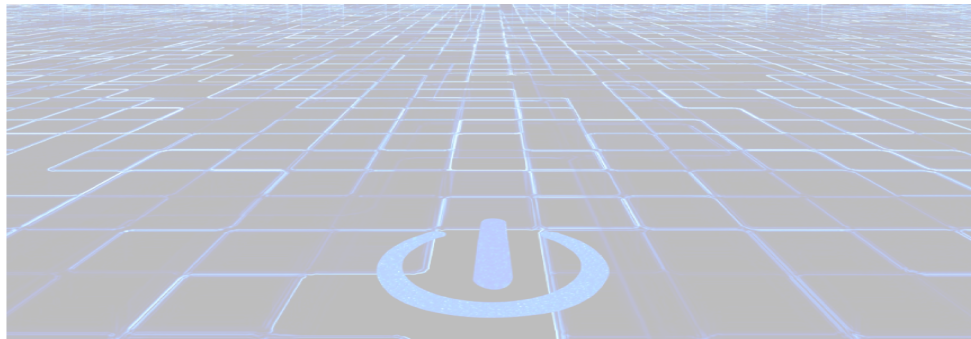


# MODELS OF ENERGY INNOVATION: BEST PRACTICES STUDY FOR STATE ENERGY OFFICIALS

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*Prepared by:*

**Clean Markets**

*Prepared for:*

**National Association of State Energy Officials**

**Association of State Energy Research and  
Technology Transfer Institutions**

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NASEO, one of this study’s sponsors, is the only national non-profit organization whose membership includes the governor-designated energy officials from each state and territory. NASEO was formed by the states in 1986. The organization was created to improve the effectiveness and quality of state energy programs and policies, provide policy input and analysis, share successes among the states, and to be a repository of information on issues of concern to the states and their citizens.

NASEO is an instrumentality of the states and derives basic funding from the states and the federal government. NASEO members are senior officials from the 56 State and Territory Energy Offices (SEOs), as well as affiliates from the private and public sectors. Member state agencies work on an extremely wide range of energy programs and policies. SEOs pay particular attention to driving private-sector economic development through support for renewable energy production and the adoption of energy efficiency technologies. These offices invest more than \$3 billion annually of their own state-based funds. ([www.naseo.org](http://www.naseo.org))

ASERTTI, the other sponsor of this study, focuses on state level public interest Research, Development, Demonstration and Deployment (RDD&D) needs. Its membership includes state and federal agencies, universities, and private corporations committed to working together to promote greater investment in energy research as a primary means of achieving the nation's energy supply, environmental, economic, and national security goals. ASERTTI's mission is to increase the effectiveness of energy research efforts in contribution to economic growth, environmental quality, and energy security. ([www.asertti.org](http://www.asertti.org))

NASEO and ASERTTI operate several joint programs, including the State Technologies Advancement Collaborative (STAC). The unique partnership of STAC with the U.S. Department of Energy is a mechanism to efficiently invest in innovative energy efficiency and renewable energy technologies. It was the success in operating STAC which led to this jointly- sponsored study. ([www.stacenergy.org](http://www.stacenergy.org))

Clean Markets creates public and private sector partnerships among organizations that are advancing clean energy technologies. Its mission is to make the world a healthier place to live by creating viable markets for sustainable, natural resources. Clean Markets positions companies, institutions and government agencies for success by developing and executing impactful market development strategies and models. The result is market transformation success for government clean energy programs, long- term growth for companies, and a better quality of life for citizens and consumers. ([www.cleanmarketswork.com](http://www.cleanmarketswork.com)) Clean Markets’ contributors to this study include: Ellen Lutz, Karine Shamlan, Jim Fong, Chris Bentley, Yvette Brown and Mark Micciche.

## INTRODUCTION

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The government sector has played a historic role in advancing and introducing innovative technologies to the world, such as the compact fluorescent bulb and the Internet. It is a critical role of government to invest in technologies that serve a public good, but that are too high risk for the private sector to invest the resources needed to complete initial research, development and market introduction. This is especially true today, with over \$90 billion invested from the U.S. Department of Energy (DOE) alone in 2009-2010, for the research, development and deployment of energy efficiency and renewable energy technologies. The extraordinary amount of funding presented considerable opportunities and challenges, providing the ability to fund energy projects, yet presenting challenges related to merit review and the selection of projects that will produce results.

In recent years, the DOE has stepped up its innovation efforts. Examples of this include the Regional Bioenergy Research Centers, the Office of Industrial Technologies' Regional Resource Centers for Innovation, and the "DOE Energy Innovation Hubs", introduced in 2010 and modeled after the DOE Bioenergy Research Centers.

In 2009-2010, State Energy Offices and universities received over \$3 billion through the U.S. State Energy Program (SEP) under the federal American Recovery and Reinvestment Act (ARRA). These funds were matched with \$4.7 billion from the private sector as states used market-oriented approaches to direct these resources for greater economic development. In addition to these funds, each year State Energy Offices and institutions invest more than \$3 billion of state-derived funding in clean energy and energy efficiency projects and programs.

In response to the growing focus on advancing energy technologies in collaboration with the private sector, the National Association of State Energy Officials (NASEO) and the Association of State Energy Research and Technology Transfer Institutions (ASERTTI) commissioned this "Innovation Best Practices" study in 2010 to help states better understand best practices in energy innovation, and thereby create programs and select projects with the highest likelihood of success. While this study is tailored to states, many of the recommendations are intended for consideration by both state and federal officials and their supporting institutions involved in clean energy technology advancement.

The genesis of NASEO and ASERTTI's involvement in innovation was "The State Technologies Advancement Collaborative" (STAC), which was established in 2002. STAC was established through a Cooperative Agreement between the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (DOE-EERE) and Office of Fossil Energy (DOE-FE), the National Association of State Energy Officials (NASEO) and the Association of State Energy Research and Technology Transfer Institutions (ASERTTI). According to the Agreement, the purpose of this collaborative pilot program was "to jointly support the research,

development, demonstration and deployment of (RDD&D) of technologies where common Federal and State energy efficiency and renewable energy and fossil energy activities exist.” The term of the pilot program was set for five years.

While DOE’s Golden Field Office provided oversight of STAC’s cooperative agreement, a seven-member Executive Committee and its staff managed the solicitation process. The Executive Committee was comprised of two representatives from both NASEO and ASERTTI, one representative from both DOE-EERE and DOE-FE, and one independent representative. There were also four Alternate Members, two from both NASEO and ASERTTI.

Over the course of the five-year pilot program, STAC issued three solicitations through which it awarded more than \$16.2 million to 32 projects nationwide. The STAC funds leveraged an additional \$18.5 million resulting in a total of \$34.7 million in project value. A breakdown of these solicitations is highlighted in the following chart.

	<b>FY 2003</b>	<b>FY 2004</b>	<b>FY 2005</b>
<b>Total value of projects</b>	\$16,807,582	\$6,404,119	\$11,500,000
<b>STAC Award</b>	\$7,013,709	\$4,323,305	\$4,900,000
<b>Funds leveraged</b>	\$9,793,873	\$2,116,814	\$6,600,000
<b>Total number of projects</b>	13	8	11
<b>Number of states involved</b>	31	14	23

Each solicitation focused on specific categories. In FY 2003, STAC’s funding priorities were to promote Energy Efficiency Research, Development, Demonstration and Deployment in five specific areas: Building Technologies; Industrial Technologies; Transportation Technologies; Distributed Energy Technologies; and Hydrogen Technology Learning Centers.

The FY 2004 solicitation called for projects addressing Energy Efficiency and Fossil Energy Sciences specifically with respect to: Materials Sciences; Fuels and Chemical Sciences; Sensors and Controls Sciences; Energy Conversion Sciences; and Emissions Reduction and Environmental Sciences.

Finally, the FY 2005 solicitation was similar to the initial 2003 solicitation except it did not include funding for hydrogen technology learning centers, but rather called for projects that supported DOE’s Rebuild America program goals. Under this solicitation, the North Carolina Energy Office and its partners received \$840,000 to develop technology for plug-in hybrid electric school buses. This project is discussed in greater length in this study as a Case Study on page 24.

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## EXECUTIVE SUMMARY

State Energy Offices (SEOs) are in a unique position to foster innovation by encouraging and funding projects that may seem higher risk, but that will ultimately be game changers for their states' and for the country's energy industry. Energy Offices are at the intersection of policy, technology, research, demonstration projects, funding, and market development. This study found that this is a unique vantage point that, when strategically applied, allows the State Energy Office, in partnership with research institutions, to be a catalyst for innovation.

The purpose of this project was to:

- Understand the types of innovation models being used today by energy technology innovators, such as DOE Innovation Centers, National Labs, R&D institutions, state agencies and the private sector;
- Identify the key success factors of successful energy innovations; and
- Develop a set of recommendations that provide guidance for State Energy Officials when evaluating higher risk technology development projects.

Through an extensive literature review, coupled with in-depth interviews with 21 energy technology innovators, various models of technology innovation and development were explored. The traditional Research, Development, Demonstration and Deployment (RDD&D) model often used by the government sector, plus more current innovation models were investigated for their importance to developing breakthrough energy technologies. The stages of the more current innovation models were broken into: "Ideation", "Incubation" and "Commercialization".

It was found that innovation in the government sector would be best accomplished by adjusting the RDD&D process to accommodate the faster pace, flexibility and simultaneous development required for technology breakthroughs. One significant difference between traditional RDD&D processes and Innovation models is that, while both often include a variety of organizations, innovation requires those separate organizations to act as a cohesive unit. The innovation process looks more like an ecosystem of enterprises, government agencies, researchers and investors, in contrast to the clean lines of separation between organizations and their responsibilities in the RDD&D process.

Traditional RDD&D models employ a phase-gated approach where the phases of development are treated as individual sequenced efforts. While this process can have advantages of reduced risk, the more modern innovation approach requires significant overlap and faster, more efficient prototyping and testing. Innovation models today often move quickly through the development process, relying on partnerships early in the research and development stage.

This study found value in both models, but concluded that the highest value would be derived by combining the steps used in both models, and employing best practices identified in four major project development areas: Goals and Strategies; Team Environment; Processes; and Resources.

**Table 1. Best Practices in Key Innovation Project Areas**

Best Practices Project Development Areas	Characteristics
Goals and Strategies	Projects tended to focus on technology breakthroughs, driven by the higher goals of environmental quality and economic development.
Team Environment	The most successful project teams had breadth and depth of expertise, personal commitment, market knowledge, a project champion and a culture that fostered innovation.
Processes	The processes that successful innovators cited as most useful were project management and intellectual property management.
Resources	The most important project resources identified were external partnerships and funding.

Recommendations for SEOs when soliciting and selecting projects include:

- **Strive for Game Changers:** Identify gaps in the state’s clean energy supply chain for priority technologies, and challenge stakeholders to fill those gaps with innovative solutions that will create new manufacturing industries.
- **Reward Good Behavior:** Develop project selection criteria that reward innovation best practices and methodologies.
- **Require Structure:** Require project management plans for high- risk projects, and have protocols in place for managing intellectual property arising from development projects.
- **Look for an Innovative Environment:** Create the right team environment that will foster innovation. State Officials should look beyond the project to the culture within the project team itself.
- **Encourage External Funding:** Secure external partnerships and adequate funding, as these were cited as the most critical resources contributing to success. If an SEO alone cannot adequately fund a breakthrough project, cost share requirements from private sources are common.

Results from the personal interviews conducted have been aggregated for this study, and specific case studies of participating SEOs can be found starting on page 24. The names of all participating organizations are provided in Appendix B.

## APPROACH

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In the spring of 2010 Clean Markets conducted both a literature review<sup>1</sup> and 21 in-depth interviews with organizations involved in creating breakthrough products, components or processes within the clean energy sector. Interviews were conducted both by telephone and in-person. Interviewees represented national laboratories, private companies, universities, research institutions, State Energy Offices, non-profit organizations, and venture capital firms, and were selected from the following:

- The Cleantech list of the top 10 universities involved with clean energy technology breakthroughs<sup>2</sup>
- Recommendations from the Executive Committee of the National Association of State Energy Officials (NASEO)
- Recommendations from the Executive Committee of the Association of State Energy Research and Technology Transfer Institutions (ASERTTI)

One basic survey was tailored for three types of interviewees: government and national labs; universities and research institutions; and private sector companies. The difference between the surveys was that language was tailored for each sector, but the basic categories remained the same. An example of an interview guide can be found in Appendix C. Each interview lasted approximately one hour, and focused on the goals, key success factors, resources, processes, partnerships, group interactions and communication methods that contributed to the success of their project. In some cases, the project discussed was not a new technology, but a component that led to a breakthrough, such as the creation of a new process or software model, or the discovery of a new enzyme or polymer, which facilitated a breakthrough.

All interviews were then grouped according to the stage of development of each project, and similarities and differences within and between phases were noted. The interviews were divided into the following phases of project development:

- R&D (6 projects),
- Demonstration (5 projects), and
- Deployment (10 projects).

It is important to note that the number of projects in the deployment group is almost double the number found in either the R&D or demonstration groups. This reflects the success of the projects on which this study focused. Many of those projects started out as R&D projects that successfully were deployed or commercialized. The models of how that was accomplished provide valuable insights for State Energy Offices and technology transfer institutions.

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<sup>1</sup> A complete list of references consulted for this project can be found in Appendix A

<sup>2</sup> <http://cleantech.com/news/5384/top-10-cleantech-universities-us>

## INNOVATION MODELS

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Reviews of secondary literature on innovation and product development revealed that the approach and nomenclature used by innovation thought leaders outside of the government sector is slightly different than that used by government agencies. Government agencies describe the RDD&D cycle of Research, Development, Demonstration and Deployment. Innovation experts often describe similar phases as “Ideation”, “Incubation” and “Commercialization”. Are these different processes, or just different names for the same activities? It is a little bit of both.

The processes are somewhat similar, and the activities that take place at each phase can be overlapping. The major difference is that the intention of innovation is to discover a completely new way of doing something, while the intention of R&D is often to gain incremental progress in the performance of an existing technology. Both goals are highly important, but breakthroughs will occur faster and in greater numbers by combining the steps of both.

One significant difference between traditional RDD&D processes and Innovation models is that while both often include a variety of organizations, innovation requires those separate organizations to act as one. The process looks more like an ecosystem of enterprises, government agencies, researchers, and investors. This is in contrast to some more traditional RDD&D models, where clean lines of separation exist between organizations and their responsibilities.

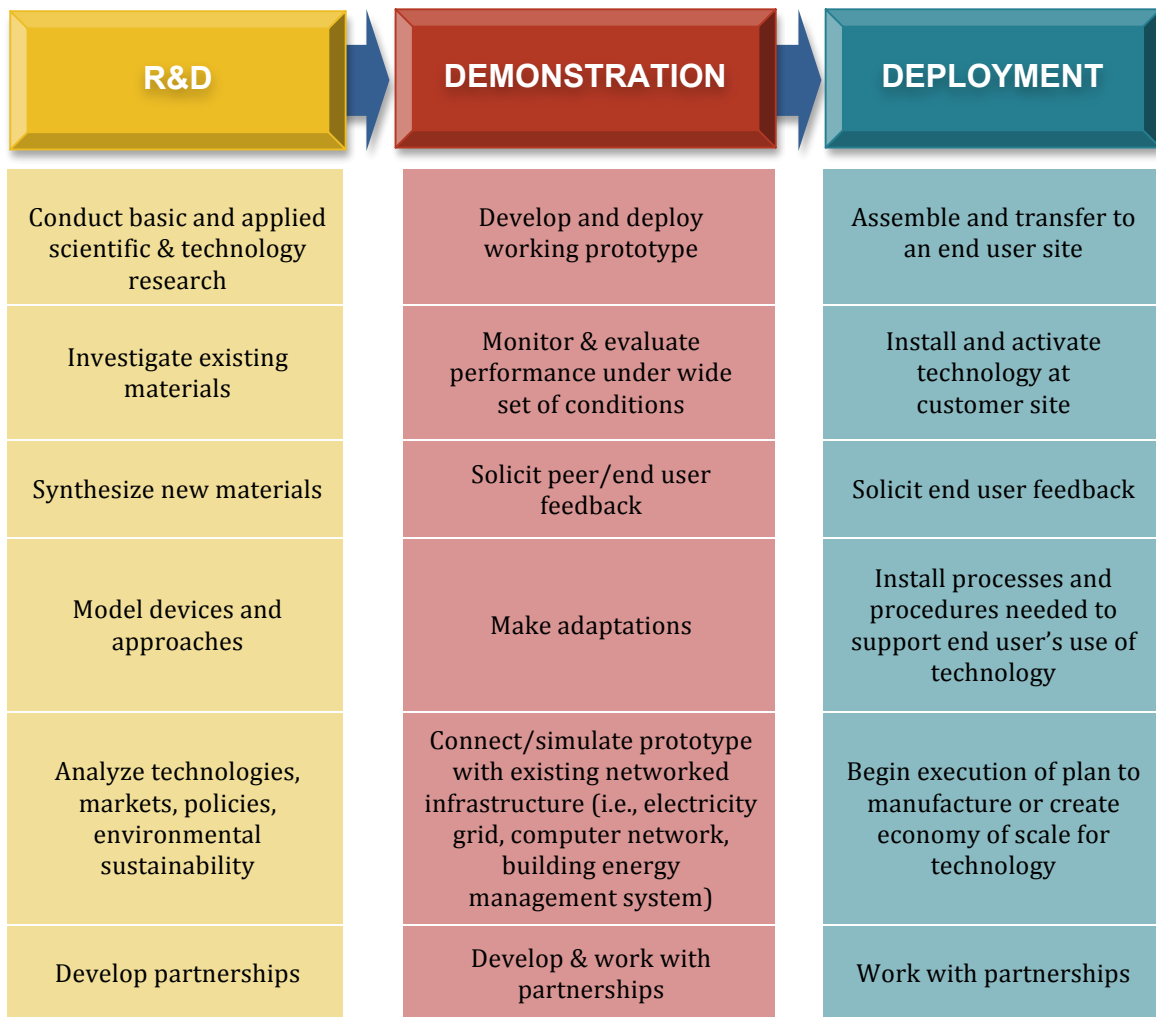
Another difference lies in how early market needs are integrated into the RDD&D process. RDD&D often “pushes” a technology into the development stage, rather than “pulling” early market analysis and understanding of market needs early in the research process, thereby creating a market “pull” rather than a “push.” Other key ingredients to a working innovation model include: openness to outside solutions, breadth and depth of expertise, and the ability to recognize unexploited market opportunities.

Traditional models for development and design employ a phase-gated approach where each phase of development (R&D, Demonstration, and Deployment) is treated as individual, sequenced efforts. While this process can have advantages including reduced risk, it fails to take advantage of the pace at which technology and market changes can evolve throughout the life of the development of a new innovation.

The more modern approach requires significant overlap and faster, more efficient prototyping and testing. It also requires the process to be much more flexible, to allow different phases of development to occur simultaneously.

Figures 1 and 2 show the type of focused activities that take place at each phase.

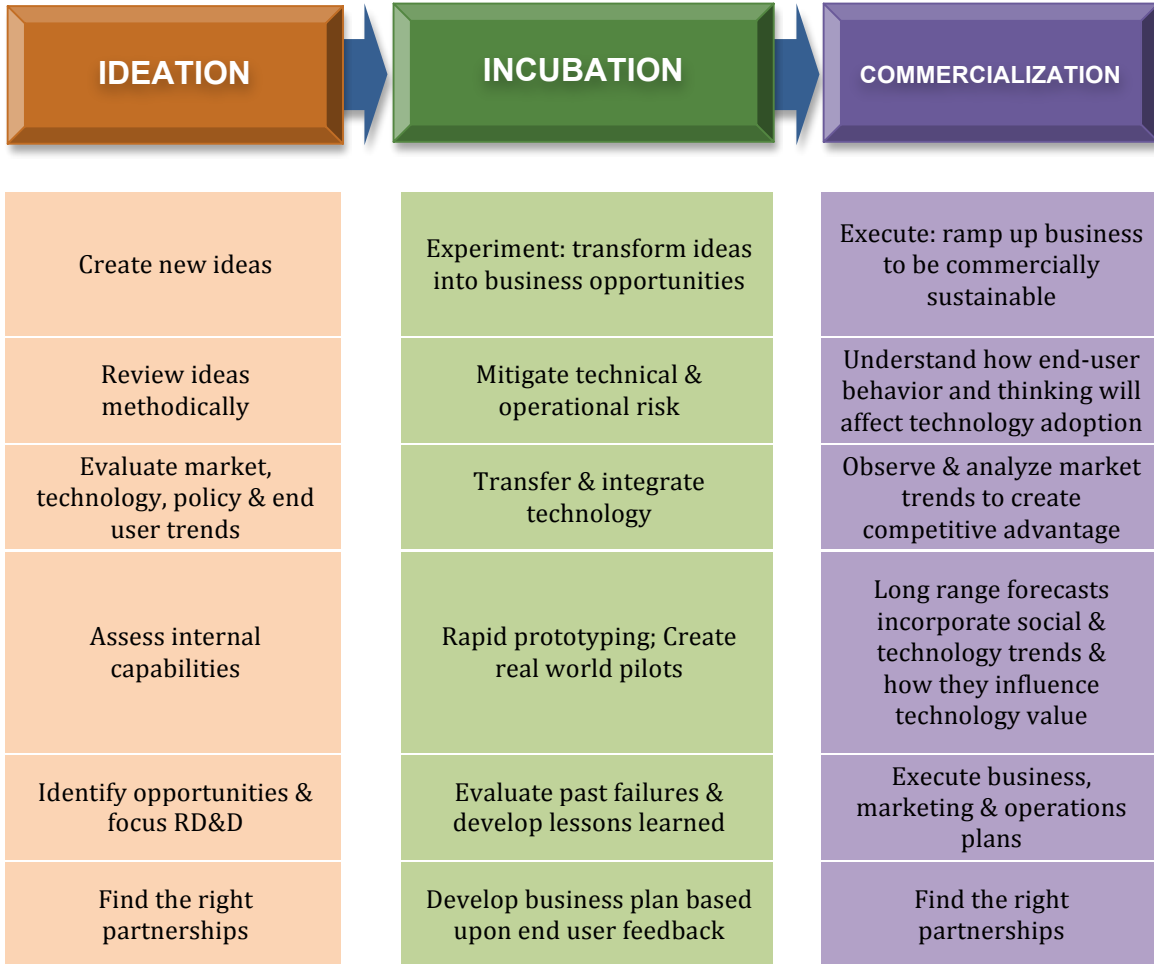
**Figure 1. RDD&D PROCESS**



The major differences between the models shown in Figures 1 and 2 are:

- The purpose of the Innovation Process in Figure 2 is to create a new idea, informed by market analysis and feedback; while the research in the RDD&D Process in Figure 1 seeks incremental improvement and is primarily informed by existing research.
- The Innovation Process in Figure 2 is focused on commercialization from the outset, assessing the teams' capabilities and business potential at each stage.
- The goal of the RDD&D process, "Deployment", generally refers to a technology being used at an end users' site, while the goal of Innovation, "Commercialization", is to reach economy of scale and form a viable market.

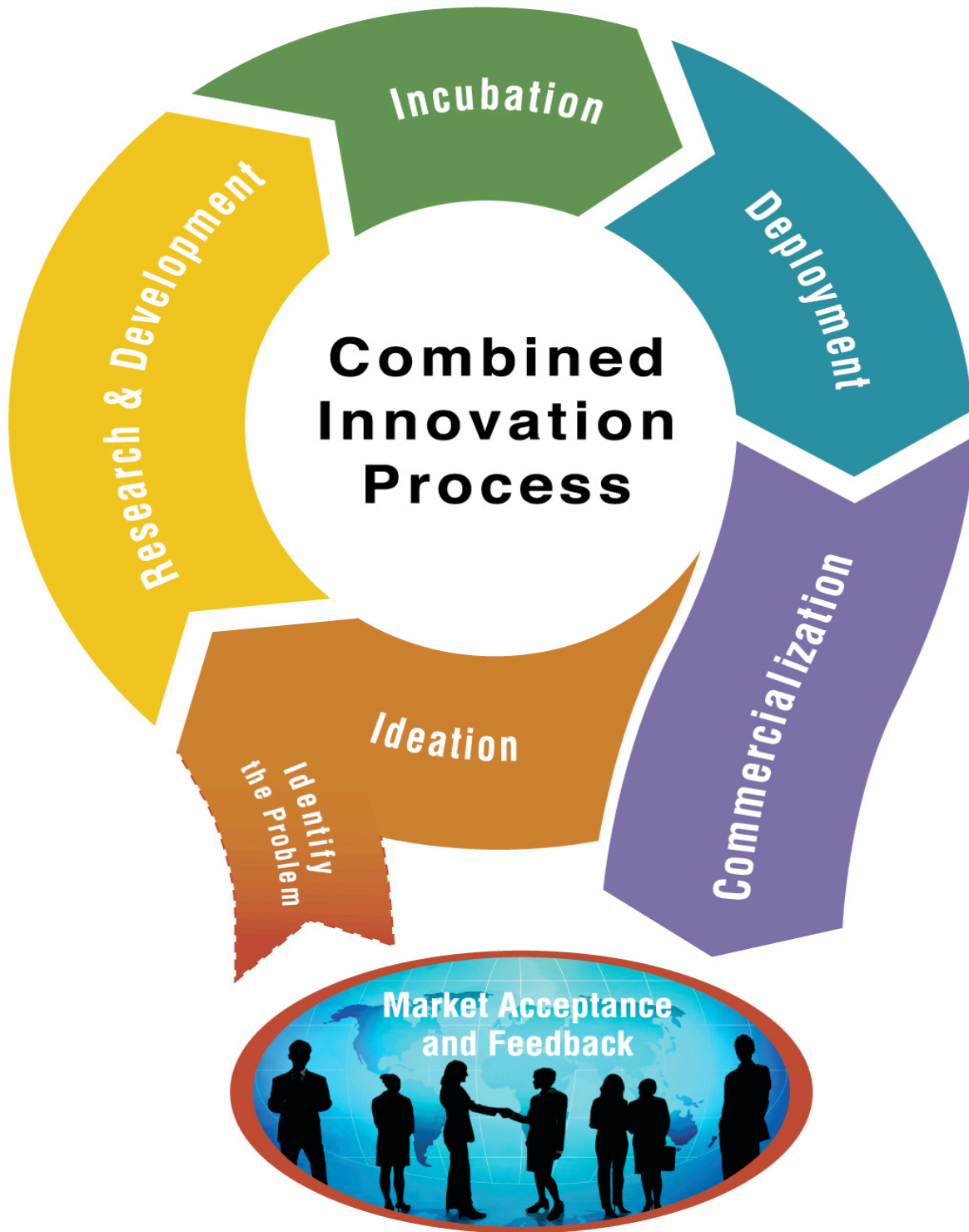
**Figure 2. Innovation Process**



SEOs are in a unique position to incorporate innovation best practices into their planning and funding activities. Unlike the DOE technology programs, which approach innovation through the lens of individual technology development, SEOs are able to address the broader climate and economic development goals of their states and consider all technological solutions to address them. When evaluating proposals for innovative technologies, SEOs can increase their likelihood of success by choosing those proposals that emulate the key success factors present in best practice innovation models.

The best practice interviews conducted for this study show that there is a benefit in combining the phases and focus of each model when creating energy technology breakthroughs. The sequencing of this combined model is shown in Figure 3 below, Combined Innovation Process. Figure 3 shows that breakthrough innovations are created through a continuous loop that begins and ends with market feedback. This feedback about end user behavior, preferences and concerns fuels the pipeline of new ideas and helps researchers to identify which problems they are trying to solve.

Figure 3. Combined Innovation Process

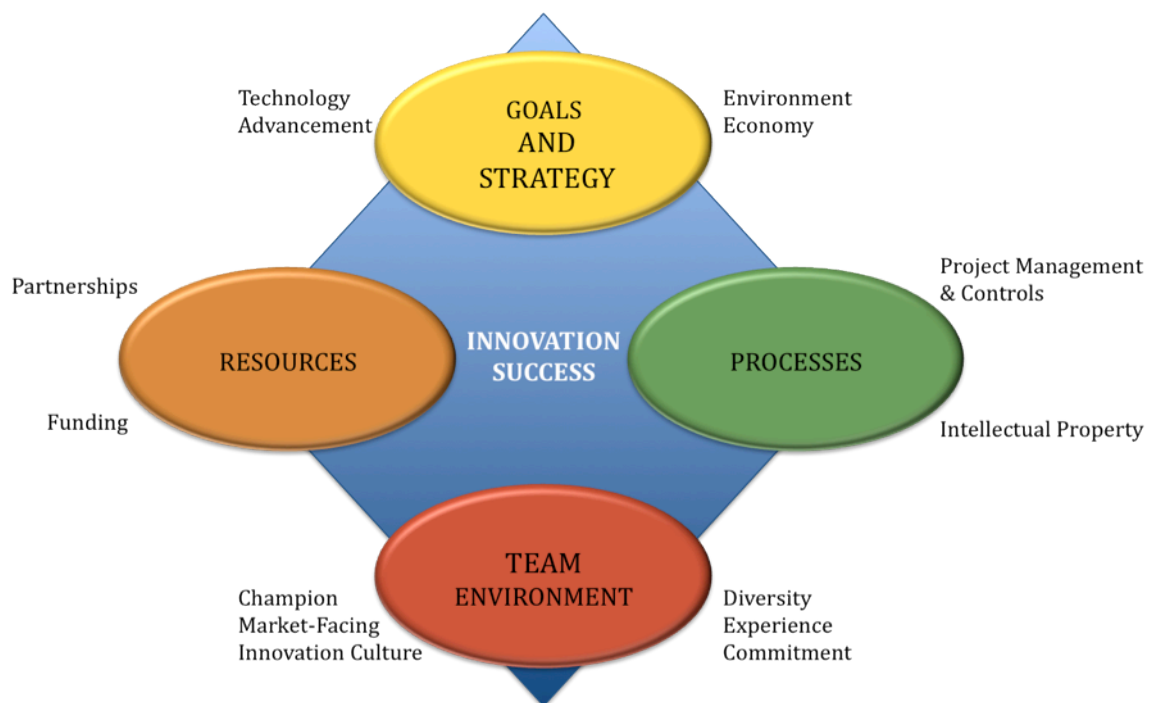


## SURVEY RESULTS

From April through June of 2010, Clean Markets conducted 21 interviews with individuals involved in the creation of breakthrough products, components or processes within the clean energy sector. An example of the interview guide used for research institutions, one of the three sectors interviewed, can be found in Appendix C.

Survey results were divided by the stage of development of each project (i.e., R&D, Demonstration, Deployment). Results were analyzed for similarities and differences across all three stages. The results of the analysis showed that the most successful projects followed similar best practices for innovation, which could be seen as common denominators. These best practices were grouped into the four major categories shown in Figure 4 below.

**Figure 4. Innovation Best Practice Areas**



These four basic categories dovetail well with the “four points of performance” named by Dr. Robert Cooper in his book, “Product Leadership”, which studied the best performing product development companies.<sup>3</sup> Overall, this Innovation study sought to uncover best practices and key success factors in each of these categories by answering the following questions:

<sup>3</sup> Cooper, Dr. Robert G., “Product Leadership”, Second edition, New York: Perseus Books, 2005.

- **Goals and Strategies:** What were the goals of the project? Did the goals change as a project advanced from R&D through Demonstration and Deployment?
- **Team Environment:** How did the project team environment affect the performance of the project?
- **Processes:** What processes used by the project team most contributed to the success of the project?
- **Resources:** What were the most critical resources contributed by the project team and its partners or funders?

### *Goals and Strategies*

Goals across the three phases of R&D, Demonstration and Deployment did have some relevant overlap, due to the fact that projects that started out in R&D and moved through to demonstration and deployment kept the same general goals but added more specific tasks at each stage. Most of the successful R&D projects had broad reaching goals, such as creating new technologies that would solve environmental or economic development problems, or improving upon existing technology performance and production.

Demonstration project goals tended to focus more narrowly on specific technology performance aspects or bottlenecks affecting achievement of a larger R&D goal. At the deployment stage, goals were added to create a sustainable market for the technology or product. The goals shown in Table 2 below show the shift in focus that occurred at each stage.

**Table 2. Sample Project Goals of RDD&D Projects Studied**

<b>STAGE</b>	<b>GOALS</b>
<b>R&amp;D</b>	To reduce the price of jet fuel derived from bio fuels
<b>Demonstration</b>	To create a unique lighting solution of dimmable ballasts that would facilitate the bidding of lighting loads into the demand response market
<b>Deployment</b>	To commercialize and find a sustainable market for a breakthrough method of conducting solar electricity

One company interviewed, which had successfully commercialized a breakthrough solar product, had this advice for state agencies about establishing R&D goals:

*In selecting R&D projects to fund, states need to recognize the importance of the whole industry supply chain, not just look at immediate jobs created. If you create an entire new industry, it brings manufacturing back to the state. Most states shoot from the foul line all the time. They should shoot more often and take a chance at some three pointers.*

Another interesting perspective came from Clark Gellings of the Electric Power Research Institute:

*To understand if an R&D project is worth undertaking, these factors must be taken into consideration:*

- *What is the scale of the impact?*
- *What value does the R&D provide to the existing supply chain?*
- *What is the technical and market risk?*
- *What is the distribution channel to market?*
- *Can it be developed and demonstrated?*

Once a project reaches the deployment stage, goals naturally take on market performance indicators, due to return on investment expectations of private sector funders. In three cases, even projects funded by state agencies had provisions for a return on investment back to their state funders. The deployment phase focuses on providing the resources necessary to develop or support a market for the product, technology or business that the state is funding. The overarching goal is to attract market forces to take over and sustain the economics of the state's investment.

At the deployment phase, goals generally fell into two major categories:

- To expedite market adoption of a new technology, product, service or process; or
- To successfully deploy a commercial application of a prototype technology. An example of this is the Verdant East River project, the world's first grid connected array of tidal energy turbines.

## Team Environment

The overall environment in which a project is developed involves the attributes and culture of the project team, as well as their understanding of the market conditions into which their innovation will be introduced.

### 1. Qualities

When interviewees across R&D, Demonstration and Deployment projects were asked to name the most important factor as to why their project was successful, most respondents focused on the characteristics of the project team, as opposed to financial resources or other factors. Across all phases, the leadership capability as well as staff talent, expertise and commitment were most often cited as key success factors.

At the R&D stage, a successful project team was described as having an experienced, passionate leader and highly committed and collaborative researchers with the autonomy to be creative in their approach. For Demonstration projects, the most important qualities of the team included subject matter expertise, a visionary leader and commitment from the team. Similarly, deployment project interviewees felt that a high level of expertise among the project team and the team's commitment to the project's outcome were most important.

One State Energy Official described an important attribute as having "T-shaped" people on the project team:

*It is critical to have "T-shaped" people as a resource for the project team. These are people who think broadly but have deep expertise in specific areas. They are the ones who will bring big ideas to the group.*

When asked about the importance of having an experienced staff versus new members with fresh ideas, all respondents agreed that it was important to have an experienced team, especially at the leadership level. Having new and fresh ideas or being open to new technologies was considered helpful, but ultimately project team experience was the most important factor.

### 2. Diversity

There was general agreement that involving a diverse group of stakeholders as early as possible in the project development process would produce the best outcome. R&D respondents said that teams should range from researchers, to commercialization partners, to end-users. One R&D institution did say that sometimes bringing in industry partners too early can be difficult because manufacturers might not be able to envision the breakthrough concepts proposed. Their advice is to make sure that the concepts are clearly supported by trend,

market and end user data at the “Ideation” stage before engaging industry partners in visioning exercises for disruptive technologies.

### **3. Project Champion**

The majority of respondents at all phases felt that having a project champion was one of the most important success factors. The project champion provides the long-term vision and a strong belief in the project’s ultimate success. Project champions were often the catalyst for bringing diverse project partners to the team. Often the Project Manager was the project champion, but sometimes the champion came from outside the organization, such as a university outreach director, a state Governor or legislator. A National Renewable Energy Laboratory participant described the effect of the project champion on their successful project:

*The project champion instilled the belief that we could create a robust PV industry and change the world. He kept that long-term vision throughout the development process.*

### **4. Market Expertise**

Several State Energy Offices said that their market position and market understanding were the keys to the project’s success. For example, in North Carolina a key success factor was market aggregation – being able to reach out to all school districts and aggregate their buying power for hybrid school buses. In New York, having a strong understanding of market needs – the ability to shed commercial lighting load during peak hours - contributed to the development of a new product, the dimmable ballast.

### **5. Culture**

Finally, organizational culture seemed to play an integral role in fostering innovation. Rosa Yang from the Electric Power Research Institute felt strongly that people need to be given the time to be creative and innovate, as demonstrated by the examples she described below:

*People can be more innovative if you give them more time. At 3M and Google, each technical person is given 30% of their time to work on projects outside of their primary area of responsibility. Europeans and Japanese are more thoughtful about setting program directions. Japanese nuclear field funding has a 20 -year plan.*

Similarly, Joyce Ferris of Blue Hill Partners, a venture capital firm funding clean energy technologies, felt that a focus on the “chemistry fit” of the project team with the rest of their portfolio reduced their risk of investment:

*We focused on the “Chemistry fit” with the management teams of each new company with that of the rest of our portfolio of companies. The biggest factor to success was the strategic fit of each business. Applying strategic and chemistry screens reduced risk of the investment, created a team atmosphere and continuous learning for all involved.*

## *Processes*

### **1. Project Management and Controls**

The majority of respondents at all stages acknowledged that the project management plan or communications process was very important to the success of the project, providing clear direction and a touchstone for expectations and evaluations. However, several respondents noted that it was important that the plan be modified as conditions changed. Several respondents reported using a Stage Gate type process, where funding would be discontinued if milestones were not met or if the project results were not as useful as anticipated.

The degree of the use of project management plans became greater as projects moved further toward deployment. However, some successful R&D organizations had rigorous project management milestones and accountability metrics in place.<sup>4</sup> One research institution partnered with a private sector company described their R&D accountability process:

*All Research Leaders meet twice a year with our funders and advisory committee. They all meet every day for a week from 8-5. The advisors provide real time feedback to the research teams and the teams are given 6 months to correct any issues. If corrections are not possible within that time, they need to develop a case for additional funding.*

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<sup>4</sup> See the Renewable and Sustainability Institute’s (RASEI) commercialization process, which provides funding and technical support to commercialize technologies. Details of the process can be found at [https://www.cu.edu/techtransfer/proof/renew\\_en\\_fund.html](https://www.cu.edu/techtransfer/proof/renew_en_fund.html)

One State Energy Official involved with both R&D and demonstration projects felt that, in the interest of fostering creative thinking, it was important to stay fluid with metrics at the R&D stage. But once the state started to commit more sizeable funding for a demonstration project, then project schedules, scope of work and contracts were designed to keep the project team on task.

As for communications processes, many reported that routine meetings and regular reporting requirements kept staff accountable. Staff performance was based on successfully meeting project milestones and sometimes staff compensation was based upon achieving those milestones.

The majority of projects had an exit strategy in place if milestones were not met. For interviewees who were funders of projects, such as State Energy Offices, or research institutions managing large portfolios, the exit strategy was often to sunset unsuccessful projects and redirect resources to other research areas or projects.

## **2. Intellectual Property**

The subject of management of intellectual property often produced a lively response, and the great majority of respondents across all sectors did have a process for managing intellectual property that resulted from their project. The specifics of those processes were often confidential, but respondents did share their overall arrangements, and conclusions could be drawn about the handling of intellectual property at each development stage.

At the R&D stage, intellectual property is a major concern. Research is often conducted by universities, whose researchers may be evaluated based upon the number of patents they have. Most universities have specific offices that handle intellectual property issues that will develop an IP plan if a project involves partners outside of the university. If an outside partner is a private company, then the company will often want first right of refusal to the patent license.

At the Demonstration phase, manufacturers are often involved on the project team. In those cases, the manufacturer will most always want the exclusive right to manufacture the product. In the technology Deployment stage, where private companies are more heavily involved, intellectual property rights are very well defined. Two State Energy Officials stated that the private companies they funded retained the intellectual property rights, but the state had negotiated royalty fees. One state assessed a higher fee for revenue generated outside of the state, while another assessed royalty fees until their grant was repaid.

### **3. Project Shareware**

Most interviewees responded that various software programs such as Microsoft SharePoint, Citrix's WebEx or GotoMeeting were not critical or instrumental to project success. These programs were seldom used, if at all. The majority of institutions interviewed conducted face-to-face meetings, email or teleconferences. One respondent noted using PeopleSoft but stated that it was too cumbersome and not geared for research teams and has, therefore, stopped using it. Another acknowledged using SharePoint and Webinar software noting that they used the webinar software more as a consumer rather than an originator.

The lack of use of these software programs is not an indicator that these programs will not be useful. It is more likely that the shareware tools for project management were just not widely available when these projects were being developed many years ago. However, it is interesting to note that most projects did cite interpersonal communication as a key success factor, so these tools, however useful, will probably not replace the importance of interpersonal communication.

## **Resource**

### **1. Partnerships**

All of the interviewees for this study overwhelmingly agreed that external partnerships were critical to the successful outcome of their projects. Partnerships were seen as the most effective and expeditious way to fill gaps in experience, knowledge, technology, funding, intellectual property management or networks among the team. The right partners also provided the project team with the ability to react to market conditions at the right time, eliminating the need for the team to create infrastructure from scratch.

At all stages, external partners provided a variety of contributions, determined by the gaps in the skill set of the interviewee's organization for each project. In some cases R&D partners provided technology or research capability to a team with business acumen, and in many cases partners provided market-facing knowledge and business acumen to an R&D team. The partners who had the most influence were naturally the funders, to whom the project team was generally accountable. In some cases where the predominant skill set needed was highly specialized, such as software development, it was helpful to have partners from outside of the energy industry.

For all stages of projects, the goal was to obtain multidisciplinary partners that rounded out the skill sets and experience of the team. Most respondents agreed that their projects would not have succeeded were it not for the contributions from their partnerships. A few thought that their projects could potentially have been

successful without their partners, but would have taken much longer to achieve that success.

Respondents at all stages, but especially deployment, felt that having a commercialization expert or partner on board early in the process was critical to success. Several R&D respondents said that for some projects it was critical to have a manufacturer on board to help develop the product specifications so a plan could be developed to reach economies of scale. In those cases where manufacturers were on an R&D or Demonstration project team, they often would require an exclusive license to manufacture the product.

A university innovation center offered these two insights:

*First, timing is important. A technology around which a valuable business can be aligned needs to match up with what is going on in the market. Second, the speed with which things happen is important. Universities need to move quickly to engage the marketplace. The market moves and adjusts quickly.*

Non-profit organizations or innovation centers often provided the mission and the vision for the project and the facilitation function for all of the partners. One non-profit innovation center said that they were the “glue that held everything together,” managing project implementation from the initial development of the project proposal, identifying funding sources, and building the regional support infrastructure.

When asked how they found their partners, answers varied slightly across each stage. At the R&D stage, respondents connected with their partners either through existing contacts or through networking. At the demonstration phase, partners were often actively sought out through an industry search or an RFP, or they were found through existing networks. Project partners were also often proactively sought at the deployment stage through RFPs, RFIs or proactive networking. In the case of a funding organization, such as a State Energy Office, partners often approached the state with their idea.

## **2. Funding**

At the R&D stage, the overall budget amount was a good indicator of success. All projects had multiyear budgets ranging from two to ten years. One interviewee noted that the shorter the budget period, the greater the sense of urgency to get things done. All respondents agreed that having a multiyear budget was critical because consistency reduces waste and maintains project momentum. Anxiety over the availability of future funding can be disruptive to a project. Many R&D institutions said that it was difficult to build a sustainability plan beyond their initial

round of multiyear funding for each project, because successful projects will graduate from R&D to go on to the next stage of development.

At the Demonstration phase, the majority of respondents knew what their budgets were going to be over a one and a half to a three-year period, enabling them to plan accordingly. All agreed that having a robust budget was an important factor for project success. Project budgets ranged from an initial seed grant of \$400,000 to \$10.3 million over three years. However, it was noted that additional resources were required to implement the projects successfully. One organization noted that at least \$1 million is required to develop and manufacture a technology once the R&D process is complete. Another institution suggested that it was important to be able to compensate industry leaders for their contributions to the demonstration process.

Although budget figures were not available for all deployment projects, budgets for some of the deployment projects studied ranged in size from \$3 million to \$130 million over multiple years. Some respondents stated that even small amounts of capital are valuable, because it can be leveraged with other funding sources. The majority of respondents agreed that multiyear funding was critical to project success. It is important to have a budget commitment over a 2-3 year period in order to develop a business, as the first three years in business are generally the most financially constrained.

The one exception to finding value in a larger budget was a solar energy center that developed an energy efficient fan. This project had very limited resources invested (essentially the principal investigator's time) compared to the profit gained from the final product. In this case, the respondent noted that having a limited budget led to efficiency and a low-cost method to prove the project concept.

A major research institution, whose respondent felt that demonstrating efficiency with funding could often attract more, supported this view:

*“Success is possible without a large budget, because if you have early success with a small budget you will be able to attract additional resources.”*

Most demonstration and deployment projects in this survey had developed plans for long-term sustainability. Several of the projects had developed into viable, stand-alone companies that address sustainability through their business plans. In the case of at least two State Energy Offices, sustainability has been addressed successfully by commercializing funded products or business lines, allowing the market to provide consistent demand and funding.

## CASE STUDIES:

### Convening Power of State Energy Offices

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State Energy Offices have at their disposal many tools and resources with which to facilitate innovation. SEOs are strategically located at a distinctive vantage point. They have staff highly trained in project management and financial assistance. They have access to a network of R&D contacts through their states' institutions of higher education. Assistance with deployment and commercialization can be obtained through state departments of commerce and trade, or through local manufacturing entities. Additionally, the SEO has immediate and direct access to technical and financial resources provided by the U.S. Department of Energy and its network of researchers and national laboratories. However, an SEO's greatest strength, no matter the size of its staff or budget, lies in its "convening power" – its ability to bring all these key components and partners together to work towards a common objective, innovation in energy efficiency and renewable energy.

The following three case studies illustrate how SEOs have used their "convening power" to facilitate innovation successfully. The first example highlights the efforts of an SEO with limited financial and technical resources, the North Carolina Energy Office, to foster innovation in the transportation industry. The second example focuses on a large SEO with extensive financial and technical resources, NYSERDA, in developing a new lighting product and cultivating the market for it. The third case study demonstrates how a relatively new SEO, the Colorado Governor's Energy Office, was able to spark the growth of the biomass industry in its state.

#### *North Carolina – Plug-in Hybrid Electric School Buses (PHESB)*

**Problem:** In 2004, the U.S. Environmental Protection Agency (EPA) had designated North Carolina's three major, metropolitan areas as "nonattainment" for ozone, noting that more than 50% of the emissions came from the transportation sector. Just a few years earlier in 2001, the Natural Resources Defense Council (NRDC) and the Coalition for Clean Air issued a report entitled "No Breathing in the Aisles: Diesel Exhaust Inside School Buses," citing the detrimental health and environmental effects of diesel exhaust from school buses.

**Solution:** In 2005, the North Carolina Energy Office (NCEO), other SEOs and local government entities partnered with Advanced Energy, a non-profit research corporation based in North Carolina, and applied for funding for a Plug-in Hybrid Electric School Bus (PHESB) project under the 2005 STAC Solicitation for Transportation Technologies. The purpose of the project was to address the energy and environmental problems associated with standard, diesel-operated school buses. In general, these school buses have very poor fuel efficiency and the emissions generated by the diesel engines had been shown to contribute to low air

quality in and around the buses. Thus, the project partners set out to achieve the following goals: reduced fuel consumption, increased air quality and improved health conditions for schoolchildren.

The opportunities for project success were great for many reasons. First, school buses typically have short routes which require frequent braking (regenerative battery charging) and buses sit idle for most of the day and all night (plug-in recharging) making them a suitable fit for the plug-in hybrid technology. However, the challenge the project partners faced was applying a relatively new technology (hybrid plug-in technology) to a vehicle type in which it had never been used (school buses). The second factor which contributed to the project's success was that the purchase of all public school buses in North Carolina is aggregated statewide, allowing for economies of scale on the manufacturing side. Finally, one of the top three bus manufacturers in the country is located in North Carolina. Although this company was not selected as the manufacturing partner under the STAC award, the potential for future collaboration and manufacturing opportunities with this company would yield an economic benefit for North Carolina-additional jobs in the local economy.

The project champion, Advanced Energy, developed the project concept based on its experience with plug-in technology and approached the NCEO for assistance, given their long history of working together. The North Carolina Energy Office used its convening powers to assist in the assembly of the project team which included: the North Carolina Department of Environment and Natural Resources; the North Carolina Department of Public Instruction; NYSERDA; the New York Power Authority; the Florida Department of Education; the South Carolina Department of Education; and school districts in Arkansas, California, Iowa, Texas and Washington.

In addition to its extensive network of contacts, the NCEO's additional strengths contributed to the project's success. Although the office was limited in its ability to provide significant financial and technical assistance, the NCEO staff had effective project management skills and knew how to facilitate the efficient transfer of funds to the targeted recipients. Another success factor included the NCEO's willingness to look at new technologies and ideas. Flexibility was also important because the technology was new and staff needed to be able to adapt to changes which arose from the research and development phase. Finally, given the NCEO's lack of technical expertise in plug-in technology, the most significant success factor was partnering with an external organization that had an established research and development track record in this field.

The total project cost submitted to STAC was \$1,890,191 of which \$1,050,191 was provided in cost share by the project partners. STAC provided an \$840,000 grant for this project. The actual total budget exceeded \$4.5 million, with additional funding and resources leveraged from project partners and financed by school bus purchases.

**Results:** The PHESB project demonstrates how an SEO with limited resources can successfully leverage partnerships to implement an innovative energy efficiency program from the R&D phase through commercialization. By finding the right mix of government, research, manufacturing and commercializing partners, the NCEO and Advanced Energy were able to leverage the resources to build and deploy sixteen PHESBs nationwide which in some cases had a 40% improvement in fuel economy over traditional school buses. The NCEO and its partners were successful in developing this innovative technology and deploying it into the marketplace. Today, Advanced Energy continues to move the market for hybrid electric school buses forward by working with manufacturers to develop new technologies and testing protocols as well as with school districts to determine needs and make purchasing decisions.

### ***NYSERDA – Load-Shedding Ballasts***

**Problem:** New York has a constrained electricity distribution system which it compensates for by running an aggressive demand response program, allowing load to be shed from the grid when needed. Although lighting accounted for 21% of building loads, it was not significantly contributing to New York’s demand response market. Connecticut Light and Power and Rensselaer Polytechnic Institute’s (RPI) Lighting Research Center, with funding from the California Energy Commission (CEC), had developed a load-shedding ballast but the technology required additional development to be successfully deployed in the marketplace.

**Solution:** To further advance the load-shed ballast, NYSERDA funded the Lighting Research Center to: 1) develop a method of signaling a grouping of load-shed ballasts to reduce the lighting level/load on demand; 2) conduct a number of field demonstrations of the load-shedding ballast in New York State to validate the technology; and 3) engage a major manufacturer to produce and market the load-shed ballast.

The challenge was to develop a reliable, low-cost method for remotely signaling the ballasts to reduce load without needing to wire each, individual ballast for control. This remote control would allow lighting, in both new construction and retrofits, to have a more flexible load and be offered into a utility direct load control program or bid into New York’s wholesale demand response market.

The Lighting Research Center responded to the challenge and developed a signal injector that allowed the ballast to shed load by 33% using power line communication (PLC). Together with manufacturing partner Osram Sylvania, NYSERDA and the Lighting Research Center began work on advancing this technology innovation.

NYSERDA played the role of funder and facilitator in bringing this product from the prototype phase to the manufacturing arena and, ultimately, the marketplace. NYSERDA’s greatest asset was its staff, many of whom have more than 25 years of

experience in energy technologies. In this case, the project champion was NYSERDA's project manager. He was the catalyst in identifying the consumer and utility needs for demand response in the lighting sector and connecting that need with the R&D requirements for a new technology. NYSERDA stated that the critical success factors for this project included: the ability to be at a vantage point to see the market need; strong communications throughout project; good internal project management; knowledgeable staff; a strong budget and favorable market conditions. In the beginning of the project, it was important to stay fluid, maintaining an overall objective but not be bound to a specific plan. However, once the project was started NYSERDA expected tighter controls, schedules, statements of work and contracts.

NYSERDA's financial contribution to the project was \$400,000, which is considered a relatively small investment given that the costs to develop and manufacture such an innovative product are typically more than \$1 million. While the RPI Lighting Research Center maintained the intellectual property rights for the signal injector, NYSERDA requested a percentage of the licensing profits in return for its initial investment.

**Results:** Through the NYSERDA-funded work at the Lighting Research Center, successful technology demonstrations in New York State and stakeholder engagement, NYSERDA accelerated the technology development, market demand and introduction of the load-shed ballast. Osram Sylvania began selling the load-shedding ballasts in 2010. Through this project, NYSERDA was able to enhance the success of New York's demand response program.

### *Colorado – Biomass Boiler Systems*

**Problem:** The Oak Creek School District is a traditional, rural coal mining community located near the Twenty-Mile Mine. In the past, the school district benefitted from the mine by getting a free supply of coal for its furnace. Eventually, the furnace fell into disrepair and pipes cracked, requiring the system be replaced. In addition, there had also been a problem with coal dust in the school and there were concerns about student health.

**Solution:** The school district approached the Colorado Governor's Energy Office (GEO) for technical and financial assistance in replacing their antiquated system. The GEO began implementation of this project with the established process used for all school districts across the state, the use of an Energy Savings Performance Contract (ESPC), in which a technical energy audit is performed; problems are identified; energy efficiency measures are recommended; and a financing plan is developed. As a function of this energy performance contract, the engineering firm McKinstry recommended a biomass boiler as a potential replacement for the aging coal fired furnace.

At the time, the GEO was a relatively new office with many new team members. However, the office adeptly combined the expertise of existing staff with the fresh, innovative outlook of new staff. One of the office's strengths was the staff's commitment to communicating the benefits of renewable energy and ESPCs to the school district.

Having a diverse base of partners engaged was important. Previously, the school district was getting its heating fuel for free so there was no incentive based on fuel cost savings to be gained by converting the coal-fired system to a biomass boiler system. The GEO partnered with the Colorado Department of Education (DOE) and the Colorado Department of Local Affairs (DOLA) who had previous experience with and understood the benefits of using an ESPC and renewable energy. DOE and DOLA were instrumental in getting the school administration and local government leaders onboard with the project. The willingness of the school district to entertain innovative opportunities and new ways of providing heat to the school in a sustainable way was essential to the project's success.

The Energy Services Company (ESC) selected to perform the work, McKinstry, was the project champion. McKinstry had expertise and a strong belief in a particular, albeit new, renewable energy source. Colorado, like many states in the West, had been suffering from an infestation of mountain pine beetles which were killing trees throughout the state. The resulting dead wood, called beetle kill, was plentiful and a sustainable biomass fuel-source.

A new company, Confluence Energy, was forming in nearby Kremling, Colorado. Confluence Energy converted the beetle kill into pellets that could be burned in a biomass boiler. The technology was already proven so it was not a high risk effort. The company successfully presented its proposal to the school district and an ESPC was put into place for a full, efficiency upgrade. The old coal-fired furnace was retrofitted with a biomass boiler which used beetle kill as its fuel source. In addition to its technical expertise, McKinstry also provided financial resources to the project.

The project management plan and accountability were extremely important. Staff kept on track through regular communication, ensuring everyone was on schedule. Controls were in place and much of the engineering and financial modeling had been completed prior to the project's start.

Most of the costs were upfront capital costs and were covered by the four funding partners: the GEO, DOE, DOLA and McKinstry. Having good project modeling and an established financial analysis, which identified needs and costs, was critical information essential in getting the school administration's buy-in. A multiyear budget was provided to the school district allowing them to plan accordingly.

**Result:** This project resulted in multiple benefits for the Oak Creek School District, the environment and the local economy. The school was able to replace its old,

inefficient and polluting furnace with a newer, energy-efficient one which used a cleaner burning, renewable fuel source. Indoor air quality in the school improved.

Another benefit to the school was reduced personnel costs. This was a serious issue because operating and maintaining the old system was a labor-intensive effort and staff turnover was high. On average, the school district went through one maintenance person per year, thus having to constantly train new staff. By replacing the old system with a new, energy-efficient one, the school district reduced its costs associated with hiring and training new staff.

Environmentally, the new boiler system reduced carbon emissions and operated using a locally available, sustainable fuel source that was carbon neutral. Beyond that, it helped in the reduction of a serious forest health threat throughout the state.

This project also helped jump-start the “biomass from beetle kill” industry in Colorado. It helped Confluence Energy get a foothold in the market to serve more commercial customers in-state. Soon after the work in Oak Creek was completed, Confluence Energy provided pellets for a recreation center in another community in Colorado. The company has since constructed the largest pellet plant west of the Mississippi, bringing more jobs to Colorado and providing a plentiful supply of renewable energy.

## STATE R&D INITIATIVES

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### *California – Public Interest Energy Research Program*

The California Energy Commission's Research, Development and Demonstration (RD&D) Division manages the Public Interest Energy Research Program (PIER). The PIER program provides funding to support research, development and demonstration activities in eleven program areas: Buildings Efficiency; Demand Response; Clean Advanced Electrical Generation; Advanced Grid Technology; Energy-Related Environmental Research; Climate Science; Industrial/Agricultural/Water End-Use Energy Efficiency; Renewable Energy Technologies; Transmission and Distribution; Transportation; and Energy Innovations Small Grant Program.

The RD&D Division has an annual budget of \$83.5 million which supports technology innovations in electricity (\$62.5 million) and natural gas technologies (\$21 million). A combination of contracts and grants are used in making awards through competitive solicitations, interagency agreements and sole-source contracts. A committee provides oversight of the program by reviewing program budgets yearly to ensure progress is being made in achieving program goals and to set new funding levels for the next year. The PIER program implements the following investment strategies:

- *Research Roadmaps - Identify technology gaps and cutting-edge research opportunities.*
- *Competitive Solicitations and Small Grants - Ensure that promising new technologies are developed and demonstrated.*
- *Achieve Economies of Scale - Use community-scale research opportunities with multiple technologies and participants to achieve what individual projects alone cannot.*
- *Integrate Energy and Land Use - Ensure that state land use policies reflect the impact of land use decisions on energy systems, including renewable resources, electricity generation, transmission corridors and transportation.*
- *Targets of Opportunity - Work with individual companies on specific applications, such as testing new technologies on the California electricity grid; leverage other current research, such as enhancing "green buildings" initiatives; and respond to unexpected opportunities, such as the new federal economic stimulus package.*
- *Engage the Research Community - Focus California's world-class scientists and engineers at its universities, national laboratories, and industries on the state's energy priorities, including support for new and existing collaborative campus-based energy technology research centers.*

Strategic partnerships play a vital role in implementing RD&D activities. The California Energy Commission works closely with a variety of partners including

other state agencies, state institutions of higher education, national laboratories, industry, utilities, and high-tech companies among others. These partnerships leverage resources and facilitate market transformation based on research findings.

### **Energy Innovations Small Grant Program**

The Energy Innovations Small Grant Program (EISG) supports early-stage proof of concept research and development projects that address electricity, natural gas or transportation technologies. Proposed projects must target one of the PIER R&D program areas. Grant sizes vary, with up to \$95,000 awarded for hardware projects and \$50,000 for modeling projects. Solicitations for the EISG program are issued periodically throughout the year: up to four per year for the EISG Electricity program; one per year for the EISG Natural Gas program; and up to two per year for the EISG Transportation program. Eligible recipients include individuals acting independently; small businesses (defined as less than 500 employees and gross receipts no more than \$5 million); non-profit organizations; and public or private academic institutions. Applicants are given access to Subject Matter Experts to assist them in developing research teams. The EISG program is developing a public database of Subject Matter Experts which can identify individuals willing to participate in grant projects based on energy technology expertise and education. Applicants may not submit multiple proposals per solicitation and may not receive more than one grant at the same time. Projects must be completed within twelve months.

### **Buildings Efficiency**

The goal of the Buildings Program is to improve the energy efficiency of new and existing buildings, commercial and residential, by supporting the research, development and demonstration of energy efficient technologies, tools, strategies and building performance evaluation processes. The Buildings portfolio targets five areas: 1) Building Envelopes; 2) HVAC, Controls and Diagnostics; 3) Lighting and Lighting Controls; 4) Appliances, Consumer Electronics and Office Equipment; and 5) Whole Building and Community Systems Integration. Funding is primarily awarded to projects that focus on short- and middle-term initiatives.

A critical component of the Buildings Program is what is referred to as the Buildings End-Use Energy Efficiency Market Connections. Also referred to as Program/Project Advisory Councils (PACs), these connections are established by research teams in order to recruit industry players early in the process to cultivate market acceptance and application of research findings. PACs are comprised of representatives from various entities with a vested interest in energy-efficient buildings and building components. These Councils include building code officials, utilities, product manufacturers and building managers and operators, among others.

Working in conjunction with the PIER Research and Development Programs is the PIER Demonstration Program, called the State Partnership for Energy Efficiency Demonstrations (SPEED). This program facilitates market transformation by

providing opportunities for field testing of PIER-funded energy technology innovations. SPEED is a collaborative effort between California's public institutions of higher education (University of California, California State Universities and California Community Colleges), federal, state and local government entities, and commercial and industrial partners. These partners provide the buildings and facilities in which to test the real-world applications of research findings. The SPEED program provides useful tools for demonstration projects. These tools include site surveys, pre- and post-installation baseline monitoring and assessments, and technology assessments. To further the market penetration of building technologies, SPEED offers additional resources such as outreach and education services and group purchasing assistance.

### *New York State Energy Research and Development Authority*

The New York State Energy Research and Development Authority, better known as NYSERDA, has long been at the forefront of energy innovation. As its name suggests, one of NYSERDA's principal responsibilities is to facilitate energy research and development in order to further its mission to "advance innovative energy solutions in ways that improve New York's economy and environment." NYSERDA provides incentives for R&D initiatives in seven program areas: 1) Buildings; 2) Energy and Environmental Markets; 3) Energy Resources; 4) Environmental Research; 5) Industry; 6) Transmission and Distribution; and 7) Transportation and Power Systems. Projects are predominantly funded through competitive solicitations and applicants are expected to contribute a cost share. Award amounts vary but most projects receive a sum of up to \$200,000. Below are some examples of the types of R&D initiatives that NYSERDA funds.

#### **Buildings**

The goal of the Buildings R&D program is to facilitate the development and use of energy efficient technologies in the various components of both residential and commercial buildings. Within the Buildings program at NYSERDA, there are six subprogram areas: Heating and Cooling; Lighting; Building Envelope; Controls and Meters; Advanced Buildings; and Distributed Generation and Combined Heat and Power (DG/CHP). In general, NYSERDA issues annual funding solicitations for these subprograms. There are two exceptions. First, the DG/CHP program solicitations are issued twice a year for demonstration or feasibility projects and the development of DG/CHP technologies. Second, solicitations for the Advanced Buildings program are issued periodically. Through the Buildings R&D program, NYSERDA has seen the introduction of 40 new products, energy savings of \$161 million and increased sales of \$238 million for energy-efficient building products manufactured in New York over the past ten years.

#### **Industry**

Industry plays a significant role in New York's economy. NYSERDA's Industry R&D program provides New York manufacturers the opportunity to reduce the risks involved with improving the energy efficiency of their operations and developing

energy-efficient products. The Industrial program offers funding assistance in five program areas: Industrial Process and Product Innovation; Distributed Generation as Combined Heat and Power (CHP); Hydrogen; Controlled Environment Agriculture; and Ultraviolet and Electron Beam Curing.

NYSERDA has a robust Distributed Generation as Combined Heat and Power program. As of mid-2008, the CHP program had funded \$85 million for the installation of CHP at 110 sites and 150 feasibility studies. These CHP projects are expected to produce 153 MW of electricity.

Under the Hydrogen program, NYSERDA and its partners have developed the New York State Hydrogen Roadmap, developed school curricula on hydrogen, prepared a guide that addresses hydrogen applications as they pertain to New York building and fire codes, and have supported various RD&D projects that will contribute to the establishment of a hydrogen economy within the state.

### **Transportation and Power Systems**

The Transportation and Power Systems program is comprised of two distinct program areas. The former program addresses technology innovation related to Advanced Vehicles, Vehicle Components, Rail and Transit, Infrastructure, and Intelligent Transportation Systems and Alternative Fuels. The latter program concentrates on: Power Generation; Power Transmission, Distribution and Systems; and Energy Conversion and Storage. However, NYSERDA has recently established a cross-cutting initiative, the New York Battery and Energy Storage Technology (NY-BEST) that addresses highly innovative technology critical to both programs.

NY-BEST was established in 2009 in response to the Clean Air Interstate Rule (CAIR) issued by the Environmental Protection Agency, which aims to reduce NO<sub>x</sub> emissions. The goal of the program is to establish New York as a global leader in battery and energy storage technology by advancing all components of the value chain within the state. In order to meet this goal, the NY-BEST program will provide research grants, access to battery testing facilities and facilitate technology transfer and commercialization activities.

The program is implemented by a consortium comprised of more than 65 members representing academic institutions, national laboratories, corporations and DOE Frontier Research Centers among others. NYSERDA is responsible for administering the program, which received its initial funding of \$25 million from the sale of NO<sub>x</sub> cap-and-trade allowances. One objective of the program is to become self-sustaining within three to five years by leveraging other resources and through membership dues.

## *Ohio – Ohio Third Frontier Program*

In an effort to promote technology-based economic development in Ohio and to position Ohio as a global leader in technology innovation and commercialization, the state of Ohio created the Ohio Third Frontier (OTF) program in 2002. The OTF program is managed by the Ohio Department of Development. The state initially funded the program with \$1.6 billion over a ten-year period. Due to the demonstrated success of this initiative to date, Ohio recently extended the program for another three years and increased its funding by \$700,000, making the total program budget \$2.3 billion through 2015.

Five strategic goals are the drivers for OTF program implementation. These goals are to: 1) increase the quality and quantity of technology research in Ohio; 2) increase access to and availability of investment capital; 3) increase and provide support to entrepreneurial management talent; 4) provide technical assistance to existing companies; and 5) cultivate a skilled, high-tech workforce. The OTF program works towards achieving these goals by targeting funds across what it refers to as the “Technology Commercialization Framework,” a five-phase continuum defined as follows: Imagining>Incubating>Demonstrating>Market Entry>Growth and Sustainability. Heavy emphasis is placed on funding projects in the first three phases, also referred to as the “Valley of Death” in the technology commercialization process.

The OTF portfolio consists of four main components: Cluster Development; Entrepreneurial; Talent; and Research and Commercialization. The Cluster Development initiatives support R&D activities that facilitate the advancement of commercialization in seven technology-specific sectors. These technology sectors include: Advanced Energy (focusing on wind, biomass and energy storage); Advanced Materials; Biomedical; Fuel Cell; Medical Imaging; Photovoltaic; and Sensors. In addition, this initiative funds Research Commercialization Grants, an Innovation Loan Fund and Industry Attraction Grants.

The Entrepreneurial initiative funds two programs. The first program, the Entrepreneurial Signature Program, provides business services to entrepreneurs and small businesses and is implemented through six regional entities. The second program is the Pre-Seed Fund Capitalization Program which seeks to increase the availability of risk capital.

The Talent Program provides internship opportunities for Ohio students in the above-listed technology sectors. The program cultivates Ohio’s future high-tech workforce by providing students with practical experience and businesses with prospective employees.

Finally, the Research and Commercialization initiatives support several programs that bolster research activities within the state. These programs range in scope

from funding the recruitment of top research faculty at state academic institutions to the creation of large R&D centers, to the purchase of capital equipment at Ohio colleges and universities.

Funding for these programs is awarded through competitive solicitations and most awards made are grants. According to the FY2011 solicitations for the Advanced Energy, Fuel Cell and Photovoltaic programs, up to \$7 million in grants will be awarded under each of these programs. Individual awards may not exceed \$1 million and applicants must provide a dollar-for-dollar cost share. In addition, applicants may also apply for up to \$1 million in Wright Capital Funds which provide funding for capital equipment purchases at Ohio's institutions of higher education and research institutions.

Two other state programs work in tandem with the OTF program. The first initiative is the Technology Investment Tax Credit Program which provides tax incentives for investments of risk capital in start-up technology companies. The second program, managed by the Ohio Venture Capital Authority, is the Ohio Capital Fund. The purpose of this fund is to attract venture capital firms to and investments in Ohio.

In a December 2009 report entitled "Ohio Third Frontier Analysis of Performance," the Ohio Business Roundtable highlighted the achievements of the OTF program as of June 2009. Some of the more notable findings were:

- In addition to the \$473 million the OTF has spent to date, the program has leveraged \$3.2 billion in follow-on dollars, a seven-fold increase in technology investment.
- The average annual return on investment has been 22%.
- Since 2003, the amount of venture capital investment in Ohio has been greater than the U.S. average (20.4% vs. 8.6%).
- Of all Midwest states, Ohio realized the largest increase in high-tech employment from 2004 to 2008.
- Licensing income at Ohio universities and research institutions more than doubled between 2002 and 2007.
- The annual product sales from OTF-funded projects are \$440 million.

The report credits Ohio's success to the OTF program's targeted investment across all phases of continuum of the commercialization framework. The Ohio Business Roundtable's report can be found at: <http://development.ohio.gov/ohiothirdfrontier/Documents/RecentPublications/ThirdFrontierPerformanceReviewDec82009.pdf>

## *Pennsylvania – The Ben Franklin Technology Development Authority*

Established in 2001, the Ben Franklin Technology and Development Authority (BFTDA or the Authority) was created to transform Pennsylvania's economy to one driven by technology and innovation. The purpose of the Authority is to prepare Pennsylvania's businesses, workforce and industry to be competitive in the high-tech global marketplace. The BFTDA provides funding and manages seven program areas. These programs, described below, work together to provide technical assistance and financial resources across the continuum of the business lifecycle in R&D innovation: conceptualization, formation, growth, maturity and reinvention. These programs place strong emphasis on collaboration with Pennsylvania's Institutions of Higher Education (IHEs). To further strengthen the success of these programs, the Authority has introduced "initiatives" which serve as funding strategies for grant recipients. Two of these initiatives are the Pennsylvania Initiative for Nanotechnology and the Pennsylvania Initiative for Energy and Environment.

### **1. University Research Commercialization Grant Program**

The University Research Commercialization Grant Program is designed to support the concept phase of R&D innovation. The program strengthens the R&D alliances between universities and technology businesses through funding for the development of new technologies and technology transfer. Eligible applicants are IHEs or non-profit entities that partner with a Pennsylvania IHE. The selection criteria for this program give higher consideration to applications submitted by a consortium of IHEs. Grant amounts vary. In the past, grants have ranged between \$125,000 and \$3.5 million. There is no cost share requirement. However, projects which leverage funding from other sources are given priority.

### **2. Innovation Grant Program**

The purpose of the Innovation Grant Program is to promote technology transfer and Intellectual property commercialization between academic medical institutions, non-profit research institutions and Pennsylvania IHEs and technology businesses. This program works in conjunction with the Keystone Innovation Zone Program (KIZ), and IHEs participating in the KIZ program are given preference. Grants may be used for patent filings, IP licensing and royalty agreements and/or other purposes that facilitate the transfer of technology into the marketplace. The FY2010-2011 budget for this program is \$1.5 million. The maximum grant amount is \$100,000 and recipients must provide a dollar-for-dollar cost share of which 50% must come from non-state sources.

### **3. Keystone Innovation Starter Kit Program**

The goal of the Keystone Innovation Starter Kit Program is to strengthen and secure Pennsylvania's position in the forefront of nanotechnology and energy innovation. The program provides funding to recruit leading research faculty specializing only

in the fields of nanotechnology and energy. In addition, these funds may be used to hire support staff and purchase equipment. Eligible recipients include IHEs, academic medical centers and non-profit research institutions who participate in the KIZ program. The FY2009-2010 budget for this program was \$1 million. Awards may not exceed \$150,000 and recipients must provide a \$1:\$1 cash match.

#### **4. Keystone Innovation Zone Program**

The Keystone Innovation Zone Program serves as a catalyst in establishing partnerships between universities and communities that facilitate technology transfer and job creation. These partnerships must include an IHE that has research capabilities and ties to a KIZ, which is a geographically-defined area. Other partners may include, but are not limited to: private business, economic development organizations, business organizations, venture capital, and lending institutions. Business partners must be for-profit entities located within the zone and less than eight years old. It is strongly recommended that partnerships also include local government representatives.

Projects which address identified, targeted industry sectors are eligible for funding. In the first year of funding for each project, the maximum grant is \$250,000. Award amounts are reduced over the next two years. After three years, projects must be operational without further funding from the state. All recipients must provide a \$1:\$1 cash match. There are two additional benefits to participating in the KIZ program. First, KIZ companies that meet specific guidelines may receive up to \$100,000 per year in tradable tax credits. Second, the DCED gives priority to KIZ participants when reviewing applications for other DCED-funded programs.

Under the KIZ enabling legislation, prospective participants had until July 2007 to submit their application to become a KIZ partnership. To date, there are 29 functioning KIZs with no applications for new zones being accepted.

#### **5. Technology Development Grant Program**

The purpose of the Technology Development Grant Program is to advance the adoption and implementation of technology in Pennsylvania businesses. Eligible participants are non-profit entities that implement regional or statewide programs and engage various stakeholders in the process. Ultimately, the goal is to promote innovation and economic development by creating and supporting high-technology, high-growth companies. There are twelve activities that are funded through this grant program. These activities include, among others: technology business development; technical assistance to technology businesses in Pennsylvania; applied research and commercialization projects; and operation grants for KIZs in funding cycles five through eight. Funding amounts vary. Recipients must provide a \$1:\$1 match of which 50% is a cash match.

## **6. The Ben Franklin Technology Partners**

The Ben Franklin Technology Partners (Partners) are four regional, non-profit entities that together make up the Ben Franklin Technology Partnership. The Ben Franklin Technology Partners of Southeastern Pennsylvania was a participant in this innovation study. The Partners play an instrumental role in providing capital, strategic partnerships and business and technical assistance to technology-driven businesses. The Partners receive funding from the Authority to implement activities which fall into four general categories: The first is Company Investments which fund process/product technology transfers and applied R&D for products nearing commercialization, among other activities. The Partners primarily target companies with less than 250 employees and are strongly encouraged to provide support to those companies with less than 50 employees. The second type of funding is Business and Technical Assistance which includes services that support strategic planning, manufacturing, finance, marketing and sales and other germane business activities. The third funding category is Technology/Entrepreneurial Infrastructure. These funds are used to create and support investor networks and to promote regional and statewide business education and forums. The final category is Administration Expenses which entail routine operational expenses as well as expenses incurred while managing the Authority's Challenge Grants. Partners are required to match the Authority's funding on a \$1:\$1 basis. This match may be comprised of cash, equipment and in-kind contributions.

## **7. Venture Investment Program**

The mission of the Venture Investment Program (VIP) is to increase the availability of risk capital for technology-oriented businesses in Pennsylvania. Loans are provided to venture capital funds and "angel investment funds." Higher priority is given to projects in which the majority of the capital is invested in seed- or early-stage development. Recipients must invest four times the amount received from the VIP into "Pennsylvania-related" businesses (businesses with a majority of their workforce in Pennsylvania).

One recent example of the impact the Authority's initiatives have had on promoting R&D innovations in Pennsylvania is the establishment of the U.S. Department of Energy's new Energy Innovation Hub in the Philadelphia Navy Yard. The Hub, located in a Keystone Innovation Zone, is managed by the Pennsylvania State University and is comprised of a consortium of other universities, national laboratories and private enterprise. In addition, the Ben Franklin Technology Partners of Southeast Pennsylvania is located at this facility. Thanks to the Authority's various funding programs, the project team was strategically positioned to receive a \$122 million Federal award.

Since these programs began in 2003, there have been more than 1,000 companies and 20,000 new jobs created in Pennsylvania. In addition, through these initiatives, the Authority has provided funding and technical assistance to more than 26,000 businesses in the Commonwealth.

## CONCLUSIONS AND RECOMMENDATIONS

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The results of this study indicate that adjustments need to be made to the traditional RDD&D process to accommodate the faster pace, flexibility and simultaneous development required for technology breakthroughs. One significant difference between traditional RDD&D processes and Innovation models is that while both often include a variety of organizations, innovation requires those separate organizations to act as a cohesive unit.

State Energy Offices are in a unique position to foster innovation within their states by encouraging and selecting projects that may seem higher risk, but that will ultimately be game changers for their state's and the country's energy industry. Energy Offices are at the intersection of policy, technology, research, demonstration projects, funding, and market development. This is a unique vantage point that should allow the State Energy Office, in collaboration with state research and technology institutions, to be a catalyst for innovation within each state.

This report has provided case studies of SEOs in North Carolina, New York and Colorado who successfully used their "convening power" to foster technology innovation. It has also provided in-depth examples of state-led R&D initiatives in California, New York, Ohio and Pennsylvania.

### 1. Best Practices

Since technology innovation is a higher risk area than deployment programs, it is advisable for states to become familiar with best practices in energy innovation to minimize their funding risk. Projects that are utilizing best practices will have the following characteristics:

- **Clear Goals and Strategies.** Goals at the R&D stage generally strive to create new technologies that would solve environmental or economic development problems, while projects at the Demonstration stage focused more narrowly on specific technology performance aspects or removing bottlenecks to achieving the larger R&D goal. At the Deployment stage, goals take on market performance indicators, due to return on investment expectations of funders.
- **An Innovative Team Environment.** Creating the right team environment will foster innovation. Attributes include cross-functional diversity of team members; experienced and passionate leadership and staff; commitment to the project; a clear project champion; market knowledge; and a culture that allows time for innovation.
- **Processes in Place.** Two key processes that provide a roadmap for successful innovation are project management and controls, and management of intellectual property rights.
- **Secured Resources.** The most critical resources cited as contributing to innovation success were external partnerships and adequate funding.

External partners should fill critical skill gaps of the core project team, so that the team's skills are wellrounded and multidisciplinary. Most teams found that having a commercialization expert or partner on board early in the process was critical to success. Adequate budget was seen to be an indicator of success, and most agreed that a multiyear budget was necessary to create a successful innovation.

## 2. Recommendations

Recommendations for consideration by State Energy Offices when soliciting and selecting projects include the following:

- ***Strive for game changers:*** Identify gaps in the state's clean energy supply chain for priority technologies and challenge universities and industry to fill those gaps with innovative solutions.
- ***Reward good behavior:*** Develop project selection criteria that reward innovation best practices and methodologies.
- ***Require structure:*** States should require project management plans for high- risk projects, and have protocols in place for managing intellectual property arising from R&D projects<sup>5</sup>.
- ***Look for an innovative environment:*** State Officials should look beyond the project to the culture within the project team itself.
- ***Encourage external funding:*** If a State Energy Office alone cannot adequately fund a higher risk innovative project, there is still value in soliciting the project but requiring external partners to contribute the needed cost share.

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<sup>5</sup> The Energy Commercialization Institute (ECI) operated by the Ben Franklin Technology Partnership in Philadelphia has developed an extensive set of protocols to manage intellectual property issues that are in the public domain. The ECI can be contacted by visiting: <http://www.sep-energy.org/eci.html>.

## APPENDIX A: REFERENCES

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## APPENDIX B: STUDY PARTICIPANTS

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### DOE Innovation Centers

Great Lakes Bioenergy Research Center at the University of Wisconsin-Madison  
Joint BioEnergy Institute

### Private Companies

Blue Hill Partners  
Plextronics

### Research Institutions

Ben Franklin Technology Partners  
Electric Power Research Institute (2 interviews)  
Energy Services Coalition  
Gas Technology Institute  
National Renewable Energy Laboratory (NREL)

### State Energy Offices

Colorado Governor's Energy Office  
Iowa Office of Energy Independence  
New York State Energy Research and Development Authority (NYSERDA) (2 interviews)  
North Carolina State Energy Office

### Universities

Georgia Institute of Technology, Enterprise Innovation Institute  
University of California-Berkeley, Energy Biosciences Institute  
University of Central Florida, Florida Solar Energy Center (FSEC)  
University of Colorado, Renewable and Sustainable Energy Institute (RASEI)  
University of Texas at Austin  
Washington State University

## APPENDIX C: INTERVIEW GUIDE



Universities/Research Institutions: Interview Script

### **I. Introduction.**

### **II. Innovation**

1. What goals and objectives did you or your organization have for this project?(ie, energy savings, reduction in carbon emissions, creation of new jobs or new technologies, impacted energy production or showed a profit in the long-run?
2. Did you use “innovative” ideas or processes to come up with your project? Did you use any proven methods or new processes around innovation?
3. Did you feel that the outcome of your efforts was innovative and opened new opportunities for your company or the economy?
4. How would you say your project helped societal needs or will continue helping society in the future?

### **III. Identification of Key Success Factors**

5. I have a number of specific questions that follow, but in your own words, what would you say was the most important success factor as to why this program worked so well?
6. Now, I’d like to go into more of a survey type of scale on a range of topics. Please rate from “1” to “10,” where a “1” is not at all a factor or important to the success of the program and a “10” is a critical factor or very important to the success of the program.

Possible Success or Importance Factor	Not Crit./ Not Import.				Very Crit. Very Import.					No Answer	
a. Have a good project manager	1	2	3	4	5	6	7	8	9	10	N/A
b. Having a good project management plan or developing a good plan of action.	1	2	3	4	5	6	7	8	9	10	N/A
c. Having strong communications throughout the process.	1	2	3	4	5	6	7	8	9	10	N/A
d. Having accountability through the process.	1	2	3	4	5	6	7	8	9	10	N/A
e. Having good staff to support the process.	1	2	3	4	5	6	7	8	9	10	N/A
f. The expertise and experience your organization brought to the project.	1	2	3	4	5	6	7	8	9	10	N/A
g. The established research and development or deployment process that your organization brought to the project.	1	2	3	4	5	6	7	8	9	10	N/A
h. Having clear objectives from the grant and RFP process.	1	2	3	4	5	6	7	8	9	10	N/A
i. Having a strong budget to see the entire project through.	1	2	3	4	5	6	7	8	9	10	N/A
j. Favorable market factors or economic conditions.	1	2	3	4	5	6	7	8	9	10	N/A

7. Where there other success or importance factors and why?

#### IV. Internal Office Staff

We earlier talked about factors such as having a project leader or champion, and internal staff and resources that may have contributed to the success of the program. Before we get into some other areas, such as the project's external relationships or partnerships, or the market conditions, I'd like for you to tell me about ...

8. How much of a role did the experience of your internal staff play if any in the success of the project? What about the staff of your grant partner or funder?

8a. [If staff was not experienced] Did fresh ideas from new additions to the team contribute to the project's success? Did success result from teams of more experienced staff and new team members coming together?

9. [Probe if not asked] Was there a project champion throughout the process and what role did he or she play if any regarding the success of the project?

10. Were there any other success factors around the role of staff in the process?

## **V. Strength of the Institution**

Let's talk about your organization's role in the effort.

12. How would you say your organization contributed to the success of this project, versus the project's funder or partners? What do you think your institution brought to the table that made the project successful?

12a. [Probe if not addressed in Q12]: Did innovation occur as a result of your partnerships and what each party brought to the process, including subject matter expertise?

12b. [Probe] Do you believe that the project's funders or partners could have come to a similar outcome in the end, understanding that it may take more time or effort, without the involvement of an organization such as yours? Please explain.

13. How did your institution and its partner or funder initially connect on the project or how did you first hear about it?

14. What was the process for managing intellectual property or technology transfer issues, as well as future rights and revenues? Did it work well or fairly for both parties?

15. Were there other partners besides institution and its funders that contributed to the success of the project? Please explain.

## **VI. Processes**

Let's talk about the processes that may or may not have contributed to the success of the project

16. How important was the project management plan or communications process to the success of the project? Please explain.

17. How did you keep your staff and your partner's staff accountable and on task during the process? Was accountability an important factor in the project's success? Please explain

17a. If the project was not going well, did you have an exit strategy? Or were there controls in place to tell you when your project needed adaptations?

18. Were there other processes that contributed to the overall success of the project, such as technology or IT, financial processes, the initial grant or RFP or something else that we may not have talked about? Please explain.
19. How important was specific software in the process, such as Microsoft SharePoint, Citrix's WebEx or GotoMeeting or project management or communications software? Did any specific software or technologies stand out as being instrumental in your project's success?

## **VII. Budget Questions**

20. How did the amount of the overall budget for this project contribute to overall success? What was your budget for this project?
21. Did this project have a multi-year budget? If so, how did knowing the longer budget picture contribute to the overall success of the project? (Did you even know what the budget was beyond each year or how long where you able to see the funding for this effort?)
22. Has a long term plan for sustainability of this project over time been developed?

What other resources did you or other external partners bring to the project?

## **VIII. Wrap-Up/Conclusion**

We are wrapping things up and I just have a few more questions to ask you.

23. In reflecting on our conversation, are there critical areas or factors that I may have missed that we need to document in the interview?
24. Are there any examples of innovation and success that, outside of your own project, you've followed or can identify for us as models for the future?
25. I've asked you a lot of questions. Do you have any questions for me about the process or interview?
26. If for a rare occasion, would you allow us to follow up on clarifying your answers or if we need to ask you an additional question or two, as a result of speaking with others in the process, would you be open for a follow up call?

Thank you so much for your valuable time and all the helpful information you provided.