BREAKTHROUGH INSTITUTE

BRIDGING THE CLEAN ENERGY VALLEYS OF DEATH

HELPING AMERICAN ENTREPRENEURS MEET THE NATION'S ENERGY INNOVATION IMPERATIVE

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→ INTRODUCTION ←

The United States faces an urgent national imperative to modernize and diversify its energy system by developing and deploying clean, and affordable advanced energy technologies. Domestically, developing new energy supplies and ensuring affordable energy prices will bolster American competitiveness and economic growth. Reducing the cost of advanced energy technologies is the key to finally ending a dependence on volatile global oil markets that holds the American economy hostage, compromises our foreign policy, and bleeds more than a billion dollars a day out of the US economy.[1] Abroad, the military has already begun deploying innovative clean energy technologies to reduce the high cost, paid in both lives and money, associated with transporting fossil fuels across war zones. Moreover, the impending risks posed by climate change compel the accelerated improvement and widespread deployment of low-carbon energy technologies.

Countries around the world are already recognizing the critical need for new advanced energy technologies and are positioning themselves to lead the next wave of energy innovation.[2] Global energy demand is rising steadily, straining the ability of conventional energy systems to keep pace. For security, economic, and environmental reasons, the global energy system is thus modernizing and diversifying. Developing and developed nations alike are seeking new forms of advanced energy technologies that reduce dependence on foreign nations, insulate economies from volatile energy markets, and are cleaner and thus less costly from a public health perspective. Supplying this $5 trillion global energy market with reliable and affordable clean energy technologies thus represents one of the most significant market opportunities of the 21st century.

Despite this clear energy innovation imperative, the United States and the world remain overly reliant on conventional fuels and exposed to the price volatility and persistent public health impacts that reliance entails. The necessary course of energy modernization remains impeded by the high cost and barriers to scalability of today's clean energy technologies.[3] These are barriers that only innovation can overcome.

However, two obstacles currently block the progress of energy innovation, obstacles which can only be addressed through effective public policy. Due to pervasive market barriers, private sector financing is typically unavailable to bring new energy innovations from early-stage laboratory research to proof-of-concept prototype and on to full commercial scale. This leads to two market gaps that kill off too many promising new energy technologies in the cradle. These gaps are known as the early-stage "**Technological Valley of Death**" and the later-stage "**Commercialization Valley of Death.**" This pair of barriers is endemic to most innovative technologies yet is particularly acute in the energy sector. As a result, many innovative energy prototypes never make it to the marketplace and never have a chance to compete with established energy technologies. These valleys of death particularly plague capital-starved start-ups and entrepreneurial small and medium-sized firms, the very same innovators that are so often at the heart of American economic vitality.

In effect, the current lack of public policy to address this pair of barriers acts to protect today's well entrenched incumbent technologies from full market competition, while hamstringing American entrepreneurs and innovative ventures seeking to develop and deploy advanced energy technologies. The implementation of creative policies to effectively deal with the Technological and Commercialization Valleys of Death will foster vibrant competition in the energy sector and help drive technological innovation and job creation throughout the economy as a whole.

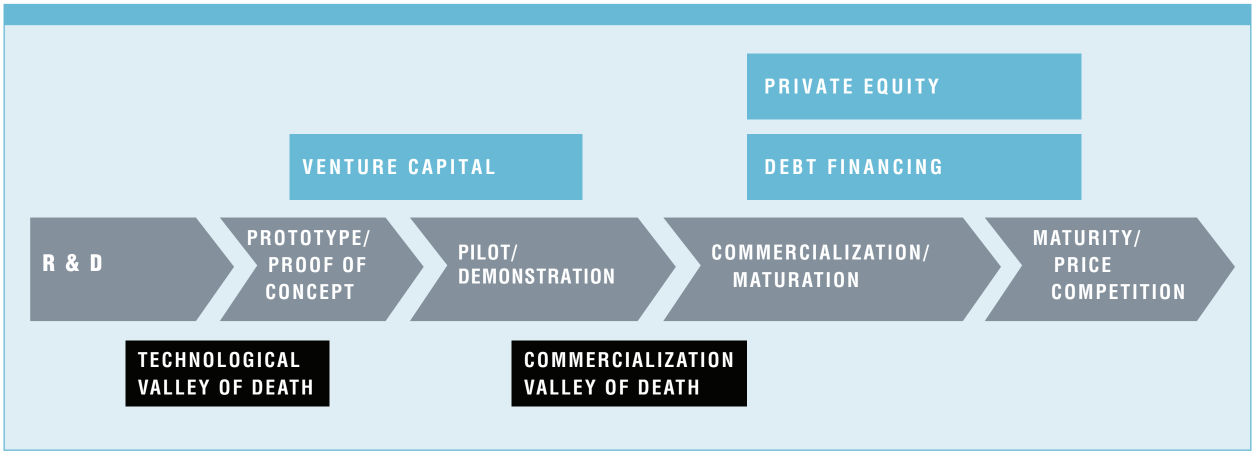
In the past, the United States has driven immense and far-reaching technological transformations. As the pioneering global innovator of the 20th century, the United States built the world's largest economy because of the ingenuity and creative enterprise of its entrepreneurs and citizens. Each step of the way, proactive public policy has played a crucial role in driving American innovations, from railroads and jet engines to microchips, biotechnology, and the Internet,[4] unleashing long waves of economic growth and shared prosperity.[5] New and advanced clean energy technologies afford the same opportunities to the United States today—*if* public policy is shaped in a way that allows American innovators to thrive once again.

→ THE ENERGY INNOVATION CYCLE ←

Innovation is best described as a fluid and cyclical process, comprised of a myriad of actors and institutions whose actions and decisions will ultimately affect the development, deployment, maturation, and price of new technologies. Typically, new technologies pass through a series of five interlinked activities to drive an innovative idea from basic science to a fully developed business. These five stages of technology development are presented in Figure 1 below. At each phase in this continuum, a set of public and private actors and institutions plays a critical role in developing and financing innovative technologies, as well as facilitating their passage to the next technology stage. Among the most influential actors in this innovation cycle are researchers, entrepreneurs, venture capitalists and larger financial intermediaries, end-users, and local, state and federal governments. The role of public policy in this process should be to encourage and sustain the continuous progress of innovative energy technologies throughout this cycle by reducing or eliminating pervasive obstacles to the flow of capital and knowledge or by establishing institutions devoted to innovation.[6]

Figure 1

THE ENERGY INNOVATION CYCLE AND THE CLEAN ENERGY VALLEYS OF DEATH



Two distinct and proven barriers for energy technologies impede this innovation lifecycle and are the subject of this brief: the **Technological Valley of Death** and the **Commercialization Valley of Death**, both of which are depicted in the graphic above. The Technological Valley of Death sits between the first and second stages of technological development, as laboratory research seeks further capital to develop a commercial product and prove its basic market viability. The Commercialization Valley of Death occurs later in a technology's development, as entrepreneurs seek capital to fund demonstration or first-of-a-kind commercial-scale projects or manufacturing facilities.

Both valleys of death exist due to a perception of risk and a scarcity of appropriately matched risk capital in the energy technology market. Because of these barriers, many advanced and innovative energy ventures fail to reach commercialization, and as a result, potentially transformative innovations are never introduced into the marketplace. These barriers, and effective public policy to address and overcome them, are discussed below.

→ THE TECHNOLOGICAL VALLEY OF DEATH ←

The first valley of death occurs early in the development of a technology, as breakthrough research and technological concepts aim to achieve commercial proof-of-concept. At this stage, innovators and entrepreneurs conducting basic and applied research need further capital to undergo a process of developing, testing, and refining their technologies in order to prove to private funders that these technologies will be viable in markets beyond initial success in the laboratory. However, investors are typically reluctant to fund such early-stage research and product development, largely due to the high technical, market, and management execution related risks and long development horizons associated with as-yet-unproven technological concepts. As a result, many entrepreneurial start-up firms and research laboratories fail to accumulate the necessary capital to see their innovative research concepts translated into commercial products and ventures (see Figure 1).

This early-stage Technological Valley of Death, while endemic to the development of most innovative technologies, is particularly acute in the energy sector. In this sector, the process of developing technologies is both capital- and time-intensive, and new innovations must quickly compete with well entrenched and commoditized conventional energy technologies. The early stage expenses necessary for nascent advanced energy technologies to demonstrate market validity, including prototyping and laboratory costs, are significantly higher than many other sectors. In the "garage culture" of Internet startups, for example, it takes comparatively little capital or time to advance an innovative research idea or product concept into a provable business plan. In contrast, bringing innovative energy research to its pre-deployment phase requires significant capital and as much as 10-15 years time (see Table 1).

Venture capitalists usually expect a shorter time frame for exit from an investment (often just 3–5 years), and the long investment payoff periods typical to new energy technologies only serve to further discourage investors.[7] Alternatively, angel investors, who tolerate high-risk projects, often provide funding for startups in exchange for ownership equity. Yet these entities only provide financing on the order of $1–2 million, not nearly enough to bring these capital-intensive projects across the Technological Valley of Death (see Table 2).

Adding to this challenge is the fact that large, risk-averse corporations dominate the energy market. The energy sector is not a research-intensive industry, where large, incumbent firms reinvest a substantial share of profits in every stage of the innovation process, from basic research to deployment (see Figure 2). Instead, the energy industry has until present been reluctant to launch large-scale advanced energy innovation efforts, largely due to the competitive and profitable nature of conventional fossil fuels. The transportation fuels market is dominated by oil & gas providers with highly profitable core businesses and little expertise in most aspects of alternative energy technologies. Meanwhile, the electricity market is dominated by utilities that have a regulated mandate to provide power at the least cost and least risk to end-users. As a result, these utilities are typically unwilling (or unable) to take risks on nascent energy technology ventures.[8]

Table 1

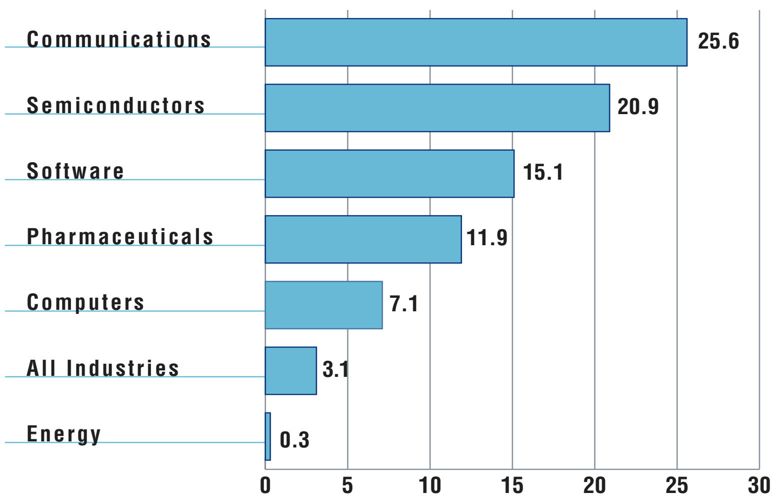
INNOVATION IN VARIOUS SECTORS

	PHARMACEUTICAL	SOFTWARE & IT	ENERGY
Time Required to Innovate	10-15 years	1-5 years	10-15 years
Capital Required to Innovate	Medium to High	Low to Medium	High
New Products Primarily Differentiated By	Function/Performance	Function/Performance	Cost
Actors Responsible for Innovation	Large Firms Reinvesting in R&D; Biotech startups, often VC & govt. funded; Govt. (NIH, NSF)	Dynamic Startups, often VC-funded; Large Firms Reinvesting in R&D	Various: Utilities, Oil & Gas Co.s, Power Tech Co.s, Startups, Govt.
Typical Industry Risk Tolerance	High	High	Low
Innovation Intensity	High	High	Low
Intellectual Property Rights	Strong	Modest	Modest

As such, early stage energy research and commercialization activities are concentrated in university research laboratories and seed-stage companies who have significantly less capital at their disposal to push innovative technologies forward. In this way, the advanced energy sector also differs from, for example, the pharmaceutical sector, where large pharmaceutical companies are willing to assume the risk of investing in early-stage drug research and reinvest profits into drug trials and testing. In the pharmaceutical sector, strong intellectual property (IP) protections provide a guaranteed return on investment for any blockbuster innovations. In contrast, advanced energy technologies are often complex engineering systems that build upon numerous individual components and typically offer modest IP guarantees. Research intensity in the energy fields thus remains significantly lower than in other comparative fields, such as information technology or the pharmaceutical industry (see Figure 2).

Figure 2

US INDUSTRY R&D SPENDING AS PERCENT OF DOMESTIC SALES[9]



Furthermore, the energy market is deeply complex, highly competitive, and commoditized. The cost of conventional fossil fuels has been driven downwards through more than a century of competition, while persistent subsidies and favorable tax rules continue to skew markets towards entrenched incumbents. Furthermore, like steel or copper, energy is a commodity, valued not for its own qualities, but for the services and products derived from it. As a result, while new software, electronics, or pharmaceutical products often compete on new features and value-added, new energy technologies must routinely compete on cost alone. This is a difficult feat for any nascent technology entering a commodity market but is particularly acute for innovative energy technologies that have to compete against mature (and still-subsidized) fossil energy technologies.[10] As a result, venture capitalists, already reluctant to invest in such early-stage research, are strongly deterred from investment in a market where barriers to market entry are particularly high, making expected risk-adjusted returns on investment too speculative to invest in.[11]

While venture capital investment in clean tech startups rose from 2006 to 2009, it has since fallen sharply as VC firms gained experience with the real challenges facing innovative clean energy ventures and as the recession reduced overall risk appetite and capital liquidity. VC investment in US clean tech deals fell by more than half (55 percent) in the third quarter of 2010, relative to the year prior, according to Ernst and Young.[12] Peachtree Capital Advisors reports that investments fell another 12 percent in the first half of 2011. As the firm explains, "In the US, venture capital firms have responded to impending cuts and uncertain policy by either pulling out of greentech altogether or investing in safer technologies with more predictable returns and shorter time horizons, such as energy efficiency."[13]

When combined with an already sparse funding environment for any early-stage, high-risk venture, these particularities of the energy sector create a perilous Technological Valley of Death for advanced energy technology ventures.

POLICY RESPONSES:
ARPA-E AND REGIONAL CLEAN ENERGY INNOVATION CONSORTIA

There are two policy responses that can address this clear and persistent gap in financing and investment for translational clean energy research and development and help overcome the Technological Valley of Death. These policies restore the kind of public-private innovation partnership responsible for so many great American technology breakthroughs,[14] and they work to "de-risk" investment in entrepreneurial advanced energy ventures, helping unlock significant private sector investment.

1.

The Department of Energy's Advanced Research Projects Agency-Energy (ARPA-E) was authorized by the bipartisan America COMPETES Act of 2007 and signed into law by President George W. Bush. First funded in 2009 by the American Recovery and Reinvestment Act, this agency seeks to bridge the Technological Valley of Death by funding the cutting-edge, high-risk, high-reward research that is deemed too risky for venture capital investment, helping advanced energy ventures cross the gap between the laboratory and private financing. ARPA-E operates at the intersection of basic and applied research, driving breakthrough concepts towards market-viable technologies. As such, ARPA-E operates between the DOE's Office of Science, which performs basic and fundamental research, and the DOE's applied research offices, including the Offices of Energy Efficiency and Renewable Energy, Nuclear Energy, and Fossil Energy. ARPA-E performs a fundamental function that none of these offices support, addressing the "translational" stage that brings basic science and goal-driven technological development under one roof.[15]

ARPA-E's efforts have already proven to effectively catalyze innovation and help firms cross the Technological Valley of Death. In FY2009 and FY2010, ARPA-E invested $39.5 million in eleven advanced energy projects, enabling these innovative ventures to overcome technological barriers ahead of schedule and develop products to the point where these firms were able to attract more than $200 million in private-sector investment—leveraging this initial public investment into a greater than 5:1 ratio of private to public funding.[16]

ARPA-E's early success underlines the catalytic role the public sector has played in mitigating risks and developing and validating advanced energy projects that the private sector later brings to fruition. As Arun Majumdar, director of ARPA-E, recently argued, "What ARPA-E does best is identify the opportunities and create the competition. And eventually, the market will pick the winners."[17] Here, the public sector's role is to competitively award modest amounts of funding, often just $2-10 million per project, spread across a broad portfolio of more than 180 potentially breakthrough projects to date.[18] The innovative grant recipients then utilize these funds to achieve critical technical milestones and attract private risk capital. In this way, ARPA-E effectively unlocks private sector investment in these early-stage technologies and supports risk-taking American entrepreneurs.

2.

Regional Clean Energy Innovation Consortia are a second policy response to the Technological Valley of Death. Many lab and early-stage, pre-venture energy projects show great technological promise, yet lack critical market insights, an understanding of customer needs, business and financing strategies, and/or an experienced team required to attract capital investments. These insights and assets exist in regional innovation clusters, and Clean Energy Innovation Consortia are cluster development partnerships designed to bring together stakeholders across a cluster or region to connect these assets to promising innovations. These consortia aim to align the interests of those conducting research with the experience of actors more closely connected to the market, including venture capitalists, end-users such as utilities, and manufacturers and technology companies who often take innovative products to market.

Regional consortia also facilitate the handoff from laboratory research to technological commercialization by encouraging collaboration over time among major research universities and public and private research centers, entrepreneurs, venture capital firms, manufacturers, and the energy industry. These consortia support promising regional projects with direct grants from government and private funds (often of $1 million or less) and connect these projects with the resources of regional public-private partnerships to facilitate translational research and development, prototyping, and business validation. These efforts are specifically geared towards the seed stages of technology development and commercialization and target the challenges associated with the Technological Valley of Death. Regional Clean Energy Innovation Consortia also reduce the informational asymmetries between entrepreneurs and investors, by providing access to data and critical information for investment decisions, helping entrepreneurs develop to a stage that addresses the full range of investment risks, and establishing crucial partnerships between the research, entrepreneurship, and investment communities.[19]

While federal policy models like ARPA-E are critical to address the Technological Valley of Death, Clean Energy Innovation Consortia bring to bear the full resources of America's vibrant regional clusters to accelerate advanced energy innovation and regional economic development.

→ THE COMMERCIALIZATION VALLEY OF DEATH ←

The second persistent market gap, named the "Commercialization Valley of Death," exists between the pilot/demonstration and commercialization phases of the technological development cycle and aligns with a gap between the traditional role of venture capital and the later stage investments of project finance and debt/equity investors (see Figure 1).

This Commercialization Valley of Death plagues technologies that have already demonstrated proof of concept but still require large capital infusions to demonstrate that their design and manufacturing processes can be brought to full commercial scale (e.g., a first-of-a-kind full-scale power plant or manufacturing facility). To move a technology from the pilot/demonstration stage to the commercialization stage, the central challenge is accumulating enough capital for the commercialization, production, and manufacturing processes associated with demonstration and market launch. Clean energy technologies are routinely more capital-intensive than typical innovative technologies, and large sums of capital, often on the order of hundreds of millions of dollars, are necessary to build commercial-scale facilities and demonstrate the validity of a first-of-a-kind technology in the field.

As the US Chamber of Commerce's Christopher Guith explains:

"[E]nergy projects face multiple risks, including engineering risks, construction risks, commodity risks, execution risks, resource risks, technology risks, permitting risks, and policy risks. While clean energy projects can mitigate a majority of these risks using normal project development processes, overcoming the technology hurdle will take years if left to business-as-usual market processes. … This lengthy process has resulted in multiple technologies demonstrating promising laboratory results but failing to meet national energy goals because they never reached full commercial scale."[20]

Accelerating the rate of clean energy commercialization and ensuring American entrepreneurs have every opportunity to bring innovative advanced energy technologies to market requires proactive policy. Absent innovative policy, neither venture capital nor traditional project finance or equity/debt financiers will provide adequate financing to address the nation's energy innovation imperative.

Venture capital firms are accustomed to handling the risks inherent with innovative technologies and build the costs of technological demonstration and learning into their investment plans. Typically, venture capital firms will invest in early-stage companies commercializing innovative technologies, despite the high-risks of these technologies and improbability of success. However, to manage the associated risks, venture capital investment funds must be distributed across multiple innovative technologies, with the expectation that most ventures will fail and the few that succeed will yield high returns. As a result, to be able to maximize returns, venture capitalists prefer less capital intensive companies, where returns to investment occur on a relatively short time frame so that any profits can be reinvested into other innovative technologies.

Unfortunately, most energy technologies are capital intensive and can frequently require five to ten years or more to demonstrate proof of commercial viability. Before full commercialization, many new energy technologies must demonstrate operational characteristics and reduce real and perceived technology risk at the utility-scale power plant, refinery, or manufacturing plant level, often an immensely capital-intensive process.[21]

Traditional venture capitalists are accustomed to investing in demonstration and pilot projects, but only at much smaller scales. The "Greentech" fund of noted Silicon Valley venture capital firm Kleiner Perkins Caufield and Byers, for example, currently stands at $500 million and funds at least 25 clean energy entrepreneurs and firms.[22] Indeed, the average size of VC-backed clean energy sector deals in the second half of 2010 was under $10 million.[23] The financing necessary to demonstrate capital-intensive energy technologies far exceeds the typical capacity of venture capital; the first manufacturing facility capable of producing an innovative solar photovoltaic or advanced battery technology requires hundreds of millions of dollars to construct, for example, while a full-scale carbon capture and sequestration-equipped power plant may require more than a billion dollars. Venture capital funds are simply not institutionally structured to be able to invest in such large-scale projects, leaving an acute Commercialization Valley of Death in the clean energy sector.

A financing challenge of this scale requires a pool of capital that only traditional project financiers, like banks or other debt financiers, have the capability to provide. Typical debt or project finance is aimed towards a lower rate of return than venture capital investment. Unfortunately, these financiers also have a much lower tolerance for risk than venture capitalists and are only willing to back later iterations of innovative technologies, where commercial validity has already been proven. Examples of such technologies include conventional solar photovoltaic technologies and utility-scale wind power.[24]

Table 2

PRIVATE SECTOR ACTORS IN THE ENERGY INNOVATION CYCLE

	SEED FINANCING	ANGEL INVESTORS	VENTURE CAPITAL	DEBT FINANCING	PRIVATE EQUITY	UTILITIES
Typical Investment Amount	Small	Small	Small-medium	Any size	Any size	Large
Technology Financing Stage	R&D, Prototype	R&D, Prototype	Prototype, Commercial-ization	Commercial-ization, Deployment	Commercial-Ization, Deployment	Deployment
Expected Time for ROI	Long-term	Long-medium-term	Short-medium-term	Medium-long-term	Medium-long-term	Long-term
Risk Tolerance	High	High	High	Low	Low	Low

As Bloomberg's New Energy Finance argues, no set of actors or institutions currently exists with the capabilities to address this high-risk, high-capital technology category (see Table 2):

"Even in 2008, as stocks touched all-time highs and interest rates dipped to all-time lows, virtually no truly private project finance capital was available for projects that sought to deploy unproven technologies. Indeed, the pre-recession boom years for clean energy offer virtually irrefutable proof that the Commercialization Valley of Death challenge is one that the private sector will not address on its own."[25]

As a result, a multitude of advanced energy technologies currently find themselves stuck in this Commercialization Valley of Death between venture capitalist financing and traditional debt financing. Examples include: carbon capture and sequestration plants, small modular nuclear reactors, advanced solar manufacturing facilities, engineered/enhanced geothermal, various utility-scale energy storage technologies, advanced biofuels production facilities and new manufacturing for advanced batteries.

POLICY RESPONSES:
CLEAN ENERGY DEPLOYMENT ADMINISTRATION AND NATIONAL CLEAN ENERGY TESTBEDS

The government must play a key role in helping entrepreneurial American firms bring advanced energy technologies past the Commercialization Valley of Death. It can do so most effectively by reducing financial and other barriers to commercialization. Pervasive market barriers mean that the private sector will not address this gap on its own. If the public sector shoulders a portion of the risk, however, it could unlock large amounts of private capital while leveraging the distributed, entrepreneurial nature of the US economy.

1.

The Clean Energy Deployment Administration (CEDA) is a flexible, independent government investment agency—effectively a bank—that aims to unlock the capital necessary to move innovative energy technologies across the Commercialization Valley of Death.[26] Like the successful US Export-Import Bank and Overseas Private Investment Corporation, CEDA would be initially seeded through government funds, but would then operate like an independent, not-for-profit, private-sector investment fund offering a variety of financial tools that currently elude nascent energy technologies. These tools include: an advanced energy investment fund, loan guarantees, insurance products, clean energy project-backed bonds, and debt instruments. These financial products would reduce the perceived risks of investing in innovative energy technologies, allowing energy entrepreneurs to attract and leverage significant private sector investment in the development and deployment of their novel yet capital-intensive advanced energy technologies.[27] CEDA would focus principally on accelerating the rate of commercialization of advanced energy technologies with the potential to become independent of ongoing subsidy as they mature. In pursuit of this mission, CEDA would be staffed by experienced project finance and technology assessment experts. This new program would replace the troubled DOE Loan Programs Office (home to the Section 1703 and 1705 loan guarantee programs and the Advanced Technology Vehicles Manufacturing loan program), incorporating the loan program's functions into the flexible suite of financing and risk mitigating tools at CEDA's disposal. Indeed, as policy makers bring an intense focus to public investment strategies in the wake of the Solyndra bankruptcy, establishing a well-structured CEDA offers an opportunity for a smart reassessment of government's role in bridging the Commercialization Valley of Death and a chance to incorporate key lessons from the operation of the Loan Program Office.

For more on establishing CEDA, please see "A Clean Energy Deployment Administration: Unlocking Advanced Energy Innovation and Commercialization," Breakthrough Institute, November 2011.[28]

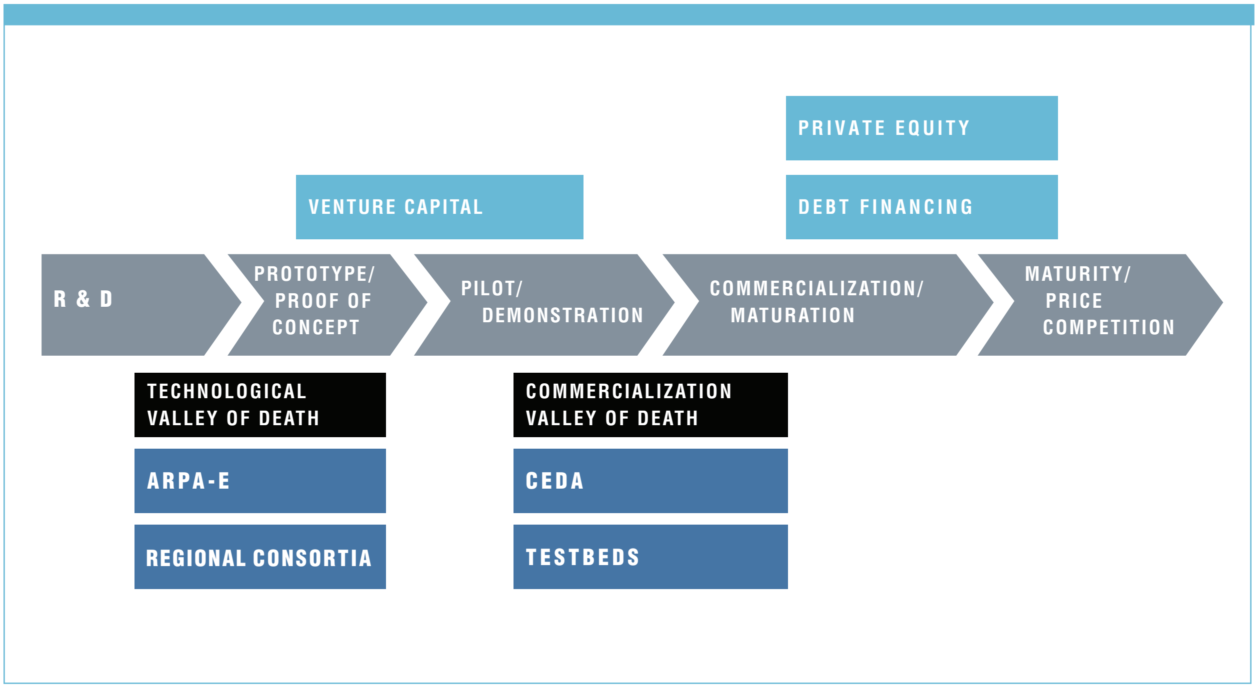
2.

A National Clean Energy Testbeds (N-CET) program offers a second response to the Commercialization Valley of Death. This proposed program is aimed at reducing the cost, time, and permitting challenges associated with innovative energy technology demonstration. N-CET follows a "plug and play" demonstration model, providing pre-approved, monitored, and grid-connected public lands for demonstration of innovative energy technologies. The program would be a collaboration between the Departments of Energy, Defense, and Interior, to identify and pre-permit sites on federal lands and waters appropriate for advanced energy technology demonstration. A national network of demonstration zones sites, each with multiple pre-approved demonstration testbeds and established common infrastructure (i.e., roads, substations, etc.), would be made "open for business," allowing innovative firms to test and validate next-generation energy technologies. Ultimately, by reducing the time burden associated with site identification and permitting and the costs associated with securing land and key enabling infrastructure, the program would reduce the hurdles associated with clean energy demonstration and commercialization.

For more on establishing N-CET, please see "A National Clean Energy Testbeds Program: Using Public Land to Accelerate Advanced Energy Innovation and Commercialization," Breakthrough Institute, November 2011.[29]

Figure 3

POLICY RESPONSES TO THE CLEAN ENERGY VALLEYS OF DEATH



→ CONCLUSION ←

The energy sector is a complex industry of enormous scale, characterized by regulated markets and a fully developed infrastructure. Energy sources, dominated by incumbent and well-established energy firms, typically compete on a commodity basis with cost as the primary differentiation between products. Consequently, this sector is among the most difficult for innovative technologies to navigate, providing substantial obstacles for deployment of clean and affordable advanced energy technologies and hampering American competitiveness in the industry as a whole. Today, too many innovative energy designs fall victim to one of two "Clean Energy Valleys of Death" that exist in the perilous gap between early-stage research and market launch. As a result, the pace of innovation and commercialization for new, advanced energy technologies has remained too slow to meet national needs and allow the country to become a leader in energy innovation.

The energy sector as a whole is a roughly $5 trillion market, and it is expected to grow by more than 50 percent by 2035.[30] Supplying this market with clean and affordable advanced energy technologies thus represents an enormous economic opportunity for American entrepreneurs and firms and the US economy as a whole.

Yet in order to dramatically catalyze the development and deployment of clean energy technologies and seize this economic opportunity, innovative public policy must be employed. Here, the public sector's role is to overcome certain persistent market barriers and help bridge often-fatal gaps in the innovation cycle, from the risk asymmetries that inhibit investors from recognizing the profitability of innovative energy technologies, to the informational asymmetries that deter effective partnerships and alignment of incentives between entrepreneurs and the investment community. A combination of the policies and public-private partnership mechanisms described above—including programs like ARPA-E, Regional Energy Innovation Consortia, a Clean Energy Deployment Administration, and a network of National Clean Energy Testbeds—can play a crucial role in addressing these market barriers and unlocking private sector investments in advanced energy innovation.

The goal of such policies is not to ensure that *every* new venture passes safely across the two valleys of death. Indeed, rigor must be maintained in assessing the validity and prospects of advanced energy technology ventures to properly "weed out" unpromising technologies. Today, however, far too many promising firms with high-impact potential unjustly fall victim to the structural and market barriers we describe here as the Technological and Commercialization Valleys of Death. These innovative ventures must be given the chance to succeed and fail on their own true merits.

Today, the need for clean, cheap, and widely available advanced energy technologies is clear. To meet this challenge, the country must build an institutional system that fosters innovation, entrepreneurship, and competition and avoids picking incumbent technologies over innovative, yet risky, technologies. Make no mistake: by failing to address the Technological and Commercialization Valleys of Death discussed in this brief, the country *is* making the decision to pick winners in the energy sector—the conventional, incumbent, and dirty energy technologies that dominate the nation's energy supply today and the international competitors now positioning themselves to dominate the advanced energy markets of tomorrow. However, in taking the steps necessary to fill the financing and institutional gaps for innovative advanced energy technologies, the public sector will allow these nascent technologies to compete on an even keel with incumbents and give time for worthy winners to emerge on their own. In so doing, the country will once again ignite America's entrepreneurial spirit and begin to address a set of the nation's most pressing challenges.

→ NOTES & CITATIONS ←

1 In April 2011, the United States imported an average of 12 million barrels per day of crude oil and petroleum products at an average cost of $117.44 per barrel. The price tag for US oil imports therefore totaled approximately $1,409,300,000 per day. See "US Imports of Crude Oil and Petroleum Products," US Energy Information Administration, June 29, 2011, accessed July 1, 2011, http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=mttimus1&f=m; "Weekly All Countries Spot Price FOB Weighted by Estimated Export Volume," US Energy Information Administration, June 29, 2011, accessed July 1, 2011, http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=WTOTWORLD&f=W.

2 See Rob Atkinson *et al.*, "Rising Tigers, Sleeping Giant," Breakthrough Institute and Information Technology and Innovation Foundation, November 2009. And "Who's Winning the Clean Energy Race: 2010 Edition," The Pew Charitable Trusts, 2011.

3 See discussion in Rob Atkinson *et al.,* "Climate Pragmatism," The Hartwell Group, July 2011, at pages 12-13.

4 Jesse Jenkins *et al.,* "Where Good Technologies Come From: Case Studies in American Innovation," Breakthrough Institute, December 2010.

5 Rob Atkinson, *The Past and Future of America's Economy: Long Waves of Innovation that Power Cycles of Growth*, Edward Elgar Publishing, 2005.

6 *Ibid.* See also Charles Weiss and William Bonvillian, *Structuring an Energy Technology Revolution,* MIT Press, 2009.

The public sector also has an important role to play in ensuring an adequate supply of scientific research and new ideas, pointing to the importance of direct public investment in new energy science and research. That is a subject of other briefs. See Joshua Freed *et al.,* "Jumpstarting a Clean Energy Revolution with a National Institutes of Energy," Third Way and Breakthrough Institute, September 2009.

7 "From Innovation to Infrastructure: Financing First Commercial Clean Energy Projects," California Clean Energy Fund (CalCEF), June 2010, at pages 5–33.

8 The few utilities that have made proactive investments in carbon capture and sequestration (CCS), wave power, solar thermal, and other early-stage technologies tend to be the exception to the rule and often face persistent challenges in balancing the investments needed to demonstrate and commercialize new technologies with obligations to serve ratepayers at least cost. For example, Ohio-based American Electric Power announced in July 2011 that it would abandon a promising CCS demonstration project in West Virginia citing concerns over rate impacts. "It's just not the time to go to regulators and ask to add this to our other costs," said Pat Hemlepp, a spokesperson for the utility. See Christa Marshall and Evan Lehmann, "AEP Move to Stop Carbon Capture and Sequestration Project Shocks Utilities, Miners," *New York Times / ClimateWire*, July 15, 2011. Available at: http://www.nytimes.com/cwire/2011/07/15/15climatewire-aep-move-to-stop-carbon-capture-and-sequestr-83721.html

9 Figure 2 sources: For all sectors excepting energy, see Raymond Wolfe, "US Businesses Report 2008 Worldwide R&D Expense of $330 Billion: Findings from New NSF Survey," NSF 10-322, National Science Foundation, May 2010, see Table 1. Figures are 2008 domestic expenditures in R&D performed by companies as a share of domestic sales, as reported to the Business R&D and Innovation Survey of the National Science Foundation and US Census Bureau; Energy R&D expenditures as percent of sales not specified by NSF survey and sourced from Charles Weiss and William Bonvillian, 2009, *op. cit.* note 6.

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