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Prepared under Task No. (7200.2050)

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EXECUTIVE SUMMARY

Technology innovation has been strongly stimulated by federal financing for more than 50 years. In fact, public investment often guides or directs private sector investment to areas of the public good – such as clean energy technologies. The U.S. Department of Energy (DOE), along with its National Renewable Energy Laboratory (NREL), have made remarkable technological advancements, efficiency improvements and cost reductions in a spectrum of clean energy technologies, with the expectation that industry would move emerging technologies into the marketplace. Thus the public good benefits resulting from the advancement of science and technology in terms of energy diversity, security and environmental protection would also accrue. These achievements notwithstanding, nothing near a revolution in how we use energy has occurred.

Instead what we see is a new generation of clean energy entrepreneurial firms finding it very difficult to make the leap from public sector financing to private sector funding for their innovations. Without new capital, many of our nation's most promising energy entrepreneurs will fail. According to a recent study by Gompers and Lerner (2001, pp 21, 28), "…. ninety percent of new entrepreneurial ventures that don't attract venture capital will fail within the first three years." It is often assumed that when a company fails to commercialize a world-class technology the investment community is to blame for lack of vision or greed. In reality, ventures fail to obtain funding because there are significant gaps between what the ventures are offering to investors and what the potential investors are seeking.

This paper focuses on the difficulties in the hand-off to private sector investors of publicly funded, early stage technology investment opportunities in entrepreneurial ventures. In particular it explores the financing disconnects between public sector and private sector investors using three perspectives:

1. *Divergence of public and private sector values, requirements, and goals*
2. *The cash flow "valley of death," and*
3. *Private sector perspectives on risk*

Each of these perspectives illuminates the nature of the problem in a slightly different manner; however, from these different lenses several common themes emerge that point to a set of remedies that are both straightforward and powerful. These remedies are:

1. *Reduce information gaps or asymmetries between the two sectors*
2. *Foster an accelerated shift from a technology to a market focus*
3. *Explore and develop novel co-investment partnerships with the private sector*

As this paper indicates, DOE and NREL have begun to apply these remedies through NREL's Enterprise Development Programs by building linkages between public and private sector investors. Many other opportunities further expand and apply these remedies exist.

I. Divergence of Public and Private Sector Values

Clean energy entrepreneurs are regularly in a position where they must try to simultaneously satisfy the divergent criteria, goals, and values of the public and private sectors in order to obtain financing. It is extremely difficult to conduct high-risk early stage research to satisfy the public sector, while simultaneously prioritizing market and product development to obtain private sector financing. Neither group believes it is within their purview to finance the transition stage of commercialization. This presents a significant challenge. Key differences in perspectives, goals, and investment approach are summarized in Table S-1 below.

Table S-1. Key Characteristics & Perspectives of Public and Private Sector Investors

	Public Sector Investors	Private Sector Investors
Key Goals	• Develop promising technology options that meet public sector needs by reducing early technology risks that private sector investors would otherwise not assume • Private sector will subsequently exercise its option to invest	• Profitable investments in technology based businesses that address real market needs - investments that are technology neutral within the context of meeting customer needs
Investment Focus	• **Technology Focused** development of high quality innovations o Early, high risk RD&D o Technology performance and cost reduction o Technology certification and performance verification	• Early, prudent investments in **market focused businesses** that emphasize: o Strong management teams o Products - not technologies o Market development and access to these markets; customer driven
Biggest Concern	• Technical showstoppers	• Customer and market showstoppers
Other key contributing investor insights / expertise / strengths	• **Technology** based perspectives on: o Capabilities, benefits and applications o Technical competition (possible) • **Macro market perspectives** on energy needs and trends • Perspective on **public policy and public good needs** & trends, as well as the potential to impact • Standards development	• **Business and Financial** perspectives on: o Market driven, customer benefits o Broader (beyond energy) sets of industry applications o Market competition • Specific market perspectives and trends for energy and other applications including market beachhead, and entry strategies • Ability to factor public policy impacts into investment and business formation decisions effectively
Key constraints on collaborations	• Investment collaborations must abide by governmental regulations including those for fairness of opportunities, and not competing with the private sector • Commercialization viewed as responsibility of private sector	• Investment collaborations should reduce the risk and improve the profitability of investments
Key enablers needed	• Collaborations that **accelerate the deployment** and use of the technology in which the public sector invests	• Access to the information, people, knowledge and data necessary for sound investments • Entrepreneurs that are predisposed to, and/or already focused on, market /customer product and business development issues
Differences in funding Process	• Competitive written proposals judged mainly by a technology focused review team; decisions sometimes appealed • Non-disclosure agreements (NDA's) not unusual	• Final decisions based in large part on presentations by management team; supported by extensive due diligence; decisions seldom reconsidered and not subject to review by higher authority • NDA's very rarely used
Pay Off	• Technology is commercialized and public good goals are met including energy diversity, security, and environ-mental protection • Public sector has no direct ownership	• Profit through capital appreciation, i.e., increase in value of ownership stake. Profits are often realized at later investment stages through an exit strategy

For their part, DOE and NREL are often constrained, by public policy and legal mandates, to treat commercialization as the responsibility of the private sector – public sector managers know they can't be perceived as picking winners and losers in the marketplace. Rather, the public sector sees its role as funding high-risk, long-term research and occasionally funding cost-

shared demonstration projects. They hope that the private sector will exercise its option to further invest in entrepreneurial ventures based on these technologies.

Private sector investors, on the other hand, must pursue return on investments and profits for the companies in which they invest.[1] Private sector profits result from developing effective businesses with market driven products and robust markets, and not just technology.

These two groups have only a vague understanding of what drives each other – thus creating a chasm between the two worlds and a formidable gulf that entrepreneurs must navigate on their own. Particularly striking is the need for entrepreneurial firms to evolve from a technology focus to a market and customer focus, which is primarily due to the requirement that the private sector make a profit. The public sector does not have this requirement. Thus, without adequately addressing these differences, it is not surprising that many promising entrepreneurial firms that have had significant public sector technology investments are unable to raise private sector capital – and as a result the public sector investment can easily lie fallow.

II. The Cash Flow Valley Of Death

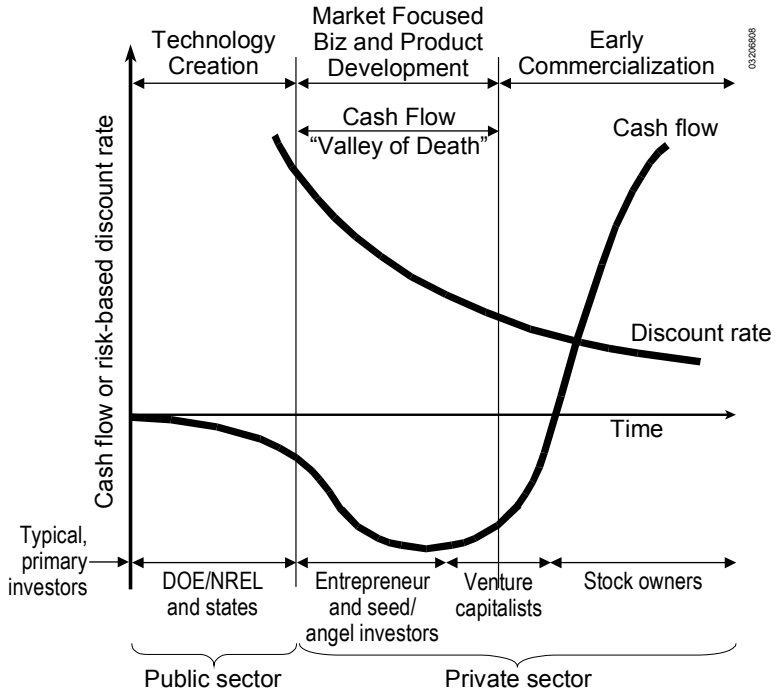

Figure S-1. Normalized cash flow and risk adjusted discount rates as a function of business development stage, time, and the type of investors that are typically involved.

While the values and goals of the financiers are one piece of the equation, it is equally important to analyze what is happening to the entrepreneur's cash flow during this transition from public to private sector financing. Getting a venture to the position where it is successful and can produce a commercial product is an arduous task usually requiring a trek through the "cash flow valley of death." In the "cash flow valley of death" entrepreneurs face the dangerous

[1] As venture capitalists like to say – they are, after all, capitalists!!

convergence of high cash demands and low ability to raise it. The "cash flow valley of death" and the corresponding financing context for this challenge is illustrated schematically in Figure S-1, where we have plotted normalized cash flow, and the normalized risk related discount rate[2] for a typical entrepreneurial energy venture, versus time, along with typical investors for each corresponding stage.

Focusing first on the cash flow curve, note three broad stages of development where investment is needed to keep the venture solvent: 1) the technology creation stage where the public sector focuses its investment, 2) the cash flow valley of death where there is typically a dearth of funding, and 3) the early commercialization stage – typically the earliest point at which private sector investors like to invest. Venture capitalists typically prefer to finance the venture when solid initial sales have been established – just before the sharp upturn in cash flow that is associated with rapid market acceptance, adoption, and sales; when more robust, large scale markets can be more reasonably assured; and when the risks are much lower. Further, we can see that the cash needed in the cash flow valley of death is extremely large compared to the cash needed for the technology creation stage.

Moreover, the availability of public sector funds decreases abruptly after the technology is created because, as noted above, the public sector views subsequent investment as the purview of the private sector. This drop off of public investment occurs at the same time that the investment needs of the venture are actually growing. Also, since bootstrapping is often not feasible when large cash needs are considered for many clean energy ventures, there is also limited ability to service debt financing. Hence, the entrepreneurial venture must often turn to equity financing for at least part of the resources needed. Further, adequate levels of angel and seed investor resources are often not available as a precursor to venture capital, especially for high technology investments (Lerner 2001). This is why we call the region between the technology creation stage and the early commercialization stage the cash flow valley of death.

III. Private Sector Risk Perspectives

The public sector contributes significantly to the reduction of technical risks through its investments, and the private sector highly values the technology certification value that these early investments provide. However, there are numerous other risks. And while clean energy investments can be very profitable, they are still perceived as high-risk, large-dollar investments by much of the investment community – and for good reason. The amount of money needed and the time to recover those resources (the exit), are especially large relative to other technical investments such as for software.[3] These differences and higher risks occur because of:

1. Information asymmetries resulting from an entrepreneur knowing more about his technology and his company's prospects than investors or strategic partners.
2. Lack of real products. The need to transform the new technology into market driven, market ready products, and "whole product" solutions (often requiring significant time and money).[4]
3. The markets for these technologies are often immature and need to be developed.
4. Multiple and costly prototypes are often necessary for initial markets.

[2] The risk related discount rate will be discussed more in the next section below.
[3] To put this in perspective consider that for many software concepts, $1M can often take an entrepreneur a long way towards commercialization, but with energy investments an investment of one-to-two orders of magnitude (+) more can often be required.
[4] See Moore (1995), Inside the Tornado.

5. Energy is generally perceived (inaccurately, in many instances) as a commodity market with low margins and high volatility.
6. Emerging energy companies often have management teams heavily weighted with researchers and very little business experience – increasing the private sector's perception of risk especially the private investor's strong emphasis on business management expertise.

While the biggest of these perceived risks is usually information gaps or asymmetries, most risks are interrelated, and we can correlate the overall risk profile with the development stage of the business and the time to commercialization. Venture investors typically discount the value of a business to compensate for the uncertainties and inherent risks they perceive. This is illustrated in Figure S-1 where a typical risk adjusted discount curve is shown. Hence it is seen why private sector investors typically want to invest (and why entrepreneurs can get relatively good valuations) only after most risks are reduced to acceptable levels – this means that a fundable venture must be more mature than is typical at the time the technology creation phase is completed.

By better understanding the nature of these risks, there is much one can do to position public sector investments such that the private sector is more inclined to exercise its option to invest in the corresponding entrepreneurial ventures.

IV. Building a Bridge Between Public and Private Sector Financiers

By examining the entrepreneur's funding situation from various perspectives several common themes emerge. Though simple, they are powerful tools, which the public and private sectors can exploit collaboratively to close the gap between the two investment sectors and to accelerate the commercialization process. We propose three strategies for the public and private sectors to adopt to assist clean energy companies in reaching their full potential:

1. **Reduce information gaps or asymmetries between the two sectors by providing appropriate access to data, knowledge, and insights critical to making sound investments.** This includes:
    - Encouraging early and frequent interactions among the public sector, the clean energy industry, and the investment community. In addition to reducing information asymmetries, this early involvement can foster the development of relationships with private sector investors, can help leverage investor expertise in market identification and creation, and can decrease the time-to-market and the size of the cash flow valley of death.
    - Providing private sector investors with technical advice and assistance, and information such as published macro-level market and technical data of a nonproprietary nature.
    - Establishing appropriate procedures that allow private sector investors early access to public sector technology programs and program managers along with related data and insights, within the constraints placed on the public sector.
    - Including private sector investor perspectives in the evaluation criteria that public sector investors use for selecting their investments, to enhance earlier invest-ability.
2. **Fostering an accelerated shift from a technology focus to a market focus.** This includes:
    - Encouraging companies to develop more evenly along both technology and business development dimensions, while leveraging the insights and guidance from investors,

incubators and other business experts, as well as from potential technology users and product customers.

- Having the public sector continue to stage its investment while making funding contingent on progress toward goals and additional milestones that address the viability of the business. For instance, other milestones might be tied to receiving an invitation to present at an NREL Industry Growth Forum (described below), being accepted in one of the Alliance Incubators (described below), obtaining substantial licensing agreement, or receiving venture financing.
- Fostering the ability of entrepreneurs to respond to market opportunities in a timely fashion before the competition can beat them to it. And looking at how public-sector cost share requirements may be limiting these opportunities.
- Evaluating the advantages of fostering the development of technologies that are platforms for multiple applications and products, which can thus increase the value of the technologies and reduce the risk to the private sector considerably.
- Encouraging entrepreneurial venture organizations to access and use the best business development expertise available, including that which is available in the nation's top business incubators such as the National Alliance of Clean Energy Business Incubators.

3. **Exploring and developing novel co-investment partnerships with the private sector** to help address significant funding gaps. This may include experimenting with approaches such as those already underway with the U.S. intelligence community,[5] and using a "poster child" approach to demonstrate its efficacy before more widespread application is considered.

V. Taking the First Steps in Building the Needed Bridges

DOE and NREL have already embarked down this road through NREL's Enterprise Development Programs, which act as catalysts in bridging these gaps by fostering linkages and partnerships between investors, entrerpeneurs and other key players in the commercialization process. These partnerships can help reduce risk to further investment, while speeding up the the commercialization process, and increasing the yield on DOE/NREL investments. These programs are relatively early in their development, but the corresponding linkages and partnerships are already expanding rapidly. The four key elements of this program are:

1. **NREL Industry Growth "Venture" Forums** - These forums are similar to venture capital forums and provide clean energy entrepreneurs opportunities to present their business cases to an expert panel of investors and energy executives.
2. **The National Alliance of Clean Energy Business Incubators** - This is an alliance of the nation's top incubators committed to incubating and providing business services to clean energy entrepreneurs.
3. **The Clean Energy Network & Investor Directory** – This directory contains contact and profile information for more than 90 investors that are currently interested in making quality clean energy investments, and in assisting the clean energy entrepreneur to become a market success.
4. **NREL Growth Link** - Growth Link is a web-based directory of clean energy companies seeking financing, partnering, and growth opportunities. Investors and energy firms can

[5] The CIA has recently initiated the In-Q-Tel venture fund, and the US Army has initiated a similar venture fund, to assist in the development and commercialization of technologies that support their missions while building more effective working relations with private sector businesses and financiers.

use the directory to find clean energy technologies that match their investment and strategic interests.

Preface

The idea for "Bridging the Cash Flow Valley of Death" emerged in 2001, the day after NREL's 13th Industry Growth Forum. After listening to two days of presentations by dozens of entrepreneurs it became clear that government financing and private sector financing rewarded two different types of companies – and that government programs were not necessarily creating financeable ventures.

At the same time, venture capital investor Peter Edwards was coming to the same conclusion: that clean energy entrepreneurs who have benefited from public sector funding should be better prepared to seek private sector financing. Peter had noticed too many instances in which founders or entrepreneurs had developed excellent skills in obtaining government financing but were ill prepared for the competitive marketplace.

Peter and I (Marty Murphy) compared notes and found that we shared many of the same views on this subject – his coming from a venture capitalist perspective and mine from the government perspective. We agreed to explore together how public and private sector investors can combine their efforts to improve the "yield" on the government's early investments by accelerating the commercialization of clean energy technology.

What we provide in this report draws on our observations and experiences working with entrepreneurs, technologists, and the venture capital community over the past decade. More directly, our ideas were refined in many hours of conversation with entrepreneurs, technical program managers and the venture capitalists that finance innovation; albeit each with our own limited "window" on the issues, but also backed up with insights from the literature. Hence, some of the perspective we provide is subjective. We hope it will be looked on as the opening volley in an ongoing dialog leading to further improvements.

Finally, many of our colleagues greatly enhanced the writing of this report, but we especially wish to thank a number of key reviewers for their insights and perspectives, along with their generous willingness to take time from very busy schedules: Gerry Braun of Energetix Group, Julie Brokaw of Bechtel, and David Mooney and Ralph Overend, both of NREL.

L.M. (Marty) Murphy
Peter Edwards

Bridging the Valley of Death:
Transitioning from Public to Private Sector Financing

I. Introduction

Public sector financiers make significant R&D investments in technology and the associated early stage ventures while hoping to entice private sector investors to exercise their option to build on, and to further invest in, the early technology based businesses, thus leading to successful commercialization. The purpose of this paper is to help the two sectors better foster the transition of the entrepreneurial ventures and thereby accelerate the commercialization of clean energy, technology-based products, while improving the yield of these public sector investments. The importance of making this transition to the private sector financing is underscored in a recent work by Gompers and Lerner (2001) that "ninety percent of new entrepreneurial ventures that don't attract venture capital will fail within the first three years." In addition, since effective financing of these ventures requires an increasingly large amount of interdependent collaboration, we hope this paper helps to increase the dialog and understanding among public and private sector investors, as well as clean energy companies.

The U.S. Department of Energy (DOE), along with its National Renewable Energy Laboratory (NREL), is a major public sector sponsor and financier of clean energy technology creation and development. Further, DOE and NREL have worked in close collaboration with the clean energy[6] industry for the past 25 years on R&D, with the expectation that industry would take its technology based products to the marketplace.[7] This is because the government views commercialization as the responsibility of the private sector. However, even though remarkable progress on both technology performance and associated costs has often occurred as a result of this R&D, expectations for commercialization have been largely under-met, due primarily to a number of commercialization barriers.

The limited ability of many clean energy ventures to attract private financing is certainly one of these major barriers. However, it is also very often a symptom of other underlying, and more fundamental issues that we will explore in depth below. We will also explore what the public and private sectors can do collaboratively to address these issues. Quite simply, great technology and opportunities to build linkages with the financial community are necessary but not sufficient for successful commercialization; numerous investors have noted that there is sufficient money available if the investment is high quality. When risks are factored into the quality equation however, many investments often don't look very attractive. Unfortunately, when investment needs are greatest – the risks are the highest, and the entrepreneur is unable to attract the needed financing.

[6] We are defining clean energy technology as renewable energy, energy efficiency, and hybrid-renewable technologies as well as related technologies that facilitate distributed energy generation options. For example, related technologies include fuel cells that can utilize a range of fuels such as hydrogen and ethanol that can be derived from renewables.

[7] About half of the NREL budget is allocated annually to collaborative R&D, mostly with these industry partners.

Reprising Earlier Work on What Entrepreneurs Can Do to Create Financeable Companies

Many entrepreneurs are surprised to learn about the numerous additional requirements that must be addressed – beyond having a great technology – in order to attract the interest of the financial industry and in particular, the venture capital community. In a classic chicken-and-egg scenario, energy entrepreneurs need private financing to turn their new technology into marketable products.

How then can these hurdles be overcome? What do successful entrepreneurs have in common besides a good technology? In an earlier study (Murphy et al. 2002) we discussed in depth the need to prepare and position the entrepreneurial enterprise for private sector financing. In particular, we identified this need as private financiers who often want to see marketable products and a well-rounded business plan before they risk any funds. In fact, entrepreneurs that successfully overcome the financial hurdles have typically done a lot of groundwork as a prerequisite for the financing. In particular, we have found that these entrepreneurs have three key characteristics, which are under their control and that will most likely allow their venture to attract financing. Successful entrepreneurs:

1. Strengthen business fundamentals early in the commercialization process, thereby significantly increasing value in the enterprise
2. Take time to understand, involve, and build trust with the financial community early in the developmental process
3. Are highly focused on, and driven by market considerations.

Taken together, these three characteristics encourage entrepreneurs to build strong market-driven businesses while developing working relationships with financiers. Though, as we noted in this earlier report (Murphy et al. 2002),[8] many of the things we advocate, improve the chances of success but by no means guarantee it. And it is for this reason that the partnerships with experts who focus on positioning new ventures for success in the marketplace are so important. Obviously, the earlier this inevitable process is started, the better. Building effective relationships is time consuming and essential to building the trust that is needed to enhance their chances of success.

What The Public Sector Can Do

We also know that there are numerous ways that public sector financiers can foster this process of transitioning from public sector to private sector financing – ways that go beyond funding additional technology development. In particular, the public and private sectors can work together in partnership to reduce risks to the investments. This is consistent with the fact that the public sector investment in R&D has long been thought of as helping to reduce the technical risks that the private sector would not otherwise assume. Further, as we will see below, investors have a very strong focus on reducing risk as a way of protecting their investment. Finally, any risk as perceived by the private sector financier, at some level, represents a risk that the R&D investment will lie fallow, even after the sponsored R&D is successfully completed.

[8] In particular in Murphy et al. (2002), we discussed the need for a strong market focus and that such a focus implies the simultaneous evolution, orchestration, and execution of: a well defined and developed market for the product / service; a strong management team; the development and prototype testing of a refined market driven product; and manufacturing and distribution channels.

There is also sound motivation for the public sector to foster these partnerships and engagement with the private sector to help reduce the various risks, especially in cases where the private sector sees the risks as too high for their involvement. This motivation includes improving the rate and number of product market successes based on these technologies. It also includes the need to provide good stewardship for the public sector investments. Moreover the private sector can provide considerable insight that can help the private sector in their technology development. For example, the President and CEO of In-Q-Tel, Louie Gilman (May 2002) recently testified before congress, and noted that "the venture capitalists in the United States are often in the best position to identify those technologies that have the best chance of succeeding in the market place." This is because VC's have a market and customer focus.

While it is well known that the public and private sectors have different values, goals and requirements for success, in fact, public-private partnerships can do a lot to bring the values and needs of the two groups more in line with one another. In particular, public sector sponsors can play a significantly larger role in better aligning the two financing tracks to reduce risks and better enable this transition. Our previous work gives us some indications here as well as does the input from numerous investors at NREL Industry Growth Forums (Murphy 1999), and as do the numerous private conversations with investors of all kinds.

What the public sector can do to abet this process of moving technologies to the private sector includes the following:

- Reduce information gaps between the two sectors, by providing appropriate access to data, knowledge, and insights critical to making sound investments – within the constraints placed on the public sector. Private sector investors crave access to information that will make their investments less risky – information that the public sector often has, or controls access to.
- Mold technical innovators into entrepreneurs by accelerating their focus on business and market issues. In the process these ventures move closer to financing earlier, and they simultaneously are able to leverage additional resources needed for commercialization.
- Use novel public-private co-investment strategies to close funding gaps.

The good news is that the private sector financial community is supportive, and has a strong interest in identifying investment opportunities in sound entrepreneurial clean energy businesses. Also, we believe that the private sector is already demonstrating their receptivity to this, even while acknowledging the difficulties of developing and commercializing clean energy products based on the technologies developed with public sector funds. And they are willing, and even wanting to become involved early in the process in building relationships, as a way of reducing information gaps and asymmetries. Reasons for this interest in clean energy technology and products are numerous, including: the business opportunities being created by utility deregulation, distributed generation trends and the related security issues, environmental imperatives, and volatility in the prices of conventional fuels used by existing technologies.

Next, to provide the appropriate context for a better shared mindset between these two sectors and, and for developing a better understanding of these opportunities by applying the above principles, we address the values, perspectives and requirements that the public and private sector investors each have, especially as these relate to risk. Clearly this understanding will develop only as the two sectors work together more closely and develop the trust that is needed for creating more effective partnerships and co-investment.

II. Transitioning from Public to Private Sector Financing - Looking at, and Unraveling the Financing Issues Using Different Perspectives

Public and Private Sector Values

Public sector energy groups such as DOE and state energy offices have "public good" values and goals that include: energy and public security, improved environmental quality through the use of clean energy, and economic benefits such as jobs, and a correspondingly larger tax base. While the government sector has a perspective of public good that goes well beyond the use of the technology it creates,[9] those public sector agencies that focus on and create technology know that if the public never utilizes that technology, much of the corresponding opportunity for public good is lost. For instance, the DOE as a technology development agency focuses on development of energy technology innovations that can be incorporated in to commercial products and contribute to these long-term public good values and goals. And much progress has been made; e.g. in many cases the cost/performance has been dramatically improved over the last two decades – sometimes by more than an order of magnitude.

Private sector investors, on the other hand must – or they don't stay in business – emphasize return on investments and profits for the companies in which they invest.[10] Private sector profits result from developing effective businesses with market driven products and robust markets, and not just technology – and in-turn they ultimately also contribute to the public good.

Not only can the respective goals of the public and private sectors often seem to be quite different, they are in some ways in opposition, especially in the context of profits and return on investment. Also, unfortunately, a commitment by the public sector to successfully develop technology in no way represents a commitment (or even interest!) on the part of the private sector to develop and commercialize products based on this technology. This is because public good doesn't necessarily translate into opportunities for profits especially in the short-term – thus the need for public sector involvement, including policy development in the early stages of developing technology that meets a public good.

However, these divergent values can actually be quite complementary from a broad and long-term perspective given the U.S. emphasis on free markets. Further, though investors must emphasize return on investment and profits, they frequently have "dual bottom line" perspectives and values that also include "public good."[11] The challenge however is to better align the activities of two investment sectors in a way that fosters the values of each sector, while providing a basis for long-term trust and investment synergisms between the two sectors.

Public Sector Perspectives

After a technology is developed, the public sector normally views its role as largely finished (though there is some variation as to the definition of largely finished across agencies) while industry must assume the role for the development and commercialization of products based on the technology. Moreover, beyond its primary mission of technology development, congressional mandate limits what the public sector can do on its own initiative. For instance the DOE must invest and operate in a way that is consistent with fairness of opportunity with all

[9] The value of knowledge created for the sake of science, or that develops national laboratory capability is often cited.
[10] As Venture capitalists like to say – they are, after all, capitalists!!
[11] The primary bottom line, i.e. return on investment and profits is a must, while the social investment bottom line is often more of a desire than a hard and fast requirement.

the groups that it works with, and it must not compete with the private sector. This also includes limitations in being directly[12] involved in commercialization efforts. NREL as a DOE laboratory has this same focus.

In addition, the public sector must also constantly justify their budgets, to the sponsoring organizations (e.g. Congress) while providing a balanced description of technical achievements, and good public benefits – often in a time frame that is unrealistically short. As a result of the above, there is often pressure to accelerate the hand-off to industry, a process that can be abrupt and often ineffective. This is true even though the DOE/NREL have taken great pains to carry out partnership based collaborative R&D with Clean Energy Industry members – albeit partnerships that traditionally also have a very strong technical focus.

The public sector knows that the strong technology focus and bias in early ventures, though sound and extremely valuable, often results in a naïve understanding of business and markets by the technology creator; and that it is not easily changed. Further, a rigid technology focus and perspective can also keep both resources and attention (Gompers and Lerner 2001) away from the issues that, if addressed effectively, can make the business a success.

For the enterprises in which the public sector is investing, these challenges are daunting. Their efforts require significant financial resources, over an extended period of time during which the cash flow is quite negative (the so called Cash Flow Valley of Death) as described in the cash flow curve in Figure 1, below.[13] But to get these resources, entrepreneurial ventures must be able to assuage the risk perceptions of private sector investors by demonstrating significant progress towards these achievements – a sort of "Catch – 22," if you will.

Private Sector Perspectives

From the perspective of a private investor, public sector financing, including grants and subcontracts, can be a double-edged sword. On the positive side, private sector investors recognize the significant "certification" value for investments that public sector R&D provides. Also, the standards and interconnection work that can lead to greater credibility for the technology and acceptance by customers is seen as quite valuable. Further, the macro level market studies that the federal sector performs and the corresponding insights are often considered quite important. The key to private investors seeing value in public sector investments is their ability to leverage those investments in a manner that complements other investment dollars that move the company down a clear commercialization path (Lerner 1996).

Also, investors view government programs that further commercialization through prototyping a technology with real customers or optimizing the manufacturing process quite positively. The DOE/NREL PVMat Program is an excellent example of such a program. It leverages government support to assist groups of photovoltaic companies tackle critical manufacturing issues. This program is well received by financiers since it provides credibility to the technical adequacy of the technology. It also directly supports commercialization, putting the entrepreneur on the commercialization track.[14] Other activities that are viewed as short-term government "buy downs" of technology that have the intention of building manufacturing experience and bringing down real operational costs can also be viewed as quite positive.

[12] NREL's activities with investors, incubators, and networks of experts are catalyst efforts.
[13] Most often equity financing is needed since cash flow is negative and therefore the ability to service debt financing is quite limited; and available collateral is often not adequate.
[14] Also, very often the improvements in manufacturing go right to the bottom lines in terms of profitability

While private venture capitalists back young firms under conditions of tremendous technological, product-market, and management uncertainty, these investors often see technologies that result from public sector R&D as much less advanced than what public sector sponsors do. And, investment in technology alone, at this stage is just too risky,[15] primarily because the ultimate commercialization of a product based on the technology is often quite remote from the technology creation stage.

Investors have high expectations that entrepreneurs should understand (see sidebar: **Preparing the Company for Eventual Private Venture Financing**). When you add the perspective risk to high expectations the additional challenges become apparent. Moreover, by adding the perspectives on risk (which will be addressed in much more detail below) to the high expectations of investors, the additional challenges become apparent.

The Cash Flow Valley Of Death

Consider an entrepreneurial venture[16] that has negative cash flow, or initial investment needs, but at the later stages generates positive cash flow, or return on the investment. One can look at the nominal net cash flow over time to get insights and understand the difficulties faced by the entrepreneur relative to the timing and magnitude of the needed investment. Also, the possible sources of funding for such ventures, and the issues associated with obtaining that financing can be discussed, along with the need to engineer the interfaces between the

Preparing the Company for Eventual Private Venture Financing

Entrepreneurs are well advised to tailor their companies from inception with venture capital investment in mind. There are several key elements that venture investors look for in the ideal investment. More specifically (in order of importance) these are:

- Management. Personal qualities should include integrity and adherence to a set of concrete, constructive principles. Management should be highly motivated and focused. "Renaissance" individuals who can deploy many skills while remaining creative and flexible are preferred. Successful entrepreneurial experience of the CEO is a major advantage.

- Market. To attract venture capital, the market and growth opportunities should be huge. The larger the investment, the larger the market should be. Venture investors play in a high-risk, high-reward arena, and they generally will only look at an investment opportunity offering potential returns of at least 10 times their initial investment within a three- to five-year period. This target may be relaxed somewhat for later-stage enterprises.

- Technology. The company should have a technology that: is *significantly* better than that of all known competitors; will provide the company with a competitive advantage for at least as long as it will take the company to hit its high-growth period; is proprietary to the company; and that is legally protected, preferably with worldwide patents.

- Liquidity. Venture capitalists and other private financiers must be able to get their money out of a company either in the form of cash or marketable securities. This generally occurs when the company goes public or is acquired. If a company has no likelihood of going public or being acquired for cash or marketable securities, investors will generally not invest in it.

- Company structure. Ideally the investee company should be a corporation rather than a partnership or LLC. There should be one class of stock–common stock–immediately prior to the venture investment. Except in rare circumstances the company should own all the core technology outright rather than being a licensee, even if it is an exclusive licensee.

[15] There are exceptions of course, such as some of the successes that have occurred in Silicon Valley on occasions; but the more likely result is what has happened in the "dot.com" arena in the recent past.
[16] We use the term "venture" broadly to include any kind of entrepreneurial effort, from mere concept to unexecuted business plan to research and development effort to actual business.

various financiers (Appendix A). A pictorial description of this negative cash flow valley of death is shown below in Figure 1, along with the various players and stages of business development.[17] Several trajectories, indicating different levels of success for the venture are also indicated.

To keep the venture solvent, the negative cash flow obviously has to be offset with some form of investment; be it from bootstrapping, debt or equity investment (or combination, thereof). How the entrepreneur will identify and raise the necessary investment is a crucial issue. Further, unlike a project, in which the commitment for funding is obtained up front, the new business venture must obtain the funding in stages from a number of different investors each having their perspectives, values, and requirements.

In the early technology creation phase of clean energy ventures, the public sector (e.g. DOE, states, etc.) often provides a significant portion of the financing needed in combination with the entrepreneurs who frequently contribute a significant amount of bootstrapping,[18] i.e. cost sharing. In the early stages of clean energy technology development, the DOE, in fact does act as the key early stage high-risk investor, and thus its investment contribution is often essential in keeping the clean energy venture in the black.

A Successful Business is Much More Than a Technology

Much more than good technology is needed for attracting investors and success in the market place. This is because technology does not a product, business, market, and wealth make. A technology is not a product – often far from it, and its value is context driven (Boer 1999); the key context is the product, applications, and markets. This is why investors are interested in businesses (not technologies) that are strongly market focused with products that reflect that focus.

If the venture is to evolve into a successful business that will attract the needed investment, it must learn to grow and adapt to market forces. This includes creating market-focused products, which are based on the technology, developing markets and distribution channels as well as manufacturing for the product, and dealing with the competition.

And most importantly it means assembling a strong management team that can align all the pieces of the business, leverage partnerships, raise the needed resources, and successfully navigate all the pitfalls on the way to success. That is why start up experience is important, and why some investors note that they would rather invest in a company with an "A" management team and a "B" technology (Armstrong 2001), but not the other way around.

While technology creation has been the major focus for the public sector investor and for the entrepreneur in the initial stages of the venture, other priorities take center stage as this stage is completed. As one investor has said, "after the technology is created, then the real challenges begin (see side bar: **A Successful Business is Much More Than a Technology**)." Once the technology has been created, the development of products based on the technology, and a business that will take that product to the marketplace becomes the focus. This requires that the entrepreneur shift his or her focus from a technology to a market focus, and he or she must both understand and address the associated financial risks that the private sector investors envisions to get the resources

[17] The concept of the valley of death, from a technology development perspective, has been around for a number of years; see Markham (2002). The cash flow valley of death provides a financial resource perspective and overly that extends this concept.
[18] See for instance, Van Osnabrugge and Robinson (2000, Chapter 2)

needed to address these new priorities. Further, at this stage, the entrepreneur must re-align his or her perspectives and goals with that of the private sector investor.

If these issues are not fully appreciated, then there is a tendency for the venture to develop unevenly with the public sector abetting this process primarily by allowing, or keeping (thus delaying) the entrepreneur from focusing on, and addressing the key business development issues that must be addressed if the venture is to be successful (Murphy 1999).

And by continuing to over emphasize technical issues, the entrepreneur and the early stage public sector sponsors can be easily misled into thinking that the venture is much further along in its development and more ready for public sector financing than it really is. This is because technical progress that is not guided by insights from the market/customer perspective may ultimately not be productive from a business perspective. We will discuss these issues in much greater depth below.

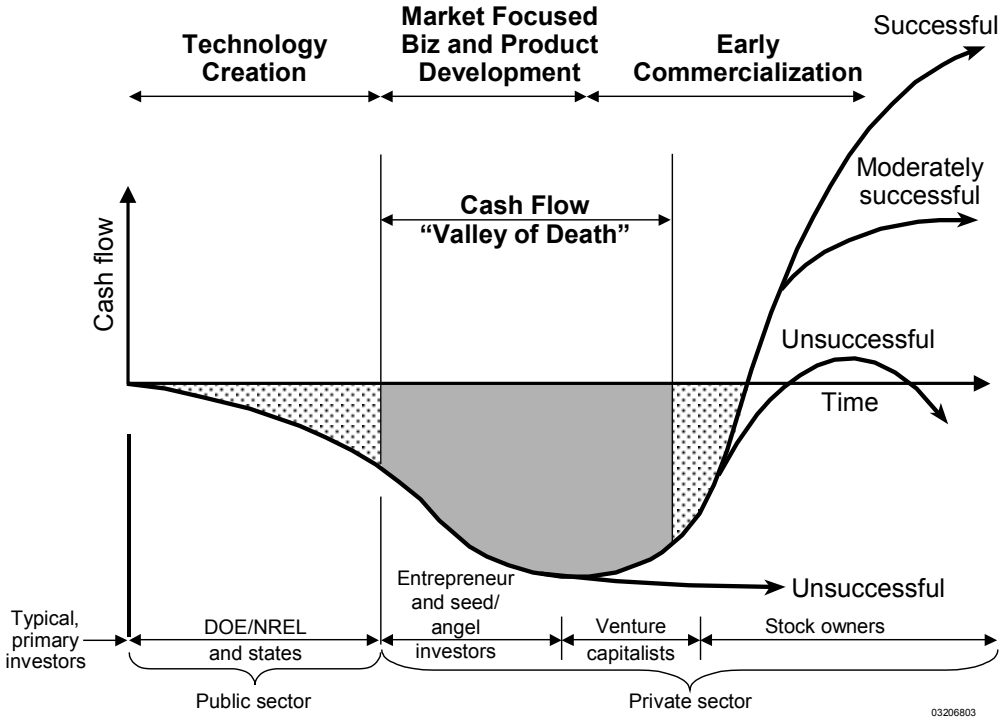

Figure 1. The Cash Flow Valley of Death as a function of development stage (Time), with typical investors shown for the various stages.

In addition, this transition to private sector financing is made difficult since the availability of public sector funds decreases abruptly after the technology is created.[19] This, as noted above, is because the public sector views subsequent investment and further progress towards commercialization as the purview of the private sector. This drop off of public investment occurs

[19] This is not to say that no public sector funds are available, as a number of excellent programs such as DOE's PVMAT, do extend technology development into this area, but in reality the relative amount of funding available compared to that needed is quite low for the majority of clean energy technologies.

at the same time that the investment needs of the venture are actually growing. Also, since bootstrapping is often not feasible when large cash needs are considered for many clean energy ventures, there is also limited ability to service debt financing. Hence, the entrepreneurial venture must often turn to equity financing for at least part of the resources needed.

Venture capitalists typically want to finance the venture much later when solid initial sales have been established – just before the sharp upturn in cash flow that is associated with rapid market acceptance, adoption, and sales occur as shown in Figure 1: when more robust, large scale markets can be more reasonably assured; and when the risks are much lower. Further, though angel and seed investors may be available as a precursor to venture capital, this is often not adequate for high technology investments (Gompers and Lerner 2001). We thus call the region in Figure 1, between where public sector funding drops off, and when there starts to be strong interest by the private venture capital sector, the cash flow valley of death – the stage where the entrepreneur's business development needs are the greatest and where he or she is least able to access the resources to meet those needs.

We believe that successfully addressing the risks as perceived by potential investors is a key element in resolving this dilemma, as will be discussed next.

Understanding Private Sector Risk Perspectives in the "Valley"

To understand the private sector risk, one must address the traits of energy technology investments that make them more challenging compared to many other technologies: why are energy investment needs are so large; what are the key characteristics of cash flow needs. The amount of financing needed and the risks are relatively high for energy investments. For instance, the amount of money needed and the time to recover those resources (the exit), are especially large relative to some other technical investments such as for software.[20] This is because of:

- The need to transform the technology into market driven, market ready products, and "whole product" solutions (often requiring significant time and money),[21]
- The need to develop multiple costly prototypes for initial markets
- The high cost of manufacturing, longer time frames (there are many more possibilities for things to go amiss, e.g. strategic partnerships do not materialize as planned) thus causing the business to be less than fully successful

Secondly, the need to develop and create markets must also be successfully addressed, and this also often requires significant resources and time as well. Adding to this challenge is the fact that, energy is often sold as a commodity with lower margins, and sometimes higher volatility making the investment that much more risky and difficult to obtain.

Thirdly, and very importantly, at the very early stages the venture most often does not have the appropriate management team in place to successfully position and guide the venture into a commercial success. Thus all the above requires the dedicated attention of investors to mitigate these risks – which may not be reasonable given other more lucrative opportunities that they may have.

[20] To put this in perspective consider that for many software concepts, $1M can often take an entrepreneur a long way towards commercialization, but with energy investments an investment of one-to-two orders of magnitude or more can often be required.
[21] See Moore (1995), Inside the Tornado.

Defining and Categorizing Risks

As a preface to our discussion of risks, we should note that we have taken a qualitative approach, for a number of reasons. First, a full description of risks and analysis of those risks is beyond the scope of this report. Second, for many of the risks that we discuss, a tractable analytical approach is not available, and even in cases where such approaches are available, adequate data/information to use those tools is often not available. That said, by better understanding the nature of these risks, there is much one can do to position public sector investments such that the private sector is much more inclined to pick up their option to invest in the corresponding entrepreneurial ventures.

While the public sector as noted above (and in particular the DOE/NREL and the states), do a great deal to mitigate technical risks, many other types of risks exist. And private sector investors must identify, focus on, and mitigate these other risks to protect their investments and therefore profits; hence their emphasis on understanding and addressing risks.

Gompers and Lerner (2001)[22] discuss four basic risks that pose some serious concerns for potential venture capital investors, and limit financiers' willingness to invest capital. In addition, in cases where the public sector is a major investor player, we believe that there is a fifth area of risk (i.e. what we call technology push) in which the public sector can, and often does, play a particularly significant role.

These five areas of risk are:

- **Information Asymmetries/Gaps** – that result from the fact that an entrepreneur, and or the public sector investors can often know more about his company's prospects (especially about the technology and its "warts") than investors, suppliers, or strategic partners. Without the ability to screen out unacceptable projects and entrepreneurs, investors are unable to make appropriate decisions regarding where and when to invest. Information gaps may also lead to problems after the investment is made. Relative to the discussion in this paper, investors also have many questions relating to the public sector investment decisions and choices. For instance investors worry that relevant test results, that call into question the readiness of the technology may not be fully available. Access to the relevant information, within the bounds of public sector confidentiality, and other related requirements is quite important to private sector investors.
- **Technology Push** – Investors become concerned if the public sector efforts tend to focus, or push technology development and capability without sufficient regard for market realities such as market size, customer benefits and the profitability needed for commercially successful products. For instance, a focus on the very best performance can be counter productive if it is done at the expense of addressing scale up and manufacturing cost issues. Also, of particular relevance here are cases where demonstrations of the technology are scaled up too rapidly, when the relative level of technical maturity is low (e.g. possibly to indicate large energy displacement capability). Further, if the public sector technology investments are overly constrained to markets and applications, that may well be appropriate for the long term, but which may not be best for market entry or beachhead development, this will limit, or at least delay private sector investment interest.

[22] See chapter 2. in particular.

- **Uncertainty About the Future** – a measure of the array of potential outcomes for a company or project. The wider the dispersion of potential outcomes, the greater the uncertainty. Uncertainty surrounds the question of whether the research program or new product will succeed. Also, the response of a firm's rivals may also be uncertain. Of particular relevance to the discussion below are uncertainties about technical risks (will the technology work in the intended applications?), markets, and value of specific commercial applications. Also questions regarding what is being developed secretly (privately unbeknownst to the entrepreneur) are of particular importance, as are questions relating to underlying assumptions that have not yet been evaluated critically (e.g. ….. is market growth driven strictly by cost reduction or is reliability an equally, or more important issue?).
- **Market Condition Volatility** – including both the financial and product markets, which may be subject to substantial variations. This volatility can make the supply of capital from public investors and the price at which this capital is available dramatically variable. If there is exceedingly intense competition or a great deal of uncertainty about the size of the potential market, firms may find it very difficult to raise capital from traditional sources. An example of particular interest is whether tax credits that the venture is using to justify market share and/or valuation will expire or be repealed and leave the investor holding the bag.
- **"Soft" Assets** – such as trade secrets, patents, and key human resources. Having all the crucial expertise in one or two persons can be a concern to investors, for example. Even though these assets are key elements of any successful business, it is much more difficult for an investor to accurately estimate the value of soft assets, than hard assets, such as machines, buildings, or land. Therefore, raising outside financing from traditional sources may be more challenging.

We provide a good number of additional examples of potential risks corresponding to each of these categories in Appendix B, where the public sector can have a significant impact.

Controlling Risk

Private sector investors use a number of tools to assess, share, and control these risks. Moreover, rather than trying to eradicate all the risks and uncertainty in advance, investors generally remain actively involved after each investment stage; e.g. they incrementally finance the venture based on the attainment of milestones as described below. These various tools, which are often interrelated and also cut across multiple risk areas, are described briefly below.

- **Due Diligence.** This is an ongoing process of evaluation and assessment that includes investigation into all aspects of the business, including management, and business development progress. It also includes across-the-board monitoring of all the five basic risk areas defined above. This process is the way the quality of the investment is initially assessed, and over the long-term it is a sort of early warning system for emerging problems with the venture.
- **Syndication of Deals.** The sharing of deals with other investors helps to address a wide range of risks, including overall financial risk and competition. This is accomplished by increasing the expert talent base, insights and perspectives focused on the deal. Shared due diligence among the participants, though the lead investor often does the most, is also a benefit of syndication.
- **Portfolios of Related investments.** Investors use an analog to portfolio theory for securities to offset risks; e.g. they look for investments that are complimentary in that if

one investment fails, then another may succeed, thus providing robustness to the total portfolio. In practice, this can be difficult to do effectively with energy investments.

- **Incremental funding.** Investors typically provide staged funding based on successfully meeting agreed-to business, as well as technical and budget milestones, and providing planned/promised deliverables; the business milestones would include those related to market development, and productization of the technology. This very powerful tool allows more effective control of the development process for the venture, and forces periodic formal evaluation and progress assessments. This also creates options. An investment at one stage is really paying for the option to make further investments at the next stage, after more information is obtained.
- **Active Involvement and Mentoring.** It is not only the monetary value that the investor brings to the partnership, but his or her mentoring and business expertise that also bring value to the partnership. Moreover, the contacts and linkages with a wide range of financial and other experts that these investors can provide can also be quite important.
- **Special Covenants and Restrictions.** Investors use their contractually specified control rights to guide, and at times, provide shared leadership for the firm in response to changes in product-market strategy, the management team, and so forth – changes that arise naturally during the investment process. Rounding out the management team is an area where these covenants are frequently invoked. Venture Capitalists frequently put people on the board of directors and may even have one of the Venture Capitalist firm's principal's serve on the senior management team.

Finally, to compensate for the inherent risks and uncertainties still remaining, these investors typically discount the value of the business in their funding decision as depicted in Figure 2 below,[23] where the cash flow curve of Figure 1 along with the development stage, is also shown for comparative purposes; curve amplitudes are normalized. While Brealy et al. (1999), and Willinge (2002) caution that one should not build macro market risk and other "fudge factors" into the discount rate, the inherently large number of uncertainties for early stage investments requires a large amount of judgment on the investor's part in this area.

Thus, by considering the effects of aggressively discounting the deal (e.g. at levels above 0.8 in the technology creation stage, down to 0.25 in the early commercialization stage) it is easily seen why the entrepreneur will receive what she perceives to be a prohibitively low evaluation from many investors, particularly in the early stages of the business formation process. However, this high level of discounting should be put in perspective with the fact that, according to Zieder (1998), although venture capitalists are well compensated, on average, for the industry as a whole, nearly 60% of their deals are financially unproductive.

[23] The discount curve in Figure 2, is an adaptation of (Appendix B), in Murphy et al. (2002) where discounts of more than 80%, for pre-seed (technology creation stage in Figure 1 above) investments are cited. Moreover, Willange (2002) notes that discount rates of 40-70% are frequently used by Venture Capital investors; Gompers (January 1999) cites corresponding values for the discount rate in the 50-100% range. See also Appendix C of this report.

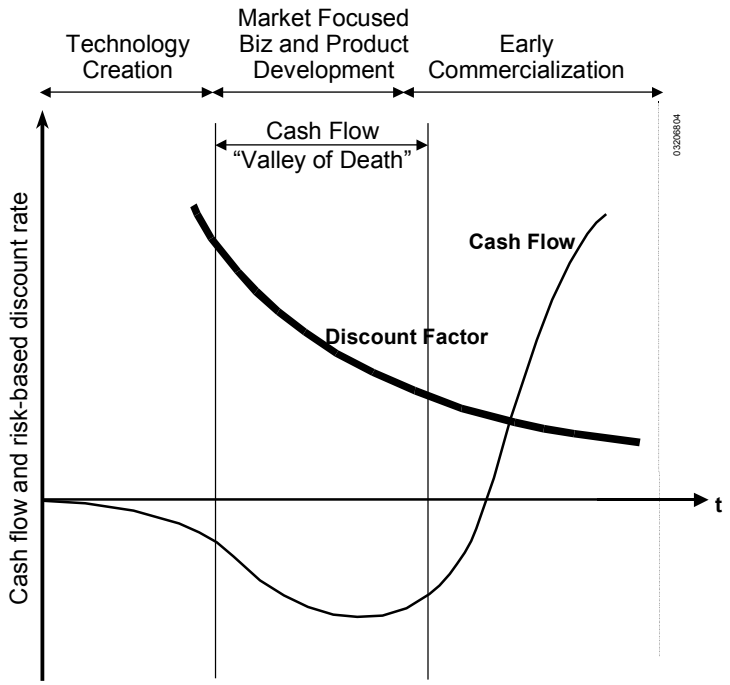

Figure 2. Typical risk adjusted discount rates that would be required by investment bankers as a function of business development stage. Cash flow shown for comparative purposes.

Market Creation Imperatives and The Perception of Risk

The existence of robust markets can also significantly mitigate risks in the eyes of the investors because strong markets can serve to compensate for some other weaknesses in the business. The opposite is true as well, and in the absence of credible strong markets with very good margins, many venture capitalists and investment bankers will simply not invest. For this reason, they often won't invest in ventures that are focused on commodity markets (and energy is one of the largest commodity markets that there is). Morover, putting money at risk requires a significant incentive beyond cost competitiveness for most professional investors. Thus, while a new product that provides a 15-25% savings in an existing market application will be of little interest to venture investors (the added risks of bringing these new products to market aren't worth it),[24] they do look for dramatic cost improvements or significant new capabilities that can justify premium prices.

As noted above, investors often want to see initial sales along with additional proof of strong potential markets, and the ability to deal with the competition, before they put money at risk. The problem for many clean energy technologies is that after the technology creation phase, highly attractive markets are frequently not obvious or simply don't exist – yet. Hence, the real size of the potential market is difficult to capture with any real credibility in the early biz development stages. Thus, early on, the market development strategy must often by necessity

[24] It obviously can be a good investment, say for a product improvement by a company already in the business, especially if they have established markets and methods to reach those markets.

be focused on market creation or establishing new market channels rather than on selling into existing markets – a difficult, costly, but potentially highly rewarding process.

This is particularly true for many clean energy technologies since they provide a new solution approach to a particular set of business/customer problems, where direct substitution for the existing solution may not really capture the true value of the technology product in the marketplace. For instance, many renewable technologies are particularly well suited for distributed electricity, applications where their value can be significantly higher than if they were used in a bulk central station electricity generation applications (commodity markets). Such technologies are termed disruptive technologies (Christensen 1997). However, it is not the disruptive nature of these technologies that will make them attractive to private sector investors; rather it is their latent "stealth" nature, which provides the potential for innovative (and ultimately highly profitable) solutions to specific business and other problems that makes them attractive investment opportunities.

Creating markets for such disruptive technologies, has been discussed extensively by Moore (1995, 1999), who details the difficulties of market creation and challenges in bringing new and disruptive high technology products to the marketplace. Figure 3 illustrates Moore's (1995) technology adoption life cycle, or sales, as a function of time and business development stage, where at the market creation stage there is no actual market yet, and no adoption – though hopefully there exists early application and market entry strategies. Curves amplitudes are normalized for comparative purposes. Figure 3, also qualtitatively illustrates the concurrence of the rapid upswing in the cashflow curve, with the growing adoption of the technology, and hence market penetration. Moore discusses the diffent stages in the technology adoption cycle, and the need to tailor the efforts to address the stages differently. Each market development stage presents different tactical, strategic and resource challenges.

For instance in the innovators stage, the challenge is to take the technology that has been created and embody it into a problem solving tool for business and to make it work. The early adoption stage focuses on developing total solutions for, and strong working interfaces with a limited number of selected users and getting those folks to provide credibility, thus leading to a successful crossing of Moore's "chasm" and establishing a strong beachhead in the targeted initial market. It is also important to note that at the market entry stage where the strategy to establish a beachhead, in a way that will allow other markets to be rapidly exploited later is key; thus the successful entrepreneur may initially want or need to attack a market segment that is significantly different from the ultimate end target market (e.g. such as those that the public sector investors are most interested in).

Those investors that are willing to become involved this early, where risks are still relatively quite high, typically want to have a role in developing these market entry and beachhead strategies. Constraints on this flexibility increases risk to these investors. Moreover the broad macro market intelligence that the public sector can provide can be quite valuable to the private sector as they work with the entrepreneur in developing beachheads, while helping them to position themselves for longer term strategies and profits.

The early majority stage (Moore 1999) changes the "close to the customer" focus to one that is directed at saturating the beachhead markets with product as quickly as possible. And in the final stage of significant interest (late majority), customer focus again becomes important. Finally, Figure 3 also indicates that timing is also crucial. If you are selling into existing markets, this situation depicted in Figure 3 may be satisfactory – but if you need to create these markets,

then you've probably got to start the market creation and development much earlier (shift the market development curve to the left) if you want to enhance your chances for success.

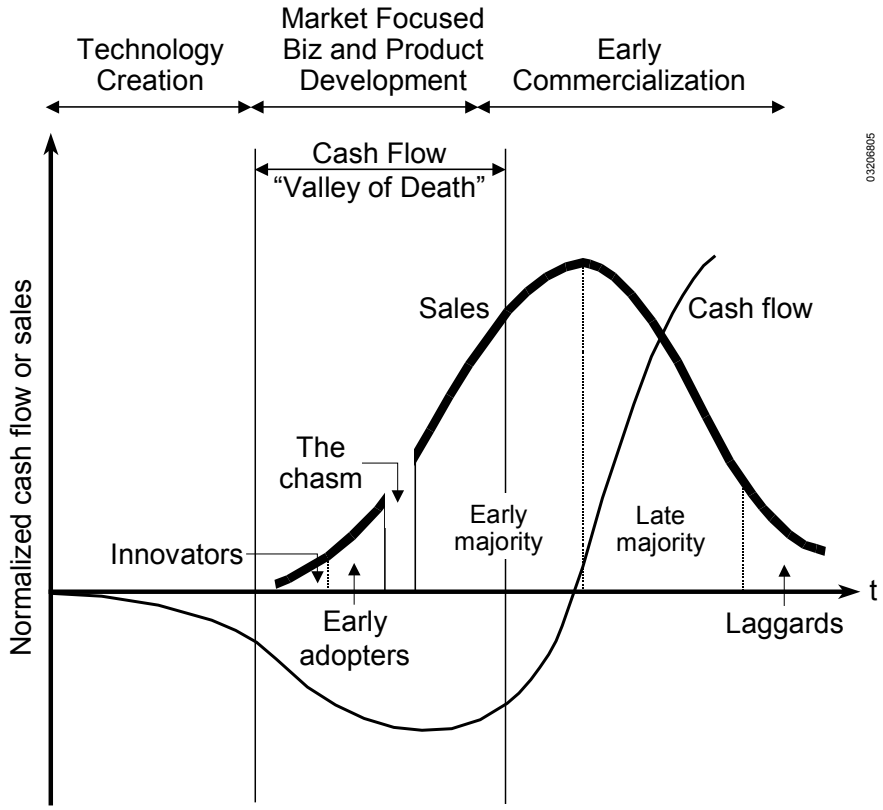

Figure 3. Market development and creation as described by Moore (1995 and 1999) as a function of business devlopment stage. Cash flow shown for comparative purposes.

Reducing Risk and Shrinking the "Valley" – Initial DOE/NREL Efforts in this Area

A number of approaches can be used to reduce the risks to private sector investors while shortening the time span, as well as the depth of the "valley." This is illustrated schematically in Figure 4 below. Essentially, that which allows more effective leverage of other resources, and reduces the time frame to success will help reduce risks and help decrease the amount of direct investment needed.

For instance, NREL's Enterprise Development Programs were designed with this in mind. These are partnership building, or catalyst activities that leverage other expertise and other resources at minimal cost to the entrepreneur, while speeding up the the commercialization process and simultaneously reducing risk to further investment. The four key elements of this program are:

1. **NREL Industry Growth "Venture" Forums** – These forums are similar to a venture capital forum and provide clean energy entrepreneurs an opportunity to present their business cases to an expert panel of investors and energy executives. This is a competitive process.
2. **The National Alliance of Clean Energy Business Incubators** – This is an alliance of the nations top incubators committed to incubating and providing business services to clean energy entrepreneurs.
3. **The Clean Energy Network & Investor Directory** – Contains contact and profile information for more than 90 investors that are currently interested in quality clean energy investments, and in assisting the clean energy entrepreneur to become a market success.
4. **NREL Growth Link** – Growth Link is a web-based directory of profiled clean energy companies seeking financing, partnering, and growth opportunities. Investors and energy firms can use the directory to find clean energy technologies that match their investment and strategic interests.

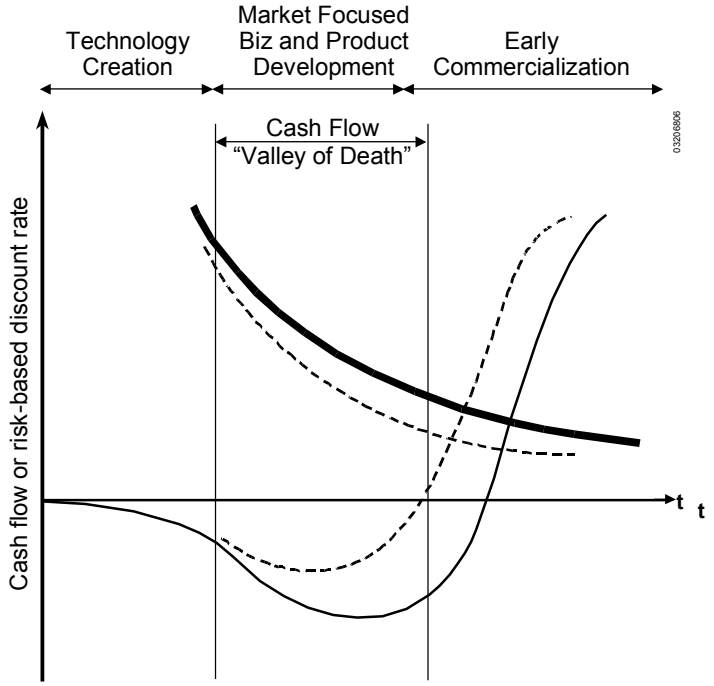

Figure 4. Reducing Risk, e.g. through earlier involvement with private sector investors, market creation and other mechanisms, can serve to decrease the time to market and the size of the cash flow valley.

These are only the first steps, and there are many other opportunities for the public sector to work in partnership with private sector investors to collaboratively reduce risks and decrease the magnitude of the depth in the valley and thus making these public sector investments more attractive to private sector investors. We explore these other opportunities next.

III. Building a Bridge Between Public and Private Sector Financiers

We take it as a given there is no public interest in funding inferior technologies and the associated enterprises. We also assume that the public sector's objective is to partner with, and entice the private sector investment community to exercise their option to build on, and further invest in, clean energy technology based ventures. Then it is reasonable for the public and private sectors to view each other as partners in this investment process. In this spirit of partnership, there are opportunities for the two sectors to work together more effectively from an investment perspective in a way that does not violate the special public-sector requirements, and which benefits both sectors commensurately.

Regarding public sector requirements, two "concerns" that frequently arise are:

1. That the public sector should not pick winners and losers.
2. It should not foster corporate welfare.

Ironically, working more closely with the private sector can actually negate both of these concerns. By working with the private investment sector, they – not the public sector – will provide guidance and insights on markets; and earlier private-sector investment is the antithesis of corporate welfare.

Even within the constraints experienced by public-sector organizations and program managers, discretion can be applied regarding how they manage and administer programs within their purview. These organizations can assist entrepreneurs by encouraging and fostering savvy business behaviors and characteristics in companies that they fund. Below are some suggestions on how the public and private sectors can collaborate to help entrepreneurial companies with mature technologies more effectively move out of the government sphere and into the realm of private financing.

A key to effective partnership between the public- and private-sector investment communities is the willingness of the public sector to understand and address the risk perspectives of the private sector financial community – especially the venture capital community – as described above. The public sector can obviously play a role in reducing uncertainty; but the areas where we feel that collaboration can most enhance these partnerships are those related to information gaps and information access, as well as risk reduction by developing an earlier and more effective market focus. We emphasize technology push, and market volatility risks in the discussion on market focus. These risk reduction opportunities are discussed next.

Reducing Uncertainty

The public sector has been – and continues to be – a good, early-stage, high-risk investment partner, addressing the many risks associated with technical uncertainties. Thus, a strategy of continued investment in R&D that is focused on reducing technical uncertainty risk is appropriate and represents good stewardship of public sector funds and a solid business approach – especially if the R&D is on the critical path leading to successful commercialization. Beyond supporting early stage R&D to get new technology innovations into the development pipeline, it is very important to continue supporting R&D for its "certification" value, as well as to continue the standards and interconnection work that can lead to greater credibility for the technology, as well as acceptance by customers.

The public sector can further contribute to reducing uncertainty through ongoing due diligence in both technical ***and*** non-technical areas. This also applies to the companies in which they invest and which are likely to produce commercial products. Taking a page from the private sector, the public sector can stage their investment and make funding contingent on progress toward goals and milestones that address the viability of the business. Rather than the public sector paying for attaining these business and market development milestones (which is illegal[25]), these milestones can be viewed as one of the evaluation criterion for attaining the next subcontract – just as a business plan is often required now.

The difference is that the investment community and the incubator community can, in collaboration with the public sector, be the arbitrators of what is a good/acceptable business plan, and progress along the commercialization path, rather than making this the responsibility of the public sector technologists and R&D managers. For example, other milestones might be tied to successfully receiving an invitation to present at the NREL Industry Growth Forums, being accepted in one of the Alliance Incubators, obtaining a substantial licensing agreement, or receiving venture financing. Receiving other public sector financing would not necessarily qualify, unless it is shown to be directly on the commercialization path.

Reducing Information Gaps – And Providing Access to the Needed Information

This is an area to which the private sector can significantly contribute and help reduce risks. Information access can build trust, help the public sector's R&D partners with the most mature technology, and more effectively position their enterprises to make the leap to private sector funding.

Care must be taken initially, especially since government investors must abide by a host of requirements such as those related to confidentiality. However, it is very important to have venues where public and private sectors can interact early on in the process and build effective working relationships, and trust and confidence in each other. It is also important that the public sector assure that interactions are constructive. This is especially critical early in the process, when the preliminary R&D results of a novel technology may not provide a clear picture of the technology's value.

One of the best ways for public sector technology sponsors to reduce information gaps and to help entrepreneurs in whom they invest, prepare for a transition to private sector financing is to familiarize and involve themselves with the financial community, particularly energy technology investors. This includes:

- Discovering whom the main financial players are in their technology area and begin a dialogue with them. A good way to start finding them is through the Clean Energy Investor Directory http://www.nrel.gov/technologytransfer/entrepreneurs/directory.html.
- Inviting active financiers to attend key program planning, road mapping and stakeholder meetings to provide insights, input and ideas. Their input can help align program R&D goals with market imperatives. The more familiar a financier feels with the technology the more likely they are to have a level of comfort with investing in the technology, if not now, then down the road. They will also have the opportunity to build relationships with key technologists as well.

[25] The private sector does pay for, and require them.

- Attending energy-focused venture forums, such as the NREL Industry Growth Forums, to gain a better understanding of the financing process and what venture capitalists are looking for in an investment opportunity.
- Encouraging and helping their industry R&D partners to participate in, and take advantage of these, and other venues that foster interaction with the financial community.

  In addition, to help in this process, there is a plethora of free and inexpensive services offered by local and state economic development agencies, the small business administration, local colleges, and entrepreneurial organizations. And the National Alliance of Clean Energy Business Incubators can provide valuable business development and mentoring services to fledgling companies. Also, with the growth of the Internet, hundreds of sites have been developed that provide assistance on human resource issues, operations, business plan development, etc.

While the public sector, of course, cannot make broad commercial endorsements of the products or technologies of private companies, it can assist members of the investment community in reaching their own conclusions. This can be accomplished by offering technical advice and assistance within the bounds of appropriate confidentiality requirements as well. In addition, as public sectors work more with private sector investors they become more able to translate their insights into other areas, such as policy development. More specifically the public sector can also reduce information asymmetries by:

- Providing private sector investors with technical advice and assistance, and information such as published macro level market and technical data of a nonproprietary nature.
- Establishing appropriate procedures for early access to public sector technology programs and program managers along with related data and insights, within the constraints placed on the public sector.
- Fostering insightful dialogue with the financial industry about policy development can help assure that new policies supporting the development and utilization of clean energy technologies have the intended consequences, such as reducing both real and perceived investment risk by the private sector. For instance, tax credits that can quickly expire can actually be a negative from an equity investment risk perspective (while at the same time may be viewed as a positive from a project finance perspective). Also, issues surrounding deregulation are extremely important – and what looks attractive from the short-term perspective may not serve the clean energy industry over the long-term.

By taking the perspective as co-investors, the two sectors can move to optimize the use of both sectors' resources. The earlier and more efficiently the system can winnow out companies that do not merit financing, the more capital will be available to the meritorious ventures.

Moreover, the public sector can benefit from the corresponding insights of investors, by seeing how to more effectively help move these entrepreneurial ventures towards a market focus and earlier commercialization. This issue is discussed next.

Accelerating the Shift From a Technology, To a Market Focus

Markets are what the investor cares about most; and this is an area where inclusions of insights from the private investment sector can be of the most benefit. In fact strong markets and the ability to address these markets will often be an advantage that can compensate for other weaknesses in the business; e.g. a very large market can in some cases make up other

uncertainties such as how much of the market is addressable by the venture. Hence for ventures in which public sector investments have been made, an environment for assisting these ventures in making the transition from a technology to a market focus can pay big dividends.

Further, we believe that having a market focus is probably the most important characteristic of a successful entrepreneurial venture since such a focus will implicitly drive the business to do all the other right things – like assembling a full capability management team, and developing a sound approach to market creation. In fact, the need to foster this market focus was one of the primary reasons that the National Alliance of Clean Energy Business Incubators was created. Quality incubators will not only drive the business evolution in this direction, they can also leverage many other resources in helping to launch these ventures.

In thinking about developing a stronger market focus it is good to consider the alternative as expressed by Gompers and Lerner (2001, p178) where they note that…"the investment portfolios of many public venture capital programs today contain far too many underachieving firms. How can these managers learn to reduce risk? By conducting due diligence effectively. One red flag is a company that has received numerous research grants from different government sources but has few, if any, tangible results to show for these R&D dollars.[26] By attributing their lack of results to the high-risk nature of technology development, these firms can avoid accountability indefinitely. Indeed, government-backed research organizations often drift from one federal contract to the next, feeling little motivation to satisfy the program's objectives or to generate respectable returns."

We suggest the following considerations to enhance early market awareness:

- We think that early involvement with the private sector investors will not only help to lessen information asymmetries between the two sectors as noted above, but such early interactions can also help focus attention on customers and markets. These early market discussions can have a potentially large impact on entry and beachhead markets. They can also help bring the insights of the two sectors together on other market related issues, such as the:
    - whole value chain
    - broader utility of the technology
    - competitive advantages of the technologies,
    - insights on the needed parallel infrastructure technology, and
    - product development efforts for successful commercialization.

  Moreover, this early involvement should be accompanied with inputs from potential technology users, and product customers.

- In the rush to perfect an exciting technology, encouraging the entrepreneur to keep his or her sights on market trends and developments can be quite helpful. If the firm fails to make it to the marketplace, all the careful research and technology development will be of limited value. This problem will be greatly alleviated if the entrepreneur is strongly encouraged to follow a parallel path of technology development and business development, which includes congruent sets of milestones for both paths. The parallel path is especially important since

[26] Another red flag is that the venture, even after several R&D funding contracts does not have a credible business plan and value proposition, including a realistic market strategy and development approach that can withstand even rudimentary scrutiny by the financial community.

addressing market driven product engineering issues and forces and the required technology iterations in a serial fashion can seriously delay product launch which a new venture can ill afford.

This can be abetted by encouraging young companies to seek business advice on market development and marketing from business incubators, energy focused venture firms, major users, and other reputable sources. These sources can also be used to develop and help evaluate progress towards market driven milestones. It is also important to recognize that public sector cost share requirements can inhibit progress in this direction – this is discussed in more detail below.

Also, prior to making future subsequent government awards, one evaluation consideration might be related to progress along a set of technology and business milestones. The milestones might be established in concert with the financial community, and progress might be measured by acceptance into a good incubator, and/or the evaluation of business plans by Alliance incubators.

- Entrepreneurs need to respond to market opportunities in a timely fashion. Program managers are often inhibited by legislative mandates, but to the extent possible; if entrepreneurs have the freedom and flexibility to move in the direction of best market opportunities, especially if working with private sector financiers, this will improve their chances of success. It is equally as important to not drive the technology down a market path that is inconsistent with the market entry needs that the entrepreneur must define and focus on, again early and frequent involvement with public sector investment community is helpful here.

  The entire entrepreneurial process is fraught with unpredictability. Very few entrepreneurs, whether in high- or low-tech settings, commercialize a new product or service in the time frame they originally imagined. Rather, successful entrepreneurs gather signals from the marketplace in response to their initial efforts, and then adjust their plans accordingly. Once they identify an opportunity, they must be able to move quickly to take advantage of it before major corporations can beat them to it.

- Platform technologies that will allow for dual applications and products to be derived from the technology can increase the value of the technologies and reduce the risk to the private sector considerably. This not only provides for additional market avenues and channels, it can lead to synergisms and leverage in the development process from other development efforts not funded by the energy-focused public financing. Interestingly enough, the Department of Defense (DOD), and the Defense Advanced Research Projects Agency (DARPA) have been encouraging this “dual use” approach to lower their development costs of defense-related technologies by leveraging commercial investments in closely related technologies – and the private sector seems to be benefiting commensurately along with the defense agencies.[27]

- Due diligence to determine the seriousness of commitment of the R&D partner in commercialization can pay big dividends. From the public investment perspective, this due diligence is also quite important even if the venture is within a large corporation. For example, just because a private sector company is committed to the R&D being sponsored

[27] For instance we frequently see the best licensing opportunities at NREL for technologies in non-energy applications, but that were originally developed for energy applications.

by the public sector, this may not necessarily represent a strong commitment, or even significant interest by corporate management to develop and commercialize products based on the technology. In determining how committed, and well positioned a company is for developing a successful commercial venture, an important consideration is that the company needs to have all the key pieces of the business aligned, and commitment from the senior management (whether the company is small or large) if they are truly serious about commercializing products based on the technology.

- When administering technology development programs, a broad look at the needs of the entrepreneurial company, including funding requirements is warranted, especially in light of the need for the enterprise to develop evenly in both the technical and business dimensions. In particular, to the extent possible it is important to assure that technology focused funding requirements, such as cost sharing, do not unintentionally hinder or detract from business development. Each business must pursue business development activities such as developing markets and distribution channels in addition to technology focused R&D. Thus, to the extent possible and within the appropriate legal constraints,[28] not requiring all cost shared monies be focused on technology issues can pay big dividends. And finally, realize that *"funding for technology development alone* will not properly prepare a company to qualify for even seed funding unless key business development gaps have been addressed. It is very important for these small entrepreneurial companies to have a well-articulated pathway to commercial success.

- Efforts that foster and/or enable the adoption of the technology are helpful and much needed. For example the standards, interconnection, and technology certification work that the public sector carries out provides a great deal of credibility for the technology and can be essential to gaining acceptance by users of the technology. Thus, this is a big help in reducing the product risk, and acceptance for the technology, and it is also generally helpful to the creation of a wide number of infrastructure technologies and related businesses – thus adding robustness to the whole clean energy industry.

[28] Gompers and Lerner (2001, p177-180) discuss the challenges faced by public sector financiers in this area. An example in the context of the ATP/Commerce program is discussed extensively.

IV. Bridging the Remaining Financing Gaps

We believe by taking advantage of the opportunities outlined above, a good deal more alignment between the public and private sectors than currently exists will result, as will a significant reduction in many risks. However, a potentially big financing void still exists for entrepreneurial ventures in energy technology. As explained above, this is because private sector venture money is typically focused on enterprises that are at a later stage than is normally seen with ventures for which their public sector financing (e.g. from DOE/NREL) is just coming to an end. Moreover, the relatively large sums of money needed for many energy ventures are also beyond the scope of what angel investors can, or are willing to fund (Gompers and Lerner, 2001).

We expect these financing gaps to continue and even grow – as will the opportunities – because the energy industry is large and complex, and there are many different types of products available. Experts anticipate that literally thousands of new infrastructure products will accompany the large-scale use of distributed, clean energy technologies.[29] While many of these products had their genesis in DOE-funded projects and other public efforts, each of these products will require funding in order to move successfully from conception to commercial reality.

To assist in the efficient allocation of our nation's capital resources to clean energy, DOE and the other public players would be well served to have an expanded set of venues in which to reach out to the broader entrepreneurial and investment communities. This will allow the DOE to impact, influence, and support a large cross section of clean energy technology at modest cost. Ideally, we envision this venue consisting of a coordinated and well-publicized series of seminars, forums and conferences that attract a wider range of participants from the entrepreneurial, investment, and technical communities than has been done up to now. We discuss specific funding gaps next.

Where the Financing Gaps Are

Following are common financing gap scenarios in our experience. In each scenario we may assume certain underlying facts. A clean energy R&D project has been funded by the public sector on a lean budget, and the principal researchers on the project wish to commercialize the technology. They have compiled a reasonably sound business case. Private financiers (e.g., venture capitalists) have expressed strong interest but require that risk be substantially reduced (i.e., that the venture be farther along the commercialization path) before they will investigate the opportunity seriously. Numerous ventures fail or are delayed every year in each of the scenarios below. They are listed in the order in which they would typically occur and therefore are in *decreasing* order of difficulty for the funding effort.

- Proof-of-concept. The venturers have developed technology, which exists only on paper or on a small scale. They require funding and facilities to demonstrate the technical soundness of their theories, so they can proceed to the next step on the path to profitability and getting private sector financing.

- Prototype product development. The venturers are ready to build a prototype product embodying the technology, which requires a large infusion of cash. This is an especially

[29] One can look back at the telecommunications industry in 1984 just after deregulation, and recall that there was little understanding of the thousands of products, and application variations that were enabled at that time.

common scenario in the energy field, where products and technologies are particularly capital intensive. Very likely the development of the market and business fundamentals have not progressed apace with the technology development. There is an urgent need to construct several prototypes and place them in market settings to address product risk concerns, and customer acceptance, before finalizing the design of the commercial product.

- Pilot, and firsts plant project financing. The venturers are ready to build a first-of-its-kind pilot plant for promising renewable technologies. They hope to refine their designs and move closer to proving commercial feasibility and profitability. A very large amount of financing is needed. For example a PV plant or a bio-fuels processing plant might represent such an investment opportunity. This is different from a project for a relatively early operational plant that may not yet be of optimal size, but where the revenue generated (e.g. from commodities such as electricity or ethanol) to offset the debt portion of the project, [30] is considered to be low risk.

- Commercial product development and demonstrations. The venturers have completed the above steps and are ready to finalize the commercial product designs. Typically designing a product so that it can be manufactured profitably and in quantity is costly and time-consuming. It is often a collaborative process between the product engineers and the manufacturing engineers. Though some investors will invest at this stage of product development if the efforts described above (e.g. prototypes, pilots) have been successful and there appears to be customer demand for the manufactured product, many will not.

- Market creation and development. Frequently a new product is not readily accepted because the target customers are reluctant to change. This is especially true for large capital items, which may comprise a large portion of future clean energy products. Often the venturers require financing simply for staying power, so the business can continue to operate at a loss while awaiting market growth and acceptance. If a venture is not profitable but has nonetheless demonstrated market acceptance of its products in the form of revenue growth, it may be attractive to early-stage venture investors. The business risk faced by this stage enterprise may seem relatively low compared to the earlier stages, but it is regarded by the investment community as quite high in comparison to more traditional equity investments.

- Infrastructure development and enabling technologies. Frequently, because of overly constrained budgets, public sector investments cannot hope to address but a small fraction of the technology development needs associated with the technology infrastructure that will be required for key technologies to make it into the market place. For example, until fairly recently, the need for storage associated with a large number of clean energy technologies, such as for wind and hydrogen fuel, has limited application, market and investment interest. This is because these technologies are enabling. Also, related is the technology that enables the integration of cross cutting and supporting technology for hybrid applications such as those that include combined wind, PV, hydrogen generation, and fuel cells.

[30] Traditional private sector project financing, where the debt portion is relatively high will be quite risk averse, even more so than equity venture capital investment.

Bridging the Gaps with Financial Engineering and Additional Financing Sources

The opportunity for financial engineering to define pathways for bridging these gaps by integrating the capabilities and resources of various financial groups appears to be rich,[31] as the financial industry has been rapidly expanding its supermarket of financial products and solutions. Moreover, there is the possibility of developing joint public/private sector partnerships, where the private sector leader provides the overall direction and stewardship of the investment.[32] Also, while venture capitalists syndicate deals among themselves and often work closely with project financiers and investment bankers, the opportunities for even broader based syndications may be possible.

We provide a few examples of generally underutilized sources of funds for business development in clean energy technology and the associated infrastructure. In some cases these sources are already exploited to some extent, but there are opportunities to use them much more effectively.

Additional sources (each with different risk aversion profiles) of financing from the private sector include:

- Groups of angels
- Wealthy individuals
- The investment arms of foundations
- Pension and Retirement funds
- Fund managers for wealthy individuals
- Pooled state resources

Direct and Indirect Public sources include:

- WB/EX-IM (like) banks
- Regulatory agencies
- Other government agencies
- State investment funds
- SBICs

Consideration of Novel Public-Private Venture Funds and Partnerships

There has been a recent flurry of activity around new forms of government and private sector financing partnerships. The CIA has recently initiated the In-Q-Tel venture fund, and the Army has decided to start a similar venture fund. Both of these funds aim to assist in the development and commercialization of technologies that support their missions while building more effective working relations with private sector businesses and financiers.

Also, the Rand Corporation recently published a report (Held 2002) looking at innovative financing approaches that the government might pursue in partnership with the private sector. One of the approaches discussed in the Rand report was the establishment of venture funds. It

[31] The public sector may want to participate in more broadly based financial engineering (as well, in order to increase the effectiveness of its investment).

[32] For example risk buy down, or insurance, by the public sector, especially for project financing of early start-up (e.g. for a first plant) stage ventures that are clearly on the path to commercialization, as determined by the financial community, could be quite valuable. Learning from past mistakes from related prior approaches and efforts is crucial here.

is too soon to tell whether this approach would work for clean energy, but it deserves further consideration. See Appendix D. for a brief summary of these efforts.

Regarding the CIA and Army venture funds, the Government is the primary direct beneficiary of the technologies that the funds may finance. In contrast, in most clean energy scenarios, the direct beneficiaries would more likely reside in the private sector. Nonetheless, the CIA and Army funds do establish a precedent for out-of-the-box thinking in this area and a basis for further progress. Further, the CIA, Army, and public sector energy investors all have roles that support the public good. For instance, on an experimental basis, a limited fund might be developed in partnership between the public and private sectors. Such a fund might be initially seeded with government funds but managed by private sector investors. The fund would be focused on early stage clean energy ventures as a way of smoothing the transition to private sector financing. This would also be an experiment in getting clean energy technologies to the marketplace sooner while improving the financial returns of public sector investments. The public benefits also include increased energy supply, reduced energy costs, improved environmental quality, and an expanded tax base through the creation of new jobs.

Enhanced Collaborations Between Public Sector Agencies to Further Enable Commercialization

Another area where additional resources, in effect, may be available is through enhanced coordination and more efficient use of public sector funds. While acknowledging that there has been a considerable amount accomplished here,[33] much more appears to be possible because of newly emerging and overlapping priorities. In fact the opportunities appear to be both many and rich.

For instance, high on the agendas of both the DOE and DOD are related technology development objectives that address energy diversity, energy production, and homeland security needs that can be addressed with numerous clean energy technologies. In this case Both DOD and DOE might be able to better meet their own objectives by collaboratively helping clean energy ventures take better advantage of not only DOE's technology development efforts, but also DOD's dual use approach to technology development as well as the DOD's willingness to fund appropriate product development opportunities. This approach could help many entrepreneurs meet the funding needs for further product development as a prerequisite to obtaining venture funding. Further, the DOD provides entry markets, often with high margins, for the products that are developed.

Learning From the Past, and Engaging the University Community

As we look at new ways of filling the funding gap by using novel approaches and partnerships it would be a wise investment to not repeat unsuccessful history, while leveraging our successes. Over the course of more than thirty years, the public and private sectors have expended a lot of effort and resources on developing the technology as well as adapting commercialization models from other market sectors through various partnership efforts. However, in parallel, we have invested relatively very little in systematically learning from our successes and probably more importantly, from our most expensive failures in getting these technologies commercialized.

[33] For example the DOE/NREL works closely with many corresponding stage agencies. Also, there are collaborative efforts with the DOC, and the DOD (including their dual technology approach), which a limited number of DOE/NREL industry subcontractors have been able leverage.

This issue can be addressed by developing a more complete understanding of, along with the ability to communicate, the available lessons from our major commercialization efforts to date. As part of that effort, we need to distinguish between models that work over the full development and commercialization cycles, those that work for a while, and those that don't work at all. We also need to be aware of how the various approaches taken to date match up (or haven't matched up) with the unique challenges of clean energy technology commercialization. In addition we need to be careful to simultaneously consider the impacts of the cost of strong technology progress and performance, and the considerable evolution of the markets over the last thirty years as we evaluate various past commercialization efforts.

This kind of effort will be quite valuable in providing an informed approach of developing and using alternative commercialization processes and models that are uniquely adapted to clean energy. This might be accomplished by using a case study approach, such as used in many of the top University MBA programs, while involving key public and private sector individuals with long and varied institutional memories. Such an approach if executed judiciously with top university MBA programs, also should add to credibility of the results, well as tap into the entrepreneurial spirit and formal programs that are growing rapidly in these institutions.

V. Conclusions

In support of the public good, technology development investments by federal and state governments have always been primarily focused on reducing technical risks. This has been done so that the private sector can more readily develop and take technology-based products to the marketplace. While the public sector has a larger set of risk concerns than those related to just technical issues, there is also a chance that the public R&D investments will lie fallow. Hence a closer look at opportunities for collaboratively reducing this larger risk spectrum is warranted. Fortunately there are a number of things that the public and private sectors can do collaboratively. Some are straightforward and simple extensions of what the public sector does now – without violating the legal and mission scope constraints placed on the public sector.

Opportunities for collaboratively reducing risk can add robustness to the technology commercialization process, and thus benefit both the public and private sectors. Given the relatively large investment needed for energy technologies and the associated infrastructure development, as compared with many other technologies, it makes good sense for both sectors to collaboratively build synergies wherever possible. Closer collaboration can lead to better yield of public sector investments and shorter times to commercialization.

As part of this collaborative process it is important to understand and keep in mind the differences in perspectives and drivers for the two sectors. These differences can represent both challenges and opportunities. For instance, while the financial resources that the private sector brings to the table are key, the public sector can also gain additional benefits from early interaction with the private sector investors and business experts; these benefits include the insights and expertise on markets, the competition, and the development of business fundamentals.

Beyond continued efforts to reduce technical uncertainties with its technology investments, the biggest opportunities for the public sector to collaboratively reduce risks with the private sector are:

- **Reduce information gaps or asymmetries** between the two sectors, by providing appropriate access to data, knowledge, and insights critical to making sound investments. This includes:
  - Encouraging early and frequent interactions among the public sector, the clean energy industry, and the investment community.
  - Providing private sector investors with technical advice and assistance, and information such as published macro level market and technical data of a nonproprietary nature.
  - Establishing appropriate procedures for early access to public sector technology programs and program managers along with related data and insights, within the constraints placed on the public sector.
  - Including investor perspectives in public sector investment decisions in the evaluation criteria to enhance earlier investability.
- **Fostering an accelerated shift from a technology to a market focus** and supporting ventures. This includes:
  - Encouraging companies to develop more evenly along both technology and business development dimensions, while leveraging the insights and guidance from investors, incubators and other business experts as well as by gaining inputs from potential technology users, and product customers.

  - Fostering the ability of entrepreneurs to respond to market opportunities in a timely fashion before the competition can beat them to it. And look at how cost share requirements may be limiting these opportunities.
  - Evaluating the advantages of platform technologies that will allow for dual applications and products to be derived from the technology that can increase the value of the technologies and reduce the risk to the private sector considerably.
  - Encouraging entrepreneurial venture organizations to access and use the best business development expertise available, including that which is available in the nation's top business incubators such as members of the National Alliance of Clean Energy Business Incubators.
- **Exploring and developing novel co-investment partnerships with the private sector** to help address significant funding gaps that continue to exist. This may include experimenting with approaches such as those already underway with the U.S. intelligence community, and using a "poster child" approach to demonstrate its efficacy before more widespread application is considered.

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Appendices

Appendix A
Sources of Private Financing

The financial community (and even the venture community within the financial community) is far from monolithic. A number of financing options are available depending on the stage of development of the business. Table A-I shows different kinds of financing that are available at different stages of development. The table is based on one in *Pratt's Guide to Venture Capital Sources (2001)*, the leading source of information on the topic. *We have added angel equity, which is appropriate in the start-up and early growth stages, to this table.* It is important to also point out that most of the venture capitalists that have supported Industry Growth Forums focus on earlier-stage and smaller deals than is typical of many venture capitalist firms.

Table A-1: Sources of Business-Development Financing

Stage of Development	Risk Profile and Principal Risk Elements	Financial Characteristics	Typical Financing Instruments
Start-Up	Highest: Management Product Market Financial	Losses Minimal assets Negative cash flow	Founders' equity Angel equity
Growth	Moderate: Management Financial	Break-even to profitable Rapidly growing assets Negative or modestly positive cash flow	Bank loans (mid-later growth) Leases (equipment) Private equity (early growth) Public equity (later growth) Strategic alliances
Maturity	Lowest: Competition	Profitable Stable asset levels Positive cash flow	Bank loans (working capital) Leases (equipment) Public and private equity Strategic alliances Mezzanine debt Private and public debt placements
Decline/ Turnaround	High: Financial Management Product strategy Market strategy	Losses Declining asset values Cash flow positive or negative (asset liquidation)	Asset-based financing Public equity (dilutive) Turnaround investors

An excellent source on private equity can be found in Josh Lerner's, A note on Private Equity Information Sources (November 1998).

Roberts, goes a step further (see Table A-2 below) in a similar and related table, by further segmenting the growth stage, and providing typical amounts invested in each stage of the venture.

Table A-2: Equity Financing Rounds over the Early Life of a Company
(Roberts, et al. 2000)

Financing Round	Definition	Typical Amounts	Who Typically Plays
Seed	Prove a concept/qualify for start-up capital	$25K - $500 K	▪ Founder's Equity ▪ Angels ▪ Early-stage Venture Capitalists
Start-up	Complete product development and initial marketing	$500K - $3 M	▪ Angels ▪ Early-stage Venture Capitalists
First	Initiate full-scale manufacturing and sales	$1.5 M - $5 M	▪ Venture Capitalists
Second	Working capital for initial business expansion	$3 M - $10 M	▪ Venture Capitalists ▪ Private Placement Firms
Third	Expansion capital to achieve break-even	$5 M – $30 M	▪ Venture Capitalists ▪ Private Placement Firms
Bridge	Financing to allow company to go public in 6-12 months	$3 M - $20M	▪ Mezzanine Financing Firms ▪ Private Placement Firms ▪ Investment Bankers

Tables A-1, and A-2 show that typically, the entrepreneur can expect to deal with more than one round of public sector financing, including additional partners. Of course, there will be strong motivation to limit the number of financiers, and rounds involved to keep complications to a minimum, and to avoid over diluting their investment.

In Murphy et al. (2002) we took another step and further elucidated the early stages prior to seed funding – where investment is typically dominated by public sector and to a lesser extent bootstrapping investment. We recreate and update that table below in Table A-3 with a few modifications, including a very early basic research stage. An important part of Table A-3 is a listing of the requirements at each stage that must be met before financing of the next stage can be obtained, as well as the key interlinked processes defined by Jolly (1997) that are needed for each stage. The requirements column lists milestones typically required for each financing stage. This illustrates why the entrepreneur, and often the associated public sector financiers, often wrongly assume that the venture is ready for seed or start-up financing when, in reality, they have not satisfied basic market and business planning milestones.

For instance, note that each stage of private sector financing, including the pre-seed stage, includes a distinct *market component*. Lack of attention to market considerations is one of the most common mistakes of energy entrepreneurs. Technologists often wrongly assume that an elementary understanding of the market will carry them through the seed and start-up phase and are perplexed when they fail to raise any capital.

The extent of the market focus for each stage evolves as the business evolves. For example, in the pre-seed stage, the entrepreneur must define the market need and attempt to roughly quantify it. In the seed stage, markets must be carefully quantified, competition characterized, and initial customers identified with letters of intent to purchase if possible. In the start-up phase, the customer base must be growing rapidly to obtain the next round of financing.

Because many energy entrepreneurs develop their enterprises in an uneven fashion, focusing almost exclusively on technology development and engineering, they often assume they are ready for seed or start-up financing when, in reality, they have not satisfied basic market and business planning milestones.

Table A-3: Typical Qualifying Requirements for the Next Round of Financing and Key Processes Involved for Specific Financing Rounds

	Financing Round	Who Typically Plays	Typical Qualifying Requirements for Next Round	Key Processes
Technology Creation	**Basic Research**	Public Support (e.g. DOE) / Personal / Bootstrapping	▪ Technical feasibility established ▪ Potential applications identified	▪ Basic Research ▪ **Market** Application Scanning
	Concept Generation	Bootstrapping / Public Support (e.g. DOE/ATP/SBIR/States)	▪ Technical capabilities demonstrated ▪ Specific Applications identified and explored ▪ Exciting technology concept, linked to a specific market needs	▪ Applied Research ▪ Development ▪ **Market** Need Defined
	Pre-Seed: Technology Development	Personal / Bootstrapping / Public Support (e.g. DOE/ATP /SBIR/States)	▪ Key patents applied for/secured ▪ Technical feasibility and initial commercial feasibility with prototype demonstrated ▪ A plan for taking the business forward is available ▪ Substantial market need quantified and competition identified	▪ Development ▪ Engineering ▪ **Market** Definition & Assessment
Market Focused Business Maturation	**Seed:** Prove a concept qualifies for start-up capital	Individual Angels Angel Groups Early-stage Venture Capitalists	▪ Business/commercialization plan available ▪ Specific markets, including competition, well characterized; and initial customers identified ▪ Attractive market-ready products or processes available. ▪ Management team identified	▪ Development ▪ Engineering ▪ Manufacturing ▪ **Market**ing
	Start-up: Complete product development and initial marketing	Select Individual Angels Angel Groups Early-stage Venture Capitalists	▪ Launch of commercial product and/or process ▪ Strong management team in place ▪ Rapidly expanding customer base	▪ Manufacturing ▪ **Market**ing
	First: Initiate full-scale manufacturing and sales	Venture Capitalists	▪ Large customer base, and still growing by new constituents ▪ New products and new processes	▪ Research ▪ Development ▪ Engineering ▪ Manufacturing ▪ **Marketing**

Relative to Tables A-1 and A-2 the public sector financing in Table A-3 is truncated after the First (or Initial Growth) Stage. Further Table A-3 shows that most of the public sector financing corresponds to the top three rows, while the private sector financing is in the bottom three rows. Also, we have highlighted the two stages where there are typically too little resources available (i.e. in the Pre-seed and Seed stages), and why it is important for the public and private sectors to work more closely together where the transition from public to private sector financing is occurring.

Appendix A
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Appendix B
More Examples of the Risks that Concern Private Sector Investors – Specific to Clean-Energy Ventures

A number of additional examples, corresponding to each of the risk categories described in the main body of the report are provided below. These examples correlate to private sector investor comments and observations, and are specifically related to clean-energy technology investments made by the public sector. It should also be noted that these examples are intended to be illustrative and that the list is clearly not exhaustive. Moreover in some instances a given example may actually be applicable to more than one category of risks; e.g. we give several examples that relate to both Technology Push and to Market Volatility.

Information Gaps / Asymmetries

When investments are made by the private sector, investors worry that the entrepreneur knows more about the technology and its potential success in the marketplace than they do. And when the federal sector is involved in the long-term R&D funding of the technology, investors have additional worries surrounding this issue. If funding for a given technology is being phased out, then they naturally want to know why the public sector really wants to off-load this technology. For example, they may ask the following questions:

- Is the venture really a pig in a poke that private sector doesn't want to deal with any more, or spend additional money on? Are there technical limitations that they, the investors, don't know about? Did test results really not reach expectations? Is there information that may bring into question the ability of the technology to address follow-on markets effectively.
- Is the public sector aware of what the real requirements of the customer are likely to be? Do they really understand what the real buy decision is, and who the real buyer will be?
- Is this the last risk money that the public sector will likely Invest? Is the likely needed additional money (investment) much higher than the public sector anticipates, and much higher than the public sector has invested to date? Sunk costs are irrelevant in the eyes of the investor. The investor likes to syndicate the deal and share risks and due diligence.
- Does the public sector investor such as DOE/NREL have another technology in the wings that will supercede the current one, and which is being developed by someone other than the current company. (Maybe the current company has ultimately non-viable technology and doesn't know it, or is unwilling to own up to it.) After all, the DOE has as its mission the development of cutting edge technology. Or is the technology one of several parallel developments DOE is carrying along as potential options to see which one will capture the fascination of the marketplace and/or investors?
- Does the public sector have knowledge about the investment such that a likely viable win/win situation can be found by the private sector, or is the private sector just wasting its time? For instance, the public sector has a pretty good sense of whether the company it invests in wants to continue to focus on R&D, or is serious about making his or her company a successful market focused venture.

Technology Push

Because of their technology development charters, government agencies often constrain their entrepreneurial partners to overly focus on technology issues to the exclusion of market and the development of important business fundamentals. Gompers and Lerner (2001) provide a relevant discussion noting that all too often, the government administrators view shifts away

from or beyond the technology development issues, not as natural aspects of the innovation process, but as troubling indications that investees are deviating from the plan. The problem only worsens when federal agencies, worried about being accused of just "picking winners," push entrepreneurs to focus purely on pre-commercial research. But by doing so, the firms risk missing out on an essential source of information: customer feedback. Even more dangerous, some publicly backed companies become afraid to chase after an attractive commercial opportunity because the companies' managers fear jeopardizing their public funds. Though well intentioned, restrictive investment policies may thus unwittingly punish success.

Gompers and Lerner (2001) give a good example where a company met their contractual agreements on an Advanced Technology Program (ATP) program, and then expanded R&D into non-essential areas while also establishing a major strategic alliance with a major firm to accelerate the commercialization process. The ATP Program was merely trying to demonstrate good stewardship for its mandate to focus only on essential technology development while not jeopardizing its public sector financing mission. Because of this inflexibility, the ATP and the company quickly became embroiled in an acrimonious, expensive, and lengthy resolution process that resulted in the company paying a steep price for its success.

In addition, sometimes investors become concerned that government agencies appear to be trying to push the technology out of the laboratory along a direction that is not what the market can support or needs. Specific concerns are included in the following examples:

- The perception that there is an over-dependence on government contracts causes investors to question whether there is a real market for the technology. This is especially true if the government-sponsored efforts appear to be diverting the focus away from market entry and business development needs required for rapid commercialization. If there is a perception that the market is driven by technology push rather than market pull, investors will shy away. They don't want to be left holding the bag when a technology falls out of favor or a subsidy has ended.
- If a technology is moved into the demonstration stage, especially on a large scale, before it is technically ready, or is not correctly embodied in a market driven product, then a potentially large problem looms, especially if there is the possibility for a highly visible failure. Such a failure can hurt the future chances of the technology and the corresponding product in the marketplace. Also, if the market is not well understood and the particular product being demonstrated is not likely to enter the marketplace successfully, the demonstration project will raise further questions as to whether the company is correctly market focused or relevant.
- If the selection process of public sponsored entrepreneurial ventures is biased for certain markets (even if this is correct from a long-term perspective), successful market entry, and even the success of the venture, may be compromised for those selected for funding. For example, in the mid to late 1970's NASA originally, and then DOE, focused on very large wind turbines. However, early market opportunities were for much smaller turbines. While from a long-term perspective, the larger turbines have been shown to meet many current market needs quite well (since the early 1990's), this represented a less than ideal early market entry focus for the late 70's.
- Because there is often a desire, and a need, by the public sector sponsors to show progress towards a large level of energy displacement, entrepreneurs can be urged to focus on market directions that can displace large amounts of energy–markets that are often essentially driven by commodity costs, which in turn represent a difficult competitive

position.[1] Private sector investors want the ventures in which they invest to have the flexibility to address the most appropriate early market entry / beach heads, and they view constraints to the contrary as counter productive.

- Investors are always concerned that too much technology development may indicate that the company is not market focused.[2] They worry that continued R&D is being aimed at "gilding the lily," rather than providing an adequate technology base for market driven products. If there is still appreciable technical risk, then it is generally too early for even early-stage venture investment. Several investors at NREL's Growth Forums have noted "off the record" that the NREL/DOE is not doing companies any favors by allowing them to put off real market development activities.
- The limitations caused by unduly focusing on a single product for a technology can also be limiting. Looking at technology platforms that can lead to other products (for which the entrepreneurial venture can develop a market) gives a company additional flexibility and adds value in the eyes of potential investors. This can be very important in cases where the technology is being developed for commodity applications, such as energy, where margins can be slim. If the company can make other products that are higher value and margin, this can thus be of additional benefit, especially in the short-term. For instance, if a company is focusing on mass-producing PV panels for applications, it may be quite beneficial to make additional products like battery chargers, PV roofing tiles etc. Yet another example of multiple applications from a single technology—Ocean Thermal Energy Systems—was the possibility of generating electricity, producing clean water, and developing aquaculture; though this was never pursued.
- If the public support fosters company activities that build a series of projects in a build and sell progression, this can be viewed by the private sector as a big negative if the overall commercialization effort is slowed. This can often indicate to investors that the enterprise is not serious about commercialization, or is really more focused on a service or project business. Equity investors are in general not interested in service or project businesses.

Uncertainty about the Future

Public sector technology investments that have ties to public good issues for which public policy also plays a role[3] raise questions in the minds of investors. And public sector investors should be aware of these concerns. For example:

- Are there, or are there likely to be, legislative mandates that may require or exclude certain technologies from the market place, such that the corresponding ventures would be placed at a strategic disadvantage in the marketplace?
- Are there tax credits that have an uncertain future, and therefore have an uncertain benefit to the entrepreneur in demonstrating the economic competitiveness of his or her technology to the investor. This is especially problematic if the market relies heavily on government subsidies such as tax credits that can disappear before the life of the investment.
- If the government has a hand in providing subsidies (beyond the early development of the technology), and the entrepreneur needs those subsidies to make his/her business case,

[1] A number of venture investors that have worked with NREL on its forums and Alliance Incubators have noted that they will not even consider commodity markets.

[2] If the understanding and development of markets has not kept pace with the technology development, then it is unlikely that a market driven product is available, or can be easily developed. In such situations where the entrepreneurial ventures have limited understanding of their markets, then one must ask: "how can continued R&D be market focused?"

[3] Most technologies do have a tie to public good (e.g. because of environmental, security and other considerations).

then the investor will be concerned about what will happen to the investment when the subsidy ends. Investors want to know with high confidence what will happen, including the impacts of subsidies, over the full life of their investment.

Market Condition Volatility

Examples of risks perceived by the private sector include:

- The view that the government is distorting the real market by financing or "buying down" the technology over an extended period of time. For instance the Japanese and German subsidies for photovoltaic technologies have been viewed by some investors as distorting world markets, though this is not a universally held view. This in turn can lead to concern that the entrepreneur's assessment of the markets may be unrealistic especially from a long-term perspective, and or that the entrepreneur is not ready to aggressively pursue market windows of opportunity in timely manner.
- The question of whether DOE/NREL has knowledge about the markets that they, the investors, don't. For instance, did they just find out that the margins of the competition are really very much higher than originally thought? Or are there about to be some new regulations or subsidies that give the old competitor technology a new lease on life for the next five or more years.

Soft Assets

The public sector has little direct impact on the soft asset questions, and at times, often only limited knowledge of the situation. Nevertheless, the public sector can impact, for instance whether the entrepreneurs protect the intellectual property for the venture. Also the public sector financiers often have (or should have) information on the business strength of the management team and the direction of the company in R&D terms, or market focus. And though this information cannot be shared directly with potential investors because of various conflict of interest issues, it should be considered as they develop and support programs that foster these entrepreneurial efforts. For instance:

- Despite often having dealt primarily with the technical people in the company, do the public sector financiers know how open the company is to bringing on a management team with all of the requisite capabilities? What does the current, technically focused CEO really want out of the deal? Has the current company senior management clarified it?

Appendix B
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Appendix C
Risks and Valuation Methods used by Investors

The impact of higher risks and correspondingly higher discount rates can be understood by looking at the valuation methods used by investors. John Willinge of Harvard Business School (September 1998) describes five approaches to valuation, along with the pros and cons of each method.[1] We will discuss briefly only the "Venture Capital Method" here.

In the "Venture Capital Method," investors use a targeted rate of return (TROR) to discount the terminal value for the business, and a value in the range of between 40% and 75% is common. This range is obviously significantly higher than would be typically inferred by a more traditional cost-of-capital approach. Venture investors feel that that this relatively high TROR is required to justify taking the risk and the effort of this particular investment; for instance they cite the lack of liquidity for the investment and the services including mentorship that they provide.[2] The terminal value of the business, calculated at the time-to-exit the investment, is then discounted using the targeted rate of return.

The effects of using the TROR to discount the terminal value, as a function of time-to-exit are shown in Figure C-1 below.[3] We also show the impact on the fraction of investor ownership, as well as the effect of a variable TROR; higher TROR's correspond to earlier stage investments.

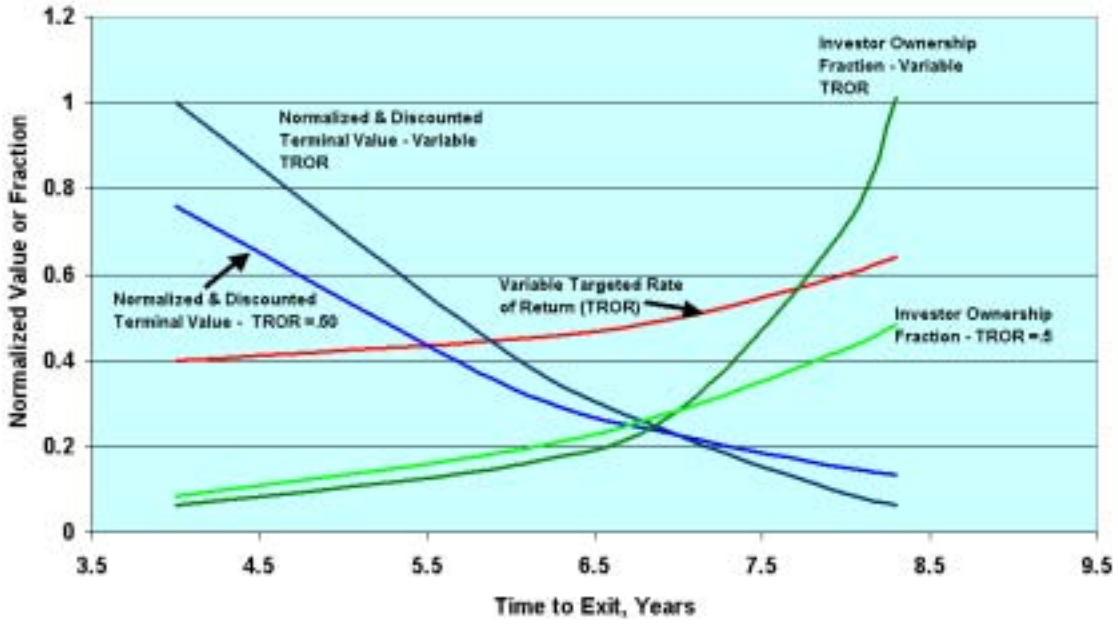

Figure C-1. Normalized discounted terminal value, fraction of business owned by investor, and discount rate, all as a function of time to exit, using the venture capital method as described in Harvard Business School (September 1998).

[1] Including concerns about using fudge factors in discount rates for dealing with risks.
[2] Nevertheless, financial economists suggest that these rates may be too high to justify.
[3] As a baseline we used the same case as described in Appendix 4, Willinge of Harvard Business School (HBR) (September 1993), but varied the targeted rate of return as shown in the Figure for two of the curves. In the HBR example, a terminal value for the business of $300M was used, and we assume that this is attained at the time to exit.

Figure C-1 shows how high discount rates coupled with larger times, required to exit the investment, can quickly erode the valuation of the business, while rapidly increasing the fraction of the business that the investor will assume.

Appendix C
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Appendix D
Some New Financing Approaches

In-Q-Tel, launched in 1999, is a private, non-profit enterprise funded by the Central Intelligence Agency (CIA). Its mission is to identify and invest in cutting-edge information technology (IT) solutions that serve U.S. national security interests. In-Q-Tel works from an evolving strategic blueprint that defines the Agency's most pressing IT needs and seeks out, connects with, and invests in leading edge technologies under development by start-ups, established companies, universities and national and private labs—most of which have never worked in the government market before. They help to mature these technology solutions and prepare them to succeed in the marketplace. But most importantly, they deliver new capabilities that will help contribute to realizing the CIA of the future.

In-Q-Tel defines itself as a hands-on investor—bringing technical expertise, operational and business support, and access to a potential lighthouse customer. In-Q-Tel provides a source of capital, technical and operational expertise, a beta/prototyping site with "power users", a fast track to commercialization, and a potential source of revenue. In-Q-Tel now includes a 45-person staff and two strategic business teams, technical and venture, with a bi-coastal presence in Arlington, Virginia and Menlo Park, California. For more about In-Q-Tel, read about its guiding vision, its company history, its business model and its relationship with the CIA; see their website at http://www.in-q-tel.com/.

The Army and DOD are following the same model as the CIA (Wilen, 2002). They are planning a $25M non-profit venture capital fund, and they are now soliciting a private sector manager for the fund. The fund's purpose is to "accelerate the transition of innovative technology into a transforming Army." Initially, that means the Army wants lightweight, long-lasting power supplies for soldiers. "Technologies of interest … will include … devices, systems, and software that generate, store, control, and manage the power and energy required by the individual soldier for communications, computing, sensing, weapons functioning, mobility and comfort." The Army clearly hopes that improving "the business relationships between the entrepreneurial community of high technology innovators and the United States Army," will help it speed innovative, groundbreaking technologies to its soldiers in the field.

The Rand Corporation (Held et al. 2002) has been studying this and related issues for the Army. In particular they looked at the venture capital approach along with two other approaches: (1) a real estate-based public-private partnership, and (2) spinning off Army activities into Federal Government Corporations. Relative to the venture capital approach, they enumerate a number of issues with such an approach but conclude that: Using a venture capital model for funding research and development of interest to the Army is one option for addressing the lack of access to the commercial technology sector. In particular an Army venture capital fund (1) can exploit innovation, (2) can better access commercial technology, (3) can leverage non-Army resources, and (4) can provide a return on investment (ROI).

Appendix D
References

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