Stakeholders' partnership synergy and its impact on commercialization of new technologies: renewable energy industry study

Agassy Manoukian

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Dissertation

entitled


by

Agassy Manoukian

Submitted to the Graduate Faculty as partial fulfillment of the requirements for the Doctor of Philosophy Degree in Manufacturing and Technology Management

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The University of Toledo
December 2013
An Abstract of


by

Agassy Manoukian

Submitted to the Graduate Faculty as partial fulfillment of the requirements for the Doctor of Philosophy Degree in Manufacturing and Technology Management

The University of Toledo

December 2013

This study examines the impact of the partnership synergy and inter-organizational cooperation between government (federal, state, local), public agencies, private companies and local on successful communities commercialization of renewable energy (RE) technologies. The study produced several interesting results: (i) a model was developed that analyzes the role of partnership synergy on technology commercialization, conceptualizing the relationships among partnership drivers, partnership synergy, resources, and commercialization performance; (ii) the major drivers motivating stakeholders of RE projects have been identified and differences between those were recognized; (iii) a novel theoretical and analytical basis of commercialization through partnership and synergy has been established; (iv) interrelated effects of partnership synergy, dynamic capabilities and technology implementation mechanisms on various performance measures of project success have also been identified. Overall, this study and its conceptual model provide a richer understanding of the factors that lead to successful commercialization of RE technologies, possibly applicable to other infrastructural projects, as well.
I dedicate my dissertation to my parents, my children and my wife.

To my parents Rafik Manoukian and Aida Avetisyan, whose guidance, care, unconditional love and support throughout my life helped me to reach the goals I would never imagined possible and who constantly encouraged throughout the research process.

To my children Aida, Rafael and Inessa who are my true inspiration and who make my life happier every day.

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Chapter 1

Introduction

1.1. Background and Introduction

Contemporary lifestyles depend tremendously on the availability and use of fossil fuels. Continued increase in the demand for energy, coupled with increased environmental awareness, triggers the necessity for rapid diffusion of renewable energy (RE) technologies. There are two main reasons for the growing interest in RE sources: reducing dependence on fossil fuels and reducing greenhouse gases (Jagoda et al., 2011). However, so far commercialization efforts to diffuse RE technologies have remained the greatest challenge for this field (Balachandra et al., 2010). The greatest barrier is that the current energy markets, institutions, and policies have been developed to support the production and use of fossil fuels.

Various RE technologies have existed for many decades. Some of them, such as small hydropower plants, have actually been commercialized and are often referred to as ‘first generation RE (International Energy Agency, 2007). Yet a number of prominent RE technologies—such as solar heating and cooling, solar photovoltaic, wind power, and modern forms of bio-energy—have not been fully commercialized despite the fact that they appear to have gone through the development process, are mature, and even have
proven economically viable in many instances. This research primarily focuses on such technologies, classified as ‘second generation RE’.

Many studies indicate that obstacles to the widespread commercialization of renewable energy technologies are primarily political, rather than technical. They identify a range of “non-technical barriers” for RE use (Margolis and Zuboy 2006) that put it at marketing, institutional, or policy disadvantages relative to conventional sources of energy. Thus it is not surprising that many countries, including the United States, have introduced RE implementation programs in an attempt to help overcome these barriers. Governments realize that diversifying their energy mix can reduce their dependence on imported fossil fuel and, at the same time, curtail greenhouse gas emissions. The major goal pursued by federal, state, and local governments through these mechanisms is to substantially reduce the initial costs of RE systems and make them cost competitive with conventional energy sources. Large-scale deployment of RE technologies will trigger market forces to pick up these technologies and carry them forward even after inceptive mechanisms are removed.

It is worth mentioning that government support is vital for this emerging industry. In the initial stages the private sector is not ready to bear the risks associated with RE technologies. Regardless of increase in deployment of renewable technologies in recent years—especially after introduction of U.S. President Barak Obama’s American Recovery and Reinvestment Act of 2009 (Pub. L. 111-5) whereby $40 billion were allocated for energy efficiency and renewable energy programs—there are still some serious concerns among different RE stakeholders about the long-term performance of the technologies. This is where the government has an increased role in mitigating these
risks. According to the Stern Review on the Economics of Climate Change, in the past 30 years only one out of 14 key innovations was funded entirely by the private sector and nine were publicly funded (HM Treasury, 2006). Most governments around the world realize that innovation is an engine for economic development and a major source of creating new jobs and increasing the skill base (Jagoda et al., 2011). The appropriate implementation mechanisms that support research, development, and commercialization of renewable energy technologies and the creation of proper market mechanisms by governments could potentially solve domestic energy problems, improve the competitiveness of domestic companies, and create export markets.

In addition, commercialization of RE technologies differs from that of many other technologies and products, as the end result is not a commodity, but, rather, a means to produce a commodity (i.e. energy for consumption). Moreover, a commercialized RE technology takes the form of numerous individual, location-specific projects with a package of services provided during and after the project, instead of just mass production in a few most convenient places. These circumstances add importance to stakeholders’ partnerships in the commercialization effort.

1.2. Statement of Problem

Eventually, the world will run out of fossil fuels for energy and we will have no choice but to prepare for a new age of energy production since, human demands for energy will increase, not decrease. Nobody really knows when the last barrel of oil, ton of coal, or cubic foot of natural gas will be collected from Earth. It will depend on how well
we manage our energy demands, and how well we can develop and use RE sources. Hence, the need for renewable energy is not going to disappear. Eventually, we are going to have to switch to renewable energy to power our industry; to provide electricity, heating and cooling to our homes; and propel our cars.

At the same time, it is apparent that, despite being technologically mature, practically tested, and even commercially proven, second generation RE technologies are commercialized quite slowly and there are no real signs that this process will accelerate soon. This situation is viewed as the main practical problem to be considered in this research. As correctly noted in literature (e.g. Siegel, 1997) there are many new technologies and know-how in North American and European companies and universities, but not enough of those get out of the door and create new revenues, profits, and jobs. Unless there is a large-scale and long-term diffusion, RE simply remains a good technology option in theory, and, at best, such products will lie on the shelf collecting dust, despite the obvious need for them. It seems the main reason for this situation is the non-technical barriers since the technical ones for second generation RE technologies have been already overcome. Recent studies of large-scale deployment of second generation of RE technologies show that it is technically feasible. (Jacobson and Delucchi, 2009; Fthenakis et al., 2009; Cleetus et al., 2009; and Sovacool and Watts, 2009). However, the transformation process from conventional energy sources to renewable energy will take longer because of difficulties in implementing all necessary policies during the same period (Jacobson and Delucchi, 2011). The non-technical barriers for commercialization of the second generation of renewable energy will remain an impregnably serious challenge unless various stakeholders (i.e., government, financial
institutions, and utilities) are willing to work with renewable energy companies in commercializing these technologies. Extensive literature review and research conducted at the National Renewable Energy Laboratory (Margolis and Zuboy, 2006) has identified the key non-technical barriers that must be addressed to enhance the commercialization of RE and other energy efficiency (EE) technologies. The authors suggest that the major barriers are:

- Lack of government policy supporting EE/RE.
- Lack of information dissemination and consumer awareness about energy and EE/RE.
- High cost of solar and other EE/RE technologies compared with conventional energy.
- Difficulty overcoming established energy systems.
- Inadequate financing options for EE/RE projects.
- Failure to account for all costs and benefits of energy choices.
- Inadequate workforce skills and training.
- Lack of adequate codes, standards, and interconnection and net-metering guidelines.
- Poor perception by public of renewable energy system aesthetics.
• Lack of stakeholder/community participation in energy choices and EE/RE projects.

As it can be seen, only the cost of technology, inadequate workforce skills, and training are directly attributable to renewable energy companies. The other barriers are more related to public policy issues and other problems directly unrelated to the technology itself. To make matters even more complicated and highly dependent on collaboration of the involved parties, commercialization of RE technologies occurs through separate projects/installations of various sizes and natures, which cannot be considered final products/commodities, since they combine a number of products and services and actually serve as facilities to produce the end-user commodity (i.e. energy).

It seems only closer cooperation between different RE technology stakeholders can help overcome the non-technical barriers. Since each RE stakeholder pursues its own individual goal in the partnership, the strategic issue is to identify how a better partnership synergy can be achieved among them and why such synergy is important for commercialization success of RE technologies. At the same time, unique partnership arrangements between stakeholders-driven by the problems arising from climate change, pollution, energy insecurity, and so forth-will help a government develop incentive mechanisms which will accelerate the commercialization of second generation RE technologies.

In this research, the main causes of non-technical barriers were explored, particularly the inadequate level of partnerships and ensuing synergy between the RE stakeholders, with the purpose of suggesting ways of eliminating such barriers. A model was
developed to highlight the main drivers of partnership synergy, their influence on the partnership’s dynamic capabilities, and RE implementation mechanisms, as valuable resources for accelerated commercialization.

Therefore, the premise of this research is:

*How to develop effective partnership synergies between different renewable energy stakeholders which will enhance the partnerships’ resource base (micro and macro) for timely and successful commercialization (diffusion) of mature renewable energy technologies which do not require further major technology development.*

This study also focuses on covering a number of gaps in academic literature.

Although there are many external and internal drivers for creating partnership synergies in the renewable energy industry, there seems to be no conceptualization of this in academic research. Academic literature addresses, in a limited manner, the question of which drivers have more influence on bringing together different RE stakeholders to collaborate in creating synergies for successful commercialization of these technologies (Griffiths and Webster, 2010; Mondal et al., 2010; Gill and Andrews, 2005). By cooperating and creating partnership synergies, they will be able to support each other by leveraging, combining, and capitalizing on their complementary strengths and capabilities (Alter and Huge, 1993). The nature of interactions between RE companies and other stakeholders is explored in this research, along with a review of the external factors influencing the involvement of other stakeholders in these types of partnerships.

Another shortfall in academic literature relates to the scarcities of studies on
partnerships between industry, governments, and other organizations that try to achieve goals of mutual interest. The existing literature has focused more on inter-firm partnerships, where the influences of partnership relationships on performance are studied (Ellinger, Keller, and Ellinger, 2000; and Brinkerhoff, 2002). In some cases, while concentrating on just short-term performance outcomes, some authors ignore the long-term value-creation process (Schonberger, 1996; and Kaplan and Norton, 2001). In the RE industry, when reviewing the process from a policy perspective where the role of different stakeholders including government are considered, the long-term value creation for society is considerably more important than a single company’s commercialization success. Creation of unique partnership synergies between different stakeholders sometimes is mentioned in literature, but they are neither elaborated on nor measured (Dobbs, 1999). Because these types of partnerships deserve an investigation in their own right, this study focuses on creating partnership synergies between different renewable energy stakeholders and unique resources that this relationship produces to help RE companies succeed.

Greater involvement of public or private entities and non-governmental organizations in partnerships is generally attributed to pragmatic factors, such as resource constraints (Leach et al., 1994). Unique resources gained through the partnerships become a major source of competitive advantage (Wernerfelt, 1984). These resources should be valuable, rare, as well as neither perfectly imitable nor substitutable without great effort (Barney, 1991). One such resource is the dynamic capabilities embedded in a company which help achieve competitive advantages and commercialization successes (Eisenhardt and Martin, 2000). Inter-firm capabilities are perhaps the most important part
of inter-firm partnerships (Dyer and Singh, 1998). Although dynamic capabilities of inter-firm partnerships are well presented in academic research, there appears to be no study on the impact of government, industry, and other stakeholders’ partnerships on stakeholders’ dynamic capabilities. The research question is whether dynamic capabilities play a similarly essential role in partnerships between different RE stakeholders as well.

In addition to the resources embedded in the partnership, there will be external resources stemming from this relationship. Companies need to be able to integrate, build, and reconfigure their internal competencies (for example, marketing capabilities (Lado, Boyd, and Write, 1992)) and external factors (incentive mechanisms) to be competitive in a dynamic marketplace (Teece et al., 1997). Incentive mechanisms seem to have not been studied previously in terms of being an external resource that influences commercialization. Therefore, the research addresses this shortfall in literature as well.

1.3. Research Objectives

This study uses an analytic approach, providing a model aimed at finding out how the commercialization of RE technologies can be accelerated and made widespread, resulting in a greater benefit to society, higher energy security, and less damage to the environment. In this overall context, the main purpose of the research is developing a comprehensive commercialization framework that examines influences among partnership drivers, partnership synergy, resources, and outcome.

The main research objectives of this work can be formulated in short as:
I. identify the major factors that motivate different RE stakeholders to create true partnerships that result in synergy;

II. explore the effects of the generated partnership synergy on the partners’ resource combinations (dynamic capabilities and implementation mechanisms);

III. uncover the ways in which the resource combinations impact commercialization of RE technologies; and

IV. develop a new economic theoretical framework of commercialization through partnership synergy, using RE technology case studies.

1.3.1. Research Objectives Expounded

Successful commercialization implies effective transition from the “testing and validating stage” to the “full production and market launch stage” in the new product development process. To date, RE commercialization through various government-driven initiatives without a significant private renewable energy stakeholder participation has had limited success (Balachandra et al., 2010). In a highly regulated industry, such as the energy sector, the joint involvement of public and private sectors—and, in the case of RE, also the non-governmental organization community—and a higher level of partnership synergy in commercialization of new technologies appears particularly critical.
The aim of this dissertation is to study the influence of the partnership level and inter-organizational cooperation between government (federal, state, and local), public agencies, private companies, and local communities in overcoming non-technical barriers towards commercialization of RE technologies. On one hand, the relationship between external and internal factors at the level of partnership synergy is explored. On the other hand, the impact of partnership synergy on the effectiveness of the introduced renewable energy implementation mechanisms, as well as dynamic capabilities of the partnership, are reviewed.

Consequently, the major focus of the research is to study how partnership synergy is achieved and how it influences performance outcome (commercialization) based on the unique internal/external resource combinations this partnership generates. Partnership involves cooperation. In public policy it can be defined as cooperation for mutual benefit between people or organizations in the private or public sectors (Holland, 1984). The link between the level of partnership synergy and commercialization success is studied, where synergy is viewed as a function of competitive advantages derived from shared/combined resources (Chang, 1990).

The Stage-Gate Model had been developed to describe the new product development process from fuzzy front-end to commercialization. Prior research assumes new product development performance as a single variable associated with all stages of the process. However, there are many RE technologies that have been developed, but are either not in the market yet or not widely used because of non-technical barriers to commercialization (Margolis and Zuboy, 2006). One apparent reason for this might be that commercialization must ensure that newly developed technologies meet not only
performance and reliability requirements, but also economic requirements. These products need to be cost-competitive to be accepted by the marketplace (Balachandra et al., 2010). Therefore, in this research, commercialization is explored as a performance variable, which is defined as “the creation of self-sustaining markets that thrive—without any kind of favor—in a level playing field with other competing technologies” (Balachandra et al., 2010).

In this study, a substantive, integrative theoretical framework on partnership synergy for commercialization of RE technologies is introduced, aimed at helping the stakeholders involved better comprehend and implement their partnership to achieve synergy, and, hence, better performance outcomes.

1.3.2. Major Research Contributions

To develop a clear understanding of relationships of partnership synergies and technology commercialization, an extensive literature review has been conducted. Although there are vast volumes of literature on different forms of partnerships and new product development performance outcomes, still there is no evidence that the models produced in these studies yield any successes in the RE business environment. With this in mind, there are several important contributions planned in the work.

- The focus of this research is the commercialization success of RE technologies through a higher level of partnership synergy between stakeholders. The lack of an integrative definition for the partnership synergy phenomenon is due to an absence of a collective economic synergy theory. A major contribution of this
study is the introduction of a theoretical framework where stakeholders’ partnership synergy is analyzed as an example and within the context of RE technology commercialization.

✓ The dynamic capabilities theory is well known and widely cited. However, it has not been viewed in the context of stakeholders’ partnership and related effects. Thus, another contribution is enhancing the dynamic capability theory by revealing the nature of such partnership’s dynamic capabilities.

✓ Finally, the theoretical framework produced in this study can help a broad array of people and organizations—that fund and participate in RE projects—maximize returns on their investments by realizing the full advantage of collaboration with other RE stakeholders.

The results of this study can serve as a valuable resource for government RE program coordinators to develop better policies that facilitate the successful commercialization of these technologies in the market. This study can also act as a tool for practitioners (renewable energy companies) to evaluate the status of their current commercialization efforts to more effectively use the resources that other RE stakeholders can provide.

1.4. Organization of the Dissertation

The rest of the dissertation is structured as now outlined. In Chapter 2, the extensive literature review with subsequent development of the theoretical framework is provided. In this chapter, theoretical framework development and literature review
culminate in a model with variable definitions and propositions supported by theory and literature. Chapter 3 reviews the research methodology used in this study and provides justification as to why the selected methodology was used. Descriptions and results of the large-scale study are provided in Chapter 4. Chapter 5 highlights the major conclusions of the study and recommendations for future research.
Chapter 2

Literature Review and Theoretical Framework Development

2.1. Chapter Outline

This chapter includes a review of various areas of literature relevant to our study of RE commercialization, as well as formulation of a number of propositions to be confirmed or denied in the course of the research. First, the background of commercialization of new technologies is examined to better understand how it is implemented and how it corresponds to new product development literature. This will help understand the process of commercialization and how it can be accelerated. Second, the commercialization literature is reviewed with a focus on the renewable energy industry. Third, all the relevant literature on renewable energy implementation mechanisms that influence successful commercialization of new technologies is reviewed. Fourth, the companies’ internal attributes/capabilities influencing commercialization success are examined. Finally, the literature on stakeholder’s partnerships is reviewed along with external and internal drivers that affect the level of
synergy the partnerships can create. It is critical to understand how the level of partnership synergy influences a company’s dynamic capabilities and to identify effective incentive mechanisms companies can use to achieve commercialization success of their technologies. The dynamic capabilities, along with renewable energy implementation mechanisms, are reviewed from a resource-based perspective.

Much of the literature is critical for the development of the theoretical framework, as well as the research methodology, which is described in Chapter 3. The primary objective of this chapter is to organize and combine the existing knowledge on proposed constructs in order to reveal the gaps in this research area. In this chapter, the literature review is followed by several propositions, the purpose of which is to try filling these gaps and extending our knowledge in the research area. In order to facilitate this process and visualize the outline of the theoretical framework, the constructs of interest are presented in Figure 2-1 in the form of an unfinished model. At this point, it does not display relationships between the constructs as the model continued to develop as literature review progressed and relationships between proposed constructs and sub-constructs emerged.
2.2. Commercialization

Commercialization is quite a complex process by which a new product or service is introduced into the general market. It creates self-sustainable markets that succeed—without any kind of favor—in a level playing field with other competing technologies (Balachandra et al., 2010). Commercialization ensures that the technology in question meets not only the performance and reliability requirements, but also the economic requirements (i.e. it must be available at an acceptable price (Balachandra et al., 2010)). Without a proper commercialization process in place there is usually a temptation to simply take research results that “work” and then “draw it up and get it into production.”
In certain cases, this might work for a time; but, generally, such an approach is doomed to fail because the newly developed product would not be ready for the manufacturing environment to mass-produce it. This would result in delays, during which time many resources would be wasted. Additionally, the costs associated with the product could increase substantially, which would make the product uncompetitive in the market.

There is a vast volume of literature about various aspects and schemes of commercialization reflecting both scholarly views and business practices regarding the matter. Subsections below cover the most important and widely accepted ones.

2.2.1. New Product Development

New product development (NPD) is a term used to describe the complete process of bringing a product to market (Ulrich and Eppinger, 2004). Consistent and regular introduction of new products is important for the success of many companies. The motivation for rapid development is different for each company (Smith and Reinertsen, 1998). At the basic level, companies usually accelerate the product development process to increase sales. For example, if a product is introduced earlier than similar products, it will create a first mover advantage for the company and, therefore, better prospects for obtaining and retaining a large share of the market. Apple Corporation’s success in the 2000s is largely attributed to implementation of this strategy. iPhones and iPads were among the most successful products of the past decade, making Apple the highest market capitalization, publicly traded company as of June 2012. Other motivations for rapid new
product development include increased competitiveness, flexibility, and maintaining a market leadership position. Based on their motivation for rapid processing of new product development, companies determine which tools to use and how vigorously to apply them (Smith and Reinertsen, 1998). Hence, companies heavily investing in NPD often follow procedures set beforehand. These procedures may vary from industry to industry and even from company to company, but most commonly the NPD process involves idea generation, product design and detail engineering, market research, and marketing analysis (Smith and Reinertsen, 1998). Some companies establish ongoing laboratory research programs for NPD, whereas others may pull together resources for new product development in a less structured manner. In either case, however, to make a final decision on investing in new products, managers of the companies need to evaluate the costs and benefits of any particular NPD project. They face this dilemma at different stages of product development. Since companies put a lot of resources into various NPD projects, they would like to know which projects have more potential for success. The Stage-Gate Model, developed in 1984 by Robert G. Cooper, became a popular tool for evaluating new product development projects, helping many companies to use their resources more efficiently.

2.2.2. Stage-Gate Model

The Stage-Gate Model is a conceptual and operational road map for moving an innovation from idea to launch. It is designed to manage the new product development so as to improve overall effectiveness and efficiency (Cooper, 2008). The model divides the
NPD process (or any other project) into stages where the project team undertakes the work, obtains the needed information, and does the subsequent data integration and analysis. Each stage is followed by gates where there are four types of decisions to be made: go, kill, hold, or recycle.

Source: Cooper (1994)

Figure 2-2: Stage-Gate Model

Basically, the Stage-Gate Model tool is used by companies to optimize their spending on new product development. Each stage is designed to collect information to reduce project risks. Each following stage costs more than the previous one, thus the unknowns and uncertainties are driven down so that risk is effectively managed. The stages are followed by gates, which serve as quality control checkpoints or prioritization decision points.

The traditional stage-gate process has five stages and five gates (Figure 2-2): preliminary investigation (scoping), detailed investigation (building a business case), development, testing and validation, and full production and market launch (Cooper,
These stages can be grouped into three major areas: fuzzy front end, structured new product development process, and commercialization (Koen et al., 2002). In the new product development processes, the “fuzzy front end” refers to the chaotic "getting started" stage where scoping and building a business case is involved. It roughly covers the period from generation of an idea to its approval for development or termination (Murphy and Kumar, 1997). On the other hand, commercialization is the final stage of the new product development process where the actual launch of a new product into the market takes place. Although both stages are very important for companies to be successful, the commercialization stage of the new product development process has received less attention from researchers.

2.2.3. From Fuzzy Front-End to Commercialization

Continuous introduction of new products plays an important role in building competitive advantage and can contribute significantly to a firm’s growth and profitability (Abdul, 1994; Calantone et al., 1988; and Kleinschmidt and Cooper, 1991). For many companies, the speed of new product development is a central component in their competitive strategy (Radas and Shugan, 1998; Shanker et al., 1998; and Zhang and Markman, 1998). Time to market is in particular strongly associated with competitive advantage (Gupta et al., 1992). As life cycles shorten and technological and competitive environments change fast, companies need to introduce the new products not only as quickly as possible, but also make sure that customer needs are met (Herstatt and Verworn, 2001). Otherwise, these efforts are certain to fail. Since the fuzzy front-end of
new product development process has a key role in deciding which project to initiate, it needs to be decided in the beginning what product idea is most attractive for allocating resources. This decision dilemma is the most difficult one for managers, who describe front end as the greatest weakness in product innovation (Khunara and Rosental, 1997). To handle this problem and to make sure that they will always have new products to launch in a given time period, most companies initiate too many NPD projects. As a result, the scarce resources are spread among too many projects and it impacts the quality of work in particular projects (Robert Cooper et al., 1996, part 2). This is also caused by the pressure both from customers and the companies’ own sales force. Therefore, once a project is launched there is often no mechanism to “kill” a project (Robert Cooper et al., 1996, part 2) if it proves to be inefficient or ineffective. Several authors emphasize the importance of filtration of new product ideas in the early stages of development, which would allow the innovative companies to save their scarce resources and spend them on more valuable projects (Cooper, 1986; and Baums, 2001). They have introduced several techniques, such as the Stage-Gate Model, or have created a decision tree which incorporates all the possible outcomes of management decisions in each event (Baums 2001). For example, Baums (2001) proposed the net present value (NPV) of each decision starting from final year of the evaluation phase and going backward. The highest NPV alternatives automatically get a “Go.” The procedure brings significant clarity to the decision making process. Currently, most companies use the Stage-Gate Model to manage the product development process, typically using five stages and five gates (Figure 2-2). They consider fuzzy front end to entail the first two stages, which is completed at Gate 3 with a business plan that includes product specifications and detailed
business and financial analysis (Koen, 2007). Thus, early reduction of the number of projects reduces market and technological uncertainty and positively impacts new product development success (Verworn et al., 2008).

Although most authors did not specify what “new product development success” means, it can be assumed that it is the successful commercialization of developed technologies, which is the last stage in Stage-Gate Model (Cooper, 2001). Before a new technology reaches the commercialization stage, it passes through different points in the innovation process (Foxon et al., 2005). The ICCEPT and its E4tech report (2003) define the innovation process as a clearly identified stage in the development of new technologies from research and development (R&D), demonstration, and commercialization to diffusion. While the Stage-Gate Model focuses more on the decisions related to the fate of each new product development project in different stages of development, the report describes the new product development process as a procedure of matching technical possibilities to market opportunities, including multiple interactions and types of learning. It also assumes that the success of new product development may depend on the knowledge accumulated from the projects which were “killed” in early stages of development, as well as external framework conditions (government, investors, and others) (Freeman and Soete, 1997). Figure 2-3 provides stages of the innovation chain that are different from the traditional Stage-Gate Model. Its aim is to show the major conventional drivers of the innovation chain—from technology push (R&D) to market pull (customer demand)—which can be supported by feedback from different stages and by the influence of other players such as government, investors, and other stakeholders in the industry where innovation occurs (Foxon et al., 2005).
According to Figure 2-3, regardless of where the innovation occurred—in academia or in private business—when a newly developed product passes the demonstration stage it falls into the pre-commercial stage where two different forces—push and pull—interact. Here the overall success of a new product introduction depends on the ways in which the company promotes a validated technology, facilitates customer demand, utilizes the existing incentive mechanisms, and persuades investors to participate in commercialization of these technologies (ICCEPT and E4tech, 2003). No doubt, successful commercialization of new technologies is the riskiest and most rewarding form of new product development activity (Paschalian, 2002).

As seen, the successful commercialization of new technologies is no less important than the Fuzzy Front End; however, it has received less attention in academic
literature. As pointed out in Chapter 1, not much research is available in the academic literature that focuses on the commercialization portion of the NPD process. Most of the literature is related to NPD processes and their success factors (Cooper and Kleinschmidt, 1995a) without distinguishing the commercialization component of the process. The general notion of these studies is that the existence of the NPD process is comprehensive and characterized by professionalism throughout. Especially in terms of selection of new ideas, development (Parry and Song, 1994) and market introduction (Schmalen and Wiedemann, 1999) have positive effects on the success of new products (Song and Perry, 1996; and Griffin, 1997). However, there are studies that point to high failure rates of new products at the commercialization stage (Urban and Hauser, 1993). Therefore, it is crucial to find out whether the NPD process is aligned with the customer’s needs and the market (Cooper and Kleinschmidt, 1995a), emphasizing the importance of market orientation for the NPD’s success (de Brentani, 1989).

The studies on the success factors of the NPD process often ignore the fact that a technology can be developed by one entity, but commercialized and owned by a different one. (Balachandra et al., 2010). Yet this is a very important issue that needs to be considered while studying the NPD process. For example, a government-sponsored research institute or a university that is market-oriented could develop a new product and successfully demonstrate it. However, they will hardly be able to commercialize it if no interest is shown by private companies (startups) or entrepreneurs. This leads to a conclusion that the stage-gate process or innovation chain might involve different organizations (stakeholders of the technology), thus making one of the gates a transition point from one business entity to another. In most cases such transitions occur at the gate
leading from demonstration to pre-commercial (Figure 2-3). The academic literature pays little attention to technology transfer from new product developers to private business entities that compete for technology in open markets (Pries and Guild, 2007). Balachandra (2010) argues that, in the transition between the demonstration and commercial phases, there is a “Valley of Death” where the cost of production is high and the market penetration is low (Figure 2-4). The “Valley of Death” refers to the gap between the development stage of the technology and its commercialization.

Many newly developed products never emerge from this valley and the ventures are left with no alternative other than to go out of business (Socolow and Grubb, 2005). This is the reason why commercialization is important since it makes technologies increasingly profitable over time by enlarging the scale of production and reducing the need for any kind of support mechanisms that are essential in the demonstration stage. The partnership synergy between different stakeholders is crucial for the technology to emerge from the “Valley of Death” as it boosts the joint effort to help the technology to become commercialized.

![Figure 2-4: Technology Valley of Death](image-url)
Although commercialization itself is divided into two stages—supported commercialization and full commercialization—the existing academic literature views commercialization as a complete process or cycle for introducing a new product into a market (Jolly, 1997). It also explains the required actions and decisions in getting a product to a given market (Clark and Wheelwright, 1993; and Isabelle, 2004).

Balachandra (2010) defines commercialization as “the creation of self-sustaining markets that thrive—without any favor—in a level playing field with other competing technologies”. It is a process of moving technology from laboratory to market acceptance and use, thus taking it to the mainstream economic activity.

Other authors define commercialization in a similar manner as they all outline the importance of market acceptance and use. For example, Siegel et al. (1995) describe commercialization as converting a new product, process, or other “know how” into a profit-making position. Lockett and Wright (2005) view commercialization as a process of bringing science and technology capabilities or R&D capabilities into the marketplace. Christen (2001) ascribes three essential elements to commercialization: profitability, competition, and regulation. It is thus implied that commercialization leads to transformation of a business into a profit-making entity. Kollmer and Dowling (2004) define it as the designing, manufacturing, and marketing of products with developed technology. It implies that the ultimate value of the technology lies in the applications where it gets incorporated.

Since commercialization is a process of moving technology from laboratory to the market, the majority of academic literature on commercialization focuses on challenges
of different enterprises, including entrepreneurial business ventures, to commercialize new technologies in various industries. McCoy et al. (2009) studied the role of the developers/builders to further develop the domain-specific commercialization model for residential construction products. There are research studies on the commercialization of medical technologies (Scanlon and Lieberman, 2007; and Tilney, 2003), nanotechnology (Nobson, 2009), new technologies in the food industry (Horton, 1995) and many others. These studies have two things in common: they all focus on success factors, actions, and decisions that influence technology commercialization in a particular field; and they are conceptual in their nature rather than empirical. Moreover, most of these studies emphasize the important role of the government in facilitating commercialization process (Caerteling et al., 2008; Kumar and Jain, 2001; and Kumar and Jain, 2002). They indicate that the government provides the technology infrastructure, which leverages the ability of the companies and other technology stakeholders, in a national innovation system to participate efficiently in the innovation process and thereby to contribute to the technology-based economic growth (Link and Link, 2009).

Later in this chapter the literature on the role of government and other technology stakeholders is reviewed. It has to be noted that these studies on commercialization highlight the fact that not only economic, but also social and political factors, have to be considered when studying technology commercialization (Das and Van de Ven, 2000). It follows that, to be commercialized or adopted, a new technology needs to go through a diffusion process by which, over time, it spreads through different communication channels among different political and social groups (Rogers, 1983). Many technology developers do not take much time to understand why their new technologies are or are
not adopted. Understanding the factors that influence adoption of new technology would help technology developers identify the factors that facilitate the diffusion (Balachandra et al., 2010). To better understand the commercialization process and be able to develop its systematic and prescriptive model, the literature on the diffusion theory of innovations needs to be reviewed.

2.2.4. The Theory of Diffusion of Innovation

The diffusion theory was first introduced by Everett Rogers, a professor of rural sociology, in 1962. He synthesized research from many diffusion studies and produced a theory for the adoption of innovations among individuals and organizations. The main elements of the process of diffusion of innovations have been described by Rogers (1983) as: an innovation, which is communicated through certain channels, over time, among the members of a social system. Sarkar (1998) defined technology diffusion as a mechanism that spreads “successful” varieties of new technologies through economic structures and displaces the existing “inferior” varieties. He provides a clear distinction between the process of new product development and commercialization, stating that, while the processes of invention and innovation are necessary preconditions for new technology development, it is the process of diffusion that determines the extent to which the new technology is being put into productive use.

According to Rogers (1983), technology diffusion is typically modeled as an S-shaped curve over time (Figure 2-5).
Figure 2-5: S-curve of Technology Diffusions

Each new technology undergoes four different phases: learning, growth, saturation, and decline (Rogers, 1983). Each technology starts declining at the saturation stage, when a newer technology that is more efficient gains wider acceptance. This process repeats with each new technology entering the market. He also outlined five different stages of technology diffusion over time:

Knowledge—potential technology adopters learn about it.

Persuasion—people are persuaded to believe in its advantages.

Decision—adopters decide whether to acquire it or not.

Implementation—consumers decide to make a purchase.

Confirmation—if satisfied, consumers continue using it.

Since different individuals have different degrees of willingness to accept a
technology, Rogers (1983) segregated the population of adopters into five segments: innovators, early adopters, early majority, late majority, and laggards. At one end, there are innovators who are the risk takers and adopt the technology in the early stage of the diffusion process. At the other end, there are laggards who resist the adoption of the technology (Figure 2-6).

![Figure 2-6: Rate of Adoption of Innovation](image)

In the early stages, the adoption rate of new technologies is slow. The probability that an early majority will adopt the technology increases with its growing popularity. This is because more and more consumers will increase their knowledge and confidence in the newly developed technologies (Morgenstern and Al-Jurf, 1999).

If reviewed from a company’s prospective, some major questions remain (Chen, 2005):

- What are the major factors that accelerate the adoption of new technology by early majority?
• Are there enough resources allocated to the commercialization of the company’s technology assets?

• Do investments in commercialization pay off in terms of bottom-line financial performance?

Continuous development and market introduction of new technologies, which are important determinants of sustained company performances, assume that the technology diffusion time cycle needs to be shortened (Blundell et al., 1999; and Capon et al., 1990). In today’s world, the time-based requirements for the diffusion of new technologies are becoming major determinants for competitive success (Stalk, 1988). Cooper and Kleinschmidt (1995c) indicated that time performance along with financial performance are the key variables of new product development success. Therefore, another set of literature on time performance and financial performance was reviewed.

2.2.5. Time Performance

In the contemporary business environment, one of the key problems companies face is their inability to move new products into the market fast enough (Stalk and Webber, 1993). The speed of commercialization of new technology becomes a central component of their business strategy (Shanker et al., 1998; and Zhang and Markman, 1998). The existing literature on the speed of new technology development is quite rich; however, no differentiation is made between the speed of NDP and the speed of
commercialization. In general, the abundance of research on NPD speed indicates the importance of the subject to the academic and business communities. One of the most significant work in this field was done by Smith and Reinertsen (1998). The main focus of their study is based on the time cycle of the new product development process. They argue that the general belief that a fast time in getting to the market is universally good is not correct. In today’s competitive environment it is very important to know how much a reduced time cycle would cost a company. This means the companies that buy time cycles at the right prices will win the race for customers (Smith and Reinertsen, 1998).

It is worth mentioning that there is a study that focuses on the influence of a rapid introduction of new products into the market on the product’s performance. Cohen et al. (1997) build an analytical model that explicitly examines the tradeoff between product performance and the time it takes to get it to market. On one hand, shortening the time for development may impact the quality of product performance. On the other hand, a longer product development time will shorten the amount of time remaining for the firm to collect high margins on the new product before the opportunity window closes.

Regardless of all these concerns, in a greater part of the literature reviewed the time to market issue is strongly associated with competitive advantages and higher profitability (Karagoszoglu and Brown, 1993; and Stalk, 1988). Gupta et al. (1990) outlined increased competition, rapid technology changes, and changing market demands as the major drivers for the new technology’s rapid introduction into the market. This helps companies improve their profitability, create an opportunity to charge premium prices, and allow utilizing the advantages of development and manufacturing (Rosenau, 1990; and Smith and Reinertsen, 1998). Smith and Reinertsen (1998) recommended some
tools be applied through the development process to improve the time performance. These tools should be used in an organizational system designed to compress the schedule, organize a team, facilitate communication, control the process, manage the risk, and so on. Datar et al. (1996) went further, proposing that if new product development activities are concentrated in one location rather than being scattered in many places, then time to market will be shorter.

Manon and Lukas (2004) built a conceptual framework for fast product development based on antecedents and outcomes of NPD speed. In studying the determinants of speed they revealed two procedural (coordination and control) and two infrastructural (structure and culture) variables as drivers of NPD speed. They acknowledged that speed will probably influence performance variables (learning and stress) internal to the organization. Since commercialization is the last stage of the product development process, the outcome variables can be used to measure organizational time performance. This suggests that, when the commercialization process has to be accelerated, organizations could afford more scope to learn, for instance, due to more frequent feedback opportunities. However, there was one concern that over-focusing on speed can compromise organizational capabilities, causing tension at the workplace.

Interestingly enough, the majority of the studies are based on literature reviews, scattered cases, and anecdotal evidence. They all conceptualize the NPD speed as the pace of production development activities that occurs between idea generation and its introduction to commercial market. This literature review did not identify any comprehensive study which would focus on time performance of commercialization.
Only Siegel et al. (1995) provide a conceptual framework for the speed of technology commercialization, where cooperation is indicated as the most essential factor for acceleration. They recognized that “lots of new technology and know-how existed in North American and European companies, but not enough was getting out of the door and creating new revenues, profits, and jobs” (Siegel et al., 1995). Researchers also pointed out that there are many other technologies “sleeping” in university and government laboratories (Pries and Guild, 2007). Lack of knowledge about the business environment, insufficient commercialization experience, as well as a scarcity of financial resources are pointed out as the major problems for companies to commercialize these technologies (Chen, 2009). Cooperation between different technology stakeholders will help companies overcome these problems and accelerate technology commercialization (Siegel et al., 1995). (The literature on cooperation and partnerships among different technology stakeholders is reviewed later in this chapter.) According to Chen (2009), “commercialization speed refers to the extent of the competence in developing and launching the product to the market in timely manner.” In this study, however, the speed of the commercialization is defined as the pace of bringing new technology from its pre-commercial level to a fully commercial one. Such a definition seems more appropriate for this work because the study is focused on RE technologies requiring no further testing or validation.
2.2.6. Financial Performance

The management literature on NPD and innovation has a long history of struggling with the performance measurement of innovative companies. Both generally available measures—such as R&D inputs, patent counts, patent citations, or counts of new product announcements—and more specific survey-based measurements of this particular performance by companies have been used in trying to capture innovative performance of companies (Ernst, 2001). A broader understanding of innovative performance encompasses achievements of companies in terms of ideas, sketches, and models of new devices, products, processes, and systems. It indicates that the achievement of an idea up to the introduction of the invention into the market (Ernst, 2001). This broad assessment of innovative performance, therefore, overarches the measurement of all stages from R&D to patenting and new product introduction. In other words, this definition of innovative performance, in a broad sense, focuses on both the technical aspects of innovation and the introduction of the new products into the market, but it excludes the possible economic success of innovations (Archibugi, 1992; and Ahuja and Katila, 2001). Generally, the financial performance of R&D companies and new venture-funded start-ups has not been studied well in the literature. There are traditional, quantifiable measures that well-established companies or industries use to gauge or compare financial performance in terms of meeting their strategic and operational goals. These measures include net income, sales, sales per share, market share, return of investments (ROI), and so on. Some studies (Corbertt, 2005; and Xin et al., 2009) use three profitability performance measures: return on assets (ROA), return on
sales (ROS), and sales growth. Since the commercialization of new technology by itself requires a lot of financial resources (Chen 2009), many high-tech new ventures on their way to full commercialization have negative cash flows. Yet this may not reflect the actual market value of the company. This is the reason why these traditional financial performance indicators, except for the sales growth, are not applicable in measuring performance of such companies. Here the market-based measure of financial performance should be applied to the companies under the study (Adams et al., 2009). In many studies, Tobin’s $Q$ was used as an indicator of a company’s long-term performance. (Montgomery and Wernerfelt, 1988; Chang and Pruitt, 1994; Jose et al., 1996; and Lin et al., 2006,) Tobin's $Q$ was developed by James Tobin (1969) as the ratio between the market value of the firm and the replacement value of its tangible assets. Unlike the traditional short-term financial performance measures (ROI, ROA, ROS, etc.), Tobin’s $Q$ reflects expected future earnings and captures the lag between investments in NPD and commercialization and realized benefits (Dushintsky and Lenox, 2006). It also represents a longer-run equilibrium measure capturing both the risk and return dimensions (Jose et al., 1996). When Tobin’s $Q$ is greater than 1.0, investors have a positive outlook on the company’s growth opportunities. The higher Tobin’s $Q$ is for a firm, the greater the growth opportunities for that firm (Dushintsky and Lenox, 2006). This financial performance measure is best applicable to RE companies, which are on their way to commercializing the second generation of renewable energy technologies. However, since the focus of this dissertation is not the renewable energy company performance, but, rather, the commercialization success of already developed RE technologies, Tobin’s $Q$ is not applicable.
2.3. **Commercialization of Renewable Energy Technologies**

Even though commercialization success in different industries is important for respective companies to be competitive and, at the same time, improve prosperity and quality of life in society, there are priority areas for innovation and research where governments and societies anticipate major breakthroughs. These areas are life sciences, information and communication technologies, and renewable energy. Thus, besides companies involved in these industries, there are many other stakeholders who are concerned about getting new products into the market as soon as possible. In most cases for commercialization to be a success, it is critical to involve these stakeholders early in the process. This is especially true for the renewable energy industry where commercialization of new technologies has increasingly become a major public policy issue. Currently more people in the industry, government, investor community, and general public are putting forward questions about the need to accelerate new product development and commercialization of RE technologies for energy production, as well as for stationary, transportation, and portable applications.

RE technologies have received a lot of attention in the past decade as possible contributors to solving the world’s current energy challenges, as well as reducing the CO₂ emissions associated with burning fossil fuels (Falconett and Nagasaka, 2010). However, these technologies are not mature enough to compete with conventional energy sources (Jager-Waldau, 2007). Currently the world economy heavily relies on non-renewable coal, oil, and natural gas for its energy. These natural resources are finite and will be
depleted over time, driving their prices higher and increasing the environmental damage required to extract them. On the other hand, renewable energy resources—such as wind, solar, and biomass energy—are constantly replenished and may never run out.


According to a report from the U.S. Energy Information Administration, renewable energy consumption within the entire U.S. energy supply in 2011 was 9 percent, of which only 16 percent was attributed to second generation RE technologies (Figure 2-7). With wider application of second generation technologies, several problems associated with climate change, pollution, and energy insecurity can be solved, which would necessitate major changes in energy infrastructure (Jacobson and Delucchi, 2011),


Figure 2-7: RE Consumption in the US Energy Supply, 2011
in turn requiring a lot of investments. However, the numerous benefits of RE technologies make their commercialization a major priority for governments around the world.

The U.S. National Renewable Energy Laboratory has outlined key benefits of RE technologies (Grover, 2011).

- Environmental Benefits—clean source of energy with much lower environmental impact compared to conventional energy technologies.
- Infinity—resources may never run out.
- Jobs and Economy—investments made locally on materials and skills to maintain the facilities—rather than spending the funds on costly imports—creates jobs and fuels local economies.
- Energy Security—diminishes the dependence on foreign oil supplies.

However, advancement of RE technologies did not show significant progress even when oil and gasoline prices were on the rise, hitting record highs in mid-2008. There was a belief that nuclear energy is safe and cheap enough to replace oil and gas, and could provide the necessary energy to meet the growing demands of economies around the world. Conversely, there was a belief that RE technologies are too costly and still unattractive, regardless of many advantages. However, the March 2011 events in Japan prompted many to revise their opinions after the “safest” nuclear power plants did not survive an earthquake and subsequent tsunami.
The review of management literature did not reveal any NPD study that would focus particularly on renewable energy technology, though the literature on NPD is vast. The majority of the literature on commercialization of RE technology is published by either *Energy Policy* journal or *Renewable Energy* journal. Moreover, most of the published research is based on case studies, which are a type of empirical inquiry that investigate a renewable energy commercialization process within its real-life context. There is a general belief that, after several decades of continued funding for research and development of renewable energy technologies, now is the time to transform these research results into commercially viable products (Charters, 2001). The major renewable energy implementation mechanisms need to be introduced by stakeholders to make those technologies commercially attractive (Alishahi et al., 2012). Moreover, the various types of renewable energy technologies and their different commercialization stages require corresponding individual innovative implementation mechanisms to make these technologies competitively viable in relation to fossil fuels (Effendi and Courvisanos, 2012). Foxen et al. (2005) have attempted to position the second and third generation of renewable energy technologies in the letter of commercial maturity, trying to find out which technology occupies what position in the commercialization process (Figure 2-8). As it is seen in Figure 2-8, solar PV, wind energy, solar water heating and small hydro plants are the nearest to full commercialization.
When trying to identify how these technologies are implemented individually, this study revealed that the geography of studies on renewable energy implementation mechanisms is quite wide—from developed countries to developing ones. Obviously, there are a lot of differences between the implementation of renewable energy technologies in developed and developing countries. The cost per kilowatt of energy from conventional energy sources in developed counties is much less than in developing countries (Charters, 2001). This is caused by the efficiency of energy production and developed infrastructure for production and distribution of energy to the final consumers. The developing countries are less energy efficient than their developed counterparts and their energy use/GDP ratios can be up to 60 percent higher than those normally present in developed economies (Charters, 2001). Moreover, the introduction of renewable energy technologies might require some costly investments in modification of existing infrastructures of production and distribution energy in developed countries, while the
lack of infrastructure in developing economies becomes a strategic advantage for introduction of new renewable energy production and distribution systems (Charters, 2001).

Balachandra (2010) conducted the most comprehensive study on renewable energy commercialization. His study dwells on the key question of how to achieve large-scale and long-term diffusion of RE technologies. The study addresses the issue of slow commercialization of RE technologies in India, where government-driven initiatives more often than not involved no private participation. He proposes the private-sector-driven “business model” approach for diffusion of renewable energy technologies where different innovative financial, marketing, incentive, monitoring, and delivering mechanisms are present. Many other studies also indicate the importance of the introduction of support mechanisms by government for successful commercialization of RE technologies (Stapleton, 2009; Alagappan et al., 2011; and Loiter and Norberg-Bohm, 1999). However, the efforts to commercialize renewable energy technologies have largely remained as government-sponsored schemes (Reddy and Assenza, 2009). There is an urgent need for private sector involvement in commercialization efforts of these technologies. Another issue addressed in the RE commercialization literature revolves around major non-technology-related barriers towards implementation. In Chapter 1, the report prepared by Margolis and Zuboy at NREL was the major comprehensive study on the subject, where they listed the most frequently identified non-technical barriers to solar and other renewable energy and energy-efficient technologies. Another investigation on the subject was conducted by Anthony Owen (2006) who studies market barriers towards the implementation of renewable energy. He states that “market barrier perspectives
characterizes the adoption of a new technology as a market process and focuses on the frameworks within which decisions are made by investors and consumers.” Hence, anything that slows the rate at which the market for a technology expands can be referred to as a market barrier. The core issue addressed in this study is related to the existence of externalities where certain environmental costs associated with the production of conventional energy sources are not reflected in the market cost of a kilowatt of energy. So, the energy consumer does not pay the full cost to compensate the harm done to the health of the people (Owen, 2006). Consequently, the use of the conventional energy is being implicitly subsidized, which makes renewable energy less attractive for final consumption. A table developed by International Energy Agency in 2003 summarizes the types of market barriers and typical measure that can be employed to alleviate them (Table 2.1).

Painuly (2001) also indicated that market distortion, as well as externality costs, are the major economic barriers in renewable energy implementation. The other barriers indicated in his study included political, financial, social, institutional, cultural, and behavioral ones. Interestingly, Sovacool (2009) examined another barrier among electric utility operators who were reluctant to change because of the inertia comfort. Utility operators prefer to do their business in a traditional way, dealing with the conventional energy sources. The introduction of renewable energy into their system represents a large change in procedure, routine, and culture in their activity (Sovacool, 2009).

The next section will focus on literature pertaining to dynamic capabilities and renewable energy implementation mechanisms, which companies have to possess in
order to overcome the mentioned barriers and accelerate the diffusion of these technologies in the market.

Table 2.1: Non-technical Barriers towards Renewable Energy Commercialization (Source IEA 2003a.)

<table>
<thead>
<tr>
<th>Barrier</th>
<th>Key characteristics</th>
<th>Typical measures</th>
</tr>
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</table>
| Uncompetitive market price | Scale economies and learning benefits have not yet been realised | * Learning investments *
| Price distortion | Costs associated with incumbent technologies may not be included in their prices; incumbent technologies may be subsidised | * Regulation to internalise 'externalities' or remove subsidies *
| Information | Availability and nature of a product must be understood at the time of investment | * Standardisation *
| Transactions costs | Costs of administering a decision to purchase and use equipment (overlaps with "Information" above) | * Labelling *
| Buyer’s risk | * Perception of risk may differ from actual risk (e.g. 'pay-back gap') * Difficulty in forecasting over an appropriate time period | * Reliable independent information sources *
| Finance | * Initial cost may be high threshold * Imperfections in market access to funds | * Convenient & transparent calculation methods for decision making *
| Inefficient market organisation in relation to new technologies | * Incentives inappropriately split—owner/designer/user not the same * Traditional business boundaries may be inappropriate * Established companies may have market power to guard their positions | * Demonstration *
| Excessive/inefficient regulation | Regulation based on industry tradition laid down in standards and codes not in pace with developments | * Routine to make life-cycle cost calculations easy *
| Capital stock turnover rates | Sunk costs, tax rules that require long depreciation & inertia | * Third party financing options *
| Technology-specific barriers | Often related to existing infrastructures in regard to hardware and the institutional skill to handle it | * Special funding *
| | | * Adjust tax rules *
| | | * Capital subsidies *
| | | * Focus on system aspects in use of technology *
| | | * Connect measures to other important business issues (productivity, environment *)
2.4. Resources-Based Perspective of Commercialization

2.4.1. Resource Based View (RBV) of the Firms

The concept of dynamic capabilities and RBV of companies, with particular focus on renewable energy companies, is regarded as the fundamental knowledge base for this thesis. RBV is a theoretical viewpoint that brings in a unique dimension on managing growth and company development.

The RBV argues that companies possess the combination of productive resources that can be utilized to create value and competitive advantage (Penrose, 1959). The more valuable and rare the resources are, the greater the advantages the companies obtain (Dierickx and Cool 1989). While studying the resources of sustained competitive advantage, Barney (1991) looked into the relationship between company’s resources and its competitive advantages. He assumed that all the resources of strategic nature, which are distributed across the companies, are heterogeneous and thus make each competitor different from others. Besides being valuable and rare, the resources also need to be non-substitutable and non-replicable (Barney, 1991; Grant, 1991; and Rugman and Verbeke, 2002). A proper coordination and integration of resources stimulates the development of strategic capabilities and core competences (Nelson and Winter, 1982). Persistent superior performance can be achieved to the degree to which these competencies and capabilities are unique (rare), valuable to the customers, non-substitutable with similar products and difficult to imitate (Rugman and Verbeke, 2002).

In should be noted that the most fundamental studies on RBV of companies were
conducted in late 1980s and early 1990s. At the time the dominant stream of resource-based research was focused on a more static perspective, where resource configuration and acquisition were the main research interest (Wernerfelp, 1984; Barney, 1991; and Grant, 1991). These researches did not take into account the fact that over time the resources can deteriorate depending on the nature of the resource itself, as well as the innovation rate of the industry (Boccardelli and Magnusson, 2006). So, the stock of resources accumulated over time needs to be substituted, improved or reinforced based on the innovative changes in the industry where the innovation occurs. Additionally, the competitive advantage needs to be sustained through continuous process of accumulating firm-specific resources (Boccardelli and Magnusson, 2006). Moreover, Dierick and Cool (1989) pointed out that only internally developed resources can generate sustainable competitive advantages, while all the assets based on resources acquired in open markets can be easily replicated by competitors. While this finding is generally true for most of the established industries, in some emerging industries assets acquired in open market still can be a source of competitive advantage. For example, in the RE industry where the diffusion process needs to induced, apart from the internal company resources, there are other external resources available to the companies in open markets. These can include innovative mechanisms related to regulatory policies, finance, marketing, and incentives (Balachandra et al., 2010). Since the major competition of renewable energy comes from energy producers of conventional energy sources, these resources are external to the company and cannot be used or imitated by the competition. Thus they will become a valuable factor in gaining a competitive advantage. However, according to Teece et al. (1997) accumulation of resources (in this case, internal resources coupled
with the external ones available in the open marketplace) is not enough to support a significant competitive advantage. The companies with timely responsiveness, and rapid and flexible product innovation together with many useful management capabilities to effectively coordinate and redeploy internal and external competencies, are the winners in the global marketplace (Teece et al., 1997).

2.4.2. Dynamic Capabilities

In the academic literature, dynamic capabilities are defined as “the company’s ability to integrate, build, and reconfigure internal and external competencies to address [a] rapidly changing environment” (Teece et al., 1997). In other words, it is the company’s processes that use resources to match and even create market changes. Dynamic capabilities are the organizational and strategic routines by which firms achieve new resource configurations as markets emerge, collide, split, evolve, and die (Teece et al., 1997). For example, product development routines where managers combine varied skills and functional backgrounds to create revenue-producing products and services are dynamic capabilities. Similarly, resource allocation routines, which are also dynamic capabilities, are used to distribute scarce financial or manufacturing resources within a company. Obviously, the role of these routines is the transformation of existing resources into new, functional competencies that better match the environment (Eisenhardt and Martin, 2000).
Since the continuous creation of innovation is recognized as the only way for the firm to gain a competitive advantage, Chang (1996) proposes technological and marketing capabilities as the main resources that enable firms to achieve higher performances. Moreover, he provided evidence that there is a synergy effect of technology and marketing capabilities on a company’s market share. Marketing capabilities include building privileged relationships with customers and suppliers, market knowledge, control over distribution channels, and a strong “installed” customer base (Lado et al., 1992). Technological capabilities include R&D intensity, technical knowledge, and infrastructure (Leonard-Barton, 1995).

In addition to these two capabilities, Teece et al. (1997) pointed out organization capabilities as another source of competitive advantage. He formally proposes three distinct processes as part of organization capabilities—reconfiguring, learning, and coordinating/integrating. Among these three processes reconfiguring is the most essential one for the outcome of dynamic capabilities (Henderson and Cockburn, 1994) and is particularly relevant to NPD where the new products are creative adaptations of existing ones. Learning is a primary enabler of reconfiguration. The existing functioning competencies can be reconfigured if new knowledge is created through the learning process (Zahra and George, 2002). Then effective coordination is implemented through resource allocation, task assignment, and activity synchronization (Crowston, 1997). Finally, these new configurations need to be integrated into the organization’s functions (Zollo and Winter, 2002).

While earlier studies on dynamic capabilities have emphasized that the competitive advantage results from the resources which reside within a single company,
Dyer and Sigh (1998) proposed that the company’s critical resources can extend beyond the boundaries of a single firm. So, their study focuses on the inter-firm capabilities of the companies. The inter-firm capabilities can increase the company’s performance by lowering the transaction costs, enhancing flexibility of their partnerships, and reducing their dependence on the environment.

Ettlie and Pavlou (2006) studied dynamic capabilities that result from inter-firm partnerships during the joint NPD processes. They proposed three capabilities to capture the dynamic capabilities of inter-firm partnerships: absorptive capacity, coordination capability, and collective mind.

The concept of absorptive capacity was first introduced by Cohen and Levinthal (1990) and later was re-conceptualized by Zahra and George (2002) as a dynamic capability. Absorptive capacity reflects the inter-firm NPD capability to recognize the value of new knowledge, assimilate it, and apply it to commercial ends (Cohen and Levinthal, 1990). Then coordinating capability reflects the inter-firm NPD capability to synchronize resources and tasks to improve the performance of the NPD activities (Crowston, 1997). Last, collective mind reflects the inter-firm NPD ability to heedfully integrate their diverse and unrelated resources into a collective system through contribution, representation, and subordination (Weick and Roberts, 1993).

Since the literature review did not reveal any study on dynamic capabilities generated through stakeholder partnership relationship, in this work, the inter-firm partnership approach was applied to capture dynamic capabilities of stakeholders’ partnerships.
2.5. Renewable Energy Implementation Mechanisms

The main purpose of introducing RE implementation mechanisms is to increase the production of renewable energy, but this has little empirical support (Song, 2011). To increase renewable energy production, the diffusion process of new RE technologies needs to be accelerated. This diffusion process has to be stimulated by bringing together different renewable energy stakeholders, designing mechanisms, and involving intermediaries in achieving the diffusion goals (Balachandra et al., 2010). Balachandra’s team outlined several RE implementation mechanisms used in different countries to facilitate the use of RE technologies: regulatory policies, finance, marketing, and incentives. In the study, from an example in India, the researchers emphasize the importance of involving all renewable energy stakeholders since government-driven initiatives are not effective without private participation.

The diffusion target of the technology for stakeholders should be renewable energy companies that commercialize technologies (entrepreneurs) rather than the end users (Reddy et al., 2004), while government should be a facilitator of the partnership (Caerteling et al., 2008). The entrepreneurship in the renewable energy field will not emerge automatically since the majority do not view renewable energy technologies as commercially attractive propositions. A favorable environment needs to be created by involving all stakeholders (public, private, and government) so the RE businesses can emerge. Additionally, the effectiveness of newly introduced, innovative RE implementation mechanisms needs to be monitored to check their influence on the commercialization success (Song, 2011). Two of the criteria for evaluating the
effectiveness of RE implementation mechanisms are renewable capacity and generation growth (Gielecki et al., 2001). In academic literature, mainly three such mechanisms are examined predominantly through case studies and anecdotal evidences: innovative financial mechanisms, incentives, and policy instruments. In this study, these three mechanisms were assessed in terms of their effectiveness and impact on commercialization success. Moreover, incentives and policy instruments need to be reviewed together, since they both are introduced by government.

2.5.1. Innovative Financial Mechanisms

Usually, renewable energy projects require high level of financing. They normally have very high start-up costs relative to the expected monetary returns and lengthy pay-back periods (Sonnetag-O’Brien and Usher, 2004b). There are two major problems associated with financing the commercialization of renewable energy technologies. First, renewable energy companies need long term loans (Demirguc-Kunt and Maksimovich, 1999), while lacking sufficient volumes of output with attractive returns (Balachandra et al., 2010). Especially, the access to bank loans is a serious problem for small- and medium-size companies (Beck et al., 2004a). Second, the limited access to financing for renewable energy companies is attributed to the competition from fossil-fuel projects, which have a longer track record, relatively lower up-front costs, shorter lead times, and often favorable political treatment (Head, 2000; and Sonnetag-O’Brien and Usher, 2004b). Balachandra et al., (2010) summarized some of the most applicable financial mechanisms that need to be available for supporting the commercialization of RE:
Leasing – a flexible form of financing, where a company rents out its fixed assets against contractual payments.

Venture Capital – usually these are funds, which are ready to back risky investments against higher returns and will invest in producers of new technology that have difficulty raising capital elsewhere.

Micro-credit – are prepared to lend to the firms, which are ignored by conventional financial institutions.

Loan guarantee – government backed scheme to support small scale entrepreneurs.

The importance of the private financial sector for the development of the renewable energy industry has been pointed out in several studies in past two decades. Churchill and Saunders (1989) discussed a policy framework for private financial sector involvement in energy projects. Then, Babbar and Schuster (1998) and Head (2000) found gaps in these policy frameworks applied to the renewable energy sector. Wohlgemuth and Painuly (1999) discussed and proposed several policy recommendations. MacLean and Seigel (2007) concentrated on small-scale RE projects and outlined three financial fields: end-user financing, business financing, and small-scale project financing.
2.5.2. Innovative incentive mechanisms and regulatory policies

In markets where consumer preferences have been shaped by the long-term use of existing conventional energy technologies, incentive mechanisms and regulatory policies play a decisive role in the creation and expansion of niche markets that, through learning mechanisms, facilitate the improvement of product performance and adaptation to demand (Menanteau and Lefebvre, 2000). It is the government that introduces the incentive mechanisms and regulatory policies important for technology commercialization success (Caerteling et al., 2008).

There are a number of ways how government can affect the conditions for successful technology commercialization. First, government may intervene in technology commercialization by regulating the allocation of resources and defining the nature and scope of property (Ring et al., 2005). Second, standards setting can affect market completion, such as the strict environmental standards in California (Shapiro, 2000). Third, government is a large sponsor of technology commercialization through its financial support of R&D and new business development (Lerner, 1999). Fourth, government is the first adopter of newly developed innovations (Dalpe et al., 1992). Fifth, government as a customer often has significant buying power, which affects market price (Lustgarten, 1975). Therefore, during commercialization, government must simultaneously support technology development and create new markets (Norberg-Bohm, 2000).
Table 2.2 provides a summary of some incentive mechanisms and regulatory policies which are currently applied in different countries around the world (Balachandra et al., 2010).

Table 2.2 Government-Introduced Incentive Mechanisms and Regulatory Policies

<table>
<thead>
<tr>
<th>Incentive Mechanisms</th>
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<tbody>
<tr>
<td>Reimbursement of expenditure incurred on the purchase of RE</td>
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<tr>
<td>Mortgaging RE technology</td>
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<tr>
<td>‘Green Credits’ – credits based on the value of saved energy</td>
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<tr>
<td>Tax incentive for RE purchase</td>
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<tr>
<td>Energy price discounts for RE adopters</td>
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<table>
<thead>
<tr>
<th>Regulatory Policies</th>
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<tbody>
<tr>
<td>Information diffusion through large scale campaigns</td>
</tr>
<tr>
<td>Creation of standards</td>
</tr>
<tr>
<td>Quality labeling programs</td>
</tr>
<tr>
<td>Adoption of systematic approach in Demand Side Management (DSM)</td>
</tr>
<tr>
<td>Collective procurement programs</td>
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</tbody>
</table>
Some observation have been provided that “technology-forcing instruments” — such as the introduction of minimum efficiency standards and labeling programs—can greatly increase the RE diffusion. Additionally, Falconett and Nagasaka (2010) developed a model to assess the effectiveness of the RE supporting mechanisms on the financial return of different projects, such as government grants, feed-in tariffs and RE certificates. Specifically, they simulated the impact of these supporting mechanisms on the net present value on the small scale renewable energy projects. Similarly, the relationship between cost-effectiveness and performance of support mechanisms has been discussed by Agnolluchi (2008), Meyer (2003), and Toke (2007). Feed-in tariff is a policy that sets the energy price above the market price and has been the main driver behind the construction of RE power plants (Song, 2011). RE certificates (known as green certificates in Europe) are tradable commodities proving that certain electricity is generated using renewable energy sources (Song, 2011).

Although RE incentive mechanisms and regulatory policies did not have a significant positive effect on successful commercialization of technologies, it does not mean they are useless (Balachandra et al., 2010; and Song, 2011). The existence of these mechanisms and policies create a ground for RE energy technologies to be commercialized. That is why governments, with all the RE private and public stockholders, should actively play a greater role in increasing the effectiveness of these instruments to accelerate the commercialization process.

Oxford Advanced Learner’s define effectiveness as the degree to which objectives are achieved and the extent to which targeted problems are solved. For this work, the effectiveness of RE implementation mechanisms is defined as the degree to which all the
RE innovative implementation mechanisms contribute to the success of commercialization of RE technologies.

2.6. Stakeholders’ Partnership Synergy

2.6.1. RE Stakeholders

In 1980, Michael Porter developed a well-known technique to analyze industrial structures and their competitive forces. His technique is based on the “Five Forces Model” which describes an enterprise in relation to its economic environment. Gian et al. (2005) applied Porter’s five forces model to the fuel cell industry for transportation applications, where they added three additional forces: infrastructure and fuel; government policy; and public and private investments. All eight competitive forces together provide a good overview of the attractiveness of the RE industry and can help one estimate its future profit potential (Gian et al., 2005). The presence of government, as well as private and public players, becomes a critical factor that influences the success of commercialization. Together, these players develop into major stakeholders of RE technologies. Balachandra et al. (2010) classified stakeholders into the following groups: developers of technology, owners and suppliers of technology, entrepreneurs, buyers and end-users, financers of technology commercialization, information providers, market intermediaries, and government. These stakeholders should work together, under the effects of external and internal factors, on developing synergetic strategies to ensure commercialization success. An extensive search of academic literature has shown no
studies on how these stakeholders can develop partnerships, or how to create and sustain their synergy that will influence the creation of a unique set of external (RE implementation mechanisms) and internal resources (dynamic capabilities) that play an important part in commercialization success. In this study, the traditional inter-firm partnership relationships were reviewed and the possibilities of applying these approaches to RE stakeholders’ partnerships were explored.

2.6.2. Partnership Theory

Brinkerhoff (2002b) defines a partnership as a dynamic relationship among diverse actors, based on mutually agreed on objectives, pursued through a shared understanding of the most rational division of labor based on the respective comparative advantages of each partner. A partnership with other players is pursued precisely because these other players have something unique to offer, whether it be resources, skills, relationships, or approvals. He measured partnerships in terms of mutuality and organizational identity. Mutuality includes the spirit of partnership principles and refers to mutual dependence that requires respective rights and responsibilities on each player’s part (Kellner and Trackray, 1999), while organizational identity is seen as distinctive and enduring in a particular organization (Gioia, 2000). One of the factors that influence the partners’ decisions to participate actively in a partnership is their perception of the relative benefits and drawbacks involved (Alter and Hage, 1993; and Goddman et al., 1998). Partners who are more active in partnerships perceive that they gain significantly
more benefits than those who are less active, and these benefits relate as much to their own mission and economic validity as to the partners’ joint goals (Prestby et al., 1990).

Weiss (2002) used the term partnership to encompass all types of collaboration (e.g. coalition, alliance, consortia) that brings people and organizations together to achieve mutually accepted goals. However, there is a general belief that building an effective partnership is time consuming, resource intensive, and very difficult because collaboration requires relationships, procedures, and structures that can be quite different from the ways in which many people and organizations worked in the past (Mitchell and Shortell, 2000). In order to find out if collaboration achieves its goals, researchers and evaluators have increasingly focused their attention on how a partnership is functioning (Lasker et al., 2001). These researchers outlined various aspects of how the partnership was functioning, such as partner participation, partner relationships, staff support, sufficiency and flows of resources, leadership, management, communication, governance, partnership structure, and external environment. The outcomes of this collaboration arrangement could be the effectiveness of partnerships, satisfaction of stakeholders, the sustainability of partnerships, and many other measures, which however, have been difficult to document due to a lack of valid indicators (Kreuter et al., 2000; and Roussos and Fawcett, 2000). It is very important for the partnership in its early stage to determine if the partners are making the most of these collaborative efforts (Weiss et al 2002). As of today, most studies have focused more on why partnerships form, while relatively little is known about how this collaboration works, and what the pathways are through which partnership functioning influences partnership effectiveness (Lasker et al., 2001). In order to get these answers, the level of partnership synergy
should be measured since it the primary characteristic of a successful collaboration process (Weiss, 2002).

2.6.3. Partnership Synergy

The power to combine the skills, resources, and perspectives of a group of people and organizations has been called synergy (Mayo, 1997). The synergy that a partnership can achieve is more than simply an exchange of resources and skills. When partners effectively merge all their resources, skills, and perspectives, a valuable outcome is achieved as a whole, which is greater than the sum of its parts (Shannon, 1998; and Lasker et al., 2001).

A major study on partnership synergy has been carried out in the health care industry by Weiss et al. (2002). They suggest that partnership synergy is an outcome of the partnership functioning, which makes collaboration especially effective. The results of their study suggest that partnership synergy may be an important proximal outcome of certain dimensions of partnership functioning, for example leadership effectiveness and partnership efficiency.

The academic literature suggests several cases of partnerships between various organizations and explores some scope of synergy achieved while pursuing their goals individually. This includes studies on partnerships between government and industry on R&D synergy (Best, 1989), university and industry (Camilleri and Humphries, 2005), local government, and community based organizations (Krishna, 2003)
The largest gap in the academic literature is that the partnership and the level of synergy between different stakeholders of innovative technologies (not only RE) appear not to have been studied. This is due to the absence of collective economic theory of synergy. An attempt was made in this study to cover this gap in the RE synergy area. Clearly, the synergy created by collaboration can be very powerful. The “raw materials” for synergy are the stakeholders that come together in a partnership. Collaboration with diverse players (stakeholders), whose heterogeneous traits, abilities, and attitudes bring complementary strength to the table, may have the greatest potential for generating valuable external and internal resources for companies and will contribute to commercialization success. The next question to be answered is: what will drive the major stakeholders of the technology to collaborate, and to help the companies commercialize their technologies?

2.7. External and Internal Drivers of Renewable Energy Technologies.

As a result of the development of the free-market economy, most countries are engaged in radical changes, not only in their economic functions, but also in the characteristics and the respective roles of the state and the private sector. The traditional concept of an autonomous private sector acting in pursuit of its own immediate goals, notably profit maximization, and a public sector, with discretionary powers and multiple objectives that relate to the pursuit of long-term goals in the public interest, has changed (Pongsiri, 2002). For private firms, external factors are represented by Porter’s (1991)
industrial forces. However, when reviewing governments’ motivations in promoting a technology, the general benefits that the technology brings to the economy and society need to be considered. Hence, the external factors in this research are represented by the benefits the RE technologies provide. Internal factors are individual company attributes, which negatively influence performance and drive the company to seek support from other RE stakeholders. Currently, public and private sectors have common interests and the balance between these interests can be reached only through partnering arrangements (Saltman and Figueras, 1998). What are the major drivers, which bring together different stakeholders (public and private) of RE industry to achieve a partnership synergy to develop more effective mechanisms and skills required for successful commercialization of RE technologies? The international environmental concerns (encompassing especially such problems as greenhouse gas and toxic emissions, water pollution, climate change/global warming) and domestic concern of energy security are mentioned as key drivers for the governments around the world to get involved in developing incentive mechanisms and regulatory policies to support RE technologies (Kobos et al., 2006; Jagoda et al., 2011; Alagappan et al., 2011; Alishahi et al., 2012; and Zahedi, 2011). However, without active involvement of other public and private players in assisting the government to develop these mechanisms, the latter will not be effective (Balachandra et al., 2010). It is very important to understand what each stakeholder is looking for in this collaboration with other stakeholders? On one side, there are companies directly engaged in RE technology commercialization. On the other side, there is the government which can act as a champion. Yet there are also other stakeholders who can contribute to the success of RE technology.
Certeling et al. (2008) define government championship as a supply-oriented policy to provide technical assistance, political support, and human resources for companies engaged in commercialization. The championship can create demand conditions for RE products among consumers. It is known that governments must be involved with RE dissemination because markets alone are ineffective in mainstreaming, while the motivation of the government is that energy is an economically strategic sector that ought to require political and policy guidance (Marques and Fuinhas, 2011). The need to address global climate change, reduce dependence on foreign energy sources, and lessen consumer exposure to volatile fossil fuel prices has led government to mandate the development of renewable energy (Puga and Lesser, 2009). Additionally, the deployment of renewable energy technologies will contribute to the creation of jobs and fuel local economies since most RE investments are spent on material and labor to build and maintain facilities, rather than costly energy imports (Painully, 2001). So the introduction of RE technologies would be a key source of economic growth (Mokyar, 2002) and new employment opportunities and skills (Grubler, 1998; and Ruttan, 2001).

From an RE company prospective, as Jogoda et al. (2011) noted, the RE market increase provides two major opportunities. First, the use of RE sources drives down energy costs in the long run, where the initial costs are reduced by introduction of different incentive mechanisms by federal, state, and local governments. So the cost of technology is seen as the major driver for a company to seek partnership opportunities with other stakeholders. Second, RE companies will always have competitive advantages because of their eco-friendliness and an opportunity to create loyal, environmentally friendly clientele for the future (Jogoda et al., 2011). In addition to this, Foxon et al.
(2005) suggested that the skills needed for large-scale demonstration and early commercialization are different from the skills possessed by those involved in the R&D and first demonstration stage. Hence, from the RE company’s perspective, the drivers to seek collaboration with government and other stakeholders are the high cost of technology and lack of necessary skills to commercialize these technologies (Margolis and Zuboy, 2006; and Owen, 2006). Demirguc-Kunt and Maksimovich (1999) and Chen (2009) pointed out lack of financial resources to commercialize technologies as a major problem as well.

The motivation behind all other public and private stakeholders to contribute to the development of effective implementation mechanisms is not well documented in academic literature. However, it is generally recognized that environmental and social economic benefits derived from RE technologies are a good motivation for them to be involved (Balachandra et al., 2010). Moreover, for other private stakeholders—for example, financial institutions—commercialization of RE technologies will create more business opportunities (Brunnschweiler, 2010).

2.8. Theoretical Framework

After conducting a rigorous review of literature, it was concluded that there is no theoretical framework linking partnership synergy and commercialization success, and that in the existing theories/models their relationship can only be indirectly inferred (e.g. technology "valley of death.") It also turned out that most of the relationships between
internal/external drivers, partnership synergy dynamic capabilities, implementation mechanisms, and commercialization have not been explored. Moreover, in the management literature which covers a large variety of industries on its way to improved decision making in the direction of organizational goals, no studies related to the RE industry were found. This makes one believe that in the coming decade, upon the gradual introduction of RE technologies into the markets, there is a huge opportunity for academicians in management science to fill this gap. With this research an attempt is made to start filling the gaps in the theory, as a whole, and in the RE industry, in particular. For this purpose, a theoretical model was proposed with constructs derived from the study of the existing literature. For reasons described in the next chapter, a case study approach was used to determine the relationships between the constructs in the framework, the model of which is depicted in Figure 2-9.
In the proposed framework it is contended that success of commercialization for RE technologies depends on dynamic capabilities which are acquired through partnership arrangements between stakeholders, as well as effectiveness of the RE implementation mechanisms. The level of synergy of this partnership, driven by external and internal
factors, has an impact on dynamic capabilities of a partnership. It does also influence the effectiveness of RE implementation mechanisms.

It has to be emphasized that this research is a theoretical one founded on cases studies, rather than an empirical one based on survey statistics. The propositions explored through case studies are presented in the following section.

2.8.1. Theories Supporting a Proposed Model

As noted earlier, besides a lack of an integrative definition for the partnership synergy phenomenon and a collective economic synergy theory, there are no studies or formulated theories/models that would integrate partnership synergy in a comprehensive commercialization theory. The major contribution of this study is the introduction of such a theoretical model related to RE stakeholders’ partnerships. Other theories that the proposed model brings together are the theory of diffusion of innovations, partnership theory, dynamic capabilities theory, and a resource based view of firms. The theory of diffusion of innovations provides a clear distinction between the process of new product development (invention and innovation) and commercialization. It is a process of diffusion that determines the extent to which the new technology is commercialized. Partnership theory describes collaboration as a process that brings stakeholders (people and organizations) together to achieve commercialization goals. Dynamic capabilities theory describes dynamic capability as a critical resource, which is the result of stakeholders’ partnership. In a broader view, from RBV perspective, dynamic capabilities along with RE implementation mechanisms are the critical resources that the partnership
possesses and that can be utilized to create value and competitive advantage to successfully commercialize RE technologies. These theories and other concepts suggested in the existing scientific literature were used to derive constructs for the model proposed in this study. The constructs are summarized in Table 2.3, along with their respective definitions and references.

Table 2.3: Definitions of the Constructs

<table>
<thead>
<tr>
<th>Construct</th>
<th>Definition</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic Capabilities</td>
<td>The company’s ability to integrate build and reconfigure internal and external competencies to address rapidly changing environment</td>
<td>Teece et al 1997, Eisenhardt and Martin 2000, Zahra and George 2002</td>
</tr>
<tr>
<td>Absorptive Capacity</td>
<td>Stakeholders’ commercialization capability to recognize the value of new knowledge, assimilate it and apply it to commercial ends</td>
<td>Cohen and Levintal 1990, Zahra and George 2002</td>
</tr>
<tr>
<td>Coordinating Capability</td>
<td>Stakeholders’ commercialization capability to synchronize resources and tasks to improve the performance of the commercialization activity</td>
<td>Crowston 1997</td>
</tr>
<tr>
<td>Collective mind</td>
<td>Stakeholders’ ability to heedfully integrate their diverse and unrelated resources into a collective system through contribution, representation and subordination</td>
<td>Weick and Roberts 1993</td>
</tr>
<tr>
<td>Effectiveness of Renewable Energy Implementation mechanisms</td>
<td>The degree to which all the RE innovative implementation mechanisms contribute to the success of commercialization of RE technologies.</td>
<td>Balachandra et al 2010, Song 2011, Falconett and Nagasaka 2010</td>
</tr>
</tbody>
</table>
2.9. Proposition development

Based on the foregoing review and theoretical arguments, several propositions are suggested to support the research model. The following six categories of propositions represent the direction of the relationship between constructs as well the nature of proposed relationships. The first set of propositions are developed to test the influence of different RE drivers on the level of partnership synergy between stakeholders:
P1. External Drivers – Partnership Synergy

Partnership synergy is an outcome of partnership functioning (Weise et al., 2001; Lasker et al., 2002; and Jones and Barry, 2011). Academic literature does not provide any evidence of research on the partnership between different technology stakeholders. While trying to understand how this partnership is functioning, it is very important to understand what the major drivers are behind each stakeholder to participate in this partnership arrangement. What are they looking for in this collaboration with other stakeholders?

At the present time, environmental and climate change concerns are known (Kobos et al., 2006; Balachandra et al., 2010; and Jagoda et al., 2011). Because of these concerns, governments around the world adopted the Kyoto protocol in 1997, which took effect in 2005. According to this protocol, 191 countries have committed themselves to reduction of four groups of gases. However, it is vital to test if these concerns are applicable to stakeholders other than governments. Will these concerns bring them together into a partnership with other stakeholders? This leads to the first proposition:

P1.1 The higher the environmental and climate change concerns, the higher the possibility of partnership synergy among RE stakeholders.

Besides environmental concerns, the speed of economic development to meet the basic social and developmental needs of the people is a priority for most governments
Introduction of renewable energy technologies will create many jobs (IEA, 2012). Having this in mind, Obama’s administration introduced ARRA of 2009 with the intention of saving and creating many jobs immediately (Pub. L. 111-5). The RE stakeholders’ concern about the creation of jobs and economic development, and whether it is a driver behind their involvement in partnership is tested with the following proposition.

**P1.2 The higher the concern over the social-economic conditions, the higher the level of partnership synergy among RE stakeholders**

Renewable energy resources exist over wide geographical areas, in contrast to other energy sources, which are concentrated in a limited number of countries. Rapid deployment of renewable energy would result in significant energy security (IEA, 2012). Several case studies were conducted in the early 1990s regarding U.S. energy security and policy after the first Gulf War (Sohn, 1990; and Georgiou, 1993) where renewables are mentioned as one of the major sources that will ensure energy security of the country. However, there is no research which would address the issue of influences on energy security concerns on partnership arrangements. Therefore, it is proposed that energy security concerns might have some kind of influence on stakeholders to get involved in partnerships with other stakeholders.

**P1.3 The higher the energy security concerns, the higher the level of partnership synergy among RE stakeholders**
P2. Internal Drivers – Partnership Synergy

High cost of solar and other EE/RE technologies compared with conventional energy is mentioned as one of the major non-technological barriers to the widespread commercialization of RE technologies (Margolis and Zuboy, 2006). With the introduction of ARRA of 2009 and several other incentive mechanisms in some U.S. states, certain RE technologies became cost competitive (DOE, 2009). However, it is proposed that cost can be further reduced if there is a closer partnership between various stakeholders such as technology developers, technology entrepreneurs, financers and others. They all might see the opportunity for growth, but might not recognize the cost impact of their partnership synergy. In any event, having information about existing incentive mechanisms and looking for opportunities for further cost reduction would both make renewable energy project developers seek partnership with other stakeholders.

\textit{P2.1 The higher the cost of the RE products and services, the higher the level of partnership synergy among the RE stakeholders}

Inadequate workforce skills and training are also mentioned as barriers to RE technology commercialization (Margolis and Zuboy, 2006). This issue, coupled with the lack of sufficient information about business opportunities created by these technologies keeps many entrepreneurs away from getting involved in RE technology commercialization. This also applies to financers of the technology. In most part all RE
stakeholders realize about the benefits of the technology, however, it should be tested, if the motivation of having sufficient skills for commercialization of the technologies influences their high level involvement in partnership with different stakeholders. Renewable energy project developers should be highly motivated to seek partnership with government and other stakeholders.

**P2.2 The higher the demand for skills for successful commercialization of RE technologies, the higher the level of partnership synergy among RE stakeholders**

Many renewable energy projects require up front financing since the potential customers of RE technologies are not willing to bear high initial costs for installations. Some scholars consider this as one of the major problems of RE commercialization (Demirgus-Kunt and Maksimovich, 1999; and Chen, 2009). This is the reason why early involvement of financers of the RE projects is critical. It is proposed that desire to increase its profitability motivates RE project financers seek partnership with RE stakeholders and achieve high level of synergy in this partnership.

**P2.3 The higher the desire to increase the profitability of RE stakeholders, the higher the motivation to increase the level of partnership synergy among RE stakeholders**

A second set of propositions is developed to test the influence of the level of partnership synergy between different RE partners on external and internal resource base for successful commercialization of RE technologies.
P3. Partnership Synergy – Dynamic Capabilities

As defined, synergy is an ability of two or more business units or organizations to generate a greater value working together than if they would work apart (Naude et al., 2002). The partnership synergy would result from better usage of resources, which each stakeholder would provide. (Juga, 1996). That includes not only physical assets but also practical knowledge, technological expertise, information and culture. The involvement of different RE stakeholders in partnerships with superior dynamic capabilities will have superior new product success (Ettlie and Pavlou, 2006). RE stakeholders that learn better and faster (superior absorption capacity) are more likely to achieve superior functional competencies (Danneels, 2002). Learning ability through information sharing is an essential problem-solving process that is needed to reconfigure existing functional capabilities by building knew knowledge about how to successfully commercialize renewable energy technologies (Cohen and Leviathan, 1990; Zahra and George, 2002; and Zollo and Winter, 2002). This leads to the following proposition:

P3.1 The higher the level of partnership synergy among RE stakeholders, the higher the absorptive capacity of the partnership

Besides learning, the partnership arrangements require high level of coordination among RE stakeholders. Resource allocation, task assignment and activity synchronization are the key components of effective coordination (Crowston, 1997).
More appropriate and efficient coordination (coordination capability) is more likely to enable superior configurations of new functional competencies of the partnership (Weick and Roberts, 1993). Hence, the next proposition is:

*P3.2 The higher the level of partnership synergy between RE stakeholders, the higher the coordination capability of the partnership*

Partnerships with a fully developed collective mind have the capacity to anticipate how to react in novel situations and reconfigure themselves (Loch and Terwiesch, 1998). RE stakeholders possess disparate resources which need to be combined into collective system to ensure commercialization success. Also, faster integration (collective mind) is more likely to enable superior configurations of new functional competencies of the partnership, as well (Weick and Roberts, 1993). This leads to the following proposition:

*P3.3 The higher the level of partnership synergy between RE stakeholders, the stronger the collective mind developed among the stakeholders*

P4 Partnership Synergy – Effectiveness of RE Implementation Mechanisms

How effective have RE innovative implementation mechanisms been? It is virtually impossible to quantify the effect of any single action, because of the interdependence of many of the RE programs in effect at any one time. Even the effects of straightforward incentives such as tax credits are difficult to determine, because it is
not known how much generation would have been produced in the absence of tax credits. The involvement of different stakeholders in partnership and achieving higher level of synergy perhaps would result in better financial mechanisms offered by financial institutions involved in the partnership and inceptive mechanisms and polices enacted by governments, the result would be increased power generation from RE.

There are several innovative financial mechanisms which can help companies to ensure RE project financing: leasing, venture capital, micro-credits, loan guarantees, etc. (Balachandra et al 2010). It is up to financial institutions to decide if the financing of renewable energy projects need to be with same terms or conditions like financing other business projects. Perhaps, if the stakeholders join efforts with government, better financing conditions could be produced for RE projects. This would lead to the following proposition.

**P4.1 The higher the level of partnership synergy among different RE stakeholders, the more effective financial mechanisms can be developed**

Tax credits, feed-in tariffs, and RE certificates are among the few RE inceptive mechanisms that exist to finance renewable energy projects. Both financers and project developers need to learn about their existence and the benefits they provide in order to be able to participate in commercialization of the technology. They can learn more about incentive mechanisms offered by governments if they have more communication and coordination within stakeholders. This will increase the effectiveness of introduced incentive mechanisms, since more awareness among larger number of entities may lead
to a wider use of such mechanisms.

P4.2 The higher the level of partnership synergy among different RE stakeholders, the more effective the incentive mechanisms become.

The same concept is applied to regulatory policy mechanisms. Better communication and coordination among different renewable energy stakeholders will increase the effectiveness of regulatory policies conducted by government.

P4.3 The higher the level of partnership synergy among different Re stakeholders, the more effective the regulatory policies become.

A third set of hypothesis are developed to test the impact of the dynamic capabilities of the firm resulting from partnership synergy between RE stakeholders and effectiveness of RE innovative implementation mechanisms with regard to commercialization success of RE companies.

P5. Dynamic Capabilities – Commercialization success

The research conducted by Ettlie and Pavlou (2006) revealed that inter-firm NPD partnership has a positive impact on NPD partnership success. The propositions below are designed to test the impact of dynamic capabilities on both dimensions of commercialization success (time and financial).
First, the influence of absorptive capacity of the stakeholders’ partnership on time and financial performance of RE companies needs to be tested. More renewable system installations lead to higher revenue generation for RE companies, as well as for all stakeholders involved in development and financing of the technology.

\[ P5.1.1 \] Higher absorptive capacity of the firm (stakeholder partnership) has positive impact on commercialization success of RE technologies in terms of a positive impact on time performance

\[ P5.1.2 \] Higher absorptive capacity of the firm (stakeholder partnership) has positive impact on commercialization success of RE technologies in terms of positive impact on financial performance.

Similarly, better coordination capabilities will decrease the time consumed on RE project implementation and increase the revenue of all the stakeholders.

\[ P5.2.1 \] Higher coordination capability of the firm (stakeholder partnership) has positive impact on commercialization success of RE technologies in terms of positive impact on time performance.

\[ P5.2.2 \] Higher coordination capability of the firm (stakeholder partnership) has positive impact on commercialization success of RE technologies in terms of positive impact on financial performance.
The partnerships with a more fully developed collective mind have the capacity to anticipate how to react to a novel situation and reconfigure themselves. Each stakeholder would provide a unique resource essential for the success of RE project.

*P5.3.1 Higher collective mind of the stakeholder partnership has positive impact on commercialization success of RE technologies in terms of a positive impact on time performance*

*P5.3.2 Higher collective mind of the stakeholder partnership has positive impact on commercialization success of RE technologies in terms of a positive impact on financial performance*

P6. Effective Implementation Mechanisms – Commercialization Success

As mentioned before, the diffusion target for stakeholders should be RE companies which are involved in commercialization (project developers), not the end user, whereas the government needs to be a facilitator of stakeholder partnership with its policy instruments and inceptive mechanisms. Financers need to be informed about existing opportunities in the RE field and offer effective, innovative financial mechanisms which will contribute to the commercialization success of RE technologies. If RE project developers have more information about existing financial mechanisms available to them, shorter time would be required to complete the projects and may
generate more profit to stakeholders. Therefore, the following propositions are suggested:

**P6.1.1 Higher effectiveness of the developed financial mechanisms has positive impact on commercialization success of RE technologies in terms of a positive impact on time**

**P6.1.2 Higher effectiveness of the developed financial mechanisms has positive impact on commercialization success of RE technologies in terms of a positive impact on financial performance**

According to the latest U.S. Department of Energy (DOE) report, most of solar electric systems last 30 years and pay for themselves in four to five years after tax credits and rebates. That means home owners can enjoy free electricity for years (DOE, 2012). However, most RE stakeholders including final consumers are not aware of this. Higher awareness by RE stakeholders about the existence of RE incentives will attract more customers who would like to have such systems installed in their homes. Hence, the following propositions are put forward:

**P6.2.1 Higher effectiveness of the developed incentive mechanisms has positive impact on commercialization success of RE technologies in terms of a positive impact on time**

**P6.2.2 Higher effectiveness of the developed incentive mechanisms has positive impact on commercialization success of RE technologies in terms of a positive impact on financial performance**
Similarly, if the public is informed about RE technologies and their advantages through various campaigns, quality labeling programs, for example, the public would be more willing to adopt RE technologies. This would grow the customer base for the technology. The time consumed on implementation of a single project will decrease and the profitability of RE project developers will increase.

P6.3.1 Higher effectiveness of the developed regulatory policies has positive impact on commercialization success of RE technologies in terms of a positive impact on time performance

P6.3.2 Higher effectiveness of the developed regulatory policies has positive impact on commercialization success of RE technologies in terms of a positive impact on financial performance
Chapter 3

Research Methodology and Design

3.1. Methodology remarks

As mentioned in Chapter 2, in this work the case study methodology was used to gain insight information about how partnership synergy among different RE stakeholders functions and how it influences RE technology commercialization. The case study method is most appropriate for understanding the how and why of phenomena in their natural setting (Yin, 2003). Moreover, case studies are most suitable when the object under the study is difficult to quantify, as in this instance. Also, the case studies were used to develop a collective economic synergy theoretical framework, an approach that has been known since long ago (e.g. Eisenhardt, 1989).

There are several reasons why survey method was not selected. First of all, given that there are not many renewable energy companies around, it is not possible to obtain sufficiently large samples in order to perform an econometric or input-output analysis. There are no centralized databases on RE companies and their projects, from which data can be collected. Second, surveys are inflexible in that they require the initial study design to remain unchanged throughout the data collection. This is not possible in this
case, since the topic is new and while trying to answer to the how and why questions, certain changes during the data collection might be required. Third, in survey methodology the questions developed should be general enough to be minimally appropriate for respondents, possibly missing what’s appropriate to many respondents, who have different backgrounds. And last, as opposed to direct observation, survey research can seldom deal with the context. This makes case study a suitable method to be used in such analysis.

The case study method allows identifying the unique set of relationships, which are hidden in quantitative research. The primary advantage of a case study is that it provides much more detailed information than, for example, survey method. Case studies are rich, empirical descriptions of particular instances of a phenomenon that are typically based on variety of data sources (Yin, 1994). This ensures that the problem is not explored only through one lens, but rather in variety of lenses, which allows for multiple facets of the phenomenon to be revealed and understood (Baxter and Jack, 2008).

Regardless of the many advantages of case study methodology, many researchers disdain it. They view case study as a less desirable form of inquiry than either experiments or surveys. First, they consider qualitative analysis as less rigorous and objective. The case study results depend on the opinions of those interviewed and on the choices made by the interviewer when developing the questions, and collecting and interpreting the information. Yin (2003) suggests that every case study investigator must work hard to report all case evidence fairly, to try to find the general patterns and avoid collecting anecdotes. It should be clear beforehand who should be interviewed and what
type of information would be required. It is possible that some scientific rigor will be lost, but the richness in identification of relevant details will be gained.

Second, a common complaint about case studies is that they are difficult to generalize from one case to another. For this, Yin (2003) advises case study analysts to generalize findings to theories, as a scientist generalizes from experimental results to theories. In this sense, the case study, like an experiment, does not represent a “sample” and the researcher’s goal is to expand and generalize theories (analytic generalization) and not to enumerate frequencies (statistical generalization). And the last complaint about the case studies is that they can be lengthy. Because they provide detailed information about the case in narrative form, it may be difficult to hold a reader’s interest, if too lengthy. In writing, care should be taken to provide the rich information in a digestible form (Yin, 2003).

Despite the fact that these common concerns can be alleviated as Yin (2003) suggested, the author of this thesis realizes that good case study is very difficult to implement. However, the case study design has been considered because the focus of this study is to answer “how” and “why” questions. Namely, how and why the partnership synergy among stakeholder in RE is formed and how it influences the dynamic capabilities of the partnership as well as the effectiveness of RE implementation mechanism. By understanding these phenomena it would be possible to understand how commercialization of second generation RE technologies can be accelerated.

It should be noted, that in case study research methodology propositions are not always present (Yin, 1994). However, when a case proposal includes specific propositions it increases the probability that the researcher will be able to place limits on
the scope of the study and increase the feasibility of completing the project. That is the reason why six sets of propositions have been suggested in the previous chapter, which help this study to stay within feasible limits.

It is important to mention that this research includes not only specific cases, but also information support of data gathered from a number of individuals who have been directly involved in multiple relevant cases of RE projects. This serves a checking tool to support or show any contradictions/gaps in the case study findings.

3.2. Research Design

3.2.1. Unit of Analysis

Yin (2003) defines research design, informally, as “an action plan for getting from here to there, where here may be defined as the initial set of questions to be answered, and there is some set of conclusions about the questions.” Before compiling a set of questions to be answered, it is very important to clearly define the unit of analysis for this research.

As defined in Chapter 2, commercialization is the process or cycle of introducing a new product or production method into the market. Commercialization of RE technologies assumes deployment of second generation of technologies in the market in large quantities. It is not a simple sale transaction when the products, like solar modules, are sold to the final consumers. It is a more project oriented transaction, where buyer of the technology gets full package of services including final installation and after-sale
maintenance. The buyers are the primary stakeholders in RE commercialization process. The big buyers, such as state-owned or commercial establishments may directly obtain the technology from developers and owners of the technology, whereas small buyers like household consumers can obtain RE technologies through entrepreneurs. It is worth mentioning that most buyers are not ready to pay up-front expenses for the installations. Therefore the role of financers is increasing. They will lend to entrepreneurs or invest in the projects directly to acquire the technology from owners. However, neither such entrepreneurs, nor financers will emerge automatically. Majority of entrepreneurs and financers do not view RE as commercially attractive proposition. This is the reason why it is important to create an enabling environment, where such entrepreneurs and financers can emerge and actively play a role in creating businesses in the RE field (Balachandra, 2010). The increased number of RE system deployments will cause the market to emerge and grow, which in turn would provide profit to technology developers, owners, sellers and financers. Hence, the partnership synergy between stakeholders needs to be reviewed within framework of a single project, where all the stakeholders interact. In addition to being a potential customer of the technology, the general public can also act as a benefactor of projects though the social-economic effects of RE deployment on local communities, such as the impact on employment, increased standard of living, or environmental impact (del Rio and Burguillo, 2009). Government, as a representative body of the general public, acts as a facilitator of RE project implementation through its public policy instruments and tax incentives (Caerteling et al., 2008). The role of market intermediaries, such as consultants, media, and energy service companies (ESCO), would be to influence the buyer’s decision by providing information about the technology.
Additionally, intermediaries can assist entrepreneurs in preparing business plans, bring potential partners together, educate financers about the technologies, and channel investment proposals (Balachandra, 2010).

Thus, there are two types of stakeholders involved in the project: those who directly participate in projects and seek commercial benefits, and those who seek other types of benefits. Therefore, the unit of analysis of the research is going to be an RE project where these two groups interact. This case study would allow the identification of relationship between actors involved in the project which are hidden in quantitative studies. The latter usually establishes the general relationships and omits the critical aspects of interaction which can have an impact on project success. In contrast, this case study would adopt an “on the ground” approach, which goes down to the level of local actors and is capable of capturing synergetic aspects of their interactions which usually remain unnoticed in a more aggregated analysis.

3.2.2. Data Collection

Yin (2003) considers two to three cases as adequate for literate replication. Although each RE project is unique in terms of influence of various objective and subjective factors on the project outcomes, however, they all are similar in terms of interaction of different renewable energy stakeholders, whose level of participation varies from project to project. To implement either residential or large commercial wind, solar electric or solar thermal projects, it is necessary that technology developers, owners of the technology, entrepreneurs, market intermediaries, government and local community interact. The successful outcome of the project depends on efficiency of this interaction.
Given the above considerations and aiming to achieve construct validity of the model, data collection for this study is organized in a two-pronged approach:

(i) Interviews with 12 NREL members responsible for projects implementation and an executive of Vector Delta Design Group (VDDG, a solar power consulting organization), to gather comprehensive insights on partnership synergy in RE industry.

(ii) Data collection on four actual cases of sizeable RE projects for specific case studies.

Each of the individuals mentioned in (i) have been involved in a multitude of RE technology deployment projects, including new product development, product commercialization, and interaction with government in terms of funding, policy making and incentive generating programs. Information gathered from them collectively represents observations and opinions regarding RE drivers, partnership synergy, and commercialization outcomes. The generalized information about a project implementation and the stakeholders’ partnership function within the project in effect helped cover a larger chunk of the industry, reveal additional insights to support the case study findings, or, at least, show any contradictions and gaps left by the case studies.

NREL is a government-owned R&D laboratory which, besides R&D, works closely with a number of private partners to transfer technological developments in renewable energy and energy efficiency technologies to the marketplace and social arena (NREL, 2011). Deployment of technologies is accomplished by developing technology partnerships with private industry. NREL serves as a reduced-risk platform for research, and through partnerships these advances can effectively be translated into serving the
interest of both the private sector and the public sector. In RE deployment projects NREL acts as technology developer, technology owner, market intermediary, or government representative. Therefore, this would allow interviewing various stakeholders of RE technologies within one organization. These interviews were be carried out in a simplified version of the case study research protocol, boiled down to the essentials relating to the most important and common aspects of the external/internal drivers, partnership synergy and resulting commercialization outcome.

An additional interview was conducted with an executive of California based solar power consulting company Vector Delta Design Group (VDDG). He is one of the renowned experts in RE system construction and economics, involved in numerous projects with participation of various partners.

As a result of these 13 interviews, an overall industry review with appropriate reference points were established that will function as “reality check-points.” This helped mitigate limitations of the case study methodology and small number of cases, and improve the construct validity.

Regarding the four real project case studies mentioned in item (ii) above, interviews and other information gathering were conducted with two established companies in California to gain insights into the effects of partnership synergy on RE technology commercialization. The owner of SunChiller was interviewed about his experience in implementation of two large scale heating, ventilation and air conditioning (HVAC) solar thermal projects: University of Arizona Student Recreation Center: Combined Solar HVAC and Pool Heating Plant with Central Plant District Cooling and Heating and Central Plant District Cooling and Heating on Los Angeles College Campus. The
founder/CTO of Amonix was interviewed in a similar manner regarding new product development and technology commercialization of concentrated photovoltaic (CPV) systems.

These two people are the primary providers of information for the case studies. They both had been champions, movers and shakers, in the RE industry, who initiated and implemented dozens of RE projects. Having been in charge of these projects, they seem to be the most appropriate sources for overall information as to what drivers helped initiate RE projects and product commercialization, how synergies played into their implementation, and so on. In addition, whenever possible, further interviews were conducted with other stakeholders in the implemented projects, such as the representatives of the site owner, local government leaders, financing entities, and end users.

In addition, secondary sources of information were used to strengthen the structure of the case studies. These include project documentations such as meeting minutes (if available), contractual arrangements, reports, other project documents, and professional and media articles written about or based on the subject matter cases.

Table 3.1 gives an overview of the data sources:
Table 3.1: Overview of Data Sources

<table>
<thead>
<tr>
<th>Sources of Evidence</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference/Validity</td>
<td>Interviews</td>
</tr>
<tr>
<td>Real Case 1 Greensburg Wind Farm</td>
<td>3 Interviews Documentation</td>
</tr>
<tr>
<td>Real Case 2 Amonix</td>
<td>3 Interviews Documentation</td>
</tr>
<tr>
<td>Real Case 3 SunChiller</td>
<td>3 Interviews Documentation</td>
</tr>
<tr>
<td>Real Case 4 Lusakert Biogas Plant</td>
<td>3 Interviews Documentation</td>
</tr>
</tbody>
</table>

During the interviews, interviewees answered questions concerning all the aspects of partnership functioning: how exchange of resources and skills take place within the project, partnership characteristics, relationship among the partners, the factors influencing the involvement into partnership, what attributes (capabilities) partnership gains through the partnership synergy, is there a feedback that stakeholders receive, how level of partnership synergy influences effectiveness of renewable energy implementation mechanisms, how both this resource base influence commercialization success of RE technologies. The total length of each interview at NREL was to be 20 minutes. The total length of the interviews at VDDG was 120 minutes. There were three 90-minute interviews for each case with the owner of SunChiller supplemented with one site visit between the interviews and an additional 30-minute meeting with other stakeholders. The
interviews at NREL were short because the interviewees have information within their own scope of work and do not possess the global picture on the projects. Therefore the questions asked were related to their specific activities, in simplified research protocol. Before the interviews, a questionnaire was sent to the interviewee for him or her to prepare for the interview. During the interviews notes were made and used to type the interview transcripts. Furthermore, interviewees were asked to provide documents or other written or electronic materials to illustrate or complement their statements. To avoid excluding findings, the respondents were asked to add any events they found relevant for the project outcome. For each interviewee, these topics were adapted to the interviewee’s specific role in the commercialization process (project implementation) and contextual setting.

To ensure internal validity of the study, the pattern-matching logic was used. This tactic is mostly used in explanatory case studies similar to this one. Such logic compares an empirically based pattern with a predicted one. If patterns coincide, it can be claimed that a case study has high level of internal validity.

Another issue that needs to be considered is the possibility of generalizing the results, which ensures the external validity of the study. Since a multiple-case study on RE projects is conducted, it would be possible to track whether findings in each case are replicable, with additional checking through reference/validation points generated through interviews with NREL and VDDG. If such replication is evidenced, the results might be accepted for other similar RE projects as well.
3.2.3. Case Study Protocol

In the past, case research procedures have been poorly documented, making external reviewers doubtful of the reliability of the case study (Yin, 2003). Currently, having a case study protocol where researchers document all the research procedures is desirable under all circumstances. It becomes essential if multiple-case study design is used. The inclusion of the research protocol increased the reliability of research. This is needed if later investigators conduct similar case studies with same procedures; all over again they should come up with same findings and conclusions.

Appendix A shows the case study protocol of the topics discussed with the interviewees. The references included show that these topics are embedded in the relevant literature. This would allow a structured examination of the cases and comparison of findings.

3.2.4. Data Analysis

Data analysis of this research consisted of building individual case descriptions and then making a comparison across the cases to reflect on the theoretical framework (Eisenhardt, 1989). To start with, all recorded responses were grouped by events. Then, secondary information related to the projects was reviewed. After this, a case description of each project was written in chronological order. The reference/validation points were built based on aggregated information from 16 respondents at NREL and VDDG. Four individual case descriptions were discussed with the project participants in four RE fields (wind, solar PV, solar water heating and cooling, and biogas) to achieve a realistic description of the developments. Once the reference/validation points and four individual
actual cases completed, a cross-case analysis was conducted. Miles and Huberman (1994) suggest to group events in a partially ordered matrix. This matrix helped achieve the research objectives I, II and III mentioned earlier. The template of the matrix is presented below in Figure 3-1.

<table>
<thead>
<tr>
<th></th>
<th>Real Case 1</th>
<th>Real Case 2</th>
<th>Real Case…</th>
<th>Reference/Validation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal drivers</td>
<td></td>
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<tr>
<td>External drivers</td>
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<tr>
<td>Partnership synergy</td>
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<tr>
<td>Dynamic capabilities</td>
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<tr>
<td>Implementation mechanism</td>
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<tr>
<td>Commercialization outcome</td>
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</tbody>
</table>

Figure 3-1: Template of Matrix for Cross-Case Analysis

Findings on the relationship of the constructs were discussed and analyzed in relation to the propositions of this study.

Finally, the obtained data were analyzed from different perspectives to develop a collective economic synergy theoretical framework. The information derived from the research protocol on the processes of partnership functioning (e.g. resources, leaderships, governance, and efficiency), stakeholder’s behavior, government reaction, project performance, and so on were used to generate categories of information (open codes), positioning those within a theoretical model (axial coding), and establishing the interconnection of these categories.
Chapter 4

Case Studies and Analysis

In this chapter, four cases are discussed and analyzed on the basis of the dimensions in Figure 2-9. In the beginning of this chapter, the descriptions of each individual case are provided. After each case, the breakdown of the information extracted from the case related to each variable in the model is presented. Then aggregated case analyses are followed on each variable. Last, there is cross-case analysis where propositions are supported or rejected.


On May 5, 2007, a small town of 1,500 people in Greensburg, Kansas, was devastated by a massive tornado destroying 95 percent of the community and killing 11 people. After the tornado, while developing a plan of action for rebuilding the town with support of the entire nation, the local government saw an opportunity to make Greensburg something even better than it had been before. A Sustainable Comprehensive Master Plan for the next 20 years was developed and adopted by the City Council. One of the major components of this plan was developing a 12.5 MW wind farm, which would
cover 100 percent of energy consumption in Greensburg. One of the obstacles for this plan was lack of knowledge and skills in wind farming. Another obstacle was that Greensburg had a very strong connection with its long-time coal-based power supplier, with whom the city council was close to finalizing a long-term contract for its electricity supply. And the last obstacle was that not all community members were excited about these plans.

As early as June 2007, city officials invited a team of consultants from NREL to conduct a study on wind electricity options that Greensburg can pursue, estimate local wind energy resources, analyze potential business and financing options. Meanwhile, the city dropped the idea of signing a long-term deal with its traditional electric power supplier and chose to sign one-year power purchase agreement (PPA), thus buying time to fully assess the feasibility of a large scale commercial wind farm deployment as an alternative to coal. With request of the city authorities, NREL consultants developed a detailed wind map to determine the optimal site for the wind farm. Additionally, business plan was developed with thorough life-cycle cost analysis and potential financing options to demonstrate how wind energy could be successful for a small municipal utility. Through several meetings and presentations the plan was introduced to the city leaders, which helped them realize the benefits of the project. Several other meetings had been required to persuade those who were opposing the plan in the local business community. Ultimately, the plan was accepted by all the local stakeholders. Even more, some of the progressive local businesses saw an opportunity to save energy and cut costs by using energy innovations, while others went even further deciding to participate in the project.

Once the plan was accepted, the town teamed up with a local John Deere
dealership—BTI Greensburg—run by local businessmen, to do the construction and maintenance of the wind farm. The total cost of the project was $23.3 million, of which $17.4 million was provided by the U.S. Department of Agriculture Rural Development, while the reminder of the project was financed by equity investments from John Deere Renewables and gap funding by NativeEnergy, Inc., a worldwide provider of climate solution services. John Deere Renewables would recover its investments by entering into a long-term Power Purchase Agreement (PPA) with Kansas Power Pool, a green power provider, which is a cooperative of 40 Kansas cities, while NativeEnergy, Inc. will recover its investment by selling the societal/environmental benefits stemming from the project in the form of Renewable Energy Credits (REC). Each REC represents one megawatt hour (MWh) of renewable-generated energy. The customer which will purchase REC from NativeEnergy will able to claim the equivalent MWh of energy reduction as on offset to their conventional energy use. For the project ten 1.2 MW wind turbines were imported from China.

With a strong commitment from all the stakeholders, the Greensburg Wind Farm was put into operation in March 2010. Currently, the project is owned and operated by Exelon Wind LLC (formerly John Deere Renewables, LLC).

Today, Greensburg has emerged as a model of sustainability. Because of the project, homes and businesses pay lower energy bills. Businesses with a sustainability agenda are looking for opportunities in Greensburg. Ecotourism and other small businesses are emerging. As Dr. Lynn Billman indicated during the interview, the wind farm’s exceptional community benefits include job creation and a better environment.
External Drivers:

Environmental

Given the fact that the town was completely destroyed and it was necessary to rebuild the infrastructure from the beginning, the city took the opportunity to explore RE solutions. Before the tornado, the electric power generated by burning coal was supplied from long distance and there was no direct impact of that on CO$_2$, water pollution locally. Just a general knowledge of the environmental benefits made the city to explore this opportunity.

Social-Economic

In addition to NREL, other stakeholders while being environmentally conscious would participate in the project if they see more social-economic justification of the project implementation. The economic benefits along with many social benefits reflected in the master plan were the most influential driver to all the stakeholders to participate in the project.

Energy Security

Energy security as a driver had no influence on partnership development and synergy, because none of the directly involved stakeholders had concerns about this, and generally, energy security is more of national level issue.
Internal Drivers:

Financial

John Deere and Native Energy participated in the project because they saw an opportunity for new revenue generation. Profit maximizing was also important; however, it was mostly linked with cost minimization of both project and technology.

Cost

For John Deere Renewables, which was involved in the project development and the Chinese supplier, the cost depended on economies of scale. The creation of a bigger market was the ultimate goal.

Knowledge and Skills

BTI-Greensburg and the city did not have much knowledge and experience in wind technology and this prompted them to partner with NREL and together make the project happen.

Partnership Synergy

This is a typical case where the contributions of all the partners make the project successful. Under the lead of NREL team of experts several meetings and presentations have been conducted to show all the parties the benefits of the project. In the beginning the common goals were not understood and supported by all the parties. The most
resistive were some members of business community and the utility company, which is no surprise, since utilities are traditionally conservative. However, in the end, they all supported the project. John Deere was the lead initiator of the partnership. Eventually all the individuals, institutions, and agencies within the community fully supported the project. Because of the higher level of partnership synergy between all the stakeholders it was possible to complete the project in less than 3 years period.

Dynamic Capabilities:

Absorptive Capacity

The NREL team did a tremendous job educating all the stakeholders about the technology. The fact that the project was completed in a short period of time is an indication of high learning capability of the stakeholders involved. After the project’s success, some of the stakeholders involved in the project extended their green opportunities beyond the borders of Greensburg.

- BTI established Harvest the Wind Network (HTWN) which latter installed 125 turbines nationwide with total generating capacity of 5 MW. Additionally, 100 other wind projects were undertaken by the company.
- With its newly acquired, greater knowledge, Greensburg officials helped other communities to recover from natural disasters, including Joplin, Missouri, and the Sichuan Province in China.
Coordination Capabilities

The interviewees reported high levels of coordination among the stakeholders, driven by the sense of importance and interest to the project. Federal government support to tornado recovery activities has also played a role in inducing cooperation.

Collective Mind

In the beginning of the project there was no indication of a collective system in place. There was a common understanding that the community needed to be rebuilt. However, afterwards, while realizing all the benefits of the project’s implementation, a common understanding appeared that integration of diverse and unrelated resources in a collective system will make the project successful.

Effectiveness of Implementation Mechanisms:

Financial Mechanisms

USDA Rural Development, with a mission to help improve the economy and the quality of life in rural areas, provided $17.4 million in low-interest loans to the project. John Deere participated with equity financing. Gap funding was provided by Native Energy.

Inceptive Mechanisms

John Deere benefitted from Wind Energy Production Tax Credits. In the United States, wind power receives a production tax credit (PTC) of 1.5 cents per kWh in 1993
dollars for each kWh produced, for the first 10 years; at 2.2 cents per kWh in 2012. Application of tax credits made the project competitive with conventional energy technologies. Native Energy will recover its investment by selling the societal/environmental benefits stemming from the project in the form of Renewable Energy Credits (REC).

Public Policy

Since 2009, demand for renewable energy in Kansas by public utilities has been driven by the Renewable Portfolio Standards, as passed by the Kansas Legislature in May 2009 through Senate Substitute bill for H. 2369 and incorporated by Kansas Statutes Annotated (K.S.A.) 66-1256 through 66-1262. Under the RPS, every regulated public utility in the state is required to own or purchase renewable generation, such that the nameplate capacity of the renewable generation owned or purchased by the utility satisfies the following minimum threshold percentages of the utility’s average three-year annual peak retail sales:

- 10 percent for 2011 through 2015
- 15 percent for 2016 through 2019
- 20 percent for 2020 and beyond

Importantly, for renewable capacity generated in Kansas, utilities are awarded an additional 10 percent credit toward their requirements, thus incentivizing utilities to keep the renewable projects, and the economic benefits that they create, within the state.
Commercialization:

Time Performance

The project was completed over a period of less than three years.

Financial Performance

Although the socio-economic benefits were fully realized by the stakeholders involved in the project, the financial benefits have yet to be realized. John Deere Renewables (later acquired by Exelon Corp.) would recover its investments by entering into a long-term Power Purchase Agreement (PPA) with Kansas Power Pool. The performance guaranteed for the technology is provided by the Chinese supplier of the wind turbines.

4.2. Case # 2. Amonix Solar Power Generation Station at University of Arizona Science and Technology Park

Amonix Corporation was established in 1989 by Dr. Vahan Garboushian. At the time oil prices were less than $20 per barrel and hardly anyone looked into any power alternatives other than fossil fuel. Back then, the solar PV market was non-existent if viewing it the way we would today. Dr. Garboushian was among the few solar technology enthusiasts who believed that he could create a technology that could deliver reliable, low-cost electricity at a utility scale. After two decades of hard-work to establish a solar
market, now not only is a traditional PV market a reality but also a Concentrated PV (CPV) market has materialized. Amonix is at the forefront. CPV technology, developed by Amonix, works by converting solar light into electricity. Compared to traditional rooftop solar PV modules which rely on a basic concept to generate electricity, CPV systems have an optical component which “concentrates” significant amounts of sunlight onto “multi-junction” solar cells. These special cells have higher energy conversion efficiencies than high-efficiency silicon solar cells. For best results, CPV systems developed by Amonix also use trackers to continually adjust the position of the cells to track the sun. Amonix CPV has higher efficiencies and lower overall system costs than traditional PV in sunny and dry climates. CPV solar cell efficiency today is 40 percent in production, considerably higher than traditional PV, which is about 25 percent.

According to Guy Blanchard, Senior Vice President of Sales and Corporate Development at Amonix, development of a large utility-scale solar power station requires involvement of and support by many stakeholders. The technology developed by Amonix is not a commodity. Electricity produced as result of joint efforts by all the stakeholders is a commodity. Although the energy source (sun) is free, upfront investments are quite high and require some efforts and a well-organized partnership between the stakeholders to make the projects attractive commercially. Even simple opposition by local community members can stop the implementation of the project. For example, Dr. Garboushian remembers that he had to negotiate with local residents many times to convince them not to oppose the project because many of them did not want to see CPV stations on the horizon. Therefore, full realization of the benefits of the CPV project is necessary by all the stakeholders who are directly involved in the project implementation or impacted by
the project.

A 2MW solar power station at the University of Arizona Solar Zone, launched in 2011, was one of the largest CPV stations in the United States at the time. Located on a 12-acre facility and comprised of 36 Amonix CPV solar power systems, it provides power to 500 Tucson homes and offsets 5,000 tons of CO₂ emissions per year. The success of the project was the result of cooperative efforts between the University of Arizona, local and state authority, as well as the local utility and Amonix.

In the market, Amonix positions itself as a developer and manufacturer of CPV solar systems. In most parts, it sells complete integrated systems only to ensure optimal performance and reliability. The ownership of the project and electricity sale is not part of Amonix’s business model. However, the CPV solar station at the University of Arizona (UA) Solar Zone turned out to be owned by Amonix. As Mr. Blanchard indicated there were many advantages for Amonix in this project. The main benefit was that the Amonix team wanted to learn from the project implementation process and, afterwards, about operation and maintenance performance of the CPV system. Additionally, the favorable environment created at the University of Arizona, Solar Zone, where there was nothing much to worry in terms of getting permission from nearby residents, as well as a very low land lease, resulted in Amonix decision to own the project in the end.

Solar Zone at the University of Arizona Science and Technology Park was established in 2009 under a partnership between the University of Arizona and the regional utility Tucson Electric Power (TEP) to become one a showplace for solar application and promotion in order to demonstrate and educate the community on solar energy. TEP was
one of the most highly motivated stakeholders in the Solar Zone because it wanted to start testing various solar technologies which could potentially secure an electricity supply in the near future. Under the state’s Renewable Energy Standard and Tariff (REST), approved in 2008 by the Arizona Corporation Commission—the public utilities commission for the state—TEP and other electric utilities in Arizona are required to supply increasing amounts of RE, with a target of 15 percent of total power sales by 2015.

Since Amonix considers all the southern states including Arizona as potential markets for its products, it already had established communications with TEP about potential projects in the state. When Solar Zone was established, TEP issued a request for proposals to companies interested in constructing solar generation facilities that would demonstrate different solar generation technologies. It contacted Amonix as one of the potential tenants at Solar Zone. Subsequently, TEP awarded a 20-year PPA to Amonix. Under the PPA, TEP committed to purchase the power generated by the CPV solar system to feed into its electric grid.

The estimated cost of the project was $30 million, including equipment, design, and construction. Amonix secured financing for the project and all the costs associated with preparation of the site, design, and construction of the facility and operation of the solar arrays and power plant. Amonix also performed all required environmental, archaeological, and floodplain mitigation.

The project was designed by three different engineering companies. The construction of the project was undertaken by Granite Construction which is specialized in public and private sector transportation infrastructure projects. As Mr. Blanchard indicated,
construction companies also were looking for new revenue generation opportunities in RE markets.

The construction was undertaken within 150 days and the project was completed by spring 2011. In their inauguration speeches, all the parties involved in the project praised the effective partnership among all the stakeholders that led to the facility’s construction.

External Divers:

Environmental

As a result of implementing the project, it was mentioned several times in many media releases that the CPV solar power station would offset 5,000 tons of carbon dioxide (CO₂) emissions per year. Additionally, the 12-acre facility would preserve the local environment by producing no water during power production, thus not contributing to water contamination or water depletion.

Social-Economic

Local construction and later the operation and management provided employment to people in the local community. It was also noted that that the UA Tech Park contributes a total of $3 billion annually to Pima County’s economy and is one of the region’s largest employment centers. Pima County supervisors indicated that the people in the community were looking for industries which will create good job opportunities.
Energy Security

This driver was not indicated as a motivation factor for the stakeholders. It was indicated that when the federal government unveiled newly proposed incentives and policies on RE, the nation’s energy was a composite part of the decision making.

Internal Drivers:

Financial

For Amonix, the project was financially successful and created a source of new revenue stream generation. Although the project is owned by Amonix and it sells the electricity to TEP under a PPA, it is planning to sell the project to the next owner who will take over operation of the power station. Additionally, Granite Construction also was looking for opportunities in the RE market to generate revenue.

Cost

Amonix invests significant funds in cost minimization of the technology. Additionally, it saw an opportunity to reduce manufacturing costs by selling more systems, which meant getting involved in many projects.

Knowledge and Skills

Mr. Blanchard indicated in one of the interviews that, through this project, the company learned a lot and acquired skills that helped it later to do projects 10 times bigger than this one.
Partnership Synergy

Solar Zone, established in partnership with the University of Arizona and TEP, was created to evaluate different types of solar power systems. It allows comparing how these technologies perform side by side, under identical operating conditions, so the developers may determine which systems are more efficient and economical for southern Arizona. Solar Zone became a good platform for collaboration between the different companies and research centers that are committed to growing this industry. The partnership synergy achieved during the project implementation, for the most part, was due to the existence of the Solar Zone, where the goals and objectives of all the stakeholders were understood and supported. Individuals, agencies, and institutions of Pima County supported the project. This is the reason why the project was implemented in just a one-year period.

Dynamic capabilities

Absorptive Capacity

The components of Solar Zone include not only solar power generation facilities like CPV systems done by Amonix, but also research and development, distribution and storage, manufacturing and assembly, public education and demonstration, and workforce training. It also helped the companies learn from each other’s experiences. From the results of the project, Amonix learned about the project implementation process and possibilities for optimizing it. This knowledge helped it prepare for much larger projects later in Nevada, Colorado, and Arizona.
Coordination Capabilities

The Solar Zone was operated by Campus Research Corporation (CRC), an independent Arizona non-profit corporation organized solely to assist in the acquisition, financing, improvement and operation of the campus, research park, and properties including design, development, construction, marketing, and leasing of commercial land and space. It was responsible for appropriate resource allocation (information, time, reports) for the project implementation. The high level of coordination between CRC, TEP, and Amonix made this project successful.

Collective Mind

From the beginning of the project all the stakeholders made their contributions to the outcome with attention and care and they had a global perspective of each other's tasks and responsibilities.

Effectiveness of Implementation Mechanisms:

Financial Mechanisms

For the project implementation Amonix received a cash grant from the U.S. Department of Treasury (under the American Recovery and Reinvestment Act of 2009). This cash grant was taken in lieu of federal investment tax credit (ITC). The amount of grant was equal to 30 percent of the cost of the solar equipment that was used to generate electricity. Additionally, some other costs related to the project were pre-financed by the
University of Arizona with the provision that it will be paid back through the electricity generated by the project.

Inceptive Mechanisms

Besides 30 percent investment tax credits, the federal government offers five-year accelerated depreciation for all solar energy equipment. The equipment installed by Amonix is eligible for accelerated depreciation. Additionally, there is a state incentive that all RE installations pay lower property taxes.

Public Policy

Under the state’s Renewable Energy Standard and Tariff (REST), approved in 2008 by the Arizona Corporation Commission—the Public Utilities Commission of the State of Arizona—TEP and other electric utilities in Arizona are required to supply increasing amounts of RE, with a target of 15 percent of total power sales by 2015.

Commercialization:

Time Performance

The project was completed within 1 year time period, which is considered to be a very quick turnaround.

Financial Performance

Both Amonix and UA still have to recover their investments by selling the electricity to TEP. The performance guaranteed for the technology is provided by Amonix.
4.3. Case # 3. SunChiller LLC. Combined Solar HVAC and Pool heating Plant at the University of Arizona Recreation Center

SunChiller LLC is a strategic partner of the Beijing Sunda Solar Energy Technology Company, which was jointly founded by Daimler-Benz Aerospace and Beijing Solar Energy Research Institute in 2004. The main profile of the business is distribution of SUNDA brand solar thermal collectors in the U.S. market. With evacuated tube technology, the company designs and implements cost-effective solar thermal solutions, such as domestic hot water, space heating and cooling, and pool heating. Although, in recent years, the residential market for hot water system solutions has been growing exponentially, SunChiller sees its market opportunity in high-value addition in industrial applications. As Mr. Serge Adamian, President of SunChiller, indicates, educational institutions are currently the best markets for SUNDA products. Being centers of knowledge and innovation, educational institutions are much more willing to accept innovative solutions for their campus operations. For this reason, all the commercial projects done by SunChiller have been at universities. The first large project implemented by SunChiller was a 350-ton solar thermal-driven air conditioning and heating project at Los Angeles Valley Community College (LAVCC) in 2009. In 2005 when LAVCC had to decide whether to construct a new building to replace an old one, Mr. Adamian proposed replacing the existing electric chillers in the central plant with the 350-ton solar thermal-driven absorption chiller. (An absorption chiller works similar to a refrigerator or air conditioner, except that it uses a process relying on heat from the Sun rather than
electric power.) The hot water for the absorption chiller was to be supplied by SUNDA 1-16 Vacuum tubes, which later were installed in the North Gym and the Campus Center buildings. The proposal was accepted even after the LAVCC management realized that evacuated tube technology was a bigger investment yet its benefits certainly outweighed the costs. Any additional costs may also be offset by solar hot water rebates. In California, commercial properties qualify for rebates of up to $500,000. Since through this project the LAVCC could reduce its electric bill, it opted for financing the project with internal resources. Chevron Energy Solution was a contractor on this project.

Although this project was not purely commercial since the College was not going to buy or sell hot water from the plant but just reduce the load on the grid, it became a good showcase for SunChiller to demonstrate validity and the benefits of the technology to other potential customers.

So when the University of Arizona announced that it was looking for renewable energy opportunities to heat its student recreation center pool, Mr. Adamian saw the opportunity to promote this technology to the university. Previously, the university looked into different options to solve this problem. One of them was a simple thermal installation, just heat the pool. However, this approach was not attractive financially. SunChiller’s approach of using air conditioning along with pool heating looked much more financially attractive. However, to make this project happen, many other parties were needed. First of all, the university did not have the financial resources to cover upfront costs for design and installation; therefore, third-party financing (a tax/equity investor) was required which would also be able to claim a 30-percent tax credit from the federal government. It took several months until one reputable investment bank
(Investor) in Washington, D.C., was persuaded to participate. As Mr. Adamian says, nobody had much knowledge about the technology and, for the most part, investors were very cautious about investing in RE. He said it was luck that the project could bring these investors onboard. The University of Arizona and Investor agreed to a long-term contact whereby the university would provide roof space and settled on a price schedule for chilled and hot water produced, while Investor owned 99 Percent of the plant. Since the investor was interested in managing the project, ESCO Company, Amaresco (1 percent), was invited to do the development, installation, management, operation, and maintenance of the project. It would also identify energy-saving opportunities resulting from the process and suggest improvements that could pay for themselves through the resulting savings. This project also was eligible for an accelerated depreciation schedule. In this project, 85 percent of the investments in assets would depreciate within six years. According to Mr. Adamian, with tax credits, depreciation gains, and Arizona Thermal REC paid by the utility, the IRR of the project will be 10 to 15 percent, which is a good return for any investor.

As a result of this project, the University of Arizona has a solar thermal system that produces energy and cost-savings throughout the year. Although the primary purpose of the system to heat the pool, and because of the warm climate in Arizona, chilled water demand will also be met throughout the year as well. Currently, this innovative solar-thermal system harvests almost 2 million kWh of solar energy per year. Environmental

Although numbers were not given on how much the project positively influenced
the environment, it was said that, by reducing the load on the current electrical grid and natural gas consumption, the project indirectly contributed to cleaner air, cleaner water, and less global warming. The UA was also environmentally conscious and hence it requested an RE solution for pool heating. It was also mentioned that the state government was supportive of the project because it also wanted to see more clean energy solutions across Arizona.

Social-Economic

As a result of the project, few jobs were created for operation and maintenance of the plant. However, it was indicated that socio-economic conditions in the area were a driver in this project implementation.

Energy Security

This driver was not indicated as a motivation factor for the stakeholders.

Internal Drivers:

Financial

Amaresco got involved in the project because it is in its business model (for ESCOs). It saw a good business opportunity by getting involved in all stages of the project’s development and afterwards in the project’s operation. Revenue increase and project both were indicated as good drivers for partnership synergy with all stakeholders. The investor also saw a good business opportunity for long-term revenue generation by offering unique value proposition to the UA.
Cost

Installed were 5500 SUNDA evacuated tubes atop the roof of the University’s Recreation Center Pool. The cost of this proven technology now depends on economies of scale. As it was mentioned, more projects like this would definitely reduce the manufacturing cost of the technology. Additionally, more projects done by Amaresco would reduce the cost of the projects, as well.

Knowledge and Skills

It was said that availability of financing was one of the critical parts for the project to happen. However, a majority of financial institutions in the country see more investment opportunities in other industries rather than renewable energy because of a general lack of knowledge by bankers. The opportunity to learn about the financial benefits in participating in the project was a driver to attract third party financing to the project.

Partnership Synergy

SunChiller CEO and President Serge Adamian approached the UA representatives at a renewable energy conference. There were people in UA who were RE fans and who pushed the project forward. Later a third-party financer and ESCO were approached to participate in the project. Several meetings were required. All project partners were active in communication and the project moved forward. All the goals and objectives were understood and supported by each partner.
Dynamic Capabilities:

Absorptive Capacity

It took almost a year before the investor decided to get involved. First of all, the investor wanted to understand the risks (performance risks, maintenance risks, control system risk, etc.) involved in the project and get guarantees to mitigate these risks. It also needed to learn about federal and state incentive programs, utility prices, and solar resources availability before deciding to finance the project.

Coordination Capabilities

It was indicated that good coordination between the partners was key to the successful completion of the project. Unfortunately, after the project’s completion, not all the members get information about the thermal plant’s continued performance. SunChiller received only a few messages that the system was operating much better than it was planned and this fact prompted the investor to do another, similar project at the University of Arizona-Phoenix campus.

Collective Mind

All the stakeholders contributed to the outcome with attention and care, and there were no delays at the project implementation stage. The responsibilities of each partner were clearly defined and they all knew who was doing what and when. The project implementation process was synchronized to complete the project as soon as possible.
Effectiveness of Implementation Mechanisms:

Financial Mechanisms

The project was fully financed by the investor (third-party financing).

Inceptive Mechanisms

Financially, the project benefitted by claiming a 30 percent investment tax credit and accelerated depreciation (less than six years) on the equipment. So they will get an IRR of 10 to 15 percent, which is a good return. Additionally, as in the previous case, there is a state incentive that all renewable energy installations pay lower property taxes.

Public Policy

Amaresco has gotten an opportunity to sell REC to the utility.

Commercialization:

Time Performance

From the beginning of the first contact at the conference, it took three years to complete the project.

Financial Performance

The owner of the project (the investor) still has to recover its investments by selling the hot water and chilled water to UA. A PPA was signed for 20 years with possible
extension of an additional 10 years. The performance guaranteed for the system was provided by Amaresco, while SunChiller provided a 10-year warranty for its supplied vacuum tubes.

4.4. Case #4. Biogas plant development in Armenia

After the collapse of the Soviet Union, the supply of meat to local markets was organized by companies that were using animal breeding technologies dating back to the 1950s. Modern animal breeding technologies, which assume zero waste, were not introduced until the mid-2000s. As a result, food safety issues and growing production of meat caused a lot of environmental problems associated with foul smells, water pollution, and soil contamination. Increasing volumes of organic waste were threatening the environment and creating frustration among the communities surrounding animal breeding farms. All these problems must be seen as part of an unsustainable resource use system that prevailed worldwide at the time. Biogas technology was one of the important hardware components in a chain of measures to counteract the above-mentioned problems.

The Lusakert Pedigree Poultry Farm was among the largest animal farms in Armenia which was facing these problems with its chicken manure removal system. The smell of manure from the poultry farm—which produced about 3,000 tons of chicken meat and 150 million eggs per year—became a big headache for the management because of complaints from nearby villagers. That was when the United Nations Development Program (UNDP) approached the management of the farm to assist in building the first biogas plant in Armenia. The project could qualify for the UN Clean
Development Mechanism (CDM) by showing a reduction in greenhouse gas emissions. CDM is the UN program designed for the reduction of greenhouse gas emissions, or for the promotion of investments in absorption projects in developed countries. The establishment of CDM was driven by the Kyoto protocol, an international treaty that sets binding obligations on industrialized countries to reduce emissions of greenhouse gases adopted in December 1997 and entered into force in 2005. The Lusakert Biogas Plant was the first application of a clean development mechanism in Armenia. Being a CDM project, a lot of companies in northern Europe expressed a desire to invest in it, among which were the Bigadan Company, the largest producer of biogas equipment in Denmark; a Danish private investment fund; and the Norwegian Growth Fund.

It took about a year to complete all the paperwork and get the approval for the launch of the construction, which started in August 2007 and was completed in late 2008. In the project outcome, the Lusakert plant produces biogas (methane) which is a result of the decomposition of the organic manure material. The gas is later used in an electric generator to produce electricity. If it runs at full capacity, it can generate 5 million kWh of electricity. Additionally, the generator produces heat, which later is used for space heating. As in many European countries and unlike the U.S. government, the Armenian government subsidizes green energy generation through a Feed-in Tariff of 10 cents per kilowatt. It obliges utilities to purchase electricity from RE producers.

Besides the electricity and heat, there is also another byproduct from plant which has economic value. When all the gases are removed from the manure, it becomes organic fertilizer, which can replace chemical fertilizers that are heavily used in Armenia. In conclusion, by mitigating methane emissions from the treatment of chicken manure, it
is forecasted that the project will reduce greenhouse gases by about 63,000 tons of CO₂ equivalent per year.

Another biogas project, which is currently underway in Armenia, is the modernization of the Nubarashen pig farm, a joint project implemented by Vasanavi LLC, specialized in pig farming, and VDL Agrotech, a Dutch company and the largest pig and poultry farm equipment supplier in The Netherlands. As in the first case, this second one is also by a company facing a lot of problems with its slurry removal system. The current system used (as was done in Soviet times) is discharging all the waste into the valley where agricultural lands are located. Besides the smell, which harmed the surrounding environment, it caused contamination of agricultural land.

This two-and-a-half-year project is designed to modernize two large sheds on the pig farm, building biogas digesters, gas-holders, a feeding system, a biogas purification system (desulphurization dehydration towers), biogas storage and delivery system, and a biogas generator (CHP). As the Vasanavi owner states, the company is going to use the knowledge acquired in the Lusakert Biogas Plant during the implementation of this pig farm project. Vasanavi is going to use that information to better organize and coordinate work activities to reduce time and costs of the pig farm project. The Lusakert project costs 5.2 million Euros, while the Nubarashen pig farm project—for the same size biogas system as was installed at Lusakert—is estimated at 1.3 million Euros. One of the explanations for the lower cost is that, because of an increased number of biogas system installations around the world over the past six years, equipment prices have been reduced significantly. This also happened due to the entrance into the market of Chinese suppliers of biogas equipment, whose services Vasanavi is going to use.
External Drivers:

Environmental

Major problems caused by a lack of appropriate slurry removal systems from animal breeding farms is water and soil contamination. Additionally, as there is no decomposition of the methane gas produced in the waste lagoons, and methane is 21 times stronger than greenhouse gases such as CO$_2$, this has an impact on global warming. The local partners in the projects were mainly interested in reducing dangerous impacts on the local environment and neighboring communities to their business activities, while the foreign partners were driven by reducing greenhouse gas emissions, which contribute to global warming. Under the Kyoto protocol, all the countries that have signed the treaty have some quotas to meet in reducing the emission of greenhouses gases. Additionally, they can buy more quotas from countries where emissions are below their allotted quotas. This emission trading is used around the world to control pollution by providing economic incentives for achieving reductions in the emissions of pollutants and to avoid dangerous climate change. The Danish Environmental Protection Agency agreed to purchase a Certificate of Emission Reduction generated by the Lusakert project.

Social-Economic

Solving pollution problems was at the root of these projects and will have huge social impacts on the local communities by improving living conditions of the population of local villages. There was/will be an economic impact on the local job market by
building these plants since each of the projects creates jobs for construction and operation of the facilities. However, it was stated that job creation was not a major driver for the stakeholders to get involved in the projects.

Energy Security

Energy security for Armenia as a driver had no influence on partnership development and synergy.

Internal Drivers:

Financial

All the parties involved in the project implementation indicated that they saw the opportunity to generate additional revenue for their respective businesses by selling electricity and fertilizers. Profit maximizing was also part of the decision making for the projects’ implementations; however, it was clear that, in the second project, it will be higher because the cost of both the project and its technology will be lower.

Cost

The increased volume of biogas system installations over the past six years has reduced the price for the equipment. Additionally, the Nubarashen pig farm is planning to save on water supply costs by reusing water from the biogas plant. It has a garden of apricot trees and it is going to irrigate this garden with the water generated by the biogas system.
Knowledge and Skills

Some of the European partners had extensive experience in developing biogas plants. Other stakeholders were eager to learn about the technology and acquire skills necessary for operation of the plants.

Partnership Synergy

In the first project, the UNDP was the leading organization who selected both partners from Europe and Armenia. The designated operational entity was Norwegian Det Norske Veritas Certification Ltd. Along with the Armenian and Danish partners, the Norwegians developed the proposal for the UN CDM. Several interviews were conducted with all the stakeholders involved in the project, including Armenian government representatives from the Ministry of Environmental Protection. On the Armenian side, including the government, people were highly interested in the implementation of the project. Support letters were provided by all the organizations and institutions in the local community. After conducting an environmental assessment report, it was concluded that after the installation the plant would be “neighbor friendly.”

The second project is underway; however, it was stated that all the stakeholders are very supportive of the project.

Dynamic Capabilities:

Absorptive Capacity
The Danish supplier of the equipment conducted several trainings with local construction workers, as well as prepared the staff for operation of the facilities. That knowledge also is going to be transferred to the second project at the pig farm.

Coordination Capabilities

A local company has pledged to provide manpower and local construction materials to the project under an adopted schedule. The equipment also arrived on time since there were no delays in supplying funds for it. Because of the high level of coordination, there were no delays in the implementation of the project.

Collective Mind

Throughout the implementation of the project, at least one of the project partners from Europe was in Armenia and supervising the construction process. The documents and all the required paperwork including permission for the project’s implementation and construction, was done on time. There was a common understanding of the benefits of the project for the community, as well as for the country as a whole.

Effectiveness of Implementation Mechanisms:

Financial Mechanisms

The project was financed by Lusakert Pedigree Poultry Plant LLC (Armenia), Vekst Project Financing Facility AS (Norway), Bigadan A/S and Industrialization Fund for Developing Countries - IFU (Denmark).
Inceptive Mechanisms

Locally, there was only one incentive: the Feed-in Tariff of 10 cents per kWh produced from the biogas plant, while the retail price to homeowners is 6.5 cents per kWh. However, the UN CDM played an important role by providing additional incentives in the form of the Certificate of Emission Reduction (CER) which could be traded for cash.

Public Policy

The Danish Environmental Protection Agency agreed to purchase the CER generated by the project under the Kyoto protocol.

Commercialization:

Time Performance

The project was completed in about two years.

Financial Performance

Although the environmental benefits were fully realized by the stakeholders involved in the project, the financial benefits have yet to be gained. Biogas facilities will sell electricity under a PPA to local facilities. The Feed-in Tariff will apply, which is subsidized by the Armenian government. Additional revenues will be generated from the sale of organic fertilizers, while heat generated from the operation’s electrical general will be used for space heating of the animal breeding houses, substantially reducing electrical load off the local power system, thus saving financial resources.
4.5. Case Analysis

4.5.1. External and Internal Drivers

As it was indicated before, public and private sectors in RE have common interests, and balance between public and private interests can be reached only through partnerships (Saltman and Figueras, 1998). However, public stakeholders differ from private stakeholders in their motivation to be part of RE project. For this reason, case analysis for External and Internal Drivers will be done on each stakeholder separately.

Federal Government

Federal government is not directly involved in the projects. Federal incentives are adopted based on general statistics on RE installation, as well as feedback received from different lobbying groups such as American Wind Energy Association, American Solar Energy Association, Solar Energy Industries Association, etc. It is generally believed that legislation on RE adopted by Congress is driven by environmental, social-economic and energy security concerns. Without the relevant legislation it is unlikely for a single project to be implemented, since there are no economic reasons for private sector to get involved in the project. As a check point, all 16 interviewees confirmed this fact. Only in Case 1, the federal government was involved directly through its National Laboratory – NREL – that was a major facilitator of the wind farm development. One interviewee, who was involved in several projects in the State of Hawaii, indicated that because of high energy prices there, solar water heating technology cost becomes competitive. It is
worth mentioning that the federal government policy on RE is also dependent on costs of conventional energy which needs to be introduced as a separate external driver in the model. As some interview respondents indicated the invention of new shale cracking and horizontal drilling technology cause natural gas price to drop from $15 per million BTU (British Thermal Unit (BTU) is the amount of heat energy needed to raise the temperature of one pound of water by one degree F) to $3 per BTU.

State and Local Government

State and local government are more involved in project level activities, trying to solve local problems with introduction of RE. As 12 respondents indicated, legislation on RE varies from state to state. The states with abundance of RE resources, such as Texas (Wind) or Arizona (Solar) have more incentives on RE than states with less resources. The projects described in Cases 1, 2, 3, and 4 contribute to the cleaner environment. In Cases 1 and 3 the development of 1.2 MW wind farm and Combined HV AC system, respectively, assumed the reduction of CO₂ emissions from coal (natural gas) burning facilities and greenhouse gas emissions. These installations also prevent water contamination, because the water is used for cooling in coal burning process. In Case 2, it was indicated that CPV plant offsets 5,000 tons of carbon dioxide and contributes to the cleaner water resources, since there is no water usage in the process. In Case 4, the development of biogas system prevents water and soil contamination and reduces greenhouse gas emissions which contribute to the global warming. Hence, for the state and local governments, in jurisdiction of which these projects were implemented, the
desire to mitigate the negative impact on local environment is an important driver to support RE projects and part of the partnership synergy among stakeholders. Only in Case 1, where wind project was implemented, the Environmental Assessment report was required in order to assess the negative impact of Wind turbines on bird migration. As, one of the interviewees from NREL indicated, this is the most time consuming process in implementation stage of the project.

State and local governments also support RE projects because their implementation facilitates economic growth in the communities around project sites. Particularly, according to all 16 interviewees, in most parts the electricity generated from fossil fuel is not produced locally, and consequently, the money paid for electricity was taken away from the local economy. In case of RE project implementation, there is a possibility that design, construction, operation and management will be done by local community members, as a result bringing higher social-economic impact on the local community.

Individual Members of the Local Community

In general, individual community members in most part have a positive attitude towards renewable energy installations. In Cases 2, 3, and 4, the RE installations had a direct or indirect positive impact on local environment, brought improvements in air and water quality. However, as Amonix CTO indicated, there are cases when some community members were opposing the project implementation because of desire not to change the landscape which they accustomed to. Similarly, the interviewees brought the
example of the first U.S. offshore wind project—Cape Wind—where owners of the properties at the Shore of Boston Area did not want to see the wind turbines from their properties. Besides environmental and social-economic benefits, the local community members have a desire to acquire knowledge on benefits of RE technologies, positive effects on their life from those technologies, as well as costs associated with the introduction of the technology. They will be willing to buy electricity from RE as long as they do not incur upfront costs. In Case 1, since the wind project was owned by a local company, all the revenue from the sales of the electricity stays in the local economy, which brings employment to the local community members. Similarly, in Cases 2, 3, and 4, revenues stayed in the communities.

Two of the interviewees also mentioned that, as end-users of electricity, individual community members are more concerned about the cost of the electricity produced from RE sources. If they were told that, with their participation, the cost of electricity will be lower than from conventional sources, they would definitely support projects.

Technology Owners/Suppliers

In Case 2, the company founder was a solar enthusiast whose motivation was to create a technology that could produce clean, reliable, low cost electricity to the customers. In Case 3, the founder of SunChiller was a RE enthusiast, who was involved in various RE projects since 1990s. As most of the check point interviewees indicated, usually, the companies which develop and supply RE technologies are run by people, who are advocates of cleaner environment and see the opportunity to develop their
business around these trends. Thus, among the environmental drivers which motivate technology owners/suppliers to see more project deployments, they also are looking for cost minimization of the technology and the project, to make the technology cost competitive with conventional energy sources. All interview respondents indicated that the economies of scale issue was very important in making technology cost competitive. It was also pointed out that revenue generation and profit maximization are important for suppliers and technology owners.

Financiers

Finding financing for project implementation is the most difficult part for these RE projects. As all the interviewees indicated, investors are looking for maximum returns. Environmental, socio-economic, and energy security drivers cannot influence their decisions as they are after profit maximization in the form of higher returns on their investments. In Case 1, the project was financed by private entities, which were looking for 8 to 10 percent return on their investments. In Case 3, where the project was financed by investment banking the company anticipated return was 10 to 15 percent. However, it was indicated that before making investment decision, potential investors want to make sure that risks associated with immature technologies are taken by other stakeholders. Technology owner should provide performance guarantee to project financer. The long term power purchase agreement needs to be signed between project owner and host and/or utility (in Case 1-Kansas Power Pool, Case 2–TEP, Case 3–the university, and Case 4–the Armenian Power Grid).
Utilities

The respondents also mentioned about utilities, which although have to be part of the project as final purchaser of electricity or heat; however, being highly regulated companies, utilities are influenced by local and state government regulation policies, which in turn results in more attention to environmental and social-economic drivers. Utilities are more conservative and less willing to accept changes in their electric grid unless they have to do it under pressure. One of the respondents indicated that utilities like power sources with a continuous supply of electricity while solar and wind resources are intermittent. This makes it a lot harder to match the demand and supply of electricity, creating additional difficulties for the utilities. For this reason, 30 states and the District of Columbia have introduced RE portfolio standards, which set a minimum requirement for the share of electricity to be supplied from designated renewable energy resources by a certain period. Since quite often the solar, wind, biogas power generation produces more renewable electricity than required to meet their own RPS obligation, it is possible to trade or sell RECs to the utilities that do not have enough RPS-eligible renewable electricity to meet their RPS requirements. In Case 2, TEP was the most active player in Solar Zone, testing different solar technologies which would help meet its RPS obligations by year 2015.

Project Owners
In Case 1, three project owners were the main financers of the projects. In Case 1, John Deere Renewables invested in the project with anticipation long term revenue stream and potential return on investments of 8 to 10 percent. In Case 3, the investor with all the policies and incentive mechanisms in place anticipates 10 to 15 percent return. In addition to investment return guarantees from other stakeholders, all the project owners in cases 1 through 4 were driven by a desire to gain knowledge and skills which they believed would provide them a competitive advantage in the emerging RE market.

Contractors

As in the case of the project owners, the contractors on the projects were involved in the design and construction of renewable energy generating plants and were more motivated by having opportunities to generate a new revenue stream from the emerging RE market. As one of the respondents indicated, contractors approach RE technology companies and look for opportunities in working in such projects. Environmental, socio-economic, and energy security drivers are not part of their motives in getting involved in RE project partnership.

The summary of external and internal drivers for the RE project implementation by stakeholder is given Table 4.1. The numbers denote the number of positive responses by 16 checkpoint interviews.
Table 4.1: Summary of External and Internal Drivers for the RE Project Implementation by Stakeholder

<table>
<thead>
<tr>
<th>Drivers</th>
<th>RE Project Stakeholders</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Federal Government</td>
</tr>
<tr>
<td><strong>External</strong></td>
<td></td>
</tr>
<tr>
<td>Desire to minimize negative impact on Environment</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>16</td>
</tr>
<tr>
<td>Desire to improve Social-Economic conditions in communities</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>16</td>
</tr>
<tr>
<td>Desire to achieve Nation’s Energy Security</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>16</td>
</tr>
<tr>
<td>Cost of Conventional Energy Technologies</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td><strong>Internal</strong></td>
<td></td>
</tr>
<tr>
<td>Seek financial benefits</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Desire to minimize cost</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>15</td>
</tr>
<tr>
<td>Desire to acquire skills and knowledge</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>12</td>
</tr>
</tbody>
</table>
4.5.2. Stakeholders’ Partnership Synergy

As seen, for the success of the project, it is very important to have an initiator of the project, and later a champion, which will lead the process. In Case 1, the role of initiator was taken by local government and NREL experts, while John Deere became a leader organization for the project, which also acts as financer of the project. In Case 2, UA Solar Zone was an initiator of the project, which later was led by Amonix. Similarly, in the projects of Cases 3 and 4, they both had initiators and leaders of the process. Meetings, discussions and presentations were chosen as a common platform for communication within a project. In Cases 1 and 4, separate meetings were organized with public stakeholders in order to make sure that there will be no resistance to the project. In all four cases, local and state governments were informed about the details of the project implementation. Although in all four cases presented the projects received support from individual community members as well as institutions, the interviews at NREL revealed that this is not always the case. A lot of projects stop just in the planning stage because of resistances from some local organizations, community members, agencies. This proves the fact that in order to achieve partnership synergy the project needs to get support from all the individuals, agencies and institutions active in the community. Some of the experts also mentioned that common goals should be understood and supported by all partners. However, it was not happening always, which makes some projects costly and takes longer time to complete.

The bottom line is that the success of the project depends on contribution of all the partners, something that all the interviewees supported.
4.5.3. Dynamic Capabilities

Absorptive Capacity

In the beginning of the process in all 4 cases the knowledge of the benefits of technology and its cost competitiveness with all the incentive mechanisms was a technology owner attribute. The other stakeholders were more or less informed about the technologies. While in Cases 2, 3, and 4, the owners of the technology took the role of educator, in Case 1 that role was taken by NREL. In Case 1, after NREL evaluations a master plan was developed by John Deere Renewables. Since it was one of the biggest businesses in the community, it had all the channels for communication with other stakeholders in the community, as well as to invite respected companies to do the design and construction for the project. In Case 2, Amonix was invited by TEP to develop a project in Solar Zone. TEP wanted to learn about the performance of the technology and compare it to other solar technologies in order to decide on what technologies to rely on in the future. In Case 3, simple solar water systems for space heating, as well as the pool heating, was not a very attractive solution. The role of SunChiller was to put forward a value proposition for space heating and cooling, and use of the heat that otherwise would have been dumped (as in the case with the LAVCC) to heat the pool. However, the plan was developed to demonstrate the cost advantages of the technology which was presented to other stakeholders. Similarly, in Case 4, although there was general knowledge about the existence of biogas technology, the Danish supplier of the equipment took the role of educator in the process.
As all four cases demonstrated, after completion of the project the stakeholders which acted as students in the projects used their acquired knowledge to do larger RE projects in other places. For example, in Case 1, BTI established its Harvest the Wind Network (HTWN) which later installed 125 turbines nationwide. In Case 2, TEP learned about the technology, Amonix learned about the project development process, knowledge which it used later in much bigger projects. In Case 3, the owner of the system and the investor were more willing to participate in similar projects and, as a result, a similar project was launched at the University of Arizona-Phoenix. And, in the last case, Vasanavi was using the knowledge from the Lusakert Biogas Plant to develop its own biogas project.

Coordination Capabilities

Most interviewees at NREL mentioned that the existence of the champion in the project is key to the successful completion of the project. In all 4 cases, the existing lead organization synchronized the resources and tasks to improve the project performance. In Case 1, in the master plan developed by John Deere, the time schedule was clearly defined for all the stakeholders starting from getting approvals, launching the construction, supply of materials and deadlines of completion. Similarly, in Cases 2, 3, and 4, the plan was developed with clear timeline for allocation of resources for the successful completion of the plan. Some of the checkpoint interviewees mentioned that development of information technologies helps a lot in coordination of the activities by the lead organization, in terms of getting timely feedback on the project activities.
Unfortunately, as it was also mentioned before that, in Case 3, the supplier of the technology later was not able to get data for the performance of the system.

Collective Mind

On the checkpoint side, the interviewees mentioned that all the stakeholders should make their contribution to the outcome of the project with attention and care, but not necessarily to have a global perspective of each other’s tasks and activities. In Case 1, in the beginning of the project, there was no collective system in place to complete the project successfully. The partnership synergy contributed to the establishment of such system. For example, after completion of the project, BTI Power Network was established to do wind projects in other locations of the country. Its ability to organize and manage the project was a result of a collective mind developed during the implementation of the Greensburg Wind Project. In Case 2, a collective mind was a result of the existence of the technological park at the University of Arizona. It was used as a platform for integrating resources into a collective system through contribution, representation and subordination. In cases 3 and 4, although the collective mind was present in the beginning, during the process it was possible to achieve higher levels of integration of the resources into a collective system.
4.5.4. Effectiveness of RE Implementation Mechanisms

Financial Mechanisms

As stated, renewable energy projects require high levels of financing. In all four cases the availability of financing was a key factor for the successful implementation of the projects. In Case 1, the project was financed by the U.S. Department of Agriculture Rural Development; equity financing was provided by John Deere; Native Energy provided gap funding. In Case 2, Amonix received a cash grant from the U.S. Department of Treasury. Other expenses were pre-financed by the University of Arizona Solar Zone and equity financing came from Amonix itself. In Case 3, in the first project, LAVCC pre-financed the project with its own financial resources. In the second project, an investment banker fully financed the project with some minor pre-financing from the University of Arizona. In Case 4, the project was co-financed by Lusakert Pedigree Poultry Plant LLC (Armenia), Vekst Project Financing Facility AS (Norway), Bigadan A/S, and Industrialization Fund for Developing Countries-IFU (Denmark).

As seen in Cases 1, 2, and 4, the financing came from federal governments, whereas Case 3 financing came from a private company or a consortium of private companies and development agencies.

Incentive Mechanisms

The Greensburg Wind Farm, like many other wind projects, was eligible for production tax credits. The latter provide a 2.2 cent per kWh tax credit for the first ten
years of electricity production from utility-scale turbines. As with any incentive mechanism provided by the federal government, the production tax credit has its expiration date. Since 1992, when it was first introduced, the expiration date was extended five times. On January 2, 2013, Congress temporarily extended the PTC for wind as part of the “fiscal cliff” bill. As interviewees mentioned, short-term extensions of the PTC are insufficient for sustaining long-term growth of renewable energy. The planning and permitting process for new wind facilities can take at least two years to complete. As a result, many renewable energy developers who depend on the PTC to improve a facility's cost effectiveness may hesitate to start a new project.

The projects in cases 2 and 3 were eligible for investment tax credits (ITC), which are a 30-percent tax credit for solar system installations. Under the current law, the ITC will remain in effect through December 31, 2016. This provides market certainty for companies to develop long-term investments that drive competition and technological innovation, which in turn, lowers costs for consumers. Due to the existence of the ITC, the project in cases 2 and 3 became cost competitive. Additionally, before 2009, there was a $2,000 credit cap on solar hot water installations. In 2009, under the American Recovery and Reinvestment Act (P.L. 111-5), that credit cap was eliminated, which made it possible for the Case 1 project become more attractive for investment.

And last, the projects described in Case 4 were eligible for a Feed-in Tariff of 10 cent/kW. This RE incentive mechanism is prevailing in many European countries. Feed-in Tariff proved to be effective especially in Germany where, in 2011, 20 percent of electricity was produced from RE sources.
Public Policy Mechanisms

The Renewable Portfolio Standards are a written policy designed to require retail power suppliers to provide a certain minimum percentage of electricity, from a specific renewable power source, for a specified period of time. In most part it is a state policy mechanism, which obliges utilities to either invest in RE generation facilities or buy Renewable Energy Certificate from those companies who produce electricity from renewable energy. Since the states of Kansas and Arizona have this policy in place, this policy mechanism made projects described in Cases 1, 2, and 3 financially more attractive.

4.5.5. Commercialization

Time Performance

As it was found out from the cases, all the projects were completed within a three-year period. In Cases 1 and 3, projects took longer to complete because of the longer time period needed for due diligence. In Case 1, before construction launch the environmental assessment report for the project had to be done. As the wind expert at NREL indicated, it takes up to two years. In Case 3, due diligence was required for the investor to learn about the project.
Financial Performance

All the projects described in these cases still have to recover their investments by selling power to either a utility or a host under the PPA. As said during the interviews, anticipated investment returns on wind and solar power projects is from 8 to 10 percent. However, in Case 3, return on investments was 10 to 15 percent.
**4.6. Cross-Case Analysis**

The cross-case analysis involving the proposed model dimensions case by case and with checkpoints is presented in the Table 4.2 below.

Table 4.2: Cross-case analysis

<table>
<thead>
<tr>
<th>Drivers</th>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
<th>Case 4</th>
<th>Checkpoint</th>
</tr>
</thead>
<tbody>
<tr>
<td>External drivers</td>
<td>Greensburg leaders championed a green approach to rebuild the town.</td>
<td>Solar Zone was established to promote Solar technologies to mitigate impact on environment. One of the missions of Solar Zone is to accelerate commercialization of solar technologies that will contribute to the economic development of the region and the state, which in turn will have social impact on population.</td>
<td>There was a full realization of the fact that completing the project will help offset the CO2 and greenhouse emissions.</td>
<td>Lusakert Biogas plant was built to help to eliminate the negative impact of poultry operations on air and water pollution as well land contamination. The project supported also for the fact that it will create new jobs and improve health in the community.</td>
<td>All 16 interviewees confirmed the strong presence of environmental and social-economic drivers on partnership synergy. Additionally, they indicated about the cost of conventional energy sources as a driver as well.</td>
</tr>
<tr>
<td>Internal drivers</td>
<td>John Deere, Native Energy, Constructors and Supplier of the equipment were seeking new sources of revenue to maximize their profit. The desire to achieving economies of scale was import factor the cost reduction for wind turbine supplier and federal government while John Deere was interested in Project cost reduction. Some of the stakeholders were after knowledge and skills, some just knowledge.</td>
<td>Amonix was interested to sell as many CPV modules as possible to turn into profitable business. Constructor, Granite Construction was looking for opportunity to expand to new markets. The cost of technology and cost of project was important for Amonix that can be achieved with increased number of projects. They wanted to show the cost competitiveness of their technology. Some of the stakeholders were after knowledge and skills, some just knowledge.</td>
<td>The motivation of SunChiller was to sell Solar Vacuum tubes. Investor of the project was after new investment opportunities. SunChiller indicated that the cost of the technology today depends on market expansion while the investor (owner) of the project looked at cost minimization. Some of the stakeholders sought to acquire knowledge and skills, some just knowledge.</td>
<td>Lusakert Poultry farm saw an opportunity to get additional revenue stream by selling electricity and organic fertilizers. Danish supplier was after opportunity to sell its equipment. Some of the stakeholders were after knowledge and skills, some just knowledge.</td>
<td>All 16 respondents agreed that technology owners (suppliers), financers, project owners and contractors seek financial benefits. Cost of technology and the project is important for Federal Government, Technology owner and Project owner.</td>
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<tr>
<td>Partnership Synergy</td>
<td>NREL organized several meetings. John Deere joined the project and took the lead. They developed a master plan. USDA pledged to provide a loan. John Deer provided equity financing, gap funding received from NativeEnergy. The project got support from the community individuals and institutions. All the permissions were received within a year. Common Goals were clearly communicated.</td>
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<td>-------------------------------------------------</td>
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<tr>
<td></td>
<td>UA and TEP developed a partnership to create the Solar Zone. They requested Solar system deployment proposal. Amonix applied. Several meetings and presentations were conducted. The project was approved. UA was a self-permitting organization, so there were no delays in getting construction permits. UA provided the site and infrastructure, Amonix provided the equipment and technical support, Granite Construction was involved in construction. The project received a cash grant from US Department of Treasure instead of Federal Tax Credit.</td>
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<tr>
<td></td>
<td>UA announced about its intention to find RE solutions to heat the pool. SunChiller learned about it when he met UA representatives in the conference. The proposal was developed jointly with UA. Amaresco was invited to develop the project. They attracted Third Party Financing, to own the facility and sell hot and cold water to the university. There was a full support to the project from all the stakeholders.</td>
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<tr>
<td></td>
<td>UNDP approached the management of the farm. CDM was proposed. Danish supplier of the equipment and private investment fund, as well as Norwegian Growth Fund joined the project. Lusakert Biogas Plant company was established. Several meetings and presentations with all the stakeholders were organized. They all supported the project. There were no delays in providing financing, equipment supplies arrived on time. Local construction works were implemented within time schedule. The goals and objectives of each partner were understood.</td>
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<tr>
<td></td>
<td>According to interviews the platform for communication for most stakeholders are the conferences organized by Federal Government, Interest Groups and Associations as well as individual meetings within the projects. The issues need to be well communicated. There should be a lead stakeholder (champion). Not always the project gets support from institutions and individual community members. Not always common goals are understood and supported by all partners. The success of project depends on contribution of all partners.</td>
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</tbody>
</table>
### Dynamic Capabilities

| Besides NREL and John Deere, other stakeholders did not have knowledge about the wind projects. During the process they gained knowledge and some of them later used it for other projects in the country. In the beginning NREL and later John Deere ensured the appropriate allocation of resources for successful completion of the project. The output of the joined work is available to all stakeholders when needed. John Deere was a respected company in the community and with the support of NREL they made sure that other stakeholders be motivated to carefully interrelate actions with each other to accelerate the project implementation and complete high quality work on time. |
| Beside Amonix, other stakeholders did not have knowledge about the technology. For Amonix it was one of the few big projects they have ever done. Other stakeholders learned about the technology, while Amonix learned about large scale project implementation process, which was applied in much bigger projects later. UA and TEP initiated the project and Amonix took the lead. The reports and information dissemination were organized on time, so there were no delays in funding release. The process was well synchronized. In the Solar Zone collective mind was present, where all the stakeholders were motivated to make their contribution with their capabilities and resources towards the success of the project. |
| In the beginning besides SunChiller other stakeholders were not well informed about the technology. When the project was approved, Amaresco was invited, taking the lead for disseminating knowledge about the technology. Later, this knowledge was used by the financier (project owner) to get involved in another projects in Phoenix, AZ. Amaresco coordinated all the project activities, as an ESCO it is specialized on RE project development. They made sure that supply of the resources and information from all the stakeholders were well synchronized. All the stakeholders made their contribution to the success of the project with attention and care. |
| UNDP initiated the CDM project – Lusakert Biogas Plant. The knowledge and expertise were passed to the local stakeholders through different training programs. This knowledge is used by Vasanavi to implement Nubarashen project. Lusakert Biogas Plant coordinated all the activities during the project implementation. The supply of resources and dissemination of information was well synchronized. All the stakeholders made their contribution to the success of the project with attention and care. |
| All the respondents positively responded to the dynamic capabilities questions. It was mentioned several times that there should be higher absorption capacity among the stakeholders. There should be champion to coordinate the activities and eventually such leader should be able to integrate diverse resources into a collective system with contribution, representation and subordination, because otherwise RE project success may become unlikely. |
| Effectiveness of RE Implementation Mechanisms | John Deere with support of other stakeholders developed a well justified master plan that was accepted by USDA Rural Development Program, which provided low interest loan to the project. The results of joint efforts made it possible for John Deere to be eligible for 30% production tax credits and for NativeEnergy to sell REC to the utilities. | The project was eligible for cash grant from the Federal Government, which was taken instead of investment tax credits. It was provided based on a well-developed proposal, where or the stakeholders confirmed their participation and contribution. This project also helped TEP to share of contribution in order to meet RPS. | The Project Owner after completion of the project filed for tax deduction against 30% of total investment value, while Amresco sold REC to the utility. | The Project has been materialized under Clean Development Mechanism (CDM) of the Kyoto Protocol, co-funded by Lusakert Pedigree Poultry Plant LLC (Armenia), Vekst Project Financing Facility AS (Norway), Bigadan A/S and Industrialization Fund for Developing Countries - IFU (Denmark). After project completion Lusakert Biogas plant started to sell its electricity with higher rates (Feed-In Tariff). | The project needs to be financially well justified in order to get Third Party Financing. The incentive and policy mechanisms help to reduce the cost of the project for the investors making the project cost competitive with conventional energy sources. Incentives and Policy mechanisms proved to be effective because with their introduction the number of RE installation increase exponentially in the last few years. Once they are removed, the number project deployments will decrease substantially. |
| Commercialization | The project was completed within 1 year. The information on the return of the investments is not provided. John Deere is still to recover its investments through electricity sale. | The project was completed within 1 year. The information on the return of the investments is not provided. Amonix and UA are still to recover their investments through electricity sale. | Project was completed in about 3 years. IRR of the project is between 10 and 15%. | Project was completed in about 2 years. Biogas Plant works with 60% of its capacity. The return of investment is planned in 6 years. | Usually large scale RE projects take from 1 to 3 years. It depends how well the process is organized and how many permits are required. With incentives present. RE projects bring good rates of return to its investors. |
4.7. Discussions on propositions

Table 4.2 summarizes the main results on the cases. Cross-case analysis along 16 checkpoint interviews indicated the following:

- Desire to mitigate negative impact on environment from energy production from conventional energy sources is an important driver for RE stakeholders to get involved in partnership and successfully complete the project. It is worth mentioning that for each project solution of a particular type of environmental problem depends on the specific RE technology. For example, development of wind project helps reduce CO2 and greenhouse gas emissions, development of solar systems contribute to air and water pollution reduction, while biogas systems, in addition, help solve soil contamination problems. The desire to start and complete project in the last case was even higher since the local community was directly impacted from animal breeding farm operations. However, all other cases also provided a support to environmental driver impact on partnership synergy. In addition to the cases, all 16 outside interviewees supported proposition P 1.1. It can be concluded that, there is a strong positive relationship between Environmental Drivers and Partnership Synergy. Therefore, proposition P1.1 is supported.

- Desire to improve social-economic conditions in the local community is also an important driver to get involved or to support RE projects. Justifications of social-economic benefits were present in the master plan or project proposals in Cases 1, 2 and 4. Besides job creation, the interviewees indicated the fact that the money generated from the sale of the power from RE power stations stays in the community rather than flowing outside the community. This results in more financial resources available to the local
economy, which assumes larger budget for the state and local government to invest in public health and education. All 16 outside interviewees supported proposition P 1.2. It can be concluded that there is a strong positive relationship between Social-Economic Drivers and Partnership Synergy. Therefore, P1.2 is confirmed.

• Case analysis shows that the desire to achieve Energy Security for the country is not a driver for partnership synergy at the project level. The majority of the interviewees indicated that energy security is mostly discussed at the Federal Government level. Moreover, for the Federal Government RE sources bring some share in the energy mix of the country along with usage of own county reserves, such as exploring new shale gas resources, as well as focusing on energy saving and low gas/millage technologies for the transportation. Therefore, the case findings revealed that there is no relationship between the desire to increase the energy security of the country with partnership synergy. Therefore, preposition P.1.3 is not supported.

• During the interviews some of the RE experts who have been interviewed, mentioned conventional energy prices as a driver for partnership synergy. Since the beginning of 2000s when the energy prices skyrocketed, RE energy was always cost competitive with all the incentives and policy mechanisms. However, with the shale gas revolution, even with the incentives, some of the technologies like solar HVAC systems for heating and cooling had negatively impacted the demand of that technology in the market. As SunChiller President, Serge Adamian mentioned, it is increasingly difficult to promote the technology which is in direct competition with natural gas. Although it was proven that shale gas technology has a lot of negative impacts on environment, however, the fivefold cost reduction of the natural gas prices from $15/BTU to $3/BTU will make
many customers face the dilemma of whether going green or paying less. With all of this in mind, a new proposition P 1.4 is introduced, as follows:

\[ \text{P1.4 The higher the cost of conventional energy sources, the higher the level of partnership synergy among RE stakeholders.} \]

As discussed above, this proposition is supported.

- For the second generation of the technologies described in all four cases, the cost of the technology and project are apparently linked to the market growth and expansion. Some of the stakeholders were interested in cost of the technology reduction, while others were focused on the project cost. For example, as Vice-president of Amonix Guy Blanchard mentioned that the demand for solar PV modules is about 30 GW, while the supply is about 50 GW. In such situation Amonix ends up competing not so much with conventional energy power generation sources, but with peer companies. Consequently, American PV manufacturing companies, such as Amonix, face a fierce competition from China. As it is obvious from case descriptions, the project owners in Cases 1, 3, and 4 preferred Chinese made technologies, which lowered the project costs. Therefore, it can be concluded that both desire to reduce the cost of the technology and cost of the project brings to a higher level of partnership synergy among the stakeholders. All 16 interviewees supported P 2.1 proposition. So, it can be concluded that the preposition P 2.1 is supported.
• Many of the interviewees also mentioned that many stakeholders are curious to learn about opportunities of making money from RE projects, the market growth potential, other new opportunities that participation in the project will bring to them, and the project impact on the local economy or environment. Analysis of all four cases showed that all stakeholders in the beginning had a great desire to learn, while some of them, such as technology owners, project owners or constructors would like get necessary skills in developing RE projects. Without engaging in partnership with other stakeholders and achieving high level of synergy, all of this would not be possible. So, it can be concluded that, the proposition P 2.2 is supported.

• Investors around the world always look for low risk, high return investment opportunities. The availability of financing for RE projects is one the major issues in RE industry. As Mr. Adamian said, there should be a high value proposition for the investor to join the projects. Fortunately, there are a lot of financial organizations that are willing to invest in RE projects, but naturally, before making a decision to invest, they first would like to learn about the risks and returns associated with the project. In some other cases, other stakeholders need to put a lot of effort to bring in the financers and only the desire to maximize their return on investments makes financers willing to join the project. Other stakeholders, such as contractors and technology owners, are looking for additional revenue sources. Additionally, all the interviewees positively responded the questions on P 2.3. So, it can be concluded that the proposition P 2.3 is confirmed.

• Tremendous efforts were required from the lead stakeholders to organize meetings, discussions and presentations for the stakeholders, and later to develop a good plan or proposal for better allocation of resources, including not only physical assets, but
also practical knowledge, technology expertise and information from various stakeholders. As the interviewees indicated, the partnership synergy needs to be achieved for the project to start and be completed on time, not to mention that without the support of at least one of the stakeholders the project will not even start. It is the result of partnership synergy that all the stakeholders expand their knowledge on the project through information sharing. As it was seen from the cases, the projects were completed successfully because of the high level of partnership synergy among the stakeholders expanded their knowledge base. So, it can be concluded that, the proposition 3.1 is supported.

- Similarly, it was concluded from the cases that partnership synergy made it possible for better allocation of resources, task assignments and activity synchronization, which are the key components of effective coordination. All of the respondents also positively responded to the questions related to relationship between partnership synergy and coordination capabilities. Therefore, proposition P 3.2 is supported.

- As it was seen from the cases, in the beginning there was no fully developed collective mind in place. The development of such collective mind was the result of immense endeavors undertaken by the champion to persuade other stakeholders to commit their desperately needed resources into a collective system to ensure the success of the project. All 16 respondents supported the proposition P 3.3. Therefore, the proposition P3.3 is supported.

- As it was seen from the cases, except for Case 3, projects were partially financed by the government or international organization. Only in Case 2 the financing was linked to investment tax credit incentive mechanism, while in other cases, it was the low interest
loan or loan guarantees from the government to keep the project moving. In order to evaluate the effectiveness of innovative financial mechanisms proposed by government or private funds for RE technologies, the stakeholders need to be directly or indirectly involved in the partnership. As 14 of interviewees indicated, success of the project resulting from partnership synergy can increase the effectiveness of innovative financial mechanisms. So, it can be concluded that, the proposition P 4.1 is supported.

- Similarly, the government learns about the effectiveness of RE innovative incentive mechanisms from the feedback from the projects. All the interviewees indicated that stakeholders partnerships in various RE project lobby the government to extend the incentives which are about to expire. The policy makers always have meetings with RE industry representatives and get the information on how to assist the industry to grow and expand. As it was seen from the cases the main Federal incentive mechanisms are production tax credits on wind energy, investment tax credits on solar and feed-in tariffs which are mainly used in Europe. All 16 respondents supported the relationship between partnership synergy and effectiveness of RE innovative mechanisms. So, it can be concluded that, proposition P 4.2 is supported.

- Cases 1, 2, and 3 shows that the main policy mechanism to support RE deployment is State introduced RPS. The work with other stakeholders in RE industry made states to introduce RPS and monitor its effectiveness. All interviewees supported the proposition P 4.3 which explores the relationship between partnership synergy and effectiveness of RE policy mechanisms. Therefore, proposition P 4.3 is supported.

- As seen from the analysis of the cases, the project in Case 2 was completed quicker than the ones described in Cases 1, 3 and 4. This was attributed to the fact that
there was more knowledge accumulated in the Solar Zone, influencing the time performance of the project. In other projects it took longer to achieve partnership synergy and in turn accumulate knowledge. In terms of financial performance, most of the projects still have to reach breakeven. However, the anticipated rate of returns from the projects fluctuated between 8 to 15 percent. All interviewees indicated this fact which supports the propositions P 5.1.1 and P 5.1.2. So, it can be concluded that propositions P 5.1.1 and P 5.1.2 are supported.

• Likewise, the interviewees supported the propositions P 5.2.1 and P 5.2.2, which state that high coordination capability of the stakeholders’ partnership has positive impact on time and financial performance of the project. In all 4 cases, the existing lead organization synchronized the resources and tasks to improve the project performance. For the cases the clear timeline was developed and the project was completed based on that timeline. All the projects started to provide a steady revenue streams to its owners, which, as it was mentioned by respondents, is a result of good coordination activities during the project implementation. Therefore, propositions P 5.2.1 and P 5.2.2 are supported.

• Similarly, the interviewees supported the proposition P 5.3.1 and P 5.3.2, stating that high collective mind of the stakeholders’ partnership has positive impact on time and financial performance of the project. As it was mentioned, all the stakeholders should make their contribution to the outcome of the project with attention and care, but not necessarily have a global perspective of each other’s tasks and activities. In all 4 cases, having collective system in place helped to complete the project on time as well as made
projects financially successful. Therefore, propositions P 5.3.1 and P 5.3.2 are supported.

- All the interviewees supported the propositions that relate to the influence of effective innovative financial mechanisms on both time and financial performance of the RE commercialization. As it was described previously, innovative financial mechanisms were present in all four cases. During the implementation stage neither project suffered because of lack of funding. As a result, the projects were completed on time and, as it was seen, financially successful. Therefore the propositions P 6.1.1 and P 6.1.2 are supported.

- All the interviewees supported the propositions that relate to the influence of effective innovative incentive mechanisms on both time and financial performance of the RE commercialization. Case studies also show that the existence of incentive mechanisms, such as tax credits and feed-in tariffs, positively influenced both time and financial performance of the project. Therefore the propositions P 6.2.1 and P 6.2.2 are supported.

- All the interviewees supported the propositions that relate to influence of effective regulatory policies on both time and financial performance of the RE commercialization. Case studies also show that the existence of state policy mechanisms, such as Renewable Energy Portfolio standards, influenced both time and financial performance of the project. Therefore the propositions P 6.3.1 and P 6.3.2 are supported.

Results of the findings of this study are depicted in Figure 4-1.
Figure 4-1: Study Findings in Relation to the Propositions and the Developed Model
Chapter 5

Conclusion

5.1 Major Research Results

This study produced several interesting research results.

First, this study yields a model to analyze the role of partnership synergy on technology commercialization. This model conceptualizes the relationships among partnership drivers, partnership synergy, resources, and commercialization performance. Furthermore, this model focuses more on project-level activities with the participation of all the public and private stakeholders of the technology.

The second result is the identification of the major drivers that motivate these technology stakeholders to create true partnerships that result in synergy and contribute to commercialization success. It was found that different stakeholders have different motivation in participation in the project. Federal, state, and local governments are more driven by environmental, socio-economic issues or high energy prices in the market, whereas private companies are mostly looking for revenue generation and profit maximization opportunities and acquiring necessary knowledge and skills regarding the technology.

The third major result is the introduction of a new economic theoretical framework
for commercialization through partnership synergy. The study revealed that, without stakeholders’ partnership synergy, the commercialization goals and objectives cannot be achieved. Furthermore, all private and public stakeholders should be involved in the process.

The fourth major result is the finding that the partnership synergy, if achieved, produces a unique internal and external resource combination that will result in successful technology commercialization. New knowledge, better coordination activities and collective thinking of the stakeholders involved in the project is a product of partnership synergy. At the same it was clear that partnership synergy influences on the effectiveness of technology implementation mechanisms.

The fifth result of this study is that the dynamic capabilities and effectiveness of the technology implementation mechanisms positively impact the time performance of the project and perceived financial performance (“perceived” because the financial benefits of the completed projects have yet to be realized).

The conceptual model provides a richer understanding of the factors that private companies engaged in technology commercialization have to take into account to be successful.

Furthermore, given the similarities between RE projects and other large infrastructural projects, it is likely that the application of the model extends to the technology development in large-scale infrastructural projects.
5.2 Theoretical Implications

The findings in this research support the results of other studies on technology diffusion theory (Cooper-Kleininschmidt, 1995c; Morgenstern and Al-Jurf, 1999; and Chen, 2005), which emphasizes the importance of the rate of technology adoption on company’s success. Therefore, in this study, the partnership synergy is seen as one of the key variables, which influences the rate of technology adoption and potentially addresses the questions Chen (2005) raised in his study, that focus on major factors influencing technology adoption, resource allocation and potential investment payoff in terms of bottom-line financial performance. Five different stages of technology diffusion introduced by Rogers (1983)—knowledge, persuasion, decision, implementation, and confirmation—are present in a partnership synergy process during the RE project implementation. In our cases either technology owners or NREL took a lead to provide knowledge and persuade local government, local community members, universities, and private financers to support or finance projects. Then technology owners took the lead on the implementation and confirmation stages. Both public (government and local community) and private stakeholders get all the necessary and required capabilities to accelerate the process of diffusion of second-generation renewable technologies. It is worth mentioning that this study extended dynamic capacities theory by exploring dynamic capabilities of stakeholders’ partnership. Dynamic capability theory introduced by Teece (1997) was extension of most fundamental studies on RBV of companies (Barney, 1991; and Grant, 1991) focused more on single company resource base as a source of competitive advantage. In later studies (Dyer and Sigh, 1998; and Ettlie and Pavlou, 2006), when it became obvious that closer integration with suppliers and
customers is becoming one of the major source of competitive advantage, extended their research on inter-firm dynamic capabilities.

This study continues this trend and proposes to extend dynamic capability theory on stakeholders’ partnership relationships for large scale infrastructural projects. It suggests that dynamic capabilities acquired though stakeholders’ partnership synergy help to address all the non-technical barriers and pass a “Valley of Death” for technology commercialization. This study also suggests that introduced partnership synergy among stakeholders makes sure that existing RE implementation mechanisms are fully utilized, thus making the technology financially attractive. Additionally, through partnerships, different levels of government get feedback on the effectiveness of the incentive and policy mechanisms.

As a summary, this study combines all existing studies, which closely relate to the NPD process and introduces a new theoretical framework, which addresses one of the least explored components on the five stages of the NPD model—commercialization.

5.3 Limitations and Future Research Directions

There are several limitations in this study. First, although the findings are based on an extensive literature review, four case studies and 16 validity/reference interviews with NREL experts who are involved in policy and technical support of RE projects, additional empirical data are needed to generalize the findings. This will require future researchers to develop a single database of all completed RE energy projects in the country. Therefore, future research could focus on testing the propositions in a large-
scale study. The theoretical framework introduced in this study examines influences among partnership drivers, partnership synergy, resources and outcome in RE industry. However, a second limitation is that one market, namely large-scale RE technology deployment, is considered. Future research could extend it to other markets, for example, study on commercialization of new technologies in large-scale infrastructural projects or the health care industry. Additionally, this study did not focus on individually non-technical barriers. Future researchers can attempt to explore the impact of partnership synergy on each non-technical barrier of technology commercialization. Finally, a future study could possibility test the model on individual stakeholders by conducting survey research on policy makers, financers, project contractors, technology owners, or the general public impacted by project implementation.

If the described limitations are addressed, it would become an important contribution from the academic, managerial, and policy points of view. Non-technical barriers exist in any industry. This research focused on the RE industry and proposes a framework addressing non-technical barriers for RE commercialization. Consequently, it lays a useful foundation for expanding the investigation into large-scale studies and into other industries. This will broaden the knowledge about technology commercialization in other industries as well.
5.4 Conclusion

Partnership synergy among technology stakeholders can have substantial effects on technology commercialization. Technologies are not commodities, and require involvement of different stakeholders, who directly or indirectly are impacted by the introduction of these technologies. However, the literature review in this study did not identify any major research on technology commercialization. Once a database is developed, future research can build on this study to construct measurements that link partnership drivers with the level of stakeholders’ partnership synergy, resources and outcomes. The first step to examine these links is given in this study.

The model in this study provides a richer understanding of stakeholders’ motivations to get involved in the project partnership. It clarifies how the achieved partnership synergy influences partnership’s resource base and how this resource base affects time and financial performance of technology commercialization.

The theoretical framework produced in this study helps a broad array of people and organizations that fund and participate in RE projects maximize the return on their investments by realizing the full advantage of collaboration with other RE stakeholders.
References


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Appendix A.

Case Study Protocol
CASE STUDY PROTOCOL

Interviewee________________________ Date__________ Start Time __________
Organization ______________________ End Time __________
Position________________________

1. OPENING EXPLANATION

Thank you again for finding time for the today’s interview meeting. These interview questions, developed by a Ph. D. Candidate from the University of Toledo (Toledo, OH), are designed to learn with your kind consent about your approach on how to develop effective partnership synergies between different renewable energy stakeholders. Such partnerships and synergy normally should enhance a firms’ resource base for timely and successful commercialization of renewable energy technologies that already exist and do not require a further major technology development. I am interested in learning about your experience related to interaction with different renewable energy stakeholders, such as developers of technology, owners and suppliers of technology, entrepreneurs, buyers and end users, financers of technology diffusion, information providers, market intermediaries and government within the framework of single RE commercial project. Specifically, it would be good to learn about the major factors that motivate different stakeholders to get involved in a RE project and create partnership synergies that will positively influence and contribute to successful commercialization of renewable energy technologies. Also, I would appreciate knowing your opinion on how these synergies will enhance dynamic capabilities of RE companies and increase the effectiveness of innovative RE implementation mechanisms? The results of the study will serve as
valuable resource for different government institutions that are involved in policy-making in the RE industry. This study will also act as a tool for practitioners to evaluate the status of their current commercialization efforts and more effectively use the resources that other renewable energy stakeholders can provide. High-quality input from professionals like you will help make this study a success.

Sections 2 – 7 ------------------ Variable Questions
Sections 8 – 13 ------------------ Link Questions

2. GENERAL INFORMATION ABOUT RENEWABLE ENERGY COMMERCIAL PROJECT

1. Please describe your role in RE project implementation

2. Please describe how the renewable energy project is implemented; it would be interesting if you can describe the process
   a. Expected outcome in terms of duration, investment, technical specifications
   b. Involvement of the stakeholders:
      i. Those who are seeking profit
      ii. Those who are seeking other benefits
   c. Types of arrangement, division of tasks and risks, planning of work, project implementation procedure

3. EXTERNAL, INTERNAL DRIVERS (external and internal factors that are likely to stimulate partnership synergy among various renewable energy stakeholders, resulting in accelerated RE commercialization.)
1. In your opinion, what are the most important external drivers that influence the decision of stakeholders to initiate the RE project? Please indicate which stakeholders are driven by which of the following external drivers?

a. Environmental concerns related to pollution from fossil fuels. Please check the box in the table that in your opinion reflects the environmental concerns that are likely to stimulate partnership synergy among various RE stakeholders.

<table>
<thead>
<tr>
<th></th>
<th>Federal Government</th>
<th>Local Government</th>
<th>Individual Community Members</th>
<th>Technology Owners</th>
<th>Contractor</th>
<th>Financers</th>
<th>Project Owner</th>
<th>Other</th>
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<td>Emissions (CO2, sulfur dioxide, etc.)</td>
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<td>Water contamination</td>
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<td>Global Warming</td>
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b. Desire to improve social-economic conditions in the local communities.

Please check the box in the table that in your opinion reflects the social-economic factors that are likely to stimulate partnership synergy among various RE stakeholders.

Social – higher employment, better health, better education, clean environment

Economic – financial wealth of the community, increased number of successful businesses, local economic growth.
a. Desire to increase energy security – uninterrupted physical availability of energy at affordable prices. Please check the box in the table that in your opinion reflects the energy security factor that is likely to stimulate partnership synergy among various RE stakeholders.

2. Please provide your opinion about internal drivers that influence the stakeholders' decision to get involved in the RE project, particularly:

a. Desire to reduce cost of the technology and overall project
### Cost of the Technology

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### Cost of the Project

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<th>Technology Owners</th>
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#### b. Potential profitability increase resulting from project implementation

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<th>Local Government</th>
<th>Individual Community Members</th>
<th>Technology Owners</th>
<th>Contractor</th>
<th>Financers</th>
<th>Project Owner</th>
<th>Other</th>
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<td>Increased Revenues</td>
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<td>Profit maximization</td>
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#### c. Desire to acquire skills and knowledge on RE projects

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<th>Local Government</th>
<th>Individual Community Members</th>
<th>Technology Owners</th>
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<th>Financers</th>
<th>Project Owner</th>
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<td>Knowledge</td>
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<td>Skills</td>
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### 4. PARTNERSHIP SYNERGY (The power to combine the skills, resources and perspectives of a group of people and organizations, the value outcome of which is greater than the sum of its parts). Here the term “partnership” encompasses all of types of collaborations
before, during and after project implementation that bring people and organizations together to successfully commercialize RE technologies.

The following set of questions is aimed at understanding the information exchange, partnership and synergy mechanisms between the actors mentioned in the section 2.

1. What are the platforms for communication for the RE technology stakeholders?
2. Do RE stakeholders clearly communicate on how their actions will address problems that are important to the success of RE project?
3. Is there any lead stakeholder who initiates the partnership process among the stakeholders?
4. Does the partnership incorporate the prospective and priorities of all the stakeholders into its work?
5. Do you think that stakeholders’ partnership within the project gets support from individuals, agencies, and institutions in the community that are in position to either block the RE project or help move it forward?
6. Are the developed common goals understood and supported by all partners?
7. Does the project success depend on contribution of all the stakeholders?

10. DYNAMIC CAPABILITIES (Partnership’s ability to build, integrate, and reconfigure internal and external competencies to address the rapidly changing environment)

   ABSORTIVE CAPACITY - Stakeholders’ commercialization capability to recognize the value of new knowledge, assimilate it and apply it to commercial ends

1. While communicating with other project stakeholders, will you be able to identify, value, and import new knowledge from them? Please explain how each
stakeholder is approached and how their contribution to the success of the project is realized?

2. Do you successfully integrate the existing knowledge with the new knowledge acquired from RE stakeholders? Please explain.

3. Can you successfully assimilate the new integrated knowledge and turn it into successful RE project? Please explain.

COORDINATING CAPABILITY - Stakeholders’ commercialization capability to synchronize resources and tasks to improve the performance of the commercialization activity

1. Do you believe that the output of your joint efforts with other stakeholders (knowledge, expertise, resources) is of a form useful to your project? Please explain.

2. Do you make sure that the output of joint work is available to all RE stakeholders when needed? Please explain.

3. Do you ensure an appropriate allocation of resources (e.g., information, time, reports) with RE stakeholders? Please explain.

COLLECTIVE MIND - Stakeholders’ ability to heedfully integrate their diverse and unrelated resources into a collective system through contribution, representation and subordination

1. Do you think each stakeholder make their contributions to the outcome with attention and care? Please explain.

2. Do you think that each stakeholder have a global perspective of each other’s tasks and responsibilities? Please explain.
3. Do you think that each stakeholder carefully interrelated actions to each other to maximize the project performance? Please explain.

11. EFFECTIVENESS OF RE IMPLEMENTATION MECHANISMS (The degree to which all the RE innovative implementation mechanisms contribute to the success of commercialization of RE technologies.)

This section is about the project financing, as well as incentive mechanisms and policy instruments applied during implementation of RE project.

1. What are the major sources of financing of RE commercial project? What types of tax incentives and public policy mechanisms are available? Please explain.

2. What are the major benefits of these tax incentives and public policy mechanisms provide to the project? Please explain.

3. Do you think that tax incentives and public policy mechanisms or policy instruments are effective and helpful to boost commercialization process? How you measure effectiveness? Please explain.

4. Do you provide feedback to other RE stakeholders about the effectiveness of these mechanisms and policies? Please explain.

5. What are the major issues you that in your opinion hinder these RE implementation mechanisms? Please explain.

12. COMMERCIALIZATION SUCCESS

1. How long did it take to complete the project? Please explain.
2. Is the time of project completion important for the stakeholders or are they more concerned about other performance variables? Please explain.

3. Did the project participants benefit financially from the project implementation? Please explain.

4. Do they seek long term or short term financial benefits? Please explain.

13. EXTERNAL DRIVERS → PARTNERSHIP SYNERGY

1. Do you think that environmental concerns make stakeholders more willing to combine the skills, resources and perspectives and be concerned about the successful outcome of the project? Do you agree that the higher those concerns, the more likely they are to participate and create partnership synergy? Please name the stakeholders for whom environmental concerns are priority.

2. Do you think that social-economic concerns make stakeholders more willing to combine the skills, resources and perspectives and be concerned about the successful outcome of the project? Do you agree that the higher those concerns, the more likely they are to participate and create partnership synergy. Please name the stakeholders for whom social-economic concerns are priority.

3. Do you think that country’s energy security issues make stakeholders more willing to combine the skills, resources and perspectives and be concerned about the successful outcome of the project and create partnership synergy? Do you agree that the higher those concerns, the more willing they are to participate. Please name the stakeholders for whom the country’s energy security issues are priority.
14. **INTERNAL DRIVERS → PARTNERSHIP SYNERGY**

1. Do you think the desire to lower the project cost will make the stakeholders more likely to combine the skills, resources and perspectives more frequently in order to address each other’s concerns? Will this lead to a higher level of partnership synergy for the stakeholders where everybody wins?

2. Do you think the desire to acquire necessary skills and knowledge for successful implementation of the project will make the stakeholders more likely to combine the skills, resources and perspectives more frequently and extensively? Will this lead to a higher level of partnership synergy for the stakeholders where everybody wins?

3. Do you think the desire to increase the profitability of the project will make the stakeholders more likely to combine the skills, resources and perspectives more frequently and extensively? Will this lead to higher level of partnership synergy for the stakeholders where everybody wins?

15. **PARTNERSHIP SYNERGY → DYNAMIC CAPABILITIES**

1. Do you think that partnership synergy among stakeholders will influence stakeholders’ ability to better understand the issues associated with the project, lead to better usage of the information acquired from other stakeholders for successful completion of the project?
2. Do you think that partnership synergy among stakeholders will lead to a better coordination among the stakeholders regarding the issues related to the project, thus helping save resources and make the project more successful?

3. Do you think that partnership synergy among stakeholders will lead to more collective thinking about projects’ benefits, goals and outcomes?

16. PARTNERSHIP SYNERGY → EFFECTIVENESS OF THE RE IMPLEMENTATION MECHANISMS

1. Do you think that the partnership synergy among the stakeholders (including the financers of the project) will lead to a better understanding of the issues associated with RE project, and thus lead to introduction of much better financial mechanisms? Please explain.

2. Do you think that the partnership synergy among the stakeholders (including government) will lead to a better understanding of the issues associated with RE project, and thus lead to introduction of much better incentive mechanisms, which will make the project attractive? Please explain.

3. Do you think that the partnership synergy among the stakeholders (including government) will lead to a better understanding of the issues associated with RE projects, and thus lead to enacting much better policies, which will make the project attractive? Please explain.
17. **DYNAMIC CAPABILITIES ➔ COMMERCIALIZATION SUCCESS**

1. Do you think that the higher the stakeholders’ ability to recognize the value of new knowledge, assimilate it and apply it will accelerate the project approval and completion? Please explain.

2. Do you think that the higher the stakeholders’ ability to recognize the value of new knowledge, assimilate it and apply it will make the project financially successful? Please explain.

3. Do you think that the higher coordination among the stakeholders will accelerate the project approval and completion? Please explain.

4. Do you think that the higher coordination among the stakeholders will make the project financially successful? Please explain.

5. Do you think that collective mind among the stakeholders will accelerate the project approval and completion? Please explain.

6. Do you think that collective mind among the stakeholders will make the project financially successful? Please explain.

18. **EFFECTIVENESS OF THE RE IMPLEMENTATION MECHANISMS ➔ COMMERCIALIZATION SUCCESS**

7. Do you think that availability of better financial mechanisms will accelerate the time of project completion? Please explain.

8. Do you think that availability of better financial mechanisms will make the project financially successful? Please explain.
9. Do you think that availability of better incentive mechanisms will accelerate the time of project completion? Please explain.

10. Do you think that availability of better incentive mechanisms will make the project financially successful? Please explain.

11. Do you think that better policies on RE will accelerate the time of project completion? Please explain.

12. Do you think that better policies on RE will make the project financially successful? Please explain.