Energy Innovation:
What's Here and What's Coming

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Governor Pawlenty, Governor Rendell, thank you for the privilege of speaking at this historic meeting.

I would like to discuss the role of technological innovation in solving our energy problem, and, especially, the important question of what role for policy – state as well as federal – in accelerating the innovation process.

I want to begin with three simple messages.

Recent progress in the clean technology field has been substantial. New kinds of generating capacity are being added -- in some cases, notably wind, at an impressive rate. Costs are coming down, albeit sometimes more slowly than was promised.

Investment in next-generation technologies is increasing. The strong interest of the venture capital community is particularly welcome.

Ambitious targets are being set. Some of the most effective policy interventions are occurring at the state and local levels. California has been a leader. In my own state of Massachusetts, important clean energy legislation was enacted just this month. Other states are on a similar path.

That said -- and here is my first message – these activities aren't remotely close to the scale of effort that will be required to solve the problem.

My second message concerns the future of nuclear power and of coal-fired electricity with carbon capture and storage.

These two options won't win any popularity contests, and some would fiercely dispute that they belong in the clean technology category at all. But without large-scale deployment of both, especially in the critical 2020 to 2050 timeframe, it is unlikely -- to the point of implausibility -- that the world will be able to avoid serious and perhaps even disastrous ecological and economic damage from climate change.

Coal is an abundant, relatively low-cost energy resource that is widely distributed around the world, and in the US we depend on it for half of our electricity. We cannot continue to burn it as we have, but we cannot afford to turn our back on it either. We must therefore find ways to capture carbon emissions from coal-fired power plants and to store the carbon dioxide safely underground, at reasonable cost.

Nuclear power is the only carbon-free energy source that is already contributing on a large scale and that is also expandable with few inherent limits. Public opinion has been gradually shifting in its favor, but the failure to demonstrate and implement an effective final disposal strategy for high-level waste remains a tremendous barrier to public acceptance, no matter how many expert panels and commissions opine that this is a technically feasible task.

The Yucca Mountain project may or may not meet the regulatory criteria that will eventually be applied to it. But there is no doubt that we can do better, and doing better should be a high priority.

No serious person would dispute the importance of these two innovation goals: affordable carbon capture and storage, and safe, implementable high-level nuclear waste disposal. But my basic message here is that in both cases current U.S. policies are putting our nation at least partly on the wrong track, and that this is almost certain to cause further delays in the availability of viable coal and nuclear power -- delays that we can ill afford.

My third message is perhaps best conveyed by the poet Wallace Stevens, born not far from here in Reading, PA. Stevens wrote of 'the lunatics of one idea . . . . in a world of ideas'. He was referring to ideologues and fanatics, who, blinded by their single idea, couldn't see the world around them. But he might as well have been talking about the energy debate, where such lunacy has unfortunately been all too common.

The fact is that there is no single idea, no silver bullet, that will solve the problem. First and foremost, we need new ways to use energy more efficiently. But very likely also much bigger contributions from solar, wind, biomass, nuclear, and also advanced fossil fuel technologies. In our current circumstances, we can ill afford the self-indulgence of those who -- however well-intentioned – like to tell the world that they are anti-this, or anti-that.

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So far I've been talking about our energy problem. But this is incorrect. Because we really have three separate problems, each on its own very difficult to solve. And because the solutions to one will sometimes make the others worse, the overall difficulty is more than additive – the whole is greater than the sum of the parts.

The first problem is the projected increase in the use of energy. Unless the world goes into a deep and prolonged recession, by the middle of this century global energy use will likely have doubled, and electricity use will have tripled, placing great pressure on energy supplies and prices.

And in case there is any doubt: whatever role speculators may be playing in the current oil price spike, the underlying issue here is growing demand.

This is an era in which hundreds of millions of people, perhaps even billions, are lifting themselves out of poverty into what we in this country might recognize as at least a way-station on the road to a middle-class standard of living, all within the span of a few decades. This is an economic accomplishment that has no precedent in all of human history, and we should celebrate it.

One of the consequences is sharply increased energy use. But in case anyone thinks that a tripling of electricity demand by mid-century implies irresponsible, profligate consumption, I point out that this would mean, roughly speaking, that the richest billion of the world's population at that time would be using electricity at about the same rate that the average American uses it today, the middle 7 billion would be using it at a rate that the average Chinese is likely to reach in just a few years (or a bit more than a third of the average American's usage today), and the poorest billion would still have no electricity at all. That is what a tripling of electricity demand by mid-century will mean.

The second problem is that for at least the next several decades the world will remain heavily dependent on the Persian Gulf for its premium fuels.

More oil and gas will certainly be found and produced in other parts of the world – though perhaps not at a rate sufficient to offset the decline in existing fields. In any case these new supplies will generally be more costly, and because of the twist of geological fate which led much of the world's low-cost oil and gas resources to be deposited in the Gulf region, that volatile area will continue to dominate the global supply picture for the foreseeable future.

The third problem is of course that of climate change. This may or may not be the most serious problem of all, but it is certainly the most complex when we consider the scientific, technological, economic and political aspects together – as of course we must.

Much has now been learned about this problem, but many major uncertainties remain. So when the question is asked: how fast should we move to try to slow climate change? – the answer isn't obvious.

Figuring it out will mean finding a strategy that strikes a balance between the increased economic cost of actions to reduce emissions, on the one hand, and the benefits of those actions (in terms of ecological and economic damage averted in the future), on the other. Unfortunately almost every element in that equation is uncertain. What is certain, though, is that the longer we wait to take action, the more costly the consequences will be. The clock is ticking, and it won't stop ticking simply because we can't or won't decide what to do.

The best chance we have – perhaps the only chance -- of solving these problems, of breaking out of this triple straitjacket of price, climate, and security pressures, is to accelerate the introduction of new technologies for energy supply and use and deploy them on a very large scale.

Accelerate relative to what? Relative to what would happen if we left innovation entirely to the forces of the marketplace. This may be an obvious point, but it is still worth emphasizing.

Energy innovation is different from other kinds of innovation for a very important reason. The major impetus for it comes from outside the marketplace. Two of our three big problems – energy security and climate change – are not now factored into the great majority of the millions of decisions made in the marketplace every day by suppliers and consumers of energy.

So, even if innovation can help solve those problems – and there is no doubt that it can -- the economic incentives created by the play of market forces alone won't be enough to bring it about. The question is not whether to augment these forces, but how.

Some are calling for a crash program by the federal government -- a Manhattan Project or an Apollo Project for energy innovation.

These calls helpfully communicate the urgency and the scale of the challenge. But in another sense they are a distraction because, if we take them literally, we will end up solving the wrong problem.

In both the Apollo and Manhattan Projects there was a single, clearly-defined (though high-risk) technical goal. There was also just one customer – the federal government. Success meant achieving a single implementation of the new technology. In both cases this took just a few years to achieve. And cost was essentially no object.

Not one of these things applies to the case of energy. Here we have multiple and sometimes conflicting goals (lower prices, reduced carbon emissions, increased security). We have many different kinds of customers – from individual tenants and homeowners to giant industrial energy users. We have multiple time-scales, from a few years to many decades. Success will come not from a single implementation but only if the technology is adopted by many firms, or by many more individuals. And finally, energy is a commodity, so cost is crucial.

In this last sense, the upcoming energy revolution is not only not like the Manhattan project, it isn't even like the digital revolution, to which it is sometimes also compared. It is actually much harder. Because energy innovations, unlike many digital technologies, usually must compete against an incumbent technology in an existing market, and this imposes tough, non-negotiable requirements on cost competitiveness, on quality, and on reliability from the very beginning.

So, if we don't need a Manhattan Project for energy innovation, what do we need?

One thing we surely need is a strategy for energy prices. Many experts argue that the greatest spur to innovation would be to make sure that the full costs of energy provision and use are incorporated in the market price paid by consumers, including the cost of mitigating greenhouse gas emissions or their consequences, and the full cost of ensuring uninterrupted flows of oil from the Middle East.

Some argue, in fact, that if only we could get the price right, the market will do the rest -- that a properly adjusted energy price will call forth the necessary innovations by making new technologies more attractive in the marketplace.

Price is very important, but it won't be sufficient on its own.

Partly this is because we aren't likely to 'get the price right' in that sense. For example, while the U.S. will probably have a carbon price at some point, perhaps even quite soon, this is sure to have escape ramps, exemptions for critical sectors, and other loopholes that will make it fall well short of what the economic models prescribe -- that is, a uniform price across the economy which ramps up at the economically optimal rate. Even more elusive, of course, will be the ideal of a carbon price that is harmonized across the globe.

But equally important, a pricing approach won't be sufficient because it won't address the rest of the energy innovation system -- by which I mean the entire complex of direct support, indirect incentives, regulations, public and private research and educational institutions, codes, standards, and markets within which new technologies are developed and taken up by energy suppliers and users.

In the coming decades this system will be called upon to deliver hundreds of billions of dollars of mostly private investment in innovative technologies, make hundreds of sites available for the construction of controversial new energy facilities, and every year train tens of thousands of young people with a strong background in energy systems engineering.

The evidence of the last three decades tells us that the current innovation system has fallen short. Yet the demands on it going forward will be much greater than anything we have yet seen. This system is in need of a major overhaul.

This effort must address the entire innovation process, including obstacles to commercial demonstration, to early adoption, and to large-scale deployment. This is not just about research and development.

There is no doubt that funding on a much larger scale will be needed for both fundamental research and technology development. Both government and private investment in energy R&D are far below where they should be.

But the whole point is to achieve scale in technology applications. And without attention to critical bottlenecks downstream of the R&D stage -- including commercial technology demonstrations, which have often been poorly handled by the federal government -- many of the potential benefits of more R&D funding won't be realized.

In short, we must be as creative and rigorous in our thinking about how to redesign the institutions for innovation as we will need to be about the innovations themselves.

For example, we must find a way to overcome the obstacles to sound innovation strategies created by the annual government budgeting and appropriations process, by federal procurement regulations, and by shifting political winds.

Here is one idea: Suppose we adopted the principle that the public good part of the energy innovation system beyond basic research (which the Department of Energy manages quite well) should be directly funded by industry sales, rather than by general tax revenues.

Suppose that these funds were collected in the form of a small fee applied to all end-user sales in a given industry segment – electricity service, for example, or gas service -- ***if*** the majority of the firms in that segment voted to do so (Congress would probably have to approve this.) A fee of less than three tenths of a cent per kilowatt hour – or about 60 cents per week for the average household – would generate an annual stream of revenue five times larger than the total annual DOE budget for applied energy research, development and demonstration.

Suppose, then, that the firms in this industry organized themselves into interest groups, or innovation boards, which would each be responsible for a different technological pathway – smart grid technologies, carbon capture and storage, next generation photovoltaics, and so on.

Each board would request proposals to fund work in its domain from businesses, public research laboratories, universities, and others. To qualify to receive these funds, bidders would have to agree to put the resulting intellectual property into the public domain – available to everyone.

At the beginning of each cycle, every firm in the industry would distribute the fees collected from its customers among these boards based on their work programs and its own priorities. If, say, a utility was particularly eager to see progress in carbon capture and sequestration, it might allocate funds to the carbon capture and sequestration board. Or, if it was concerned about skilled manpower shortages, it would allocate funds to the energy education and training board, which might have an ongoing scholarship program for power engineering students.

If a utility was unhappy with the progress being made by one board, it could redirect its funding to another. Or it could itself decide to form a board in a new area and fund that, perhaps in conjunction with other firms. It would in any case have to commit all of its innovation fees to one board or another.

Such a scheme would create a guaranteed stream of revenues for energy innovation, while avoiding both the Federal appropriations process and the problem of underinvestment by private free riders. It would ensure that decisions on what to do and who should be funded to do it would be made by those closest to the energy marketplace. And by requiring IP to be shared, it would avoid unfair competitive advantage.

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Another idea: There is great potential for small, entrepreneurial firms to contribute to innovation in the energy sector, as they do in other industries.

But the energy industries are dominated by large incumbent providers who are often slow to embrace transformative or disruptive innovations. These firms typically have tightly integrated supply chains and close ties to government regulators, and they rely on highly-regulated pipelines or wires to deliver energy services to end users. This creates a formidable barrier between entrepreneurial newcomers and end users, and tends to force innovation towards the upstream end of the value chain.

But many opportunities for innovation lie right at the interface with the end-user. Most consumers are indifferent to energy itself – that is, to BTUs or kilowatt hours. What they care about are the services that energy enables: affordable comfort, mobility, lighting, and so on. The provision of energy is almost always just one part of a larger set-up in which a value-added service is delivered to the consumer.

Finding opportunities to combine energy services in creative new ways with other services and products is exactly where smaller entrepreneurial firms can be expected to shine. We need to find ways to let these firms compete and grow in this important innovation space.

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What role for the states in all this?

Decisive progress on the major energy issues will require decisive action at the federal level. It cannot be achieved by states alone. And the longer the delay in serious leadership at the federal level, the more difficult it will be to harmonize conflicting policies.

But many of the relevant authorities – to regulate utilities, to make land-use decisions, to set building codes and zoning requirements, to support public education, and so on – reside at the state and local levels. So the task will require a partnership of federal, state, and local governments.

There is more than enough to do here for everyone. Whole new industries are likely to develop in support of the energy transition, and state-level policies promoting innovation take-up and the development of a skilled workforce will be vital.

Jobs will be generated at every skill level – not just the top end of the range -- and since many of these jobs must be located close to the point of energy use, they are at less risk of outsourcing to lower-wage economies.

Just as one example, let's suppose that by the year 2030 the U.S. was generating 5% of its electricity from small-scale photovoltaic installations – an ambitious goal, though not as ambitious as some recent targets. A rough estimate is that this would create twenty years of steady local work for 45,000-50,000 installers – mostly electricians and construction workers – and perhaps double that number if we include indirect labor. About two hundred thousand additional jobs would be created upstream in the PV value chain – some of which would also be located here in the U.S. And of course this doesn't include the other 95% of the power sector, where many more new jobs are also likely to be created.

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And so, to conclude, it is long past time for serious federal leadership on energy innovation. But it is also time to move beyond the Manhattan/Apollo Project metaphor. A better metaphor might be a domestic Marshall Plan for energy innovation. The original Manhattan project involved a relatively small number of people working in secret. The original Marshall Plan took everyone, working together, to rebuild the broken European economy.

Let us recapture that inspired exercise of American leadership at home. As we did once before on foreign soil, let us combine a vision of what can be with a command of hard facts and data to build an effective system for energy innovation in every one of our United States.

Thank you again for the honor of being with you this morning.

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Richard Lester is director of the Industrial Performance Center (IPC) and a professor of nuclear science and engineering at the Massachusetts Institute of Technology. His research focuses on industrial innovation and the public and private management of technology. In recent years he has led several major studies of national and regional productivity, competitiveness and innovation performance commissioned by governments and industrial groups around the world. His latest books include: *Innovation – The Missing Dimension* (Harvard University Press, 2005), co-authored with Michael J. Piore; *Making Technology Work: Applications in Energy and the Environment* (Cambridge University Press, 2004), co-authored with John M. Deutch; and *The Productive Edge: A New Strategy for Economic Growth* (W.W. Norton, 2000). His new book on the role of universities in local and regional innovation systems will be published by Princeton University Press next year.

Professor Lester is also active in research on energy technology innovation, and co-teaches a popular MIT course on "Applications of Technology in Energy and the Environment". He is a co-author of the recent MIT reports on *The Future of Nuclear Power* (2003) and *The Future of Coal* (2007), and has published widely on the management and control of nuclear technology. He is currently leading the Energy Innovation Pathways Project, an interdisciplinary MIT assessment of the capabilities of the U.S. energy innovation system.