# Transforming the Energy Economy: Options for Accelerating the Commercialization of Advanced Energy Technologies

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Framing Statement
Energy Technology Innovation Policy Research Group

Executive Session at
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# TRANSFORMING THE ENERGY ECONOMY: OPTIONS FOR ACCELERATING THE COMMERCIALIZATION OF ADVANCED ENERGY TECHNOLOGIES

## FRAMING STATEMENT

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Prepared by Harvard Kennedy School's Laura Diaz Anadon, Erik Mielke, Henry Lee, Matthew Bunn, and Venkatesh Narayanamurti with contributions from Booz Allen Hamilton's Gary Rahl and Richard Goffi in four of the case studies.

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# Table of Contents

# Executive Summary

*Introduction to the Workshop*

On December 1 and 2, a select group of senior representatives from government, industry, finance, and academia will convene at the Harvard Kennedy School for an off-the-record workshop on what the U.S. government could and should do to accelerate the commercialization of advanced energy technologies.

The purpose of this framing paper is to provide background information on the topic, establish a common framework, and ultimately stimulate discussion at the workshop. The report format is consistent with the workshop agenda: a discussion of the challenge, followed by a framework for designing policy options, and illustrative case studies.

*The Need to Transform the Energy System*

There is broad political consensus that the current energy system in the United States is unable to meet the nation's future energy needs, from the security, environment, and economic perspectives. New energy technologies are required to increase the availability of domestic energy supplies, to reduce the negative environmental impacts of our energy system, to improve the reliability of current energy infrastructure (e.g., smart grid, energy storage), and to increase energy efficiency throughout the economy.

Rapid transformation of the energy system would require wide-scale introduction and adoption of new, advanced energy technologies. Several factors make the introduction of new energy technologies inherently more difficult than in other sectors. These factors, some of which are listed below, have fostered a very conservative approach to investment in technology innovation, providing a challenging backdrop for rapid transformation.

- High capital cost and slow asset turnover give incumbent technologies an advantage
- Commoditized product leaves limited scope for differentiation other than cost
- The regulatory premium on reliability favors incumbent technologies, and the regulatory environment limits the upside from innovation

*The Demonstration Challenge*

If adequately incentivized, the private sector is usually able to take on the risk and financial burden of deploying new technologies. But before deployment can be realized, new technologies need to be demonstrated at near-commercial scale and in operating conditions closely approximating the commercial environment in which the technology would be deployed.

There are several barriers to private sector investment in demonstration projects, and they vary by technology and energy sub-sector. This framing report explores these barriers in greater detail, including seven mini-case studies, ranging from nuclear power, CCS, and biofuels to solar PV and smart-grid technology. These barriers can be summarized into three main categories:

- Access to capital for large-scale projects
- Technology risk

- Policy, regulatory and market uncertainties

Does the absence of private sector investment automatically mean that there is a sound public, as well as economic, policy argument for government intervention? There is general agreement that with the current regulatory environment, technologies such as CCS will not be demonstrated and commercialized without government support, but there is less agreement about whether the government has a role to play in supporting the large-scale manufacturing of new energy technologies, e.g., solar PV manufacturing.

Some reasons that have been articulated that may justify an increased government role in supporting the demonstration of energy technologies include:

- Without government support, many advanced technologies needed to reduce the environmental impacts of the energy sector may not be tested at a commercial scale as quickly as we need them to be.
- Enabling the demonstration of some technologies may be desirable to increase U.S. energy security and economic competitiveness.
- Having access to and knowledge about a wide array of new technology options could have long-term value to the U.S. economy and society as a whole, particularly as new circumstances arise that are difficult to predict today. This option value may not be adequately understood or captured by the private sector alone.
- Some technologies developed and demonstrated in other countries may not be appropriate for deployment in the United States, e.g., for regulatory reasons.

*Options for Accelerating Commercialization*

It is clear that the government cannot, and should not, support demonstration of all technologies. The heterogeneity of various energy technologies, and the energy industry itself, means that there is no one-size-fits-all or "silver bullet" solution. A framework to support energy technology demonstration projects should consider the following:

- *Choosing Projects*. What criteria should be used to decide which projects to support?
- *Institutional Design*. Should policy implementation rest within existing Department of Energy (DOE) agencies or would it be better to create new institutions. e.g., the Clean Energy Deployment Administration (CEDA)?
- *Appropriate Mechanisms*. Which of the current mechanisms work and should be expanded and/or improved? Are there any other options that should be considered?

*Workshop Objectives*

The lack of consensus on the appropriate course of action for the government partly reflects established technology biases (e.g., coal vs. nuclear vs. wind), as well as different perceptions of the role to be played by the government vis-à-vis the private sector in the general economy. A similar diversity of views is likely to be present at the workshop. The event is not intended, however, to resolve all questions.

Instead, by bringing together some of the most engaged individuals from the governmental, industrial, financial, and academic sectors, we hope that we will be able to identify: (1) areas where there may be a degree of agreement regarding the case for government intervention; (2) some of the appropriate tools that the government could

use and mechanisms for the government to take action; and (3) areas where research or future workshops may be helpful to determine the best policy options.

# 1. Defining the Problem

## 1.1. The Energy System Poses Unique Challenges

There are several factors that make the energy sector structurally different from most other industries. Lessons can still be learned from the successes and failures of other sectors, but there are unique features, which make the rapid diffusion of advanced energy technologies (particularly in energy supply) harder to achieve and deploy, and favor incremental change. These factors have fostered a very conservative approach to investment, providing a challenging backdrop for rapid transformation.

- *High capital cost and slow asset turnover*. The U.S. energy infrastructure has been built up over many decades. It is a large, interconnected system of mostly very expensive facilities, often costing more than $1 billion per facility.[1] The energy-supply infrastructure also has much longer lives than is normal for industry. For instance, the median age of the current fleet of coal-fired power plants in the United States is 44 years.
- *Incumbent advantage*. The high cost and long life of the infrastructure give existing energy assets a substantial cost advantage over new competing technologies. New technologies may have superior operating performance, but high capital cost makes it harder to compete with incumbent projects with depreciated assets (e.g., 40-year old coal-fired power plants). It also emphasizes another important feature of the energy system: investment decisions made today will be part of the energy system for many decades to come.
- *Commoditized product with limited scope for differentiation*. Sectors that experience a rapid pace of innovation, such as the information and communications technology sector are able to offer significant product improvements to users from one generation to the next. The same is not true for the energy system. Consumers are generally indifferent about whether their source of electricity comes from a modern wind farm or a 40-year old coal-fired power station.[2]
- *Reliability premium favors incumbent technologies*. The energy system, especially the electricity sector, places a premium on reliability, as consumers, regulators, politicians, and other stakeholders' tolerance for blackouts or fuel shortages is very low. This favors existing technologies, which have already been tried and tested.
- *Regulatory environment limits upside*. Many aspects of the energy system are heavily regulated, especially the electric utilities. This can limit the upside from taking additional technology risk, with incentives geared towards reliability and low

[1] Typical power stations cost about $400 million for a 400 MW advanced combined-cycle gas turbine (CCGT) to $1.4 billion for a 550 MW integrated coal-gasification combined cycle (IGCC) facility. Cost estimates for new nuclear power plants carry greater uncertainty but would likely be close to or exceed $5 billion for a 1,350 MW facility (2008 estimates from DOE/EIA Annual Energy Outlook 2010). Modern oil refineries are also expensive, with an advanced 200,000 barrel per day refinery having a price tag in excess of $4 billion.

[2] Carbon pricing or portfolio standards may introduce a meaningful degree of product differentiation at the wholesale level.

costs in the present. As a result, electric utilities have limited incentive to be early adopters of new technologies.

## 1.2. The Need to Accelerate Energy Transformation

There is broad political consensus that the current energy system in the United States is unable to meet the nation's future energy needs, from the security, environment and economic perspectives. New energy technologies are required to increase the availability of domestic energy supplies, reduce pollution (including greenhouse gas emissions), improve the reliability of the grid with "smart" technologies and added storage capacity, and provide enhanced energy efficiency in the transportation section and in buildings.

The upward trend in oil prices over the past decade has added renewed urgency to the economic imperative for reduced reliance on imports, as have the prospect of rising competition for resources from the large emerging economies, especially China and India.

## 1.3. Energy Technology Commercialization

The private sector cannot shoulder this challenge alone. It has neither the financial capability nor the willingness to shoulder a disproportionate share of the financial, operating and demand risks inherent in new cutting edge technologies. If this is true -- what role should the government play in accelerating this transformation?

Without government support, many advanced technologies will not be tested at a commercial scale. And even where the private sector may ultimately be able to bring certain technologies to market, accelerating this process may be desirable to reduce the environmental impacts of the energy sector and to increase energy security and economic competitiveness in the United States.

Having access and knowledge about a wide array of new technology options could be seen as having long-term value to the U.S. economy and society as a whole. This option value may not be adequately understood or captured by the private sector alone. Carbon capture and sequestration (CCS), Gen IV nuclear power, and advanced biofuels technologies are some examples of what such technology options may be.

The desire to transform the energy economy and seize the growing energy technology market is shared by many other countries, some of whom have adopted more aggressive policies than the United States, e.g., China and the European Union. The international trend represents both an opportunity and a threat for the United States. The opportunity stems from the ability to share risk and leverage investment by others. It also provides U.S. companies with access to other markets. The threat is that the United States might not be able to compete and will lose not only international markets, but also domestic markets to China and other countries in what has become a highly competitive global market.

## 1.4. Government and Private Sector in Energy Innovation

This framing paper differentiates between four main "stages" of innovation — Research, Development, Demonstration, and Deployment (which is itself divided into market

formation and widespread diffusion), while recognizing that energy innovation is not a linear process, as it involves multiple feedback mechanisms between the four stages, and phases are unlikely to be as discrete as is suggested by the headings. [3]

#### *1.4.1. Government Versus Private Sector*

There is general acceptance that the government has a positive role to play in support of basic and applied science (R&D), e.g., university research and federal labs, and other recent initiatives like ARPA-E and Energy Innovation Hubs.

It is also generally accepted that the private sector is ultimately responsible for deployment (selecting, financing and maintaining the energy capital stock). Although the government is not passive in the deployment phase, as regulation of the utilities, fiscal policies including taxation and subsidies, influence the private sector's decision whether and where to invest.

Deployment only takes place if the private sector is incentivized, either by an adequate expected return, or as required by regulation as part of the cost of being in the business (see Appendix III, Risk-Reward Framework).

The government is also a large consumer of energy, giving it a unique opportunity to influence energy supply.

#### *1.4.2. Demonstration "Valley of Death"*

The demonstration of new technologies – the construction and operation of a technology at a commercial scale for the first time – is usually a role played naturally by the private sector in most industries. The private sector will demonstrate a technology when it is close to being commercial, and the rewards of commercializing new technologies are adequate compensation for the higher risk investment.

This is not always true for the energy sector. There is widespread acceptance that there is a demonstration "valley of death" for new energy technologies. The term signifies the challenge that new technologies face when trying to move from the R&D laboratory to commercialization in the market place.

Demonstration projects are rarely commercially viable on a stand-alone basis, even if technically successful. They are intended to demonstrate that the technology works at a commercial scale and can support a particular revenue model, demonstrating economic feasibility in addition to the performance of the technology. They provide an important cost baseline, which should improve as more facilities are built, expanded, and operated. Demonstration projects also provide operating performance history and information about reliability, efficiency, and operating costs. Both of these factors increase the likelihood of obtaining commercial financing for future projects, and allaying concerns that the customers (the companies that will ultimately deploy the technology at scale) may have about cost and performance.

[3] There are many variations on this theme: e.g., Discovery, Development, Demonstration, Commercialization, and Maturation (CAP: How to Empower the Energy Innovation Lifecycle); and Invention, Translation, Adoption, and Diffusion (E. S. Rubin).

The demonstration challenge exists for all technologies, but it is greater for the energy sector for the reasons outlined earlier: high investment needs, low capital turnover, competition from incumbent, mature technologies, and commoditized nature of end product. The demonstration challenge also varies within the energy sector. There is general agreement that with the current regulatory environment, technologies such as CCS will not be demonstrated and commercialized without government support. Conversely, there is less agreement about whether the government has a role to play in supporting the large-scale manufacturing of new energy technologies, e.g., solar PV manufacturing.

#### *1.4.3. Heterogeneity of Energy Technologies*

Challenges and opportunities vary greatly by energy technology. For instance, constructing an advanced nuclear power reactor has fundamentally different challenges from those of demonstrating the potential of smart-grid technology. Likewise, the challenge of demonstrating a biorefinery technology at scale is very different from the challenge of commercializing a new energy storage technology. Policy responses need to be flexible, tailored appropriately to adjust for such differences, and yet be part of a coherent overall energy strategy.

#### *1.4.4. Heterogeneity of Energy Sector Participants*

The energy companies are equally diverse in their willingness to adopt new technologies. This willingness varies greatly across subsectors, by size and geography, but more importantly, also by risk appetite. A marked difference can be seen between the large oil and gas companies and the electric utilities. Both make very large investments in energy infrastructure, but with very different risk-reward profiles.[4] Electric utilities also vary greatly, depending on their ownership structure, technology mix, and exposure to regulated and deregulated electricity markets.

A policy mechanism for incentivizing investment should reflect the diversity of the energy sector. For instance, an oil company investing in a biofuels project may be willing to tolerate greater technology and price risk if the upside is uncapped. In contrast, a utility investing in grid-scale solar PV would settle for lower expected returns if these came with lower variability (e.g., through production tax credits or a feed-in tariff).

## 1.5. Barriers to Private Sector Investment

The heterogeneity of energy technologies and sub-sectors means that there is no "silver bullet" or one-size-fits-all solution to the demonstration and commercialization challenge. Nevertheless, some natural groupings of barriers to demonstration emerge. We summarize below each of the dominant barriers: (i) access to capital for large-scale projects, (ii) technology risk, and (iii) policy and regulatory uncertainty.

[4] Integrated oil companies have historically provided significantly higher return on equity (ROE) compared to electric utilities, but with much greater volatility of returns for the oil companies (i.e., higher risk). For the last five years, the six largest oil majors averaged 20.5% ROE compared to 11.1% for the ten largest U.S. electric utilities (data sourced from Zacks Investment Research via ycharts.com).

For one group of technologies, the first (access to large amounts of capital) and second (technology) barriers are very important. These technologies include nuclear, advanced coal, and biofuels technologies. CCS also fits into this category, although the policy uncertainty about carbon pricing is the key barrier. Manufacturing of solar PV and energy storage devices also fit this description, albeit the scale challenge is due to the need to achieve economies of scale of manufacturing.

For another group of technologies, technology risk and policy and regulatory uncertainty are the primary barriers to investment. This group includes smart-grid, offshore wind, geothermal, and utility-scale storage technologies, and end-use efficiency improvements for vehicles, appliances and buildings.

We provide below seven examples in mini case studies to illustrate some of the barriers to the demonstration of energy technologies and some examples of current policies that might address demonstration needs. Technologies represented in the examples include CCS, nuclear, biofuels, solar PV manufacturing, and advanced coal. The policy tools in the cases include grants, loan guarantees, reverse auctions, and government funded and run test-bed facilities.

### *1.5.1. Access to Capital for Large-Scale Projects*

There are different views on whether the private sector's inability to finance very large demonstration projects should be considered a separate part of the demonstration challenge, or rather the outcome of technology risk, and policy and regulatory uncertainty. If all technology risk could be removed, and political and regulatory uncertainty dealt with, would there still be a demonstration challenge? The answer would appear to be no, at least for commercially viable projects.

While this argument clearly has merit, it risks paying inadequate attention to the importance of size in companies' perception of risk. Companies view investment in new technologies as buying options, essentially options on different outcomes (technologies, commercial environment, regulation, etc.).

A company might view a $50 million-a-year R&D budget as a relatively low-cost option, even though the technology and other risks are very high at the R&D stage. A large demonstration facility with a $500 million price tag is a different story, even if the technology risk has been substantially reduced from the R&D stage. The project is competing with existing, mature technologies for limited risk capital, and the size of investment makes it a much more expensive option, as it significantly reduces the availability of capital for other investments (it has a high implied cost).

Nuclear, CCS, advanced coal and biorefineries are clear examples of how the scale of the investment acts as a barrier that significantly amplifies technology risk. For instance, the large size of the required investment is arguably one of the reasons for the increased interest in modular nuclear reactors.

Some technologies (e.g., biorefineries) need to be built at large scale to demonstrate reliability and performance, as small-scale pilots do not yield the necessary performance and cost information required to move to commercial deployment. For other technologies (e.g., solar PV), the project may need to demonstrate that costs will come

down with manufacturing scale, even if the performance and reliability of the individual component (the product) may already known.

### *1.5.2. Technology Risk*

Technology risk is perhaps the most obvious barrier to investment. If the technology risk did not exist, deployment of the technology would primarily depend on whether the technology is able to compete with alternatives under different market conditions.

The primary purpose of a demonstration is to verify that a technology costs and performs as intended. These risks differ during the construction and operating phases of a project.

The *construction* part of the demonstration project is meant to show whether the facility can be built to specification within a given timeframe and construction budget. The *operating* phase should demonstrate a variety of performance factors, including operating costs, efficiency/output performance, availability factor, and maintenance costs, as well as environmental performance.

### *1.5.3. Policy, Regulatory, and Market Uncertainties*

Policy and regulations have a significant impact on almost all aspects of energy technologies. Lack of, or uncertainty about, policy and regulations are a major barrier to commercialization. The list below includes some of the uncertainties and factors that are likely to affect the private sector's willingness or ability to invest in commercialization:

- *Policy and market uncertainty*. The private sector is naturally reluctant to anticipate new policies when such policies are uncertain, e.g., carbon pricing or other regulation of carbon emissions. Uncertainty about whether current policies will remain can also have a detrimental effect on the incentives, e.g., wind deployment varied substantially as the production tax credit was on-and-off, making it harder for a successful domestic windmill manufacturing industry to thrive. This uncertainty can also extend to markets created by mandates, if there is evidence that the current policy may not be sustainable in its present form (e.g., the Renewable Fuel Standard's requirement for cellulosic ethanol), or that mandates will not materialize (e.g., a Renewable Portfolio Standard or a Clean Energy Portfolio Standard for electricity).
- *Legal uncertainty*. Some technologies would require enabling legislation, e.g., a legal and regulatory framework for carbon sequestration, irrespective of carbon pricing.
- *Network access*. Established networks favor incumbent technologies unless regulation can lower the barriers to entry. This is true for new fuels (e.g., compressed natural gas (CNG) and hydrogen), grid access for certain renewable technologies (e.g., offshore wind may not be able to compete with existing sources without access to the grid), and incorporation of smart-grid technologies.
- *Regulatory recognition*. It is unclear how those utilities investing in utility-scale energy storage will be compensated for their investment under the regulatory framework.

- *Uncertainty about infrastructure developments*. Establishment of new infrastructure for a new system, e.g., a supply network of biomass for biofuels and a charging network for electric vehicles.

## 1.6. Case Studies

The following seven short case studies illustrate the key barriers to commercializing new energy technologies, as discussed above. The studies are intended to give a sense for some of the more important barriers, and are not meant to provide a comprehensive review of any given technology or company.[5]

### *1.6.1. Access to Capital for Large-Scale Demonstration Projects Examples*

For certain energy technologies, the scale of the project and the required capital acts as an amplifier of technical risk and other uncertainties. The following three case studies provide examples of: (i) a technology that has been unable to secure financing in the United States and is looking to China for capital instead (advanced coal gasification); (ii) an innovative approach to financing demonstration plants through reverse auctions for biofuels; and (iii) a solar PV maker seeking manufacturing on a large, commercial scale.

**Case 1: Advanced Coal (GreatPoint Energy)**

*Issue: Potentially transformational technology with major long term significance, undercut by lack of funds for commercial scale demonstration plant and near term drop in commodity prices*

GreatPoint Energy has developed a coal gasification process that has the potential to radically transform the use of coal and the associated capture of carbon dioxide. Its technology is a catalytic process that, compared to current gasification technologies, operates at much lower temperatures, involves fewer processes, is less corrosive, and is less expensive. It also produces pipeline quality natural gas, rather than syngas, that can be fed directly into the natural gas pipeline system for widespread use. This has the same transformational potential for coal gasification as catalytic cracking did for the petroleum industry, which replaced what had been the standard in the industry (thermal cracking of petroleum).

The GreatPoint technology has its origins in ExxonMobil's response to the natural gas crisis of the early 1970s. At that time, the primary source of natural gas was co-production with crude oil, and declining oil production had triggered serious concerns over U.S. natural gas supplies. The development of non-conventional sources such as coal-bed methane and Canadian imports alleviated the crisis, and the technology was put on the shelf.

Fast forward three decades later, to 2005: natural gas prices were at record highs, Canadian imports were projected to decline, coal bed methane resources were in decline, and the general industry consensus was that significant imported liquefied natural gas (LNG) would be required to meet U.S. demand. GreatPoint was launched in this environment and began development efforts to improve the legacy ExxonMobil catalytic gasification process to produce pipeline quality natural gas from coal and other feedstocks.

The company raised $140 million and is backed by strategic investors including Dow Chemical Company, Suncor Energy, AES, and Peabody Energy, and major financial institutions and venture capital firms such as Kleiner Perkins Caufield & Byers, Khosla Ventures, Draper Fisher Jurvetson,

[5] Even though cases often display aspects of more than one barrier, they are used to provide an example of one barrier.

Advanced Technology Ventures, and Citi's Sustainable Development Investments. GreatPoint operated a test facility at the Gas Technology Institute in Illinois, and successfully constructed and ran a pilot scale demonstration project at the Brayton Point power station in Massachusetts.

Next, the company had to build and operate a near-commercial scale demonstration plant in order to convince potential industrial and utility customers that its technology was ready for commercial deployment. That demonstration plant would require some $300 to $400 million of investment. If successful, however, the facility could be expanded into a full-scale commercial plant.

GreatPoint had difficulty raising the investment for the demonstration plant because of the significant capital cost and the technical risk involved in the project. The company's strategic partners were unwilling to put up the total cost of the facility. GreatPoint was also unsuccessful in securing federal government funding from DOE.

Its continuing efforts to secure funding for the demonstration plant suffered a major blow with the collapse of natural gas prices[6] in July of 2008. With the onset of the recession, natural gas prices dropped from $13.60/MMBTU to $6/MMBTU by year's end. Natural gas has traded between $3-$6/MMBTU through the present day, driven in part by a significant increase in domestic supply due to the development of gas shale reserves. GreatPoint's cost of production is estimated to be in the upper portion of the range of prices for new-drilled shale natural gas wells and in the higher end of natural gas's current trading range. The decline in natural gas prices and the increase in domestic reserves have severely reduced the value proposition for GreatPoint's technology. The option value of the (better, cleaner utilization of coal) is inadequate for the private sector to finance the demonstration plant with the medium-term outlook for commercial deployment in the United States dimmed by relatively low-cost natural gas.

With limited domestic prospects for funding the demonstration plant, the company looked overseas and, in late 2008, signed a deal with Datang Huayin Electric Power (DHEP). After conducting the early feasibility studies however, DHEP announced in December 2009 that it was cancelling its plans to build the synthetic natural gas (SNG) demonstration project due to the low financial return shown by the studies. GreatPoint has turned its strategy to look at co-production of hydrogen and CO2 for enhanced oil recovery. Uncertainty over CO2 regulation, the availability of lower cost CO2, and high capital costs have blocked any realization of projects to date.

**Case 2: Production Incentives for Cellulosic Biofuels (Reverse Auctions)**

*Issue: Financing demonstration biofuels refineries is expensive and the fuel produced by the facility may not be cost competitive with gasoline and diesel. The provision of production incentives, with the incentives allocated using reverse auctions, could serve to promote the development of some of advanced biorefining technologies.*

The Energy Policy Act of 2005 (EPAct), Section 942, established an incentive program for production of cellulosic biofuels, using reverse auctions[7] to set the level of incentives. The purpose

[6] All natural gas prices referenced are NYMEX Henry Hub.

[7] In a reverse auction, also known as a procurement auction, the role of buyer and seller are reversed. Sellers bid for a contract or agreement with one buyer. The winning bid usually reflecting the lowest price or some other transparent criteria specified by the buyer. The buying party specifies the requirements (e.g., quantity, quality, opening bid price, and bid decrement). Selling parties enter the marketplace and bid on the auction. One variation of a reverse auction is a company seeking to buy 10,000 gallons of heating oil for December 5-10 delivery at its facility in Cambridge, MA, at a price of no more than $3/gallon with bids in

of the program is to (1) accelerate the deployment and commercialization of biofuels, (2) deliver the first one billion gallons of annual cellulosic biofuel production by 2015, (3) ensure that biofuels produced after 2015 are cost competitive with gasoline and diesel, and (4) ensure that small feedstock producers and rural businesses participate in the development of the cellulosic biofuels business.

The Energy Independence and Security Act of 2007's (EISA) updated Renewable Fuel Standard (RFS2) introduced explicit mandates for cellulosic biofuels, with a target of 1 billion gallons for 2013, but made no changes to the reverse auction program.

The Section 942 program has certain limitations: (1) no more than $100 million can be awarded in any one year, (2) total program ceiling of $1 billion, and (3) no more than 25% of funds committed within each reverse auction to any one project.

EPAct required the first auction within three years (i.e., before August 2008), but progress has been slow. The DOE published final rules for the reverse auction in October 2009:

- Bidders to be pre-cleared ahead of the reverse auction.
- Each auction is for a contract period of six consecutive years of production, starting within three years of winning the auction.
- Bidders specify volumes (in gasoline-equivalent terms, adjusted for heat values) eligible for incentives.
- Bids are assessed on the lowest level of production incentive on a per gallon basis.
- The production incentive is limited to $1 per gallon for the first four years, declining to $0.95 thereafter.
- Producer must meet minimum 50% of agreed volumes in a given year to receive the incentive, with any volumetric shortfall carried forward to the next year.

In July 2010, the DOE issued a notice of program intent, with the first reverse auction anticipated in September 2010, with a budget of $4.6 million. The auction has not yet taken place and it is not clear whether an adequate number of companies pre-qualified to make it a competitive auction (i.e., five or more, as each project is limited to a max of 25% of the award per auction).

The slow pace of the reverse auction program and the modest funding actually appropriated by Congress ($5 million in the 2008 budget) means that this mechanism has not yet supported the construction of demonstration projects for cellulosic biofuels. If the first auction goes ahead as announced, and four bidders (the minimum) share the incentive award, the amount available to each producer would be at most $1.15 million, or $192,000 for each of the six years.

**Case 3: Solyndra**

*Issue: Public sector financial support can enable a new technology to achieve manufacturing scale much more rapidly than it would otherwise. However, some of that financing is at risk depending on market conditions.*

Solyndra was established in 2005 to develop an innovative solar photovoltaic (PV) technology using a cylindrical panel design for commercial rooftop applications. The novel design features include a rack of cylindrical tubes, as opposed to traditional flat panels, which are designed to

$0.01 decrements. Potential suppliers then bid starting at $3 with the auction continuing until there are no lower bids (e.g., 25 rounds leading to a price of $2.75/gallon).

produce more consistent power throughout the day than traditional systems. The innovative rack design also reduces degradation due to snow and dirt, and is easier and cheaper to install and maintain.

The company has been very successful in raising venture capital, securing more than $970 million. That money has fueled technology development and improvements as well as initial commercialization and production. To expand its manufacturing capacity and achieve large-scale commercialization of its technology, Solyndra secured a $535 million loan from the U.S. Treasury's Federal Financing bank, with the help of a guarantee from DOE. It embarked upon building a second manufacturing plant in Fremont, California, with annual production capacity to supply 500 MW of solar PV systems, and expanded its workforce to over 1,100.

As with many technology startups, Solyndra has faced several obstacles during its five-year journey from start up to large-scale commercialization. Two principal challenges have been scaling up production to commercial levels and reducing the product costs to compete effectively with alternative solar technologies. Nevertheless, the company has seen its systems installed commercially on rooftops in the United States and overseas, and had revenues of $100 million in 2009. In December 2009, Solyndra filed its plans with the SEC for an IPO to take the company public in 2010.

Market conditions in 2010, however, have been very difficult. First, the capital markets for new public offerings have remained sluggish. Second, the international market for PV systems has become increasingly price competitive. PV prices have been fallen substantially, driven down primarily Chinese manufacturers. Falling silicon prices and increasing manufacturing volumes lowered their unit costs, supported by Chinese government support (inexpensive credit, access to land, etc.). The lower silicon prices reduced some of Solyndra's supposed cost-advantage, as its technology uses fewer such materials.

In response to these market conditions, Solyndra announced in June that it was withdrawing its plans for an IPO in 2010. Then, in early November 2010, the company announced that it would stop its current expansion efforts. It is closing its first production facility and reducing its workforce by approximately 150 employees. It will use its remaining 110 MW annual manufacturing capacity to fulfill sales orders and will focus on reducing its production and installation costs. Its 2013 target for manufacturing capacity has been revised down from 610 MW to "up to 300 MW".

There is no public information yet about how much of its federal loan guarantee may have already been used in the manufacturing plant expansion to date, or about the extent to which the federal government guarantee is "at risk" or not. Are there corporate obligations to repay the loan fully, and release the federal guarantee, if the company continues in business?

Solyndra's experience demonstrates that innovative technologies can and will attract private capital for initial investment. The experience also shows how government support can help move a technology toward large-scale commercial production more rapidly than otherwise would have been realized. In the end, however, rapid changes in market conditions (faster decline in competitor costs than anticipated due to the collapse in silicon prices and rapid manufacturing expansion by Chinese companies), has challenged the business premise.

### *1.6.2. Technology Risk Examples*

Technology risk is one of the most important aspects of demonstration projects. The following two mini case studies provide examples of how biofuels facilities at a national lab (NREL) and DOE funding for CCS projects are helping to reduce technology risk.

**Case 4: NREL User Facilities for Biofuels**

*Issue: Access to advanced testing facilities improves the results of a pilot plant and reduces the technology risk of a demonstration facility. Test beds should reduce the cost of testing and should also improve the quality of the results. The National Renewable Energy Laboratory (NREL) operates two pilot-size facilities for biomass research that are available to industry partners.*

An effective pilot project is an important part of reducing the technology risk of a demonstration facility, by allowing the company to fine-tune the design for a variety of feedstocks and operating conditions, before building the many-times more expensive demonstration facility.

In addition to its technology partnerships and licensing of technologies, NREL also operates facilities for biomass research, which are available to industry for testing feedstocks, processes, and equipment at the laboratory and pilot stage.

NREL has operated the Alternative Fuels User Facility (AFUF) for over 25 years. AFUF was originally created to provide a national center where partners could test out various processes for converting cellulosic feedstocks to ethanol or other products without having to invest in their own pilot plant. The facility allows testing of various combinations of operating conditions to determine the optimal settings for various feedstocks, enzymes/organisms. In 2010 and 2011, the AFUF is being expanded with an Integrated Biorefinery Research Facility, which will provide the cellulosic ethanol industry access to a bigger pilot and research facility.

Another biomass user facility operated at NREL is the Thermochemical User Facility (TCUF). The TCUF offers testing and development of various reactors, filters, catalysts, and other unit operations. It also has the capability to test new processes and feedstocks to obtain performance data on specific processes or equipment. TCUF operates the Thermochemical Process Development Unit, which allows testing of gasification and pyrolysis processes. It also has catalytic fuel synthesis reactors (syngas liquefaction), biomass conversion system (gasification and syngas conditioning), and fuel synthesis catalyst test facility (catalyst testing).

The private sector benefits from utilizing these facilities provided by NREL in three important ways: (1) access to advanced technology and know-how, (2) substantial cost savings compared to running tests independently, and (3) results produced at NREL facilities have greater credibility with third parties, which may reduce the perceived risk of a given technology and improve access to financing as a result.

Most of the User Facilities efforts are aimed at the pilot stage, which helps reduce the risk of subsequent demonstration projects. Are there ways that the program can be increased in scope or scale to increase the impact on enabling effective demonstration plants to be build?

**Case 5: Carbon Capture and Sequestration Demonstrations**

*Issue: CCS technologies have such high economic and performance risks that advancements must be demonstrated to work at commercial scale before they will be adopted in the*

*marketplace. Absent strong market drivers, the federal government can reduce such risks by providing a large cost-share for these demonstration facilities.*

Over 50% of the electricity generated in the United States comes from coal-fired plants and these plants are likely to remain a significant source of electricity for decades to come. As a consequence, coal-fired generation will continue to be a major source of the nation's carbon-dioxide ($CO_2$) emissions unless addressed. In the absence of market drivers for reducing $CO_2$ emissions (e.g., a price on carbon emissions), carbon capture and sequestration (CCS) technologies are unlikely to be developed.

An Administration policy goal is the development and deployment of cost-effective technologies to reduce emissions that will allow for earlier deployment and will reduce emissions with lower overall societal costs. Under any scenario, however, the addition of CCS technology will increase the cost of generating electricity from coal. Recent estimates indicate that the current cost of CCS may be $120-180/ton $CO_2$, but analysis suggests that technology advancements could reduce that to $30-$70/ton $CO_2$.[8]

The achievement of substantial reductions in the costs of CCS technology will require major advances or breakthroughs in numerous systems involved in carbon capture (pre- or post-combustion), transport, and sequestration. DOE has made CCS a key element of its RD&D portfolio and is funding the next generation of advanced capture concepts for coal-fired power plants through the seven Regional Carbon Sequestration Partnerships, among other initiatives. The 2009 Recovery Act also appropriated $1 billion for FutureGen and over $575 million to accelerate CCS research and development for industrial sources. DOE's overall goal is to develop and successfully integrate advanced technologies capable of achieving 90% $CO_2$ capture at less than a 10% increase in the cost of electricity.

A number of policy options have been under consideration, to encourage more rapid commercialization of CCS. The proposals include allowing double credit for $CO_2$ captured during the first few years of a cap and trade regime; tax credits; investment and production credits and support; government guarantees on the performance of long-term sequestration; and for regulated utilities, allowing CCS plant capital costs to be recovered in the rate base.

### *1.6.3. Examples of Policy and Regulatory Uncertainty*

The following two case studies provide examples of policy and regulatory uncertainties acting as barriers to the demonstration of energy technologies. The first case shows how a recent DOE initiative (funded by the American Recovery and Reinvestment Act of 2009) is addressing the network access problem for certain smart-grid technologies. The second study focuses on the impact of carbon pricing policy uncertainty on the investment flowing into CCS demonstration projects.

[8] The long-term estimate is for an "$n^{th}$-of-a-kind" facility. All cost estimates are from Al-Juaied, Muhammed, and Whitmore, Adam (2009), "Realistic Costs of Carbon Capture," http://belfercenter.ksg.harvard.edu/files/2009_AlJuaied_Whitmore_Realistic_Costs_of_Carbon_Capture_web.pdf

**Case 6: ARRA-Funded Smart-Grid Demonstration Pilots**

*Issue: The federal government lacks the funds to invest in many large infrastructure projects, so it is supporting demonstration, monitoring, and verification projects that will reduce the barriers to local investment by utilities and approval by public utility commissions.*

The development and deployment of a "smart grid" is widely viewed as a key enabler for a more resilient, secure and environmentally sustainable power system. The smart grid would replace the 20th century power grids with a modern "mesh" network that overlays the electrical grid with an information and real time management system that enables sophisticated computerized control.

The smart grid offers a number of potential benefits to utilities and consumers alike, including enabling active participation by consumers, optimizing asset utilization and efficient operation, anticipating and responding to system disturbances, accommodating renewable energy generation and storage options, providing power quality for the digital economy, enabling new products (such as electric vehicles), services and markets, and ensuring resilience against attack and natural disaster. Some utilities that have installed smart meters and communications systems, for example, have reported that they can save about 2% of their total energy costs by more closely matching generation to their actual customer demands throughout their systems.

However, the "smart grid" comes with a sizeable price tag. The Electric Power Research Institute has estimated a nationwide cost of $165 billion over the next 20 years. The American Society of Civil Engineers estimates the total investment needs by electric utilities by 2030 could be as high as $1.5 to $2 trillion including the cost of new generating units (solar, nuclear, etc.).

Faced with these sizeable costs, the utility industry has been slow to deploy smart grid technologies. One key barrier is the reluctance of public utility commissions (PUC) to approve smart grid investments due to the difficulty in quantifying the specific value of services and overall consumer benefit. For example, in June 2010 the Maryland Public Service Commission denied Baltimore Gas & Electric Co.'s application to deploy smart meters to all its customers because they viewed that the ratepayers would bear unnecessary financial and technological risks in return for uncertain benefits.

In the past, the federal government itself actually made some of the large-scale investments in the electricity grid, such as building the whole TVA system, the Bonneville Power System, the large hydroelectric dams in the west, and many of the high voltage transmission lines that make up today's Western Area Power Administration. In today's budgetary environment, however, that kind of federal investment is unlikely to be available.

What may be possible in today's fiscal environment is more modest federal funding for demonstration projects and efforts to monitor and verify the benefits of those smart grid projects that are being built. With that goal in mind, the American Recovery and Reinvestment Act (ARRA) included $4.3 billion of funding specifically for "smart grid" technology investment. The DOE has allocated these funds in 16 different smart grid demonstration projects (see Appendix V for a summary of the projects) that are designed to verify smart grid technology viability, quantify costs and benefits, and validate new smart grid business models, at a scale that can be readily adapted and replicated around the country. Information from these projects will be collected and provided to customers, distributors, and generators to change behaviors in a way that reduces system demands and costs, increases energy efficiency, optimally allocates and matches resources, and increases the reliability of the grid. Equally important, performance data from these demonstrations will be used by PUCs throughout the country to quantify the specific values of these multiple and inter-related benefits, helping to make informed cost allocation decisions.

**Case 7: Loan Guarantee Uncertainty for New Nuclear (Constellation Energy)**

*Issue: The loan guarantee program is intended to mitigate some of the financing risks associated with large energy projects, including nuclear power. The project-specific loan guarantee credit subsidy and other credit conditions are contentious: if set too high, it undermines the purpose of the program; if set too low, the cost of the loan guarantee program to taxpayers may become politically and fiscally unsustainable.*

Construction of nuclear power plants in the United States has been at a standstill for decades for a variety of reasons. Regulatory uncertainty, rising construction costs, and project delays, among other factors, made it virtually impossible to obtain commercial financing for new nuclear power plants.

The Energy Policy Act of 2005 included a variety of support mechanisms to help the first few new nuclear plants overcome these obstacles, including government insurance against the risk of regulatory delays, production tax credits, and federal loan guarantees covering up to 80% of construction cost. The first loan guarantee to a nuclear power project was an $8.33 billion conditional commitment offered in February 2010 to Georgia Power Company, for construction of two 1,100 MW nuclear reactors. At the time of the announcement, several other new nuclear plants were expected to get similar loan guarantees from the DOE.

One of the projects that was expected to receive a loan guarantee was the Calvert Cliffs 3 (CC3) project. CC3 is a 1,600 MW Evolutionary Power Reactor (EPR) at the Calvert Cliffs nuclear power plant in Maryland. The CC3 plant was to be built by UniStar, a joint venture between Constellation and Electricite de France (EDF), the French utility. (UniStar has three other similar expansion projects identified nationally.) In October 2010, Constellation withdrew from the CC3 project and exited the UniStar joint venture, leaving EDF the sole owner of UniStar.[9]

Constellation put forward the reasons why it withdrew from the CC3 project and the application for a $7.5 billion loan guarantee from the DOE, in a letter to the DOE from Michal J. Wallace, Vice Chairman and COO of Constellation. The letter identified the cost the government proposed to charge for bearing the risk of the loan guarantee (known as the credit subsidy cost) and the other conditions of the guarantee as "unreasonably burdensome." Constellation specifically pointed fingers at the methodology for calculating the credit subsidy, which initially came in at 11.6% of the guarantee, or $880 million. According to Constellation, subsequent negotiations "failed to meaningfully and sufficiently lower the credit cost number" and added further conditions, which made the "project economics and risks more, not less, challenging." As a result, at present the future of the CC3 project, and of other nuclear loan guarantees, is very much in doubt.

[9] The NRC is not allowed to issue a nuclear reactor license to a foreign entity, hence EDF would likely need a U.S. partner with over 50% ownership in UniStar, to be able to continue with CC3 and the other expansion projects.

# 2. Designing the Solutions

## 2.1. Choosing Projects and Appropriate Policy Tools

When the objective is to accelerate the commercialization or scale-up of new energy technologies, it is clear that not all technologies can or should be supported. Indeed, one of the most frequent objections to government support for different technologies is that governments should not "pick winners", but should instead provide a level playing field to allow market forces to decide.

The challenge, therefore, is to balance the need for accelerated commercialization with the desire for economic efficiency and effectiveness. Below are some of the key factors to consider when designing an institutional framework to support technology demonstration projects (Appendix IV, Policy Constraints, provides additional discussion on policy constraints):

- *Clear objectives*. The objectives of programs and mechanisms to enable the scale-up of energy technologies should be clearly defined. It is also important to specify how technologies, projects, and appropriate tools should be chosen.
- *Transparency*. For solicitations (e.g., request for proposals), transparency, appropriate deadlines, and application requirements are important to allow new entrants to compete for funds and access.
- *Commercial basis*. Market-based principles should be incorporated where possible in selecting project and setting appropriate incentives. Financial incentives should be designed to leverage private capital, thus creating a multiplier effect, while care should also be taken to minimize the risk of crowding-out of capital.[10]
- *Multiple awards*. As a way to avoid the charge of "picking winners" and to support the demonstration of competing technological designs, with the hope that one or more might succeed.
- *Accountability*. Transparent accounting of money spent and clear parameters for success should be implemented to enable value-for-money audits and to learn about how to improve the program.
- *Information sharing*. Information learnt from demonstration should be widely available to the public, to foster learning from these investments.
- *Integration*. The establishment of a system-wide view of the effort required for different technologies would improve the alignment of the bottom-up effort with the top-down priorities.
- *Stability*. Funding and policy goals should be set to reduce the risk of boom-and-bust policy cycles.

[10] Crowding out occurs when government expenditure causes a reduction in private sector expenditure. In this instance, government loans and other forms of financial support displace similar funding from the private sector, i.e., the project would have been supported by the private sector without public support.

## 2.2. Possible Mechanisms to Accelerate Commercialization

### *2.2.1. Considerations for Institutional Design*

Policy makers designing an institution with the objective of supporting the commercialization of energy technologies aimed by reducing technical uncertainty, capital requirements, market risk, etc., should consider several questions:

- Should policy implementation rest within existing structures of DOE or would it be better to create new institutions? A new agency might have a clearer purpose and mission if separate from the existing DOE structures, but linkages with other parts of the DOE could be weaker resulting in lower cooperation and efficiencies. The creation of a new institution could potentially distract from the urgent action required, and its high profile as a stand-alone entity could make it vulnerable to political attack (e.g., a money pit supporting "white elephants").
- What would be the appropriate hiring policy, reporting lines, and levels of autonomy?
- Is the ARPA-E management structure a potential model for a new institution, e.g., CEDA? ARPA-E has received praise for the speed with which it was set up, its ability to attract new talent to DOE, and the methods that it has used for increasing flexibility while maintaining accountability.

*Private sector involvement*

Involving the private sector is essential to ensure that the projects supported are selected and managed in such a way that the private sector obtains the information it needs to continue pushing the technology forward. In this regard it is important to think about three aspects:

- The appropriate use of external private sector experts for: (a) selecting projects, (b) managing the day-to-day operations of the institutions, and (c) selecting the appropriate financial instruments and incentives.
- The creation of mechanisms to facilitate partnership with industry. These would include appropriate and transparent risk sharing, such as the use of auctions and streamlined structures like the Financial Institution Partnership Program.[11]
- What type of technical information should be released to the public (e.g., performance and cost data)?

*Linkages*

A policy to promote the scale-up of energy technologies is of greater value if it is connected to other parts of the innovation system, including R&D and the commercial deployment:

[11] The Financial Institution Partnership Program (FIPP) is a streamlined set of standards designed to expedite DOE's loan guarantee underwriting process and leverage private sector expertise and capital for the efficient funding of specific projects. Eligible financial institutions apply directly to the DOE for partial, risk-sharing loan guarantees, up to a maximum of 80% of principal and interest during the term of the loan. The project debt must obtain a credit rating of at least "BB", i.e., one step below investment grade or better.

- Mechanisms should be put in place to integrate the choice of demonstration projects with other aspects of promoting the innovation cycle, e.g., work at the national laboratories, ARPA-E, the capabilities of the loan guarantee program for deployment, etc.
- The public should understand why the government is supporting a specific technology. For example, does government only want to support first-of-a-kind facilities or does it want to provide funds to enable early deployment, or should it support both?
- If the focus of the institution is the commercial-scale demonstration of energy technologies, it is important to create mechanisms to increase probability of subsequent deployment.

### *2.2.2. Current Policy Initiatives*

The following table summarizes some of the current policies that affect the private sector's risk and reward perception of investment in commercializing new energy technologies, or incentivizing such investment through regulation (mandates with financial penalties for non-compliance). The summary, which is not comprehensive, is provided for discussion purposes only, specifically to generate ideas for opportunities to improve, expand, or replace the policy mechanisms (see also Appendix III, Risk-Reward Framework).

**Table 1: Examples of Current U.S. Policies Affecting Investment in New Energy Technologies**

| Mechanism | Purpose | Status |
|---|---|---|
| Production Tax Credit (PTC) | Encourage development of renewable energy projects with a 10-year inflation-adjusted production tax credit for power from wind, closed-loop biomass, and geothermal ($0.22/kWh), and landfill gas, open-loop biomass, municipal solid waste, qualified hydropower, and marine and hydrokinetic facilities ($0.11/kWh). | Currently, wind projects placed in service before the end of 2012 will be eligible to receive the 10-year PTC, while the other renewable technologies have an additional year to come online (i.e., until the end of 2013). |
| Investment Tax Credit (ITC) | Encourage development of renewable energy projects with a 30% ITC for qualifying project costs for solar, fuel cells, and small wind projects, and 10% ITC for geothermal, micro turbines, and combined heat and power projects. | The ITC is currently available to qualified projects that are placed in service prior to the end of 2016 (except for geothermal credit, which has no expiration date, and the solar credit, which, if not extended, reduced to 10%). |
| Elect ITC in lieu of PTC | ARRA provision to give greater financing flexibility for PTC-qualifying facilities. Allows 30% ITC in lieu of the PTC. If the ITC chosen, the election is irrevocable. | Applies to facilities installed in 2009-13 (2009-12 for wind). |

| | | |
|---|---|---|
| Elect Cash grant in lieu of ITC | ARRA provision to give greater flexibility for ITC-qualifying facilities. PTC-eligible projects, which elect the ITC in lieu of the PTC, also qualify for the cash grant. | For projects which come commence construction before end 2010 and placed in service by 2013 for wind, 2017 for solar and 2014 for other qualifying technologies. |
| Loan Guarantee Program (LGP) | The LGP (section 1703) was designed to mitigate some of the barriers for obtaining financing for innovative technologies. The program was extended by ARRA to include commercial projects (section 1705). For section 1703 projects, the borrower covers the credit subsidy cost whereas for section 1705 projects the DOE covers the cost. | Section 1705 projects need to have commenced construction by September 30, 2011. To date (October 2010), the DOE has made four commitments under section 1703 ($10,656 million) and 12 guarantees under section 1705 with combined value of $8,959 million (four of these have closed; total value $774 million). |
| Corporate Average Fuel Economy (CAFE) | Mandated market for more fuel-efficient vehicles by setting standards for average fuel efficiency by vehicle manufacturer. Financial penalties for manufacturers who fail to meet the standard. | Currently applies to light-duty vehicles only (passenger cars and light trucks). The Obama Administration recently proposed extended CAFE standards to heavy-duty trucks, starting in 2014. |
| Renewable Fuels Standard (RFS) | Mandated volumetric targets for biofuels for blending with traditional fuels (gasoline and diesel). | First introduced with Energy Policy Act of 2005 and expanded in size and scope with the Energy Independence and Security Act of 2007 (RFS2). |

### *2.2.3. Some Proposals for New Institutions and Mechanisms*

This section highlights some of the current proposals for new mechanisms and institutions.[12]

**Clean Energy Deployment Administration (CEDA)**

CEDA is a bipartisan initiative aimed at creating an attractive investment environment for the development and deployment of new clean energy technologies. There are different versions of CEDA. The Senate version is contained in a Senate bill, S. 1462, *the American Clean Energy Leadership Act of 2009* (ACELA), and a variation was also in the Waxman-Markey bill *H.R. 2454, the American Clean Energy & Security Act 2009* (ACES). Although ACELA received bipartisan support in the Energy & Natural Resources committee, the full Senate has not voted on the bill.

*ACELA summary*

- CEDA would be an independent administration within the DOE, with a similar status to FERC.

[12] There are numerous other proposals for similar institutions. Several of these are reviewed in "Reforming the U.S. Energy Innovation System," Richard K. Lester, September 2008, including CEDA and ETC. Other proposed institutions include The Carbon Storage Research Corporation, The Climate Change Credit Corporation, The Clean Energy Investment Bank of the United States, and Discovery-Innovation Institutes.

- An Administrator and a Board of Directors (with experts from finance and energy) would govern and report to the Secretary of Energy.
- Permanent *Technology Advisory Council* to advise on technical aspects and to set goals for the administration.
- Focus on enabling deployment of high risk/high potential "breakthrough" technologies that are perceived as too risky by commercial lenders.
- May issue loans, letters of credit, loan guarantees, insurance products, or other credit enhancements, as the Administrator considers appropriate.
- Would use a portfolio approach to mitigate risk. Become self-sustaining by balancing riskier investments with revenues from other services and less risky investments.
- Would also take over the loan guarantee program to be restructured under a new Clean Energy Investment Fund. The Fund would receive a $10 billion injection as seed capital for CEDA.

*ACES summary*

- CEDA would be an independent corporation, chartered for 20 years and owned by the government.
- Portfolio approach with no single technology receiving more than 30% of total CEDA support.
- No single project to receive more than 80% of its estimated cost in loans or loan guarantees from CEDA.
- No explicit mandate for breakthrough technologies.
- Separate from DOE loan guarantee program.
- Initial funding to come from $7.5 *green bond* issue.

**Energy Technology Corporation (ETC)**

The creation of an Energy Technology Corporation was proposed by Peter Ogden, John Podesta, and John Deutch in "A New Strategy to Spur Energy Innovation," Center for American Progress, January 2008. In making the case for its creation, Ogden, Deutch, and Podesta state that: *"One of the recurring weaknesses in federal RD&D is the demonstration phase. Too often, this expensive stage in the energy innovation process is carried out in a manner that provides little useful information to the private sector."* The ETC would have the following characteristics:

- Semipublic organization, governed by an independent board of individuals nominated by the president and confirmed by the Senate.
- Mandate to finance and execute select large-scale demonstration projects in a manner that is commercially credible.
- Composed of people who have expertise in market forecasting, the use of indirect financing mechanisms, and industry requirements.

- As a non-federal agency, the ETC would be free from the federal procurement rules. It would not strive to meet production targets.
- Funded in a single appropriation, which would reduce the influence of Congress and special interest groups on its decision-making.
- Examples of demonstration projects that would dramatically improve the pace of energy innovation: Cellulosic biomass-to-biofuels plants; Carbon sequestration; Integrated coal-fired electricity generation and CO2 capture; Smart electricity networks; Production of natural gas hydrates; Nuclear power projects based on the once-through fuel cycle; and Superconducting transmission lines.

**Increased use of reverse auctions**

An increase in the use of reverse auctions as a tool for choosing and allocating financial incentives to different projects has also been suggested by several interviewees.[13] This mechanism does not on its own answer the question of which technologies to support, but allows for an efficient and transparent way to select projects once those objectives have been specified.

An example of a reverse auction could be an extension of the current production incentive for cellulosic biofuels outlined in Case 2 earlier, on a larger scale with the explicit purpose of supporting larger demonstration plants. This program involves the creation of an offtake agreement for a specific volume of biofuels product. The government would specify the quantity, quality, and other characteristics of the biofuel for the tender.

An example could be an offtake agreement for 5 million gallons per year for cellulosic biofuels over three years. Companies would bid for the lowest fixed price for the fuel, e.g., $10 per gallon or $150 million for 15 million gallons over three years. The exact numbers would vary but the scale of magnitude is along the lines of that suggested by various interviewees (in contrast with the $1.15 million per project in Case 2).

Auctions could be for multiple contracts (i.e., several bidders are allotted an offtake agreement) and could include ceilings on the price the government is willing to accept (i.e., to keep it within a specific budget). In the current reverse auction mechanism for cellulosic biofuels, the bidder specifies the volumes it is willing to supply for a given incentive (the benefit of current approach is that it is easier to quantify the total cost of the program – the disadvantage is that there is the volumes involved may be too small to achieve the objective of advancing demonstration projects).

The advantages of the larger, reverse auction approach would include:

- Transparent and competitive auction provides level playing field.
- Focus on specific performance criteria in line with policy objectives and consistent with scale required for demonstration projects.
- Reduced risk of "white elephants" – failure to meet the performance criteria (i.e., supply specific volumes) would not be funded by the government.

[13] It came up frequently in the interviews we conducted in preparation for the workshop, and regularly receives support from industry groups (e.g., the Biotechnology Industry Organization).

The disadvantages could include:

- To be effective, reverse auctions require a significant number of bidders, which may not be feasible for a lot of technologies.
- Headline risk of paying above-market prices for a commodity.[14]

The use of reverse auction for allocating production incentives for demonstration projects is more likely to be effective if combined with other risk mitigation strategies, especially for reducing technology risk. But it could be a very efficient tool for allocating and choosing individual projects to support.

**Government procurement**

Several analysts have proposed the use of government procurement, especially in the Department of Defense (DOD), as a tool for spurring energy innovation and accelerating commercialization of new technologies.[15] The U.S. government is a very large consumer of energy, with DOD accounting for 80% of the government's total energy use.[16] DOD is also a major customer of energy-consuming systems and equipment (e.g., lighting, HVAC, vehicles, etc.) for its roughly 500 permanent installations.

DOD is already investing in alternative energy sources as part of a strategy of reducing its vulnerability in fuel convoys into war zones and increasing reliability and availability of energy resources in the United States. DOD is also playing a role promoting advanced biofuels. For example, Solazyme, a biofuels company, has supplied the Navy with 20,000 gallons of advanced biofuels in 2009-10, and a new contract was signed with the DOD for 150,000 gallons to be delivered in 2010-11. It has been proposed that DOD's role could be expanded.

President Obama has ordered all federal agencies to measure and reduce their carbon emissions, with specific targets to be proposed by each agency and approved by the White House Council on Environmental Quality and OMB. This may create a major opportunity for government purchases of new low-emission energy technologies, which could potentially serve as the initial large-scale demonstrations of some technologies.

[14] The proverbial "$500 hammer."

[15] See for instance CNA (2010) and Alic et al. (2010).

[16] According to the Energy Information Administration's Annual Energy Review 2009, Defense (including overseas) consumed 880.3 trillion Btu in 2009 out of total government consumption of 1,095.7 trillion Btu. The second largest user was the Postal Service (44.2 trillion Btu) followed by the DOE (31.1 trillion Btu). Approximately half of the total energy consumed was in the form of jet fuel (506 trillion Btu) with other petroleum products making another fifth (231 trillion Btu).

# 3. Concluding Thoughts

Energy is unique. As an industry, energy has significant challenges preventing rapid transformation. The energy sector is important given its importance spurring economic activity, and its associated environmental and security challenges. Defining the role of the government in advancing the commercialization of new energy technologies is essential.

This paper is intended to frame some of the discussion at the forthcoming workshop on accelerating commercialization of energy technologies. It is meant to set the stage for the discussion and provide some tangible examples of the challenge, but it cannot be comprehensive.

Where appropriate, we have included some of the new ideas from other studies or from the interviews we conducted ahead of the workshop (e.g., some of the reasons that have been put forward to justify government intervention, the increased use of reverse auctions).

At the end of the workshop, we hope to (1) achieve greater clarity of the challenges and (2) identify actionable recommendations for policy makers to help overcome some of those challenges.

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# Appendix I: Production and Investment Tax Credits

*Production Tax Credit*

The Production Tax Credit (PTC) has been in place since 1992, and provides a tax credit for every kilowatt-hour (kWh) produced by qualifying sources of electricity generation. The tax credit, currently at $0.022 per kWh or $0.011 per kWh depending on technology, is adjusted annually for inflation and is generally available for 10 years after the date the facility is placed in service.

**Table 2: Production Tax Credit Summary**

| | Incentive | Eligibility | Expiration |
|---|---|---|---|
| ***Production Tax Credit*** | $0.022 kWh | Wind, closed-loop biomass, geothermal | Wind projects placed in service before 12/31/2012; All other eligible technologies placed in service on or before 12/31/2013 |
| | $0.011 / kWh | Open-loop biomass, qualified hydroelectric, landfill gas, municipal solid waste, marine and hydrokinetic power | Placed in service on or before 12/31/2013 |

*Source: World Resources Institute: "The Bottom Line on Renewable Energy Tax Credits"*

*Investment Tax Credit*

The Investment Tax Credit (ITC) provides for a 30% tax credit (subject to certain maximums) based on qualified expenditures for capital investment in certain renewable energy generation assets. The tax credit is available for systems placed in service before 12/31/2016, and is typically available in the first taxable year of the system's operation.

**Table 3: Investment Tax Credit Summary**

| | Incentive | Eligibility | Expiration |
|---|---|---|---|
| ***Investment Tax Credit*** | 30% of qualified capital expenditures | Solar, small wind, and fuel cells (subject to maximum incentive) | Placed in service on or before 12/31/2016<br>Incentive for solar reverts to 10% in 2016 |
| | 10% of qualified capital expenditures | Geothermal, Combined Heat and Power, microturbines (subject to maximum incentive) | Placed in service on or before 12/31/2016<br>Geothermal has no expiration |

*Source: World Resources Institute: "The Bottom Line on Renewable Energy Tax Credits"*

*Treasury Cash Grants*

Treasury cash grants are an option for ITC-eligible projects to receive the cash value of the tax credit as a grant in lieu of receiving to a tax credit. This is particularly valuable to projects which do not expect to have taxable income in the near term (or sufficient tax liabilities to utilize the ITC amount), as it provides a payment of up to 30% of the qualified capital investment within 60 days of the project being placed in service (or

within 60 days from the application date, whichever is later).

**Table 4: Treasury Cash Grant Summary**

| | Incentive | Eligibility | Expiration |
|---|---|---|---|
| ***Treasury Cash Grant*** | 30% of qualified capital expenditures | ITC eligible projects are eligible for grant (in lieu of ITC) – Solar, small wind, fuel cells (subject to maximum incentive) | Project must apply by 10/01/2011<br>Construction must begin by 12/31/2010<br>Project must be in service or construction commenced in 2009 – 2010 and thereafter in service by 2013 for wind, 2017 for solar, and 2014 for other technologies |
| | 10% of qualified expenditures | ITC eligible projects are eligible for grant (in lieu of ITC) – Geothermal, Combined Heat and Power, Microturbines (subject to maximum incentive) | |

*Source: World Resources Institute: "The Bottom Line on Renewable Energy Tax Credits"*

The American Reinvestment and Recovery Act (ARRA) extended several of the deadlines for PTC and ITC eligibility, and also allowed PTC-eligible projects to elect to receive the ITC instead of the PTC. Thus, by being eligible for ITC benefits, PTC-eligible projects can elect to receive a Treasury Cash Grant in lieu of ITC treatment, effectively allowing PTC-eligible projects to receive up to 30% of the capital cost of the project as a grant from the Treasury. This change in PTC and ITC eligibility was designed to help augment and continue the growth of the renewable energy industry despite country's current economic challenges.

For a PTC-eligible project, the decision to take advantage of the PTC, ITC, or Treasury Cash Grant is typically based on the project developer (or tax equity investor) expectations of future tax liabilities. The figure below outlines the flow of money between the electricity market, renewable generator, and project developer / tax equity investor.

**Figure 1: Illustrative Example of Cash Flows in a Renewable Energy Project**


| | Category | Description |
|---|---|---|
| Tax Benefits | PTC | ▸ Elected when developer / tax investor has low cost of equity, low current year tax liability, and expectation that generator will provide taxable income for the coming 10 years |
| | ITC | ▸ Elected when developer has expectation of a high current year tax liability which can be offset by ITC |
| | Cash Grant | ▸ Elected when developer has high cost of equity or limited sources of outside debt or equity |

The PTC has been a key driver in the ongoing development of renewable energy resources since 1992. The impact of this tax policy can be illustrated by examining the annual installations of wind capacity, particularly over the past decade, in comparison to the years in which the PTC has briefly expired. The PTC has expired three times: in 2000, 2002 and 2004, each time only for a period of months, but the uncertainty in the ongoing viability of the tax credit is blamed for significant reductions in annual wind capacity additions.

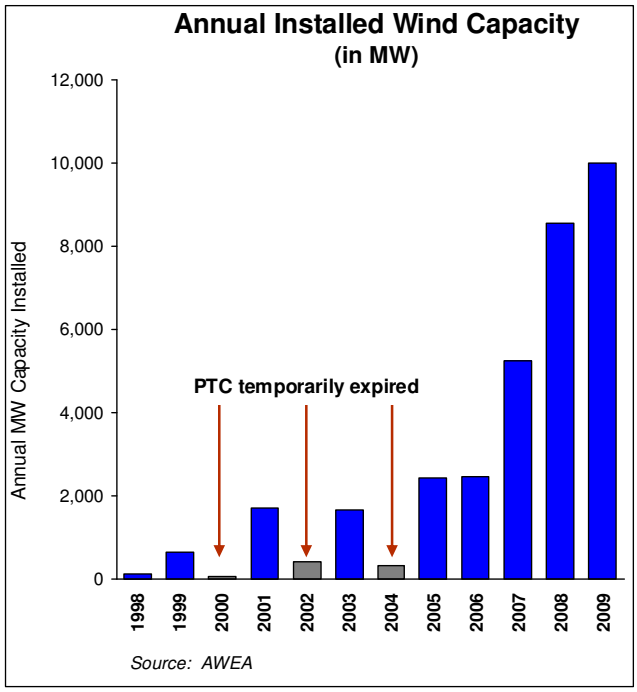



**Figure 2: Annual Wind Capacity Installations**

Currently the PTC for wind is effective for projects placed in service before the end of 2012, and for other renewable generation technologies through 2013, however the ability to elect the Treasury Cash Grant treatment for PTC-eligible projects will expire at the end of 2010 for projects that have not yet begun construction. PTC-eligible projects will continue to have the ability to elect ITC treatment through the current expiration date of the PTC, as the ITC is currently extended through 2016.

# Appendix II: Loan Guarantee Program

The loan program was created to accelerate the deployment of innovative and advanced energy and vehicle technologies. The Loan Programs Office (LPO) within the Department of Energy (DOE) manages the programs. *Loan guarantees* are provided to eligible projects, i.e., agreeing to repay specific debt obligations in the event the borrower defaults. The LPO also manages the *direct loans* to eligible manufacturers of advanced technology vehicles and components. The LPO's website (www.lpo.energy.gov) provides more details and updates on the status of the loan program and is the main source for this appendix.

The loan program is made up of three separate programs: Section 1703, Section 1705 and Advanced Technology Vehicle Manufacturing (ATVM). These are discussed in turn.

*Section 1703*

The Energy Policy Act of 2005 (EPAct) enacted the current loan guarantee program, establishing Section 1703 of Title XVII. It authorized the DOE to support innovative clean energy technologies that are typically unable to obtain conventional private financing due to high technology risks. In general, under Section 1703, the borrower is responsible for paying the Credit Subsidy Cost (CSC), which is discussed in greater detail below.

- The guaranteed loan cannot exceed 80% of total project costs.
- If the DOE guarantees 100% of the project's debt, then the Treasury's Federal Financing Bank must be the lender.
- The term of the guaranteed loan cannot exceed 30 years.
- The project sponsors must procure a credit rating of the project (without the guarantee) if the project costs total more than US$25 million.

The technologies included in Section 1703 are biomass hydrogen, solar, wind power, hydro power, nuclear, advanced fossil energy coal, carbon sequestration practices/technologies, electricity delivery and energy reliability, alternative fuel vehicles, industrial energy efficiency projects and pollution control equipment. Technologies that have already been deployed three times or more for more than five years are excluded.

**Table 5: Section 1703 Projects (Loan Program Office, DOE)**

| | Guarantee amount | Jobs (perm/const) | Date of agreement | Locations | Status |
|---|---|---|---|---|---|
| Georgia Power Company | $8.33 billion | 800/3,500 | February 2010 | GA | Conditional Commitment |
| AREVA | $2 billion | 310/1,000 | May 2010 | ID | Conditional Commitment |
| Red River Environmental Products, LLC | $245 million | 70/500 | December 2009 | CO, LA | Conditional Commitment |
| SAGE Electrochromics, Inc. | $72 million | 160/210 | March 2010 | MN | Conditional Commitment |

*Section 1705*

The American Recovery and Reinvestment Act of 2009 (ARRA) added section 1705 to EPAct. Section 1705 is a temporary program that authorized the DOE to guarantee loans for projects using commercial technologies. Projects supported by the Recovery Act must employ renewable energy systems, electric power transmission systems, or leading-edge biofuels that meet certain criteria; begin construction by the end of fiscal year 2011; and pay wages at or above market rates. Under the Recovery Act, Congress has provided nearly $4 billion to cover the credit subsidy costs for projects that meet the criteria in Section 1705.

Section 1705 also introduced the Financial Institution Partnership Program (FIPP) as a risk-sharing partnership between the Energy Department and qualified finance organizations for loan guarantees issued under Section 1705 for certain renewable energy generation projects. It is designed to expedite the loan guarantee process and expand senior credit capacity for renewable energy generation projects that use commercial technologies. In a FIPP financing, the DOE pays the credit subsidy costs of loan guarantees and provides a guarantee for up to 80 percent of a loan provided to a renewable energy generation project by qualified financial institutions. These lenders apply on behalf of the project sponsors or developers and are required to hold a meaningful portion of the unguaranteed credit exposure to the project, aligning their interests with the Department and project sponsors. An Eligible Project under FIPP is a commercial technology renewable energy generation project and construction must commence by September 30, 2011.

**Table 6: Section 1705 Projects (Loan Program Office, DOE)**

| | Guarantee amount | Jobs (perm/const) | Date of agreement | Locations | Status |
|---|---|---|---|---|---|
| Abengoa Solar, Inc. | $1.45 billion | 80/1,600 | July 2010 | AZ | Conditional Commitment |
| Abound Solar | $400 million | 1,500/2,000 | July 2010 | CO, IN | Conditional Commitment |
| AES Corporation | $17 million | 30-May | July 2010 | NY | Conditional Commitment |
| Beacon Power Corporation | $43 million | 14/20 | August 2010 | MA, NY | Closed |
| BrightSource Energy, Inc. | $1.4 billion | 86/1,000 | February 2010 | CA | Conditional Commitment |
| Nevada Geothermal Power Company, Inc. | $78.8 million | 14/200 | September 2010 | NV | Closed |
| Kahuku Wind Power, LLC. | $117 million | 10/200 | July 2010 | MA, HI | Closed |

*Advanced Technology Vehicle Manufacturing*

The Energy Independence and Security Act of 2007 (EISA) established a program to provide direct loans to support the development of advanced technology vehicles and associated components in the United States. The ATVM Loan Program provides loans to automobile and automobile parts manufacturers for the cost of reequipping, expanding, or establishing manufacturing facilities in the United States to produce advanced technology vehicles or qualified components, and for associated engineering integration

costs. Congress has appropriated $7.5 billion to support a maximum of $25 billion in loans under the ATVM Loan Program.

**Table 7: Advanced Technology Vehicle Manufacturing Loans (Loan Program Office, DOE)**

| | Loan | Jobs (perm/const) | Date of agreement | Projects # |
|---|---|---|---|---|
| Ford Motor Company | $5.9 billion | 33,000 | September 1, 2009 | 13 |
| Fisker Automotive | $529 million | 2,000 | April 1, 2010 | 2 |
| Nissan North America, Inc. | $1.4 billion | 1,300 | January 1, 2010 | 2 |
| Tesla Motors | $465 million | 1,500 | January 1, 2010 | 2 |

*Credit Subsidy Cost*

The CSC is a reserve established by the U.S. government to cover the risk of estimated shortfalls in loan repayments. The borrower is required to pay the CSC at the time the loan guarantee is provided for guarantees provided under Section 1703. For Section 1705 guarantees, the CSC is covered by an appropriation from the DOE.

The CSC represents the net present value of the estimated long-term cost to the U.S. government of the loan guarantee. Credit subsidy cost is primarily influenced by two key variables:

- Probability of default; and
- Any recovery after default.

These variables are used to "risk adjust" the borrower's principal and interest payments to the government, and provide an estimate of payment shortfalls. The calculation of the CSC has to be agreed with the Office of Management and Budget (OMB), irrespective of whether the CSC is paid by the borrower or by appropriation.

The exact CSC will vary by technology and project, and has been the subject of some controversy, most recently with respect to the Calvert Cliffs 3 nuclear power project, which is applying for a $7.5 billion Section 1703 loan guarantee.

For section 1705 loan guarantees, Congress has set aside $4 billion[17] to cover the credit subsidy costs for eligible projects. Simplistically assuming a CSC of 6% of the loan guarantee, the $6 billion appropriation would support guarantees of $100 billion of loans.

[17] Originally, Congress appropriated $6 billion but this was reduced to $4 billion as $2 billion was transferred to the "Cash for Clunkers" program in 2009.

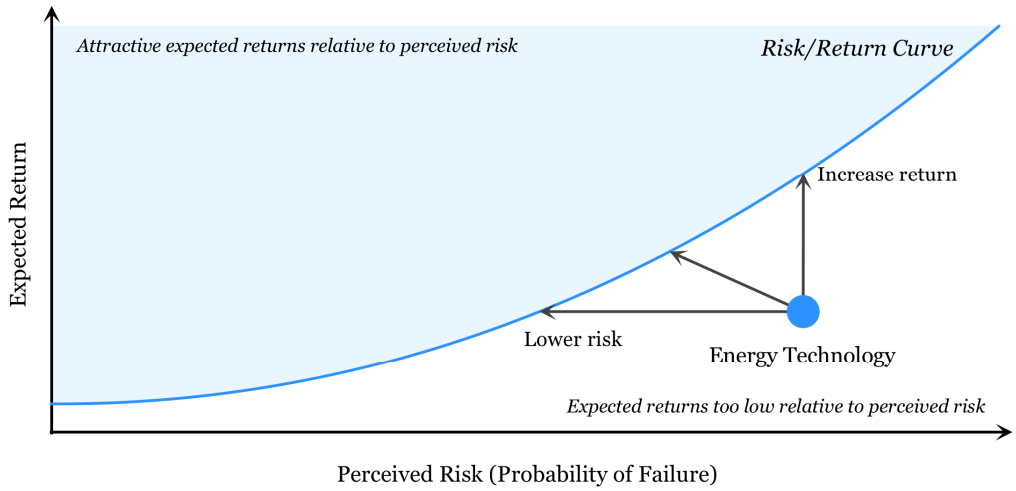
# Appendix III: Risk-Reward Framework

The private sector invests in new technologies and projects because it expects to earn a return on this investment. The higher the risk of an investment, the higher the expected return would need to be to justify the specific investment over alternatives with a more attractive risk-reward profile. This is rational behavior and is, in most instances, not a reason for public policy action.

However, in the case of advanced energy technologies, there are additional payoffs to society that provide a strong case for public policy to enable accelerated investment in new energy technologies, primarily (i) improved energy security, (ii) mitigation of the negative environmental impacts of the energy system, and (iii) maintaining or gaining economic competitiveness.

Businesses also invest to comply with regulation, although such investment should always be seen in the context of supporting a profitable business. Hence, compliance-related expenditure is part of the risk-reward calculus for a given business. To alter the risk-reward calculus in favor of greater investment intensity, the policy response should seek to lower the perceived risk of the investment, increase the expected return, or a hybrid of the two (see Figure 3).

**Figure 3: Private Sector Perfections of Risk and Returns**




A similar way of categorizing policy tools is the distinction between Technology-Push and Market-Pull policies, with the former mostly representing policies used to lower the risks of investing in a technology (e.g., DOE research grants, cost-sharing) and the latter improving the expected return (e.g., loan guarantees, ITCs, PTCs, feed-in-tariffs, carbon pricing, etc). The risk-return framework is closer to the private sector's investment-decision process, while the Push-Pull characterization better reflects how some policy makers and scholars think about policy options.

# Appendix IV: Policy Constraints

The creation and implementation of government initiatives to alter the risk-reward profile of the private sector and to catalyze the scale-up of energy supply and manufacturing technologies face several types of challenges, which may include:

*Fiscal challenges*
Many policy options require significant amounts of funding. Obtaining funding and sustaining it for a prolonged period of time is always difficult, and more so in the current fiscal climate. Indeed, several initiatives which received funding under the American Recovery and Reinvestment Act of 2009 (ARRA), such as the Advanced Research Project Agency for Energy (ARPA-E), face an uncertain funding future.

*Regulatory challenges*
A significant part of the energy system operates in a heavily regulated environment, especially the electric utilities. Some of the regulation is federal but most of the regulatory authority rests at the state level. The objectives of state-level regulators are primarily to ensure that inexpensive and reliable energy is available to consumers. This somewhat narrow objective can easily be at odds with the broader policy objectives of promoting energy security and economic competitiveness, and protecting the environment.

*Political challenges*
New legislation is required for most new policy mechanisms. Congress is often divided along geographical lines, rather than party lines, on many energy issues and it has proven difficult to obtain support for legislation—as exemplified by the stalemate over the Waxman-Markey and Kerry-Lieberman energy and climate bills. In addition, the U.S. political system has a very low tolerance for failure, which is at odds with the initiatives that are needed to promote innovation, which is often uncertain. Policies that are not designed in such a way that "failure" is recognized as part of the design may not be sufficiently robust to withstand the political cycle.

*Economic efficiency challenges*
Policy mechanisms should strive to achieve policy goals at a minimum cost. Policies should also be crafted in such a way that they complement, rather than replace, private sector activities.

*Unintended consequences*
Policy makers should consider the entire energy system and the broader economy when designing energy policies. For instance, increased use of distributed and intermittent energy sources place demands on the grid; and some biofuels may compete with the food supply for land.

# Appendix V: Smart Grid Demonstration Projects

**Table 8: Smart Grid Demonstration Projects Funded by the ARRA**

| | |
|---|---|
| **Los Angeles Department of Water and Power Smart Grid Regional Demonstration Project:** In partnership with a consortium of local research institutions, deploy smart grid systems at partners' university campus properties and technology transfer laboratories. The demonstration projects will also include gathering data on how consumers use energy in a variety of systems, testing on the next generation of cyber security technologies, and how to integrate a significant number of plug-in hybrid electric vehicles onto the grid. | **Irvine Smart Grid Demonstration:** Demonstrate an integrated, scalable Smart Grid system that includes all of the interlocking pieces of an end-to-end Smart Grid system - from the transmission and distribution systems to consumer applications like smart appliances and electric vehicles. The project will focus on the interoperability and interactions between technologies and systems working at the same time - such as communications networks, cyber-security requirements, and interoperability standards. |
| **NSTAR Automated Meter Reading-Based Dynamic Pricing:** Develop and implement a Smart Grid pilot program that will examine technologies to leverage existing automated home meters to include dynamic electricity pricing for homeowners (i.e., lower rates when demand is lower). By building on the existing meter infrastructure and broadband internet networks, utilities would be able to access some of the benefits of the Smart Grid - such as collecting data at meters at shortened intervals, communicating energy use data to consumers, direct load control, automatically reporting outages, etc. - while avoiding the full costs of implementing smart metering infrastructure or the costs associated with replacing meters prematurely. | **NSTAR Urban Grid Monitoring and Renewables Integration:** Demonstrate the use of advanced sensors and monitoring instrumentation on low voltage (secondary) networks in downtown Boston to improve grid reliability and safety. The project will provide additional visibility for operators, which will increase the system's capacity to integrate on-site energy technologies, such as solar photovoltaic energy systems, plug-in hybrid electric vehicles or battery storage. Knowledge gained from this demonstration will lay the groundwork for the broad application of smart grid and on-site energy generation programs for secondary area network grids in large urban areas such as New York City, Philadelphia, Chicago and Los Angeles. |
| **KCP&L Green Impact Zone Smart Grid Demonstration:** Demonstrate an end-to-end Smart Grid that will include advanced renewable generation, storage resources, distribution system automation, in-home customer systems and digital technologies, and innovative rate structures. The programs will benefit about 14,000 commercial and residential consumers, while providing the critical energy infrastructure required to support an urban revitalization effort, Kansas City's Green Impact Zone. | **Project Boeing SGS:** Demonstrating a Cyber Secure, Scalable, Interoperable, and Cost-Effective Smart Selection for Optimizing Regional Transmission System Operation. Demonstrate an advanced Smart Grid software technology with military-grade cyber security for improving regional transmission system planning and operation. The project includes Regional Transmission Operators (RTOs) and utilities that collectively serve all or part of 21 states and more than 90 million people. The Boeing Smart Grid Solution (SGS) software is designed to be scalable, secure, and compatible with multiple systems to help RTOs and utilities improve grid reliability and efficiency. |
| **Secure Interoperable Open Smart Grid Demonstration in New York and New Jersey:** Demonstrate a scalable, cost-effective smart grid prototype that promotes cyber security, reduces electricity demand and peak energy use, and increases reliability and energy efficiency. The system will include renewable energy generation, grid monitoring, electric vehicle charging stations, transmission automation, and consumer systems that will help expand the use of renewable energy and lead to greater consumer participation in the electricity system. | **Long Island Smart Energy Corridor:** Partner with two branches of the State University of New York (SUNY) to create a Smart Energy Corridor along the Route 110 business corridor, involving 800 customers. The project will demonstrate the integration of a suite of Smart Grid technologies on the distribution and consumer systems, such as smart meters, distribution automation, distributed energy resources, and electric vehicle charging stations. The project will also include testing cyber security systems, identifying the optimal combination of features to encourage consumer participation, and educating the public about the |

| | |
|---|---|
| | tools and techniques available with the Smart Grid. |
| **Evaluation of Instrumentation and Dynamic Thermal Ratings for Overhead Lines:** Demonstrate the effects that Dynamic Thermal Circuit Ratings (DTCR) technology can have on areas of the New York State transmission system where there is abundant wind generation potential. This project could result in a 5 to 15% increase in transmission line capacity to allow for more wind power, deferring millions of dollars in capital expenditures on transmission projects an enabling improved situational awareness for gird operators. | **AEP Ohio gridSMART Demonstration Project:** Demonstrate a secure, interoperable and integrated smart grid infrastructure for 110,000 consumers in the state that will maximize distribution system efficiency and reliability and enable consumers to reduce their energy use and save money. The project will include 13 different technologies from the substation to the customer, including distribution automation and control, smart meters and appliances, home area networks, plug-in hybrid electric vehicles, energy and battery storage, and renewable generation sources. These technologies are estimated to improve the reliability and efficiency of the distribution system 30-40%. |
| **Technology Solutions for Wind Integration in ERCOT:** Manage the fluctuations in wind power in the large Electric Reliability Council of Texas (ERCOT) transmission grid through better system monitoring capabilities, enhanced operator visualization, and improved load management. Project includes the installation of synchrophasors to enhance monitoring of grid conditions as variable wind resources move through the system, and the use of integrated Smart Grid technologies, including household and community battery storage, smart meters and appliances, plug-in hybrid electric vehicle sand homes equipped with 1-3 kW solar photovoltaics. | **The Pecan Street Project Energy Internet Demonstration:** Develop and implement an Energy Internet micro grid, located in a large mixed-use infill development site in Austin, Texas. This effort will build on Austin Energy's existing Smart Grid programs by creating a micro grid that will initially link 1,000 residential smart meters, 75 commercial meters, and plug-in electric vehicle changing sites. The project will be implemented by a unique Texas not-for-profit corporation created to research, develop and implement smart grid clean energy systems. |
| **Dynamic Line Rating Project:** Demonstrate the use of Dynamic Line Rating (DLR) monitoring technology to reduce transmission-line congestion and increase the carrying capacity of the transmission lines. The data and results from the demonstration project will help better understand DLR technologies, so that transmission systems can be utilized to their full capacity, decreasing congestion and deferring upgrades and additional construction. | **Enhanced Demand and Distribution Management Regional Demonstration:** Install and operate of a suite of diverse Smart Grid technologies and aggregate the data from 17 rural electric cooperatives across 10 states. Technologies will include over 130,000 meters, over 18,000 demand response switches, nearly 4,000 in-home displays or smart thermostats, and others. In addition to customer-focused technologies, the project will include voltage sensors and fault detectors. The demonstration data will be centralized for all sites and include studies on total demand, distributed energy resources, peak pricing, customer appliance control, and self-healing technologies for improved reliability |
| **Pacific Northwest Smart Grid Demonstration Project:** Spanning five states and affecting more than 60,000 consumers, demonstrate and validate new smart grid technologies and inform business cases; provide two-way communication between distributed generation, storage, and demand assets and the existing grid infrastructure; quantify smart grid costs and benefits; and advance interoperability standards and cyber security approaches. | **Fault Current Limiting Superconducting Transformer:** Demonstrate a Smart Grid-compatible Fault Current Limiting Superconducting Transformer for a utility substation that will help improve the stability of the system. The proposed 28 megavolt amp utility transformer will occupy approximately 50% of the physical size/weight of a conventional transformer, lower power consumption through reduction of losses, and increase the reliability of the electrical grid. |