E. Rogers. 2006. *National Action Plan for Energy Efficiency.* Washington, DC: The Leadership Group, supported by the U.S. Department of Energy and the U.S. Environmental Protection Agency. July. (http://www.epa.gov/cleanenergy/energy-programs/napee/index.html)

80. Laitner, John A. "Skip". 2008. *Testimony of John A. "Skip" Laitner Director of Economic Analysis, American Council for an Energy Efficient Economy, for a hearing to review the status of existing federal programs targeted at reducing gasoline demand in the near term and to discuss additional proposals for near term gasoline demand reductions.* Washington, DC: U.S. Senate Committee on Energy and Natural Resources. July 23.

81. Nemet, Gregory F., and Daniel M. Kammen. 2007. "U.S. energy research and development: Declining investment, increasing need, and the feasibility of expansion." *Energy Policy.* vol. 35, no. 1. January. pp. 746–755.

82. McAfee, Andrew, and Erik Brynjolfsson. 2008. "Investing in the IT that Makes a Competitive Difference." *Harvard Business Review.* July-August. pp. 98-108.

83. Laitner, John A. "Skip", and Karen Ehrhardt-Martinez. 2008. *Information and Communication Technologies: The Power of Productivity.* Washington, DC: American Council for an Energy Efficient Economy. E081. February.

84. Lohr, Steve. 2008. "As Travel Costs Rise, More Meetings Go Virtual." *The New York Times.* July 22.

85. Koomey, Jonathan, Kenneth G. Brill, W. Pitt Turner, John R. Stanley, and Bruce Taylor. 2007. *A simple model for determining true total cost of ownership for data centers.* Santa Fe, NM: The Uptime Institute. September. (http://www.upsite.com/cgi-bin/admin/admin.pl?admin=view_whitepapers)

86. Jackson, Jerry. 2008. *Energy Budgets at Risk (EBaR): A Risk Management*

Approach to Energy Purchase and Efficiency Choices. Hoboken, NJ: Wiley and Sons.

87. Inslee, Jay, and Bracken Hendricks. 2007. *Apollo's Fire: Igniting America's Clean Energy Economy*. Washington, DC: Island Press.

88. Dickson, Paul. 2003. *Sputnik: The Shock of the Century*. New York, NY: Berkley Books.

89. Rosenquist, Gregory, Michael McNeil, Maithili Iyer, Steve Meyers, and James E. McMahon. 2004. *Energy Efficiency Standards and Codes for Residential/Commercial Equipment and Buildings: Additional Opportunities*. Berkeley, CA: Lawrence Berkeley National Laboratory: LBID-2533. July.

AUTHOR'S BIOGRAPHY

Jonathan Koomey is a Project Scientist at Lawrence Berkeley National Laboratory (LBNL) and a Consulting Professor at Stanford University. For more than eleven years he led LBNL's End-Use Forecasting group, which analyzes markets for efficient products and technologies for improving the energy and environmental aspects of those products <http://enduse.lbl.gov>. The group develops recommendations for policymakers at the U.S. Environmental Protection Agency and the U.S. Department of Energy on ways to promote energy efficiency and prevent pollution. Koomey is also a Research Affiliate of the Energy and Resources Group at the University of California, Berkeley and serves on the Editorial Board of the journal *Contemporary Economic Policy.*

Dr. Koomey holds M.S. and Ph.D. degrees from the Energy and Resources Group at the University of California at Berkeley, and a B.A. in History of Science from Harvard University. He is the author or coauthor of eight books and more than one hundred and fifty articles and reports on energy efficiency and supply-side power technologies, energy economics, energy policy, environmental externalities, and global climate change. He has also published extensively on critical thinking skills.

Dr. Koomey has appeared on Nova/Frontline, BBC radio, CNBC, All Things Considered, Marketplace, On the Media, and Tech Nation, and has been quoted in the New York Times, the Wall Street Journal, Barron's, The Washington Post, The Financial Times, Science, Technology Review, Dow Jones News Wires, Christian Science Monitor, USA Today, and CIO Magazine, among others.

Dr. Koomey has received two outstanding performance awards during his LBNL career, one for his leadership role in the 1997 Interlaboratory study on scenarios of U.S. carbon reductions <http://enduse.lbl.gov/projects/5lab.html> and the other for his strategic contribution to the 2001 California Energy Crisis web site <http://savepower.lbl.gov/>. In 1993, his article, titled *Cost-Effectiveness of Fuel Economy Improvements in 1992 Honda Civic Hatchbacks* won the Fred Burgraff Award for Excellence in Transportation Research from the National Research Council's Transportation Research Board. He was an Aldo Leopold Leadership Fellow for 2004—that program trains environmental scientists and policy analysts to communicate effectively with the media and the public. In January 2005, he was named an AT&T Industrial Ecology Fellow. His latest solo book, *Turning Numbers into Knowledge: Mastering the Art of Problem Solving*, was first published in 2001 by Analytics Press <http://www.numbersintoknowledge.com/>, is now in its second edition (2008), and has been translated into Chinese.

Testimony of Mark P. Mills
Partner, Digital Power Capital (An Affiliate of Wexford Capital LLC)
Author, *Forbes Energy Intelligence* column
Co-author, The Bottomless Well (Basic Books, 2005)

Before the
U.S. Congress Joint Economic Committee
Hearing on
"Efficiency: The Hidden Secret to Solving Our Energy Crisis"
July 30, 2008

Thank you Mr. Chairman and members of the Committee for the opportunity to present some thoughts on the role of energy efficiency in the U.S. economy.

In one way or another, I've been involved in and studied the technologies of energy production and use for several decades. And in recent years, specifically in the pursuit of energy tech venture capital opportunities, I've had the privilege to talk with hundreds of entrepreneurs and companies involved in developing advanced energy technologies, and visited with dozens and dozens of them. This experience has made me quite optimistic about our long-term capability to meet the nation's energy needs – notwithstanding the caveat that there are substantial challenges in the near term.

The solutions to energy-related geopolitical, economic and environmental challenges are not going to be found in anything new in basic physics. The primary energy sources we have today are those we'll need to use for quite a long time – hydrocarbons, carbohydrates, sun, wind, water and uranium. Nonetheless, history will record that we are today on the cusp of an energy revolution – one involving efficiency -- with implications as deep and far-reaching as the industrial and electric revolutions of the previous two centuries. Each of those previous pivots in history was similarly anchored in profound changes in the efficiency with which we could use basic energy resources.

The emerging efficiency revolution directly derives from our nation's collective investment of trillions of dollars in the intellectual capital and infrastructure of the silicon and digital economy. It is not a single device, or solution, but the emergence of an entirely new structural approach to energy efficiency – *a hybrid energy economy*. The nature and implications of this technological paradigm shift are epitomized by the hybrid-electric car.

Conventional cars waste gasoline in stop-and-go, coasting, running unnecessarily at stops and generally operating an engine sub optimally. You could do manually much of what hybrids do automatically, though it would be annoying. Just turn the engine off every time you don't need it, at every stop, when braking, coasting, etc. Restart to accelerate or cruise. That alone increases a vehicle's urban fuel economy 10 to 50%. Or hybridize; wrap engine and driveshaft with sensors, power electronics, electric motors, batteries, microprocessors, software and high-speed communications buses – in short, all the stuff of the digital economy. Then let all that digital stuff seamlessly and invisibly juggle the on-off and optimally operate the constellation of energy consuming components, in real-time reacting to dynamic conditions, in ways you could never accomplish manually.

Nearly everything in our economy operates like today's cars – sub optimally. Building and running things in the physical world is difficult to do optimally. Compromises are always made to accommodate enormously varied conditions – compromises that have the collective impact of consuming more resources. The engineering challenge is to use just the right resources (largely energy, or the energy inherent in materials) at the right time and place. Cars are much simpler to fix in this regard than are factories, offices, and homes. Yet the latter, collectively, is where ***70 percent*** of our energy is used – sub optimally. Cost-effective hybrid energy technologies now emerging have potential for energy efficiency gains greater than anything in the transportation sector.

Enabling the emergence of the hybrid economy are the four inter-related domains of the silicon-digital economy: sensors, increasingly from nanotechnology, to collect information; high-speed communications networks; powerful microprocessors to crunch data; and high-power electronics to interface with the physical-mechanical world. It is only in recent years that all of these domains have achieved the necessary cost-effective capabilities to be deployed in the physical world. Sensors with astonishing sensitivity can be the size of dust motes and imbedded along with low-cost self-healing wireless mesh networks that enable microprocessors, costing literally pennies, to instruct high-power transistors to mediate the kilowatts required to move, form, shape and control physical things. This is what hybrid cars already use to achieve huge efficiency gains. It's what the rest of the economy can now do.

The technologies enabling a hybrid energy economy arrived first to serve markets for pure information systems, for data, voice and video. These came first, to put it simplistically, because information doesn't weigh anything, so the sheer power demands are relatively modest – pure information devices operate in milliwatts and watts. But you need kilowatts and megawatts to directly control steel, grain or people – to move tons of stuff instead of terabytes of pictures. Moving up the engineering power curve a thousand and million fold was difficult, and took time. It also took time to develop ultra-reliable software. A dropped call, or frozen PC screen is one thing – its equivalent in a factory, car, home, or hospital is quite another.

The hybrid economy takes America the next quantum leap beyond automation (already a $100 billion global industry), or supply chain information technology and such things as telecommuting and e-commerce. All are already responsible for energy-savings, but all are only building blocks to the deeper hybrid phenomenon -- the emergence of a capability to imbue the energy-consuming inanimate world around us with intelligence, communications and the ability to react and operate optimally. To simplify again with the car analogy; the automatic transmission which has been around since 1939 is a distant cousin of the innovations that make a 2008 hybrid car. A March 1956 *Time* magazine cover story touted, prophetically, the benefits of automation as the engine of growth. And it was for a half century. Overall U.S. energy efficiency has more than doubled since then, and our GDP increased six-fold – requiring a comparatively modest 2.5-fold increase in energy use. Now it's time for the hybrid economy to do the same, and much more.

Only a few years ago, the hybrid car was viewed as an expensive niche product. But it's already moving to the mainstream with the intersection of high energy prices and the (predictably) declining costs of silicon technology. So too the hybrid economy. Make all cars hybrid, and millions of barrels of oil are saved.

Hybridize the rest of the economy -- eventually everything physical that consumes energy to build or operate -- and billions of barrels are saved. The conventional wisdom is that the big gains in energy efficiency are behind us, the so-called "low hanging fruit." But technology also grows in cycles. We have yet to see the new crop.

Radical improvements in energy efficiency produce unexpected, beneficial outcomes. Energy efficiency is what made companies like Google and Apple possible. Operating at the efficiency of the first computers, a single Google data center would consume the entire electric supply of New York City. At the efficiency of early radios, iPhones would be trunk-sized and served by cell towers the size of the Washington Monument. Instead today, because of staggering improvements in computing and information energy efficiency, there are thousands of data centers, billions of computers and cell phones -- both are now ubiquitous industries with vast, productive sprawling infrastructures.

And while both have become major energy-consuming sectors in themselves -- collectively using more energy than the aviation sector -- the new digital technologies are, according to the Federal Reserve, responsible for one-third to one-half of GDP growth. They have thus added not only more services, features and wealth to the economy, but have done so at a fraction of the energy cost per dollar of GDP compared to the old economy. There is every reason to believe more of the same is in store with the next wave of efficient technologies emerging in a hybrid economy, but much of it inherently unpredictable in direction and form.

As with the hybrid car, the array of technologies – not to mention the constellation of players from large to small, traditional to start-up -- is broad enough to defy easy approaches to finding winners. The challenge, in fact, is the same for policymakers and investors. If there's a risk today in responding to immediate economic stresses of high energy prices, it is in the temptation to pick specific winners or paths, and to confuse true technology-based efficiency (with its deep, long-lasting benefits) from behaviorally-based conservation (which is largely evanescent).

Because efficiency – like its economic cousin, labor productivity -- arises primarily from technology progress, we face the now age-old challenge of finding ways to incentivize and accelerate innovative technology. How do we encourage markets to adopt near-term innovation, and find ways to invest in enabling infrastructure of long-term innovation? In both cases, money is the most powerful tool. High-cost energy accelerates near-term capital investment in more efficient technology. As for the long term, federal funding of basic R&D is essential to fuel the next cycle of innovation and to educate emerging innovators.

The future hybrid economy will be as different from today as the electric economy was from the industrial revolution that preceded it. But just as the 21st century hybrid car is built directly from the 20th century's automobile, so too the hybrid energy economy derives from the old. And while the challenges are global, it is clear at least from my travels that the United States will continue to be at the epicenter of this next great secular shift in energy technology.

Thank you Mr. Chairman, members of the committee. <>