Public Policy toward Clean Energy in an Uncertain World

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Executive summary

Forward-looking decisions involve an element of the unknown. Due to the nature of clean energy, which combines unknowns related both to innovation and technology as well as unknowns related to environmental impact, this "air of uncertainty" is especially large. Designing effective policy in that environment presents a difficult challenge. When they work well, markets efficiently allocate resources. Venture capital markets in particular do so in the face of significant uncertainty. The closer policy can come to mimicking market efficiencies, the more effective the policy.

This article makes the following key points:

- The stimulus policy related to green technology or clean energy broadly recognized the need to include market participants like venture capitalists. However, the policy failed to incorporate necessary market dynamics, which made the policy less likely to succeed.

- An alternative policy of providing funds to States as block grants would be an incremental improvement. Such a policy introduces an element of competition and diversification. The policy, though, is still susceptible to some of the same flaws as the stimulus policy, although likely on a smaller scale.

- A preferred alternative policy is for the federal government to auction funds for green technology investment to venture capital organizations. This policy separates the federal government from the end users of the funds and limits government interference in the marketplace. Further, the policy maintains the beneficial competitive dynamic and resource allocation efficiencies of free markets.

Introduction

Solyndra, the failed solar energy company, has become the emblem for inefficient and wasteful federal spending on environmental sustainability, and green technology in particular. Superficially, the Obama Administration's approach to stimulus spending on clean energy appeared sound. The Administration brought in venture capital experts to be part of the Administration, presumably to tap into a wellspring of experience.[1] They made large investments likely trying to achieve economies of scale quickly. Unfortunately, the same crony tendencies that often accompany large-scale federal spending remained. Even more, the episode highlights that if the federal government insists on involvement in sustainable (green) investment, the closer the process is to the competitive dynamic of the free market, the more likely the success; and the further away, the more likely to fail. Failing to recognize this may have proven fatal in the Administration's implementation of green energy investments.

I argue that the attempt to draw upon the venture capital industry in order to achieve the Administration's policy objectives is a potentially fruitful approach. The problem for the Administration was in the implementation. Their approach invited the crony tendencies that often arise from government involvement in the private sector through what economists call principal-agent problems. Additionally, their approach missed key components of free markets and the venture capital industry, specifically. These critical elements are what allow resources to be allocated efficiently. Given these critical elements, I offer two policies that may have better achieved the Administration's goals. Both have been used in public policy settings before and, thus, have the advantage of being well known. The first involves allocating government resources for green technology to the states in the form of block grants. The second involves developing an auction process for government resources similar to the Federal Reserve's Term Auction Facility (TAF).

To make the case for these policies, I begin by examining what the Administration actually did with regard to clean energy and the significant flaws built into their approach. I then explain the key elements of the free market economy that lead to efficient allocation of resources. Specifically highlighted is a longstanding concept distinguishing between risk and uncertainty.[2] *Risk* can be defined as possible future events for which the probability of occurrence is known or at least reasonably estimable. *Uncertainty* can be defined as possible future events for which the probability of occurrence cannot be reasonably estimated. The manner in which free markets resolve or overcome that distinction is critical, especially when it comes to green technology. Environmental sustainability and clean energy, in particular, likely involve a large amount of uncertainty as opposed to risk. I offer that free markets through competition as well as positive externalities help to alleviate this issue.

After the broad case for free markets is made I turn to the venture capital industry specifically. This is where the Administration had the right idea. The venture capital industry largely involves itself in market areas where there is more uncertainty as opposed to risk. Missing were the specific elements of venture capital that allow that uncertainty

[1] Leonnig, C.D., & Stephens, J. (2012). Federal funds flow to clean-energy firms with Obama Administration ties. *Washington Post*. Retrieved April 20, 2012 from www.washingtonpost.com.

[2] Knight, F.N. (1921). *Risk, Uncertainty, and Profit*. New York: Houghton Mifflin.

to be addressed. I argue that the closer policy can replicate those conditions or facilitate their usage, the more likely the policy will be successful. For effective policy, an understanding of how venture capital works, in particular, the patterns of technology investment, is needed.[3] Additionally, policy must reflect the flexibility inherent in venture capital and must be results-oriented.[4] Also critical is what I dub the *dual-sided nature of competition* as well as certain informational advantages present in venture capital that lead to positive spillovers.

Finally, I explore the details of two policy alternatives: block grants to states and an auction system. Recognizing that no policy is perfect and all choices involve tradeoffs, in addition to highlighting the benefits of these policies, I also examine their potential flaws. For any policy related to government investment, the economic issue of *crowding out* is a legitimate concern. Neither of these policies likely eliminates that potential problem. However, each policy is better suited toward fostering a more competitive environment vis-à-vis green technology and each is relatively more likely to reduce the crony tendencies that were present in the Obama Administration's approach. Thus, these policies on net would reduce the amount of resource misallocation by the government and potentially achieve more positive environmental outcomes.

Current policy

Primarily driven by the attempt to stimulate the economy through government spending during the recession that had begun in late 2007, the Obama Administration began investing in energy. The amount of U.S. government subsidies for energy increased from $17.9 billion in fiscal year 2007 to $37.2 billion in fiscal year 2010.[5] Much of this investment was directed toward clean energy.[6] For comparison, between 2007 and 2010, the total cumulative amount of investment made by venture capital across all industry types was roughly $105 billion.[7] Thus, the government's expenditure through subsidies to clean energy appears quite substantial. Given that parts of the direct subsidies by the government were used to back loan guarantees[8] , in effect the leverage exerted by the government toward that single industry was much larger.

Setting aside the motivation to spur the economy and create jobs, what is the rationale for such a large investment in green technology areas? Obviously, from an economic standpoint, the primary issue is the negative externalities associated with traditional (e.g., "non-clean") forms of energy. *Negative externalities* or *spillovers* are third-party costs not accounted for by markets. Their cost is not reflected in the price. By subsidizing cleaner forms of energy, the Administration hopes to reduce negative externalities by shifting the United States towards the production and consumption of cleaner forms of energy. Additionally, there are generally *positive externalities* or *spillovers* from research and development as the creation of new knowledge provides benefits even to those who did not necessarily pay for its creation. In particular, for energy generally,[9] and clean energy specifically,[10] there is evidence of under-investment due to the fact that private market investors do not fully reap the benefits of their investments. The need to reverse this investment pattern seems particularly vital given the potential downsides of inaction.[11] The stimulus plan reflects this mix of motivations and, perhaps, the sense of urgency as well. Some of the subsidies went toward reducing overall energy consumption and negative externalities (e.g., weatherization, energy-efficient appliances) and some went directly for research and development and promoting positive externalities.[12]

Clearly, reducing negative externalities from fossil fuels and encouraging positive externalities from research and development in cleaner energy are desirable goals. However, it is far more difficult in practice to implement policy to achieve those goals. For example, what is the optimal subsidy that should be provided? Critical to answering that question is the ability to quantify the external (e.g., non-market) benefits and costs of the energy sector, clean or otherwise. As we will discuss in the next section, the presence of uncertainty as opposed to risk in environmental markets makes quantification of externalities difficult.

Related to the sheer size of the subsidies, it seems reasonable to infer that achieving *economies of scale* in the green technology sector was a clear goal for the Administration's policy. Economies of scale are the reductions in average costs of production that come from increased capacity to produce. Achieving this reduction quickly in an industry such as solar panels would likely

[3] Lerner, J. (2002). When bureaucrats meet entrepreneurs: The design of effective 'public venture capital' programmes. *The Economic Journal*.112(477), F72-F84.
[4] *Ibid*.
[5] Morris, A.C., Nivola, P.S., & Schultze, C.L. (2012). Clean energy: Revisiting the challenges of industrial policy. *Brookings Institution Climate and Energy Economics Discussion Paper*, June 4, 2012.
[6] *Ibid.*
[7] Data from http://www.pwcmoneytree.com.
[8] Morris, A.C., Nivola, P.S., & Schultze, C.L. (2012). Clean energy: Revisiting the challenges of industrial policy. *Brookings Institution Climate and Energy Economics Discussion Paper*, June 4, 2012.
[9] Margolis, R.M. & Kammen, D.M. (1999). Underinvestment: The energy technology and R&D policy challenge. *Science*. 285, 690–692.
[10] Brown, M.A. (2001). Market failures and barriers as a basis for clean energy policies. *Energy Policy*. 29, 1197–1207.
[11] Nemet, G.F. & Kammen, D.M. (2007). U.S. energy research and development: Declining investment, increasing need, and the feasibility of expansion. Energy Policy. 35(1), 746–755.
[12] Morris, A.C., Nivola, P.S., & Schultze, C.L. (2012). Clean energy: Revisiting the challenges of industrial policy. *Brookings InstitutionClimate and Energy Economics Discussion Paper*, June 4, 2012.

make the United States more competitive with other countries such as China, which have taken the lead in the production of solar panels. One potential concern from this large investment is *crowding out* . That is, by investing in the clean energy sector, the government's dollars effectively prevent private industry from making the same investments. Thus, there is less opportunity for private investment. To my knowledge, there have been no studies of that phenomenon specifically related to environmental sectors. However, in examining venture capital industries, which often invest heavily in technology generally, the evidence of crowding out is mixed. One study found evidence of crowding out in Canada,[13] but another one found little evidence of crowding out in European countries.[14]

Of course, not all organizations are created equal and so the Administration brought in experts to aid in evaluating which ones would receive the Administration's favor. In particular, the Administration brought in experts from venture capital to tap into their experience investing in new and emerging technologies.[15] The problem was that there is some evidence that funds were funneled by these venture capitalists into companies for which they already had ties.[16] This potential conflict of interest is an example of what economists call the *principal-agent* problem. In this case, it is the taxpayers and the Administration that represents them that serve as the principals, whose goal was to see funds allocated to where they would be the most productive in the clean energy industry. The venture capitalists brought into the Administration were the agents, those who had at least some influence over where those funds ended up. The problem is that the venture capitalists may have had their own objectives, which did not align with the Administration's objectives. That is the heart of a principal-agent problem. The problem is widespread in many areas and fundamentally relates to incentives. In this case, the venture capitalists may have had an incentive (i.e., personal profit) that led them to take actions not correctly aligned with the Administration's goals. It is, of course, important to note that no one has alleged that any crimes were committed, and many principal-agent problems are symptomatic of poorly designed policy rather than criminal activity. Still, the specter of cronyism only serves to reinforce the perception that the government may waste scarce resources as part of the investment allocation process. While not yet studied, one might suspect that the attempt to achieve economies of scale so quickly accelerated or in some way exacerbated the principal-agent problems in this instance.

Free markets

To begin to understand why the Administration's approach to green technology may not have been the best approach, it is important to understand key characteristics of the market economy. Markets generate prices, which reflect market information of all participants and allow each individual market participant to assess for themselves the market value relative to their own interests. Participants are free to buy or sell at a particular market price and just as important, to not buy or sell at a given price. Critical to this process is the discipline that competition imposes on both buyers and sellers. Sellers compete with each other for customers. Those sellers unable to do so eventually leave the market or never enter in the first place. Buyers also compete with each other. There are not unlimited amounts of products and each buyer's willingness to pay determines whether that buyer will be able to obtain what they desire or not. This process is directly observable in an auction where potential buyers directly compete based on their willingness (which includes ability) to pay. This competition among sellers and buyers is the *dual-sided nature of competition*. It is the disciplining mechanism that funnels resources to the most competitive producers who produce products purchased by those that value them the most. That combination generates the most value for society.

In examining the Administration's approach to clean energy investment, it is helpful to contrast that allocation mechanism with that of the private marketplace. First, the government does not really compete to allocate investment dollars to the clean energy sector because it fundamentally is not motivated by profit. Second, the sheer size of the government and the resources leveraged grant the government at least the potential of a large amount of market power. That is, the government by its size and its inherent role of rule-maker can potentially stifle competition. If the resources were at least somewhat allocated based on which companies had connections to venture capitalists brought into Administration,[17] there was not competition on the buyer side either. Thus, the discipline derived from the dual-sided nature of competition was absent. One can argue that due to externalities, the prices markets would generate do not accurately reflect the true value of those products to society. Yet nothing about the government's approach to

[13] Cumming, D. & MacIntosh, J. (2006). Crowding out private equity: Canadian evidence. *Journal of Business Venturing*. 21, 569–609.
[14] Leleux, B., & Surlemont, B. (2003). Public versus private venture capital: Seeding or crowding out? A pan-European analysis. *Journal of Business Venturing*. 18, 81–104.
[15] Leonnig, C.D., & Stephens, J. (2012). Federal funds flow to clean-energy firms with Obama Administration ties. Washington Post. Retrieved April 20, 2012 from www.washingtonpost.com.
[16] *Ibid*.
[17] *Ibid*.

green technology developed valuation for the externalities. It is not clear that the government's policy shifted consumption in a meaningful way, though such an effect could lag considerably Nonetheless, there is no obvious evidence that the government's allocation of resources toward green energy better reflects society's valuation than the admittedly flawed market prices.

Also critical to devising effective policy is the need to create incentives in alignment with the policy objectives as well as to create incentives that do not distort market forces. In the area of environmental sustainability and clean energy, this goal is especially difficult because environmental sustainability involves a relatively large amount of uncertainty as opposed to risk. As emphasized in the introduction, *risk* involves situations where the statistical distribution is known *a priori* or potentially observable by gathering data on the underlying statistical distribution. *Uncertainty* is, for all practical purposes, immeasurable.[18] It is difficult to determine reliable estimates of the expected benefits and costs of potentially environmentally sustainable activities. This source of the uncertainty includes the fact that the time horizons related to benefits are especially long.[19] The rate society discounts those future benefits and costs is unknown.[20] For the most part, markets do not exist in this context, so comparable values cannot be defined. Thus, the probability distribution of net benefits of any possible sustainable investment is at best unknown, and, at worst, indeterminable. While markets clearly struggle with these issues, there is no reason to expect that the government will be better-suited to handling these uncertainties.

A quick examination of the biofuels industry illustrates the issue. As part of the stimulus, the Administration funneled $786 million into biofuels.[21] Biofuels may reduce greenhouse gasses[22] but may also generate greater environmental costs.[23] At issue is not whether biofuels are part of a solution to sustainable energy but, rather, that the answer is uncertain.[24] New and better metrics are needed.[25] Effective policy requires that the uncertainty be in some way addressed and acknowledged.

[18] Knight, F.N. (1921). Risk, Uncertainty, and Profit. New York: Houghton Mifflin.
[19] Pindyck, R.S. (2007). Uncertainty in environmental economics. Review of Environmental Economics and Policy. 1(1), 45–65.
[20] *Ibid.*
[21] Charles, D. (2009). Biofuels get big spending boost. ScienceInsider. Retrieved August 16 from www.sciencemag.org.
[22] Tilman, D., Hill, J., & Lehman, C. (2006). Carbon-negative biofuels from low-input high-diversity grassland biomass. *Science*. 314, 1598–1600.
[23] Scharlemann, J.P.W. & Laurance, W.F. (2008). How green are biofuels? *Science*. 319, 43–44.
[24] Hoekman, S.K. (2009). Biofuels in the U.S.—Challenges and opportunities. *Renewable Energy*. 34, 14–22.
[25] Farrell, A.E., Plevin, R.J., Turner, B.T., Jones, A.D., O'hare, M., & Kammen D.M. (2006). Ethanol can contribute to energy and environmental goals. *Science*. 311, 506–508.

Though the Administration may have created a principal-agent problem, tapping into the venture capital industry is broadly a good idea. As we will discuss in the next section, the venture capital industry is well-suited to dealing with issues of uncertainty and risk.[26] If the government is set on intervening in the clean energy market, mimicking the competitive market and finding a way to leverage the venture capital industry will improve the allocation of resources.

Venture capital

The United States has the most developed venture capital industry in the world.[27] While centered in Silicon Valley, with the wide majority of deals completed there, venture deals are done in a variety of states.[28] The industry is largely known for its focus on new startups and relatively young enterprises whose futures are uncertain and thus will largely go unfunded by traditional institutions such as banks. The key to understanding why venture capitalists are willing to take on this uncertainty requires explanation.

In the venture capital industry, uncertainty is not resolved directly as much as it is resolved by distribution. Voluminous amounts of innovations are vetted. Many of those innovations are not funded. Many entrepreneurs that are funded fail. Many entities from individual "angel investors" to venture capital funds take part in the vetting process. Thus, competition occurs for scarce investment dollars among entrepreneurs, and for the best entrepreneurial endeavors among investors. This dual-sided competition does not spread risk but, rather, spreads uncertainty among a variety of informed participants. In fact, it is common for multiple venture capitalists to invest in the same project,[29] illustrating that uncertainty is spread among participants.

Participants willingly endure this uncertainty on the hope that it resolves as positive net benefits for them. Even with this vetting, most of the funded projects will fail.[30] It is those rare few that become successful or even wildly successful. The venture capitalists and their counterparts, the entrepreneurs, provide value not only from their successful business ventures but also from willingly enduring the many setbacks and failures.

[26] Gompers, L. & Lerner, J. (2001).The venture capital revolution. *Journal of Economic Perspectives*. 15(2), 145–168.
[27] Gilson, R.J. (2003). Engineering a venture capital market: Lessons from the American experience. *Stanford Law Review*. 55(4), 1067–1103.
[28] Based on data from www.pwcmoneytree.com.
[29] Brander, J.A., Amit, R., & Antweiler, W. (2002). Venture-capital syndication: Improved venture selection vs. the value-added hypothesis. *Journal of Economics & Management Strategy*. 11(3), 423–452.
[30] Zider, B. (1998). How venture capital works. *Harvard Business Review*. November-December, 131–139.

Additionally, participants may have private information (or better monitoring and information-gathering ability)[31] that allows them to make valid estimates of the probability distributions of these investments. Thus, these investments represent risk rather than uncertainty for informed investors, perhaps signaling a market failure of asymmetric information that actually produces a positive spillover. Society benefits from the ability of individual investors that can turn immeasurable uncertainty into measurable risk. From the investments and innovation that create value, new markets, including ancillary ones, spontaneously arise. Fundamentally, this system's flexibility is what allows it to absorb high levels of uncertainty, illustrating the positive side of creative destruction—that is, the process by which outmoded organizations or industries are destroyed and newer and more innovative organizations or industries take their place. That dynamic nature of capitalism, which venture capital fuels at one end, is also wholly absent in government-directed investment programs.

In a typical venture capital deal, the venture capitalist (or venture firm) provides funds to an entrepreneur in exchange for equity in the enterprise. This effectively aligns the venture capitalist's profit motive with the profit motive of the organization. In addition to funds, venture capitalists often provide various levels of expertise about the industry. This can include anything from informal advice to the venture capitalist joining the Board of Directors. It may even include the venture capitalist bringing in outside management depending on the level of control ceded by the entrepreneur. Also of critical importance, the venture capitalist cares about the exit strategy for the investment. In other words, the venture capitalist typically has a limited time horizon whereby the organization needs to go public, be sold, or in some fashion the returns on the venture capitalist's investment must be realized. While that may not always align with the entrepreneur's (founder) desire, it does impose a type of market discipline. The funds come with strings attached. Of course, given the high levels of uncertainty, there is also a high failure rate for venture investments. Profit comes to the venture capitalist from the fact that the few ventures that turn profitable do so at extremely high rates of returns. The chance for those high returns and the culture that allows their pursuit, fuels the ongoing competitive process. Both entrepreneurs and venture capitalists willingly chase those returns.

This dynamic was not present in the Administration's effort, despite the fact that they may have hoped to create it by bringing venture capitalists into the process. Instead, the Administration's programs appear to have been rather static; they look more like traditional bank lending, and also generate a built-in moral hazard. There was no market discipline to the process. The government had no competition in the provision of funds, and once the funds were provided, there was no clear incentive for them to be returned. If a solar company became successful, economic benefits would accrue, but if a company was not successful, the taxpayer was on the hook for the bill. Incentives did not align because there was no process in place to align them. Put differently, the keys to effective policy, such as a full understanding of the venture capital industry, the inherent flexibility of the market, and the emphasis on results,[32] appear to have been absent.

The Administration's instinct to use venture capital either directly or indirectly as a model was correct. However, the structure they created missed the key elements of both free markets and venture capital specifically that make it an effective tool for creating value in areas of high uncertainty. I believe two alternatives would have worked better. One is for federally allocated funds to be given to states (or even localities) as block grants for green technology investment. The second policy is for the auctioning of funds by the federal government. In this regard, the Adminstration could have followed a process similar to what the Federal Reserve did in the Term Auction Facility (TAF). Both policies have the advantage of being familiar to government and would have at least come closer to mimicking the missing competitive dynamic. I discuss each one in turn in the next sections. Noting that no policy is flawless, I also discuss each policy's limitations.

Block grants

If the federal government engages in funding of green technology firms, one option is

to decentralize the allocation process. Doing so reduces the likelihood for misallocation of resources. Any potential for cronyism would be compartmentalized with little chance of infecting the entire allocation process. To that end, I suggest a familiar federal policy tool: the block grant. The federal government could simply allocate the desired resources to the states, with the general directive that they be used to fund green technology investments.

The primary advantage of a block grant approach is that it would allow for more variety in the types of innovative activities funded related to green technology. States already have experience in approaches to clean energy. For example,

[31] Gompers, L. & Lerner, J. (2001).The venture capital revolution. *Journal of Economic Perspectives*. 15(2), 145–168.

[32] These are a paraphrasing of the conditions mentioned in Lerner, J. (2002). When bureaucrats meet entrepreneurs: The design of effective "public venture capital" programmes. *The Economic Journal*. 112(477), F72–F84.

states have experience in allocating resources towards renewable energy such as wind.[33] States generally have taken a variety of approaches to clean energy from direct investment public-private partnerships to more indirect investments in private organizations.[34] They've funded wind to geothermal to landfill gas projects among others.[35] In 2009 alone, states supported the installation of over 19,000 clean energy projects and over 74,000 projects from 1998-2009.[36] At the very least, this approach has the possibility of mimicking a competitive dynamic, where different approaches are vetted by various sources with differing information sets. The uncertainty involved is spread out among a variety of participants. If states learn from each other and monitor their own projects and those of other states for best practices, this process could serve as a mimic for the discipline markets typically impose.

Although allocating funds via block grants to states may generate a more flexible system conducive to innovation, the policy is not without potential drawbacks. First, there is no reason to expect that the states will be any more knowledgeable at evaluating projects to invest in than the federal government will be. Further, there is similarly no incentive to consider return on investment. Thus, there is a reduced need to understand market dynamics and to effectively monitor the investments. The absence of conditions to align actions with these incentives makes it likely that there will be inefficiencies in the system. Though it is possible that the states would compete against each other to fund certain projects, it is unlikely that any state would make an investment across state lines (i.e., invest in a project or research and development in another state). Thus, the level of competition would somewhat pale compared to a free market system. Finally, the block grants are less likely to achieve economies of scale due to the lower concentration of funds to allocate. Block grants do not address the issue of optimal allocation for the spillover issues. Block grants could generate over- or under-investment in green technology just as current federal policy might.

Despite those issues, the block grants appear to be an incremental improvement over purely federal allocation, because they take an important step closer to innovation than direct federal allocation of funds. By diffusing the funds, the policy comes closer to allowing for likely failures given the uncertainty in green technology. However, if market forces could be more directly leveraged, such a policy would come closer to the efficient allocation of resources for which markets are known.

Auction

A second policy—auctioning of federal funds—would better mimic the dynamic of the free market yet still allow the federal government to direct or alter the allocation of resources towards clean energy. The model for the auction would be the Term Auction Facility (TAF) used by the Federal Reserve and implemented as one of the many responses to the 2007 financial crisis.[37] TheTAF auction was modeled on the process used for bonds by the U.S. Treasury, thus the mechanics are well familiar to the federal government.[38] The auction is referred to as a *single-price auction* .

During the financial crisis, the Federal Reserve held auctions of short-term loans for institutions qualified to borrow. The Federal Reserve defined a minimum interest rate for the loans and fixed the loan lengths and the total amount available for lending during a particular auction.[39] Bidders were allowed to submit up to two sealed bids, each of which would include a dollar amount they wished to borrow and an interest rate at which to borrow. After the bidding, the funds would be allocated to the highest bidders until exhausted, or the minimum interest rate was reached. All winning bidders would only be charged the lowest accepted bid, hence the single-price.

To give a simple illustration, suppose the Federal Reserve were auctioning $100 million for a 28-day period and four banks were bidding. The Federal Reserve sets a minimum interest rate of 1%. Ignoring the fact that banks could bid twice, suppose the respective bids are $50 million at 5%, $25≈million at 7%, $25 million at 4%, and $30 million at 3%. The bids at 7%, 5%, and 4% would be the winning bids, and each would get their loan amounts (total $100 million). Each would be required to repay their loans with 4% interest (the lowest accepted interest rate).

With regard to clean energy, the federal government could set up an auction (likely multiple) auctions of funds to Securities and Exchange Commission (SEC)-registered venture capital organizations. Governmental loans for venture capital are not without precedent. For example, Pennsylvania developed a loan program,[40] though the funds

[33] Bird, L., Bolinger, M., Gagliano, T., Wiser, R., Brown, M., & Parsons, B. (2005). Policies and market factors driving wind power development in the United States. *Energy Policy*. 33, 1397–1407.
[34] Bolinger, M., Wiser, R., Milford, L., Stoddard, M., & Porter, K. (2001). Clean energy funds: An overview of state support for clean energy. *Lawrence Berkeley National Labs*. Retrieved July 16, 2012, from http://eetd.lbl.gov.
[35] *Ibid.*
[36] Clean Energy States Alliance & Peregrine Energy Group (2011). State clean energy fund support for renewable energy projects. *Clean Energy States Alliance*, Retrieved July 16, 2012, from www.cleanenergystates.org.

[37] Armantier, O., Krieger, S., & McAndrews, J. (2008).The Federal Reserve's term auction facility. Current Issues In Economics and Finance. 14(5), Retrieved July 21, 2012 from www.newyorkfed.org.
[38] *Ibid*.
[39] *Ibid*.
[40] Pennsylvania Department of Community & Economic Development.(2005). New Pennsylvania venture capital investment program. Retreved July 23, 2012 from www.newpa.com.

were not disbursed by auction. Similar to Pennsylvania, the federal government could add conditions to the loans.[41] In this case, they could require that the loans be used to invest in green technology firms. This limitation would likely require some monitoring to insure compliance, either through occasional reports or even perhaps an audit.

The typical life cycle of a venture capital fund is 10 years,[42] so the loans would have to be at least that length. Further, venture funds often don't generate returns early in the life of the fund. Thus, loans may be structured to defer interest payments in the earlier years. Also, venture capital funds do not typically borrow amounts of more than 15% of their limited partner commitments,[43] thus, it is unlikely that the loan would represent a significant interest in any one fund. Borrowing by venture funds is also usually short-term and less than 90 days,[44] so there may need to be some marketing effort by the federal government to alter that perspective. However, the single-price aspect of the auction may be sufficiently appealing to overcome that challenge. If a venture organization believes it can return 25% on any investment and borrow at the auction at 5% (for example), that incentive will be difficult to resist.

The auction process has many advantages. First, by auctioning the funds, no one in the federal government is directly responsible for evaluating loan application or providing any advice on the disbursement of funds. Thus, there are no conflict of interest possibilities or temptations that can lead to cronyism. While any human endeavor is subject to possible corruption, and auctions are no exception, the sealed bid, single price-auction makes such actions less likely.[45] Also, because the federal government's only role is to administer the auction and perhaps monitor or audit the venture funds after the fact, there is no need for the government to predict which technologies or organizations will be winners or losers.

An additional advantage is that the auction process forces venture funds to compete against each other for the federal loans. Only those with the highest willingness to pay (i.e., willing to offer the highest interest rate) will obtain funds. Once the funds are obtained by the venture capital funds, the normal vetting process occurs. While some inefficiency may develop due to the restrictions limiting investment to green technologies, the dual-sided nature of competition is preserved. This dual-sided competition serves to spread the uncertainty of the outcomes and to ensure that resources are efficiently allocated to where they will generate the greatest expected net benefits. The auctioned funds go to the venture organizations that value them the most.

As before, the auction process does not necessarily solve all issues associated with federal involvement in green technology. For example, there is still the issue of possible crowding out. However, since venture funds are free to choose whether they participate in the auctions or not and to choose their bids, crowding out is less likely. Participation by venture capital firms would signal either that the auction offers attractive terms or that they have in some way been unable to obtain the desired amount of private funds. In fact, demand for the auction funds may be evidence of underinvestment in clean energy often thought to exist due to the positive externalities involved.[46] To the extent there is market power in the venture capital industry, an additional source of funding, one disbursed in an unbiased way such as an auction, may generate additional efficiencies. It would provide funds with limited market power more access to possible funding.

Finally, the issue of optimal funding amounts that the federal government should provide to correct the externalities is not directly addressed by the auction. However, by creating a barrier between the market and the federal government, the process resembles the free market system much more closely than previously discussed alternatives.

Conclusion

It is difficult to deny the overwhelming evidence of inefficiencies in the energy sector related to both positive externalities from research and development and negative externalities from pollution and resource degradation. Addressing these externalities is not as simple as having the federal government estimate an optimal amount of subsidy to encourage the positive, or estimate and impose a corrective tax to discourage the negative. Even without externalities, there is a high level of uncertainty and possible informational asymmetries.[47] Including the uncertainties associated with environmental outcomes, it is difficult to envision much accuracy in predicting outcomes in green technology investments for society.

[41] For example, Pennsylvania required the venture capital funds invest in companies with a presence in Pennsylvania.
[42] Metrick, A. & Yasuda, A. (2010). Venture capital and other private equity: A survey. *NBER Working Paper #16652*Retrieved July 10, 2012 from www.nber.org.
[43] National Venture Capital Association. (2009). Venture capital funds and systemic risk: An analysis. Retrieved July 23, 2012 from www.ncva.org.
[44] Ibid.
[45] Lopomo, G., Marx, L.M., McAdams, D., & Murray, B. (2011). Carbon allowance auction design: An assessment of options for the United States. *Review of Environmental Economic Policy*. 5(1), 25–43.
[46] Brown, M.A. (2001). Market failures and barriers as a basis for clean energy policies. *Energy Policy*. 29, 1197–1207
[47] Rin, M.D., Hellmann, T.F., &Puri, M. (2011).A survey of venture capital research. *NBER Working Paper #17523*. Retrieved July 24, 2012 from www.nber.org.

One of the great advantages of the free market is its ability to handle uncertainty. When markets function well, numerous informed buying and selling participants make decisions. Many of those decisions will not be successful, but some will. It is in the willingness to take the chances that value is eventually created, and new markets, arise. These markets generate additional value for market participants and for society in general. The venture capital market, in particular, is designed to deal with uncertainty. Both entrepreneurs and venture investors provide a benefit to society through the profits they generate and the uncertainties they absorb.

The prospect of failures raises an additional important point. Policymakers must be willing to tolerate failures. Clearly, everyone must be vigilant against preventable failures such as cronyism. However, even without corruption, promising new clean technologies may ultimately prove to be less than environmentally or commercially viable. For example, biofuels seemed to be (and may still be) a promising clean fuel alternative, yet there is evidence that they have some detrimental environmental impacts.[48] Given the uncertainty surrounding clean energy, it is unclear how policymakers will respond to a combination of high failure rates and the long time-horizons involved.[49]

Simply bringing venture capitalists into an Administration for advice on disbursement of stimulus funds for clean energy projects was flawed. While the venture capitalists undoubtedly added information and expertise to the process, the discipline that competition and markets impose was absent. The closer federal policy related to green technology gets to the market dynamic, the more efficient and effective it would be. To that end, I have suggested two potential improvements. One, which is an incremental step, is to allocate the federal funds to the states in the form of block grants for green technology. The second and preferred step is to auction funds to venture capital organizations via an auction process. Neither policies nor markets are perfect, but more careful policy design reduces the possibility of flaws or even failure. Designing policies that operate through markets allows for a greater alignment between the incentives of participants and goals of policy. That alignment increases the likelihood resources will be allocated in a more optimal way.

[48] Walsh, B. (2008). The trouble with biofuels. *Time Magazine*. Retrieved July 24, 2012 from www.time.com.
[49] Faucheux, S. & Froger, G. (1995).Decision-making under environmental uncertainty. *Ecological Economics*. 15, 29–42.