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Green Technology Commercialization An Analysis of the EPA's SBIR Program

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An Analysis of the EPA's SBIR Program

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Abstract

The purpose of this project was to identify how the EPA SBIR program can effectively utilize its limited funding by selecting and supporting small green business entrepreneurs with the greatest potential for bringing products to market. We interviewed representatives both from companies that successfully and unsuccessfully commercialized their technologies. Our team additionally contacted managers of similar programs, including other federal agencies' SBIR programs, a green technology accelerator, and a venture capitalist company. We also distributed an electronic questionnaire to principal investigators. From the collected data, we developed a list of recommendations for the EPA's SBIR selection and support processes.

Executive Summary

The United States Environmental Protection Agency (EPA) encourages green technology companies to become successful through their Small Business Innovation Research (SBIR) program. The EPA wants to find ways to improve this program's selection and assistance processes. Priority environmental issues, ranging from water and air pollution to waste treatment, can be addressed and solved through the aid of innovative green technologies.

The EPA SBIR program is a program that entrepreneurs can utilize to help get their technology to market and thus make an impact on protecting and preserving the environment. However, limited funding resources restrict the number of businesses that the EPA can select for participation in the program. Not all funded companies are successful in developing and commercializing their technology. Thus, it is important to research potential improvements to the program's selection process in order to make investments that will succeed in bringing environmentally healthy products to the marketplace. The goal of our research was to identify traits of successful green technology entrepreneurs and to develop recommendations on how the program can select and support companies that exhibit characteristics of successful firms. To achieve our goal we outlined four key objectives:

- Analyze EPA SBIR funded businesses
    - Identify why these businesses have been successful or unsuccessful in commercializing a funded product
- Determine forms of support that small green technology businesses need
- Evaluate internal EPA SBIR program functions

- Identify effective selection criteria and support methods from similar programs
    - Recommend possible application of these methods at the EPA.

To achieve these objectives, we used a questionnaire and interviews. Our questionnaire was developed to gather information from a broad scope of companies and give feedback on the SBIR program as a whole. We interviewed representatives from companies that have successfully commercialized their technologies in order to identify strategies that can be used as a model for other businesses to follow. We also examined less successful business ventures funded through the EPA SBIR program to reveal the challenges companies face when developing and commercializing their technologies. Data from both successful and unsuccessful proposals provided insight from two different perspectives regarding how to be successful and how to avoid failure. Beyond talking to company representatives, we interviewed managers of similar programs, including other federal agencies' SBIR programs, a green technology accelerator, and a venture capitalist company. From these interviews, we were able to identify unique and effective approaches currently being utilized to select and support entrepreneurs.

By analyzing the data from our interviews, we were able to determine some traits and practices of successful green technology entrepreneurs. Based on interviews with our sample group of successful companies, we determined that it is crucial for green technology entrepreneurs to understand the market prior to development. The importance of creating a technology that fills a gap in the marketplace is further reinforced by interviews with a venture capitalist and a representative of a green technology accelerator organization. Preemptively understanding the needs of a market by locating potential end users and business partners is essential for founding a green technology company. Locating outside sources of money in advance helps businesses to get supplemental

funding to fully develop and commercialize their products. Interview data revealed that some of the less successful companies did not do this to the same extent as other successful companies, which may have contributed to their proposals' failure. Reasons for not being able to gain third party investment included having a technology that was not unique in the marketplace and did not better replace an existing technology. A representative of a green technology accelerator program revealed that many entrepreneurs are technically oriented but lack the communication skills to effectively market their product. SBIR program managers and representatives of successful companies expressed similar sentiments in our interviews with them; thus, successful entrepreneurs often have business backgrounds and are well versed in communicating the merit of their product.

Other interview and questionnaire data were used to determine unique and effective methods of selection and support that can be implemented at the EPA. All similar programs to the EPA's SBIR program whose representatives we interviewed had an electronic submission requirement to ease the burden of a paper system. The NSF SBIR program manager described how their program uses their own software to conduct all of their business. We recommend an online tool similar to the NSF's to be implemented and, if this is not viable, some form of an electronic application process. Another recommendation to the EPA is to adopt a video requirement. To better select entrepreneurs for funding, the Department of Education's SBIR program uses video submissions of funded prototypes to aid external reviewers in evaluating proposals. Based on interview data, these videos have had a positive impact on the process for reviewers. To help green technology companies develop and commercialize their product, a representative of an accelerator program described how their organization

provides a business and subject matter mentoring program and facilitates networking opportunities. Questionnaire and interview data showed that companies would be interested in an optional mentoring program. We recommend looking into sponsoring and partnering with accelerators and similar programs to aid entrepreneurs in their business ventures. Data additionally showed that the EPA could better market funded technologies. The Department of Education uses videos to showcase invested products on their website and has described its effectiveness for their program through interviews. It is recommended that the EPA adopt this marketing tactic to assist their awardees.

This report will describe the background research conducted, our methods, results and eventual recommendations. Although not all of our recommendations will be instituted, we encourage the EPA to utilize them for future use and research areas.

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Authorship

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Chapter 2: Background: Written by Nick LaJeunesse, Stephen Johnston and Angelica Zawada; Edited by William Forster, Nick LaJeunesse, Stephen Johnston and Angelica Zawada.

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Table of Contents

List of Figures

List of Tables

1. Introduction

The degradation of the environment as a byproduct of industrial processes and industrialization is a key issue in today's society. However, it was not until 1970 that the majority of Americans were aware of the effect of pollution on the environment (EPA, 2013g). In 1962, Rachel Carson, the author of *Silent Spring*, raised public awareness of this issue in her expose of the unintended side effects of DDT by revealing how the environment is harmed by human activity. As public knowledge increased, the desire to prevent and remediate the effects of pollution became a growing concern for society. Today, both the Federal Government and the private sector research ways to address this problem. Government legislation has been implemented, limiting the amount of pollution that can be emitted into the environment. This created a space in the market for companies to be founded with the mission to convert environmental research into commercially viable green technology products. Many of these companies have innovative ideas that could have a positive impact on the environment, but lack the funding they need to get those technologies to market.

The United States Environmental Protection Agency (2013c) funds green technology companies through their Small Business Innovation Research (SBIR) program. Since the program's establishment in 1983, the EPA has awarded over $100 million to companies for research and development of their technologies (SBIR 2013b). The goal of the SBIR program is to create commercial products arising out of government funded scientific research. Ideally, all EPA SBIR funded businesses would be profitable, and their products would make a significant impact on the environment. However, due to the high-risk nature of these investments and a lack of adequate funding, the program cannot realistically reach that goal (NSF, 2013b). In an effort to improve

their SBIR program, the EPA would like to know what factors cause program funded businesses to be either successful or unsuccessful.

Previous research on potential EPA SBIR program improvements has been conducted within the agency. An Interactive Qualifying Project (IQP) done by WPI students (Brookes et al., 2006) focused on potential improvements to the SBIR program. Through the use of interviews, this research determined that the amount of funding and commercialization assistance the EPA provides should be increased, and recommended the length of the proposal review process be shortened. However, this group did not look at the factors that make a green entrepreneur successful in industry nor did the group's work evaluate the entrepreneurs who were unsuccessful in commercializing their product. Another study was conducted by Foresight Science and Technology, an external commercialization assistance company contracted by the EPA. This research included a survey of EPA SBIR funded companies focusing on the effectiveness of their commercialization support in Phase I and II (Norton Kaplan, Survey, 2013). Unfortunately, the Foresight team did not ask questions about the EPA SBIR program as a whole. Lastly, a survey conducted by a fellow from the American Association for the Advancement of Science (AAAS) was conducted in 2007 focusing on the efficiency of the EPA SBIR program (Yee San Su, survey, 2008). The survey identified the success of the program from an economic standpoint. The study did not analyze the perception of the EPA SBIR program from the perspective of funded companies and the information does not reflect the current program.

These previous studies did not focus on the factors that make green entrepreneurs successful nor on the opinion of the program from the perspective of funded companies. Identifying the qualities that make entrepreneurs successful is useful to the

EPA in order to enable the agency to better select companies that have a higher probability of commercializing their technology. Also, gathering information about the companies' experience with the program gives valuable input on how the EPA can improve the efficacy of their assistance.

The goals of this project are to determine successful traits of green entrepreneurs and to recommend ways in which the EPA can enhance the effectiveness of its SBIR program by better selecting and supporting companies those companies likely to successfully bring green technology to the marketplace. Our first objective aims to identify successful companies that have gone through the SBIR program. To accomplish this, we defined success and determined the business practices that lead to it. To get a different perspective, we interviewed representatives from companies that did not receive Phase II funding. Using that data, we developed recommendations on how to better select and support green technology companies and gathered information to reveal traits of successful green technology entrepreneurs. Through the use of interviews, archival research and a questionnaire, we collected qualitative and quantitative data to achieve our objectives. The recommendations we provided helped the EPA to identify areas where there is room for improvement. Maximizing the effectiveness of their SBIR program by creating a higher rate of commercialization success for small green technology businesses supports the EPA's mission of protecting human health and the environment.

2. Background

Competing as a small business in the green technology market is a challenging endeavor. To help explain the process of founding and maintaining a small, environmentally oriented business, in the sections that follow we will discuss: green technology, the EPA and its mission, the SBIR program, the EPA SBIR program, other SBIR programs, commercialization, skills of entrepreneurship and previous research conducted on the EPA SBIR program.

2.1 Green Technology

Green technology is "a technology that offers a more environmentally benign approach compared to an existing technology" (NSCEP, 2006, p. 79). Thus, green technology is a term for a wide range of environmental technologies that aim to prevent, monitor and reduce pollutants. Examples include wet scrubbers, filtration devices, fuel cells, clean manufacturing techniques and contaminant monitoring devices (EPA, 2000). These technologies try to guide society towards environmental sustainability. Preventing pollutants from entering the environment is the ideal situation; however, this is not always possible. Some other techniques for dealing with pollution are reuse, recycling, treatment, disposal methods and monitoring (EPA 2013f).

There is a national interest in the development of advanced green technologies that address priority environmental issues (EPA, 2013d). President Obama expressed the importance of environmental technology in his statement, "The choice we face is not between saving our environment and saving our economy - it's a choice between prosperity and decline" (Office of the Press Secretary, 2009, p. 1). Shuman Talukdar, Head of Business Development at Mojave Networks, et al. (2010) suggests that green technology can help solve the nation's environmental

problems. One agency that focuses on solving these problems through the use of green technology is the Environmental Protection Agency (EPA).

2.2 Environmental Protection Agency and its Mission

The EPA (2010) is a government agency that was established in 1970 to consolidate federal research, monitoring, and enforcement activities related to the conservation of the environment into one agency. Its mission, "to protect human health and the environment," is carried out by a workforce of approximately 17,000 employees across 12 department offices and 10 regional offices in the United States (EPA, 2013a). Each departmental office is in charge of a different problem concerning the environment, as can be seen in Figure 1, below.

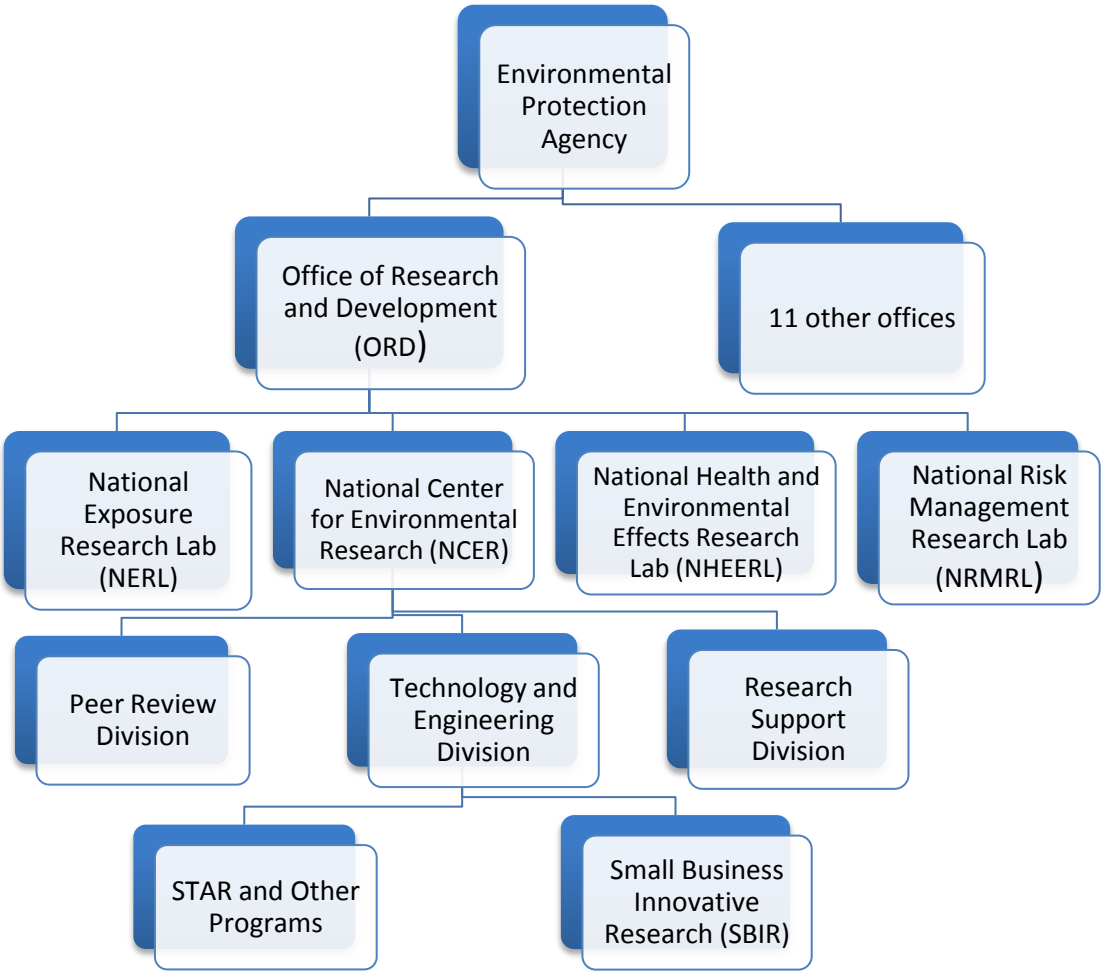

Figure 1: EPA structural organizational chart (EPA, 2013a, EPA Organization Chart)

The EPA's structure allows their direction as an agency to be split into smaller divisions, easing progress toward their goals for environmental protection. The EPA's (2010) 2011-2015 strategic goals are:

1: Taking Action on Climate Change and Improving Air Quality

2: Protecting America's Waters

3: Cleaning Up Communities and Advancing Sustainable Development

4: Ensuring the Safety of Chemicals and Preventing Pollution

5: Enforcing Environmental Laws

In order to achieve these goals, the EPA is divided into offices that have a more focused scope. The Office of Research and Development (ORD) provides the research to develop sustainable solutions to the nation's highest priority scientific needs (EPA, 2013a). Their mission is "to conduct leading-edge research and foster the sound use of science and technology to fulfill EPA's mission to protect human health and safeguard the natural environment" (EPA, 2001). Three national laboratories, four national centers and two offices located in 14 facilities across the country comprise the ORD and carry out the research (EPA, 2013a).

One research center within the ORD that pertains specifically to our project is the National Center for Research and Development (NCER). Their mission is "to support high-quality research by the nation's leading scientists and engineers that will improve the scientific basis for national environmental decisions" (EPA, 2013b, What We Do). NCER focuses their research on exposure, effects, risk assessment, and risk management through competitions for grants, fellowships, and innovative small business research contracts. This focus is shared

among the five divisions that make up the center: Health Research and Fellowships; Applied Science; Technology and Engineering; Peer Review; and Research and Support. Our team worked under the Technology and Engineering Division of NCER. Some of the projects managed by NCER are:

- Science to Achieve Results (STAR) Grant and Fellowship Programs
- Greater Research Opportunities (GRO) Fellowship Program
- American Association for the Advancement of Science (AAAS) Fellowship Program
- EPA Marshall Scholarship Program
- People, Prosperity and the Planet (P3) Student Design Competition for Sustainability
- Small Business Innovation Research (SBIR) Program.

The last program, Small Business Innovation Research, pertains directly to our project. We worked in depth within this area under NCER.

2.3 Small Business Innovation Research Program

The SBIR (2013a) program provides a way for small businesses to have their innovative ideas funded and commercialized. This program focuses on small businesses because recent studies have shown that innovative technologies were developed more frequently by smaller business than larger ones (Block and Keller, 2008). In general, smaller businesses are more willing to take risks on new technologies, while larger ones tend to focus research funding on improving existing technologies. Thus, the government decided to fund innovation through small businesses, and has been successful overall in this regard.

The SBIR program follows the mission "to support scientific excellence and technological innovation through the investment of Federal research funds in critical American priorities to build a strong national economy" (SBIR Mission and Program Goals). Investments are made in businesses that have fewer than 500 employees and have at least 51% American ownership**.** Currently, 11 federal agencies with extramural research budgets of over 100 million dollars are mandated to set 2.5% of their funding aside for their respective SBIR programs. There is flexibility for each agency to mold its program to fit its needs. However, all agencies have a similar phased approach in their SBIR program.

Phase I awards are used for initial research and development costs of the technology that the business is trying to commercialize (SBIR, 2013). The scientific value, technical feasibility and commercialization potential of technology is explored in a proposal to a federal SBIR program. External and internal evaluators review the proposals to determine which businesses will use capital funding effectively. Typically, awards will not exceed $150,000 and will have contract lengths of 6 months. Additional funding is awarded if the first phase is considered successful and the company's Phase II proposal is accepted.

The aim of Phase II is to further develop a commercial product out of the initial research and development from Phase I (SBIR, 2013a). Awards are only given to companies that have undergone Phase I successfully and have submitted a Phase II proposal outlining a plan to carry out their commercialization efforts. Awards typically do not exceed a total of one million dollars for up to two years. There is no federal funding past Phase II. However, a Phase III SBIR award, focused on receiving capital from private investors, is possible for businesses that wish to continue the commercialization efforts from Phase I and II.

The three phase SBIR program is reported to be a successful structure. Christopher Wood (2010) of the *Boulder County Business Report* states, "Billions of dollars are tunneled annually to small businesses and nonprofits through these programs, and companies make good use of those funds" (p. 30A). The SBIR program has awarded over $33 billion to companies since its development in 1983 (SBIR, 2013a). As a result, over 133,000 awards have been given to companies through the program. Federal funding programs, such as the SBIR, successfully provide opportunities for smaller companies to benefit and expand in a difficult market.

2.4 EPA SBIR Program

Small businesses in the environmental sector have the opportunity to receive funding from the EPA's SBIR program (EPA, 2010). The EPA will support development and commercialization of innovative technologies that meet the agency's mission, "to protect human health and the environment" (Our Mission and What We Do). The SBIR program at the EPA is smaller than other federal programs, but still provides sufficient funding to help small companies continue to develop a technology. The budget for small business funding for fiscal year 2013 is 3.76 million dollars. From this amount, the EPA gives out $80,000 for each Phase I proposal and $300,000 for each Phase II proposal (EPA, 2013c). Also, a $100,000 commercialization option is available to Phase II contract awardees.

Companies wishing to receive funding from the EPA (2013d) in any given year must have proposals that relate to one of the topic areas for that year. In 2013, these topic areas were: water; innovation in manufacturing; waste; air quality; and homeland security. The topic of water deals with creating safe and sustainable water for drinking and reuse. Innovation in

manufacturing deals with developing green materials and green methods for buildings and manufacturing processes. Businesses' proposals that fall under the waste category have aspirations for developing technologies that monitor or reduce waste. The topic of air quality refers to technology developed to improve air pollution monitoring and control. Lastly, technologies dealing with wastewater and drinking water disposal, treatment, and decontamination fall into the domain of homeland security.

The EPA developed the Technology Continuum, a functional set of steps that takes technology from conception to becoming utilized as a product (U.S.E.P.A. 2013e). The six-stage process is broken down as follows:

1. Research/Proof of Concept:
    a. Conception of idea
    b. Demonstration of potential for solving environmental problem
2. Development:
    a. Prototyping
    b. Pilot tests are held
3. Demonstration:
    a. Tests to show range of performance
    b. Determination of technology's applications and weaknesses
4. Verification:
    a. Tests and reporting performance
5. Commercialization:
    a. Implementation of business plans for product
6. Diffusion and Utilization:

a. Implementation of full scale marketing plans for product

The EPA SBIR program's goal is to aid the movement of a worthwhile idea through the continuum, generating a commercial product out of environmental research. The phases of the program align with different areas of the continuum and try to focus their aid on the specific needs of the companies receiving funding.

2.5 Other Agencies' SBIR Programs

Each federal agency runs their SBIR program differently. The Congressional Committee on Small Business and Entrepreneurship requested a team of researchers, a part of the National Research Council (NRC), to "conduct a comprehensive study of how the SBIR program has stimulated technological innovation and used small businesses to meet Federal research and development needs" (Wessner, 2008, p. 1). This team of researchers on the NRC's Committee for Capitalizing on Science, Technology, and Innovation assessed the SBIR programs of five federal agencies that make up 96% of SBIR program expenses. The five federal agency programs, in order of program size at the time of the study, were: the Department of Defense (DoD); the National Institutes of Health (NIH); the National Aeronautics and Space Administration (NASA); the Department of Energy (DOE); and the National Science Foundation (NSF). Similar to the EPA, the NSF, DOE, DoD and Department of Education (ED) all fund entrepreneurs in their own way.

The NSF was the first government agency that had a grant program only for small businesses (Wessner, 2007). This SBIR program started in 1977. Later, others emerged as the Small Business Innovation Development Act was passed in 1982. In contrast to most of the research funded by the NSF, this program focuses on research that has commercial applications

that can potentially transform the market. The NSF SBIR program has had extended success, and this makes it a good example to compare with other SBIR programs. Part of the NSF's success is directly related to the agency's "aggressiveness in encouraging early attention to business issues" (Wessner, 2007, p. 83). In Phase I, the companies must attend a grantee workshop that has a significant emphasis on developing a powerful commercialization plan. Assistance is provided through two commercialization planning contractors to help the companies develop their direction for product development and their business plan. Similarly, the NSF requires applicants for Phase II funding to develop strong commercially focused partnerships that will drive successful product and technology commercialization activity. Bringing a product to market is a difficult process, and NSF seeks to provide funding to help minimize the risk of the technology to facilitate commercialization. The focus is on funding companies that have the potential for a broad commercial impact, but are at a stage where they have clearly identified the problems that need to be overcome in the research and development stages. The NSF is interested in assessing the value of the proposition, the team, the intellectual property strengths, and the core innovation for which funding is sought. One trait of the NSF's SBIR program that also adds to its success is its flexibility in progression through the program. Companies who have an NSF Phase II award are given additional support through a variety of supplemental funding opportunities. These all include the ability to reach out to strategic partners, while being supported by supplemental R&D funding from NSF, which furthers the commercialization of the Phase II-funded product. One example of such a supplemental funding program is the Technology Enhancement for Commercial Partnership (TECP). This program allows companies to seek $150,000 in funding to help forge strategic commercial partnerships. Phase IIB is another mechanism, in which the NSF provides matching funds to the grantee when there is clear market validation, occurring through

investments as a direct consequence of the research and development done during Phase II. In essence, the Phase IIB program seeks to catalyze commercialization by encouraging companies to look for private investments and partnerships, as well as generate product and technology licenses. The commercialization focus of the NSF has helped their grantees succeed because private investors can give insight and capital to the product's development.

The SBIR program at the DOE is one of the larger programs, awarding over $100 million per year in grants (SBIR, 2013b). There is also a fairly significant overlap between the scope of the DOE's SBIR program and the EPA's, as the topic of clean energy is pertinent to both departments. However, the DOE SBIR program's large budget allows it to expand into the basic sciences area, in addition to its other primary concerns, such as nuclear security (U.S.D.O.E., 2013). These basic sciences include materials, life, and environmental sciences, which have a more indirect impact on energy policy. Like the EPA, the DOE also follows a three phase program, though the awards for Phase I and II funding are generally larger. In recent years, the DOE has shifted focus to commercialization by requiring evaluation of commercialization potential prior to Phase I or II funding. This change has pushed companies toward developing technologies that can be practically incorporated in consumer products.

Similar to all agencies, the DoD SBIR program follows the same policies, enacted by the Small Business Administration (SBIR, 2013). Under this directive, the DoD utilizes the three phase commercialization process outlined earlier (See Section 2.3). As the largest program, the DoD SBIR is composed of ten programs including the Army, Navy, and Air Force (Ujvari, 2004). These programs conduct internal reviews of SBIR proposals, unlike the external review process of the EPA SBIR. This type of review process tends to take less time to conduct because the time needed to contact and select external reviewers is avoided (Brooks et. al., 2006).

To make the process even faster, the DoD SBIR program offers a fast track option to applying companies that have matching funds from outside investors (DoD, 2013). After Phase II proposals are accepted, the DoD offers a Phase II Enhancement/Plus program to funded companies. This program offers annual contracts which match up to $250,000 of non-SBIR funds. One major element of the DoD SBIR program is its direct aid in the commercialization process. Typically, DoD acquisition programs and defense prime contractors are the initial consumer of the final technology (Ujvari, 2004). Therefore, the DoD helps fund the company from startup to its initial product sale. To achieve this, approximately $1 billion is set aside for the program, making it the highest funded SBIR program out of the 11 agencies (Rudolph, 2012).

Another agency that participates in the federal SBIR program is the Department of Education (ED) (ED, 2013). The ED has SBIR programs at two offices within the agency: the Institute of Education Sciences (IES) and the Office of Special Education and Rehabilitative Services (OSERS). These offices work to fund the research and development of products that improve student outcomes in education delivery settings (e.g., schools through grade 16, after-school programs), and to make teacher instructional practices more efficient (IES, 2013). Examples of funded product areas include learning software and web-based instruction technologies. The ED SBIR program utilizes video submission requirements for their funded businesses to showcase their technologies to potential stake-holders.

Each SBIR program is unique to its host agency, to better fit the needs of that agency. However, each program aims to commercialize technologies, so many successful principles can still be adopted by other agencies.

2.6 Commercialization

An indicator of success is whether a company has commercialized its product. According to Udell and Hignite (Professors in the College of Business at Missouri State University) (2007), "One of the ironies of the industrial innovation process is that high market potential is in itself a risk factor that must be reckoned with in launching a new product as new products place greater demands on firm resources" (p.75). Commercialization failures can not only lead to a product failure, but also to the failure of a company. To check for potential market failures, companies hire external auditors to predict the future success of a product before it is distributed. External review is valuable for companies wishing to avoid potential sources of product failure.

Unsuccessful commercialization of technology usually results from failures in one of three main areas: product, strategy, and experience-related factors (Udell and Hignite, 2007). Product failure refers to management neglecting to end a project when it is necessary or to correct a project when it is needed. Strategy based failures are caused by using an ineffective method when launching a product. Experience-related failures refer to management's inability to assess the success of commercializing a product in its initial phases of development. However, failures in these areas often result from the management's failure "to pursue development and commercialization in an objective manner" (p. 2). This means that entrepreneurs may not try to search for commercialization opportunities, which can be detrimental to product sales when putting a product out on the market. In order to commercialize their technology, entrepreneurs must have the right skill set.

2.7 Entrepreneurial Skills

The success of a small company in the market is dependent on the entrepreneur behind the idea as much as it does on the idea itself. Jon P. Goodman (1994), Director of the

Entrepreneur Program at the University of Southern California, points out that, if there is not a strong entrepreneur to put an idea into play, it will most likely fail. Many scholars have identified key characteristics of good entrepreneurs. However, passion, deep-knowledge, and decision-making seem to be the most significant in defining the characteristics of successful entrepreneurs.

It is crucial to look for signs of passion and self-determination in an entrepreneurial candidate. Goodman (1994) says that, when examining if there is passion, it is important to ask the following questions: "What's the passion? Does the person speak with confidence, with in-depth knowledge of the market and the industry? Has he or she conducted months and sometimes years of investigation, done due diligence, acted creatively?" (p.29). All of these questions reflect the preparation and future success an entrepreneur may have.

Imagination, defined as being able to develop alternative ideas when problems arise, is another important trait of an entrepreneur (Goodman, 1994). Successful entrepreneurs can have failures, but they interpret past unsuccessful projects as learning experiences. Those who view themselves negatively and make excuses tend not to move forward successfully. In contrast, those who make the most of what they have and create innovative ways to handle a situation have a higher chance of success. Entrepreneurs can choose to move forward by seeing every unexpected situation as a challenge rather than as a crisis, rendering them instrumental in moving the company toward success.

2.8 Previous Studies on EPA SBIR Program

An Interactive Qualifying Project (IQP) done by WPI students (Brookes et al., 2006) focused on potential improvements to the SBIR program. This group interviewed 11 successful companies that had received EPA SBIR funding to gather information on their experiences in

developing a product. They focused on the technology continuum and how the SBIR program fit their assistance into this structure. This research also contained information and a comparison of the EPA's SBIR program to other government programs. The recommendations developed were that the amount of funding and commercialization assistance the EPA provides should be increased, and that the length of the proposal review process should be shortened.

Foresight Science & Technology additionally distributed an electronic survey to companies funded through the EPA SBIR program from 2007 to 2013. Their survey was created to identify the general successes of the EPA SBIR participants with regard to awards and commercialization, details of commercialization, and details regarding Foresight Science & Technology as the commercialization support contractor. There were 36 respondents out of a potential 162, giving a 22.2% response rate. The researcher concluded that the majority of commercialization happened within three years of their Phase I award. It was determined that the primary reason for unsuccessfully commercializing technologies was technical immaturity and lack of funding. Lastly, it was concluded that companies appreciated direct interactions with mentors and the EPA's webinar series that highlight proposed technologies.

Another survey done by a fellow with Association for the Advancement of Science assessed the EPA SBIR Phase II program. The study was conducted from 2006-2008 on companies that were awarded funding from 1990 to 2007. The focus of the survey was to identify areas of improvement for the EPA SBIR program, specifically in how to better commercialize technologies. The findings of the report show that the EPA SBIR program is effective at assisting the development and commercialization of technologies in comparison to other SBIR programs. It was also found that the EPA's SBIR funding was critical to the potential success of proposed projects. Final recommendations were made to continue commercialization

data collection, possibly through an online survey, as well as to add structure to the peer review process.

2.9 Summary

The SBIR program gives opportunities to small enterprises in a wide range of fields. The EPA, in particular, gives small technology companies a chance by giving them funding necessary to develop green commercial products. However, the EPA must choose which applicants to support. The goal of the SBIR program is to give government funding to companies to create a commercial product out of research. Therefore, the EPA must keep in mind that, just as the scientific merit of the product is important, both the entrepreneur behind the product as well as market demand are equally essential to achieving success. The EPA tries to select applicants who have the highest chance of having commercial success by evaluating their current status and proposal for further development. Past evaluations of the EPA's SBIR program have been conducted, but their focus was on the Phase III commercialization assistance and the program's effectiveness as a whole. The studies neglect how to better select companies by aligning the effect of the entrepreneur with the success of the company. The studies failed to make comparisons with private and government programs. The previous research also did not take into account the suggestions of the companies that did not receive Phase II funding that went through the SBIR program. Our methods were developed to address the gap in research and to make new recommendations to the EPA on how they can improve their SBIR program.

3. Methodology

The goals of this project were to determine the traits of successful green technology entrepreneurs and make recommendations for the improvement of the EPA SBIR program's selection and commercialization assistance processes. We developed our methodology to identify: successful and unsuccessful EPA SBIR program proposals; trends among these ventures; and effective methods of selection and commercialization assistance for the EPA SBIR program and other federal SBIR programs. In this chapter we outline our approach that used both qualitative and quantitative research methods to achieve our goals.

3.1 Identifying EPA SBIR Companies to Target for Communication

There were 413 awards granted by EPA SBIR funding in the last 10 years (SBIR 2013b). While receiving data from each company would be ideal, it is not feasible due to business failure and lack of willingness for correspondence. We needed to target a diverse, but realistic, number of companies with which to make contact. Outlined in sections 3.1.1 and 3.1.2 are the methods we used to identify companies.

3.1.1 Identifying Successful Business Ventures Funded by the EPA SBIR

Initially, the EPA suggested that we select a sample of 10 SBIR program funded companies that experienced commercial success. Our team used archival records of green technology companies considered successful by the EPA to reach this number. The EPA (2013f) has a record of success stories as well as previous survey data collected by Foresight Sciences and Technology and the American Association for the Advancement of Science (AAAS). From these sources, we chose companies that most strongly exhibited characteristics of success in

commercialization. Success was defined by using information from commercialization expert Norton Kaplan of Foresight Sciences and Technology (See Appendix K for Interview Transcript). In order for a company to be successful, at least one of the following criteria had to be met:

- The company has returned a profit greater than the amount of money the company was awarded through the EPA's SBIR program
- Rights to produce the product or service have been bought by another company, where they were used independently or developed further
- The product or service has been widely utilized in its niche market or has a high market share.

These criteria allowed our team to assess the success of green technology businesses in terms of commercialization and contribution to environmental protection.

3.1.2 Identifying Companies with Unsuccessful EPA SBIR Proposals

To fully understand how success is achieved, we must also understand the challenges that SBIR funded businesses face. Information from SBIR funded companies that have had unsuccessful proposals gives us insight into these challenges. We identified a sample of 7 companies with unsuccessful SBIR proposals and compared them with successful business ventures. Companies with unsuccessful EPA SBIR proposals were defined as companies that were not able to get Phase II funding from the SBIR program after receiving Phase I funding.

There are currently few data on unsuccessful companies; thus, to get valid information, our unsuccessful sample group consisted of principal investigators who have had both successful and unsuccessful Phase II EPA SBIR applications. We decided to use this as our sample, as

opposed to companies that have had only unsuccessful applications, because we believed that the principal investors would be more apt to talk with us about their unsuccessful proposal experiences. Additionally, since these entrepreneurs have had unsuccessful proposals in the past, they would have first-hand experiences with the challenges faced when commercializing their technologies. We asked these interviewees to contrast their past experiences with successful and unsuccessful Phase II applications, attempting to isolate the significant factors that contribute to a project's success. Through the use of the EPA's (2013f) online database, we narrowed the total population of funded companies to those with both successful and unsuccessful proposals.

3.2 Interviews with Company Representatives

We interviewed representatives from 13 EPA SBIR funded businesses, and 2 non-SBIR funded green technology companies to inquire about their experiences in the green technology market.

3.2.1 Interviews with Successful EPA SBIR Funded Businesses Representatives

We contacted companies identified through the methods of section 3.1.1. Our questions were designed to elicit responses regarding the company's process of becoming successful and their perception of the value of the contribution of the EPA SBIR program (See Appendix B for Interview Protocol). Open ended questions were used to gather information on past experiences in the green technology market. By interviewing representatives from multiple companies, we were able to make meaningful generalizations on small businesses that received EPA SBIR funding.

3.2.2 Interviews with Representatives from Companies with Unsuccessful Proposals

Interviews with businesses that have had unsuccessful EPA SBIR proposals provided qualitative data from a primary source (See Appendix C for Interview Protocol). Companies with unsuccessful SBIR proposals were selected using the methods outlined in section 3.1.2. All interviewed companies also had a technology that successfully moved through the SBIR process. A comparative analysis was made by using similar questions for both successful and unsuccessful groups. Interviewing representatives from companies that had both successful and unsuccessful SBIR proposals allows us to ask representatives what they did differently across their ventures and draw our own conclusions based on the information they provide.

3.2.3 Interviews with Successful Green Technology Company Representatives

Green technology entrepreneurs outside the SBIR program also provide valuable insight regarding effective methods of technological product commercialization and successful entrepreneurial characteristics. Since we were looking for information regarding commercialization, we selected companies that successfully created a commercial product in the green technology field. Our open ended questions were focused on the commercialization process and how the EPA can improve their assistance (See Appendix D for Interview Protocol). We compared the approaches of green technology entrepreneurs not funded through the EPA SBIR program to those who received support. Through this comparison, we identified methods of funding and commercialization assistance to recommend to the EPA. Additionally, questions tailored towards identifying entrepreneurial characteristics were asked in order to achieve an understanding of what distinguishes a successful green technology entrepreneur.

3.3 Electronic Questionnaire Distributed to EPA SBIR Companies

Our team additionally distributed an electronic questionnaire to EPA SBIR recipients in order to obtain quantifiable data for trend analysis (See Appendix A for Questionnaire). The questionnaire results were used to formulate recommendations to improve the EPA SBIR program. We sent our questionnaire to representative principal investigators from companies that were awarded Phase I and Phase II SBIR contracts from 2007-2010 (See Appendix L for list of companies). A minimum time frame of 3 years is sufficient for green technology businesses to get their product in the market (Norton Kaplan, personal communication, September 25, 2013). The questionnaire was designed to be answered for each project selected by the EPA. In total, 84 projects were awarded Phase I awards during this time frame from 77 different companies (EPA, 2013h). To maximize our response rate, we created a questionnaire with fewer questions than previous questionnaires. The questionnaire by Foresight Sciences and Technology asked 17 questions and the survey conducted by the AAAS asked a total of 26 questions (Norton Kaplan, survey, 2013)(Yee San Su, survey, 2008). Our questionnaire consisted of 12 questions that were designed to be completed quickly by our respondents. The relatively small number of questions increased the likelihood of recipient responses due to relatively low time requirements for questionnaire completion.

The questions focus on commonly acknowledged reasons for unsuccessful and successful commercialization among EPA SBIR funded companies, the effectiveness of the EPA support system, and contract recipients' perception of the program as a whole. We compared successful and unsuccessful Phase II proposals within the same company to identify the factors that are essential in predicting future commercialization prospects. The information gathered from the

questionnaire helped us to formulate recommendations intended to improve the success rate of the EPA SBIR's funded businesses.

3.4 Comparison of EPA SBIR program to Similar Programs

In order to develop recommendations for the improvement of the EPA SBIR program, we compared information gathered from similar organizations such as Cleantech Open and other SBIR programs within the DOE, NSF and Department of Education (ED). These programs share the mission to commercialize technologies started by entrepreneurs and small businesses, but have their own processes that work towards achieving this goal. From the information gathered, we identified the methods each program utilizes in order to select and support green technology entrepreneurs. The methods identified were then compared to the existing approaches of the EPA SBIR program to assist us in formulating recommendations to the EPA.

3.4.1 Interview with Southeastern Regional Director of Clean Tech Open

In order to gain a full understanding of green technology entrepreneurship and how to successfully commercialize green technologies, we interviewed Joshua Greene, Southeastern Regional Director of Cleantech Open (See Appendix I for interview protocol). This organization is a non-profit entity focused on assisting clean technology startup businesses (Cleantech Open, 2013). This organization is the world's largest accelerator of clean technology startups and aims to find, fund, and foster entrepreneurs with ideas that address priority environmental issues. Due to the similarity of the company's mission to that of the EPA SBIR program, it was of value to our team to understand how this organization operates with such success.

We constructed our interview to identify what qualities Cleantech Open looks for when selecting green technology entrepreneurs and how the company supports those entrepreneurs once they are selected. As an agency with limited funds, the EPA shares economic challenges similar to those of a non-profit organization such as Cleantech Open. Thus, we additionally asked for our subject's opinion on what the EPA and other government agencies could do in order to have a higher rate of commercialization success other than by simply increasing award amounts.

3.4.2 Interviews with non-EPA SBIR personnel

Qualitative information obtained from interviews with SBIR personnel (See Appendix E-G for interview protocol) was valuable in improving our team's understanding of the strengths and weaknesses of the program. Open ended questions were asked of personnel from other federal SBIR programs within the DOE, NSF, and ED. These individuals were identified through our liaison as being experts within their respective SBIR programs. These interviews were constructed to enable us to discover what differing and effective methods other agencies use to improve commercialization rates for green technology companies. The feasibility and possible effectiveness of these methods was analyzed for the EPA.

3.4.3 Interview with Venture Capitalist

We interviewed Kevin Brophy, co-founder and Managing Principal of Meidlinger Partners, LLC, in order to gain insight on how to select and support green technology companies from a venture capitalist perspective (See Appendix J for Interview Protocol). Meidlinger Partners, LLC is a company that invests in water technologies, products and services. We

developed interview questions to evaluate both the company's selection criteria for investments and support given to invested companies. Additional questions were formulated to gain insight on his thoughts regarding what makes a successful entrepreneur. We also included questions to understand the risk associated with early-stage ventures. Finally, we incorporated a question to determine how government investment programs, such as the EPA's SBIR program, can improve.

3.5 Summary

Through application of the methods outlined in this chapter, we collected data suitable for analysis and the eventual formulation of recommendations to the EPA. Our methods were comprised of interviews, questionnaires, and archival research in order to recommend policies for reducing the number of unsuccessful commercialization ventures within the EPA SBIR program. The similarity of the methods used when analyzing all SBIR-funded companies allowed for valid comparison, strengthening our recommendations regarding the award selection process. The previously mentioned interviews, questionnaires, and research were designed to evaluate the effectiveness of SBIR support to the companies as well. By interviewing companies outside the SBIR Program, we were able to effectively identify other criteria for programmatic success. We gathered information on programs similar to the EPA SBIR program, including other agencies' SBIR programs and the programs of Cleantech Open, providing knowledge of additional techniques that are used to better select companies for funding and to promote success of small green technology businesses. This data was also used to create recommendations to assist the EPA in their mission, "to protect human health and the environment."

4. Results

Following the methods outlined previously, we conducted interviews and distributed a questionnaire to gather data from which we could develop recommendations. This chapter focuses on collected information that we found most important and the analysis of this data. For all the raw data gathered from interviews and questionnaires, see Appendices M throughU.

4.1 Identified Successful Business Ventures Funded by the EPA SBIR

Through the use of methods detailed in section 3.1.1, six successful EPA SBIR funded businesses were identified for further research. To compile a sample group for interviews, we chose businesses listed on the EPA Success Stories portal that best exemplified our definition of success. These companies exhibited success in commercializing their technology and positively impacted the environment. The list of companies and their descriptions can be seen below in Table 1.

Table 1: Successful EPA SBIR Funded Green Technology Companies

Company Name	Topic	Proposal Name	Description
Ecovative	Green Buildings	Development and Demonstration of a Low Embodied Energy, Construction Material that Replaces Expanded Polystyrene and Other Synthetic Materials	Technology is an eco-friendly packaging material that emits 5 times less CO_2 and uses 10 times less energy than traditional expanding polystyrene technologies Fortune 500 and other large companies use their packaging material 2013 Tibbetts Award for excellence in Small Business Innovation Research
Cambrian (formerly IntAct)	Water/waste	Bio-Electrochemical Systems for Ethanol Wastewater Treatment	Wastewater treatment system developed to monetize resources in waste streams. Generates electricity while reducing CO_2 emissions. Works with global corporations and has commercial partners 2012 Artemis Top 50 Water Tech Listing
Bridger Photonics	Air Pollution	Hand-Held Sensor for Remotely Mapping Carbon Dioxide Pollution Sources	Developed affordable hand-held sensor to indentify emission source and quantity of CO_2 concentrations up to 100 yards away. Boosted company revenue from $110K to $ 2 million in 4.5 years through sales. Inc. Magazine ranked Bridger Photonics #1 fastest growing engineering sector company in the US in 2011 due to sensor technology.
Green Building Studio (formerly GeoPraxis)	Green Buildings	Streamlining Green Building Design: Developing Requirements for the Sustainable Design Suite	Web-based modeling tool to stream-line and improve the design of sustainable buildings by giving consumer access to their building's energy, water, and carbon emission performance at a lower cost than traditional methods. Acquired by Autodesk Inc. as a sustainability tool for its end-users 2008 Gold Ingenuity Point Award Winner recognition from Microsoft
Aerodyne	Air Pollution	Remote Sensing Instrument for On-Road Heavy-Duty Diesel NO_x and PM Emissions	Developed numerous technologies for real time and mobile air pollution monitoring such as aerosol mass spectrometers and NO_x monitors. Commercialized technologies to industrial, academic and government laboratories.

Physical Sciences	Monitoring	Handheld Laser-Based Sensor for Remote Detection of Gas Leaks	Vehicle-mounted natural gas leak detector developed to identify source of emissions from pipelines; thus, improving sustainability of natural gas pipelines. Gained commercial partnerships with other companies and have had sales.
Faraday Technologies Inc.	Pollution Prevention	Environmentally Conscious Electrochemical Machining for Zero Discharge and Metal Recycling	Environmentally beneficial alternative chromium coating technology that effectively replaced the usage of Cr^{+6}, listed as one of EPA's "high-priority" toxic chemicals. Revenue generated and strategic partners gained.

4.2 Identified Companies with Unsuccessful EPA SBIR Proposals

Using methods from section 3.1.2, a list of seven companies with unsuccessful proposals funded through the EPA SBIR program were identified to be interviewed. This list was created from the information detailed on the EPA SBIR Award webpage. Principal investigators that have had unsuccessful and successful Phase II proposals through the EPA SBIR program were chosen, but we must keep their company's names confidential to ensure their future endeavors are not negatively impacted.

4.3 Data from Interviews with Company Representatives

The majority of our information was gathered through interviews with representatives from EPA SBIR-funded and non-EPA SBIR-funded companies. This chapter is split based on the type of company being analyzed. These sections contain analyses of the responses within each grouping. Raw data sets can be found in the Appendices.

4.3.1 Interviews with Successful EPA SBIR Funded Businesses Representatives

After interviewing six companies we were able to learn about successful green-technology small businesses. For summaries of the individual interviews, see Appendix M. Most of the companies we interviewed had little or no initial capital. This led many of the companies to get funding by making strategic alliances with other companies. Each company also had a product with a potential for broad market appeal. They each located end users and made attempts to market their products through the use of vehicles such as expos, posters, and consultants. Their products were unique enough that most of the companies we interviewed did not face a lot of competition in

their respective fields. By evaluating past experiences, company representatives described the importance of receiving feedback about products before producing them and made sure there was a need for the product in the market. Those two elements are important to a venture's success, which is why most company representatives stated that an entrepreneur needs to be able to understand the market.

4.3.2 Interviews with Representatives from Companies with Unsuccessful Proposals

Through the analysis of the seven interviews held with unsuccessful Phase II applicants, we were able to look for commonalities between responses. Noticeable trends could be compared to successful companies, as many of the questions were the same. For summaries of the individual interviews, see Appendix N.

One significant area where unsuccessful commercialization attempts differed from companies that successfully commercialized was the presence of business partners. While some of the businesses with failed commercialization attempts had partners, nearly all of the successful companies had significant partnerships that helped them either fund or market their product. Many of the successful companies found a demand in the market, and then started developing from there. In contrast, several of the unsuccessful proposals were technologies that did not have a high demand in the market place, making end users and business partners harder to locate.

Some of the companies failed to commercialize due to development issues rather than because of commercialization problems. A few of the companies we interviewed said that their technology never made it to the point of commercialization because it was never fully developed. Of these, there were two causes that came up more than once.

The first of these was lack of funding. While this can be tied to the absence of business partners, it can also be attributed to the small size of the EPA's SBIR awards when compared to other SBIR programs. Some interviewees expressed that the approximate $300,000 Phase II award that the EPA provides is not enough to commercialize most technologies without outside supplementation. To address this issue, the EPA should look into potentially increasing award size. The Phase II awards at the DoD and NIH are closer to $1 million, which allows the companies to develop their technologies much further. The EPA's lack of funding is shown in the chart below, which compares the EPA's award sizes to other agencies and the SBA suggested award size.

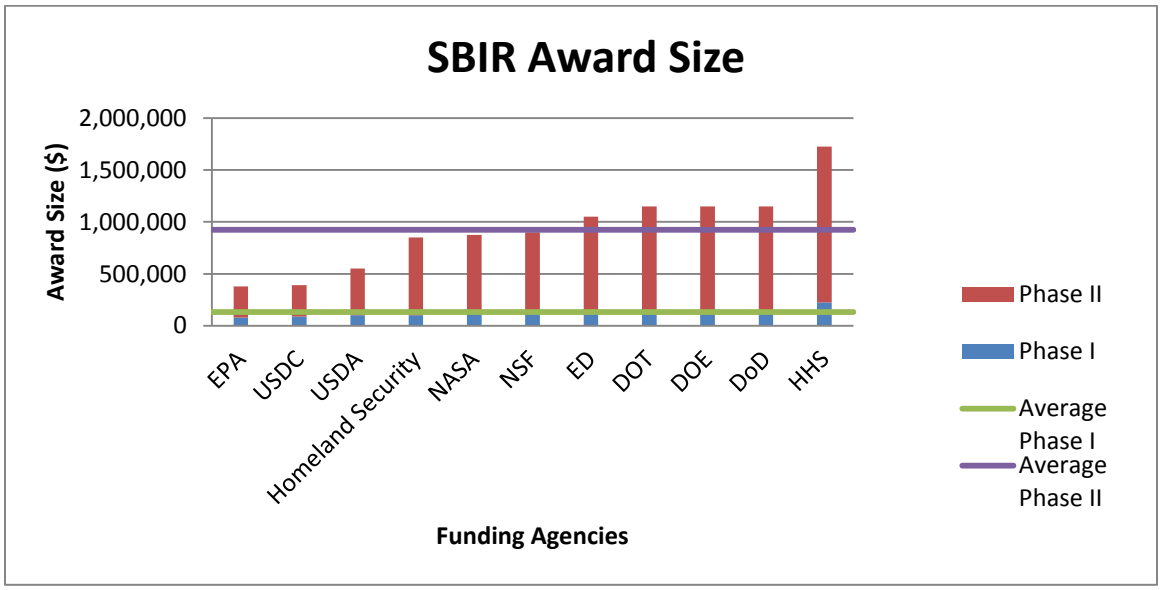

Figure 2: Comparison of Agency Award Sizes (SBIR, 2013b)

The second frequently recurring answer that we got was the presence of technical issues. Some funded technologies were not feasible to be created or scaled to the desired size. These failures are inherent when funding high-risk endeavors, but ideally this

occurrence would be minimized. Not all companies received external evaluations of their technology, which would have helped these companies determine what is feasible.

4.3.3 Interviews with Non-EPA SBIR Funded Successful Green Technology Company Representatives

In order to get information from green technology companies that did not receive SBIR funding, we interviewed representatives from two companies that received the Presidential Green Chemistry Award. Since these companies did not receive EPA SBIR funds, they needed to get capital for developing their product by other methods. They had close partnerships with their end users from the beginning of the development phase of their technologies. Networking within their respective industries made it easier for the product to be adopted. These companies both had a marketing staff and professional advisors. Both of the companies' representatives stressed the importance of basic market knowledge and understanding how the product fits into the market. Both representatives talked about how difficult it is to market a product based solely on its environmental impact. There must be another incentive for the end users to buy it. If a green approach is more cost effective or offers a more robust solution than competitive technologies, then it is more likely to be accepted.

4.3.4 Comparison of Interview Data from All Interviewed Company Representatives

Through our interviews, we found that differences between successful and unsuccessful technologies are small in number, but have a large impact. The companies that successfully commercialized their product, both SBIR funded and otherwise, developed a technology to fit a direct need in the market. Some of them aimed to fill a gap, where there was no existing technology. Other companies created a replacement

technology that was more efficient than a preexisting product to make sure they had a solid base of potential end users. Either way, having interested parties is very influential when attempting to commercialize. Along the same lines, the successful, non-SBIR companies collaborated with larger, more established companies for assistance. Many of the successful SBIR companies had internal or external marketing personnel, while the less successful businesses tended not to. A notable difference between both successful green entrepreneurs and those still striving for commercial success was seeking and adapting to customer needs. If customers are given the opportunity to make suggestions to the green technology start-up early on, the company can attempt to tailor further development toward the customers' desires. This helps ensure that end users will be present when the scientific work is done. In general, the more connected a company was with the business side of entrepreneurship and its customers, the more likely it was that they were ultimately successful. Table 2, below summarizes the differences we found between green technology companies.

Table 2: Distinctive Characteristics of Companies by Category

Successful EPA SBIR Funded	Unsuccessful EPA SBIR Funded Phase II Proposals	Successful Non-EPA SBIR Funded
• Determined the demand of the market before development • Developed technologies that had little competition • Located potential end-users/investors/partners prior to development • Sought feedback from consultants and customers	• Appeal for product not broad • Problems finding outside investment • Did not seek commercialization or technical review from external parties • Technical/Feasibility Issues • Non-existent marketing personnel	• Located end-users prior to development • Market demand a key aspect of research • Dedicated marketing staff • Collaborated with other more established companies for assistance

4.4 Data from Interviews with Similar Programs

When attempting to make improvements to a program, it is logical to look at other programs with similar goals and compare methods. We set up interviews with the program managers of three other SBIR programs and the Southeast Regional Director of Cleantech Open to search for effective methods they use when supporting companies trying to commercialize.

4.4.1 NSF SBIR

Our team gathered data regarding the methods of selection and support at the NSF SBIR program from an interview with their Program Director, Dr. Prakash Balan (See Appendix P). Starting with the application process, companies can apply for a broad assortment of grant-based SBIR awards. Having a wide variety of non-specific topics allows the applicant to find a topic that pertains to their idea. The topics cover a very broad spectrum of technology fields such as Chemical, Materials, Environmental, Biotechnology, Biomedical, Health, Manufacturing, Nanotechnology, Information Technology, and Educational Applications. If there is no topic area that is applicable to a potential applicant's idea, the NSF SBIR program will consider adding an area to the next fiscal year's research topics. Small businesses are strongly encouraged to engage in a conversation with an NSF Program Director to share their proposed idea and assess alignment with the NSF funding philosophy. Prior to proposal submission, entrepreneurs are allowed to submit an executive summary to the NSF for feedback on their proposed technology. The NSF application process is efficiently handled through NSF's FastLane system. This online interactive system was developed by the NSF and is used as the mechanism for applications to NSF's funding solicitations. Awardees use a combination

of Fastlane and Research.gov to interact with NSF. Research.gov is NSF's grants management system. This website provides access to information related to research and grants management services in one location (NSF, 2013a). The Program Director described the process as a reliable and systematic way for companies to receive guidance through the application process. Help is provided through the FastLane website as well as through in-person IT Help. FastLane is available to the public, and can be used not only by principal investigators of companies, but also NSF personnel and external reviewers. Review meetings are usually done as onsite one-day meetings. However, in the interest of cost effectiveness, the NSF has sought to run smaller panel reviews (with small numbers of proposals, typically 6 or less) as "virtual review" meetings, using web conferencing tools such as WebEx. Reviewers receive proposals four weeks ahead of the panel meeting date and typically review 6-8 of them. They submit their reviews through the FastLane web interface and later meet in person to assess each proposal. A new document is created during the meeting that summarizes the panel's consensus view. All individual reviews and the panel summary are made available verbatim (with reviewer identification redacted) to the applicants. After the decisions are conveyed to the applicants, NSF Program Directors provide debriefs through email or phone to applicants. This feedback is often used by applicants seeking to resubmit a better proposal to NSF for future review, or is used in general as valuable feedback for internal company use. The discussion is comprehensive, covering both technical and commercial aspects of the proposal. A key strength of the team managing the NSF SBIR program is that each Program Director has R&D and commercialization experience with both small businesses and large companies. Many have been entrepreneurs, having founded and run

their own technology businesses. The Program Directors are thus able to provide advice and mentorship in the management of the NSF awards.

Once the Phase I process is completed, awardees can apply for a Phase II Grant. The Phase II review process involves a team of reviewers of both technical experts and people with strong commercialization and business experience. The Phase II review process involves an in-depth review of the technical and commercial aspects of the proposals. The success or failure of Phase I funded activity completed by the applicant is critically assessed by reviewers to provide advice for the NSF's Phase II funding. NSF also conducts a financial capability review of companies being considered for funding to ensure that they are financially able to execute the funded R&D work. Companies that receive an NSF Phase II grant have, as mentioned earlier, access to additional supplemental funding to enhance their R&D program. The supplemental funding options available to Phase II grantees help broaden participation by involving undergraduates, teachers, post docs, community colleges, historically black colleges and universities, and veterans. One specific funding opportunity is the Phase IIB supplement. Before Phase IIB funding is awarded, the applicant must submit another proposal through Fastlane for NSF review. In addition to Phase II awards, this unique feature allows supplemental funding to companies that show proof of a third party investor or partner that has made a financial commitment with no claw backs and is date certain. The NSF SBIR program views such an event as potential market validation and will match up to 50% of the third party investment (up to a set limit of $500,000). Also, for requests where the NSF match exceeds $250,000, the company and the third party investor are required to make a presentation to the NSF SBIR Program Directors. This allows the NSF to assess how committed the third party is to the applicant's technology. Throughout the process, the

NSF approach seeks to identify and support ideas that meet its philosophy of funding innovations with broad impact that need capital to overcome the high risks of failure. Typically NSF funding has a larger risk profile compared to private funding/financing mechanisms and is often a significant indicator of quality used by the investment community.

4.4.2 Department of Energy SBIR

Interviews conducted with Tina Kaarsberg, DOE SBIR Program Manager, provided insight into the unique features the DOE utilizes to aid in the selection and support of funded businesses (See Appendix Q for Interview Transcript). Their program internally develops annual research topic areas for applicants based on the agency's respective administrative offices. For example, the Office of Nuclear Energy has topic areas that pertain specifically to their needs while the Office of Fossil Energy has their own separate topics that suit them. The allotment of topic areas to offices within the DOE aids in ensuring that funded research aligns with the agency's mission. In total, there are 22 topic areas for FY2014, each with subtopics that clearly define the technologies the DOE is interested in funding. The broad assortment of topic areas helps the applicant determine if their technology fits within the criteria the DOE has established. A unique aspect of the DOE SBIR program is its grant-based awards, as opposed to contractual awards. Grants offer the companies more freedom by not having certain legal requirements such as reporting requirements and payments that are dependent upon visible progress that are often necessary when developing a government contract. Grants are governed by the individual terms of the grant, contracts require the awardee to comply with Federal Acquisition Regulations(Michigan State University, 2011). To streamline the commercialization process for its applicants, the DOE utilizes a Fast-Track

option that combines Phase I and II awards for companies with technologies that seem to have a high chance of commercialization. The combination of phases allows funded businesses to take their technology to the market at a faster rate than if they had to apply for each phase separately. Additionally, the DOE is partnered with commercialization assistance vendor, Dawnbreaker Inc., to support funded companies similar to the way the EPA is partnered with commercialization assistance vendor, Foresight Science & Technology. Funded businesses can opt to receive support from this vendor if they apply for the Commercialization Assistance Program (CAP) with the DOE. Feedback is additionally given to funded businesses that participate in a kick-off meeting with agency personnel to practice presenting their technologies.

4.4.3 Department of Education

Based on an interview with the SBIR program manager at the Institute of Education Sciences of the Department of Education (ED), we gathered information regarding certain innovative approaches of selection and assistance (See Appendix R for Interview Transcript). One unique feature of the ED SBIR program is their video submission requirement. Phase I contract awardees applying for Phase II are required to submit videos for review by the agency, utilizing YouTube. The purpose of this video is to demonstrate the initial prototype of the funded technology. According to the program manager, the video has had a positive impact for proposal reviewers. The traditional process of reviewing electronic copies of proposals is mundane because of the length and technical detail. A simple four minute video, where the entrepreneur showcases the technology, allows reviewers to see how much progress has been made based on initial funding. Once Phase II awards are given out, awardees then submit a final video of their technology after funding has been exhausted. This video then is shown on the agency

website for marketing purposes and to direct inquiring stake-holders to the types of technologies which the agency funds.

Another method which the ED SBIR program utilizes is the Fast-Track option, a combination of Phase I and Phase II solicitations. Companies deemed to have high potential for commercialization can opt to apply for this expedited funding process. This feature attracts companies that are not interested in Phase I awards, because of the small award size in comparison to Phase II, and do not want to go through the long process of applying for Phase I and II funding. To help in the commercialization process, the agency's program manager personally aids the principal investigator by informing him or her of possible end-users and potential investors or accelerators for their technologies' niche market. The ED SBIR program uses a variety of unique and effective methods to select and support funded small businesses.

4.4.4 Cleantech Open

We interviewed Josh Greene, the Southeastern Regional Director of Cleantech Open, to get information regarding the type and extent of support that small businesses need and the traits of successful entrepreneurs (See Appendix U for Interview Transcript). Cleantech Open is the world's largest accelerator for clean technology start-ups.

This organization mentors entrepreneurs by assisting them in the development and commercialization of their technologies. Mentors are typically business oriented people with experience in entrepreneurship. Mentors provide support through sales pitch competitions, business workshops, and through facilitating connections within the industry. A unique feature of the Cleantech Open mentoring program is the requirement

that applicants speak with 100 potential customers in an effort to determine the market demand for their technology. This aspect of the program allows the entrepreneurs to develop their skills in communication and to identify issues with their product.

The Cleantech representative additionally explained the criteria that Cleantech Open uses for selecting small companies to support. First, reviewers within the organization must establish whether the product or service has an addressable market or not. Second, reviewers examine and assess the extent of the applicant's experience in starting up and managing a difficult company. Third, the entrepreneur needs to have interpersonal skills to effectively communicate what his or her technology is and what it accomplishes. In this interview, Josh Greene also discussed the traits he looks for when selecting an entrepreneur. The traits mentioned were ambition, intelligence and the ability to work in a team.

Josh Greene also provided valuable information on what he believes could improve the EPA SBIR process as a whole. He recommended more extensively marketing the SBIR program to small businesses. An example of this would be posting links to the EPA SBIR on websites which small companies may be searching, such as that of Cleantech Open. Similarly, he mentioned marketing the program to accelerators, incubators and institutions of higher learning. Another recommendation he provided was to make the application process user-friendly for the entrepreneur. The average entrepreneur may not be able to get through the process easily, which may discourage people or companies with promising products from applying.

4.4.5 Venture Capitalists

We interviewed Kevin Brophy, co-founder and Managing Principal of Meidlinger Partners, LLC, a company that invests in water technologies, products and services, as a subject matter expert in the venture capitalism sector (See Appendix S for Interview Transcript). The intent of the interview was to gain insight on how to select and support green technology companies from a venture capitalist's perspective. From the interview, we determined that when investing in pre-developed green technology products, it is important to make sure the product serves an established need in the marketplace. Kevin Brophy additionally mentioned that there is no general method of selecting companies, as every company is different. The desired portfolio for Meidlinger Partners, would consist of companies at multiple stages of development, yielding a net return three times greater than the original investment. Funding is invested in rounds, which depend on the product's stage of development. Investments can be anywhere from $50,000 to over $1.5 million. It is possible for the size of these rounds to double or triple. Meidlinger Partners hopes these companies will later receive bank financing, so no further investments are needed. Typically, Meidlinger Partners supports companies anywhere from 2-5 years after initial funding. They provide other means of support in addition to funding. A member from Meidlinger Partners serves on the Board of Trustees of the new investment. They also offer the new companies research and marketing services, such as providing analysts for locating end-users.

Kevin Brophy also mentioned what Meidlinger Partners looks for in potential investment teams. He stated that they aim to find an all-star CEO (preferably experienced), a good technical staff, and promising marketing personnel. Also, he discussed what he believes makes a good entrepreneur. Brophy said that it is hard to tell, but you need someone who is a Renaissance person. This implies someone is well versed

in their respective industry, hardworking, and knows how to recruit, fundraise, and sell. Finally, he said that it is uncommon for an entrepreneur to have these traits without experience.

4.4.6 Determination of Effective Methods

The table below summarizes the unique characteristics of other organizations' selection and support processes, which were covered in depth previously.

Table 3: Unique Methods of Selection and Support Used by Other Organizations

Industry	Program	Selection Methods	Support Methods
Government	NSF SBIR	• Phase I and Phase II applicant interviews • FastLane & Research.gov system • In-person and Virtual Review Panels • Financial capability review of Phase II award prospects prior to award • Broad topics that can be influenced by applicants	• Entrepreneurial/business/R&D experience of the program managers • Grant based supplemental awards • Commercialization Planning assistance for Phase I and Phase II Companies • Funding for technology enhancement through commercial partnerships • Phase IIB funding
	DOE SBIR	• Specific Topics • Electronic Application	• Grant based awards • Commercialization Assistance program • Phase IIB • Fast Track
	Dept. of Education SBIR	• Phase II application video requirement • Electronic application	• Contract based awards • Final video submission • Personnel provides mentoring • Fast Track
Accelerator	Cleantech Open	• 100 Customer interviews • 2 Person presentation • Electronic application • Business oriented judging panel	• Business/Specialist Mentoring • Workshops • Mock presentations • Facilitate networking opportunities
Venture Capitalist	Meidlinger Partners LLC	• Market analysis of sector • Risk Analysis of investment • Models expected rate of investment • Detailed electronic summary	• Potential for large investment sum • Multiple rounds of investment as development progresses • Provides research and marketing support analysts • Helps locate end-users

We gathered information from a variety of perspectives (i.e., other SBIR programs, a clean technology accelerator, and a green technology venture capitalist company) to determine effective and feasible methods to be adopted at the EPA. A list of key methods of selection and support provided to small businesses from similar programs are tabulated above in Table 4. The intent of the interviews was to identify unique and effective approaches, but some trends were revealed. All programs utilize an electronic system for applying companies to ease the burden of requiring paper copies and to reduce the amount of time required for the application process. Another commonality in the data set reveals that multiple SBIR programs offer a Fast-Track option for interested businesses and provide mentoring through their personnel. In cases of personnel mentoring, program managers typically aid inquiring companies by personal communication, informing them of potential marketplaces for their technology and assisting with any business related questions. None of the interviewed government SBIR programs or venture capitalists displayed a systematic process for business training mentoring. Accelerators such as Cleantech Open are dedicated to mentoring entrepreneurs by improving their business skills and providing commercialization assistance. Cleantech Open developed a mentoring program with experienced green technology entrepreneurs and subject matter experts in which workshops, mock presentations, and networking opportunities are facilitated.

4.5 Electronically Distributed Questionnaire of EPA SBIR Companies

We emailed a total of 53 companies after eliminating companies that were contacted for interviews as well as companies with emails no longer in service. We received a total of 15 responses from principal investigators, a response rate of 28.3% (See Appendix T for Questionnaire Responses).

4.5.1 Analysis of Questionnaire Data

Through our questionnaire, we gathered important information from the opinions of principal investigators on the EPA's SBIR process as a whole, as well as information regarding their development and commercialization status.

After our interview with Cleantech Open, we formulated a few questions in our questionnaire to better view how entrepreneurs find and understand the EPA's process. We inquired about how each principal investigator heard of the EPA's SBIR program (See figure below). Many of them discovered the program through word of mouth from their colleagues, their company's previous involvement in the program, or their bosses. Others learned about it through emails, searching online or through the EPA's website. We found that there were few similar responses as to how each respondent became aware of the program. This data helped us understand how the EPA markets its program to potential small businesses that may be searching for green technology funding.

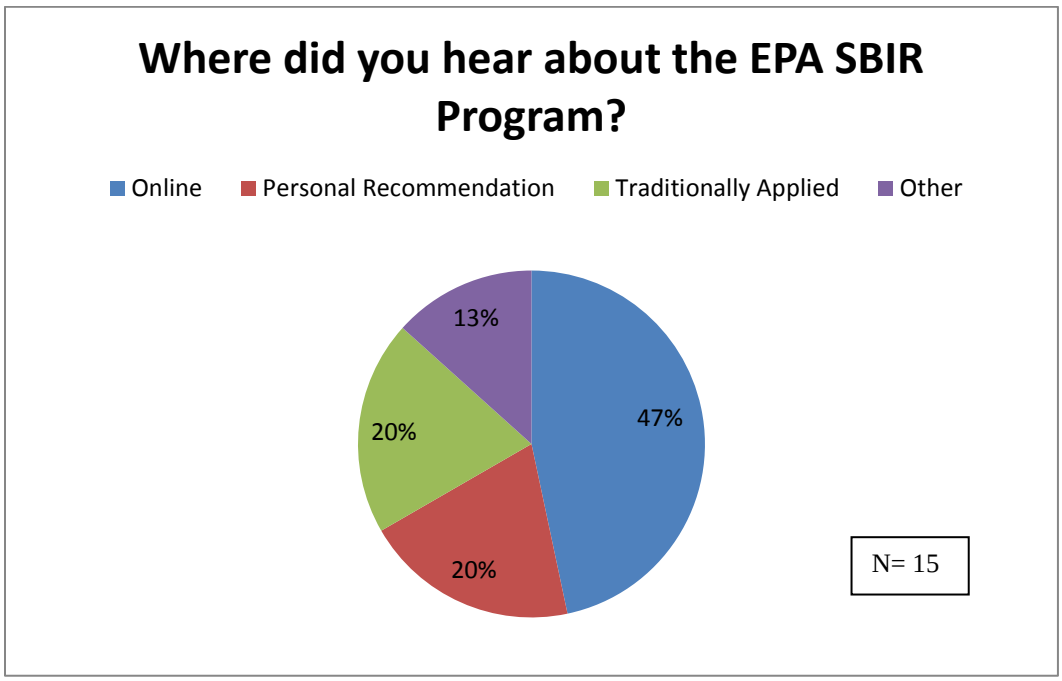

Figure 3: Pie chart showing where applicants heard about the EPA SBIR Program

We included a question on how entrepreneurs viewed the clarity of the application process. Josh Greene stated that the average entrepreneur might not understand the application process, which deters them from applying. However, that wasn't the case for our sample. The principal investigators that responded to our questionnaire replied with answers that ranged from neutral to very clear when rating the clarity of the application. These results may be skewed, however, as our sample was taken from entrepreneurs that successfully completed the application.

Josh Greene also mentioned how Cleantech Open utilizes a mentoring program for their start-up entrepreneurs, so we inquired in our questionnaire about the interest of entrepreneurs in the SBIR program. The results varied in this question. Ninety-three percent of respondents answered this question with responses between neutral and very helpful. However, one principal investigator viewed this idea to not be helpful.

Established companies may not have a need for a mentoring program, which is why our principal investigators may have different viewpoints on this topic.

We included a question on whether the peer review process provided helpful feedback, in order to assess the assistance which the EPA provided to the companies applying. The majority of entrepreneurs fell in between neutral and excellent on the Likert scale, when evaluating the peer review feedback. However, 3 responses fell below neutral, with two principal investigators believing their feedback was poor. A graph showing the exact distribution of answers is shown below, in Figure 4. This data may vary between companies because some products may have continued through to commercialization while other products halted or failed. Other agencies use other tactics when conveying feedback from peer-review, such as phone conferences.

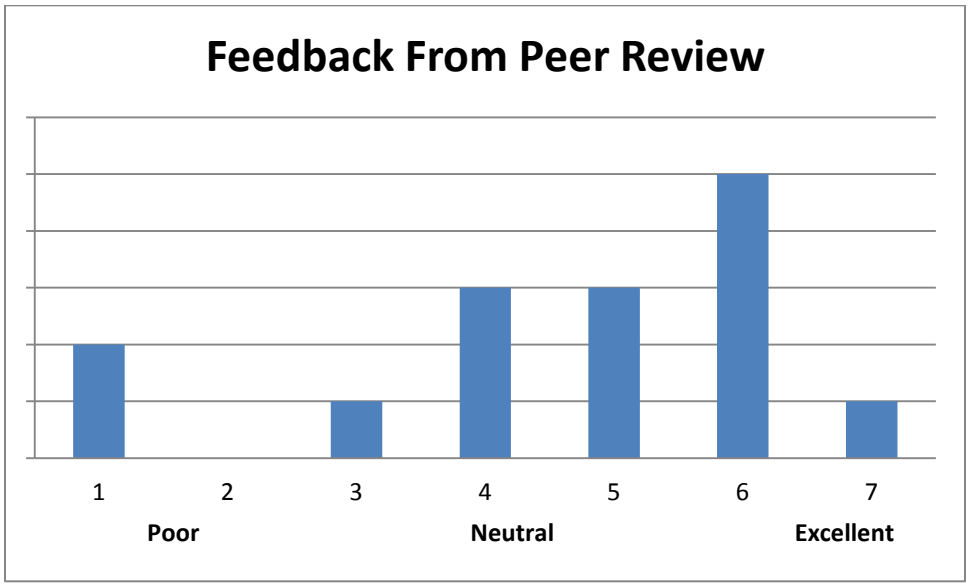

Figure 4: Rating Distribution for Feedback on Peer Reviews

In order to evaluate the effectiveness of the EPA's current commercialization contractor, we included a question as to whether or not entrepreneurs utilized Foresight's services. More than 75 percent of principal investigators used their services. However,

results varied when they were asked if the contractor was helpful. Some found the services to be helpful in providing valuable market data as well as disclosing possible partners that may interested in the developed technology. Others felt it was okay in only providing market data. One company stated Foresight might be more useful for newer companies, while the last company felt Foresight did not really understand their technology. A pie chart showing the distribution of responses to the question on Foresight's effectiveness can be seen below.

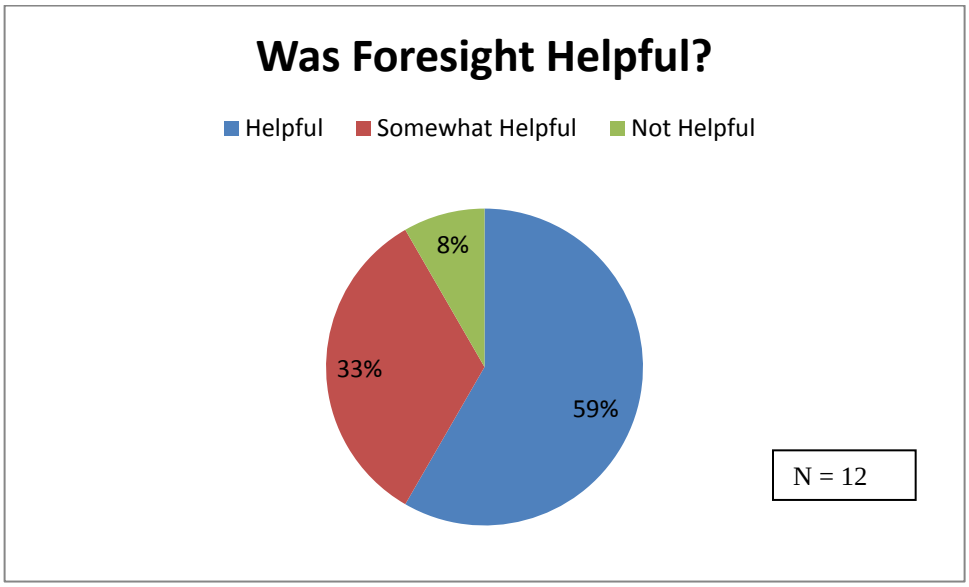

Figure 5: Was Foresight Science and Technology Helpful to Your Company?

We received several recommendations from entrepreneurs on how to improve the EPA's SBIR process. One discussed the implementation of mentors. This principal investigator stated that mentoring would be helpful only if the mentor has experience taking a product to market, rather than just providing market data. This person also mentioned that the EPA is not a first choice when looking for investments because its award size is smaller than other agencies. Another principal investigator commented on

increasing Phase II funding levels. This entrepreneur stated that EPA's Phase II funding is not enough to complete research and development. The last two recommendations focused on changing the application from a paper process to an electronic version. Some of these recommendations were already considered by our group, but are now supported by entrepreneurs that went through the process.

4.5.2 Response Rate Analysis

The responses of the questionnaire were based upon convenience sampling. This means that while we did receive a response from 15 companies out of a potential 53, we did not generalize these results to represent the overall group. As this group is quite heterogeneous, our limited response rate made developing generalizations for the group difficult. It is likely that the respondents had a good experience with the EPA SBIR program and this is why they were willing to give feedback on the program.

4.6 Limitations of Research and Future Applications

The limitations of our project revolve around the methods we used for data collection and research biases.

A major factor inhibiting our results is that all our data was self-reported. The interviewees were talking about themselves, as were the questionnaire respondents, and this is susceptible to bias. Some people may look at themselves critically, seeing or exaggerating faults that an objective third party would not see. Others may be blind to their own errors, or not remember them. Either of these cases will result in altered data, even though many of our questions were designed to revolve around hard facts.

Another issue that impacted our project is sampling bias. Since participating in an interview was completely voluntary, certain types of individuals may not wish to be part

of this study. We did not give any incentive to answer our questionnaire or interview with us, so there was a limited number of responses. Therefore, we are missing responses from the majority of EPA SBIR funded companies. We were not able to hold interviews with or distribute questionnaires to truly failed companies, as they no longer exist. Ideally, we would have been able to use failed companies for comparison with successful companies. In their place, we used companies with unsuccessful and successful Phase II applications. This was helpful because the entrepreneurs could explain to us what they did differently between proposals.

4.7 Topics for Future Research

As this project was based on a limited amount of time, we had to keep our focus narrow to make sure it would be completed within our time frame. Some areas of research that would be beneficial to the EPA SBIR program would be to:

- Measure the environmental impact of this program
- Determine the optimal award size
- Request information from the companies that inquired about the SBIR program but never applied
- Evaluate relevancy review in depth.

The environmental impact of the EPA SBIR program is a good metric because it measures the success of the program as it pertains to the mission of the EPA. This further research would require finding each SBIR funded technology and somehow measuring and quantifying the amount of pollution that they have mitigated. In our research we found that companies typically need more funding than is given through the program. The EPA has limited funding, so an optimization study would help determine the ideal

amount of money for development and commercialization by each awardee. As seen in Figure 2 (Page 32), many other agencies have found larger award sizes more ideal. Talking to the companies with relevant technologies that did not apply for funding would provide useful insight into the strengths or weaknesses of the application process. If it was too difficult or confusing, those companies would be able to explain why they did not end up applying. The process should not become a maze that only a select few companies can traverse. Our time at the EPA did not align with the start of relevancy review; therefore, we did not get to observe the full process in which the final cuts are made for Phase I awards. In order to get a full review of the whole EPA SBIR program, this aspect is important to evaluate. This step occurs after the first cuts are done by the peer reviews. Internal EPA reviewers then perform a final evaluation of the proposals.

Further areas of research that would be useful to NCER would be to create a general metric for evaluating the success of a program and to find a way to evaluate the performance and consistency of response by the proposal reviewers. For the SBIR peer reviews, there are five criteria on which each reviewer is supposed to grade a proposal. Some reviewers do not grade the same way, and this could lead to discrepancies within the awarding process. If a proposal has three overly critical reviewers, it is extremely unlikely that it will get funded. If the criteria were more specific, this would be easier to combat. EPA should consider conducting calibration sessions for reviews in order to enable reviewers to reach consensus on applicable standards.

5. Recommendations and Conclusions

We have put together a set of recommendations for the EPA to implement at their discretion. The EPA originally contracted us to formulate two types of suggestions for them: recommendations based on the analysis of previous awardees of SBIR funds, and recommendations based on our observation of the internal procedures that make up the SBIR selection and support process. As such, not all suggestions will be grounded in the previous chapter. This section will be divided based on the part of the SBIR process to which the recommendations are most relevant A table showing all recommendations and how we categorized them can be seen below.

Table 4: Categorization of Recommendations

Recommendations		
Application Process	**Internal Review Process**	**Support**
• Electronic submission of proposal • Clarify process • Develop executive summary before submission • Publicize application better • Requiring interest in technology before allowing application	• Electronic Peer Review tool • Phone Interview • Video Submission	• Better keep track of companies • Mentoring program with accelerator • Better advertise for companies • Better organized online resources page

5.1 Application Process

One potential area for reform that was brought to our attention, both internally and externally, was the use of an electronic application. Many applicants mentioned that filling out a paper application and sending it in was a hassle. EPA employees manage at least 250 applications and search through them by hand. By using an electronic

application process, the employees would be able to find what they were looking for easily, and the strain of submitting a paper application would be removed from the applicants.

Some applicants found the application itself to be somewhat unclear. This was cited particularly for companies that had not previously applied to the SBIR program. A simple way to alleviate this issue would be to include a short help section with the application, including a little extra guidance on what to focus on in the proposal.

Another way to help applicants is to allow them to submit an executive summary before the proposal is due. The summary would then be looked at by an EPA staff member, and feedback would be given on how to make the EPA more interested in the project. We think this would give first-time applicants a better chance of getting accepted, and increase the overall quality of proposals.

A couple of additional suggestions were provided to us by Josh Greene of Cleantech Open. The first of these was to publicize the EPA's SBIR program more extensively. Many green technology companies are unaware of the SBIR program's existence. Greene suggested that the EPA advertise on websites such as his accelerator's to spread knowledge of this program and its potential to help businesses attempting to develop and commercialize a new green technology.

Another suggestion, based on Cleantech Open's selection process, would be to require interest in a technology before it is funded. Cleantech Open requires 100 interviews with potential end users regarding feedback of their potential product. The company meets this requirement by using specific software to track the number of interviews that are held. If the potential customers were not interested, they can suggest changes that could make the product more appealing. This condition ensures that, if a

technology is successfully developed, it will have a place in the market, and therefore a good chance of successfully commercializing. If the EPA adopted a similar requirement, it could help the EPA fund companies capable of getting commercialization partners, and also encourage businesses to prepare for commercialization in advance.

A change that we feel would have a strong, positive impact would be the addition of a video requirement for Phase II applications. The video would be a short sales pitch, showcasing a product's technical merit, and would display the entrepreneur's ability to convey the product's usefulness. This video would be shown to external reviewers as a supplement to evaluating proposals. A requirement similar to this is already in place at the Department of Education. The goal of the video is to show what progress has been made with each award. The Phase I video is shown during the Phase II peer review sessions to help the reviewers make a decision. Peer reviewers at the Department of Education have given overwhelmingly positive feedback on these video submissions. Adding this process would allow the EPA to award funding based on entrepreneurial skills in addition to technical merit.

An alternative to video submissions is phone interviews. These would also fall between Phase I funding and Phase II consideration. Fifteen to thirty minutes would be allotted for entrepreneurs to speak with a representative from the EPA. This would allow the EPA to meet the entrepreneur on a more personal basis, and let the company tell the EPA about specific areas in which the company would like support. This method of a more personal approach to SBIR selection would be easier for companies than making a video, as they would only have to take the time to talk, instead of preparing a short film. However, this method would require more time from EPA personnel. We believe that it would be worth the extra time from both parties to implement either video submissions or

phone interviews into the EPA's SBIR program to create a firmer, more personal basis for award decisions and support.

5.2 Peer Review

One recommendation pertaining to the peer review process is to move away from the paper-heavy system. By creating an online system, the reviewers will be allowed to submit their grades before arriving at the EPA; thus, streamlining the process. Currently, the system requires each reviewer to orally communicate their grading of each proposal, and then the proposals that receive high marks are triaged to go first. If these grades were put into a system before arriving, the order of the reviewed proposals would already be determined. The primary reviewers would be notified beforehand when the proposals they were in charge of grading are staged for review. This would make sure the readers would be prepared for their proposal's review day and potentially encourage more discussion from other reviewers. This also would save time in the meeting, because there would be no requirement for distributing grading during the meeting. Ideally this system would also help in the revision process of the Peer Review Results Form. While it is the primary reviewer's job to incorporate all of the reviewers' feedback into one document for the applicant, currently, this is not done as effectively as it could be. The online system would allow for each reader to review the primary reviewer's work instantly, without having to waste all the time and paper that is associated with printing the documents.

The online system that is developed should be connected with the application system. If it requires time to switch from system to system, then it would just cause more problems. A tool like FastLane (Used by the NSF) would be beneficial at the EPA.

5.3 Support

The majority of companies would like the EPA to increase their award sizes. Representatives say that the small size of the EPA's awards encourages companies to seek funding through other agencies' SBIR programs, even if their product would be more relevant to the EPA's topic areas. Though the EPA has a limited budget, it could change how funding is allocated. The simplest way to increase award size without affecting the overall budget would be to award fewer, larger awards. However, the effectiveness of any such change would have to be researched further. We think it would be more likely that the EPA could add a Fast-Track option, like some other agencies, including the DoD, ED, and DOE. This option would allow companies to apply for a combined Phase I and II award. The fast-track option effectively raises the maximum award size by awarding both phases simultaneously. This would also eliminate the gap in funding that many companies face because of the amount of time between phases, another issue that was commonly mentioned as troublesome by company representatives.

An issue that we noticed through our questionnaire was that 43% of respondents claimed the feedback from reviewers was poor to neutral. We think that communication between the companies and their liaison at the EPA would benefit both parties regarding reviewer feedback. Debriefing both successful and unsuccessful Phase II applicants about the reviewers' comments through phone or email (as done by the NSF) would help the entrepreneur understand their weaknesses. If the entrepreneur's proposal did not pass peer review, they could then have a better understanding of what the reviewers look for if they decide to apply again. Additionally, EPA personnel will learn how Phase II

awardees plan on addressing the reviewer's comments and will establish an interpersonal relationship with the funded company.

When asked about publicization, most company representatives said that more would be better. There currently is a "Success Stories" page on the EPA's website, full of self-reported successes, but it is outdated and hard to find. If SBIR-funded companies could be viewed on the EPA's main webpage, or even if the main web page contained a link to them, perhaps the companies and the SBIR program would receive more publicity. The success stories page itself could be redone as well. In addition to the chart that is already there, it would be helpful to have a slideshow or other pictorial representation of the most recent Phase II awardees. In this way, the companies would have some publicity which could aid them in becoming successful.

From visiting other agencies' SBIR web pages, we noticed that there were some ideas that could be potentially beneficial to the EPA. Currently the EPA does not have a list of other resources for small businesses on their SBIR website. This could be implemented fairly simply. Links to trade associations, the SBA, federal laboratories, other SBIR programs, other government-funded programs and technology accelerators would provide valuable information for scientists and entrepreneurs alike. Currently, there is no resource guide on the EPA SBIR website; creating one would help inquiring entrepreneurs locate external assistance.

Entrepreneurs of start-up companies that received EPA SBIR funding often faced unfamiliar challenges when developing and commercializing their technology. Many green technology entrepreneurs do not have a business background and, because of this, they had problems getting their technology from the lab to the market. A solution to this shortcoming would be to develop an optional mentoring system where entrepreneurs can

learn business skills and seek help when needed. Mentors experienced at commercializing technologies with specific knowledge of a relevant industry can be of assistance to new entrepreneurs. A common issue in commercializing a technology is finding interested investors. With the aid of a mentor, entrepreneurs can learn how to effectively market their product and hence gain interest from additional funding partners. A dedicated mentoring program may not be feasible within the EPA due to financial restraints and shortage of personnel. However, sponsoring or partnering with other organizations dedicated to mentoring green technology entrepreneurs, such as accelerators and incubators, are viable alternatives. These organizations have the finances and personnel to mentor entrepreneurs and accelerators. Questionnaire data from EPA SBIR funded technologies revealed a positive interest in a mentoring program as long as it would be optional. This additional resource can be beneficial to entrepreneurs who seek help in commercializing their technologies.

5.4 Conclusion

As the EPA SBIR program moves forward, we encourage the adoption of our recommendations, as the agency sees fit. These recommendations were developed through feedback from green technology companies and through the evaluation of tactics used by similar programs. While the EPA's program has previously selected successful technologies for funding, we believe that these recommendations can improve how the agency selects and supports small green technology companies moving forward.

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Appendix A: Questionnaire

1. Please list your name and contact information._____
2. What is the name of the company you worked at that received EPA SBIR funding?

   _____
3. How did you hear about the EPA's SBIR Program? _____
4. Did you apply for/receive the EPA's Phase II commercialization option (funding supplement)?
   a. Did not apply.
   b. Applied, did not receive.
   c. Applied and received.

5. On a scale from 1 to 7, please rate the clarity of the EPA SBIR application.

1	2	3	4	5	6	7
Poor			Neutral			Excellent

6. Have you had any problems with the EPA SBIR application process?
   a. Yes
   b. No
7. Please explain your previous answer, if applicable.
8. On a scale from 1 to 7, please evaluate the feedback you received from the EPA SBIR program's peer review.

1	2	3	4	5	6	7
Poor			Neutral			Excellent

9. Did you utilize the EPA's commercialization contractor?
   a. Yes
   b. No
10. If so, was the contractor helpful? Please explain._____
11. Have you collaborated with any business consultants (other than Foresight) to aid in the commercialization of your technology?
    a. Yes
    b. No
12. Did you communicate with your EPA project officer or technical liaison during the process?
    a. Yes
    b. No
13. If so, was he or she helpful? Please explain._____

14. On a scale from 1 to 7, please rate how helpful would it be to have a commercialization mentoring program once you receive funding?

1	2	3	4	5	6	7
Poor			Neutral			Excellent

15. On a scale from 1 to 7, please evaluate your overall experience with the SBIR program?

1	2	3	4	5	6	7
Poor			Neutral			Excellent

Appendix B: Interview Protocol for Successful Companies funded by EPA SBIR

- Initial Contact by Phone or Email:
    - Introduce names
    - Introduce context (WPI Student volunteer for EPA)
    - Evaluating commercialization efforts of the SBIR program
    - Set up time to interview
- Send email with background questions
- Assign roles (note-taker, interviewer (s))
- Introductions:
    - Ask permission to record/ use information
        - Subject name can remain anonymous if you would like
        - Will not publish confidential business information
    - Feel free to ask us for clarification on questions, etc.
- Interview Questions:

- Background
    - What was your industry experience? Management experience?

- Commercialization
    - What was your initial capital?
    - How broad is the appeal for this product?
    - How did you commercialize your product?
        - Did you have a commercialization plan?
            - Did you have any commercialization partners?
            - Did you have any outside investors
        - How was funding allocated?
        - Did the person responsible for commercialization (if not you) have any business background?
            - Did you receive any outside business consultation?
            - How did you market your product?
            - Did you receive any outside business consultation?
        - Did you utilize the EPA's contractor (Foresight), the EPA's commercialization option or any type of outside business consultation?

                - Did you have an external commercialization review of your product?
            - When/how did you locate end users?
                - Did the product fulfill its original purpose?
        - Why do you think your product was successful in the market?
            - How did you market your product?
        - Can you evaluate the competition you faced?
        - Was there any one pivotal decision you made that you feel solidified the success of your product?
        - What do you think it takes to be a successful entrepreneur while commercializing a green technology?

- Issues
    - What problems did you run into?
        - During research and development?
        - SBIR Phase I and II Proposals?
        - Commercialization?
    - How did you overcome them? Was the EPA helpful in this process?
        - Is there anything you wish the EPA had done differently?

- Conclusion:

    - Is there anything we didn't cover that you would like to add?
    - Thanks for your time
    - Is there anything you would like to know about us or our research?
    - Can we contact you in the future if we come up with further questions?

- Follow up

    - Send "thank you" email
    - If there is anything you feel you missed feel free to contact us

Appendix C: Interview Protocol for Companies with Unsuccessful EPA SBIR Proposals

- Initial Contact by Phone or Email:
    - Introduce names
    - Introduce context (WPI Student volunteer for EPA)
    - Evaluating commercialization efforts of the SBIR program
    - Set up time to interview
- Send email with background questions
- Assign roles (note-taker, interviewer (s))
- Introductions:
    - Ask permission to record/ use information
        - Subject name can remain anonymous if you would like
        - Will not publish confidential business information
    - Feel free to ask us for clarification on questions, etc.
- Interview Questions:

- Background
    - How broad is the appeal for this product?
    - What was your industry experience? Management experience?
        - Did you have any outside investors
        - How difficult was the application process for EPA SBIR?
    - What is your industry experience/management experience?

- Commercialization
    - How did you commercialize your product?
        - Did you have a commercialization plan?
        - How was funding allocated?
        - Did the person responsible for commercialization (if not you) have any business background?
            - Did you receive any outside business consultation?
            - Did you have professional advisors?
            - How did you market your product?
            - Did you have marketing members on your staff?

        - Did you utilize the EPA's contractor (Foresight), the EPA's commercialization option or any type of outside business consultation?
            - Did you have an external commercialization review of your product?
        - When/how did you locate end users?
            - Did the product fulfill its original purpose?
    - Why do you think your product was successful in the market?
        - How did you market your product?
    - Can you evaluate the competition you faced?
    - Was there any one pivotal decision you made that you feel solidified the success of your product?
    - What do you think it takes to be a successful entrepreneur while commercializing a green technology?

- Issues
    - Are there any inherent problems with creating a green technology company that you know of?
    - What problems did you run into?
        - During research and development?
        - SBIR Phase I and II Proposals?
        - Commercialization?
    - Is there anything you wish the EPA had done differently?

- Questions for companies with failed Phase II applications:
    - Why do you think your proposal didn't pass? Was the feedback from the peer review helpful?
    - Were there any differences in the composition of your team?
    - What was your commercialization plan when applying for Phase II?
    - Did you attempt to commercialize this product through other means?
    - What would you have done differently?
    - What were the differences between the successful and the unsuccessful projects?
        - Were there differences in outside funding/partnerships? What were they?

- Conclusion:

    - Is there anything we didn't cover that you would like to add?
    - Thanks for your time
    - Is there anything you would like to know about us or our research?

    - Can we contact you in the future if we come up with further questions?

- Follow up

    - Send “thank you” email
    - If there is anything you feel you missed feel free to contact us

Appendix D: Interview Protocol for Successful Green Technology Companies

- Initial Contact by Phone or Email:
    - Introduce names
    - Introduce context (WPI Student volunteer for EPA)
    - Doing research on green technology markets and how to succeed in those markets
    - Set up time to interview
- Send email with background questions
- Assign roles (note-taker, interviewer (s))
- Introductions:
    - Ask permission to record/ use information
        - Will not publish confidential business information
        - Subject name can remain anonymous if you would like
    - Feel free to ask us for clarification on questions, etc.
- Interview Questions:

- Commercialization
    - How did you commercialize your product?
        - Did you have a commercialization plan?
            - Did you have any commercialization partners?
            - Did you have outside investors?
            - How was funding allocated?
        - Did the person responsible for commercialization (if not you) have any business background?
        - Did you receive any outside business consultation?
        - When/how did you locate end users?
            - Did the product fulfill its original purpose?
- Issues
    - What problems did you run into?
        - During research and development? (if research was done)
        - Commercialization?
    - How did you overcome them?
    - Are there any inherent problems with creating a green technology company that you know of?

- What do you think it takes to be a successful entrepreneur when commercializing a green technology?

- Conclusion:

  - Is there anything we didn't cover that you would like to add?
  - Thanks for your time
  - Is there anything you would like to know about us or our research?
  - Can we contact you in the future if we come up with further questions?

- Follow up

  - Send "thank you" email
  - If there is anything you feel you missed feel free to contact us

Appendix E: Interview Protocol for NSF SBIR

- Initial Contact by Phone or Email:
    - Introduce names
    - Introduce context (WPI Student volunteer for EPA)
    - Evaluating commercialization efforts of the SBIR program
    - Set up time to interview
- Send email with background questions
- Assign roles (note-taker, interviewer (s))
- Introductions:
    - Ask permission to record/ use information
        - Subject name can remain anonymous if you would like
        - Will not publish confidential business information
    - Feel free to ask us for clarification on questions, etc.
- Interview Questions:
    - Can you explain the interview aspect of your program?
    - Is there a particular reason why your SBIR program uses grants as opposed to contracts?
    - Can you go over your experiences with the Phase IIB funding option? Pros and Cons?
    - Can you explain your FastLane electronic application/review program?
    - Can you explain how virtual panels work?
    - Can you explain the Innovation Accelerator Network?
    - What do you think your SBIR program does well? What do you think could be improved?
    - Can you explain the NSF's Matchmaker Program?
    - Do you communicate with other agency's SBIR personnel? How, often?
- Conclusion:
    - Is there anything we didn't cover that you would like to add?
    - Thanks for your time
    - Is there anything you would like to know about us or our research?
    - Can we contact you in the future if we come up with further questions?
- Follow up

- Send “thank you” email
- If there is anything you feel you missed feel free to contact us

Appendix F: Interview Protocol for DOE SBIR

- Initial Contact by Phone or Email:
    - Introduce names
    - Introduce context (WPI Student volunteer for EPA)
    - Evaluating commercialization efforts of the SBIR program
    - Set up time to interview
- Send email with background questions
- Assign roles (note-taker, interviewer (s))
- Introductions:
    - Ask permission to record/ use information
        - Subject name can remain anonymous if you would like
        - Will not publish confidential business information
    - Feel free to ask us for clarification on questions, etc.
- Interview Questions:
    - Is there anything unique about your agency's SBIR program?
    - How do you think these differences help/detriment your success rates?
    - Does your agency fund any green technology SBIR proposals?
    - Do you feel the green technology market is different from other markets?
    - How does this affect how support is given to these companies?
    - Do you communicate with other agency's SBIR personnel? How Often?
    - Are there any traits you look for in selecting green technology entrepreneurs?
    - What other support does your agency give?
    - What are the most essential methods to supporting successful companies in your agency's SBIR program?
- Conclusion:
    - Is there anything we didn't cover that you would like to add?
    - Thanks for your time
    - Is there anything you would like to know about us or our research?
    - Can we contact you in the future if we come up with further questions?
- Follow up

- Send “thank you” email
- If there is anything you feel you missed feel free to contact us

Appendix G: Interview Protocol for Department of Education SBIR

- Initial Contact by Phone or Email:
    - Introduce names
    - Introduce context (WPI Student volunteer for EPA)
    - Evaluating commercialization efforts of the SBIR program
    - Set up time to interview
- Send email with background questions
- Assign roles (note-taker, interviewer (s))
- Introductions:
    - Ask permission to record/ use information
        - Subject name can remain anonymous if you would like
        - Will not publish confidential business information
    - Feel free to ask us for clarification on questions, etc.
- Interview Questions:
    - Can you explain the video demonstration aspect of your program?
    - Requirement for both phases?
    - Pros and cons?
    - Is there a particular reason why your SBIR program uses contracts as opposed to grants?
    - Can you go over your experiences with the Fast-Track option? Pros and Cons?
    - Do you provide additional commercialization support after awarding SBIR contracts?
    - What do you think your SBIR program does well? What do you think could be improved?
    - Do you communicate with other agency's SBIR personnel?
    - How often?
        - Is there anything unique about your SBIR program that has yet to be mentioned?
        - What entrepreneurial traits do you think are needed to make a technology successful?
- Conclusion:
    - Is there anything we didn't cover that you would like to add?
    - Thanks for your time

    - Is there anything you would like to know about us or our research?
    - Can we contact you in the future if we come up with further questions?

- Follow up

    - Send “thank you” email
    - If there is anything you feel you missed feel free to contact us

Appendix H: Interview Protocol for (Non-EPA SBIR Funded) Green Technology Companies

- Initial Contact by Phone or Email:
    - Introduce names
    - Introduce context (WPI Student volunteer for EPA)
    - Evaluating commercialization efforts of the SBIR program
    - Set up time to interview
- Send email with background questions
- Assign roles (note-taker, interviewer (s))
- Introductions:
    - Ask permission to record/ use information
        - Subject name can remain anonymous if you would like
        - Will not publish confidential business information
    - Feel free to ask us for clarification on questions, etc.
- Interview Questions:

- Background
    - What technology was/is being funded by the SBIR program?
        - How broad is the appeal for this product?
        - Did you receive any additional funding outside the SBIR Program?
        - Did you propose more than one technology to the SBIR program? How difficult was the process?
- Commercialization
    - How did you commercialize your product?
        - Did you have a commercialization plan?
            - How was funding allocated?
        - Did the person responsible for commercialization (if not you) have any business background?
        - Did you receive any outside business consultation?
        - Did you have an external commercialization review of your product?
        - When/how did you locate end users?
            - Did the product fulfill its original purpose?
    - Why do you think your product was successful in the market?

    - Was there any one pivotal decision you made that you feel solidified the success of your product?
- Issues
    - What problems did you run into?
        - During research and Development?
        - SBIR Phase I and II Proposals?
        - Commercialization?
    - How did you overcome them? Was your sponsoring agency helpful in this process?
        - Is there anything you wish your sponsoring agency had done differently?
    - Are there any inherent problems with creating a green technology company that you know of?
    - What do you think it takes to be successful as an entrepreneur while commercializing a green technology?

- Conclusion:

    - Is there anything we didn't cover that you would like to add?
    - Thanks for your time
    - Is there anything you would like to know about us or our research?
    - Can we contact you in the future if we come up with further questions?

- Follow up

    - Send "thank you" email
    - If there is anything you feel you missed feel free to contact us

Appendix I: Interview Protocol for Subject Matter Expert from Cleantech Open

- Initial Contact by Phone or Email:
    - Introduce names
    - Introduce context (WPI Student volunteer for EPA)
    - Evaluating commercialization efforts of the SBIR program
    - Set up time to interview
- Send email with background questions
- Assign roles (note-taker, interviewer (s))
- Introductions:
    - Ask permission to record/ use information
        - Subject name can remain anonymous if you would like
    - Feel free to ask us for clarification on questions, etc.
- Interview Questions:
    - What types of assistance do you give to companies?
    - How do you select companies for assistance?
        - What are the requirements for application?
    - How do you support companies that are trying to commercialize?
    - Are there any traits you look for in an entrepreneur?
    - What do you think government programs could do better to have a higher rate of success?
    - Do you know of any small clean technology companies that are good examples of creating a commercial product?
- Conclusion:
    - Is there anything we didn't cover that you would like to add?
    - Thanks for your time
    - Is there anything you would like to know about us or our research?
    - Can we contact you in the future if we come up with further questions?
- Follow up
    - Send "thank you" email
    - If there is anything you feel you missed feel free to contact us

Appendix J: Interview Protocol for Venture Capitalist

- Initial Contact by Phone or Email:
    - Introduce names
    - Introduce context (WPI Student volunteer for EPA)
    - Evaluating commercialization efforts of the SBIR program
    - Set up time to interview
- Send email with background questions
- Assign roles (note-taker, interviewer (s))
- Introductions:
    - Ask permission to record/ use information
        - Subject name can remain anonymous if you would like
        - Will not publish confidential business information
    - Feel free to ask us for clarification on questions, etc.
- Interview Questions:
    - How do you select companies for investment?
    - Is there an application process?
    - Do you conduct interviews? How so?
    - What do you think makes a good entrepreneur?
    - Is there a difference in evaluating green technology entrepreneurs in comparison to other fields?
    - What is the most common composition of the teams in companies you invest in?
    - How do you support the companies you invest in besides funding them?
    - How much capital is typically invested to companies?
    - Do you have a metric for evaluating risk?
    - How do you evaluate the market potential?
    - Do you have an expected rate of return for each investment?
    - How long do you usually support a company you've invested in?
    - How do you think government funded investment opportunities, such as the EPA's SBIR process, can improve?
- Conclusion:

- Is there anything we didn’t cover that you would like to add?
- Thanks for your time
- Is there anything you would like to know about us or our research?
- Can we contact you in the future if we come up with further questions?

- Follow up

  - Send “thank you” email
  - If there is anything you feel you missed feel free to contact us

Appendix K: Phone Interview with Norton Kaplan

September 25, 2013
Conducted by Stephen Johnston and Will Forster

Present: Nicholas LaJeunesse and Angelica Zawada

Norton Kaplan's Interview – Commercialization Expert Working at Foresight Science & Technology

- Background on our projects

Q: What type of companies have you analyzed on the topic of commercialization?

- Foresight supports thousands of companies, some technology based, and it supports the SBIR program
- The EPA is one of the participating agencies.
- It has been supporting the EPA and the companies they've funded for a number of years.

Q: What are some common factors that all companies need to succeed in breaking out into the market?

- End Users are important – You have to reach out to appropriate end-users and get their input on the project.
- Not looking at who a business's true market is the most common issue.
- Lack of funding is another issue companies that fail may face. (there is no data to say that specifically)
- Lack of long-term planning also causes issues.
- Insufficient funds early on are another way to figure out a company may fail.

Q: How would you define success with commercialization?

- Success is in sales and dollars, generating revenue, etc.
- Another way of determining success is if its beneficial for mankind
    - Ex. Vaccine for Aids

Q: How long does it take for success to be reached in commercialization?

- When technology reaches a certain life of maturity
    - On licensing (typically 9 months)
    - Direct sales and distribution
        - Distribution could take years due to:
            - Certifications
            - 3rd party testing
            - sales, marketing, distributions, and fixing problems

Q: What could we do to help these companies avoid pitfalls?

- Encourage them to search for end users by seeking them out and getting input.
- Identify who the customer base is before finishing the technology – can miss the mark if you wait too long
- Listen carefully- help resolve funding problems
- Make option based agreements with end-users
- Have the money upfront
- Help define the proper market to figure out who the end users would be.
- Start with end-users and works backwards up the chain.
- Figure out the insertion point in the supply chain.

Q: How would you find the insertion point?

- Construct an open dialogue with companies and that will lead to that information.
- No questionnaires just be flexible in conversations and see where they lead you.

Q: Does Foresight work with other organizations besides the EPA?

- NIH
- NSF* (look into more)
- DOE*
- DOD
- They work with a variety of agencies
- As well as states such as:
    - CT
    - IN
    - MD/
    - ME
    - NH, etc.
- Also works with universities and non-profits
- More than just the EPA

Q: How successful is the EPA's SBIR program in relation to others?

- 40% of the EPA's SBIR programs have had commercialization success
- This percentage is more than the average of 30% of SBIR as a whole.
- EPA's SBIR program is relatively small.
- EPA is very selective and regulatory
    - You can say that they want certain solutions and technologies
    - They look at customer needs and market needs.

Q: Can we see any data that Foresight collected?

- EPA would have to provide that
- It's numerical data.

He asked us a few questions:

Q: What is this project for us and is it our senior year project?

- IQP – Interactive Qualifying Project – Junior Year project

Q: What is the goal of it?

- To connect science with social issues
- Basically taking funding issues and environmental issues
- Get us communicating with people

He said communication is important in commercialization and marketing
He said to identify issues and expect them.

Problems that businesses have are:

- Culture or attitude problems
- Need better products
- Identify the problems that you are solving
- Prove value in what you are doing.

Appendix L: List of Companies for Questionnaire Contact Who Received EPA SBIR Funding from 2007-2010

Company	Project Title	Year of Phase I Award	Year of Phase II Award
Active Spectrum, Inc.	Sensor for Monitoring of Particulate Emissions in Diesel Exhaust Gases	2009	
Agave biosystems, Inc	Organophosphate Degrading Enzymes	2009	
Applied Sciences, Inc	Nano-Enhanced Composite Electrodes for Electrostatic Precipitators	2009	
Bridger Photonics, Inc.	Hand-Held Sensor for Remotely Mapping Carbon Dioxide Pollution Sources	2009	2010
Constellation Technology Corporation	Online Water Monitoring Utilizing an Automated Microarray Biosensor	2009	
DC Instruments	Leak Detection and Wireless Telemetry for Water Distribution and Sewerage Systems	2009	
Ecovative Design LLC	Testing the Viability of Agricultural Byproducts as a Replacement for Mineral Particles In a Novel, Low embodied Energy, Construction Material	2009	2010
Electronic Bio Sciences, LLC	Rapid Detection of Algal Toxins	2009	
Eon Corp.	Next Generation Sediment toxicity Testing via DNA Microarrays	2009	
Faraday Technology, Inc.	Enabling Commercialization of a Lead-Free Coating Manufacturing Process	2009	
Fuss & O'Neill	Electricity Generation from Anaerobic Wastewater Treatment in Microbial Fuel Cells (MFC)	2009	2010
Gevo, Inc.	Second-Generaton Isobutanol Producing Biocatalyst	2009	
Ion Signature Technology, Inc.	Development of an In Situ Thermal Extraction Detection System (TEDS) for Rapid, Accurate, Quantitative analysis of Environmental Pollutants in the Subsurface	2009	2010
InnovaTech, Inc.	Retrofit Air Pollution Control filter for Restaurant Underfired Charbroilers	2009	2010
Integran Technologies USA, Inc.	Amorphous Alloy Coatings for Hard Chromium Replacement	2009	2010

KWJ Engineering, Inc.	Reagentless Field-Usable Fixed-Site and Portable Analyzer for Trihalomethane (THM) Concentrations in Drinking Water	2009	2010
Membrane Technology and Research, Inc.	High Flux Membranes to Upgrade Biogas from Anaerobic Digesters	2009	
Mountain Creek Enterprises	Feasibility Study to Produce Biodiesel from Low Cost Oils and New Catalysts Derived from Agricultural & Forestry Residues	2009	2010
Scientific Methods, Inc.	Rapid Concentration of Viruses from Water	2009	
Senspex, Inc.	Nanostructured Planar Waveguide Device for Molecular Identification of Hazardous Compounds in Water by Evanescent Surface Enhanced Raman Spectroscopy	2009	
Sol-gel Solutions, LLC	Indoor Air Purification via Low-Energy, In-Situ Regenerated Silica-Titania Composites	2009	
TDA Research, Inc.	A Portable Microreactor System to Synthesize Hydrogen Peroxide	2009	2010
Aerodyne Research, Inc.	A Sensitive and Affordable Compact Ammonia Monitor	2008	2009
Agiltron, Inc.	Low Cost Imager for Pollutant Gas Leak Detection	2008	2009
Avatar Alternative Energy, Inc.	Advance Manure Management for Small Dairy Farms	2008	
BioTex, Inc	Sensitive, Quantitative, and Portable Anatoxin Assay using Aptamers and Quantum Dot Nanoshell Reporting	2008	
Chip Energy	Outdoor Biomass Gasifier Hydronic Heater (OBGHH)	2008	
EcoArray, Inc.	Monitoring the Effects of Nanoparticles on Human Health Using an Inexpensive Fathead Minnow Microarray	2008	
EERGC Corporation	Controlling Cooking Effluents with a Self-Cleaning Adsorbent	2008	
EIC Laboratories, Inc	Security Monitoring Using Surface-enhanced Raman Spectroscopy	2008	2009

Eltron Research & Development, Inc.	Electrochemical Treatment and Recycling of Spent Perchlorate-Contaminated Ion-Exchange Regeneration Brime	2008	
Eltron Research & Development, Inc.	Low Cost NO_x Abatement in Off-Road Sources	2008	
Entropic Systems, Inc.	Decontamination Wipes for First Responders	2008	
Eon Corp	Identifying and Monitoring Environmental Toxicity Using Ceriodaphnia Microarrays	2008	
Expansyn Technologies, Inc.	Development of Novel Proteins to Enhance Cellulose Deconstruction for Ethanol Production	2008	
Fitz Aerometric Technologies	Development of and Improved Detector for use with a Gas Chromatograph to Measure NO_x and PAN in the Atmosphere	2008	
Intelligent Optical Systems, Inc.	LSPR Nano-Immunosensor for Simple and Sensitive Water Monitoring	2008	
Johansson Industries, Inc	Surface Plasma Electrode for Electrostatic Precipitators	2008	2009
Materials and Electrochemical Research (MER Corporation)	A New Innovative Low Cost Manufacturing Process to Produce Titanium	2008	2009
National Recomery Technologies, Inc.	Automated Removal of Brominated Flame Retardant Material From a Mixed E-waste Plastics Recycling Stream	2008	2009
nGimat Co.	Nanomaterial Solutions for Hot Coal Gas Cleanup	2008	
QuantLogic Corporation	A Micro-Variable Circular Orifice (MVOC) Fuel Injector with Variable Spray Angles and Patterns for Reducing NOx Emissions from Diesel Engines	2008	
Reactive Innovations, L.L.C.	Inexpensive Drinking Water Chlorination Unit for Small Communities	2008	2009
RTA Systems, Inc.	A Novel Approach for Safe and Rapid Decontamination of Buildings and Equipment and Neutralization of Residues Using TERRACAP CB Decon System	2008	
TDA Research, Inc.	Process-intensified Low-Cost Biodiesel Production using Meat Rendering Waste, Greases, and Food Wastes	2008	2009
The Green Team, Inc.	Green Product-Service System Authentication and Registry Service for the Building Industry	2008	

Tok Welding and Fabrication	Improving Combustion Efficiency and Emissions for Logistically-Practical and Cost-Sustainable Field Operation of an MSW Burn-Management Unit Specifically Applicable to the Unique Circumstances Faced by the Small, Isolated, and Remote Communities in Alaska	2008	
Nanomaterials and Nanofabrication Laboratories D.B.A	Highly Bright, Heavy Metal-Free, and Stable Doped Semiconductor Nanophosphors for Economical Solid State Lighting Alternatives	2007	2008
Lesktech Limited	Minerals Recovery of Copper Mine Tailings on Lake Superior Coastline for Use as Raw Material in the Manufacture of Roofing Shingles	2007	2008
Eltron Research, Inc.	Removal of Sulfur From Gasified Coal AT or Above 800 C	2007	
NanoScale Materials, Inc.	Nanocrystalline Materials for Removal of Reduced Sulfur and Nitrogen Compounds from Fuel Gas	2007	2008
Southeast TechInventures, Inc.	Microbial Community Microarrays to Assess Chemical and Biological Characteristics of Water Quality	2007	
TDA Research, Inc.	Hot Fuel-Gas Sorben System	2007	
Cooper Environmental Services, LLC	Feasibility of Monitoring Heavy Metal Emissions from a Coal-Fired Thermal Hazardous Waste Incinerator Using a Multi-Metal Continuous Emissions Monitor	2007	
Advanced Fuel Research, Inc.	Graded Interference Filter Spectrometer	2007	
Li, Yan D.B.A.	Biodegradable Thermoplastic Natural Fiber Composite	2007	
Edenspace Systems Corporation	Energy Crops for Reducing Areawide Lead Soil Contamination	2007	
Compact Membrane Systems, Inc.	Small Scale Ethanol Drying	2007	2008
KSE, Inc.	Technology for Enhanced Biodiesel Economics	2007	2008
TDA Research, Inc.	Low-cost Biodiesel Production Process Using Meat Rendering Wastes, Recycled Greases and Unrefined Vegetable Oil Feedstocks	2007	

Neathery Technologies, Inc.	A Biomass Energy Process for Poultry Growing Operations	2007	
dTEC Systems, L.L.C.	A Low Cost Chemosensor for Measuring Phosphate in Water and Soil	2007	
Fort Environmental Laboratories Inc.	Rapid Test Kit for Quantifying Hormonal Activity in Animal Feeding Operation Wastewater	2007	
PLANTECO Environmental Consultants, LLC	Surfactant Modified Clay and Zeolite for Treatment of Perchlorate-Contaminate Water	2007	
Seacoast Science, Inc.	HandheldMEMS-based Detector of Toxins and Toxigenic Organisms Indicative of Harmful Algal Bloom	2007	
Operational Technologies Corporation	Handheld FRET Aptamer Sensor to Satisy the Beaches Act	2007	
CEDAR Systems	Rapid Indicator for Pollution	2007	
Media and Process Technology, Inc.	An Innovative Transport Membrane Condenser for Water Recovery from Flue Gas and Its Reuse	2007	2008
Ferrate Treatment Technologies, LLC	The Application of Ferrate for Wastewater Reuse	2007	
Xtalic Corporation	High-Volumne Hexavalent-Free Processing of Hard Coatings	2007	
Technology Applications Group, Inc.	Non-Chromate Conversion Coatings of Magnesium Alloys Used in Automotive Industry	2007	
Intelligent Optical Systems, Inc.	Nanoparticle Based Lateral Flow Microarray Test Strip Assay	2007	
Leak Indicator Pain Systems, Inc	Regenerable Biocidal Nanocomposite Through a Green Process	2007	
Eltron Research, Inc.	Synthetic Gasoline from Biomass	2007	
Technology Management, Inc.	Liquid Hydrocarbon Fuels from Biomass Materials	2007	
Integrated Genomics, Inc.	Investigation of Solvent Toxicity in Bacterial Strains Involved in Butanol Production	2007	
Lynntech, Inc.	Reduced NO_x Using On-Board Plasma Generated Hydrogen	2007	
Radiation Monitoring Devices, Inc.	Low-Cost Instrument for Long-Term Monitoring of Hazardous Contaminants in Drinking Water	2007	

Isotron Corporation	Regenerable Electrochemical Spiral Wound Decontamination Cell for Efficient Decontamination of Radionuclides in Water	2007	
ADA Technologies, Inc.	Field Test Kits for Rapid Detection of Hazardous Contaminants on Indoor Surfaces	2007	
Lynntech, Inc.	An Inexpensive Biological and Chemical Decontamination Solution from a Powdered Concentrate	2007	
Giner, Inc.	Wireless Electrochemical ClO2 Monitor for Decontamination Operations	2007	2008
Adherent Technologies, Inc	Fiber Optic Sensors with Hydrophilic Radionuclide-Selective Cladding for the Detection of Radionuclides in Water Supplies	2007	

Appendix M: Successful, SBIR-funded Companies' Interview Notes

Note: Interview data for the first four companies is below. The data for the other three companies starts on page 96.

Interview Questions	Company Responses			
	Successful Company 1	Successful Company 2	Successful Company 3	Successful Company 4
Background				
What was your industry experience? Management experience?	Technical PhD, Masters in business. High amount of industry experience.	One member of the team had some industry experience, no management experience	PhD chemist, industry background instrument development, a little management experience	Lots, especially in marketing technologies
Commercialization				
What was your initial capital?	Yes had start up capital. started in incubator.	No initial capital	Had initial capital	None
How broad was the appeal for your product?	Broad appeal across many platforms. Processes for plating metals that are widely used	Pretty narrow for the laser. Some specialized applications. The gas sensor appeal looks like it will be broader.	Broad appeal	Very broad appeal. Sold 2000 units so far. Natural gas is used throughout the world.
How did you commercialize your product?	Strategic alliances	Used NSF grant money along with EPA SBIR award money to fund project. Marketed brochure at a Photonics expo to a 19,000 person audience.	Not much marketing,	Worked with Heath Consultants Inc. identified as part of the EPA commercialization phase study. Led to several other funded projects after the EPA project. They licensed the tech and is manufacturing it worldwide.
Did you have a commercialization plan?	Yes, use SBIR funding as seed then develop process to other industries		To expand market from universities to government agencies, useful to monitoring agencies and international	

			market.	
Did you have any commercialization partners?	Strategic alliances	Yes	Distributers over country and outside	
Did you have outside investors?	Yes		No outside	
How was funding allocated?	By money from strategic alliances	NSF, EPA, same as above.		Started with EPA funding, also DOE, and natural gas pipeline industry. Distribution companies along with Heath Inc. gave funding.
Did the person responsible for commercialization (if not you) have any business background?	Yes	No		
Did you receive any outside business consultation?	Yes	No	No	
Did you have an external commercialization review of your product?	Used Foresight/ Dawnbreaker.	No	Yes	
When/how did you locate end users?	Early on, process is for customers	Expo	Built off other technology. Developed for market	Heath Inc found
Did the product fulfill its original purpose?	Yes		Yes	
Why do you think your product was successful in the market?		Expo		

How did you market your product?	Technical marketing, technology people themselves. Posters, trade shows, meetings with lots of scientists. Published technical papers. Publish in Trade rags, widely read free magazines. Technical presentations.	Expo	Have group of people who use research grade and targeted market through that. Publish in scientific journals, trade shows	
Did you have marketing members on your team?	Original team was a one man team. Adapted to do all roles.	No	No	Mostly scientists and engineers.
Can you evaluate the competition you faced?	Alternative approaches all have different problems	No one else made what we made. That helped!	Instruments are unique, many different chemicals measured at one time. Not too much direct competition	Initial foreign competition, licensed some of their technology. At the time, no other competition. Replacement technology of prior technology.
Was there any one pivotal decision you made that you feel solidified the success of your product?	Try to get feedback as soon as possible to fix problems. A warning that companies should make to their sponsors is that there could be problems because technology isn't perfect.	Expo	Everything is incremental	Collaborations with partners is the major reason.
What do you think it takes to be a successful entrepreneur when commercializing a green technology?	Perseverance, listen to market, don't take rejections personally. Listen to advice and adapt to advice.	I think you have to balance your desire to make a difference in the world with the reality that your solution must make sense from a business and market standpoint.	Understanding the market. Experience with what people are trying to measure in the field and creating niche around that	Finding the technology that the market needs.

Issues				
What problems did you run into?		As a physicist, underestimated the engineering involved. The step between the lab and getting it to the customers was huge.		Technical problems, financial problems, Dealing with regulators.
During research? (if research was done)			different technology, need to make it more robust	
Development?	Have to align technology development with funding with intellectual property			
How did you overcome them?				Technical: good engineering, addressed them from expertise. Financial: find sources of money, there's a market out there, are there people out there willing to fund technology. Marketing: need people experienced in identifying and working with customers.

Appendix M Successful, SBIR-funded Companies' Interview Notes Cont.

Interview Questions	Company Responses	
	Successful Company 5	Successful Company 6
Background		
What was your industry experience? Management experience?	Experience primarily in the lab. The have an understanding of processes and the market through learning. They have taken one other product to commercialize.	10 plus years of experience working with building energy analysis and software development and leadership experience. CTO and President of company
Commercialization		
What was your initial capital?	A good number of grants have gone through the SBIR. Cannot disclose actual amount from outside investors.	A couple grants from state programs. ~ .5 million dollars
How broad was the appeal for your product?	Lots of potential applications. Within that market there would be use for that system. There was a more specific application for his product.	Entire construction market. Big market. 2 different models, Project level vs product qualification.
How did you commercialize your product?	Customer attraction. Direct access to the customer is critical. Partners in the engineering firms. Growing and expanding - trade magazines information to the website etc.	Key partnerships to help commercialization.

Did you have a commercialization plan?		
Did you have any commercialization partners?	Vendors in fabrication manufacturing. Constantly for partners to reach out the marker.	Yes
Did you have outside investors?	Yes - have helped across the board	Grant money. No venture capitalists or Angel investors
How was funding allocated?	Being careful and frugal as possible. Some was dictated based on terms in the agreement. Steered where the funds were used.	
Did the person responsible for commercialization (if not you) have any business background?	Falls on everyone shoulders. His plate along with CEO. Less directly involved in sales or marketing side.	Yes. Developed skills through experience and courses
Did you receive any outside business consultation?	Yes	Yes. Environmental Business Cluster
Did you have an external commercialization review of your product?	No- patent projects with the NSF - took advantage of some of that assistance in the commercializing the product.	Yes
When/how did you locate end users?	Important you find them before, but have more specific info to provide after.	Product developed for a user base
Did the product fulfill its original purpose?	Happy with the progress. Not completely out yet. Very hopeful on getting things more commercially viable.	It fufilled what they were trying to do
Why do you think your product was successful in the market?		

How did you market your product?		Commercial partners and through internet
Did you have marketing members on your team?		yes, but no one with a direct marketing background
Can you evaluate the competition you faced?	Wastewater treatment field personnel - some competition. One direct competitor - in Israel.	Against manual processes for analysis
Was there any one pivotal decision you made that you feel solidified the success of your product?	Selection of the application area. Looking for a good area to comply in. Most important aspect. Ways to make the product more effective and more affordable.	Made open file type which became industry standard
What do you think it takes to be a successful entrepreneur when commercializing a green technology?	Diligence and flexibility. Stay with something but also know the right time to attack. Simultaneously knowing the weaknesses but knowing why they are weak.	Passion. Understand what you do and don't know. Don't be afraid to be hire people to cover your weakness.
Issues		

What problems did you run into?		Lack of funding and resources. Lot of money for funding but has restrictive intellectual property terms.
During research? (if research was done)		
Development?		
Commercialization?	Economic cost uncertainty and risk. Needed to make cost sense for the customer.	
How did you overcome them?	Not anything the EPA could have done. Making more connections is always helpful.	Seek out grants with better IP terms
Conclusion:		

Is there anything we didn't cover that you would like to add?	Very important program. Instrumental in helping society progress forward.	

Appendix N:Companies with Unsuccessful SBIR Proposals Interview Notes

Note: Interview data for the first four companies is below. The data for the other three companies starts on page 106

Interview Questions	**Company Responses**			
	Unsuccessful Phase II Applicant 1	Unsuccessful Phase II Applicant 2	Unsuccessful Phase II Applicant 3	Unsuccessful Phase II Applicant 4
Background				
How broad is the appeal for this product?	High demand technology.	Market isn't too large	Very diverse opportunities, many different areas where technology is applicable	Had a specific niche market in air monitoring, not that broad
Did you receive any additional investment outside the SBIR?	Only from companies that were interested in the research	Other federal grants	Other Federal SBIRs, avoided other investors for protection of Intellectual Property Rights. Venture Capitalists seemed ineffective and only measured success by monetary sales. There is a gap in support from development to sales where other investors are interested	No, had trouble finding outside investors.
How difficult was the application process for EPA SBIR?	Not difficult at all, very straightforward.	Not an easy process. Takes a good bit of time, effort and resources		Pretty good, straightforward. EPA took a while to review.
What was your industry experience/management experience?	He has experience in all areas. He was a professor at a University.		Technical experience related to field of product	Not extensive, had other products for process control commercialized. Engineering field experience doing service runs.

Commercialization				
How did you commercialize your product			Presented at conferences, partnered with an outside company who marketed	N/A
Did you have a commercialization plan?	Yes look for people that have an interest and then market to them	Always had a commercialization plan, targeted end users and developed technologies based upon market demand	Developed product for highest tolerance dependent industry and adapt the technology to other fields	Ran with it. Developed plan for proposal for Phase II
How was funding allocated? Did you have initial capital?	Small company, 13 employees, allocated resources and staff like he would any other project. Company puts in $1 for every $1 put in by the EPA. $250,000 initial capital.	As displayed in our grant proposal		Thought budgeting was good. Budget submitted with proposal, various task codes, working with universities. Challenge with universities, aren't accustomed to tracking budgets.
What was the composition for your team?	2 non-scientific, 6 scientific. Interviewee is a scientist, commercialization expert, and facility manager.	About 3 technological people to 1 marketing/business person.	Majority just technical, not enough business-minded people	All technical, one bookkeeper. Chemist, engineer, electrical engineers
Did the person responsible for commercialization have any business background?	Interviewee has experience in all areas.	Yes	Outside company was in charge of commercialization	Not extensive.
Did you have professional advisors	1 individual at Oklahoma University- some commercialization assistance and technology assistance	Yes used advisors	Outside company	No

How did you market your product?	Marketed through website, professional meetings, and made connections throughout their career.		Outside company, conference, website, contracts in industry	Contacts in industry by referral from faculty members at university
Did you have marketing members on your staff?	Yes		Outside company	No
Did you utilize the EPA's contractor (Foresight), the EPA's commercialization option or any type of outside business consultation?	He received Foresight's comments back from the survey and the results were as expected. Other than that not really.	Yes about 8 years ago used Foresight medium helpfulness, hard to know every niche market	Yes, experience was hit or miss depending on who you get at the company.	
Did you have an external commercialization review of your product?	Financial review/ commercialization review.			No
When/how did you locate end users?	Marketed through website, professional meetings, and made connections throughout his career.	Constant Contact with customers. Going to trade shows and identifying where this technology would be useful is very important.	Throughout process	N/A
Did the product fulfill its original purpose?	Yes	Often there will be an initial purpose and sometimes the scope will shift.	Yes, but still trying to adapt it to be universal	No, technical issues with reliability.
Why do you think your product was successful in the market?	High Demand technology, since it doesn't use a whole animal. Big area, a lot of money goes into this testing.	SBIR was essential for research. Market research was very important, it's not a case of "if you build it they will come" you need to build to what is needed	Strong technology. Considered when economical.	N/A
Can you evaluate the competition you faced?	There's competition, but not directly against this technology. There is endocrine disruption competition, but the ability to it is limited.		Competition from incumbent technology that people don't want to change from	None

Was there any one pivotal decision that you feel solidified the success of your product?		Having a partner that will work on having our prototype in their process line		N/A
What do you think it takes to be a successful entrepreneur while commercializing a green technology?	You need to see the short-term and long-term goals, while at the same time diagnosing the risk.	Willing to take chances and being able to find the capital	you have to believe in what you're doing and be dedicated. It's not an easy process and an uphill battle.	Risk taker, entrepreneurial spirit.
Issues				
Are there any inherent problems with creating a green technology company that you know of?	Continually feed R&D	Many times there can be a misconception on what a research wants to develop as a green technology instead of building what the market needs	Adoption problems because of lack of open mindedness	SBIR supports high risk research, hard to do in 6 months unless had previous work done to help.
What problems did you run into?	None	Phase I has a limited amount of money; you have to pick and choose what you can afford to buy.	Lack of acceptance of technology. People believed that it doesn't work	Technical problems; reliability when using technology wasn't ideal for outside investors. Did not get interest from GE and other companies.
Is there anything you wish the EPA done differently to help your problems?	No, they were straightforward and fantastic throughout the process.		Better advertisement of products, make support more like Phase III of other programs	EPA was good to work with. Helpful in workshops
Questions for companies with failed Phase II applications				

Why do you think your product didn't pass? Was the feedback from the peer review helpful?	It was outside the focus of what the EPA wanted. It wasn't as strong as they needed it to be to go through. Yes feedback was helpful.		No not helpful. Review panel was not impartial and did not seem to read proposal.	Technical problems; reliability when using technology wasn't ideal for outside investors. Did not get interest from GE and other companies. EPA was good.
Were there any differences in the composition of your team?	No			All technical, one bookkeeper.
What was your commercialization plan when applying for Phase II	Same as before.			
Did you attempt to commercialize this product through other means?	Yes and he was successful.			No
What would you have done differently	Nothing			
What were the differences between the successful and unsuccessful projects? Were there differences in outside funding/partnerships? What were they?	There were no differences really. Maybe slightly different funding from outside parties interested in the product. The proposal that didn't go through was still successful outside of the EPA SBIR program.			

Appendix N: Less Successful, SBIR-funded Ventures Interview Notes Cont.

Interview Questions	Company Responses		
	Unsuccessful Phase II Applicant 1	Unsuccessful Phase II Applicant 2	Unsuccessful Phase II Applicant 3
Background			
How broad is the appeal for this product?	No technologies funded by the EPA became commercial.	No good remediation efforts. Chance to address these remediation concerns in soil.	Wastewater treatment field has a big appeal of use. Developed a specific technology that could be widely utilized.
Did you receive any additional investment outside the SBIR?	Received other federal grants bureau of reclamation, Navy, Phase III	No additional investments	Yes, another private company.
How difficult was the application process for EPA SBIR?		Pretty clear, the EPA program requires paper copies. Generally, not too bad, application is pretty straightforward.	Wouldn't say difficult. It's pretty streamlined. Paper copies aren't ideal.
What was your industry experience/management experience?	No formal training, the interviewee was self-taught.	8 years with company, 4 years management experience at that point	Industry experience in sulfur removal. Experience commercializing one technology previous to this one. Had no previous job experience, came to company right after PhD post doc.
Commercialization	did not commercialize		

How did you commercialize your product	N/A, was not successful		
Did you have a commercialization plan?		Yes had one	Yes, interviewee worked with business people on it.
How was funding allocated? Did you have initial capital?	No initial capital.	Had some revenue from other projects.	Yes had initial capital.
What was the composition for your team?	PhD in physics, mostly technical, 18 people at largest.	1 person- management (Law degree and MBA) rest technical - 4 PhDs and 1 Masters	4 business people, rest technical in company.
Did the person responsible for commercialization have any business background?	3/4 marketing 1/4 technical person	Yes	Yes
Did you have professional advisors		No	Worked with business person within company.
How did you market your product?		Added this to portfolios about phytoremediation, wasn't strong enough to support a marketing effort	Conferences, posters, brochures at expos.
Did you have marketing members on your staff?	Yes	company president	
Did you utilize the EPA's contractor (Foresight), the EPA's commercialization option or any type of outside business consultation?	Helpful, sometimes make contacts. Foresight was the best program he went through. For novices who need assistance. Good idea to continue.	Foresight connection, 1 other technical consultant	Yes used foresight at end of Phase I. They were helpful in gathering information on market and contacts in the field.
Did you have an external commercialization review of your product?			Just foresight.

When/how did you locate end users?		Other large environmental consultations/ through other relationships with contractors	People inquired about their technologies. See marketing.
Did the product fulfill its original purpose?		No	Yes, minor changes to design.
Why do you think your product was successful in the market?		N/A	Not yet successful.
Can you evaluate the competition you faced?	If the product broke through, there would have been a specific niche market.	There was competition in excavation of soil. Not much in phytoremediation. Excavation helps to show it works in the long term.	There is competition in natural gas systems. Vacuum synthesis gave advantage for company.
What do you think it takes to be a successful entrepreneur while commercializing a green technology?	Luck, research going down a path, always science based. Never give up, keep working at things.	Timing is everything, good technology with proper timing in the market place. Combination of factors and being able to know when you need to bring your product to the market. Be persistent and resourceful.	
Issues			
Are there any inherent problems with creating a green technology company that you know of?		The financial resources - trying to get investors- they aren't as interested - they usually look for 3-4 year turnarounds on a product. Venture capitalist really isn't ready to take over yet. Developing a technology is really difficult.	Looking for additional partners/end-users after SBIR is difficult.

What problems did you run into?	Harder to strip lead paint, not cost effective. Another one didn't receive enough money to get technology over the hump. Hard to get the technology to be robust enough to get people on board.	There phase 1 are a lot smaller than other agencies. EPA only has SBIR. Can't really have university partners besides consultants.	See above.
How did you overcome them?		N/A	Worked with DOE and other organizations interested in renewable technologies.
Is there anything you wish the EPA done differently to help your problems?	EPA SBIR lowest amount of money and same amount of effort to get the same money. A lot of work for not much return	limited to Phase I, if they had received Phase II it would have been better	No. Little more funding.
Questions for companies with failed Phase II applications			
Why do you think your product didn't pass? Was the feedback from the peer review helpful?	Tougher and tougher to fund project. Probability of winning has gone down	Wrong timing and not enough financial backing	It was helpful. Technical side was hard to make to larger scale. EPA wasn't that interested.
Were there any differences in the composition of your team?	No		Same team as other project.
Did you attempt to commercialize this product through other means?		No	
What would you have done differently		Wouldn't have done it a lot differently. They needed to have more financial backing to move it beyond Phase I. Didn't have the resources to continue on that technology. No strategy thought of for finances after Phase I.	More time coming up with better design for larger scale.

What were the differences between the successful and unsuccessful projects? Were there differences in outside funding/partnerships? What were they?			We already had involvement from partners. The other project never got concrete partners.

Appendix O: Successful, Non-SBIR-Funded Green Technology Companies Interview Notes

Interview Questions	Company Responses	
	Successful Green Technology Company 1	Successful Green Technology Company 2
Commercialization		
How did you commercialize your product?	Talk to big pharmaceuticals and biotechnology companies. See what drugs are in development that might utilize their technology. Develop to meet specifications. So they start from end users	Licensing and collaboration with other companies who were interested in process.
Did you have a commercialization plan?	Yes	Yes
Did you have any commercialization partners?	Yes	commercialized through licenses and partnerships
Did you have any outside investors?	Yes	Yes
Did the person for commercialization have a business background?	Yes	Yes
Did you receive any outside business consultation?	Not really, there are databases on what companies are developing and what they're going to need. Also have internal business team	Yes, through developing contacts in industry
When/how did you locate end users?	On starting development	On starting development
Why do you think your product was successful in the market?		It was created to be part of a market. It also became visible in the market through awards.
Issues		

What problems did you run into?	Always risk in R and D. Our methods of working around these problems were based on engineering. Walking toward end solution step-by-step instead of going for it in one shot. This minimized risk.	Not easy to come up with a new product
Are there any inherent problems with creating a green technology that you know of?	Biggest challenge with green chemistry. Is to find companies that commit to a product or commit time to a product. Making something more efficient than what was there before, as efficiency often leads to environmental friendliness. How implementing a green technology fits in overall cost projections	Green needs to be something that people want. Market demand is key. End result must be useable, scalable.
What do you think it takes to be a successful entrepreneur when commercializing a green technology?	Understanding technology, being able to present it and convey it verbally, business savvy, concentrate on a reasonable amount of products	Pragmatics and common sense: is there a market, does this work and will this scale?
Anything else?		Think about what your general value proposition is: imagine a technology team that believes in promise of green types of technology is great, but can be easy to project own belief system on and there might not be a demand for these technologies.

Adversity?	Yes, not because they don't see the value of green technology, but because they've had bad experiences. With green technologies in the past. Varies with specific technology.	

Appendix P: Data from Interview with NSF Representative

Questions	Responses
Can you explain the interview aspect of your program?	After Phase I review process, program directors will interview applicant asking questions that occurred during review process. Do this for all awardees. Looks at business and technology aspects. What are their weaknesses and what are their strengths.
Is there a particular reason why your SBIR program uses grants as opposed to contracts?	Granting agency. Catalyst for funding innovation, not for NSF needs. Not all money is upfront, actively manages grant and progress. High-degree of accountability of grantee.
Can you go over your experiences with the Phase IIB funding option? Pros and Cons?	Phase II grantees are given supplemental funding options. Can apply for these and based on merit. REU program as example, has well defined R&D plan, how it will benefit NSF SBIR mission. Technology commercialization enhancement partnership as another example, works with large manufacturer, grant program supplement. Phase IIB needs to have third party investment that is committed to the company uses this as market validation and will support with matching up to 50% of investment. Need to write another proposal that shows what the funding will do to help further commercialization of technology. Need to make a detailed presentation to NSF with their 3rd party investor in person, helps determine how committed their partner is. NSF grant can only be used for R&D, not business aspects.
Can you explain your FastLane electronic application/review program?	Allows them to manage complete process through one interface, developed through NSF technology. Works great by guiding companies through the proposal process. Uses this also for awardees, the PI can make edits and changes through fast-lane. All aspects of program go through FastLane. Also helps internally at NSF as new personal can look at this.

Can you explain how virtual panels work?	Web-x sessions where panel uses web-cam as part of review. Uses when there are a small number of proposals in a specific topic area. Not cost effective to have reviewers flown in to review few proposals. Web-x has worked efficiently, short discussion of proposals. Conference rooms aren't needed; panel rooms are scarce, works well with their program. Quite good, nothing beats interpersonal communication, pretty good alternative. Audio/video quality is good and keeps information confidential.
Can you explain the Innovation Accelerator Network?	To continue commercialization after Phase I. Commercialization Planning Assistance through one-on-one mentoring, optional for companies. Businesses less than 5 years old, trying to make it to the next step typically take advantage of these programs. Non-profit organization contracted with NSF provides assistance to grantees, helps them find partners and investors. Personnel that mentor are knowledgeable within the industry of technology.
What do you think your SBIR program does well? What do you think could be improved?	NSF provides close to 20% of basic research in US. Fortunate to have access to scientists. All proposals are reviewed by panels, 3-4 reviews per product. Review criteria are transparent for anyone to read. All information is available for stake-holders online. 1-2 pg. exec summary detailing various aspects of applicant. Real feedback on technology, gives company idea of how they review proposals. Dialogue begins a year up to a week before submission of proposal. Small group of personnel with strong entrepreneurial backgrounds work at NSF SBIR, strong R&D and commercialization experience with small and big companies. Helps with mentoring companies. Broad topics for interested technologies, helps companies find a "home" for their idea. 3-5 proposals that don't pertain to topics may be used as new topics, don't always know emerging areas. Outreach through conferences, active through social media, webinars that explain process to public.

Can you explain the NSF's Matchmaker Program?	Through innovation accelerator. Large industrial company wants to learn more about small business their funding, program matches them. Connecting large companies/VC/investors to help small companies. NSF wants to be a neutral player.
Do you communicate with other agency's SBIR personnel? How, often?	April went over last year, they are happy to talk about program.

Appendix Q: Data from Interview with DOE Representative

Questions	Responses
Is there anything unique about your agency's SBIR program?	Run sbir/sttr together. Grants as opposed to contracts. Only agency with one central agency for SBIR/STTR. Offices create their own topics for proposed technologies. Fast-Track option attracts companies.
How do you think these differences help/detriment your success rates?	Choices made about topics are impacted by above. No recent surveys/studies done on success. Determining what metrics to use for success; sales, ratio of sales to government investment, public good
Does your agency fund any green technology SBIR proposals?	All energy efficiency/ renewable energy funded projects are green technologies. All agencies give priorities to this. Cooperates with office of science on topics (most green technologies). Nuclear/fossil energy arguably green technologies.
Do you feel the green technology market is different from other markets?	Energy production technology takes longer to penetrate than computer technology. Typical green technologies don't take as long as turbine technology. Fuel/transportation area has federal mandates that slow down process. Testing can take time. Building technologies (e.g., thermostat) can be faster. Efficiency technology is faster than renewable technology.
How does this affect how support is given to these companies?	Utility sector is slow, depends on what sector. Need to realize it's a process.
Do you communicate with other agency's SBIR personnel? How Often?	Not as much as I would like to. Subgroup within DOE is an additional transagency group. It would be nice to see overlap within portfolios. Talked to April Richards over phone. Sat on panel at conferences with other agencies. Before Dec 2011 with reauthorization, there was more communication in past. Asked NIH about fast track and how many companies have applied, eventually adopted at DOE. There is an interagency report with comparisons of agencies in 2009-2011 by congress.

Are there any traits you look for in selecting green technology entrepreneurs?	Ability to follow direction. Try to use expert reviewers of proposals. Setting goals with cooperation from industry. Most small businesses lack money and experience.
What other support does your agency give?	Grant program, cannot interact with them. Encourage to have a kick off meeting. Requesting orderly reports (optional), not a bad idea. Giving them advice on presentation. Has a commercializing assistance program, Dawnbreaker Inc.
What are the most essential methods to supporting successful companies in your agency's SBIR program?	Letter of intent process describing what they are going to do, make sure it is within realm of interested topics. Encouraging women in minorities intuitive. Finding ways to pay reviewers. Topics are really key.

Appendix R: Data from Interview with Department of Education Representative

Questions	Responses
Can you explain the video demonstration aspect of your program?	Instituted about 4 years ago, requiring that companies produce 4 minute videos to show what the funding is going to. Point is two fold, can see what the company is developed. Requires access to products to try them out personally. Entrepreneur explains in video, tries to showcase features. Phase I must videotape first prototype.
Requirement for both phases?	Phase I awardees applying for Phase II and at the end of Phase II. Phase I for application to Phase II and Phase II video on final technology.
Pros and cons?	Must be posted to YouTube, reviewers love watching a video instead of just looking at print.
Is there a particular reason why your SBIR program uses contracts as opposed to grants?	ED must spend a certain amount to small businesses through contracts. Advantages: better ability to keep in touch with awardees.
Can you go over your experiences with the Fast-Track option? Pros and Cons?	Fast track works so company can apply to Phase I and II simultaneously. Attracts companies who are interested in the total amount of money instead of just a small amount of money for Phase I.
Do you provide additional commercialization support after awarding SBIR contracts?	Do not have a formal CAP. Do not believe in a one size fits all. Provides assistance personally, gives names of private investors and awareness of how to get into the market of education.
What do you think your SBIR program does well? What do you think could be improved?	How can you get the reviewers to pick out the best ones? Strengthened review process based upon past applications. Past performance is a factor. Not easy to talk to each company.
Do you communicate with other agency's SBIR personnel?	Yes
How often?	about once a month
Is there anything unique about your SBIR program that has yet to be mentioned?	A lot of outreach to get program's name out there.
What entrepreneurial traits do you think are needed to make a technology successful?	Little big things. Do they have a good website, do they respond quickly, do they manage the team well, do they have coherent information about what they are doing, do they know people, and do they mention problems ahead of time. Intangibles: determination. Less successful blow a lot of steam, not a good application not opens to communication or criticism.

Appendix S: Interview with Venture Capitalist

Questions	Responses
How do you select companies for investment?	They look for a strong return potential for the risk of investment. During a pre-product situation they look for companies that have products that solve a problem. They want to make sure the product has a serving need in the market; ie new form of water treatment that significantly solves customer problems. Teams typically need to be committed and confident. There is no general way for selection.
Is there an application process?	No. Companies reach out to them through email with a high level summary. They evaluate the information to see if the company is a high-level fit for their firm, then arrange an interview.
Do you conduct interviews? How so?	Yes, they meet in person and take a look at the technology as well.
What do you think makes a good entrepreneur?	It's hard to tell. You need a renaissance person. By that I mean someone really well versed in industry, understands many aspects of life, hard-working, and mainly someone who knows how to recruit/fundraise/sell. Uncommon to have these traits without experience.
Is there a difference in evaluating green technology entrepreneurs in comparison to other fields?	Not from their perspective.
What is the most common composition of the teams in companies you invest in?	Looking for an all-star CEO, with experience (pretty rare). Also want good technical staff and promising marketing personnel too.
How do you support the companies you invest in besides funding them?	Someone serves on the company's Board of Directors. They also provide research and marketing support for companies. Helps provide analysts for locating end-users.

How much capital is typically invested to companies?	Speed round Investments can be anywhere from $50,000 to $1.5 million plus. It's not uncommon to see size of rounds double or triple. There are multiple investment rounds. They hope companies can receive bank financing, so no further investments are needed.
Do you have a metric for evaluating risk?	It's not a standalone algorithm. No standard risk metric. They look at each investment differently.
How do you evaluate the market potential?	Industry background analysts who are knowledgeable in field evaluate the technology.
Do you have an expected rate of return for each investment?	Yes, model out every return. Different for each company and stage of funding. Pre-product is highest risk and would receive highest return. Portfolio has optimal blend of companies at different stages, hopefully lead to 3x net return.
How long do you usually support a company you've invested in?	Anywhere from 2-5 years.
How do you think government funded investment opportunities, such as the EPA's SBIR process, can improve?	I've heard only positive things about the program, unaware of any problems. Rigorous process with paperwork.

Appendix T: Questionnaire data

1. Please list your name and contact information:

Text Response
Responses redacted to keep anonymity

Statistic	Value
Total Responses	14

2. What is the name of your company?

Text Response
Responses redacted to keep anonymity

Statistic	Value
Total Responses	15

3. How did you hear about the EPA's SBIR Program?

Text Response
on-line search
Regularly review all agencies' SBIR/STTR solicitations since 1990 for possible topics that we could propose; successful on 14 past SBIRs (9 Phase I and 5 Phase II).
e-mail announcement
EPA web
We compete heavily in NIH and NSF's SBIR Programs and this technology was a better fit for EPA. We then gathered additional information online.
EIC has been involved with the SBIR program since I joined the company in 1989.
Word of mouth
Boss
Colleagues
e-mail
WWW.ZYN.com SBIR Gateway
Internet
Don't remember
EPA website
From various professional literature.

Statistic	Value
Total Responses	15

4. Did you apply for/receive the EPA's Phase II commercialization option (funding supplement)?

#	Answer		Response	%
1	Did not apply		4	29%
2	Applied, did not receive		8	57%
3	Applied and Received		2	14%
	Total		14	100%

Statistic	Value
Min Value	1
Max Value	3
Mean	1.86
Variance	0.44
Standard Deviation	0.66
Total Responses	14

5. Please rate the following on a scale from 1 to 7:

#	Question	Unclear 1	2	3	Neutral 4	5	6	Very Clear 7	Total Responses	Mean
1	How clear was the SBIR Application?	0	0	0	1	3	6	4	14	5.93

Statistic	How clear was the SBIR Application?
Min Value	4
Max Value	7
Mean	5.93
Variance	0.84
Standard Deviation	0.92
Total Responses	14

6. Have you had any problems with the EPA SBIR application process?

#	Answer		Response	%
1	Yes		1	7%
2	No		14	93%
	Total		15	100%

Statistic	Value
Min Value	1
Max Value	2
Mean	1.93
Variance	0.07
Standard Deviation	0.26
Total Responses	15

7. Please explain your previous answer, if applicable

Text Response
When you are developing sensors to detect chemical warfare agents in the water supply, it is very difficult to find a commercialization end partner. The end partner is HSARPA and the EPA and there are not persons willing to place letters of commitment out there for a potential product down the road in the current funding environment. The persons at the level of need do not have the authority to commit to such a procurement.

Statistic	Value
Total Responses	1

8. Please rate the following on a scale from 1 to 7:

#	Question	Poor 1	2	3	Neutral 4	5	6	Excellent 7	Total Responses	Mean
1	Please evaluate the feedback you received from the EPA SBIR program's peer review	2	0	1	3	3	5	1	15	4.60

Statistic	Please evaluate the feedback you received from the EPA SBIR program's peer review
Min Value	1
Max Value	7
Mean	4.60
Variance	3.26
Standard Deviation	1.80
Total Responses	15

9. Did you utilize EPA's commercialization contractor (Foresight)?

#	Answer		Response	%
1	Yes		11	79%
2	No		3	21%
	Total		14	100%

Statistic	Value
Min Value	1
Max Value	2
Mean	1.21
Variance	0.18
Standard Deviation	0.43
Total Responses	14

10. If so, was it helpful? Please explain:

Text Response
provided additional useful commercialization information for our company
Yes, provided list of possible Phase III commercialization partners; still negotiating with one for possible technology licensing.
no - Help offered was naive at best.
yes. very helpful for some market insights.
I'm not sure - we receive the PhaseI award over 5 years ago...
It was fine. It is likely better for a newer start up.
Good information and contacts.
Was somewhat helpful, we also had contacted several water test instrument manufacturers and potential users to get marketing information.
Yes, I was pleased with the coraspondance and results based on the buget limit.
Did not receive the Phase II Grant
It was OK, did not really understand our technology
Very helpful. Identified companies that might be interested in developed technology
Yes, assisted us in providing feedback on our commercialization progress and on our technical conclusions.

Statistic	Value
Total Responses	13

11. Have you collaborated with any business consultants (other than Foresight) to aid in the commercialization of your technology?

#	Answer		Response	%
1	Yes		4	27%
2	No		11	73%
	Total		15	100%

Statistic	Value
Min Value	1
Max Value	2
Mean	1.73
Variance	0.21
Standard Deviation	0.46
Total Responses	15

12. Did you communicate with your EPA project officer or technical liaison during the process?

#	Answer		Response	%
1	Yes		9	60%
2	No		6	40%
	Total		15	100%

Statistic	Value
Min Value	1
Max Value	2
Mean	1.40
Variance	0.26
Standard Deviation	0.51
Total Responses	15

13. If so, was he or she helpful? Please explain:

Text Response
Yes, for option exercise of verification testing; however, funding was not available, so we found alternative state funding for independent testing (corroboration of test results) and technology certification (in CA, with reciprocity to other states).
yes.
Yes, answered any questions that we had.
In addition to James Gentry, there were several other EPA technical persons who received the monthly reports. Dr. James Magnuson, out of the Cincinnati office, was particularly helpful with several questions and suggestions that aided the research.
Yes, they answered all my questions promptly.
It was not for the EPA funding project.
Extremely helpful. Felt that they were an advocate for the project, gave excellent feedback and suggestions
Very helpful to resolve administrative items
Yes, helpful in working through application and reporting process with the EPA.

Statistic	Value
Total Responses	9

14. Please rate the following on a scale from 1 to 7:

#	Question	Not Helpful1	2	3	Neutral4	5	6	Very Helpful7	Total Responses	Mean
1	How helpful would it be to have a commercialization mentoring program once you receive funding?	0	1	0	4	3	1	6	15	5.40

Statistic	How helpful would it be to have a commercialization mentoring program once you receive funding?
Min Value	2
Max Value	7
Mean	5.40
Variance	2.54
Standard Deviation	1.59
Total Responses	15

15.

#	Question	Poor1	2	3	Neutral4	5	6	Excellent7	Total Responses	Mean
1	Please evaluate your overall experience with the EPA SBIR program	0	0	1	3	3	6	2	15	5.33

Statistic	Please evaluate your overall experience with the EPA SBIR program
Min Value	3
Max Value	7
Mean	5.33
Variance	1.38
Standard Deviation	1.18
Total Responses	15

16. What is the status of your technology now?

#	Answer		Response	%
1	Did not develop		2	13%
2	Still in development		7	47%
3	Commercializing		3	20%
4	Already Commercialized		1	7%
5	Other (please enter in box below)		2	13%
	Total		15	100%

Other (please enter in box below)
The Technology is still in development we are currently looking for a Phase II funding source
In 2007, Congress killed all mention of Chemical Biological Weapons Defeat by defunding DTRA project commercialization for that effort.

Statistic	Value
Min Value	1
Max Value	5
Mean	2.60
Variance	1.54
Standard Deviation	1.24
Total Responses	15

17. If you have any further recommendations or suggestions for the EPA, please comment here:

Text Response
Mentoring is only helpful if the mentor has experience in taking a product to market, not just in providing market data. EPA program is not a first choice for us because funding levels are much lower than the other agencies.
Consider increasing the Phase II funding levels; there is large gap between Phase I POC and field prototype instrumentation that will provide reliable performance needed to interest Phase III commercialization funds. EPA's Phase 2 funding does not allow much effort by senior scientists/engineers.
EPA is the only agency that uses paper applications for SBIR Grant. I suggest they look to Grants.gov and go on-line
Change the submission process from hard copy to internet/email. It should not be too difficult to set up a site to receive PDF files.
The monthly reports were a bit burdensome, Quarterly reports would be more streamlined for the process.

Statistic	Value
Total Responses	5

Appendix U: Interview With Josh Greene from Cleantech Open

Questions	Responses
What types of assistance do you give to companies?	Marketing (newsletters), expert mentoring, regional/national competition awards
How does mentoring work?	Finding & fostering entreprenuers. Teaching them how to receive investment and accelerate towards commercialization. Hold workshops teaching them about their metrics (business strategy, customer discovery, market evaluation, technology evaluation, intellectual property, corporate structure, sustainability)
Who are the mentors?	business oriented people, previous entreprenuers
How do you select companies for assistance?	Judges review applications.
What are the requirements for application?	All applications must fit one of the Accelerator's eight clean technology category definitions (Energy Generation, Energy Distribution & Storage, Energy Efficiency, Chemicals & Advanced Materials, Information & Communications Technologies (ICT), Green Building,Transportation, Agriculture, Water & Waste). 100 customer interviews conducted. Things they look at; initial capital, business plan, outside investments, description of entrepreneur and technology. Address metrics. Must be a 2 person team.
Are there any traits you look for in an entrepreneur/start-up?	Ambition, intelligence (being able to think on your feet), able to communicate effectively, how well they work/communicate as a team, product's market/feasbility/room for growth, management experience
What do you think government programs could do better to have a higher rate of success?	More marketing with accelerators/incubators/universities and marketing with small companies. IT platform needs to be redone to improve navigation/make more user-friendly/better FAQ. Undervalued program that is good for America and innovation should focus on marketing.
What is the common compostition of teams you notice?	Technical/academic two person teams, maybe with some sales background.
How does a green technology background relate to success?	About executing a business plan, has had examples in past where entrepreneurs had little experience in green tech field but were successful because they executed their business plan